Columbia River Crossing
Final Environmental Impact Statement
Request for Supplemental Draft EIS

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“Peak Traffic: Transportation Triage at the End of the Age of Oil
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Comments submitted October 24, 2011

A Supplemental Draft EIS is needed to redo the asssumptions that Vehicle Miles Traveled will continue to increase even as energy supplies decline.

While it is nice that the Final EIS admits that Peak Oil is a concern, the discussion is so erroneous that a SDEIS is needed to revise the basic assumptions of the project.

The Final EIS does not mention that traffic levels in Oregon have peaked, nor is there any substantial discussion of the decline of the energy supplies that run traffic levels in the study area. The Final EIS admits that Alaskan oil peaked in 1988 but it does not mention that flow rates have declined two-thirds since that peak and are approaching a “low flow” condition where flows may not be able to be maintained in the Arctic winter. When the Alaska Pipeline no longer flows in the winter, what part of the world will give up some of their energy usage so that Cascadia can maintain petroleum consumption?

The Alyeska Pipeline “Low Flow” study should be reviewed for the implication for traffic patterns in the Pacific Northwest, both the study area for this project and the region as a whole. A cut off of petroleum supplies from Alaska would have major implications for the economy and travel demand. Currently, the Alaska Pipeline has about 600 thousand barrels per day. When the flow declines to 500 thousand per day it may no longer be possible to sustain oil flows. The Alyeska Pipeline company is trying to determine if the Pipeline can be continued to lower flows than this, but even if this is technically possible it is reasonable to assume that the Alaska Pipeline will be over as an energy source before the 20 year planning horizon for the Columbia River Crossing.

My comments on the Draft EIS were not addressed in the Final EIS, and they are resubmitted for the record of the Final EIS along with background information on Peak Oil and Peak Traffic.

www.sustaineugene.org/columbia-river-crossing.html
CRC Peak Traffic Alternative, comments submitted for the Draft EIS, 2008

www.road-scholar.org/peak-traffic.html
why Peak Oil and Peak Traffic require an end to highway expansion, we will have a hard enough time maintaining what has already been built on the energy downslope

The Final EIS claims estimates of Peak Oil range from 1990 to 2040. No one seriously proposes either end of this range.

The earliest predictions of global Peak Oil were made by geologist M. King Hubbert, who originally estimated that it would occur in the mid 1990s. He qualified this prediction noting that it could be delayed about a decade if there were conservation efforts that reduced consumption, which is exactly what happened (in large part due to the price shock of the 1973 Arab oil embargo).

Former University of Oregon petroleum geologist Walter Youngquist estimated in the 1990s that the global peak would happen around 2007. He looked at petroleum figures from 42 countries to make his prediction (abstract attached to these comments). This is about as close as anyone got. Focusing on the exact peak is not important, as long as the correct decade is considered. Any energy plan that assumes a half century range of timing for the peak is useless and wrong.

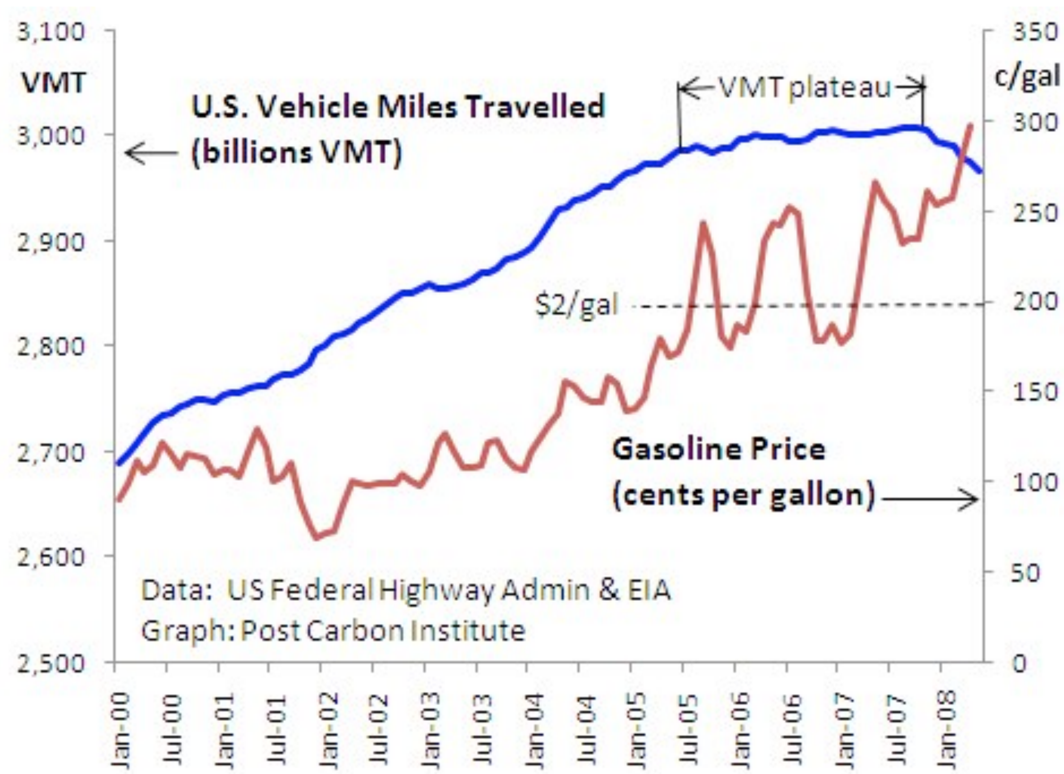
The most pollyanna predictions by geologists for global Peak are still well before 2040.

During the time period of the CRC study global oil production peaked and is now on a bumpy plateau. NEPA states that “new circumstances” relevant to a study need to be examined in a Supplemental Draft EIS. If reaching Peak Oil and Peak Traffic is not a new circumstance then nothing is.

Peak Oil for "all liquids" was 2008 and given decline of the largest fields it's unlikely that offshore drilling, tar sands and other extreme measures will make up the difference. The new “Bakken” oil field in North Dakota is difficult to extract and lacks the “energy density” or “net energy” of previous petroleum supplies. We are scraping the bottom of the barrel to go after the lower grade, more expensive supplies, but they are unlikely to offset the depletion of the supergiant fields such as Prudhoe Bay (Alaska), Cantarell (Mexico), Ghawar (Saudi Arabia), etc.

Peak Oil is not just about gasoline prices rising or the illusion of a hundred million electric cars. Energy depletion means the energy will not be there to use. You cannot burn fuel that does not exist. Endless growth was not possible on a round, finite planet. Brace for impact.

Traffic levels have also peaked as oil prices increased and economic “growth” slowed. It is not a surprise that rising oil prices stopped the rate of traffic growth. There is still a lot of traffic but the levels are not going up any more. A Supplemental Draft EIS is needed to examine how Peak Traffic will impact the alleged need for expanded highway capacity.



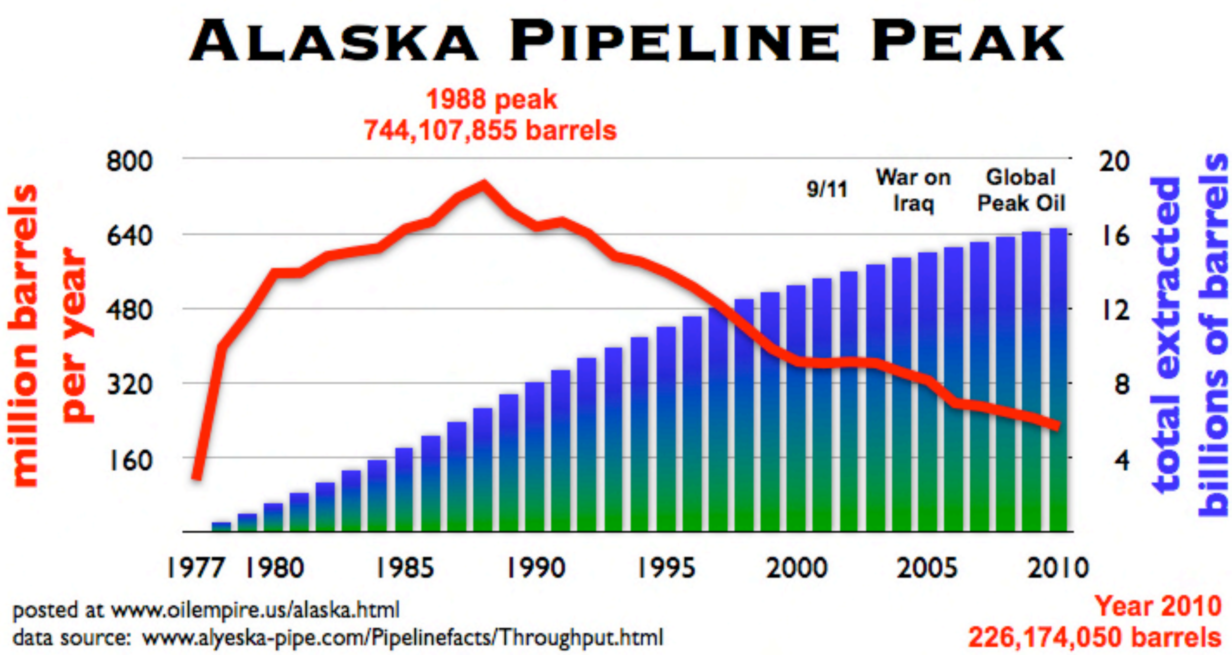
Columbia River Crossing
Final Environmental Impact Statement
September 2011
Federal Highway Administration, Oregon and Washington DOT
p. 3-321

Washington and Oregon Petroleum Supply

> "Because gasoline and diesel are the primary energy sources for the transportation sector, this analysis of energy supply focuses on petroleum-based fuel sources. **Approximately 90 percent of Washington's current supply of crude oil comes from Alaska's North Slope oil fields.** Five refineries in the Puget Sound area distribute refined petroleum products to Washington and adjacent states. **Oregon imports 100 percent of its petroleum, approximately 90 percent of it from Washington refineries. Both states' future supply of petroleum is largely dependent on domestic production and reserves. Oil production from the North Slope peaked in 1988 and is projected to continue declining."**

This ignores the fact that North Slope extraction has dropped by two-thirds and is nearing the "Low Flow" condition where flow will be difficult to maintain in the Arctic winter even though this information is on the Alyeska Pipeline website.

for more information: www.alyeska-pipe.com/Inthenews/LowFlow/LowFlow.html



EXISTING CONDITIONS AND ENVIRONMENTAL CONSEQUENCES • 3-447
3.19.12 Energy and Peak Oil

The long-term energy demand estimates prepared for the CRC project are influenced by cumulative factors. Those estimates are based on travel demand forecasts that factor in projected regional changes in land use patterns, employment, population growth, and other programmed transportation improvements.
The cumulative energy impact of primary concern is “peak oil.” Peak oil refers to the point in time at which the maximum global petroleum production rate is reached, after which the rate of production enters a terminal decline. Peak oil results from many incremental actions, few of which are individually important. However, the potential impact of reaching peak global petroleum production is an important consideration for projects, such as CRC, that are intended to address transportation needs for decades to come.
Oil production in the United States—the world’s third largest oil producing nation—reached its peak around 1970 and has been declining since then. **Most estimates place peak global production sometime between 1990 and 2040.**
When oil production drops below oil demand, it is likely to cause petroleum prices to increase. There are uncertainties, however, regarding peak oil’s timing and the availability of substitute fuels. Peak oil’s effect on transportation fuel prices and travel behavior will depend largely on when peak oil occurs and the availability of substitute fuels.
Peak oil’s potential effects on economic activity and travel behavior could affect travel behavior in the region. **The concern is that if substitute fuels are not readily available as petroleum supplies decrease, the rising cost and reduced supply of petroleum could directly reduce auto and truck travel, and could result in dramatic reductions in economic activity, which, among other effects, could further reduce vehicle trips below forecasts.** These vehicle trip forecasts influence the proposed size, design, and financing of transportation facilities.
If fuel prices increase faster than expected, then the number of 2030 highway trips could be lower than forecasted. However, even with relatively substantial fuel price increases, the future demand would still likely be greater than the expanded highway capacity. Because fuel costs represent only a portion of total transportation costs (which include everything from car payments, to insurance and maintenance), even large growth in fuel costs translates to a smaller growth rate in total transportation cost, which more directly affects travel demand in the long term.

Comment: sharper increases in fuel costs combined with decreased availability of fuel will also have substantial economic impacts that will reduce travel demand. An early version of this shift was demonstrated as oil prices increased as global production peaked. Unemployed people do not drive as much as those who have job security.

Global demand for liquid fuels is projected to grow by 21 percent by 2030, driven in large part by transportation needs (EIA 2010). Petroleum accounts for the largest percentage of liquid fuels globally. Local transportation energy demand is expected to grow as well, although the LPA is projected to reduce future transportation petroleum demand compared to the No-Build Alternative. At the global scale, these fuel savings will be very small, but incrementally more beneficial than the No-Build Alternative.

The LPA includes a number of elements that would reduce adverse impacts related to peak oil. These include:

- The bridge and highway improvements are focused on replacing or updating aging infrastructure, not on building new highway corridors.

The LPA includes substantial improvements to public transportation, with projected increases in transit mode share in the afternoon peak direction from 8 percent with the No-Build Alternative to 15 percent with light rail transit.

- It provides substantially improved facilities for non-motorized transport (such as walking and bicycling).
- It supports land use planning that seeks to control sprawl, concentrate development, and decrease auto dependency.
- It includes road use pricing (highway tolling).
- Because of the addition of high-capacity transit and the bridge toll, the LPA is projected to have lower daily I-5 river crossings than under the No-Build Alternative.
- It improves highway operations at a key pinch point, which improves fuel efficiency and lowers emissions.
- It increases highway safety, which decreases collisions and congestion, further improving fuel efficiency.

Another concern is the ability of existing transportation infrastructure to adapt to post-peak oil vehicles and technology. Based on current and prototype future alternative fuel vehicles, it is highly likely that the CRC infrastructure (transit guideway, bridges, highway, and bike and pedestrian paths) will be able to accommodate foreseeable changes in vehicle technology and fuels. Electric hybrids, electric plug-ins, and vehicles powered by biodiesel, ethanol, or hydrogen fuel cells are being designed to operate on modern roads and highways. The light rail transit guideway can be used by vehicles powered by a variety of fuels. The capacity of the proposed bicycle and pedestrian facilities can accommodate substantial growth in non-motorized transportation demand. It is likely that the proposed CRC infrastructure could readily accommodate or adapt to the transition to substitute fuel vehicles, higher than projected growth in non-motorized modes, and higher growth in transit demand.

There is substantial uncertainty regarding the timing of peak oil, the future availability of substitute fuels and technology, and the effects of peak oil on transportation. It is reasonable, however, to conclude that the CRC project can address reasonably foreseeable impacts associated with peak oil, and reduce the project's incremental adverse impact.

Outside the purview of CRC, numerous other measures will influence the timing and impact of peak oil at the global and local scale. These other actions include national and international energy policies, global oil prices, fuel and transportation taxes and fees, alternative fuel and technology research and development, agricultural policy and practices, local land use regulations, and other measures.

Comment: This section needs to be rewritten to acknowledge that oil has already peaked and the economic impacts of reaching the limits to endless growth on a finite planet. Energy creates money, not the other way around. Peak does not mean that we have run out, but it does mean that growth is over. Energy decline is not just about rising oil prices, it is about a reduction in the available supply. The level of demand that the public has for liquid fuels cannot make those fuels come into existence. There are physical limits to energy supplies that are not subject to economics or psychology. Yes, higher prices spur energy companies to extract lower quality, more expensive, more difficult to extract supplies -- and to look at alternatives to fossil fuels. But these mitigation approaches on the downslope are unlikely to offset the decline in the energy supplies that keep our transportation levels constantly increasing.

What does the U.S. Department of Energy say about peak oil?

A report by the U.S. Department of Energy (Hirsch et al. 2005) included the following conclusions:

- World oil peaking is going to happen, and will likely be abrupt.
- The problem is the demand for liquid fuels (growth in demand mainly from the transportation sector).

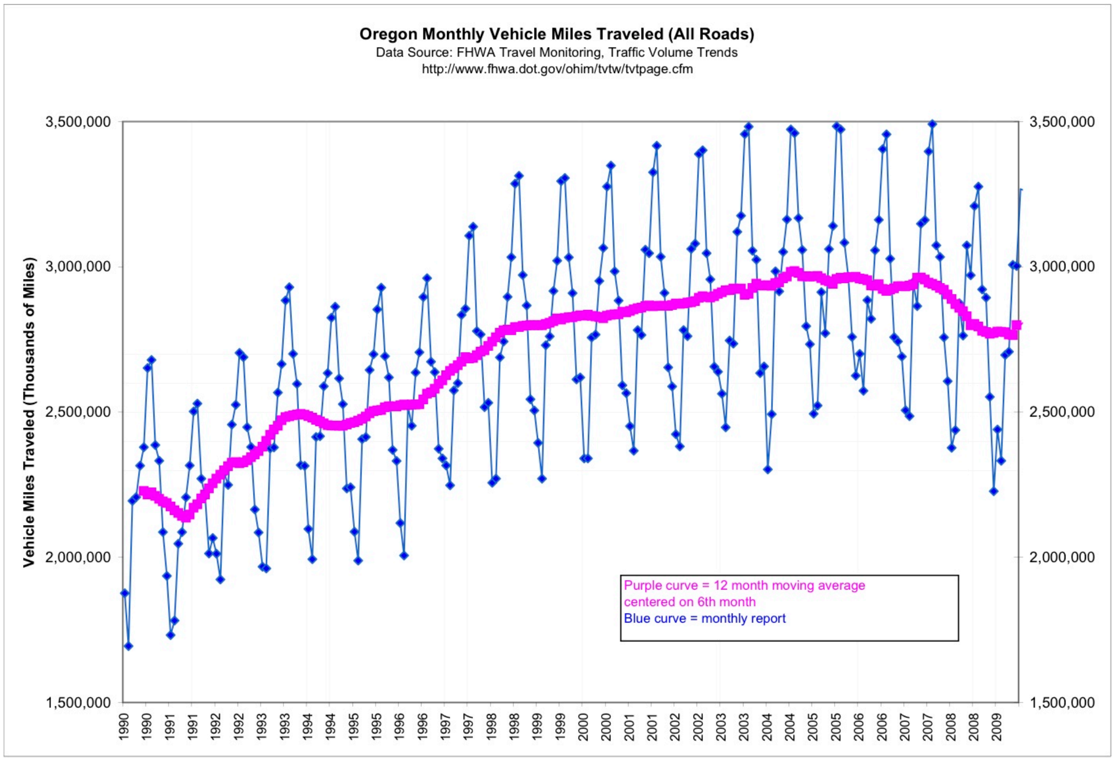
- Mitigation efforts will require substantial time.
- Both supply and demand will require attention.
- More information is needed to more precisely determine the peak time frame.

Comment: The Hirsch report concluded twenty years of preparation would be needed to prevent the economic crash from Peak Oil, even if toxic practices such as coal to liquids, tar sands and other noxious sources were extracted. Hirsch concluded that we would have a severe economic shock if we waited until the Peak to start making shifts. Ignoring this conclusion of the report invalidates the EIS and requires a Supplemental Draft EIS to examine the probable scenarios regarding travel demand and economic stability in the CRC's design year.

> Has transportation infrastructure been able to adapt to change?
> Transportation infrastructure has proven to be relatively adaptable. For example, the northbound I-5 bridge over the Columbia River was built in 1917 as a two- lane bridge that originally carried electric trolley cars and Model T autos (which ran on either gasoline or ethanol). While the bridge is now out-of-date in terms of seismic safety and traffic safety design standards, the bridge has accommodated nearly a century of changes in transportation technology, energy policy and prices, vehicle types, and travel behavior.

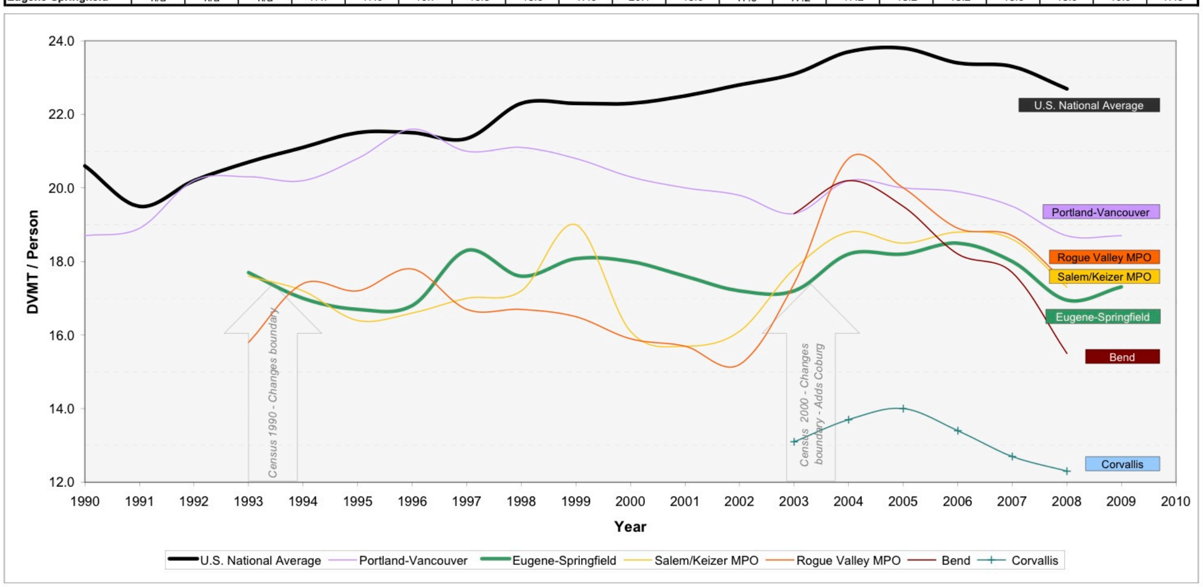
Comment: There never before has been a permanent plateau on energy availability. Reaching the limits to growth in energy needs to be examined in a Supplemental Draft EIS. Solar energy and biofuels are great but they are unlikely to be able to completely replace our current consumption.

> "The government cannot print oil."
> -- Robert Hirsch, ASPO USA 2009 conference, October 13, 2009
>
> "The economists all think that if you show up at the cashier's cage with enough currency, God will put more oil in the ground."
> -- Kenneth Deffeyes, petroleum geologist and associate of M. King Hubbert



Daily VMT (Vehicle Miles of Travel) Per Person - 1990 to 2009
Eugene-Springfield compared with other Oregon MPOS and the US National Average

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
United States	20.6	19.5	20.2	20.7	21.1	21.5	21.5	21.3	22.3	22.3	22.3	22.5	22.8	23.1	23.7	23.8	23.4	23.3	22.7	
Portland-Vancouver	18.7	18.9	20.2	20.3	20.2	20.8	21.6	21.0	21.1	20.8	20.3	20.0	19.8	19.3	20.2	20.0	19.9	19.5	18.7	18.7
Eugene-Springfield	n/a	n/a	n/a	17.7	17.0	16.7	16.8	18.3	17.6	20.1	18.0	17.6	17.2	17.2	18.2	18.2	18.5	18.0	16.9	17.3



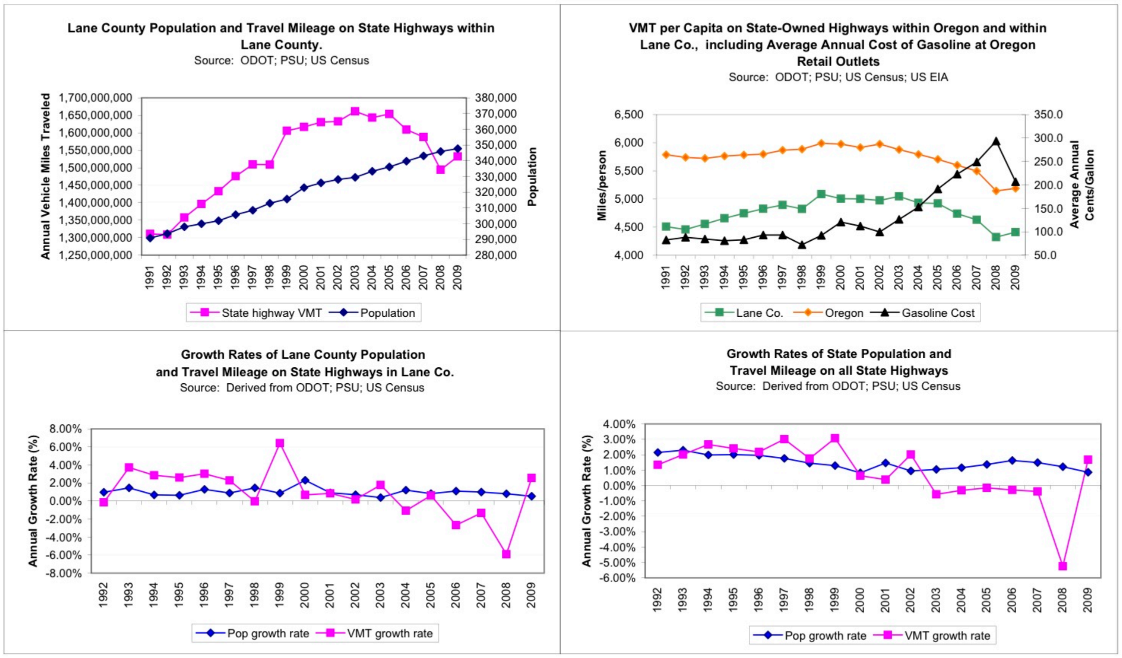
Estimated Vehicle Miles Traveled on State-owned highways in Lane County and Lane County Population, from 1991 through 2009

Sources:

VMT: ODOT (March 2011) http://www.oregon.gov/ODOT/TD/TDATA/tsm/vmtpage.shtml

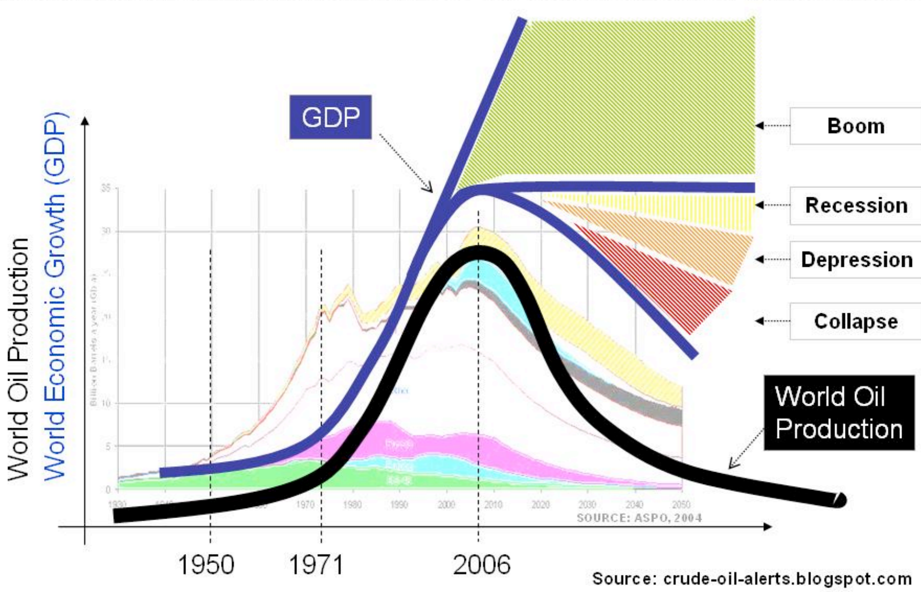
Population: US Census Bureau, Portland State University - compiled by LCOG, http://www.lcog.org/lgs/ira.html

Gasoline Prices (excl. local taxes): US Energy Information Administration, http://tonto.eia.doe.gov/dnav/pet/pet_pri_allmg_d_SOR_PTC_cpgal_a.htm

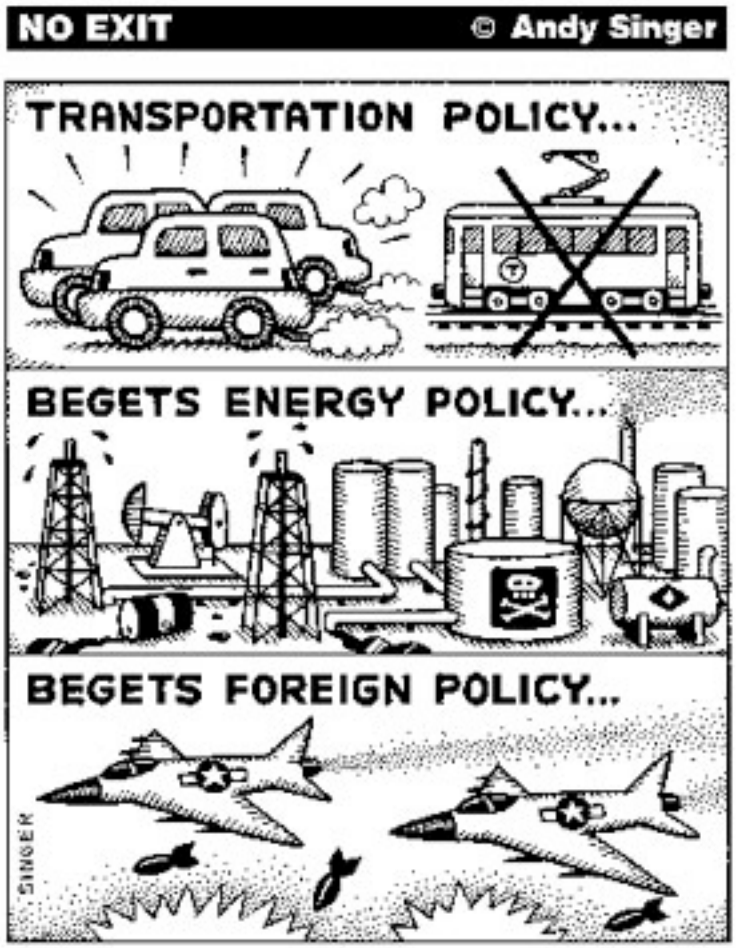


graphics from the Lane Council of Government

World Crude Oil Production and Gross Domestic Product are interrelated

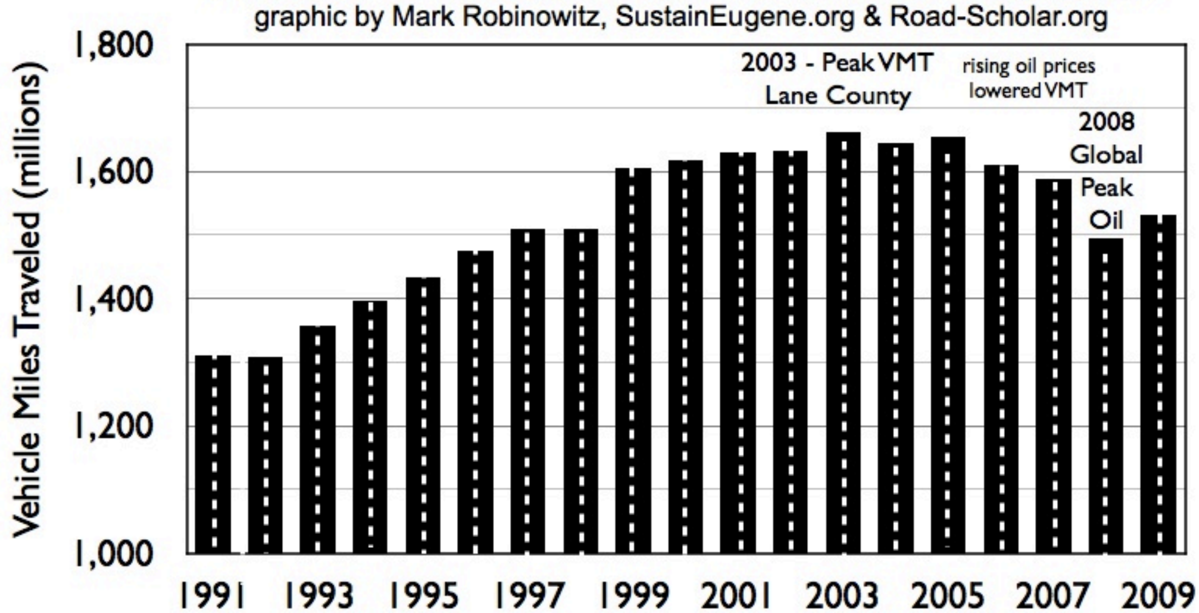


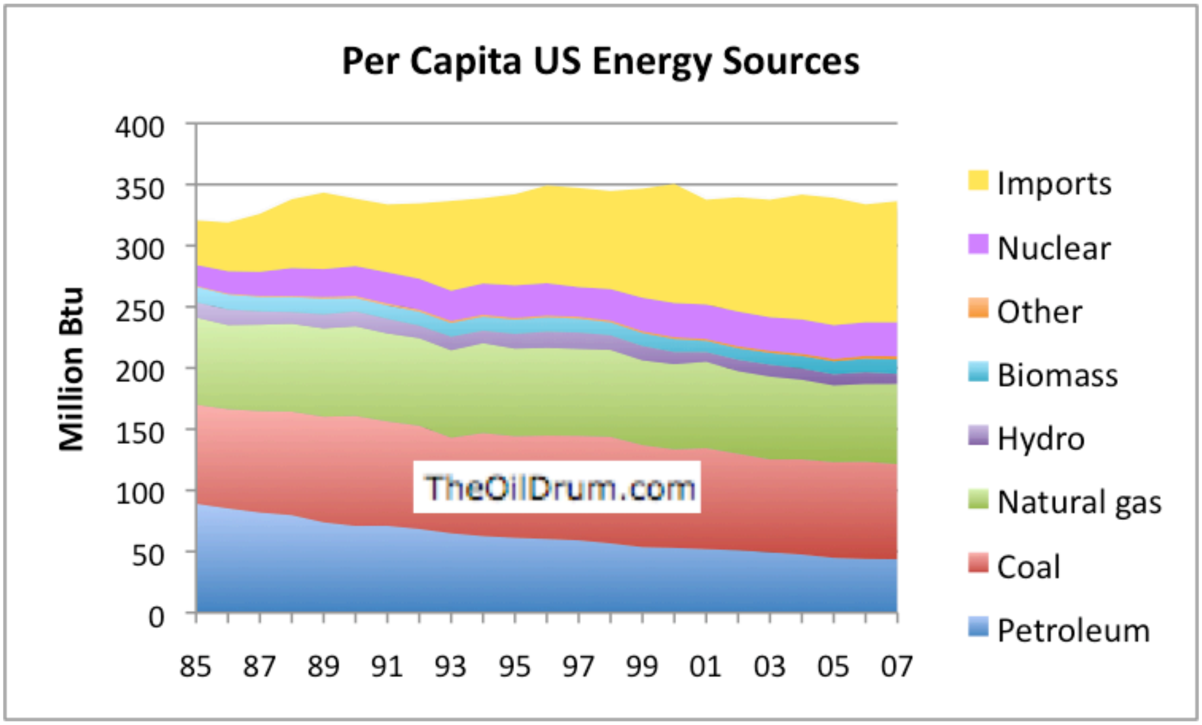
Oil Production and Economic Growth are directly related.

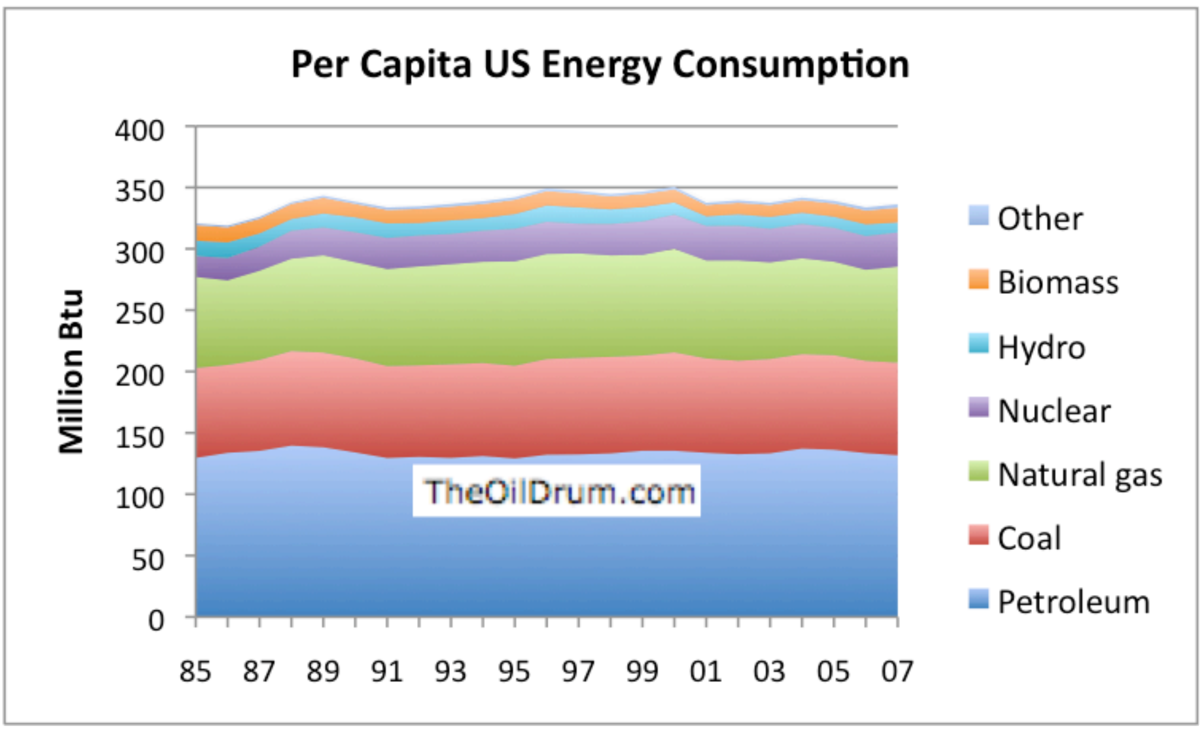


Lane County VMT - Oregon State Highways

data source: www.oregon.gov/ODOT/TD/TDATA/tsm/docs/VMTCounty.xls
graphic by Mark Robinowitz, SustainEugene.org & Road-Scholar.org




Per Capita US Energy Sources
Million Btu
400
350
300
250
200
150
100
50
0
85 87 89 91 93 95 97 99 01 03 05 07
TheOilDrum.com
Imports
Nuclear
Other
Biomass
Hydro
Natural gas
Coal
Petroleum


Per Capita US Energy Consumption
Million Btu
400
350
300
250
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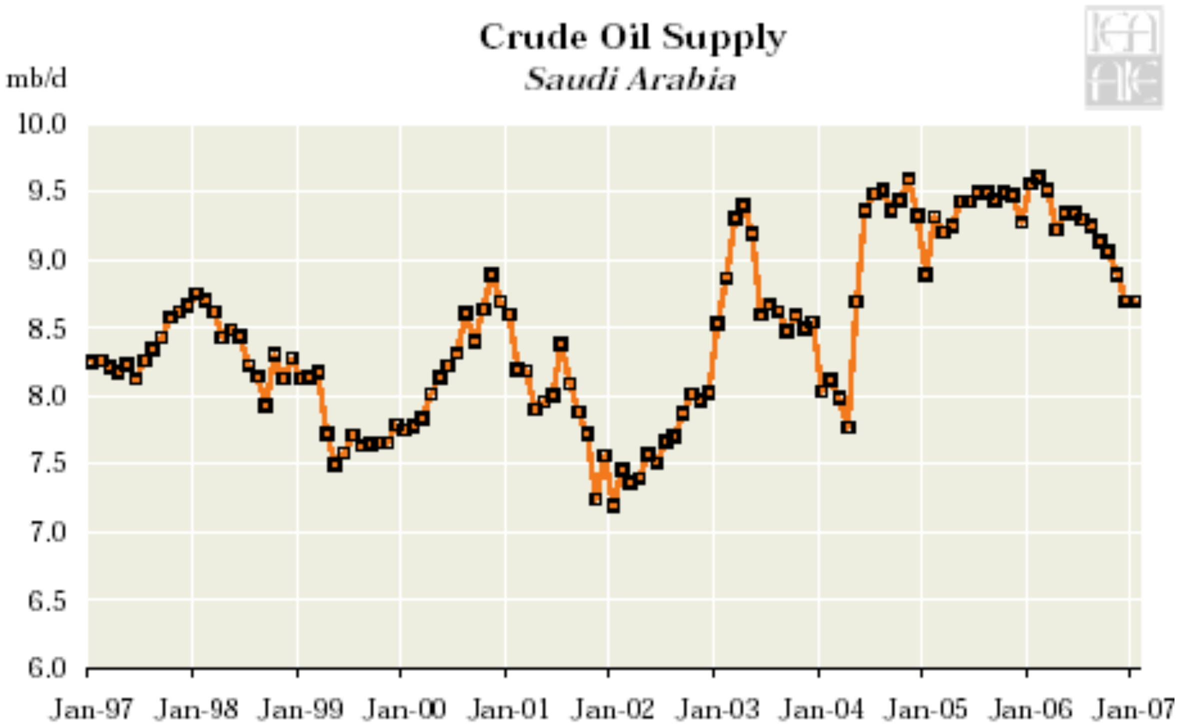
85 87 89 91 93 95 97 99 01 03 05 07
TheOilDrum.com
Other
Biomass
Hydro
Nuclear
Natural gas
Coal
Petroleum


Crude Oil Supply
Saudi Arabia
mb/d
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
Jan-97
Jan-98
Jan-99
Jan-00
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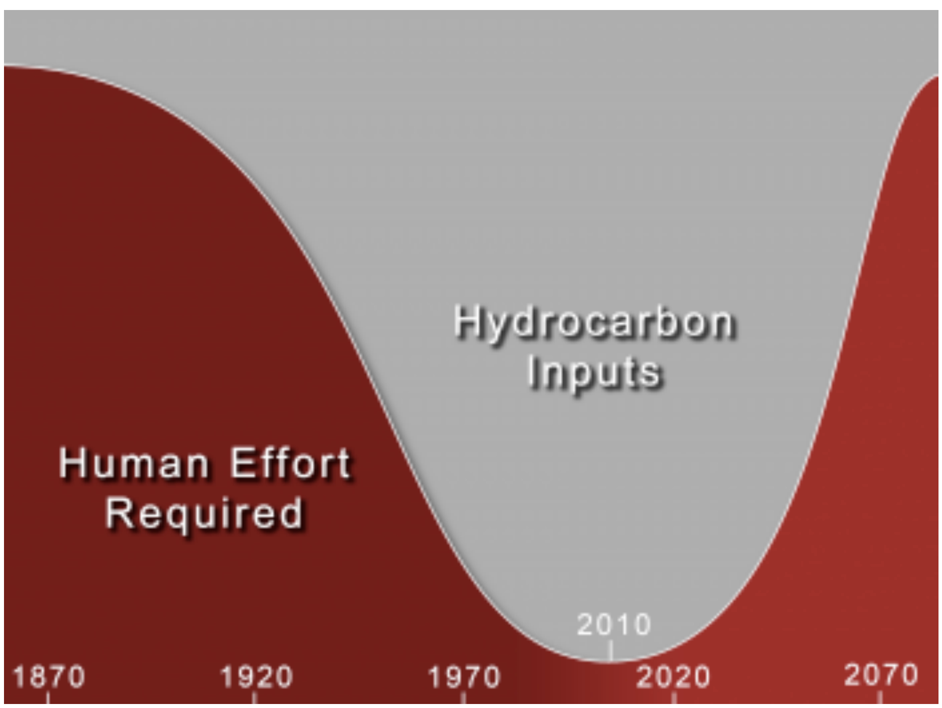
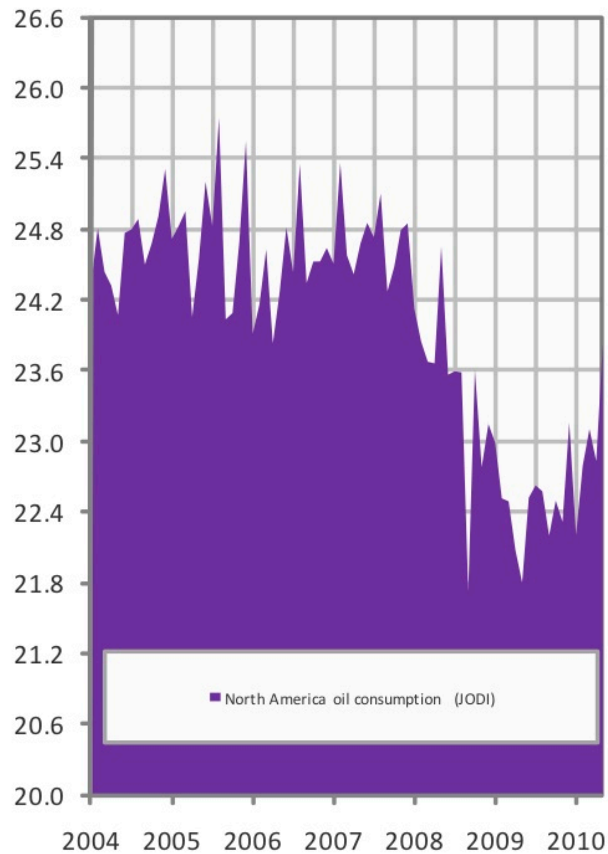
Jan-06
Jan-07


Hydrocarbon Inputs
Human Effort Required
2010
1870
1920
1970
2020
2070

North America oil consumption

Oil consumption in North America increased by 1.0 million b/d from April to May 2010. Resulting in a consumption level of 23.84 million b/d. Average oil consumption in North America in 2009 was 22.51 million b/d, versus 23.50 and 24.72 million b/d in respectively 2008 and 2007.

Chart 21: North America Oil Consumption Jan. 2004 - May 2010



Source: Joint Oil Data Initiative

graphic showing North American oil consumption dropping after global Peak Oil -- we cannot burn fuel that does not exist whether it is cheap, expensive or rationed -- from www.peakoil.nl

graphics from Energy Watch Group, Germany
US production is long past peak and the future of US oil is low grade shale, offshore drilling and Canadian tar sands.

Figure 29: Oil production in the USA

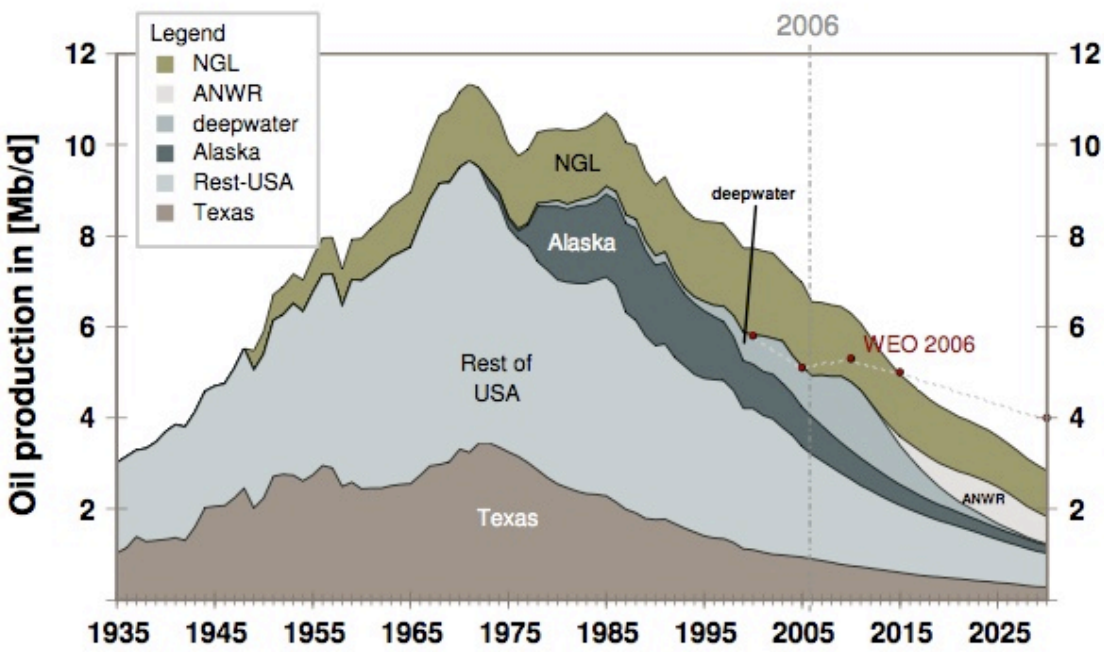
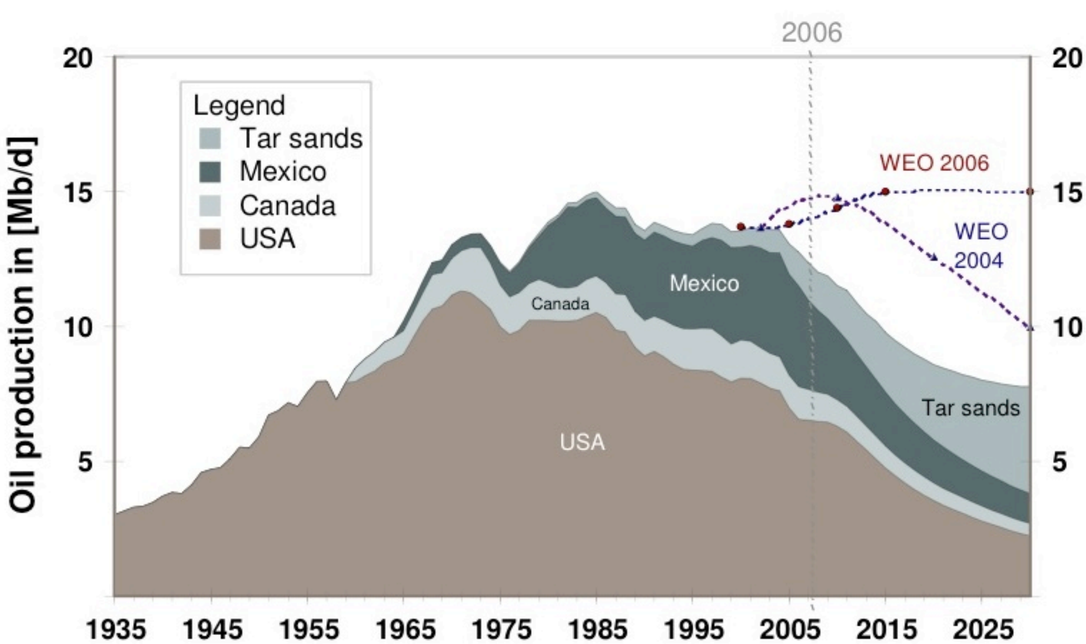
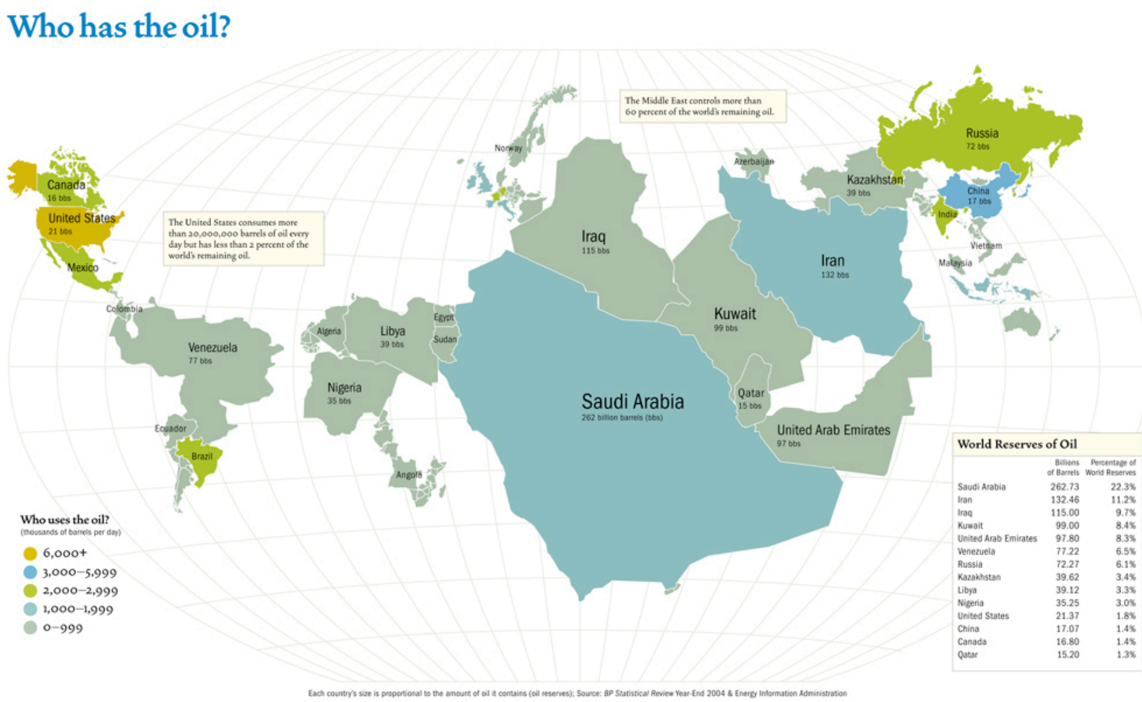


Figure 28: Oil production in OECD North America



graphic from British Petroleum

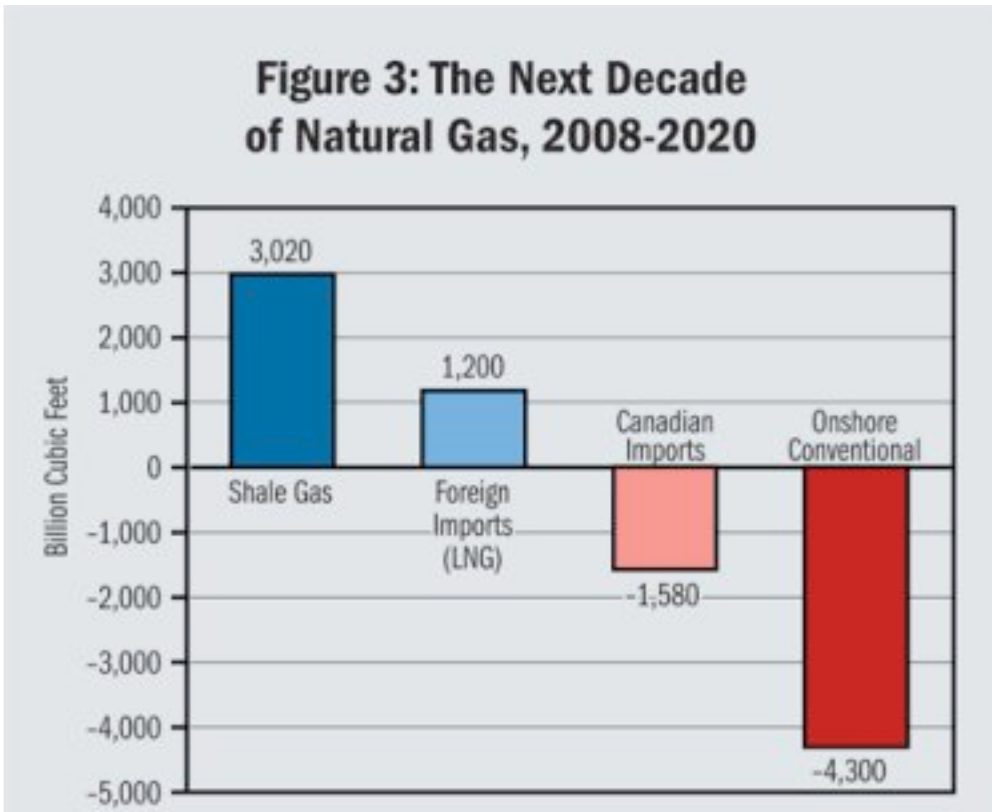


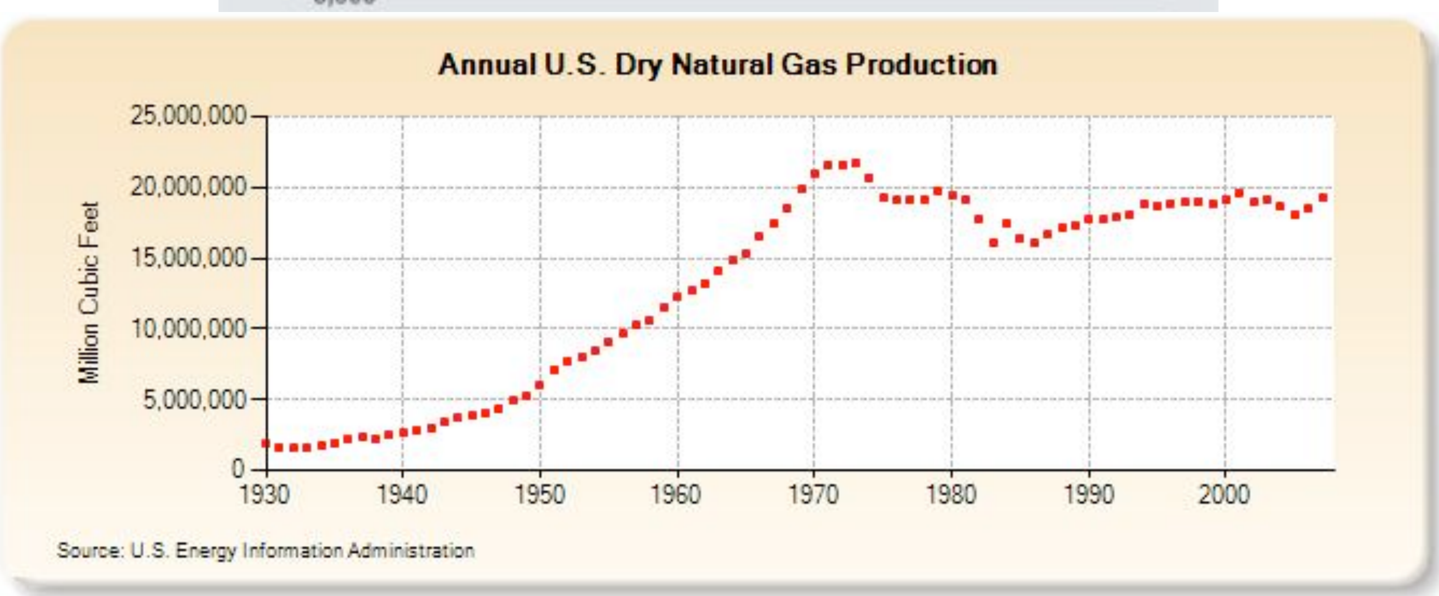
World Reserves of Oil

	Billions of Barrels	Percentage of World Reserves
Saudi Arabia	262.73	22.3%
Iran	132.46	11.2%
Iraq	115.00	9.7%
Kuwait	99.00	8.4%
United Arab Emirates	97.80	8.3%
Venezuela	77.22	6.5%
Russia	72.27	6.1%
Kazakhstan	39.62	3.4%
Libya	39.12	3.3%
Nigeria	35.25	3.0%
United States	21.37	1.8%
China	17.07	1.4%
Canada	16.80	1.4%
Qatar	15.20	1.3%

Note that Cascadia does not have ANY oil, we have the wrong geology.
Volcanic basalt and subduction zones are not where petroleum traps are created.
There is a small amount of natural gas in Oregon.

graphic from US Department of Energy
the decline of Natural Gas will have significant impact on economics, including electricity production (since there has been a lot of new power generation in the past two decades running on natural gas). Shale gas “fracking” is a short term resource that is unlikely to last as long as its promoters claim.
for details read geologist Art Berman’s reports at www.aspousa.org and reports on natural gas at Post Carbon Institute www.postcarbon.org





from the Association for the Study of Peak Oil and Gas - USA
August 24, 2009
www.aspo-usa.org

Commentary: Interview with Tom Whipple

Tom Whipple, retired CIA analyst and editor of this newsletter, will be a speaker at the ASPO-USA conference this October 11-13. When called up and ambushed for this interview, he immediately said he thought the idea qualified as "the dumbest idea of the week," but eventually assented. From his home just outside Washington D.C. in Virginia, the amount of information that Tom single-handedly has gathered and circulated about the unfolding peak oil story is extraordinary. For his relentless efforts, ASPO-USA has named their award for volunteer of the year the Whipple Award.

Question *(from Steve Andrews): when did you first become aware of the peak oil phenomenon?*

Tom Whipple: I think it was the 1998 article in *Scientific American*, by Colin Campbell and Jean Laherrere ["The End of Cheap Oil"]. This was the first time I became aware that this was serious. Prior to that, I had read a little about this in *The Limits to Growth* [1972], but that disappeared for about 25 years. Then, not much happened until 2004, when everything started moving rapidly: prices started flying up, the peak oil movement started ramping up, Peakoil.com and The Oil Drum started right about then. So I started to follow the information flow.

Question: *When did you start writing about the peak oil story?*

Whipple: The first thing I got involved with was writing a few columns for a local newspaper, the *Falls Church News Press*. For years the editor had asked me to submit some material. I finally asked him if he would publish something on peak oil. Just that week, a big story on peak oil had been in Rolling Stone, a review of *The Long Emergency* by Jim Kunstler, and the editor was quite taken by it, so he said "go ahead." That was in early 2005, and I've been writing a column a week ever since; with just a couple of breaks, I must be up over 225 by now. I've been exploring a wide range of topics related to peak oil—not so much the geology, but what some of the implications are and how we're going to get through this. Every week something new pops up. This week came the announcement that the world's oil can be replaced by growing something akin to algae; whether this can pay off or not I haven't a clue, but it shows that there are a lot of people out there working on a bunch of technologies.

Question: *When did you start assembling The Daily Countdown? [This was the precursor to the present Peak Oil News, the daily that Tom has assembled for ASPO-USA since Feb. 2006.]*

Whipple: First, I started doing the Virginia News when the major newspapers went on the internet back in 1996. My only claim to fame is that I was the first guy to recognize that it's not too difficult to go through the 25 or 30 of the major Virginia papers every morning, pick out the important stories and send them out in a newsletter. Today I've got about 2500 people reading it, including lots of editors and reporters, and it's just all by word of mouth. So when the peak oil movement came along about seven or eight years later, I had the software and processes worked out to create the same thing there; going from critical stories around the state to global stories about energy wasn't actually that much of a shift when I started it in early 2005.

Question: *Did anything in particular trigger your start of the Daily Countdown publication?*

Whipple: I think I noted early on in The Oil Drum or another site when someone posed the question "what can we *do* about peak oil?" And someone wrote back, "*tell* people about it." Then I thought, "oh I know how to do *that,*" so I immediately designed my own little peak oil newsletter. Soon afterwards I checked with 50 or 60 leading newspaper reporters and editors who were reading my Virginia News. I wrote that I was starting a new newsletter about peak oil and asked if any of them would be interested in reading this new publication that was free, just like the Virginia News. The

response to that query was exactly zero. Not a single reporter or editor seemed to care about peak oil. Yet when I missed my first mail-out of the Virginia News a couple of weeks ago—for technical reasons—the reporters went absolutely berserk.
By the time of the first ASPO-USA conference, I had about 100 subscribers for the Daily Countdown. After the conference you asked me what could we do in terms of a publication. I said this could make a good foundation for a weekly publication; we just sift through the material we collected during the week, find the most important stories, and highlight those in the weekly.

Question: *Give us a little of your background at the CIA that helps these information searches.*

Whipple: I did a whole variety of things there. I drafted National Estimates for a while. I was an analyst for a while, working on individual countries. I didn't have anything to do with oil up there. I spent a lot of time working on current intelligence, which was basically the daily publications.

Question: *What about your involvement with the presidential briefing papers?*

Whipple: There was a publication prepared every day called the President's Daily Brief. One of my jobs for years was to babysit the Brief over night; it was prepared during the day, but not printed until 5 a.m. What looked black at 5 p.m. in the evening might look white by 4 a.m.—an army that we thought, in the evening, wouldn't cross a border might have done exactly that during the night. So I had a lot of experience sifting through a vast flow of information from around the world. Following the peak oil story is very similar to what intelligence officers do. But 30 or 40 years ago, when I started doing this, you couldn't access this information you needed on a computer in your basement. You had to be in a government office with banks of teletypes clacking away and reports coming in from a dozen wire services and 100 embassies around the world. After sifting through a flood of information for years, you get a feel how to go through it quickly and how to spot what's important for policy makers.
To a certain extent, that's what some of us are doing in the peak oil realm, but now we can get information from the internet—there's so much out there. Before the internet, if magazines and newspapers didn't want to pick something up, you never heard about it. That's why the peak oil story has been an internet phenomenon: there is absolutely minimal information on it in the newspapers, in part because it's controversial. And there are many that think there will be technology that will overcome the problem. Many of us who follow the peak oil story don't think so; we think that oil depletion is going to overcome technology and new investment in the near future

Question: *So you don't think technology will be the cavalry riding over the peak oil hill?*

Whipple: In the peak oil realm, you have the doomer side and techno-fix side. The doomers tend to think peak oil is going to tear society apart. The techno-fix group thinks there is going to be something that comes along that helps smooth us into the post-fossil-fuel world, though they're not sure what it will be. I'm somewhat in the middle. On the technical side, there are a lot of things that can be done, no question about it. All of the energy we use comes from or came from the sun—or geothermal, or the Big Bang way back—so we just have to find the smartest ways to convert it and put it to use. We have to get by with a lot less energy—we can cut consumption by about a third without any real hardship…it's the main thing we can do in the near term without spending too much money. Then we get around to collecting energy in other ways, shapes and forms. So that's where I am personally on peak oil right now.

Question: *What do you anticipate will be the future for the airline and trucking industries?*

Whipple: I think they are going to have a lot of trouble. They almost went under last summer. The energy price crashes last fall helped these industries keep bumping along, but airline seats are down around 13 percent. I think we're looking at more of the same. Right now I'm looking into the relationship between much too much credit, for these and other groups, and peak oil. I just don't see how we can get out of this recession in any recognizable form. The minute you have a small recovery, oil prices will shoot up and we'll have the same problems again.

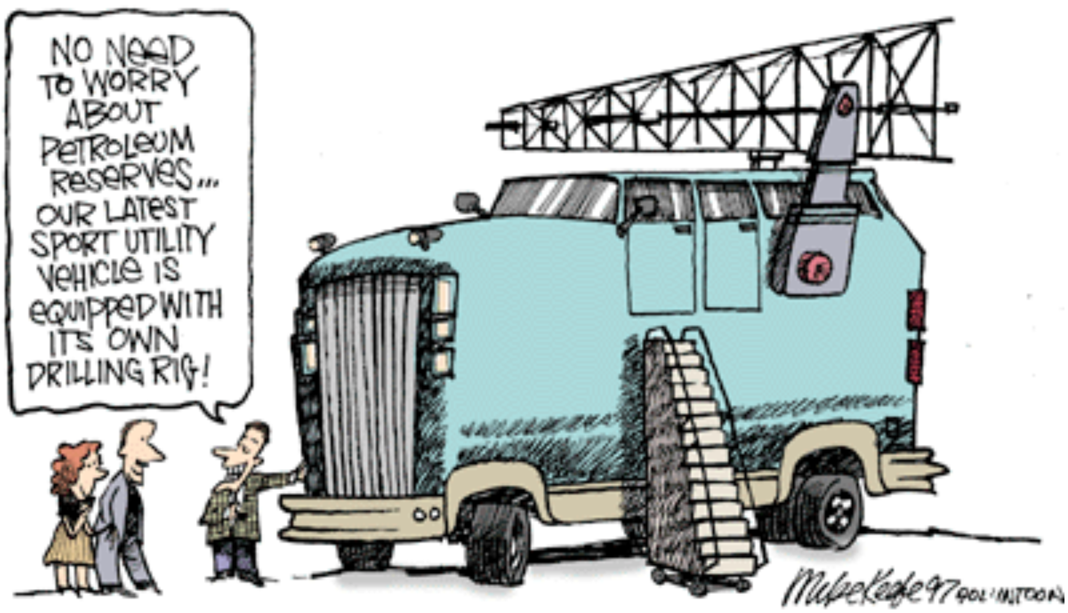
Question: *What will it take to wake people up? Just responding to more high prices?*

Whipple: I don't think anything else can do it but high gasoline prices. When they are back up at $4 a gallon, we'll start paying attention again, but prices will eventually grow from there, which will mean people will have to start cutting back, with continued painful economic consequences.

Question: *You've briefed a lot of elected officials about peak oil. How have they responded?*

Whipple: I've talked with the governor, one of our senators, a number of congressmen, a number of state-level officials, and other officials over the years. It's the same story; most people believe what I'm saying but they really have trouble internalizing the significance of all this. Everyone asks, "what are our alternatives?" They've heard of ethanol and coal to liquids and electric cars and other potential solutions, but they haven't heard that these technologies cannot happen quickly. Oil production will likely drop a lot faster than the economy's ability to invest in and bring on alternatives. It would take 25 years to replace the fleet with plug-in hybrids, etc., if we could afford to do it, given the shape of the economy over that time frame. More people are starting to understand this, but they don't quite get that it's going to happen soon.

Wrap: *Tom, thanks for your time.*



as we move beyond the age of oil and beyond the economy that is driven by the age of oil, we enter an entirely new world - there really are frankly no experts anywhere who can come forward and say exactly what we do in this situation - it is entirely new to everybody's experience - there are no investors who can say this is a good investment in this situation, there are no politicians who can say this is how we should behave in this situation, even in a humble business way there is no business that can plan its future because every single aspect of its future is going to change and so we are left with a sort of vacuum
-- Colin Campbell, founder of the Association for the Study of Peak Oil www.peakoil.net
quoted in "Peak Oil: Imposed by Nature"

http://www.postcarbon.org/blog-post/165463-alaska-and-energy

Alaska and Energy
Posted Oct 26, 2010 by Richard Heinberg

During my recent visit to Anchorage, Alaska to speak at that city's Bioneers satellite conference, the friendly locals seemed eager to educate me about their local energy issues. Some of what I learned struck me as important to share with a wider audience.

Alaska is, of course, a huge energy exporter. Crude from the North Slope saved America's energy bacon back in the '80s, helping to lower world oil prices and bankrupt the evil Soviet empire. **Production there has declined from a peak of over two million barrels per day to only 600,000 or so today. Once the flow drops below 500,000 barrels, there will be problems with icing in the Trans-Alaska Pipeline system.** Not good.

The state's economy is based almost entirely on resource extraction. Everyone gets a check annually from the Alaska Permanent Fund, set up in 1976 primarily by the efforts of then Governor Jay Hammond. High oil prices mean big dividends: in 2008-2009 extra-large payouts made Governor Palin look good to her constituents, though she was in no way responsible.

Alaska has enormous opportunities for renewables—wind, microhydro, geothermal, tidal, even solar. But these are far from being adequately developed, and progress in that direction will take time and lots of investment—a dramatically higher pace of investment than is currently evident.

Anchorage (by far the largest city in the state) faces a particular challenge with natural gas: currently nearly all houses are heated with gas, but supplies from Cook Inlet will run low in two years, even sooner with an abnormally cold winter. Most options to replace current sources (more drilling, LNG, alternative energy) will take longer than two years to develop.There is no serious planning for what to do about this.

Then there is the situation of the native villages. On one hand, the indigenous peoples of the north might seem well placed to weather the changes ahead as industrial society succumbs to peak oil, peak coal, and peak gas: they have cultural traditions of self-sufficiency, small populations relative to land area, and access to lots of wild protein on the hoof (moose, caribou). However, as James van Lanen of Alaska Department of Fish and Game wrote to me in an email just the other day:

“Alaska Native villages are in a very precarious situation. These remote villages are only accessible by motorized travel via air or watercraft. They are entirely dependent upon fossil-fuel systems for goods and services: food, heat, health care. They have no contact with the outside world without fossil fuels.

“Some villages obtain more of their food resources from wild sources than others. It would be safe to say that on average 80% of the protein consumption in a village is from wild sources. Berries and Plants supplement some part of the overall diet but this is small. The two important things to consider are (1) much of the food consumed comes from industrial sources and is shipped in via small aircraft and (2) wild food harvests are currently almost entirely fossil-fuel dependent (there is a well-embedded 'machine culture' in native villages; I believe that there is no extant ability to obtain significant amounts of wild foods without the use of machines)...”

“Peak Energy will hit Alaska villages sooner and more intensely than many other places. Fuel is already up to $9 per gallon in some places. As it becomes uneconomical for current supply operations to continue the industrial resources these villages rely on will fizzle out.”

“Most village people are aware of their complete dependence upon fossil fuels. Many elders foresee a future collapse due to increasing costs and modern dependence. However, there is no general awareness of the phenomenon of Peak Energy in these communities. There is no awareness that the entire system may break down. Alaska villages desperately need to become educated in what we are facing.”

I came away from my too-brief sojourn in Anchorage with both a deep appreciation for this land of great natural beauty, contrasts, and extremes, and an equally deep concern for how Alaskans will deal with their enormous energy challenges. Some of those challenges are going to present themselves forcibly in the very near future.

http://dieoff.com/page133.htm

This Paper is Issue #3 in a Series of Studies

Based on the World Oil Forecasting Program

(A PDF Version of this paper is available at http://www.dieoff.com/page133.pdf)

THE WORLD PETROLEUM LIFE-CYCLE

Richard C. Duncan[1] and Walter Youngquist[2]

Presented at the PTTC Workshop "OPEC Oil Pricing and Independent Oil Producers"
Petroleum Technology Transfer Council
Petroleum Engineering Program
University of Southern California
Los Angeles, California
October 22, 1998

Abstract

The world oil production peak, we assume, will be a turning point in human history. Our goal is to predict the world peak. To accomplish this goal, we have developed (to our knowledge) a unique new procedure based on oil production data, data analysis, conventional formulas, and heuristic knowledge. It comprises (1) a program, and (2) a method.

The program uses the historic oil production data and predicts by statistical and heuristic techniques future production for the world's 42 top oil-producing nations (each modeled separately), grouped into 7 regions, and the world. The method is to build up a series of forecasts which, taken together, will inevitably converge on the peak. This paper presents the third in this series of forecasts -- designated 'Issue #3.'

The peak production year and the expected ultimate recovery for each nation, seven regions, and the world are given in Table 1. Figure 1 graphs the world oil production life-cycle with the peak in 2006. Table 2 gives similar information for each region. Figures 2-8 graph the life-cycle for each region with peaks from 1985 for North America to 2011 for the Middle East.

Middle East & non-Middle East and OPEC & non-OPEC categories are compared in Table 3. Figure 9 graphs the Middle East & non-Middle East. Figure 10 graphs OPEC & non-OPEC.

Figures 11 and 12 depict by simulation whether or not new oil discoveries can delay the world peak. If so, by how much? Figure 13 is a 'phase diagram' that maps, as it were, our crooked route to the world oil summit. All tables and figures are discussed in the text.

We believe that a 'base-camp' and a series of higher camps must be established before finally ascending to the summit. 'Encircling' we call it, as illustrated by the three forecasts we've made so far. Specifically, the 1996 Issue #1 put the peak in 2005; Issue #2 put it in 2007; Issue #3 (this paper) put the peak in 2006. Of course the peak could occur before 2005 or after 2007. Perhaps 10 camps will be required. Maybe more.

En route to the summit, four predictions that we have made have since proved consistent with trends and events: Asian economic crisis, non-OPEC peak year, world peak inertia, and Caspian dry holes.

All the models are available free on the Internet at http://www.halcyon.com/duncanrc/

Looking ahead: The new forecasting method, we believe, can successfully predict the production life-cycle of any of the fossil fuels, including oil, gas, and coal.

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Comments on the
Draft Environmental Impact Statement
Columbia River Crossing
Portland, Oregon & Vancouver, Washington

by Mark Robinowitz, www.road-scholar.org

Box 51222 - Eugene, Oregon 97405 - mark@permatopia.com

July 1, 2008

Summary: Peak Oil and Peak Traffic Alternative

I support light rail transit across the river into Vancouver.

I support expanding this project to include Amtrak and freight rail, including consideration of existing plans for high speed passenger rail between Eugene and Vancouver, B.C.

I support improved bus public transit to connect people to the rail stations.

I support paying for the transit systems by redirecting highway funds and increasing gas taxes (the original light rail line to Gresham was paid for with money appropriated for the Mount Hood Freeway). Rebates need to be considered to mitigate these impacts on lower income people. There is no technical reason why public transit should not be free.

I do not support a wider, 12 lane bridge.

I do not support a surveillance system on the existing bridge (or on a new bridge) to keep track of everyone's travels through RFID, Automatic License Plate Recognition and / or GPS enabled "mileage tax" tracking systems.

I do not support adding "collector - distributor" lanes on I-5 on either side of the river or on any replacement bridge, if one is built to replace seismically unsafe structures.

I do not support traffic analyses that assume substantial rises in travel demand even though we have reached Peak Oil and Peak Traffic.

A supplemental draft environmental impact statement (SDEIS) is needed to factor in Peak Oil and peak traffic, which invalidate the traffic growth projections used for this project.

Before the rubber stamps are used, the FHWA, ODOT, WSDOT and local governments must consider that **the National Environmental Policy Act states that if there are "new circumstances" that impact a project, then they need to be factored in to the analysis. The fact that we have reached the end of cheap oil (peak oil) and the start of climate change needs to be factored into the long term "needs" analysis of the big bridge.**

The design year for this highway expansion is 2030 -- long after Peak Oil. Therefore, the traffic needs analysis needs to be changed to reflect the fact that there will be much less fossil fuel available for personal transportation on the downslope of "Hubbert's Curve."

ODOT / FHWA are planning to widen I-5 despite the lack of demonstrated need. The project is designed for twenty years in the future, not current travel demands, yet "peak traffic" has already happened and we are now at Peak Oil. Future increases in gas prices and decreases in gas availability will drop total vehicle miles traveled (the only question is how quickly). Therefore, there is no need to widen I-5 and no need to spend more money on a widened bridge and road.

If the existing bridges cannot be upgraded for seismic safety, then a replacement, permanent bridge should be built to the same number of lanes as the road on either side of the bridge -- three lanes in each direction. This would save money that could be used toward fixing or replacing other damaged bridges such as the crumbling Sellwood bridge.

If the DOTs ignore geological (and financial) realities, then it would be best to save our money by dispensing with the pretense of public input and let the DOTs do anything that it wants without the illusion of oversight. As the lawyer said to the oil man in the film SYRIANA, “we are looking for the illusion of due diligence.”

Troubled Bridges Over Water: Transportation Triage

> **“Another flaw in the human character is that everyone wants to build but nobody wants to do maintenance”**
> **-- Kurt Vonnegut**

The notorious collapse of the I-35W bridge in Minneapolis in 2007 points out the dangers of deferring maintenance in favor of building more and more roads -- a change in priorities is long overdue.

Oregon's highway network is riddled with aging bridges that no longer can support existing traffic flows because their structures are wearing out. As we shift from an era of cheap energy and abundant economics toward the era of expensive energy and conservation, it will become more difficult to repair or replace cracked bridges. **Spending billions to widen I-5 when there is a huge backlog of damaged bridges is dangerously neglectful of the need to keep the existing network functional.**

One ODOT planner told me a few months ago that the Department's priority was to keep I-5, I-84, Route 20 and Route 97 intact, and that other routes were not as much of a priority. **A better approach to "transportation triage" would be to focus on maintaining the existing**

system before even planning to make expansions to capacity, even without considering the issues of Peak Traffic.

Oregon still allows heavier trucks on its roads than California or Washington permit. Shifting some of this freight traffic to railroads would reduce energy consumption and protect our highway bridges. This change needs to be seriously factored in to the SDEIS for the Columbia River Crossing.

We can choose as a society to either expand the highway system some more (NAFTA Superhighways, more Outer Beltways and bypasses, etc) or focus on making sure that the existing network can be maintained after Peak Oil. Unfortunately, few politicians highlight the need to make AMTRAK a serious transportation system for efficiently moving people. A national priority for quality train service would create a lot of good jobs, reduce energy consumption, and make it more likely that the United States will be able to mitigate the inevitable impacts of the end of the petroleum era. Proposals for the 80 new “corridors” in the SAFETEA-LU highway expansion law are a preventable trillion dollar misallocation of resources.

It is likely that about $1 trillion has already been spent to destroy the nation of Iraq (if preparations for the conflict are included), home to the planet's second largest oil reserves. This is more than half of the cost that has been estimated for rebuilding the tens of thousands of deficient highway bridges that are aging and becoming dangerous.

There are several serious - but languishing - proposals for high speed rail in the United States that would be similar to European and Asian networks. Building all of them would probably cost less than the money spent on the War on Iraq.

Peak Traffic:
The Achilles Heel of Highway Expansion Plans

As the world passes the peak of global petroleum production, gasoline prices are likely to increase to the point that traffic demands on roads will be reduced. While it is impossible to accurately predict the price of fossil fuels in the design year of 2030, it will be surprising if gasoline is not rationed on the downslope of the Peak Oil curve (either directly by ration cards or indirectly by pricing it out of reach of many who currently consume it). While so-called alternative fuels exist and there are vehicle designs much more efficient that current models, they are only going to be able to mitigate the energy downslope. Carpooling is going to be more important than hybrids.

US federal transportation law requires that new federal-aid highway projects consider the traffic demand twenty years in the future. In the 1991 ISTEA law, a provision was added to federal highway approvals that requires all highway plans in a metropolitan area to fit into a regional long range transportation budget to avoid a form of fiscal segmentation. If a metro area wants lots of new roads, they have to show how the projects could be paid for (federal and local funds) over a 20 year period. Approving a project that lacks funding is therefore a form of segmentation. The funds need not be available when construction begins, but the entire project has to fit within a constrained transportation budget - a process similar to buying a home with a mortgage (a home buyer has to show their potential ability to raise all of the funds over the span of the loan).

While no one, not even Dick Cheney, knows precisely what will happen with Peak Oil, to ignore it completely and make more “growth” projections and traffic models that assume constant supplies and pricing of petroleum is delusional. **When FHWA finally requires energy analyses in NEPA documentation, they could examine a range of scenarios: gasoline at $10 per gallon in 2030, gasoline at $100 per gallon in 2030, and gasoline not available to the public in 2030 (only to elites and the military)**

As the world passes the peak of global petroleum production, gasoline prices are likely to increase to the point that traffic demands on roads will be reduced. While it is impossible to accurately predict the price of fossil fuels five, ten, or twenty years in the future, it will be surprising if gasoline is not rationed on the downslope of the Peak Oil curve (either directly by ration cards or indirectly by pricing it out of reach of many who currently consume it). US federal transportation law requires that new federal-aid highway projects consider the traffic demand twenty years in the future -- so the reality of Peak Oil and climate change means that the continent wide rush to build more bypasses, wider bridges, Outer Beltways and NAFTA Superhighways will not be needed. As of July 1, 2008, there are no road projects known to this writer anywhere in North America that have been scaled back or canceled because of Peak Oil and Peak Traffic.

The website **www.road-scholar.org** suggests some political and legal strategies to prevent this trillion dollar misallocation of resources so that real solutions can be implemented:

- repair or replace worn out bridges (but not with wider bridges) while we still have oil
- invest in public transit & Amtrak
- get ready to travel less
- grow food in the cities (community gardens) and suburbia (food not lawns) to reduce oil dependence of industrial agriculture

Euan Mearns on June 11, 2008 - 4:42pm

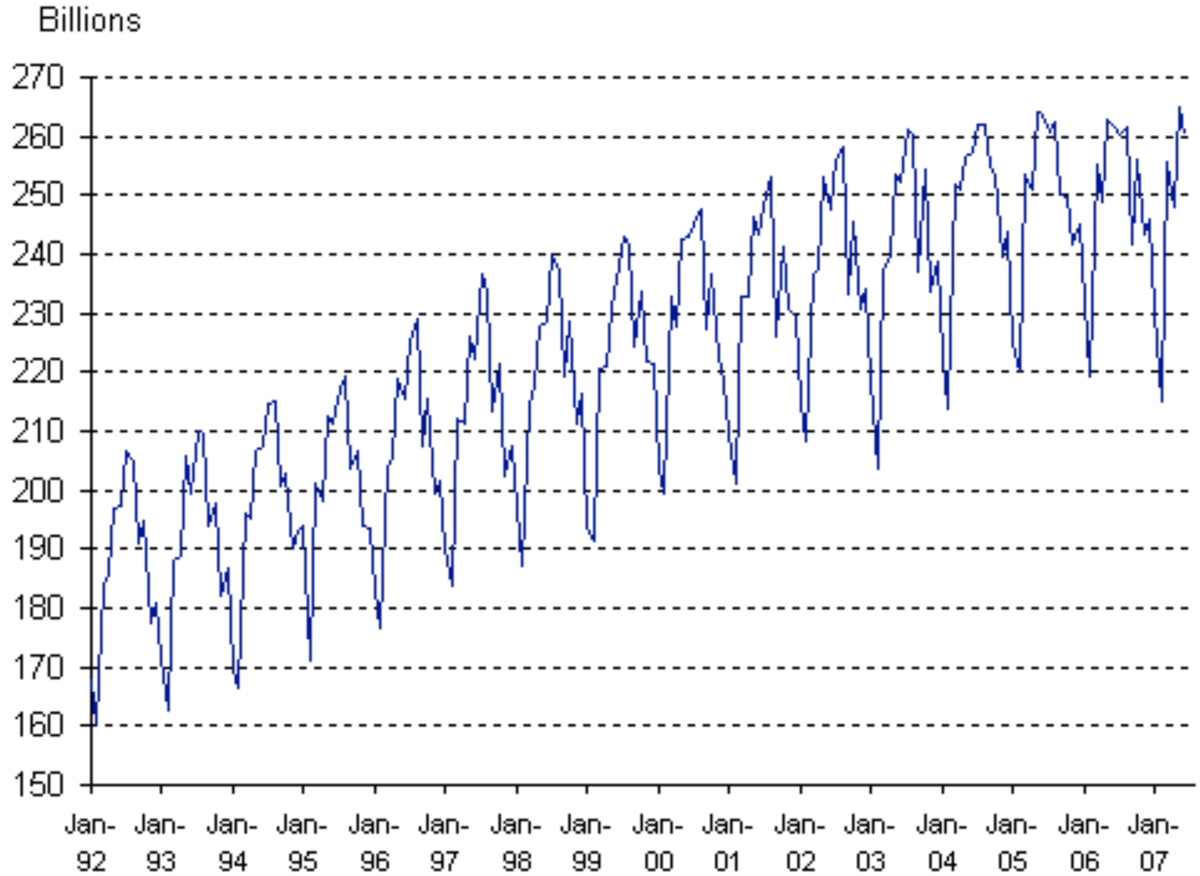
Its really hard to come to terms with the number of corporations, government agencies, consultancies, civil service departments and politicians who seem incapable of comprehending a trend break or trend reversal. Collectively they would have been incapable of working out that the wheel may change transport.

http://europe.theoildrum.com/node/4130#comment-359871

Vehicle Miles Traveled (VMT) has Peaked

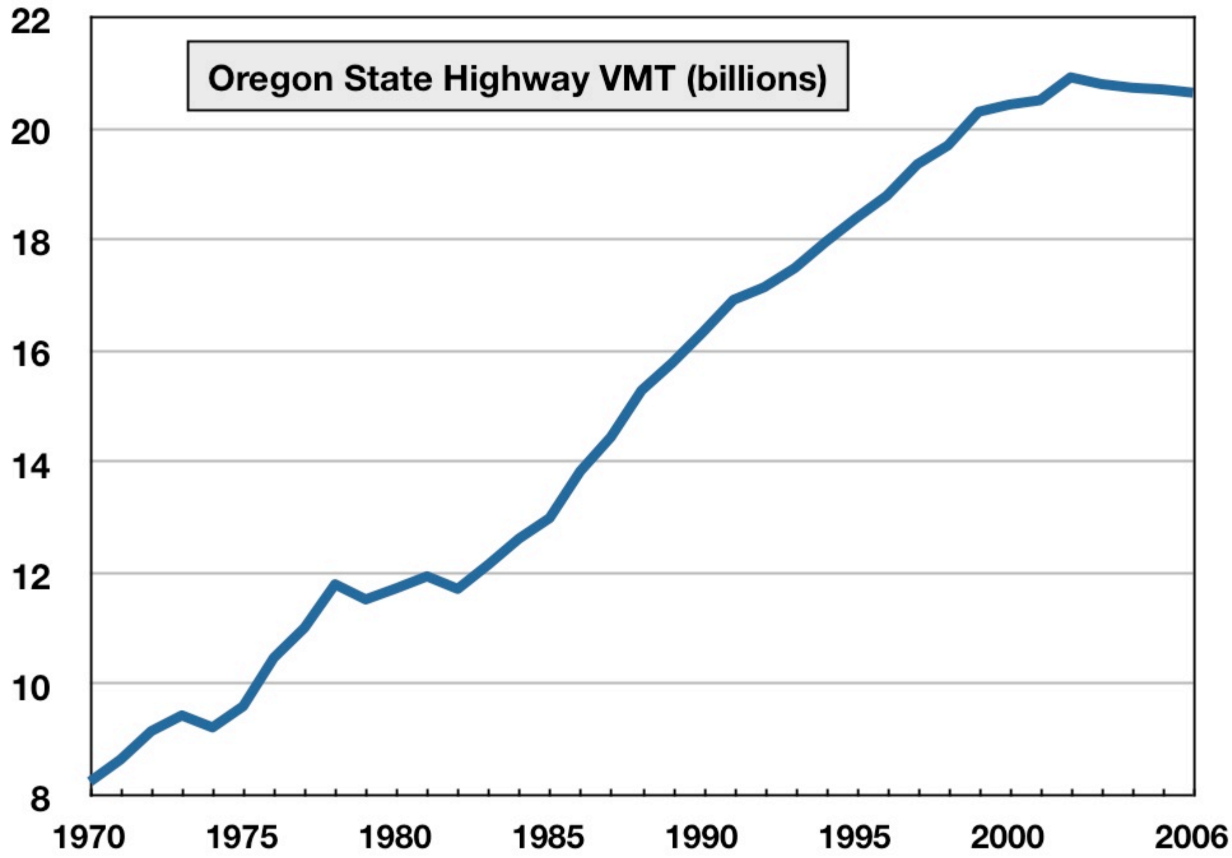
Three dollar a gallon gasoline caused the constant increase in traffic to stop, four dollars a gallon gasoline has precipitated an overall decline in traffic levels.

US Department of Transportation Bureau of Transportation Statistics



www.bts.gov/publications/white_house_economic_statistics_briefing_room/ august_2007/ html/highway_vehicle_miles_traveled.html

national VMTs peaked about two years ago
traffic levels vary through the year
(there is more driving in the summer than the winter)



Oregon state highway VMT data from
www.oregon.gov/ODOT/TD/TDATA/tsm/vmtpage.shtml

1973: dip due to Saudi oil embargo
1979: dip due to gas lines after Iranian revolution
2002: peak traffic on Oregon highways

This chart from ODOT shows that traffic levels on Oregon State Highways peaked about four years ago, and is on a plateau, mostly because of the increasing price of oil. The US Dept of Transportation Bureau of Transportation Statistics shows that national Vehicle Miles Traveled peaked in 2005. In May 2008, the Federal Highway Administration stated that March 2008 was the sharpest decline of traffic recorded since they started keeping detailed records - it was 4.3 % less than March 2007. We are on a plateau of traffic that will last as long as oil remains relatively affordable.

The current dip in VMT is not temporary,
it is more like climate change, a permanent shift in the way things work.

SDEIS needed to address “new circumstance” of Peak Oil & Peak Traffic

NEPA mandates that a “Supplemental” EIS must be prepared if there are "new circumstances" not anticipated when the scoping process was conducted. Surely reaching the peak of petroleum production worldwide is an important circumstance for a transportation project allegedly designed for travel long past the peak of petroleum.

If FHWA included Peak Oil into environmental analyses for highway projects, this could create a seismic shift in transportation planning across the United States, allowing for honest public discussion about energy and transportation policies. There are several ways this shift could happen: a successful Federal lawsuit forces FHWA to include Peak Oil, the start of gasoline rationing makes transportation planners consider alternatives, or a change in national policies (probably the least likely in the near future).

Council on Environmental Quality regulations implementing NEPA

40 CFR 1502.9: Draft, final and supplemental statements.
(c) Agencies:
(1) Shall prepare supplements to either draft or final environmental impact statements if:
(i) The agency makes substantial changes in the proposed action that are relevant to environmental concerns; or
(ii) There are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.

Federal Highway Administration regulations about NEPA

23 CFR § 771.130 Supplemental environmental impact statements.
(a) A draft EIS, final EIS, or supplemental EIS may be supplemented at any time. An EIS shall be supplemented whenever the Administration determines that:
(1) Changes to the proposed action would result in significant environmental impacts that were not evaluated in the EIS; or
(2) New information or circumstances relevant to environmental concerns and bearings on the proposed action or its impacts would result in significant environmental impacts not evaluated in the EIS.

The End of the Age of Oil: growth is over

Peak Oil does not mean that civilization is about to run out of oil. Instead, we are near (or at) the point where continued growth of petroleum combustion no longer can be maintained, which will have profound consequences for the global economy that is dependent on exponential growth of nearly everything (especially of money supplies). Energy creates the economy, a physical limitation rarely acknowledged by economists. Peak Oil is also the point where the maximum amount of economic "growth" is reached -- and ideally a turning point where we can decide to use the remaining half of the oil as a bridge toward a more sustainable way of living. It would require enormous energy, money and people power to reorient away from NAFTA Superhighways toward investing in bullet trains, away from dirty fossil fuel technologies toward efficiency and renewable energy systems, away from resource wars and toward global cooperative efforts to reduce our collective impact on the planetary biosphere.

why alternative fuels and efficient cars won't make much difference

Renewable energy systems are largely focused on generating electricity. Transportation systems in the CRC area are almost entirely based on burning liquid fuels, which are not generated by solar PV power or wind turbines.

A bigger problem is that by the design year of 2030, natural gas supplies from the western US and Alberta are likely to have dropped so low that they will no longer be able to be used to generate electricity -- the remaining gas will be needed to heat buildings, especially in the colder climates where the gas is extracted from. Whatever renewable energy systems are installed between now and then will need to replace the substantial inputs that natural gas has for the western electric power grid at the same time that there is less available energy to manufacture solar panels and wind turbines.

All of the major car companies have developed much more efficient vehicles (Greenpeace, "The Environmental Impact of the Car," 1992), with many models around 100 mpg. VW even has a small model that is highway rated that gets about 250 mpg -- the VW CEO drove it to their annual stockholder meeting a few years ago. While technological shifts may help mitigate the energy crisis after Peak Oil, it cannot eliminate the problem. There are no factories to make these vehicles. There are no capital investments to fund the conversion of existing factories to make hyper-efficient cars. The existing fleet of vehicles are not going to be instantly eliminated in favor of efficient cars, as the owners have invested heavily in their current models -- someone who bought a $50,000 SUV is not easily going to be able to absorb the loss by purchasing a new car that is more efficient. At best, the investment in more efficient vehicles may slow the decline of VMTs on the Peak Oil downslope -- but it cannot prevent that decline. There is also the problem of substantial use of oil and mineral ores to manufacture new cars, even efficient ones. Carpooling is a more promising short term mitigation than hoping for 100 mpg cars.

The main source of "liquid fuels" likely to be promoted in Cascadia is conversion of third growth forests and tree plantations to biofuels. While this could make sense on a small scale, as the downslope of Peak Oil becomes more obvious, there will be immense pressure to liquidate forests and convert them into fuel for cars and trucks and other vehicles. Widespread deforestation to create liquid fuels from tiny trees could result in massive carbon dioxide generation -- since the best form of carbon sequestration is to allow forests to return to old growth conditions. Here are some references to consider on this topic:

Mark Harmon
Professor and Richardson Chair of Forest Science
Oregon State University
www.cof.orst.edu/cof/fs/people/faculty/harmon.php
http://outreach.forestry.oregonstate.edu/silvopt/abstracts/harmon..htm
Forest Management Strategies for Carbon Storage

Olga Krankina
Assistant Professor, Sr. Research, Forest Management, Forest Ecology
Oregon State University
www.forestry.oregonstate.edu/cof/fs/people/faculty/krankina.php
several articles by Professor Krakina

Doug Heiken
Oregon Wild
www.oregonwild.org/oregon_forests/old_growth_protection/forests-global-warming/oregon-wild-report-on-forests-carbon-and-global-warming
Oregon Wild Report on Forests, Carbon and Global Warming
"The Straight Facts on Forests, Carbon, and Global Warming"
Executive Summary
Part I. Background: What determines global temperature and climate?
Part II. How does carbon move in and out of the atmosphere?
Part III. How Will Climate Change Affect the Pacific Northwest?
Part IV. How will climate change affect ecosystems, forests, and trees?
Part V. Will the Forests of the Future Become Carbon Sources or Carbon Sinks?
Part VI. What Can We do to Protect Forests from the Perils of Climate Change?
Part VII. Logging Releases Significant Amounts of Carbon.
Part VIII. What Can We Do To Increase Carbon Storage in Forests?
Part IX: Forest Management Recommendations
Part X. What about Forest Fires?
Part XI. Conclusion
Appendix: Myths & Facts about Forests and Global Warming

Lance Olsen
former president, Great Bear Foundation. Missoula, Montana
www.tidepool.org/features/forest.climate.cfm
Swiss Army Knives
How Deforestation Changes the Climate
by LANCE OLSEN [posted.5.10.01]

DEIS mention of Peak Oil is inaccurate

Laws of political physics:
For every expert, there is an equal and opposite expert.
Experts will travel in a straight line over a cliff unless external forces overwhelm inertia.
Experts will try to maintain equilibrium even when the system has become too unstable .
A critical morass of experts are impervious to inputs from outside the bureaucracy.

The CRC Draft EIS is probably the first to acknowledge the reality of Peak Oil, but unfortunately, the writers of this section failed to describe it accurately. The DEIS suggests that there is a maximum scenario for the year 2030 of $100 a barrel for oil, yet this figure was reached on the first trading day of 2008, four months before the publication of the DEIS. It is astounding that there is no mention in the DEIS of the substantial rise in oil prices during preparation of this report.

One bright spot in the DEIS is the mention of the Department of Energy's Hirsch Report (2005), although the DEIS failed to mention the conclusions of this analysis. The Hirsch Report stated that we would need twenty years to mitigate the impact of Peak Oil, even if we were using toxic technologies such as coal-to-liquids and tar sands. While the Hirsch Report did not specify an opinion on when the Peak would be, oil production worldwide has been essentially flat since 2005 as new oil fields have had a difficult time making up for declining oil fields in the North Sea, Alaska, the Persian Gulf and other areas. Most geologists who have looked closely at the facts have concluded that we are now past the peak for "conventional oil" and almost at the peak for "all liquids" - the latter being a euphemism for including tar sands, natural gas liquids and other liquids that require nearly as much energy to produce as they contain. The consensus in the scientific community is that the era of easy to extract oil that has the maximum "energy return on energy invested" is over, and now we are entering the era of difficult to extract, expensive oil that will have less return on energy invested.

The largest oil fields in the world are all in obvious decline. Here in the western hemisphere, the largest single field is Cantarell in the Gulf of Mexico (on the Mexican side), and it peaked around 2004 (the Association for the Study of Peak Oil and Gas - USA reports that Cantarell has dropped about 33% in the past year). The Alaska North Slope at Prudhoe Bay peaked in 1988, two decades ago, at about three quarter of a billion barrels for the year. In 2006, less than 300 million barrels flowed through the Alaska Pipeline. Even if the Arctic National Wildlife Refuge were opened to drilling, that development would merely slightly change the shape of the downslope. The Earth is finite, therefore there is only so much oil to extract.

2030 design year is past peak

The key points for understanding Peak Oil:

(1) the oil will take decades to run out, peaking is not the same as running out
(2) the exact shape of these curves will probably be different than these predictions,
(3) the issue is when supply no longer keeps up with demand, not when it runs out, and
(4) after the peak, the OPEC countries in the Middle East will have most of the remaining oil

Peak Oil is not about "when the oil will be gone" but rather when demand begins to outstrip supply and production / extraction peaks globally. There probably will be oil extraction for several more decades, although the current perceived abundance (one can buy as much oil as one can afford) is likely to last only a few more years. While petroleum geologists debate the exact timing of the global peak (ranging from essentially now through the middle of the next decade), there isn't any debate about the reality of Peak Oil. Even the most pollyanna view puts the peak at around 2030, although the most experts estimate that somewhere between 2005 and 2012 is more accurate. The pessimists among the geologists who said in the late 1990s that 2010 would be the peak may have been wrong, since there is evidence that 2000 may have been the precise peak, with the rest of this decade being a "plateau" close to 2000 levels before the extraction rates begin their inevitable decline. One factor for determining future levels will be economic forces -- if the global economy crashes into a depression, this would reduce energy consumption rates, making the peak lower and longer lasting (the best possible scenario for using some of the oil as a bridge toward the renewable energy, locally based society). If the economy heats up, then the peak could be higher but shorter, with the downslope coming sooner and steeper. Whatever the exact year, the days of wasteful overconsumption are limited

The only "debate" about peak oil is the exact timing -- from a long term historical perspective, it does not matter whose predictions about the exact year of peak and decline ultimately prove to be correct.

ASPO's latest estimate is the world "peaked" for conventional oil in 2005, and the peak for all oil will be in 2010. The all oil figure includes unconventional oil such as heavy oil (tarsand / oil shale), polar, deep water, and natural gas liquids. The world is now on the Petroleum Plateau, which will drop off sometime after 2010.

from the Association for the Study of Peak Oil, February 2008 (prepared 2008-01-04)

Colin Campbell, February 2008 issue of ASPO Ireland
www.aspo-ireland.org/contentFiles/newsletterPDFs/newsletter86_200802.pdf

ESTIMATED PRODUCTION TO 2100											End 2007
Amount			**Gb**	**Annual Rate - Regular Oil**						**Gb**	**Peak**
Regular Oil				Mb/d	**2007**	**2010**	**2015**	**2020**	**2030**	**Total**	**Date**
Past	**Future**		**Total**	US-48	3.7	3.1	2.4	1.8	1.0	200	1970
Known Fields		New		Europe	4.3	3.5	2.5	1.7	0.9	76	2000
1008	724	143	1875	Russia	9.7	9.7	7.8	6.2	3.9	230	1987
	867			ME Gulf	19	19	20	20	17	693	2015
All Liquids				Other	28	27	22	19	13	701	2005
1155	1345		2500	**World**	**65**	**62**	**55**	**48**	**36**	**1900**	2005
2006 Base Scenario				**Annual Rate - Other**							
M.East producing at capacity				Heavy etc.	6.5	11	5	5	6	212	2030
(anomalous reporting corrected)				Deepwater	6.5	12	11	6	1	68	2011
Regular Oil excludes Heavy Oils				Polar	0.9	1	1	2	4	52	2030
(inc. tarsands, oilshales); Polar &				Gas Liquid	7.7	8	9	9	10	261	2035
Deepwater Oil; & gasplant NGL				*Rounding*				-1	3	6	
Revised 04/01/2008				**ALL**	**87**	**94**	**80**	**70**	**60**	**2500**	2010

www.davidstrahan.com/blog/?p=57
PRIVATE INDUSTRY CONFERENCE FINDS MUCH LESS OIL
Posted on Friday, September 28th, 2007

(Podcast) A secretive gathering some of the world's biggest oil companies has concluded the industry will discover far less oil than officially forecast, according to an executive who attended the event, meaning global oil production may peak much sooner than many expect.

The Hedberg Research Conference on Understanding World Oil Resources was held by the American Association of Petroleum Geologists in Colorado Springs last November to try to reconcile widely divergent estimates of likely future reserves additions. In an interview with Lastoilshock.com, oil executive Ray Leonard said the majority view was that future oil discovery would amount to some 250 billion barrels, rather than the 650 billion barrels suggested by the United States Geological Survey.

www.energybulletin.net/25544.html
Published on 1 Feb 2007 by Bloomberg. Archived on 1 Feb 2007.
Simmons says global oil supply has peaked
by Rhonda Schaffler

Matthew Simmons, chairman of Simmons & Co. International in Houston, talked yesterday with Bloomberg's Rhonda Schaffler about the need to address energy use, his view that global supply has peaked and the likelihood oil prices could reach as much as $300 a barrel. (Source: Bloomberg)

[Transcription of the first few minutes of the interview]
Q: Tell me how you draw your conclusion that at this point we've hit Peak Oil.
A: If you look at the numbers and you follow what's going on starting with Mexico's giant Cantarell field which is now in a very serious state of decline and then you look at the North Sea and you see just the UK and Norway, it's pretty obvious to me that those three areas alone could actually decline by between 800,000 and 1 million barrels a day in 2007.
That pretty well wipes out almost all the production gains coming onstream and in implicit in that it assumes that everyone else is flat.
So I think basically too many of our oil fields are too old. Too many now are in decline. The Middle East is basically out of capacity. they're some projects that are being worked upon, but most don't hit the market until 2008, 2009 and we're running out of time.
... I am firmly of the belief that over the course of the next year or two, this issue of peak oil will replace global warming as an issue that we're all worrying, debating and talking about.

FORMER PRESIDENT BUSH ENERGY ADVISER SAYS OIL IS RUNNING OUT
Robin Pagnamenta, Energy and Environment Editor
From The Times
June 30, 2008

The era of globalisation is over and rocketing energy prices mean the world is poised for the re-emergence of regional economies based on locally produced goods and services, according to a former energy adviser to President Bush and the pioneer of the “peak oil” theory.

Matt Simmons, chief executive of Simmons & Company, a Houston energy consultancy, said that global oil production had peaked in 2005 and was set for a steep decline from present levels of about 85 million barrels per day. **“By 2015, I think we would be lucky to be producing 60 million barrels and we should worry about producing only 40 million,” he told The Times.**

His controversial views, rejected by many mainstream experts, suggest that some of the world's biggest oilfields, particularly in Kuwait and those of Saudi Arabia, the world's leading producer, are in decline. “It's just the law of numbers,” he said. “A lot of these oilfields are 40 years old. Once they roll over, they roll over very fast.”

Mr Simmons asserted that this, coupled with soaring global energy demand, meant that world oil prices were likely to continue rising. He said that even at present record highs of more than $140 a barrel, oil remained relatively inexpensive, especially in the US, the world's biggest market. “We are just spoiled rotten in the US,” he said. “It's still cheap.”

Rising prices will force a tectonic shift in the structure of the global economy by destroying the rationale for shipping many goods, such as food, over long distances, he said.

"This is already happening. In the US, our local farms, ranches and dairies are booming. They are having a huge comeback."

Mr Simmons set out a radical vision of the future, envisaging a society in which food and many other essentials are sourced and consumed locally and increasing numbers of people work from home. He claimed that the alternative was increasing political instability and conflict over the planet's diminishing resources. "We are living in an unsustainable society," he said. "If we don't change we are just going to start fighting one another...So let's just start assuming the worst and plan for it."

However, only this month, BP disclosed figures which indicated that the world had 1.24 trillion proven barrels of oil left in the ground - more than 40 years' worth at current rates of production. BP said that known global reserves had actually increased by 168.5 billion barrels, or 14 per cent, over the past decade. Tony Hayward, the chief executive of BP, said: "The good news is the world is not running out of oil."

BP blamed a lack of investment and access to reserves, rather than geology, for why global oil production was sputtering.

Mr Simmons claimed that many countries had overstated their reserves for political purposes and that so-called flow rates were a better indicator of recoverable volumes. He said that the quality of oil produced by Saudi Arabia and other big exporters was declining.

Peak Oil causing Peak Traffic

The 2005 Final Environmental Impact Statement for the Inter County Connector highway in Maryland, part of the long planned Outer Beltway around Washington, D.C., had this response to a comment that referenced Peak Oil as a reason not to build the road:

> It is speculative to assume that increases in gasoline prices will "reduce congestion." Evidence indicates that very substantial price increases might be needed in order to substantially change transportation choices and decisions. Price increases could cause a variety of responses which might not affect highway usage; e.g. production and acquisition of more fuel-efficient vehicles. The travel forecasts were made assuming a cost per mile for operating an automobile. Historically as the price of gasoline has increased the miles traveled per gallon of gas have also increased. In fact, gas costs less per mile traveled today than it did prior to the first oil embargo in 1974. Petroleum scarcity as a result of consumption in China is speculative.
> - Final Environmental Impact Statement, Inter County Connector (I-370), Maryland

This EIS was correct to state that planning for rising gas prices is speculative, but planning as if prices will remain constant for the next two decades is even more speculative.

It is not "speculation" to predict that higher gas prices will prevent traffic increases. Here is a small example of how this works, which shows that the price increases likely from Peak Oil will lower traffic demand considerably in the design year of 2030.

www.cnn.com/2006/AUTOS/11/30/gas_prices.reut/index.html
Americans drive less for first time in 25 years
Higher gas prices cut not only sales of SUVs, but also time spent on the road: study.
POSTED: 3:47 p.m. EST, November 30, 2006

HOUSTON (Reuters) -- High gasoline prices not only slowed fuel demand growth and cut sales of gas-guzzling vehicles in 2005, they also prompted Americans to drive less for the first time in 25 years, a consulting group said in a report Thursday.

The drop in driving was small - the average American drove 13,657 miles (21,978.8 km) per year in 2005, down from 13,711 miles in 2004

More riders crowd buses

The rising cost of driving sends record numbers to LTD, where human traffic jams the aisles

BY JEFF WRIGHT

The Register-Guard

Published: Thursday, April 6, 2006

TRAFFIC AT THE YORK TOLLS on the Maine Turnpike - a standard measure of tourism in the state - was down in June and even more in July compared with the same time last year. . . Traffic passing through the York tolls had increased every year until five years ago, when it became stable. This is the first time it has dropped significantly; the decrease was 5.3 percent when comparing June 2004 and June 2005, and 5.8 percent when comparing July numbers. . The national average price for regular unleaded gas was $2.41 a gallon, compared with $1.86 a year ago
http://pressherald.mainetoday.com/news/state/050813gasprices.shtml
www.maineturnpike.com/jpgraph/total_by_month.html
www.maineturnpike.com/jpgraph/yearly_totals.html

High gasoline prices filling bus, train seats
Tue Apr 25, 2006
By Bernie Woodall, Reuters

Some mass transit advocates hesitate to say the price spike has forced drivers onto public transportation, including Amtrak spokesman Cliff Black.

But in some cities where the car is undisputed king of transportation such as Houston and Los Angeles, public transportation ridership is up.

In Houston, home to many oil refineries, ridership was up 10.2 percent in the most recent fiscal year, said Houston's Metropolitan Transit Authority, which has a large bus fleet.

In Los Angeles, Metro Rail ridership rose 11.4 percent and the number of bus passengers increased 7 percent in the first quarter of 2006. About 1.4 million ride Los Angeles County buses and trains daily.

It's difficult to say how many are on board because of gasoline prices, said Dave Sotero of the Los Angeles County Metropolitan Transportation Authority.

"When gas prices go up, we do see spikes in ridership," said Sotero. "We're hopeful people who haven't used public transit, they will carry on riding even if gasoline prices drop," said Sotero.

Last week, the Washington Metropolitan Area Transit Authority in the nation's capital had the two highest ridership days in the Metrorail's 30-year history that were not linked to a special event. The highest day was April 20, with 780,820 riders, up 6.2 percent from a year ago.

But WMATA spokesman Steven Taubenkibel said it's hard to peg that on gasoline prices -- nice weather last week may have had more to do with it, he said.

These statistics do not suggest a major shift (yet) due to increasing gas prices, but they hint at much larger changes to come on the petroleum downslope.

Peak Asphalt

http://lcog.org/meetings/mpc/0806/MPC%205g1i_OregonianArticleonCostIncreases.pdf
Soaring costs throw Oregon road projects a curve
Rough road - Officials are facing steep price increases for asphalt and other materials
Monday, July 31, 2006
JAMES MAYER
The Oregonian

www.delmarvanow.com/apps/pbcs.dll/article?AID=/20060616/NEWS01/606160303/1002
Asphalt prices delay pressing road repairs
By Joseph Gidjunis
Staff Writer
The Daily Times, Salisbury, Maryland

www.duluthsuperior.com/mld/duluthsuperior/news/politics/14837423.htm
Fri, Jun. 16, 2006
Asphalt prices skyrocket, highway officials scramble to adjust
JOHN HARTZELL
Associated Press

www.ksla.com/Global/story.asp?S=5026843&nav=0RY5
SHREVEPORT, LA
Asphalt Prices May Mean Fewer New Shreveport Street

Climate greenwash: a quiz

The states of Oregon and Washington are planning to spend about $4 billion for a new, widened I-5 bridge across the Columbia River, which would also extend the Portland light rail a couple more stops (across the river into downtown Vancouver). What did Oregon Transportation Commissioner Gail Achterman say about the environmental impacts of this expansion?

a. "The Columbia River Crossing project is a major forward step in our effort to reduce the carbon footprint of our transportation system"
b. "We are canceling the highway component of this project and diverting the funds toward public transit in metropolitan Portland and high speed passenger rail for Cascadia" (Eugene to Vancouver BC).
c. "The State of Oregon recognizes the seriousness of the Peak Oil and Climate Change crises, and we are going to implement the Oregon Transportation Plan's policy guidelines to prioritize fixing existing roads before building new capacity."
d. "The I-5 widening is part of the national NAFTA Superhighway proposals, so the state is opposing this proposal to encourage support for regional business instead of outsourcing our production to foreign sweatshops."

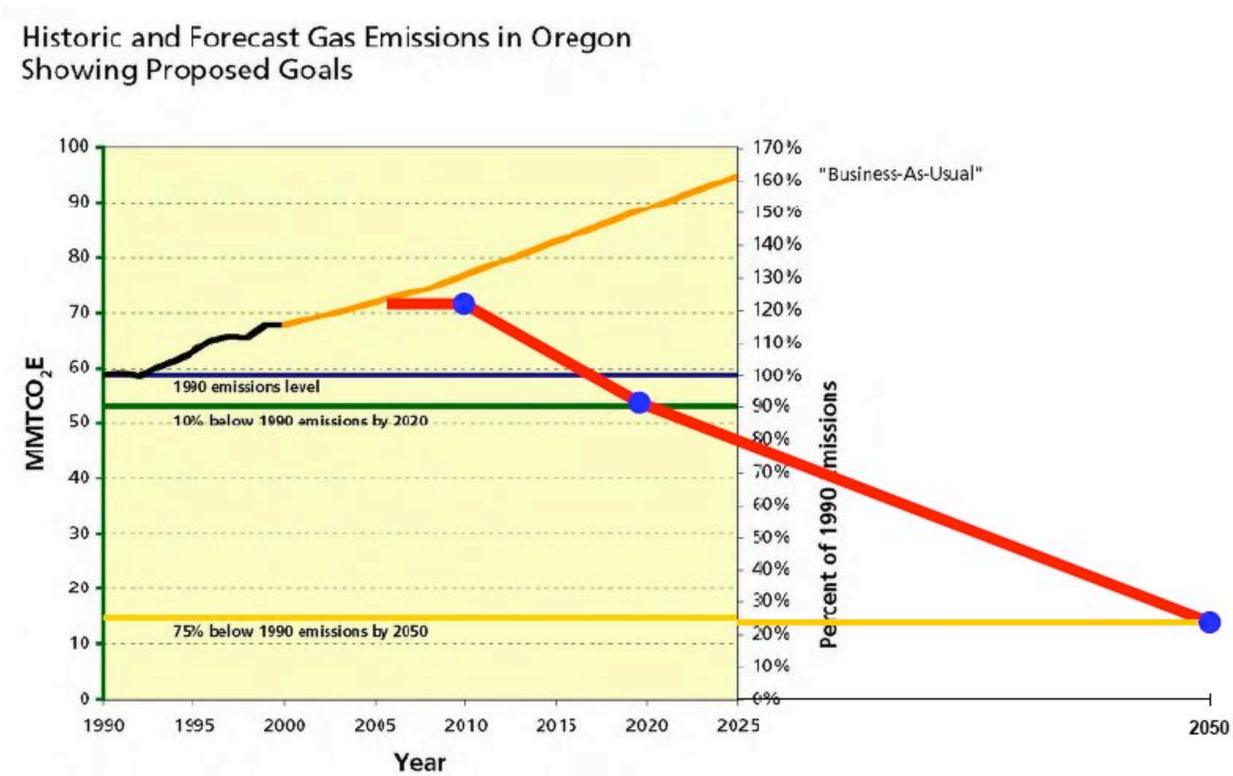


chart from ODOT of carbon pollution reduction targets through 2050. The black line includes the increases during the Clinton/Gore administration. Yellow upward line represents plans for continued "growth." Note that the shape and rate of the downslope almost mirrors the projected downslope of the Peak Oil curve.

In our new Orwellian age of greenwash, war is peace, ignorance is strength, and widening the Interstate highways will clean up the atmosphere. Building multibillion dollar bridges with huge amounts of steel and concrete is very energy intensive and generates a large amount of toxic pollution to manufacture the raw materials. Even building the light rail (and not the road bridge) would increase carbon dioxide levels in the atmosphere. “Carbon credits” and “offsets” are linguistic tricks, since building a train or installing solar panels and wind turbines cannot sequester existing CO2 back into the crust of the Earth. Proposals to reduce the rate of increase of carbon pollution are not the same thing as removing soot from the atmosphere. The natural biological capabilities of carbon sequestration are already busy absorbing normal CO2 generation from animals and other natural sources, so they are unable to absorb CO2 and methane created by burning fossil fuels.

Instead, it appears likely that oil rationing (whether from price increases or official policy) and depletion is going to reduce the growth of carbon emissions. Calls to reduce carbon levels by various percentages by the year 2050 parallel almost exactly the expected reduction in oil production / extraction. Natural gas is likely to decline faster than oil -- at least in North America. Even coal has been exaggerated, with global coal extraction set to peak around 2025 -- although coal mining requires lots of oil (for transport) and a stable electric grid.

The SDEIS needs to look at the cumulative impact of building a 12 lane bridge, of the land use patterns that would be induced from the new, wider bridge, and the total toxic impact of building the largest option bridge.

Saving Oil in a Hurry: carpooling is part of the answer

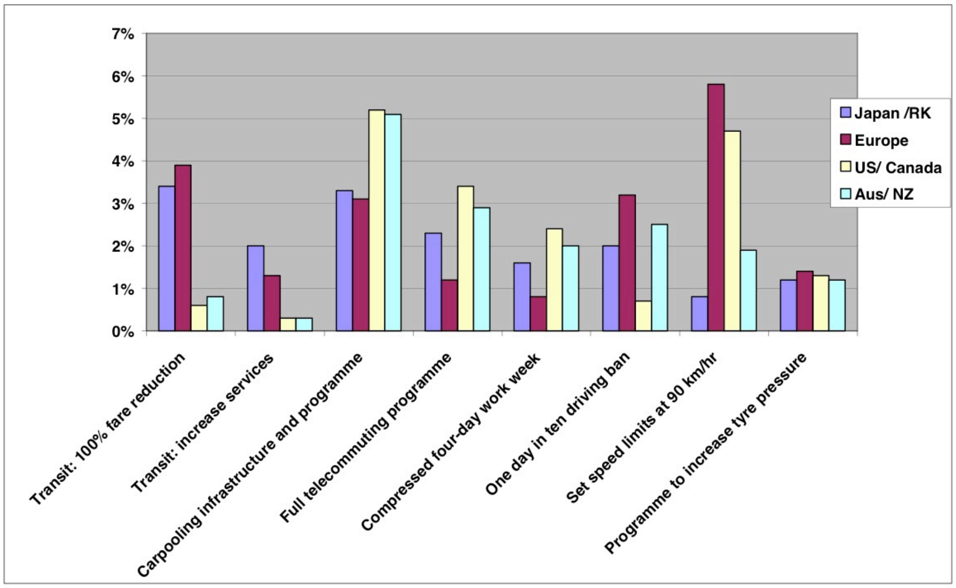
In 2005, the International Energy Agency held a forum to discuss “Saving Oil in a Hurry.” While in the long run fossil fuel supplies are going to gradually decline, there are numerous scenarios where sudden sharp downward levels of availability could happen -- conflict in oil exporting countries, severe hurricanes in the Gulf of Mexico offshore drilling areas, desire by oil exporters to reduce exports since oil will be more valuable in the future, a US / Israeli attack on Iran followed by Iranian disruption of oil flows through the Persian / Arabian Gulf. There are also plausible possibilities that some oil fields could see much more rapid decline that some planners are hoping for, especially those oil fields that are being pumped out with large volumes of water (a technique that works for a while but risks collapse of the oil field).

The Saving Oil in a Hurry report suggested that in the United States and Canada, carpooling would have greater energy reductions in the US than free public transit, although no one approach is sufficient. In Western Europe, free transit would have the single biggest reduction in oil consumption. All approaches will be needed, but the opportunity of using all of the seats in the existing traffic flow shows the potential for quick reductions of energy use -- an opportunity that is a social obstacle, not a technological problem.

Regardless of which geologists are ultimately proven correct about oil supplies, we need to prepare to live with much less energy consumption.

http://www.iea.org/textbase/work/workshopdetail.asp?id=210
Workshop: Managing oil demand in transport.
International Energy Agency
European Conference of Ministers of Transport
WORKSHOP: MANAGING OIL DEMAND IN TRANSPORT
Paris, 7-8 March, 2005

Percent reduction in total fuel use by IEA region, selected measures



Imperial College London

NAFTA Superhighway - ISTEA, TEA-21, SAFETEA-LU

The NAFTA Superhighways are not ONE highway plan, they are a large network of new highways and expanded (existing) highways, a series of north-south interstate highways across the U.S. These new and expanded roads would stretch from Canada through the U.S. to Mexico (excepting certain East Coast routes that would merely connect to ports on the Atlantic or Gulf coasts).

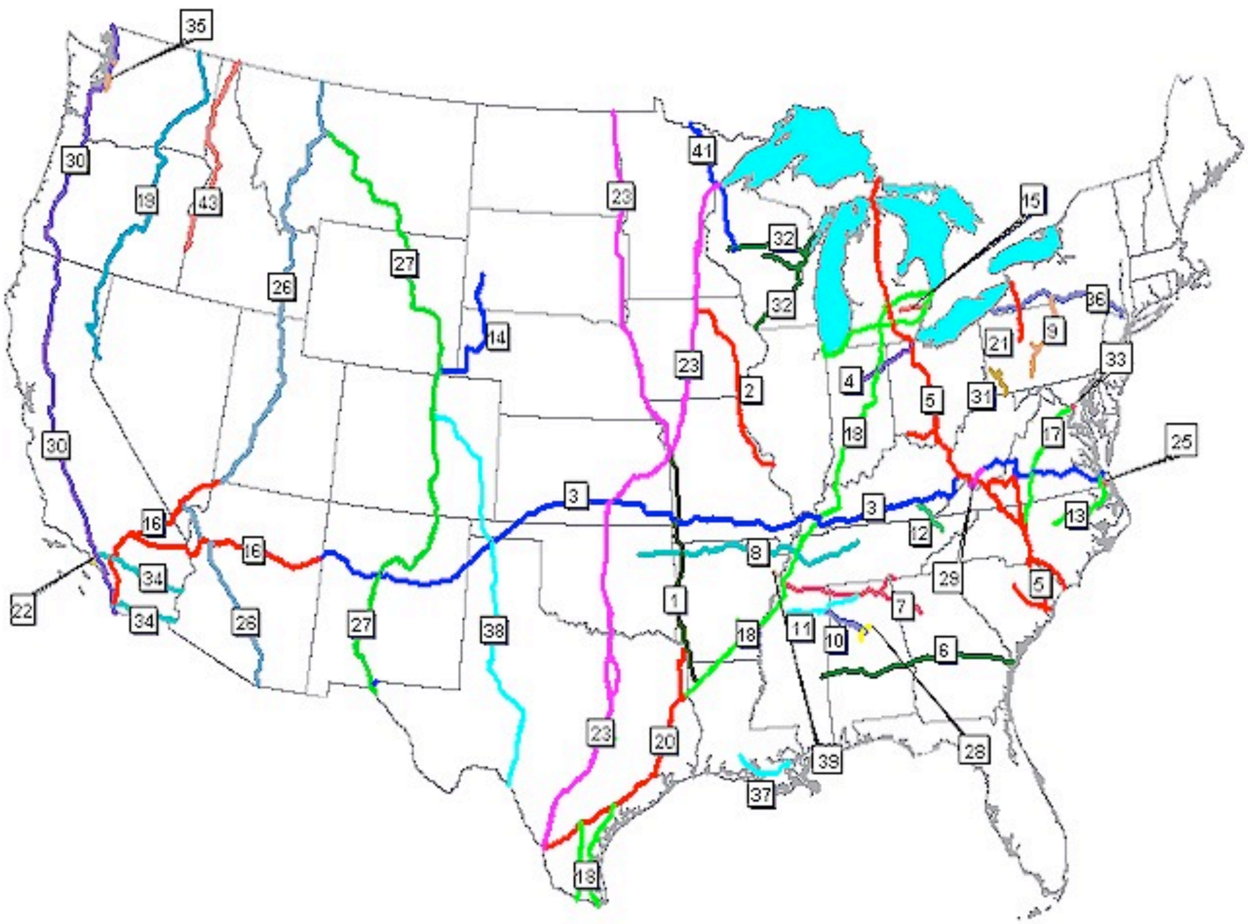
The initial proposal for NAFTA Superhighways was in the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) Federal transportation law, but has now expanded in scope to encompass several "superhighways on steroids." Some of these oversized roads would have many car lanes, truck only lanes, parallel freight train lines, passenger train lines and utility corridors (electricity, oil, natural gas, water, etc).

ISTEA specified the first iteration of the "NAFTA Superhighway" -- to extend I-69 from Indianapolis (its current southern terminus) all the way to Mexico. Highwaymen from several states who each wanted their local and regional boondoggles got together and petitioned Congress to create this full route as a national priority "corridor." The new I-69 is planned to go through southern Indiana, Kentucky, Tennessee, Mississippi, Arkansas, Louisiana and Texas. The southern Indiana section is probably closest to being built.

The 1998 "TEA-21" and 2005 "SAFETEA-LU" laws expanded from the few dozen new "corridors" in the 1991 ISTEA law and the 2005 law has a total of 80 corridors. Some of these corridors involve upgrading existing highways, some involve construction on "new alignment," a couple of the corridor designations specify numerous road projects in a region.

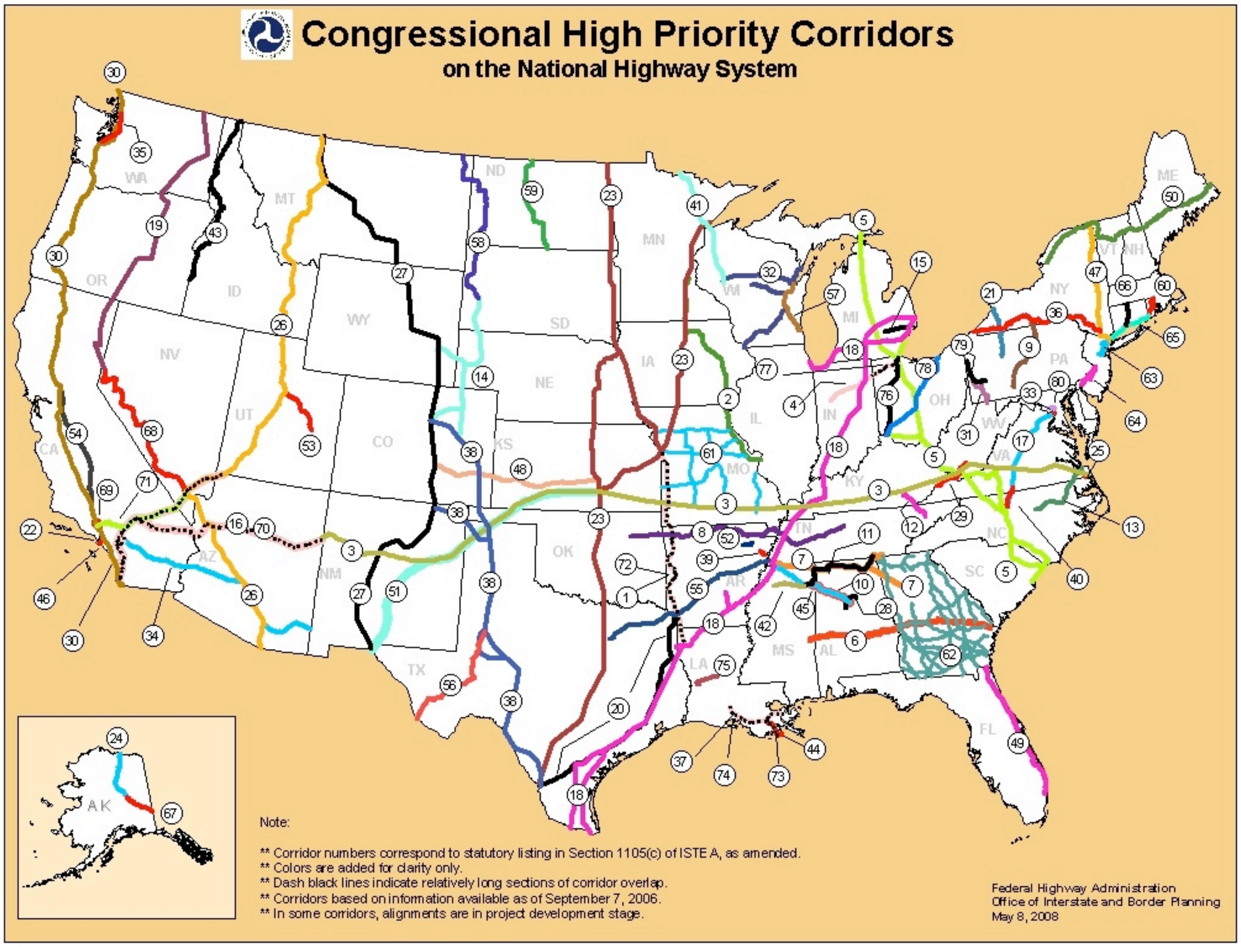
The planning for NAFTA Superhighways is predicated on continued cheap and abundant gasoline -- an assumption about to receive sobering reality from the underlying geological limits of petroleum production. NAFTA Superhighways are essentially a key component of further "globalization" of commodity production intended to homogenize local communities and further centralize control over manufacturing.

None of the national environmental groups who claim to be concerned about global warming, energy efficiency and public transportation have campaigned against passage of these NAFTA superhighway laws. Some of these groups even supported their passage since a minority of the bill included public transit funding and a few pennies (relatively speaking) for bicycle and pedestrian projects.



1991 ISTEA “priority corridors” - upgrading I-5 from Canada to Mexico is included

This is the bill that some environmental groups considered a great victory for the environment since there were some small improvements for transportation planning requirements (all State DOTs now need a pedestrian / bicycle coordiator, there are new requirements for metropolitan planning for new roads, etc.). However, the bulk of this transportation law was to fund more highways.



from the 2005 “SAFETEA-LU” transportation law

the High Priority Corridors map was copied from the Federal Highway Administration website at www.fhwa.dot.gov/planning/nhs/hipricorridors/index.html

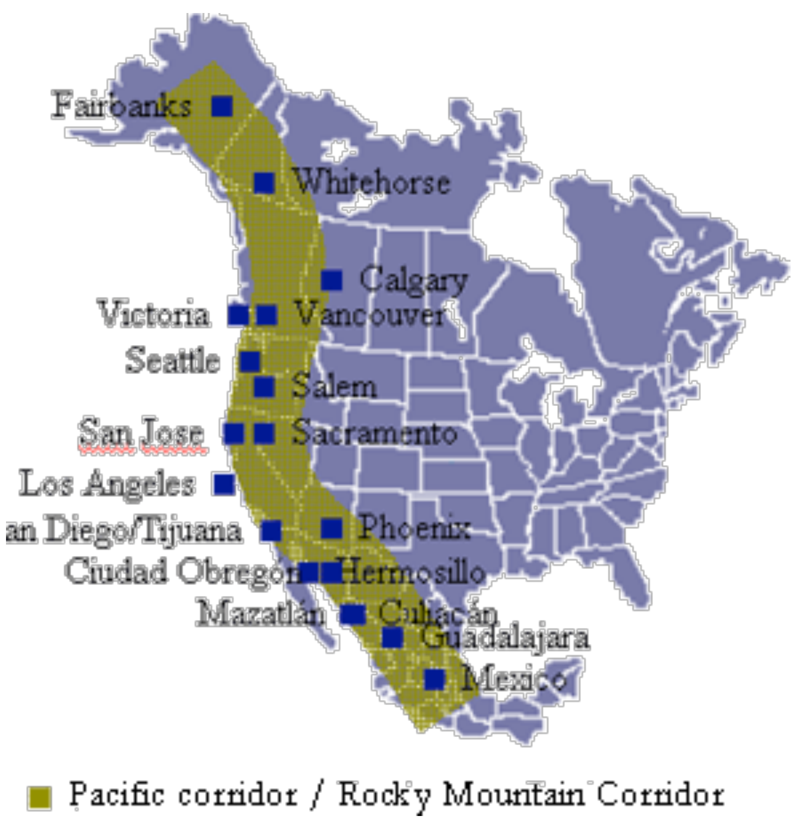
Corridors of the Future program includes CRC and upgrading I-5 in California

The FHWA "Corridors of the Future" program is a new corollary to the NAFTA Superhighway proposals. Some of the "corridors of the future" would include major expansions of east-west highways (especially near Chicago) that would interconnect the north south new / expanded superhighways.

www.fightgridlocknow.gov
www.corridors.dot.gov

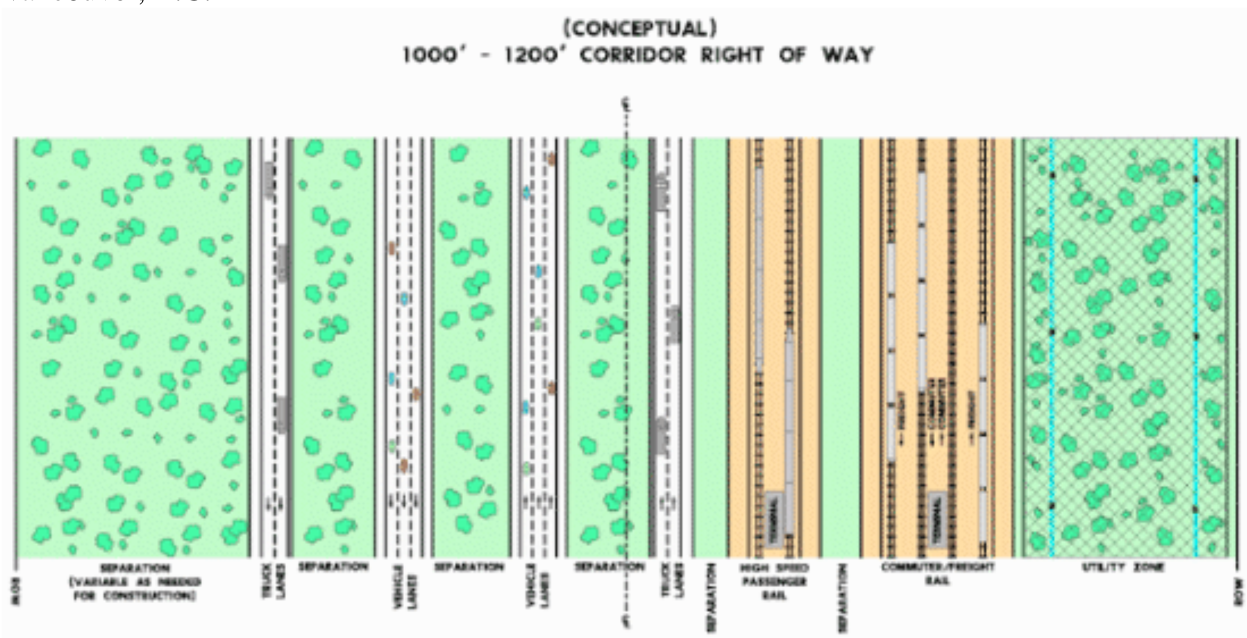
The new I-69 NAFTA Superhighway is one of the selected "corridors" for national prioritization.

Upgrading I-5 between Canada and Mexico is also a "corridor of the future," although they don't like to use the term NAFTA Superhighway even though I-5 connects Canada, the US and Mexico.



source: www.fina-nafi.org/eng/integ/corridors.asp?langue=eng&menu=integ

The biggest part of the NAFTA Superhighway is the Trans Texas Corridor project, a series of planned super highways without parallel (yes, they are bigger in Texas). It would include freeways for cars, truck only lanes, freight and passenger rail lines, and utilities - power lines, water pipes, oil and gas pipelines. It is a prototype of several other "corridors" around the country, including the Washington Commerce Corridor planned between Vancouver, WA and Vancouver, B.C.



Trans Texas Corridor cross section - the model for the “NAFTA Superhighways”

www.truthbetolled.com
movie about the planned Trans Texas Corridor superhighways (in opposition)

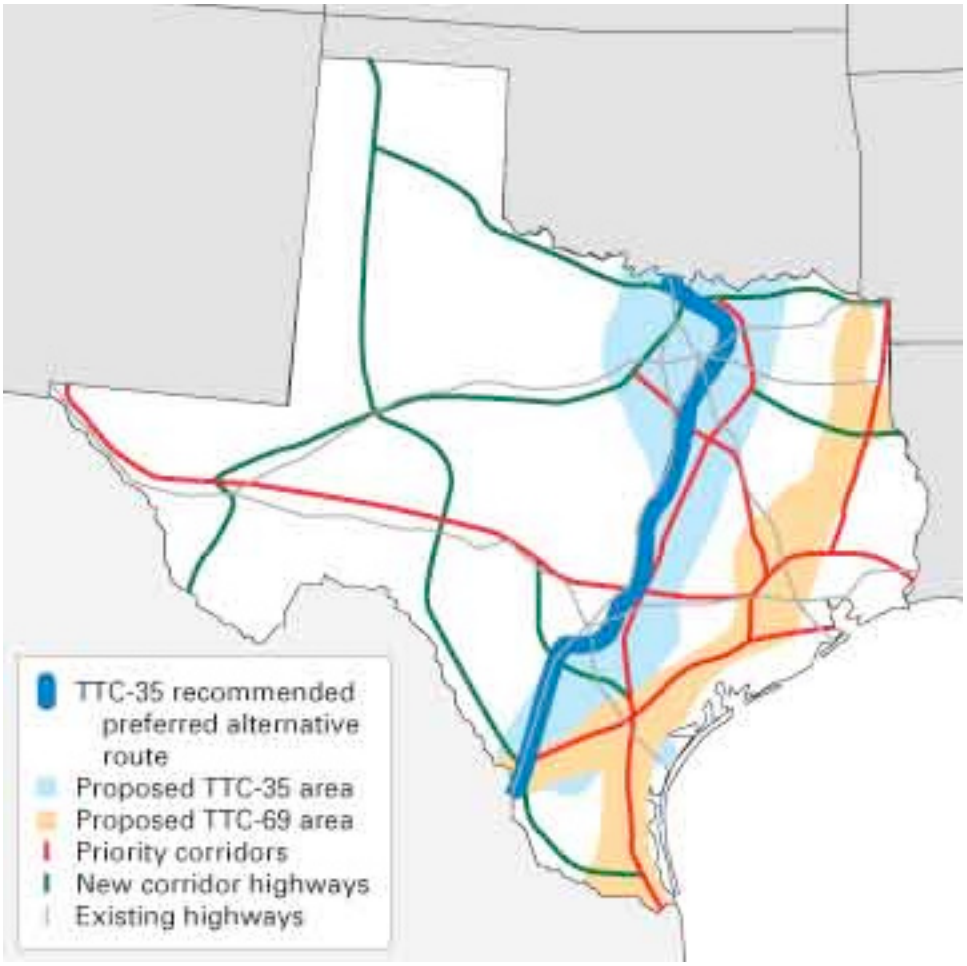
http://dfazack.typepad.com/truth_be_tolled/
blog for "Truth Be Tolled"

www.corridorwatch.org

http://corridornews.blogspot.com
The Trans-Texas Corridors, eminent domain abuse, and the Texas Toll Road Rebellion

http://transtexascorridor.blogspot.com

www.keeptexasmoving.com (pro-TTC)



www.aaroads.com/high-priority/corr18.html
excerpt:

the concept of Interstate 69 as a "NAFTA Highway" was conceived by Indiana officials who really wanted the Interstate 69 southwestern extension. To get federal funding, they planned a multi-state routing that would cut through Kentucky, Tennessee, Mississippi, Arkansas, Louisiana, and Texas on its way to Mexico. By marketing the whole "NAFTA Corridor" concept, officials and businessmen in Indiana were able to get federal money behind the project. Of course, money was also secured for the Indiana section.

www.peakoilblues.com/blog/?p=77
Get Your Kicks on Route 6-6-6

I think of a world where fuel is so expensive, and products are so costly to move, that one needs a permit to enter that NAFTA Transnational Superhighway. I imagine that without paying someone off, it will be impossible to get that permit. Wal-Mart gets one. Dole will be cruising it too. Of course Proctor and Gamble, and you can name a few dozen others. And they'll be fast freight trains and bullet trains that will carry 'approved' citizens from one place to another. There'll be fiber optic cable lines running along side to keep our communications open. Once on the highway, the limousines and huge container carriers and trains can fill-up the tank without limits, because, after all, you have a permit to be on there anyway. Along side this Superhighway, are the gas and oil pipelines, and of course, THAT's why you need the permit to enter, or at least that's the excuse. Gas flows down from Canada, for as long as it lasts, and oil flows up, until the last trickle. It is paid for by Ameros, a proposed currency I never even heard of until a few days ago. Euros, Ameros, Get it?

Washington Commerce Corridor

In Washington State, the DOT has studied creating a "Washington Commerce Corridor" between Vancouver WA and Vancouver BC with car lanes, truck lanes, freight and passenger rail, and utilities (electric lines, water, oil, gas, etc). This is the same model as the Trans Texas Corridor proposals (a large network of new highways around Texas with separate facilities for cars, trucks, freight trains, passenger rail and utilities).

The SDEIS for the I-5 Columbia River Crossing needs to explain how the CRC would interface with the Washington Commerce Corridor proposal, since the WSDOT map shows they are contiguous. Would the Commerce Corridor have "independent utility" if it was approved but the CRC is not? Is the CRC a first step toward construction of the Commerce Corridor? These issues need full examination in the SDEIS.

www.wsdot.wa.gov/freight/CommerceCorridorFeasStudy.html
proposed "Washington Commerce Corridor" - giant NAFTA Superhighway style bypass from Vancouver WA to Vancouver BC

www.seattleweekly.com/news/0427/040707_news_freeway.php
July 7, 2004
Turnpike to Perdition

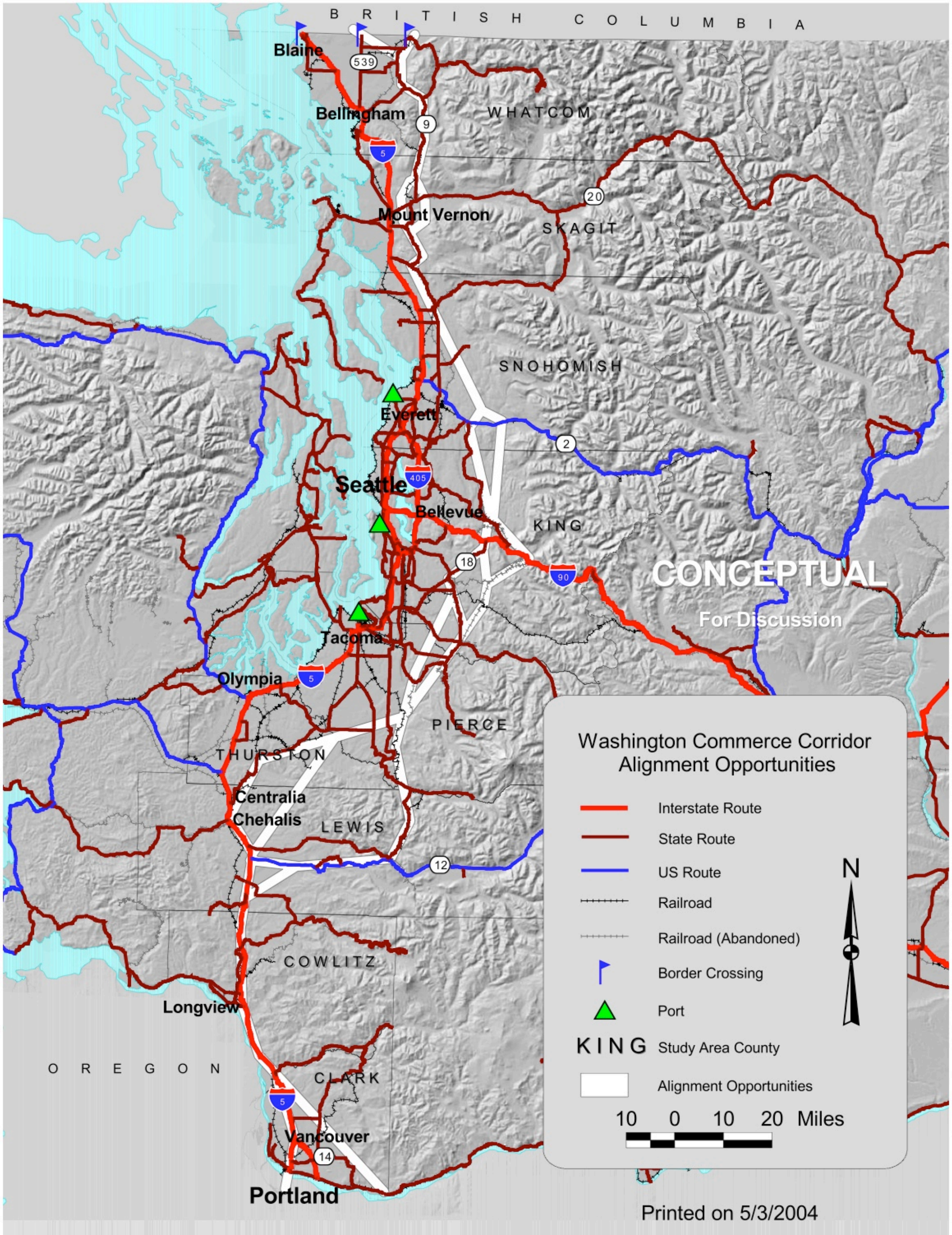
The idea of a 'commerce corridor,' an enormous toll highway through Western Washington, just won't die.

www.tahomaaudubon.org/ConsJune2004.html

www.climatesolutions.org/pages/eNewsbulletins/January_2003/TakeAction_WA.htm
Stop the "I-605 sprawl highway" –
Tell state to focus on real transportation priorities!

The Washington State Department of Transportation (WSDOT) and private consultants are studying the feasibility of a new north-south interstate highway, marketed as a bi-national commerce corridor between Oregon and British Columbia. The proposal for a new 450 foot-wide highway and pipeline corridor east of I-405, is a thinly veiled attempt to build the I-605 beltway – a new highway bypass around the Greater Seattle Metropolitan Area.

Neither a bi-national commerce corridor, nor a new I-605 beltway in the Central Puget Sound Region, would significantly reduce traffic congestion, but both would lead to urban sprawl and destroy farms, forests, and habitat. Further study and funding for I-605 is a waste of valuable time and money that should instead be used to address urgent transportation priorities.


B R I T I S H C O L U M B I A
Blaine
539
Bellingham
9
WHATCOM
5
20
Mount Vernon
SKAGIT
SNOHOMISH
Everett
2
405
Seattle
Bellevue
KING
18
90
CONCEPTUAL
For Discussion
Tacoma
Olympia
5
PIERCE
THURSTON
Centralia
Chehalis
LEWIS
12
COWLITZ
Longview
O R E G O N
CLARK
5
Vancouver
14
Portland
Washington Commerce Corridor
Alignment Opportunities
Interstate Route
State Route
US Route
Railroad
Railroad (Abandoned)
Border Crossing
Port
KING Study Area County
Alignment Opportunities
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10 0 10 20 Miles
Printed on 5/3/2004

Tolling without tollbooths: the J. Edgar Hoover Memorial Bridge

I oppose the surveillance system to track everyone's tolls. I would support instead paying for transportation projects through the gasoline tax - those who drive more, those who drive less efficiently would pay more. Pay for the transit component of this project with gasoline taxes, and you'll make more of a dent on the transportation congestion than putting up cameras to record everyone's license plate so that the voyeurs who want to know where everyone is all of the time can spy on the entire population.

The tolling system would charge someone driving a hummer the same as someone driving a hybrid. Gasoline taxes would shift the burden to those driving less efficiently, whether driving a fuel inefficient vehicle, speeding at 70 mph (versus 55) or otherwise driving aggressively in ways that increase fuel consumption.

Coalition for a Livable Future "Climate Smart" Alternative

The Coalition for a Livable Future has proposed a "Climate Smart" alternative. Part of this alternative is worthy of support, part of it is not. Their proposal would build the light rail bridge, but would also establish the surveillance system on the existing bridge.

The Coalition's CRC alternatives reports ignore Peak Oil / Peak Traffic as a reason not to build a 12 lane highway bridge and lack any awareness of the civil liberties implications of the tolling scheme that you support. Climate change is a reason not to build this, but unfortunately there doesn't seem to be any legal hooks to use rising pollution levels to stop the bridge - since EIS's merely require disclosure of impacts, not their prevention. The reality of Peak Oil, on the other hand, can alter the traffic planning analyses used to justify these sorts of boondoggles, since in 2030 we will be lucky if we will be allowed to buy oil for personal consumption. Whatever the price and availability in 2030 turns out to be, it clearly will be considerable more expensive and less available two decades in the future. The CRC project needs a Supplemental Draft EIS to redo their analysis to reflect the reality of Peak Oil and Peak Traffic -- phenomena that are not going to be substantially shifted even if we had a crash program to build hybrid cars and banned SUVs (since we've waited too long to start the transition). Peak Traffic is the Achilles Heel of highway expansion proposals, and could be used to establish a precedent in federal court that would require a shift toward maintenance and transit projects (where are the environmental groups promoting Amtrak upgrades?).

We are not going to have a "livable future" if there's not much demand from environmental groups for ecological, socially just approaches to coping with the end of cheap oil as we navigate the downslope of Hubbert's Peak. Improving transit systems is nice, but only a tiny part of what would need to be done - food is likely to be a more serious problem than the obstacles to personal transportation.

Instead of an electronic toll that gives the Department of Fatherland Security a database of everyone's travels, taxing gasoline at the pump is more equitable since it charges for all trips, rewards those who drive the speed limit (speeding wastes fuel), encourages more efficient cars (tolls tax Hummers and Hybrids the same). A gas tax coupled with rebates for the poor would be the ideal solution, one that the Democratic Party probably wouldn't support but this doesn't mean the environmental groups have to support their myopia. Merely having a toll would penalize the poor since the wealthy aren't going to be substantially impacted by paying a couple bucks to cross the bridge every day.

Some of the literature from the CRC opponents even suggests the need for a a "carbon neutral" river crossing. However, the only “carbon neutral” alternative would be swimming or perhaps paddling a canoe (if the canoe was made from locally available materials and did not involve any fossil fuels in its manufacture). Even the light rail (which I support) would not be so-called "carbon neutral" since a lot of coal and some natural gas is burned for Portland's electricity.

If the light rail fuels a lot more construction in Vancouver WA (doubtful given the economic contraction that is now unfolding) then it could lead to an increase in car traffic (since only some of the new workers or residents would use the rail system). Building with concrete and steel uses lots of fossil fuels and minerals -- something to consider given we are past the point of "overshoot." Smart growth would have been a good idea in 1950, but now it is too little, too late.

It's worth remembering Martin Luther King's objections to highways, made the week before the federal government stopped his campaigning for justice:

> **“These forty million [poor] people are invisible because America is so affluent, so rich; because our expressways carry us away from the ghetto, we don't see the poor.”**
> **-- Martin Luther King,** "Remaining Awake Through a Great Revolution," March 31, 1968

The Coalition for a Livable Future includes David Evans and Associates on their board even though they are one of the main ODOT contractors for new highway construction in Oregon. DEA is a key contractor for the Columbia River Crossing and the Sunrise Freeway in Clackamas County, among other road projects. It seems like a conflict of interest even if David Evans and Associates has some staff who do non-highway projects (light rail, perhaps?).

www.clfuture.org/about/staff-board/document_view
Jo Ann Bowman, Member at Large
Sam Chase, Community Development Network
Amanda Fritz, Friends of Arnold Creek
Lisa Gramp, Member at Large
Felisa Hagins, SEIU Local 49
Mike Houck, Urban Greenspaces Institute
Mary Kyle McCurdy, 1000 Friends of Oregon
Marcy McInelly, American Institute of Architects
Martha McLennan, Northwest Housing Alternatives
John Mullin, Social Services of Clackamas County Inc.
Marcus Mundy, Urban League of Portland
Kelly Rodgers, **David Evans and Associates**
Bob Sallinger, Audubon Society of Portland
Lara Skinner, Member at large

Reviving the Rails: a best case Peak Oil scenario

> "In the United States, we have a railroad system that the Bulgarians would be ashamed of. We desperately are going to need railroad transport for moving people around, for moving goods around – we don't have that. What we do have is a trucking system that is going to become increasingly dysfunctional, especially as the expense mounts of maintaining the tremendous interstate highway system. It costs so much money every year to maintain what the engineers call a high level of service – which means that the trucks that are delivering things from the central valley of California to Toronto don't break their axles while they're bringing those Caesar salads to Toronto. Once you have a certain number of trucks that are breaking their axles in that 3,000 mile journey, that's the end of transcontinental trucking – which also implies that this is the end of certain economic relationships that we have gotten used to."
> -- author James Howard Kunstler, from an interview in the film "The End of Suburbia: Oil Depletion and the End of the American Dream"

> It is serious time to look at the nationalization of America's critical infrastructure industries: oil, gas, electricity, and others that have gouged the American consumer and now deserve to lose their windfall profits in a nationalization effort that will return to them ten cents on the dollar, if they are lucky.
> - Wayne Madsen Report, April 25, 2006

In the 1960s, the success of freeway fighters in stopping the Boston Inner Belt spurred Congress to change transportation laws to allow money programmed for Interstate highways to be used for public transit. Several rail systems were created from unused freeway funds, most notably the initial construction phase of the Washington, D.C. Metro.

If the United States ever makes shifts to have an ecological, socially just policy to cope with Peak Oil, it would need to shift money from the NAFTA superhighway program to a serious revival of inter-city rail to efficiently move people and goods with less energy consumption.

A best case scenario for mitigating Peak Oil could include

- bullet train service between cities (with solar panels lining the tracks to provide some of the power),
- light rail and better bus service on major roads,
- major investments in renewable energy and hyper-conservation,
- land use shifts to reduce commuting distances,
- widespread suburban agriculture to convert lawns into food production (which would reduce truck deliveries),
- other steps to reduce our demand for oil, coal, natural gas, uranium, concrete, and mineral ores.

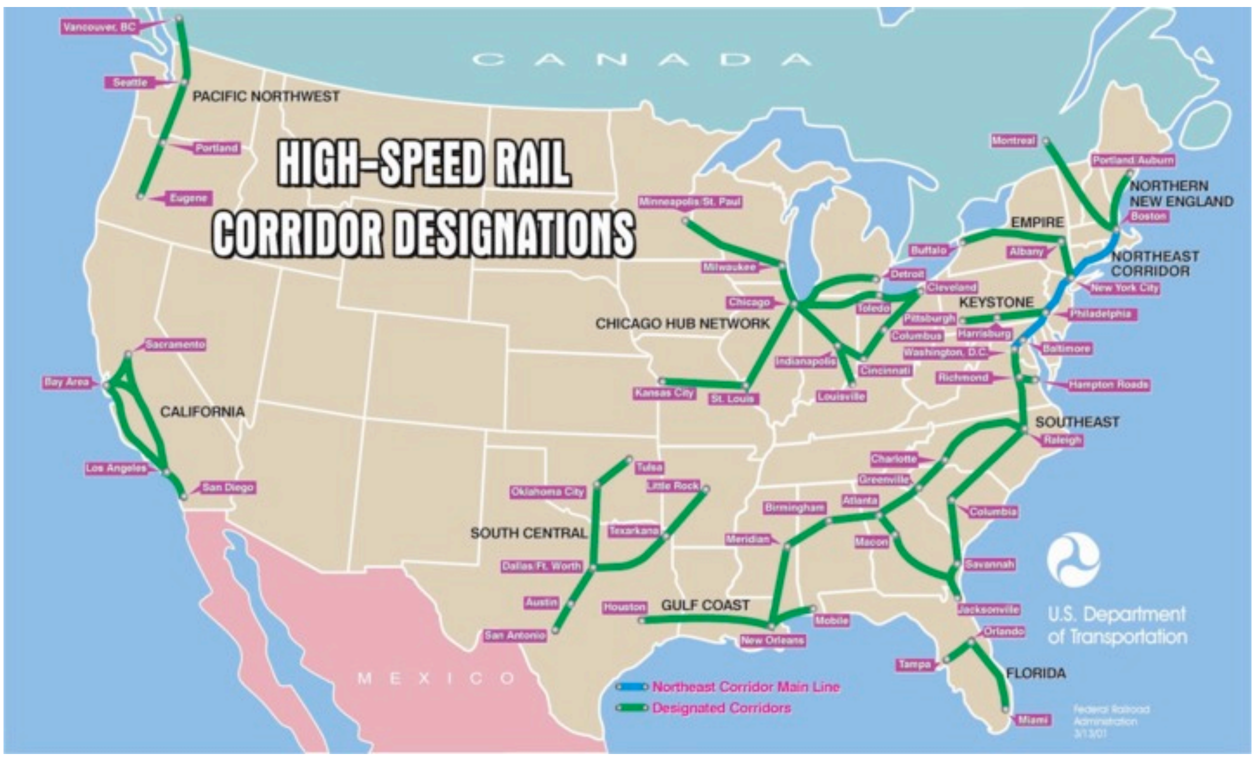
If we continue on the current road of overshoot, the likely consequence will be a "national Katrina" disaster, where a small group would still have access to fuels, capital, and quality food while a much larger underclass would be left to scramble for survival. But that dismal potential shares one outcome with the "positive scenario" -- both the cooperative, conservation future and the collapse scenario would greatly reduce need for more highways. Whether we cope with Peak Oil and climate change or continue to ignore the problems until they become catastrophic and un-mitigable, there is no need to continue to expand highway network.

Relocalizing production and building renewable energy systems is a bigger priority for using the remaining oil than more freeways for Wal-Mart delivery trucks.

Future generations will regret that essential farmland was paved over - not that one more dumb highway was not built.

Politicians who have nothing practical for the public to mitigate the consequences of Peak Oil risk being thrown out of office once the price of gas goes up and stays up. Who will get the blame for ignoring the issue?

The most important question regarding planning for 2030 is what type of economy we will have after the cheap abundant oil is replaced by expensive, scarce oil. Will we use the remaining oil to relocalize production and build lots of renewable energy equipment or will this oil be used to build more freeways and fuel a futile World War to control the remaining oil fields? The answers to these questions determine the future of the human race.



This map shows a proposal from US Department of Transportation for high speed rail in the United States. Note that the Cascadia high speed train service has languished in obscurity, unfunded, ignored by politicians proclaiming themselves to be green and interested in "sustain a bull" transportation. While Washington State is making some modest upgrades to the train line -- which will provide some slightly faster Amtrak service -- the State of Oregon is doing its best to ignore problems of Willamette Valley train service.

The ODOT report "I-5 Rail Capacity Study" (February 2003), archived at www.oregon.gov/ODOT/RAIL/docs/railcapstudy.pdf estimated it would cost about $170 million to make substantial fixes to the freight rail network in the Portland area to permit increased passenger train service and unclog freight train congestion (partially caused by the import of cheap crap from China into western ports in Portland, Seattle, Tacoma and other locations).

The SDEIS needs to consider increased Amtrak service from Vancouver, Washington to Union Station in downtown Portland as part of the transportation mix.

Amtrak: old and new (80 and 120 mph theoretical speeds if the tracks were fixed). The Amtrak Cascades could connect cities much quicker if the tracks were upgraded to accommodate the speed it is capable of.

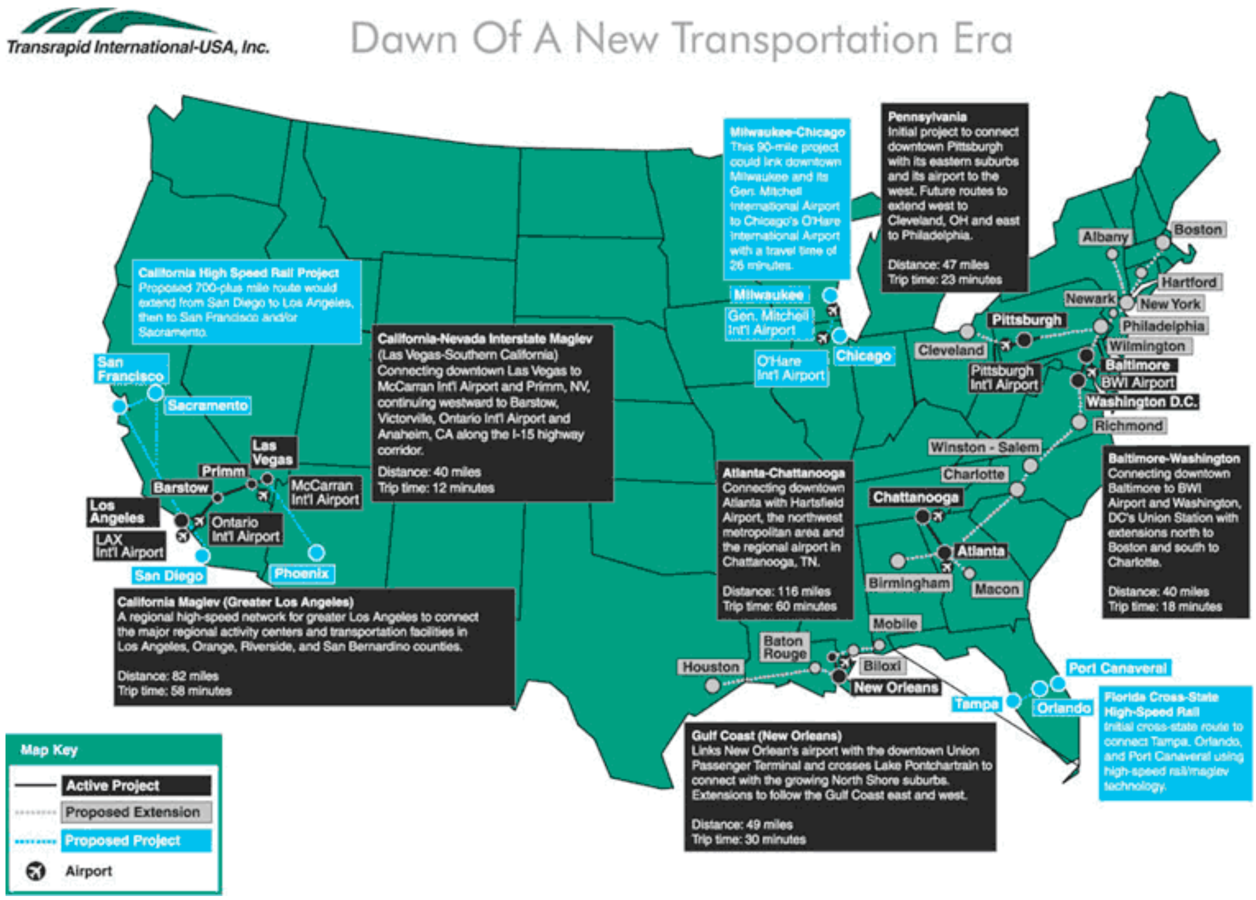
A side issue: solar photovoltaic panels should be installed along the tracks of the light rail, along I-5, and even along the freight rail routes where possible.   This is done in a growing number of European communities, since the right of way is already cleared (and usually in public ownership). Perhaps solar panels could be used to create a roof over the bike path on the future light rail CRC bridge to keep bicyclists and pedestrians dry during the rainy season.

ACELA: Amtrak's high speed service from Washington, D.C. to Boston (150 mph). It is not quite the same quality of service as found in Japan, France, Germany, the Eurotunnel, Taiwan, Korea and other places with dedicated high speed routes, but it is the best train route in North America.   How many high speed routes could be built for the cost of a new Trident submarine, more Stealth bombers or other Weapons of Mass Destruction that are Made in the USA?   Unfortunately, even if there was a national shift in priorities to build super trains, the locomotives would have to be imported since there is almost no domestic train production capacity after decades of deliberate neglect. (The Amtrak Cascades train was built in Spain, not Puget Sound or the Willamette Valley.)

Transrapid 08

Transrapid International

Maglev: 220 to 300 mph - German test track



proposed pilot projects for magnetic levitation trains in the U.S.

Rebuttal of DEIS energy sections

3.12 Energy

Policies at the federal, state and local levels support energy conservation for all sectors, including transportation. Transportation energy efficiency is largely regulated though requirements on vehicle manufacturers rather than transportation infrastructure. There are no established standards to determine when a transportation project has an energy "impact." This DEIS compares the relative energy demands of the different CRC alternatives and discusses options that could reduce energy consumption during project construction and operations. This information is based on the CRC Energy Technical Report.

3.12.1 Existing Conditions

This section gives an overview of national and state energy supply and demand, with a focus on transportation demand and on petroleum—the primary energy source for transportation.

National Energy Demand

At the national level, industrial uses had the highest share of energy demand in 2005. **However, the transportation sector's energy demand is expected to grow by 1.4 percent annually—to a 29.9 percent share by 2030—and will exceed the industrial sector's demand. Of the total energy projected to be used by transportation in 2030, 97.4 percent is expected to come from liquid fuels and other petroleum products.** Even

> note: in other words, transportation is going to remain very dependent on liquid fuels. Petroleum has the highest energy density of any known liquid fuels and has the greatest Energy Return on Energy Invested (EROEI) of any known liquid fuels.

with improvements in fuel consumption rates and increasing use of alternative fuel sources, t**he high passenger travel demand and increasing use of trucks for freight is expected to result in a substantial increase in energy demand.** The transportation sector (including aviation, marine,

> note: this alleged increase in demand is unlikely to be met with a parallel increase in supply. Just because there is a demand does not mean that oil fields can be extracted faster.

freight rail and roads) accounts for about 68 percent of our nation's petroleum consumption.

Washington and Oregon Energy Demand

The total demand for all energy sources in Washington State has grown steadily, although the per capita consumption rate has declined several times since the early 1970s. The demand for energy from coal and natural gas in Oregon and Washington is substantially lower than the national average, but is offset by the demand for hydro-electric power. Washington is the leading hydroelectric power producer in the nation. However, as of 2004, energy derived from petroleum products accounted for the largest single share (42.0 percent) of energy consumed in Washington, slightly higher than the 2005 national demand of 40.5 percent. **In 2000, approximately 47 percent of Oregon's energy consumption came from petroleum.** Since then, petroleum's share of

note: this shows that Oregon's transportation system is totally dependent on petroleum (since the non petroleum energy supplies generally run the electric power grid, not transportation

total demand has decreased, but still accounts for the largest share of energy consumption at 35.7 percent, notably lower than the national average. As illustrated in Exhibit 3.12-1, the transportation sectors in Washington and Oregon (including aviation, marine, freight rail and roads) account for about 71 percent and 82 percent, respectively, of each state's total petroleum consumption. In Washington, state-wide petroleum demand in the industrial sector is nearly four times that of Oregon, increasing Washington's non-transportation use of petroleum.

Peak Oil and Global Supply
and Demand

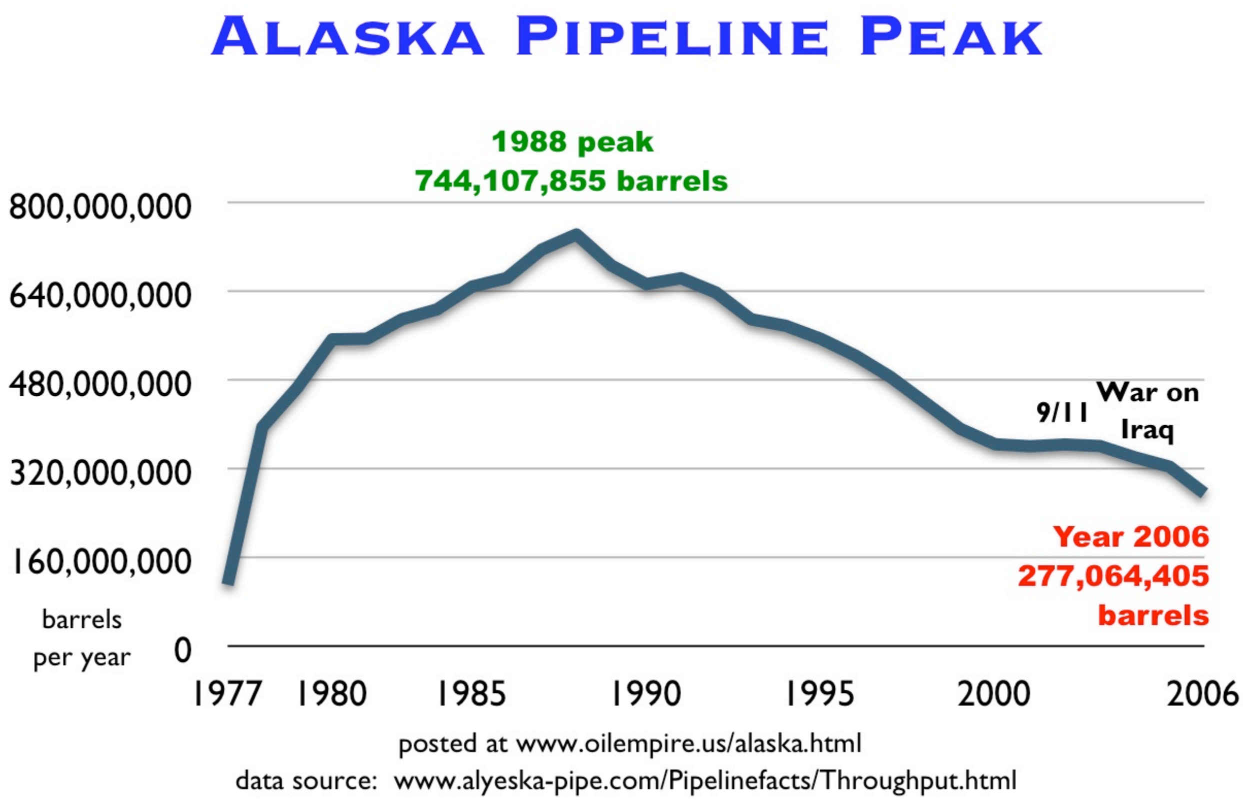
Peak oil refers to the time frame in which the maximum global petroleum production rate is reached, after which the rate of production enters a terminal decline. Peak oil and its relevance to the CRC project is discussed in the Cumulative Impacts section.

The trend toward more fuel-efficient vehicles is expected to continue in the future because of recent government requirements for higher fuel efficiency standards and rising petroleum prices. Promoting alternative fuel sources for transportation, such as ethanol, biodiesel, compressed natural gas, liquefied petroleum gas, and electricity has also been increasing. Nonetheless, petroleum demand in Washington, Oregon and the project area is projected to increase.

Washington and Oregon Petroleum Supply

Because gasoline and diesel are the primary energy sources for the transportation sector, the analysis of energy supply focuses on petroleum-based fuel sources. **Approximately 90 percent of Washington's current supply of crude oil comes from the Alaska North Slope.** Five refineries in the Puget Sound area distribute refined petroleum products to Washington and adjacent states. **Oregon imports 100 percent of its petroleum, of which approximately 90 percent comes from Washington refineries. Both states' future supply of petroleum is largely dependent on domestic production and reserves. Oil production from the North Slope peaked in 1988 and is projected to continue declining.**

note: In other words, Oregon and Washington are totally dependent on outside sources for oil, and the main source of that oil has been in decline for two decades -- down by two-thirds since the peak.



Energy Use in the CRC Project Area

The estimated existing daily energy use for the regional transit system (including the regional MAX light rail system and all of C-TRAN's and TriMet's buses and other transit vehicles) is approximately 2.8 x 10^9 Btus. For cars and trucks crossing the river on I-5 and I-205, the estimated daily energy use is about 1.3 x 10^9 Btus. The estimate for existing and future highway energy use is based only on the crossing portion of highway trips. It does not estimate regional highway energy demand or even project wide demand. The reason for setting these boundaries for the highway energy estimates is twofold. First, the impact on highway energy demand outside the corridor would be minimal. Second**, highway speeds and congestion have a strong influence on fuel efficiency and thus energy demand. Traffic analysis completed for the**

CRC project provides reliable speed and congestion estimates for the river crossing, but not elsewhere in the region. For these two reasons,

rebuttal: Neither Oregon nor Washington is planning to reduce highway speed limits to the Nixon era 55 mph to reduce energy consumption (although when the oil crunch becomes more obvious this decision may become inevitable). While idling cars do waste oil, cars traveling 55 mph also use lots of oil, and the impacts of "induced traffic" and induced sprawl development from new highway construction / expansion need to be factored in to these analyses. It is incorrect to suggest that a bigger bridge will reduce energy consumption - the excessive construction would be very energy intensive and the plans for extra traffic versus a Peak Traffic Alternative would consume vast oceans of fuel.

highway-related energy demand is based on the estimated traffic volumes, vehicle types and travel speeds for the crossings themselves. This captures the most meaningful effects and provides a reliable comparison among alternatives, even though it does not capture all of the potential highway energy savings.

The analysis of transit-related energy demand looks more broadly, primarily because this allows the analysis to capture the effect that the CRC alternatives have on transit operations outside the immediate project area.

3.12.2 Long-Term Effects of Project Alternatives

By 2030, energy consumption by vehicles on regional roadways, including I-5 and I-205, will increase substantially over existing conditions. This will occur largely because population growth will increase the number of cars, trucks, and buses on the road. At the same time, average vehicle fuel efficiency is expected to improve as new,

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more fuel efficient and alternative fuel vehicles replace old ones.

rebuttal: It is not physically possible on the downslope of oil extraction for future consumption to be greater than the peak of production. While fuel efficiency may increase, the overall availability of energy will decline faster than federal mandates to force higher mileage standards. Alternative fuels that are under consideration have substantially lower "energy return on energy invested," so they will not be able to replace existing use of oil.

Exhibit 3.12-2 shows predicted fuel consumption in the year 2030. Highway energy use is projected to decrease for all of the build alternatives compared to the No-Build Alternative. Highway-related energy savings would likely be greater than shown as this table indicates only the energy reductions associated with the actual river crossing. The lower energy demand for the highway crossing is due to three primary factors:

• **Increased I-5 bridge capacity decreases the duration of congestion**

and increases average speeds. This improves fuel efficiency. Compared to stop and go traffic, fuel efficiency improves as average speeds increase, until the speeds reach free flow conditions.

rebuttal: Peak Traffic means that before 2030, substantial reductions in traffic flow are a certainty, thus removing the alleged "need" for highway widening across the river. Instead, extra effort should be made for expanded light rail, carpooling, world-class Amtrak service, better bus service, and other initiatives to help citizens cope with the end of cheap oil.

• CRC provides high-capacity transit that is expected to divert a portion of personal vehicular travel demand to transit, which uses less energy per passenger.
• **Tolling the I-5 crossing is expected to deter some trips across the river, which reduces energy demand.**

rebuttal: a more equitable means to raise the funds would be to tax gasoline at the pump, preferably at the same level on each side of the state border. Refunds could be pro-rated to lower income people to prevent an apartheid transportation system based on class. Forcing poorer people onto the new light rail train while richer people continue to drive is a form of environmental injustice.

Total energy use would rise with Alternatives 4 and 5 primarily due to the increased level of transit operations. Total energy use would decline with Alternatives 2 and 3 compared to the No-Build Alternative.

Alternative 1: No-Build

Exhibit 3.12-2

Future 2030 Energy Consumption (Million Btu)

Alternative 1
No Build
I-5 crossing 793.6
I-205 crossing 831.7
Highway Crossing Subtotal 1625.3
Conventional bus 3,238.1
Biodiesel bus[a] 0
Light rail 520.8
Transit Subtotal 3758.9

Total 5384.2

Source: CRC Energy Technical Report.

a Both transit operators have commitments to biodiesel utilization, and have begun investing in biodiesel vehicles. But for the No-Build analysis, no assumptions were made about the percentage of the vehicle fleets that may one day run on biodiesel. There is similar support for diesel/electric hybrid vehicles, though no assumptions for such were made in this analysis

The No-Build Alternative is projected to have higher energy consumption than Alternatives 2 or 3 (by about 3 percent), and lower than Alternatives 4 and 5 (by about 6 percent).

rebuttal: it is physically impossible for any alternative proposed today for the year 2030 to have an increase in energy consumption since the energy to be consumed is non-existent. Peak Oil will force a reduction in overall consumption regardless of government plans in Environmental Impact Statements. A Supplemental Draft EIS is needed to accurately project energy supplies in the design year of 2030.

3.12.3 Long-term Effects of Project Components

This section describes impacts of the components that comprise the project alternatives.

Multimodal River Crossing and Highway Improvements (Replacement Crossing with Alternatives 2 and 3; Supplemental Crossing with Alternatives 4 and 5)

The highway improvements associated with the replacement crossing would reduce energy demand relative to the highway improvements associated with the supplemental crossing because the additional capacity would decrease the amount of time cars spend in stop and go traffic. This improves fuel efficiency.

Transit Mode (BRT with Alternatives 2 and 4; LRT with Alternatives 3 and 5)

Light rail would reduce energy demand relative to bus rapid transit, although the difference is minor. Both modes would reduce energy demand compared to providing no high-capacity transit system in the CRC corridor.

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The additional electrical energy consumed by daily operations of maintenance bases would be negligible compared to the energy consumed for transportation. Expanding either the bus maintenance base in east Vancouver or the light rail maintenance base in Gresham would not measurably affect long-term energy use.

Transit Terminus and Alignment Options (with all Alternatives)

The Lincoln terminus would use slightly less energy than the Kiggins Bowl terminus, because it is a more direct and shorter route to North Vancouver.

The transit component of full-length terminus options would consume more energy than the transit components of either of the minimum operable segment (MOS) terminus. The Clark College MOS would require approximately 1.4 percent less energy. The Mill Plain MOS, which represents the shortest high-capacity transit line length, would have the lowest energy use by approximately 2.4 percent compared to a full-length terminus. Construction energy demand would be lower for the minimum operable segments.

The transit alignment options would not affect the overall energy demand of the project, as summarized above for the alternatives.

Transit Operations

Increased transit operations (service frequency) would increase the transit operational energy demand compared to the Efficient operations option. While the Increased transit operations would result in fewer autos crossing the river, and thus some reduction in highway energy demand, that decrease is not proportional to the added energy demand from the substantial increase in transit service associated with the Increased versus Efficient transit operations.

Tolling Scenarios

Tolls on the I-5 crossing are included in all build alternatives. Other tolling scenarios were studied to analyze how tolling would affect demand on the roadway.

Under tolled scenarios, the replacement crossing would result in 178,000 daily vehicle trips across the I-5 bridges and 213,000 vehicle trips across the I-205 bridges. If no toll were collected in 2030, the I-5 crossing's daily traffic levels would increase by 32,000 vehicles (18 percent). I-205's daily traffic would decrease by 13,000 vehicles (6 percent). Without tolling, an additional 19,000 (5 percent) cross-river vehicle trips would be made in 2030.

rebuttal: It is impossible for traffic levels to increase when overall energy supplies will be substantially lower in 2030 than today in 2008. A Supplemental DEIS is needed to model a Peak Traffic Alternative.

Due to the supplemental bridge's assumed higher toll, less available highway capacity, and provision of an enhanced transit system, daily I-5 vehicle crossings would be 13,000 vehicles per day lower compared to the replacement bridge, while I-205's crossings would increase by 6,000 vehicles per day. Overall, there would be 7,000 fewer vehicle crossings of the Columbia River via I-5 and I-205.

The No Toll scenario would have the highest daily energy use.

Compared to the No Toll scenario, the Standard Toll on I-5 scenario would consume approximately 1.9 percent less and the Standard Toll on

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Estimating Construction

Energy Use

The approach for estimating energy use during construction is based on a method developed by the California Department of Transportation. It estimates energy requirements for a variety of construction activities (building structures, electrical substations, site grading, etc.) by relating project costs to the amount of energy

needed to manufacture, process, and install
construction materials and structures.
Both I-5 and I-205 would require approximately 3.6 percent less operational energy.

3.12.4 Temporary Effects

The method used to estimate energy use from construction is based on applying a factor to construction cost estimates. This provides a straightforward albeit relatively simplistic approach for comparing the relative energy demand of alternatives.

Based on this estimating method, Alternative 3 (replacement crossing with light rail) would require the most energy to construct (estimated at about 7.28 x 10^{12} Btus), followed by Alternative 2 (3.2 percent lower), Alternative 5 (about 19.7 percent lower), and Alternative 4 (about 23.3 percent lower). Energy to construct Alternative 4, the lowest-cost full alternative, is estimated at about 5.90 x 10^{12} Btus. The two minimum operable segments are shorter and less expensive to build, and would thus require less construction energy.

For the components that make up the alternatives, light rail construction would consume more energy than bus rapid transit; and, constructing the Kiggins Bowl terminus (A) would use more energy than the Lincoln terminus (B).

3.12.5 Potential Mitigation

Potential Mitigation for Temporary Effects

A variety of potential measures could reduce energy consumption from construction. As the project advances in design, and more detail is available on construction needs and activities, additional analysis will help identify specific measures and approaches for reducing energy consumption during construction. Potential measures include:

- Construction materials reuse and recycling.
- **Encouraging workers to carpool.**

The SDEIS should consider encouraging all workers to carpool, not merely those working on the construction of the CRC.

- Turning off equipment when not in use to reduce energy consumed during idling.
- Maintaining equipment in good working order to maximize fuel efficiency.
- As practical, routing truck traffic through areas where the number of stops and delay would be minimized, and using off-peak travel times to maximize fuel efficiency.
- As practical, scheduling construction activities during daytime hours or during summer months when daylight hours are the longest to

3.19.11 Energy and Peak Oil

Cumulative effects related to energy use are partially incorporated into the long-term energy demand estimates prepared for the CRC project. Those estimates are based on travel demand forecasts that factor in

59 Hamlet and Lettenmaier, 1999.

60 Enertech Consultants, 1998.

COLUMBIA RIVER CROSSING

3-438 CHAPTER 3 CUMULATIVE EFFECTS

projected local changes in land use patterns, employment, population growth, and other programmed transportation improvements.

The cumulative energy impact of primary concern is "peak oil." Peak oil refers to the point in time at which the maximum global petroleum production rate is reached, after which the rate of production enters a terminal decline. **Peak oil results from many incremental actions, few of which are individually important. However, the potential impact of reaching peak global petroleum production is an important consideration for projects, such as CRC, intended to address transportation needs for decades to come.**

Oil production in the United States—the world's third largest oil producing nation—reached its peak around 1970 and has been in a declining trend since then. Most estimates place peak global production occurring some time between 1990 and 2040.

> rebuttal: No credible estimates ever placed peak around 1990. Even the earliest projection - from M. King Hubbert in 1956 - estimated that the global peak might be in the mid 1990s. While Hubbert's 1956 prediction that the US would peak around 1970 was accurate, he was off by a decade for the global peak since he didn't include the reduction of consumption that happened as a result of the 1973 Saudi Oil Embargo and gasoline disruptions as a result of the Iranian revolution.
>
> Currently, in 2008, no credible scientist estimates that 2040 is the peak of global oil. The only debate among the experts who have closely examined the data is whether we are now at Peak Oil (on a temporary plateau) or whether the peak is just ahead, a couple of years in the future. Some disingenuous voices suggest that tar sands and coal to liquids should be given equal weight in this discussion even though they take nearly as much energy to produce as they contain. When fuels require more energy to produce than they contain, they cease to be sources of energy, regardless what the ostensible price is to purchase.
>
> The SDEIS needs to factor in the best science about the state of petroleum geology and recognize that we are at - or at least near - the point of Peak Oil.

When oil production drops below oil demand, it is likely to cause petroleum prices to increase. There are uncertainties, however, regarding peak oil's timing and the availability of substitute fuels. Peak oil's effect on transportation fuel prices and travel behavior will depend largely on

when peak oil occurs and the availability of substitute fuels.
Peak oil's potential effects on economic activity and travel behavior could affect the CRC project. The concern is that if substitute fuels are not readily available as petroleum supplies decrease**, the rising cost and reduced supply of petroleum could directly reduce auto and truck travel, and could result in dramatic reductions in economic activity, which, among other effects, could further reduce vehicle trips below forecasts. These vehicle trip forecasts influence the proposed size, design, and financing of transportation facilities. If fuel prices increase faster than expected, then the number of 2030 highway trips could be lower than forecasted.** However, even with relatively substantial fuel price

> rebuttal: Fuel prices have already increased faster than the assumptions used in the DEIS, which projected that 100 dollars a barrel might be reached by the year 2030. A SDEIS is needed to re-calibrate the traffic models to factor in the impacts of substantially higher energy prices (oil, natural gas, coal, etc) by 2030.

increases, the future demand would still be greater than the expanded highway capacity. Because fuel costs represent only a portion of total transportation costs (which include everything from car payments, to insurance and maintenance) even large growth in fuel costs translates to a smaller growth rate in total transportation cost, which is what most directly affects travel demand in the long term.
Global oil demand is projected to grow by 37 percent by 2030, driven in large part by transportation needs;[62] local transportation energy demand is expected to grow as well, although the CRC build alternatives are projected to reduce future transportation petroleum demand compared to No-Build. At the global scale, these fuel savings will be very small but incrementally beneficial over the No-Build Alternative.

> rebuttal: demand may continue to grow, but no credible geologist suggests at this point (2008) that global oil extraction can grow by 37 percent by 2030. The only debate among Peak Oil experts is whether we have already peaked worldwide, or whether there might be some extra, secret oil in Saudi oil fields and a few other locations that will delay the peak a few years (although not to 2030 under any credible scenario). The work of the Association for the Study of Peak Oil - www.peakoil.net and www.aspo-usa.org - represents the best efforts of the world's pre-eminent petroleum geologists and does not support the claim that oil flows could theoretically increase in 2030 over current levels. A more realistic analysis would show that by 2030 we are more likely to have a 37 percent REDUCTION in oil supplies, although the decline could be steeper than this.

The CRC alternatives include a number of elements that would reduce adverse impacts related to peak oil. These include:
• The bridge and highway improvements are focused on replacing or updating aging infrastructure, not on building new highway corridors

61 Hirsch, 2005.
62 EIA, 2006.

What does the U.S.
Department of Energy say
about peak oil?
A report by the US Department of Energy61
included the following conclusions:

- **World oil peaking is going to happen, and will likely be abrupt.**
- **The problem is the demand for liquid fuels (growth in demand mainly from the transportation sector).**
- **Mitigation efforts will require substantial time.**

note: The Hirsch Report stated that we would need two decades to minimize the impact. Since Peak Oil is here, now, the subtext of this report is that President Jimmy Carter was right, but the fact that his half hearted efforts were sabotaged by the financial, political and military systems suggests that we are unprepared to cope with the unfolding crisis.

- Both supply and demand will require attention.
- More information is needed to more precisely determine the peak time frame.

DRAFT ENVIRONMENTAL IMPACT STATEMENT
CUMULATIVE EFFECTS EXISTING CONDITIONS AND ENVIRONMENTAL
CONSEQUENCES **3-439**
Has transportation
infrastructure been able to
adapt to change?
Transportation infrastructure has proven to be relatively adaptable. For example, the northbound I-5 bridge over the Columbia River was built in 1917 as a two-lane bridge that originally carried electric trolley cars and Model T autos (which ran on either gasoline or ethanol). While it is now obsolete in terms of seismic safety and traffic safety design

standards, it was able to periodically adapt to nearly a century of changes in transportation technology, energy policy and prices, vehicle types, and travel behavior.

rebuttal: those changes were in the direction of increased energy consumption. We now face an era of declining energy consumption, a totally new experience without precedent (save for collapses of pre-industrial civilizations such as Rome)

• They include substantial improvements to public transportation, with projected increases in transit mode share in the afternoon peak direction from 13 percent with the No-Build to as much as 21 percent with light rail transit
• They provide substantially improved facilities for non-motorized transport
• They support land use planning that seeks to control sprawl, concentrate development, and decrease auto dependency
• They include road use pricing (highway tolling)
• Because of the addition of high-capacity transit and the bridge toll, all build alternatives are projected to have lower daily I-5 river crossings than under the no-build.
• **They improve highway operations at a key pinch point which improves fuel efficiency and lowers emissions.**

rebuttal: Peak Traffic makes this assertion somewhat moot, since less traffic by 2030 will see reduced congestion anyway. Carpooling, increased public transit, telecommuting and other approaches will have more impact on energy consumption that pretending that doubling the width of the highway will reduce energy consumption.

• **They increase highway safety which decreases collisions and congestion, further improving fuel efficiency.**

rebuttal: While there may be some traffic safety issues to be mitigated with changes to road design, requiring drivers to prove they still know how to drive and to be courteous when getting a driver's license renewal would be the single most effective approach. There is no need to double the width of I-5 merely to reduce the risk of accidents, especially as Peak Traffic sets in.

Another concern is the ability of current transportation infrastructure to adapt to post-peak oil vehicles and technology. Based on the alternative fuel vehicles that are currently being researched and developed, it is highly likely that the CRC infrastructure (transit guideway, bridges,

highway, and bike and pedestrian paths) will be able to accommodate foreseeable changes. Electric hybrids, electric plug-ins, and vehicles powered by bio-diesel, ethanol, or hydrogen fuel cells are being designed to operate on modern roads and highways. The CRC transit guideway,

rebuttal: Biodiesel is a great fuel (I use it) but it is unlikely to be scaled up to completely replace petroleum based diesel. Biodiesel also must be blended with petroleum diesel when temperatures go below 40 degrees (F). Some people suggest that (genetically altered) algae may be able to generate liquid fuels in substantial quantities, but this is not yet proven and the risks of these engineered organisms escaping into the environment and causing massive pollution is not well understood.
A biomass opponent recently wrote this:

In 1992, at the Oregon State University's botany department, Professor Elaine Ingham stepped into a potential biotech Chernobyl. One of her graduate students discovered that all the wheat plants they had been growing in jars had been turned to brown mush, a result of exposure to an engineered strain of Klebsiella planticola, a common soil bacteria. The engineered K planticola was designed to be a miracle product to decompose plant stubble and debris and to break down such for fertilizers, sludge and alcohol.

Professor Ingham saw the extreme danger presented if K planticola had escaped into the wild. (1) "That would have been the end of all terrestrial plants...it would have been dispersed any time a bird moved it to another field." she noted, even as the EPA had already approved K planticola as safe and ready for deployment. The monster germ was reluctantly shelved, Ingham and her graduate student were politically removed and the incident covered up.

Hydrogen fuel cells currently lack long term viability and require extremely scarce platinum. If hydrogen can be created (and distributed on a large scale) it might have a role in mitigating the end of the oil age.

whether built for bus rapid transit or light rail, can be used by vehicles powered by a variety of fuels. The capacity of the proposed bicycle and pedestrian facilities can accommodate substantial growth in nonmotorized transportation demand. It is likely that the proposed CRC infrastructure could readily accommodate or adapt to the transition to substitute fuel vehicles, higher than projected growth in non-motorized modes, and higher growth in transit demand.
There is substantial uncertainty regarding the timing of peak oil, the future availability of substitute fuels and technology, and the effects of peak oil on transportation. It is reasonable, however, to conclude that the CRC project can be relatively prepared, at the project level, to address reasonably foreseeable impacts associated with peak oil, and to reduce the project's incremental adverse impact.

rebuttal: If the CRC DEIS cannot even acknowledge the substantial increases in oil prices during the preparation of this document, then claims that the project will be able to address Peak Oil are ludicrous beyond language.

Outside the purview of CRC, numerous other measures will influence the timing and impact of peak oil at the global and local scale. These other actions include national and international energy policies, international relations, fuel and transportation taxes and fees, alternative fuel and technology research and development, agricultural policy and practices, local land use regulations, and other measures.

4. Affected Environment

4.1 Introduction

Because the supply and distribution of petroleum (Washington's and Oregon's primary energy source in general, and especially for the transportation sector) is regulated and distributed at the national and state levels, the affected environment is broadly inclusive of the U.S., Washington, and Oregon. This section provides a brief and general description of:

- The existing use and demand for energy resources in the nation and region.
- The present energy use for transportation.
- The available and forecasted supply of energy.

Because gasoline and diesel are the primary energy sources for the transportation sector,

this discussion provides general information on several energy sources, but focuses on the supply and demand of energy derived from petroleum-based fuel sources. Unless specifically defined otherwise, energy use refers to energy originating from crude oil products since energy derived from these sources generally account for over 95 percent of the total energy demand for the transportation sector.

4.2 National Energy Supply and Demand

The USDOE prepares annual energy outlook reports with projections into the future (USDOE 2007a). The Annual Energy Outlook analyzes trends in energy supply and demand worldwide with linkages to projected performance of the U.S. economy and future public policy decisions. The most recent report analyzes historical energy use beginning in 1980 and provides supply and demand forecasts to 2030 (USDOE 2007a). Energy supply forecasts are largely based on international oil markets, and national energy demand projections are organized by delivered energy sources and use sectors.

4.2.1 National Energy Supply

The national supply of petroleum largely depends on international factors. The majority

of oil suppliers are currently at or near production capacity, with the exception of OPEC, who is the largest contributor to the international supply of petroleum. Since its inception in 1960, OPEC has historically had a substantial role in the international and U.S. petroleum supply. In general, when the world oil price is low (price often tracks supply), OPEC curtails supply, and when the price is high, OPEC increases production.
In 2030, 66 percent of the U.S. petroleum supply is expected to be imported from international oil markets including OPEC members and other countries in the Far East, Caribbean, Europe and North America (other than the U.S.). Of this 66 percent, 37 percent is expected to originate from OPEC suppliers (USDOE 2007a).

> Rebuttal: The US already gets about two-thirds of its oil supply from outside the US. Since most of the known oil in the US has already been extracted, it is obvious that by 2030 nearly all US oil consumption is likely to be bought (or stolen via military power) from other countries. The only way that the ratio of foreign oil could remain relatively constant past the global peak is to begin to use much less oil, but that would force a substantial reduction in travel demand, which in turn means that a 12 lane bridge across the Columbia River would not be needed.

Interstate 5 Columbia River Crossing
Energy Technical Report
Affected Environment
4-2 May 2008

Historically, world oil prices have varied considerably and are expected to continue to exhibit high fluctuations as a result of political instability, access restrictions, and a reassessment of OPEC producers' ability to influence prices during periods of volatility. As a result, the 2030 national supply of petroleum could vary substantially depending on world oil prices. Due to global political and economic uncertainties, **the USDOE Annual Energy Outlook world oil prices in 2030 were forecasted for three scenarios: "High Price," "Reference Price," and "Low Price" with the cost of oil at 100, 59, and 36 dollars per barrel, respectively (in 2005 dollars). In November 2006 the price of crude oil was about 60 dollars per barrel. One year later it had risen to between 90 and 100 dollars per barrel (2007 dollars). Depending on the world oil prices, the 2030 projections for petroleum imports ranged from 13.4 million barrels per day for the High Price scenario, 17.7 million barrels per day for the Reference Price, and 20.8 million barrels per day for the Low Price scenario.**

> Rebuttal: The 100 dollar a barrel price was reached four months before the publication of the DEIS, not in the year 2030. Therefore, the traffic analysis for the CRC needs to be redone to factor in geological and financial reality - the end of cheap oil is here (regardless of the precise timing of Peak Oil).

The following discussions on national and local energy supply and demand are based on the Reference Price world oil prices.

4.2.2 National Energy Demand

The national demand for energy will depend on trends in population, economic activity, energy prices (which are reliant on the factors affecting the national supply described above), and the adoption and implementation of technology. In general, the energy consumption per capita is expected to increase 0.3 percent annually through 2030 primarily as a result of strong economic growth (USDOE 2007a). However, the nation's economy is becoming less reliant on energy as a result of energy efficient technologies and faster growth in less energy-intensive industries.

USDOE's annual energy outlook organizes national energy demand forecasts in 2030 by delivered energy source (liquid fuels/petroleum, natural gas, coal, electricity and renewables) and use sectors (residential, commercial, industrial, and transportation). According to the USDOE, the delivered energy use from all sources is expected to increase from 100.19 quadrillion Btu in 2005 to 131.16 quadrillion Btu in 2030, equating to annual demand growth rate of 1.1 percent (USDOE 2007d). **Energy from liquid fuels and other petroleum products is expected to account for the greatest share of energy demand (approximately 40 percent) with a growth rate of approximately 1 percent.**

> rebuttal: increase in petroleum based (and derived) liquid fuels are not going to be able to continue to increase on the Peak Oil downslope.

The energy demand from renewable sources is expected to have the highest growth rate (2.2 percent from biomass and 2.6 percent from other sources for a combined growth rate of 2.3 percent), but will continue to account for the smallest overall share of energy demand in 2030 (4.2 percent). Exhibit 4-1 summarizes the national demand for energy in 2005 by energy source with projections out to 2030.

Peak Asphalt

http://www.usatoday.com/printedition/news/20080606/1a_bottomstrip06_dom.art.htm

Oil prices seep into asphalt costs, detour road work

Repair projects are a blow to budgets
By Judy Keen
USA TODAY

CHICAGO — Fewer roads will be repaved this summer, thanks to soaring prices of oil-based asphalt.

Some states, cities and counties say their road-repair budgets didn't anticipate asphalt prices that are up 25.9% from a year ago, so they're being forced to delay projects.

"We will do what patching we can, but this will truly, truly be a devastating blow to the infrastructure," says Shirlee Leighton, a county commissioner in Lake County, S.D., where a 5-mile repaving project was postponed after bids came in $79,000-$162,000 higher than the $442,000 budget.

The mix used to resurface roads consists of gravel and sand held together with a binder called liquid asphalt, which is made from crude oil. As oil prices rise, so does the cost of asphalt, says Don Wessel of Poten & Partners, a consulting firm that publishes Asphalt Weekly Monitor. "Prices are the highest I've seen in many, many, many years," he says. "The concern is that they will go up considerably."

Increases in the cost of diesel fuel used to transport, heat and lay asphalt are adding to the sticker shock, too, creating headaches across the USA:

•Larimer County, Colo., would like to resurface 16-20 miles of its 450 miles of paved roads each year. "This year, we'll be lucky to do seven miles," says road and bridge director Dale Miller.

•Paul Degges, chief engineer for the Tennessee Department of Transportation, will resurface 1,600 miles of state highway this year, well short of his 2,500-mile target. "Since my budget is not growing and costs are up, we're doing less paving," he says.

•A few paved roads in Hall County, Neb., will revert to gravel surfaces, says public works director Casey Sherlock. "At some point, they'll be potholed so bad we won't be able to keep patching them." He had hoped to resurface 6-7 miles of road this spring and could afford only 2 miles.

•In Washington County, Md., acting deputy public works director Robert Slocum is using alternative treatments requiring less asphalt. The result: More miles are being treated with less asphalt, but "ride quality" can be compromised.

•Snohomish County, Wash., pays 17% more for asphalt than a year ago, says county engineer Owen Carter. It's pooling funds with four cities to get a better price.

•The Grand Traverse County (Mich.) Road Commission plans to bid out 30 miles of resurfacing before a bond issue of up to $4 million is finalized to lock in prices before they go even higher, Road Commission manager Mary Gillis says.

Ken Simonson, chief economist for Associated General Contractors of America, says the asphalt-price squeeze exacerbates the USA's infrastructure problems and "may force Congress and the states to find more money for roads sooner than they would have otherwise."

Page 1A

Spy Roads: Civil Liberties vs. Transportation Surveillance

European Parliament – Luxembourg, 6 January 1998 – Directorate General for Research
Scientific and Technological Options Assessment – An Appraisal of Technologies of Political Control
archived at http://www.cryptome.org/stoa-atpc.htm

Vehicle Recognition Systems

... A huge range of surveillance technologies has evolved, including the night vision goggles discussed in 3 above; parabolic microphones to detect conversations over a kilometre away (see Fig. 18); laser versions marketed by the German company PK Electronic, can pick up any conversation from a closed window in line of sight; the Danish Jai stroboscopic camera (Fig. 19) which can take hundreds of pictures in a matter of seconds and individually photograph all the participants in a demonstration or March; and the automatic vehicle recognition systems which can identify a car number plate then track the car around a city using a computerised geographic information system. (Fig.20) Such systems are now commercially available, for example, the Talon system introduced in 1994 by UK company Racal at a price of £2000 per unit. The system is trained to recognise number plates based on neural network technology developed by Cambridge Neurodynamics, and can see both night and day. Initially it has been used for traffic monitoring but its function has been adapted in recent years to cover security surveillance and has been incorporated in the "ring of steel" around London. The system can then record all the vehicles that entered or left the cordon on a particular day.

Such surveillance systems raise significant issues of accountability particularly when transferred to authoritarian regimes. The cameras ... in Tiananmen Square were sold as advanced traffic control systems by Siemens Plessey. Yet after the 1989 massacre of students, there followed a witch hunt when the authorities tortured and interrogated thousands in an effort to ferret out the subversives. The Scoot surveillance system with USA made Pelco camera were used to faithfully record the protests. the images were repeatedly broadcast over Chinese television offering a reward for information, with the result that nearly all the transgressors were identified. Again **democratic accountability is only the criterion which distinguishes a modern traffic control system from an advanced dissident capture technology.** Foreign companies are exporting traffic control systems to Lhasa in Tibet, yet Lhasa does not as yet have any traffic control problems. **The problem here may be a culpable lack of imagination.**

“that [surveillance] capability at any time could be turned around on the American people and no American would have any privacy left, such [is] the capability to monitor everything: telephone conversations, telegrams, it doesn't matter. There would be no place to hide. If this government ever became a tyranny, **if a dictator ever took charge in this country, the technological capacity that the intelligence community has given the government could enable it to impose total tyranny,** and there would be no way to fight back, because the most careful effort to combine together in resistance to the government, no matter how privately it was done, is within the reach of the government to know. Such is the capability of this technology ...

“I don't want to see this country ever go across the bridge. I know the capacity that is there to make tyranny total in America, and we must see to it that this agency [NSA] and all agencies that possess this technology operate within the law and under proper supervision, so that we never cross over that abyss. That is the abyss from which there is no return.”

-- Senator Frank Church (D-Idaho), 1975, quoted in James Bamford, “The Puzzle Palace”

“If this were a dictatorship, it would be a heck of a lot easier, just so long as I’m the dictator.”
- George W. Bush, December 18, 2000

Maryland's highway surveillance systems

www.baltimoresun.com/news/local/bal-te.md.reader03apr03,0,73671.story?coll=bal-home-headlines
Cameras scan license plates for stolen cars
By Melissa Harris
Sun reporter
Originally published April 3, 2006

As her marked car crawled through the parking lot, Detective Kelly Tibbs' new laptop beeped like a supermarket scanner. Two cameras, positioned like crab eyes on the cruiser's roof, snapped digital pictures of hundreds of license plates, and with each beep, the laptop checked the images against an FBI list of stolen cars.

Such cameras - called Mobile Plate Hunters - are replacing the laborious eyeball-and-keystroke method of checking for stolen cars, letting busy officers rely instead on an automated scan that takes less than a second.

Already in widespread use in London and Italy, automatic number plate recognition is a technology on the verge of exploding in the Baltimore-Washington area, fueled in places by funds from the federal Department of Homeland Security.

Howard and Anne Arundel counties deploy one each. Prince George's County and the District of Columbia have ordered more than a dozen of the cameras, which have been in use in Prince George's since August and the district since January.

Baltimore police are soliciting bids for a system that would work with the city's existing network of street surveillance cameras. And as early as this summer's vacation rush, Maryland Transportation Authority Police hope to add the cameras to the Bay Bridge as part of a pilot project with the U.S. Department of Justice.

Stationary cameras, such as those envisioned for Baltimore and the Bay Bridge, could alert nearby officers if an offending vehicle - one bearing a license plate registered to a wanted criminal, suspected terrorist or car thief - goes past.

"The uses are as limitless as your imagination," said Lt. John McKissick, director of Howard County's emergency preparedness division. "We're just in the infancy of this project, but already it saves us money and manpower."

Although proponents say the technology eventually will deny all but the most clever of criminals access to roads, privacy advocates warn that the plate hunters mark another step toward a society in which police can track a person's every move.

"Normally, your license plate number only becomes relevant when you're involved in an accident, pulled over by police or when your car is stolen," said Marc Rotenberg, executive director of the Electronic Privacy Information Center. "This technology changes that. ... It's a new form of surveillance."

The technology, which Tibbs demonstrated in the parking lot of Howard County police headquarters, was developed in Italy and used by the Italian postal service. Postcards would zip along a conveyer belt, the cameras would read them, and the computer would sort them.

"The engineers in Italy realized that if they could read Bulgarian postcards handwritten with pencil at high speeds, license plates would be a piece of cake," said Mark Windover, president of Remington-Elsag, a partnership between the U.S. gun manufacturer and the Italian postal-technology company, which sold a plate hunter to Howard County for $26,0000.

The plate hunters use infrared light to "read" as many as 900 license plates per minute zooming by at speeds of up to 120 miles per hour in the rain or dark, McKissick said.

Infrared light illuminates the plate, the camera snaps a picture and the computer converts it into digital characters - ABC 123, for example - using optical character recognition. Strapping two cameras to a roof allows the system to go through a mall parking lot, checking plates on both sides of the police car.

Each night, local police departments download FBI data to in-car laptops. When a scanned license plate matches one in the FBI database, the computer triggers an alarm, and the screen blinks red "alert" signs. Before officers can make an arrest, they must check the accuracy of the alert because the database lags a day behind, and the system does not distinguish among states.

"In one block in Washington, I recovered six sets of stolen tags and a stolen motorcycle using the reader," said state police Detective Sgt. George Jacobs, assistant commander of the Washington-area vehicle enforcement unit. "It's just amazing that there are areas out there like that. It's a great tool because manually, it would have taken me several hours to type in the tags."

Though the primary purpose of the technology is to recover stolen vehicles, Howard County and other jurisdictions plan to eventually use the cameras for surveillance.

McKissick said he envisions placing cameras around potential terrorist targets and linking them to neighboring counties' systems. For instance, if the same license plate passes emergency communications towers in Howard, Baltimore and Anne Arundel counties, the system could alert police in all three areas.

The technology also could be used to enforce laws or court orders that keep sexual predators away from schools or domestic abusers away from spouses.

Already, when Tibbs learns of an Amber Alert, she can enter the tag number manually into her laptop and search for the car. The system also is linked to the FBI's "violent gangs and terrorism organization file," though Howard County is not yet using it because the plate hunter is still new to the department, McKissick said.

"We want to be able to look at offenders with another set of eyes," said Chief Gary W. McLhinney of the Maryland Transportation Authority Police, which is working to secure a pilot program for the technology at the Bay Bridge.

McKissick and other officers dismiss concerns that the cameras invade drivers' privacy. McKissick said the machine is "strictly a numbers game," enabling officers to do more of what they already do.

Jacobs said the system does not discriminate and that the computer does not list a tag owner's information unless it sounds an alert on the car. Without the computer, officers choose which license plates they check, lacking the time to manually enter every one they see.

"There can be no discrimination," Jacobs said, "because the machine picks and runs every tag it sees."

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Britain's auto Panopticon

http://news.independent.co.uk/uk/transport/article334686.ece
Britain will be first country to monitor every car journey
From 2006 Britain will be the first country where every journey by every car will be monitored
By Steve Connor, Science Editor
Published: 22 December 2005

Britain is to become the first country in the world where the movements of all vehicles on the roads are recorded. A new national surveillance system will hold the records for at least two years.

Using a network of cameras that can automatically read every passing number plate, the plan is to build a huge database of vehicle movements so that the police and security services can analyse any journey a driver has made over several years.

The network will incorporate thousands of existing CCTV cameras which are being converted to read number plates automatically night and day to provide 24/7 coverage of all motorways and main roads, as well as towns, cities, ports and petrol-station forecourts.

By next March a central database installed alongside the Police National Computer in Hendon, north London, will store the details of 35 million number-plate "reads" per day. These will include time, date and precise location, with camera sites monitored by global positioning satellites.

Already there are plans to extend the database by increasing the storage period to five years and by linking thousands of additional cameras so that details of up to 100 million number plates can be fed each day into the central databank.

Senior police officers have described the surveillance network as possibly the biggest advance in the technology of crime detection and prevention since the introduction of DNA fingerprinting.

But others concerned about civil liberties will be worried that the movements of millions of law-abiding people will soon be routinely recorded and kept on a central computer database for years.

The new national data centre of vehicle movements will form the basis of a sophisticated surveillance tool that lies at the heart of an operation designed to drive criminals off the road.

In the process, the data centre will provide unrivalled opportunities to gather intelligence data on the movements and associations of organised gangs and terrorist suspects whenever they use cars, vans or motorcycles.

The scheme is being orchestrated by the Association of Chief Police Officers (Acpo) and has the full backing of ministers who have sanctioned the spending of £24m this year on equipment.

More than 50 local authorities have signed agreements to allow the police to convert thousands of existing traffic cameras so they can read number plates automatically. The data will then be transmitted to Hendon via a secure police communications network.

Chief constables are also on the verge of brokering agreements with the Highways Agency, supermarkets and petrol station owners to incorporate their own CCTV cameras into the network. In addition to cross-checking each number plate against stolen and suspect vehicles held on the Police National Computer, the national data centre will also check whether each vehicle is lawfully licensed, insured and has a valid MoT test certificate.

"Every time you make a car journey already, you'll be on CCTV somewhere. The difference is that, in future, the car's index plates will be read as well," said Frank Whiteley, Chief

Constable of Hertfordshire and chairman of the Acpo steering committee on automatic number plate recognition (ANPR).

"What the data centre should be able to tell you is where a vehicle was in the past and where it is now, whether it was or wasn't at a particular location, and the routes taken to and from those crime scenes. Particularly important are associated vehicles," Mr Whiteley said.

The term "associated vehicles" means analysing convoys of cars, vans or trucks to see who is driving alongside a vehicle that is already known to be of interest to the police. Criminals, for instance, will drive somewhere in a lawful vehicle, steal a car and then drive back in convoy to commit further crimes "You're not necessarily interested in the stolen vehicle. You're interested in what's moving with the stolen vehicle," Mr Whiteley explained.

According to a strategy document drawn up by Acpo, the national data centre in Hendon will be at the heart of a surveillance operation that should deny criminals the use of the roads.

"The intention is to create a comprehensive ANPR camera and reader infrastructure across the country to stop displacement of crime from area to area and to allow a comprehensive picture of vehicle movements to be captured," the Acpo strategy says.

"This development forms the basis of a 24/7 vehicle movement database that will revolutionise arrest, intelligence and crime investigation opportunities on a national basis," it says.

Mr Whiteley said MI5 will also use the database. "Clearly there are values for this in counter-terrorism," he said.

"The security services will use it for purposes that I frankly don't have access to. It's part of public protection. If the security services did not have access to this, we'd be negligent."

http://news.com.com/E-tracking,+coming+to+a+DMV+near+you/
2010-1071_3-5980979.html
DECLAN MCCULLAGH, CNET, December 5, 2005

Trust federal bureaucrats to take a good idea and transform it into a frightening proposal to track Americans wherever they drive.

The U.S. Department of Transportation has been handing millions of dollars to state governments for GPS-tracking pilot projects designed to track vehicles wherever they go. So far, Washington state and Oregon have received fat federal checks to figure out how to levy these "mileage-based road user fees."

Now electronic tracking and taxing may be coming to a DMV near you. The Office of Transportation Policy Studies, part of the Federal Highway Administration, is about to announce another round of grants totaling some $11 million. A spokeswoman on Friday said the office is "shooting for the end of the year" for the announcement, and more money is expected for GPS (Global Positioning System) tracking efforts.

In principle, the idea of what bureaucrats like to call "value pricing" for cars makes sound economic sense.

No policy bans police from automatically sending out speeding tickets based on what the GPS data say.

Airlines and hotels have long charged less for off-peak use. Toll roads would be more efficient--in particular, less congested--if they could follow the same model and charge virtually nothing in the middle of the night but high prices during rush hour.

That price structure would encourage drivers to take public transportation, use alternate routes, or leave earlier or later in the day.

The problem, though, is that these "road user fee" systems are being designed and built in a way that strips drivers of their privacy and invites constant surveillance by police, the FBI and the Department of Homeland Security.

Zero privacy protections

Details of the tracking systems vary. But the general idea is that a small GPS device, which knows its location by receiving satellite signals, is placed inside the vehicle.

Some GPS trackers constantly communicate their location back to the state DMV, while others record the location information for later retrieval. (In the Oregon pilot project, it's beamed out wirelessly when the driver pulls into a gas station.)

The problem, though, is that no privacy protections exist. No restrictions prevent police from continually monitoring, without a court order, the whereabouts of every vehicle on the road.

No rule prohibits that massive database of GPS trails from being subpoenaed by curious divorce attorneys, or handed to insurance companies that might raise rates for someone who spent too much time at a neighborhood bar. No policy bans police from automatically sending out speeding tickets based on what the GPS data say.

The Fourth Amendment provides no protection. The U.S. Supreme Court said in two cases, U.S. v. Knotts and U.S. v. Karo, that Americans have no reasonable expectation of privacy when they're driving on a public street.

The PR offensive

Even more shocking are additional ideas that bureaucrats are hatching. A report prepared by a Transportation Department-funded program in Washington state says the GPS bugs must be made "tamper proof" and the vehicle should be disabled if the bugs are disconnected.

"This can be achieved by building in connections to the vehicle ignition circuit so that failure to receive a moving GPS signal after some default period of vehicle operation indicates attempts to defeat the GPS antenna," the report says.

It doesn't mention the worrisome scenario of someone driving a vehicle with a broken GPS bug--and an engine that suddenly quits half an hour later. But it does outline a public relations strategy (with "press releases and/or editorials" at a "very early stage") to persuade the American public that this kind of contraption would be, contrary to common sense, in their best interest.

One study prepared for the Transportation Department predicts a PR success. "Less than 7 percent of the respondents expressed concerns about recording their vehicle's movements," it says.

That whiff of victory, coupled with a windfall of new GPS-enabled tax dollars, has emboldened DMV bureaucrats. A proposal from the Oregon DMV, also funded by the Transportation Department, says that such a tracking system should be mandatory for all "newly purchased vehicles and newly registered vehicles."

The sad reality is that there are ways to perform "value pricing" for roads while preserving anonymity. You could pay cash for prepaid travel cards, like store gift cards, that would be debited when read by roadside sensors. Computer scientists have long known how to create electronic wallets--using a technique called blind signatures--that can be debited without privacy concerns.

The Transportation Department could require privacy-protective features when handing out grants for pilot projects that may eventually become mandatory. It's now even more important because a new U.S. law ups the size of the grants; the U.K. is planning GPS tracking and per-mile fees ranging between 3 cents and $2.

We'll see. But given the privacy hostility that the Transportation Department and state DMVs have demonstrated so far, don't be too optimistic.

http://news.com.com/2102-1071_3-5980979.html?tag=st.util.print

www.globetechnology.com/servlet/ArticleNews/TPStory/LAC/20051128/SMARTCARS28/TPTechnology/

BIG BROTHER COMING UNDER YOUR CAR HOOD

JEFF GRAY, GLOVE AND MAIL, CA- It's the last thing many motorists would want -- a permanent, electronic back-seat driver, forcefully reminding them not to speed. But Transport Canada is road-testing cutting-edge devices that use global positioning satellite technology and a digital speed-limit map to know when a driver is speeding, and to try to make them stop. When a driver hits a certain percentage above the posted speed limit, the device kicks in and makes it difficult to press the accelerator. While the idea appeals to some road-safety experts, even the researcher in charge of the project admits many drivers -- some of whom have shown fierce resistance to photo-radar and red-light cameras -- may balk at the science-fiction scenario of a machine forcing them to apply the brakes. . . In Europe, proponents have said that the technology should be mandatory in all vehicles or that insurance companies might offer discounts to drivers who use it.

BOSTON HERALD - Over the coming year, the T will install automated fare collection equipment at every subway station and on every bus, allowing riders to pay easily with taps of special smart cards in their names. But each transaction with the plastic Charlie Cards will be recorded electronically, creating a record of where users were at a particular time on a particular day. Those records could be subpoenaed by cops, courts or even lawyers in civil cases. "The bottom line is that like other developments with consumer products and technology, the convenience does have a flip side. It’s convenience versus having the government be able to track you," said privacy expert Eric Gertler. . .

The new automated fare system will record where a passenger boards the system and at what time. The system won't capture any data on the rider’s destination. The information will be archived for a year and a half to two years before it’s erased. . .

The Massachusetts Turnpike Authority has for years recorded where and when users of the Fas tLane electronic transponders get on and off the toll highway. Unlike the MBTA, the Turnpike’s privacy protections barring outside release of the data without a subpoena are written into state law. "On a fairly regular basis we receive subpoena requests both civil and criminal," Pike spokesman Tom Farmer said.

http://news.bostonherald.com/localRegional/view.bg?articleid=118780&format=text

http://news.independent.co.uk/uk/transport/story.jsp?story=644303

Satellite toll plan to make drivers pay by the mile

Darling orders nationwide road pricing. Charge of £1.34 a mile on busiest roads

By Francis Elliott, Deputy Political Editor

05 June 2005

British motorists face paying a new charge for every mile they drive in a revolutionary scheme to be introduced within two years.

Drivers will pay according to when and how far they travel throughout the country's road network under proposals being developed by the Government.

Alistair Darling, the Secretary of State for Transport, revealed that pilot areas will be selected in just 24 months' time as he made clear his determination to press ahead with a national road pricing scheme.

Each of Britain's 24 million vehicles would be tracked by satellite if a variable "pay-as-you-drive" charge replaces the current road tax.

In an interview with The Independent on Sunday, Mr Darling warned that unless action is taken now, the country "could face gridlock" within two decades.

Official research suggests national road pricing could increase the capacity of Britain's network by as much as 40 per cent at a stroke, he said.

The rapid uptake of satellite navigational technology in cars is helping to usher in the new "pay-as-you-drive" charge much sooner than had been expected. Figures contained in a government feasibility study have suggested motorists could pay up to £1.34 for each mile they travel during peak hours on the most congested roads.

Although a fully operational national scheme is still considered to be a decade away, Mr Darling said local schemes could be up and running within five years. Manchester is considered a front-runner, with local authorities in the Midlands and London also pressing to be considered for a £2.5bn central fund to introduce the change.

Most of the necessary technology already exists. Lorries will be tracked by satellite and charged accordingly from 2007. The main obstacle to constructing a scheme to track Britain's 24 million private vehicles is public opinion, and Mr Darling is determined to start making the case now.

"You could dance around this for years but every year the problem is getting worse," he said.

"We have got to do everything we can during the course of this Parliament to decide whether or not we go with road pricing. Something of this magnitude will span several parliaments and you need 'buy-in' not just from political parties but also from the general public.

"Drivers have got to see that they benefit," he said, adding that one of the "weaknesses" of the congestion charging scheme introduced in the capital by the Mayor of London, Ken Livingstone, was that it delivered a "general benefit not a particular benefit". Motorists could feel they are paying a penalty to support buses they do not use.

The national road-pricing scheme, by contrast, has got to work so there's "something in it for me", said Mr Darling in advance of a keynote speech on the issue this Thursday.

Despite his insistence that the scheme would lead to no overall increase in the level of taxation as road taxes and fuel duties are reduced or abolished, it is bound to prompt fresh claims that Labour is waging a "war on motorists".

Some campaigners, meanwhile, are pressing Mr Darling to introduce new levies on individual roads immediately, using existing microwave technology or tolls. But that would force traffic on to quieter roads while entrenching opposition to a national scheme, ministers believe.

However, new and expanded roads are likely to see innovations such as car-sharing lanes, available to single drivers only if they pay a premium.

Geoslavery: GPS and technological tyranny

www.ur.ku.edu/News/03N/MarchNews/March5/dobson.html
March 5, 2003
KU researcher warns against potential threat of 'geoslavery'

LAWRENCE -- Jerome Dobson wants to make sure his field of research doesn't aid the greatest threat to personal freedom.

As a pioneer of geographic information systems (GIS), Dobson, a researcher at the Kansas Applied Remote Sensing Program at the University of Kansas, helped develop the technology that now is commonplace in government, business and practically every aspect of modern life.

Since 1975, Dobson has used GIS for a number of applications -- from conducting environmental analyses to identifying populations at risk of terrorism and natural disasters -- by combining data sets such as detailed population counts of every country in the world, terrain and nighttime lights interpreted from satellite images, road networks and elevations. Dobson, who is a professor of geography at KU, also is president of the American Geographical Society.

Unfortunately, the same technology that has so many beneficial uses also has the potential to create a highly sophisticated form of slavery, or "geoslavery," as Dobson calls it. What worries Dobson is that GIS technology easily could be used not only to spy on people but to control them as well.

"It concerns me that something I thought was wonderful has a downside that may lead to geoslavery -- the greatest threat to freedom we've ever experienced in human history," he said.

By combining GIS technology with a global positioning system (GPS) and a radio transmitter and receiver, someone easily can monitor your movements with or without your knowledge. Add to that a transponder -- either implanted into a person or in the form of a bracelet -- that sends an electric shock any time you step out of line, and that person actually can control your movements from a distance.

Sound like something from a bad sci-fi movie? Actually, several products currently on the market make this scenario possible.

"In many ways that's what we're doing with prisoners right now, but they've been through a legal process," he said.

In fact, many of the existing products are marketed to parents as a way to protect their children from kidnappers. Dobson, however, said parents should think twice before using such products.

"A lot of people think this is a way to protect their children," he said. "But most kidnappers won't have any compunction about cutting the child to remove an implant or bracelet."

Furthermore, these products rely on wireless networks, which are notoriously easy for hackers to break into, potentially turning the very products meant to protect children into fodder for tech-savvy child predators.

Dobson outlined the dangers of geoslavery in an article that appears in the most recent issue of the Institute of Electrical and Electronics Engineers' Technology and Society magazine. Peter F. Fisher, editor of the International Journal of Geographic Information Science, co-wrote the paper with Dobson. More than 375,000 scientists read the IEEE magazine.

One of the greatest dangers of geoslavery is that it doesn't apply just to governments. For example, individuals could use the technology to perpetuate various forms of slavery, from child laborers to sex slaves to a simple case of someone controlling the whereabouts of his or her spouse, Dobson said.

"Many people have concerns today about privacy but they haven't put all the pieces together and realized this means someone can actually control them -- not just know about them, but control them," Dobson said.

As the price of these products gets cheaper and cheaper, the likelihood rises that the technology will be abused, he said. To prevent this, Dobson's paper outlines a number of actions that should be taken, including revising national and international laws on incarceration, slavery, stalking and branding, and developing encryption systems that prevent criminals or countries with bad human rights records from accessing GPS signals.

Still, the first step is making people aware of the very real threat that geoslavery poses. The potential for harm is even greater in less developed nations without strong traditions of personal freedom, he said.

"We need a national dialogue on this if we're going to go into something so different from our traditional values of privacy and freedom," Dobson said. "We need to think about it very carefully and decide if this is a direction we as a society want to go."

Dobson said he doesn't consider himself a crusader. Instead, he is a scientist who is working diligently to ensure that people really understand the good and bad sides of the technology he helped create.

"There certainly are many, many good uses for the technology -- that's not the issue -- the issue is that it can be so easily misused," he said. "My role as a university professor is to alert people and make sure there is an informed debate."

http://www.smartmobs.com/archive/2003/03/12/gps_spawns_fear.html

CNN reports on Jerome Dobson's concerns that GPS technology may be hazardous to personal liberties. Dobson is president of the American Geographical Society. "Geoslavery" is a good word for describing one of the biggest downsides to smartmob technology.

http://charlotte.creativeloafing.com/2004-09-29/news_cover.html

NEWS COVER 09.29.04

Big Brother In Your Car

Futuristic hi-tech could save your life -- and raid your privacy

BY TARA SERVATIUS

Deep inside the United States Department of Transportation, Big Brother is rearing his head. On the third floor of the USDOT building in the heart of Washington, DC, a shadowy government agency that doesn't respond to public inquiries about its activities is coordinating a plan to use monitoring devices to catalogue the movements of every American driver.

Most people have probably never heard of the agency, called the Intelligent Transportation Systems Joint Program Office. And they haven't heard of its plans to add another dimension to our national road system, one that uses tracking and sensor technology to erase the lines between cars, the road and the government transportation management centers from which every aspect of transportation will be observed and managed.

For 13 years, a powerful group of car manufacturers, technology companies and government interests has fought to bring this system to life. They envision a future in which massive databases will track the comings and goings of everyone who travels by car or mass transit. The only way for people to evade the national transportation tracking system they're creating will be to travel on foot. Drive your car, and your every movement could be recorded and archived. The federal government will know the exact route you drove to work, how many times you braked along the way, the precise moment you arrived -- and that every other Tuesday you opt to ride the bus.

They'll know you're due for a transmission repair and that you've neglected to fix the ever-widening crack that resulted from a pebble dinging your windshield.

Once the system is brought to life, both the corporations and the government stand to reap billions in revenues. Companies plan to use the technology to sell endless user services and upgrades to drivers. For governments, tracking cars' movements means the ability to tax drivers for their driving habits, and ultimately to use a punitive tax system to control where they drive and when, a practice USDOT documents predict will be common throughout the country by 2022.

This system the government and its corporate partners are striving to create goes by many names, including the information superhighway and the Integrated Network of Transportation information, or INTI. Reams of federal documents spell out the details of how it will operate.

Despite this, it remains one of the federal government's best-kept secrets. Virtually nothing has been reported about it in the media. None of the experts at the privacy rights groups Creative Loafing talked to, including the ACLU, the Consumers Union and the Privacy Rights Clearinghouse, had ever heard of the INTI. Nor had they heard of the voluminous federal documents that spell out, in eerie futuristic tones, what data the system will collect and how it will impact drivers' daily lives.

Buried inside two key federal documents lies a chilling cookbook for a Big Brother-style transportation-monitoring system. None of the privacy experts we talked to was aware of a 2002 USDOT document called the "National Intelligent Transportation Systems Program Plan: A Ten-Year Vision" or the "National ITS Architecture ITS Vision Statement," published by the Federal Highway Administration in 2003.

What's more, no one we talked to was aware of just how far the USDOT has come in developing the base technology necessary to bring the system to life.

More than $4 billion in federal tax dollars has already been spent to lay the foundation for this system. Some of the technologies it will use to track our movements are already familiar to the public, like the GPS technology OnStar already used to pinpoint the location of its subscribers. Others are currently being developed by the USDOT and its sub-agencies.

Five technology companies hired by the USDOT to develop the transceivers, or "on-board units," that will transmit data from your car to the system are expected to unveil the first models next spring. By 2010, automakers hope to start installing them in cars. The goal is to equip 57 million vehicles by 2015.

Once the devices are installed, the technology will allow cars to talk to each other in real time, transmitting information about weather, dangerous road conditions ahead and even warning drivers instantaneously of an impending collision. When used in combination with GPS technology already being installed in millions of cars, the INTI will be able to transmit real-time information about where your car is and where you've been.

Though Joint Project Office officials refused to talk to Creative Loafing about the next step in their plan, one official defined it simply in a presentation before the National Research Council in January.

"The concept," said Bill Jones, Technical Director of the Joint Office, "is that vehicle manufacturers will install a communications device on the vehicle starting at some future date, and equipment will be installed on the nation's transportation system to allow all vehicles to communicate with the infrastructure."

"The whole idea here is that we would capture data from a large number of vehicles," Jones said at another meeting of transportation officials in May. "That data could then be used by public jurisdictions for traffic management purposes and also by private industry, such as DaimlerChrysler, for the services that they wish to provide for their customers."

According to USDOT's 10-year plan, the key "data" the INTI will collect is "the identity and performance of transportation system users."

"It's going to happen," said Jean-Claude Thill, a professor at the University of Buffalo who specializes in transportation and geographic information and who has done research for USDOT. "It's probably going to start in the large metropolitan areas where there's a much larger concentration and more demand for the services that are going to be made available."

With this system, and the fantastic technology it will enable, the government and the auto industry claim they can wipe out all but a fraction of the 42,000 deaths on America's roads by literally intervening between the drivers, cars and the road. But as they careen toward making it a reality, its costs in terms of individual privacy have barely been contemplated.

If the government has its way, these technologies will no longer be optional. They'll be buried deep inside our cars at the auto factory, unremovable by law. If things go as planned, within the next decade these devices will begin transmitting information about us to the government, regardless of whether we want to share it or not.

More chilling still is the fact that Creative Loafing isn't the first to use the "Big Brother" label to describe the system. Even the corporate leaders working to create it refer to it in Orwellian terms. At a workshop for industry and government leaders last year, John Worthington, the President and CEO of TransCore -- one of the companies currently under contract to develop the on-board units USDOT wants to put in your car -- described INTI as "kind of an Orwellian all-singing, all-dancing collector/aggregator/disseminator of transportation information."

This story really begins in 1991, the year Congress established a program to develop and deploy what is now called "Intelligent Transportation Systems," or ITS. At the time, most ITS technology was in its infancy. But even back then, the long-term goal of the federal government and the automobile industry was to develop and deploy a nationwide traffic monitoring system. A transportation technology industry quickly sprang to life over the next decade, feeding off federal money and the corporate demand for wireless technology.

Since 1991, the driving force behind the INTI has been the Washington, DC-based Intelligent Transportation Society of America (ITSA). This powerful group of government and corporate interests has spent tens of millions of dollars lobbying to bring the INTI to life and worked side by side with USDOT and its agencies to create it.

A look at its shockingly broad 500-organization membership base shows just how much clout is behind the push to create the information superhighway. Forty-three of the 50 state Departments of Transportation are members, including the North Carolina DOT. Dozens of transportation departments from large and medium-sized cities, including the Charlotte Area Transit System, are also members. So are most of the key corporate players in the transportation technology industry and America's big three auto manufacturers.

Though the membership of the Board of Directors changes every year with companies cycling on and off, over the last two years, ITSA's board members have included executives from General Motors, DaimlerChrysler, Ford Motor Company, and executives from the technology companies helping to develop the on-board units, including TransCore and Mark IV Industries. The board has also included federal transportation bureaucrats like Jeff Paniati, the Joint Program Office director. ITSA president and CEO Neil Schuster says the bulk of the group's $6 million annual budget comes from its corporate members, money that ITSA then turns around and uses to lobby Congress and the federal government for further development of the INTI.

So why haven't you heard about ITSA or the INTI? Until recently, most of the groundwork necessary to lay the foundation for the system has been highly technical and decidedly unsexy. That's because before industry leaders and government officials could hold the first transceiver in their hands or bury it inside the first automobile, they had to create a uniform language for the system and convince the Federal Communications Commission to set aside enough bandwidth to contain the massive amount of data a constant conversation between cars, the road and the system would produce.

A half-decade later, with the computer standards 90 percent complete and the bandwidth set aside by the FCC, they're on the brink of a transportation revolution.

To most drivers, the above probably sounds pretty far-fetched. National databases to track our every move? A national network of government-controlled traffic management centers that use wireless technology for traffic surveillance by 2022? But the reality is that much of the technology and infrastructure needed to bring the system to life has already been put in place.

In the old days, if you turned on your windshield wipers, power just went to the wipers. But in the cars of today, a miniature self-contained computer system of sensors and actuators controls the wipers and just about everything else the car does. All that information winds up on something inside your car called a data bus.

"We have the ability to communicate essentially any of the vehicle information that's on that data bus, typically encompassing the state of about 200 sensors and actuators," said Dave Acton, an ITS consultant to General Motors. "Anything that's available on the bus is just content to the system, so you could send anything."

For automakers and tech companies, the databus is a goldmine of information that can be transmitted via imbedded cell phone or GPS technology. This year alone, 2 million cars in General Motors' fleet were equipped with the GPS technology that would enable customers to subscribe to OnStar-type services if they choose. Eventually, says Acton, all cars will likely be equipped with it.

But the same technology installed in GM's fleet is also capable of transmitting the car's location and speed to any government agency or corporate entity that wants it without the driver knowing, whether they subscribe to OnStar-type services or not.

Though government-run transportation centers across the country are not yet collecting the data, Acton predicts they will begin to within the next decade.

Ann Lorscheider agrees. She's the manager of the Metrolina Region Transportation Management center on Tipton Drive in Charlotte.

At the center off Statesville Avenue, traffic management specialists stare at dozens of television screens mounted on a massive wall, watching for accidents or anything out of the ordinary. From their workstations, they surveil 200 interstate miles, including I-77 from the South Carolina state line to US 901 in Iredell and I-85 from the state line into Cabarrus County.

When they need to, they can swivel the cameras mounted along the interstate or zoom in to get a better look at an accident. Sensors in the road constantly dump data back to the center on traffic patterns and speed. A system based on predictive algorithms tells them if a traffic pattern signals a potential problem.

The cameras and the sensors were installed by the state in 2000, at a cost of $41 million. Traffic management centers like the one Lorscheider runs can now be found in just about every major to mid-sized city or region across the country, most constructed in over the last decade or so.

News reports show that over the last five years alone, there has been an explosion in the construction of these centers. During that time, over 100 such centers have opened across the country, part of a boom driven by the USDOT and its sub-agency, the Federal Highway Administration, which has secured funding to help bring the centers to life.

"They're booming," said Lorscheider. "They're all over the place now."

Everywhere they've opened, the centers have decreased response time to accidents and slashed, sometimes by as much as half, the number of law enforcement personnel needed to respond to accidents and get traffic moving again. Congestion and travel times have also improved.

This all sounds fine and safety-centered. But in the future envisioned by USDOT and ITSA in federal documents, the centers will be far more than a handy congestion management tool. They'll form the very hub of the INTI itself, interacting with regional and national traffic centers and, ultimately, with immense national databases run in partnership with the private sector that will cull data from vehicles, crunch and archive it.

To bring the INTI to life the way the government plans, the system will have to do far more than use GPS technology to transmit where cars have been and what they did along the way. Cars will need to swap information instantaneously with each other and with roadside readers at highway speeds in real time, something today's GPS technology can't do. To solve the problem, the federal government is pushing back the boundaries of wireless technology to create devices that can make the vision possible. Using something called Dedicated Short Range Communications, or DSRC, the transceivers the government is developing would allow cars to carry on simultaneous conversations with each other and with corresponding roadside units, sending messages or warnings throughout the transportation management system instantly.

These "conversations" could prevent collisions or stop drivers from running off the road, while giving transportation managers an instantaneous view of road and weather conditions. With a DSRC transceiver and GPS technology in every car, automakers believe they can wipe out nearly all automobile fatalities in the US. It's a goal they call the Zero Fatalities Vision.

"There is a basic consensus that we have to change the safety paradigm," said Chris Wilson, Vice President of ITS Strategy and Programs at DaimlerChrysler Research and Technology North America, Inc. "Everything we've done up until now -- airbags, seatbelts -- was to mitigate accidents once they occur. Now we're looking to prevent accidents. To do that we need live vehicle-to-vehicle communication and vehicle-to-vehicle infrastructure."

The tantalizing prospect of saving thousands of lives comes with a heavy price. The same technology that will allow cars to talk to each other in real time would also allow the government and ultimately private business to use the INTI to track every move American drivers make -- and profit from it.

This is the dark side of the information superhighway, the one executives and federal bureaucrats don't like to talk about. That's probably because they know it's entirely possible to use the technology the government is developing to prevent fatal collisions without harvesting information from automobiles and archiving it.

For all their talk about saving lives, there's ample evidence that the driving force behind the push to develop the national information superhighway is to profit from the data it collects. Both the corporations and the government -- including the more than 40 state departments of transportation that are members of ITSA -- stand to eventually rake in billions in revenues if they can bring the system to life. (See sidebar, "A Marketer's Dream.")

But first, they must find a way to harvest and archive the data.

That's where the ADUS, or Archived Data User Service, project comes in. For the last five years, while they were laying the foundation for the INTI, USDOT and ITSA have also begun setting standards for the massive databases that will collect and archive information.

According to federal documents, when it's completed, the brain of the INTI will essentially be a string of interconnected regional and national databases, swapping, processing and storing data on our travels it will collect from devices in our cars.

According to the "ITS Vision Statement" the Federal Highway Administration published in 2003, by 2022, each private "travel customer" will have their own "user profile" on the system that includes regular travel destinations, their route preferences, and any pay-for-service subscriptions they use.

Neil Schuster, president and CEO of ITSA, further clarified that goal in a recent interview with Creative Loafing.

"In fact, when we talk about this, the US government is talking about creating a national database, because where cars are has to go into a database," Schuster said.

Most INTI enthusiasts, like Schuster, insist that the lives potentially saved by this technology are worth giving up some privacy.

"When I get on an airplane everyone in the system knows where I am," said Schuster. "They know which tickets I bought. You could probably go back through United Airlines and find out everywhere I traveled in the last year. Do I worry about that? No. We've decided that airline safety is so important that we're going to put a transponder in every airplane and track it. We know the passenger list of every airplane and we're tracking these things so that planes don't crash into each other. Shouldn't we have that same sense of concern and urgency about road travel? The average number of fatalities each year from airplanes is less than 100. The average number of deaths on the highway is 42,000. I think we've got to enter the debate as to whether we're willing to change that in a substantial way and it may be that we have to allow something on our vehicles that makes our car safer. . . I wouldn't mind some of this information being available to make my roads safer so some idiot out there doesn't run into me."

Schuster insists that drivers shouldn't worry about the government storing information about their travels because personal identifying information would be stripped from it.

"They're not going to archive all of the data, they're going to archive the data they need," Schuster said. "They want origin, they want destination, they want what route that vehicle took. They don't want the personal information that goes with that because it's useless to them."

Schuster's words would be more reassuring if they didn't contradict planning documents authored by his organization and USDOT.

ITSA's own website on ADUS says data archived by INTI databases will include "vehicle and passenger data." So does the USDOT's Ten-Year-Plan. In fact, according to ITSA's own privacy principles, which are printed on its website, transportation systems will collect personal information, but only that information that's relevant for "intelligent transportation system" purposes.

"ITS, respectful of the individual's interest in privacy, will only collect information that contains individual identifiers that are needed for the ITS service functions," the site reads. "Furthermore, ITS information systems will include protocols that call for the purging of individual identifier information that is no longer needed to meet ITS needs."

In other words, identifying information will be purged when government and corporate users no longer have a need for it, not when it becomes a privacy issue for an individual driver.

Everyone Creative Loafing spoke to for this article, and every federal document we examined, insisted that safeguards would be put in place to protect this data. So far, though, no one has been able to specify exactly how these safeguards will work.

It's a problem Eric Skrum, Communications Director for the National Motorists Association, is familiar with.

"Information on this is awfully hard to get and it's also very conflicting, where one hand will be telling you one thing and the other will be saying oh no, we wouldn't possibly be doing that," Skrum said.

It's a problem Creative Loafing ran into as well. For instance, Schuster insists that the data the system will eventually collect won't be used to issue people speeding tickets or other traffic citations.

But according to ITSA's own privacy principles, the information won't be shared with law enforcement -- until states pass laws allowing it. In fact, the US Department of Justice and USDOT are already working on a plan to share the data ITS systems collect with law enforcement. It's called the USDOT/DOJ Joint Initiative For Intelligent Transportation & Public Safety Systems, and its aim is to coordinate the integration of the system with police and law enforcement systems by developing the software and technical language that will allow them to communicate.

After Sept. 11, ITSA and USDOT added a homeland security addendum to their 10-year plan. The system, through wireless surveillance and automated tracking of the users of our transportation system, could bolster Homeland Security efforts, it said.

Sensors deployed in vehicles and the infrastructure could "identify suspicious vehicles," "detect disruptions" and "detect threatening behavior" by drivers, according to the addendum. Those who take public transit wouldn't escape monitoring, either. The addendum suggests "developing systems for public transit tracking to monitor passenger behavior."

So who will control the information transmitted by the on-board units? That's still up in the air, too. Like the black boxes now installed in cars that record data before a crash that can later be used against the driver, it's possible that the on-board units will be installed in new cars before the legal issues surrounding the data they collect are fully resolved, says one industry insider.

Robert Kelly, a wireless communications legal expert who has acted as legal council to ITSA, says privacy law will have to evolve with the technology. In other words, privacy issues probably won't be resolved until the technology is already in place. Legislatures and Congress will have to guide how everyone from law enforcement to corporations use the data and exactly what information they have access to, Kelly said.

But again, with privacy organizations largely in the dark and the development of the system hurtling forward, the question is how much influence, if any, privacy advocates will be able to wield before these devices are installed on the first future fleet of cars.

That's part of what frustrates Skrum, the National Motorists Association communications director. "Because this is being done behind closed doors to a certain extent, the public isn't really going to have much to say about it," said Skrum.

The good news is that there's still time for the public to weigh in. It will take USDOT at least three more years of development and consumer testing before the first prototype "on-board unit" is ready. In the meantime, the federal government, automakers and the state departments of transportation will have to hash out a couple of billion-dollar details. So far, the government has borne nearly all the cost of developing the on-board units. But that will soon change. For the system to work, automakers must sign on to mass produce the on-board units and install them in cars, a move that will cost billions.

At the same time, the government must install the roadside readers to transmit the messages cars send, or the on-board units will be useless. So to bring the system to life, the government must spend millions, if not billions, on roadside units to communicate with cars at roughly the same time automakers begin installing the on-board units.

As Japan, Europe and foreign carmakers dash to develop similar technology, US automakers are under tremendous pressure. This is creating something of a chicken and egg situation. Given the nature of federal and state transportation budgets, the rollout of roadside units is likely to be gradual, starting at select trouble spots across the nation. But automakers say they need a mass deployment to make their effort worthwhile. They want to see a rollout of at least 400,000 roadside readers over about a three-year period.

A decision is currently slated for 2008, when automakers and the USDOT plan to come together to hash out a deployment strategy. At stake will be billions of dollars -- both in investments and profits. If the government and automakers can agree on a deployment plan, technology companies are expected to begin investing more heavily in the further development of programs the technology will enable.

ITSA projects that $209 billion could be invested in intelligent transportation technology between now and the year 2011 -- with 80 percent of that investment coming from the private sector in the form of consumer products and services.

Jean-Claude Thill, a professor at the University of Buffalo who specializes in transportation and geographic information systems, says he believes the system will be deployed, just not as fast as car makers would like.

"It's not going to happen all at once," said Thill. "Look at cell phones. Right now in large urban areas you have a high density of cell towers so you have good coverage. If you venture on the interstate your signal gets weak and sometimes you lose it. You can't expect this to be different."

Thill says he believes the automobile manufacturers are playing hardball with the government to make sure the infrastructure is put in place quickly.

"I think the automobile manufacturers will do it," said Thill. "There is money in it. I think as the market develops in large urban areas, they will see that it is in their interest to get on the wagon. But nothing is going to happen until they are on board."

From the government's perspective, the good news is that a few sensors in a few cars and a little GPS technology can go a long way.

"Only a relatively small percentage of the approximately 260 million vehicles on US roads today need to be equipped with communication devices for the system to start producing useful data," said Bill Jones, the Technical Director of the USDOT's ITS Joint Project Office in a speech to the National Research Council's Transportation Research Board in January. "With 14 to 15 million new vehicles sold in the US each year, within two years you can have 10 percent of all vehicles equipped. We already know from our previous studies that a vehicle probe saturation of less than 10 percent can provide good information."

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Data Mining and Surveillance

www.fromthewilderness.com/free/ww3/012605_watching_you.shtml

They're Watching You (about data mining corporations versus personal privacy)

... We appear to be on the brink of a post-September 11 surveillance society. In one optimistic scenario, the U.S. is employing its full range of technical ingenuity to ferret out terrorists, using all the resources of the Digital Age and its quirky software geniuses. Meanwhile, dazzling new biometric identifiers -- iris scans, voiceprints, DNA registries, and facial recognition software -- are about to reduce identity theft to a quaint memory even while they shorten airport security lines and speed up credit approvals.

But in a less appealing second scenario, we could be on the verge of surrendering every detail about our private lives to an all-knowing Big Brother alliance of cops and mysterious private security corporations. They'll promise to protect us from terrorists. But along with that safety, we'll face arbitrary and unappealable decisions on who can fly in a commercial airliner, rent a truck, borrow money, or even stay out of jail.

That's the conundrum at the center of No Place to Hide, a finely balanced look at the see-saw struggle between security and privacy. Author Robert O'Harrow Jr., a Washington Post reporter, deftly shows how the government and its contractors have been lurching between these two goals ever since the September 11 terrorist attacks raised homeland security to the public's top priority.

The biggest threat and the biggest promise seem to lie not with official government databases but with the private companies that sell their information to all levels of government and to banks, airlines, credit-card companies, mortgage holders, car-rental agencies, and the like. ...

After September 11, it was only natural that these companies would volunteer their services in tracking terrorists. They had a head start in a critical technology: data mining. In practical terms, that involves cross-indexing every conceivable source of information -- unlisted telephone numbers, credit-card records, appliance warranty cards, insurance claims, arrest warrants, Social Security numbers, child custody orders, book purchases, E-ZPass records -- to compile a list of suspects or even possible terrorists that need to be placed on the Homeland Security Dept.'s "no fly" list.....

www.fromthewilderness.com/free/ww3/012005_ptech_pt1.shtml
PTECH, 9/11, and USA-SAUDI TERROR - Part I
PROMIS Connections to Cheney Control of 9/11 Attacks Confirmed, by Jamey Hecht, With research assistance by Michael Kane and editorial comment by Michael C. Ruppert

.... Total Information Awareness or TIA, an Orwellian nightmare of data mining that uses PROMIS-evolved technologies and artificial intelligence, is now operating and able to incorporate vastly divergent data bases of personal information on private citizens from computer systems using different languages in near-real-time. Every bit of personal information from grocery shopping habits to driving records, credit reports, credit card transactions and medical records is now almost instantly accessible. Access will be expedited and broadened to local law enforcement agencies when what will become a national ID card comes into being. That will happen as driver's licenses are standardized nationwide (following the recent intelligence reform act) to include a simple UPC-like code that will allow approved agencies to get all of our data. The surveillance and intervention capabilities of PROMIS progeny can now be used to prohibit a credit card purchase or (soon) prevent someone from boarding a commercial aircraft. These capabilities could also be used to empty a private bank account or - when coupled with biometric face recognition technology - prevent you from making a withdrawal from your bank or even buying food.

In every one of these software applications there are two themes: machines that "talk" to each other and artificial intelligence. (Please see Crossing the Rubicon). As you will see below, these capabilities are now known to exist.

TIA has been renamed several times. We know that the first software was delivered to the Defense Advanced Research Projects Agency (DARPA) in 2003. Its latest nom de guerre is TIE or Trusted Information Environment. According to the San Francisco Chronicle last October TIE now allows the government to access private databases without a warrant. I go one step further to assert that TIE allows access to private databases without the knowledge of the database owners, provided only one condition exists: the database can be accessed through the internet.

And although the public face of TIA pretends that these technologies have not yet been applied, we are certain with the publication of this story that the same software the government needs is already in use by private corporations - the big ones - and we remind the reader that FTW's map of the world states that the government has been turned into a franchise operation of these corporations anyway. So where's the seam?

What the courageous and brilliant Indira Singh has to tell us is a matter of monumental importance. Based upon these new revelations which confirm what I suggested in Crossing

> the Rubicon every American and quite likely every citizen of an industrialized nation should assume that all of these technologies are operational today. A bit of breathing room is left as I conclude that they have not been sufficiently deployed yet to monitor all citizens in real time. My best assumption is that right now perhaps a million or so high-interest Americans are under constant surveillance; all by computer technology which has proven so accurate that it can detect suspicious movements just by correlating gasoline and food purchases with bank withdrawals and utility consumption. [--Michael C Ruppert]

www.theage.com.au/news/technology/how-they-keep-track-of-our-every-move/2006/02/03/1138836402623.html?page=fullpage#contentSwap2
Eyes on the road
February 3, 2006 - 11:19AM

Speed cameras, red-light cameras, e-tags. Innocuous technology to make the roads safer and our journey simpler ... or a series of "Little Brothers" keeping track of our every move? Nikki Barrowclough looks behind the boom in traffic monitoring.

Eight years ago, on the night that a Saudi diplomat was brutally murdered in his Canberra apartment, a car was filmed travelling south along the Hume Highway towards the national capital. Then, a few hours later, it was filmed heading north back towards Sydney.

The car wasn't being tailed by the Australian authorities, the Saudis or anyone else. The "spy" was a humble traffic camera, although this emerged only after four people were arrested and brought to trial over the diplomat's violent death. The fact that the camera had been set up to monitor speeding and unregistered trucks didn't cause a ripple. The candid Safe-T-Cam had, in fact, filmed every vehicle travelling along that stretch of the Hume. So when the diplomat's ex-lover insisted to police that she and her new boyfriend had been in Sydney at the time of the crime, the authorities had only to look at an image of her car fleeing back up the highway to know that she was lying.

Few people would be troubled by the use of traffic cameras to locate criminal suspects. But the Canberra incident highlights how the mass surveillance of motorists, far from being an Orwellian conspiracy theory, is now routinely practised and growing more pervasive by the year. In Australia and other major Western countries, traffic is increasingly monitored with the sort of sophisticated technology that makes the image of a shadowy figure watching through binoculars seem impossibly quaint. Whether we're appearing in "real time" on one of the hundreds of traffic cameras operated by central command centres in Melbourne and Sydney, being "flashed" on a speed or red-light camera operated by the police, or clocked on a toll road with our seemingly innocent e-tags, it's almost impossible to drive anywhere without being monitored and/or leaving an electronic data trail.

It's even getting harder to disappear on obscure back roads thanks to GPS - the US military-developed global positioning system whose satellite tracking can pinpoint a car's location to within a few metres. A group of Stanford University academics in the US are reportedly working on satellite navigation systems so accurate they will be able to tell authorities whether you're in your car or standing next to it. This is revolutionary technology, and great if you get lost or have an accident or your car is stolen. But there's a chilling aspect to it all as well - namely, the loss of individual privacy.

Two years ago, the Office of the Victorian Privacy Commissioner devoted an entire edition of its newsletter, Privacy Aware, to just one subject: "Privacy and the Car". It included a brief section on telematics, the term used to describe the combining of satellite GPS, in-car computers and mobile phone technologies. "Telematics raises concerns because, while GPS receivers cannot send data back to a central location, mobile phones can. Used together, they turn the vehicles they're embedded in into very powerful tracking and monitoring devices," the report declared.

How much covert monitoring goes on in tandem with open surveillance, such as speed cameras, is anyone's guess, because that's not the sort of information governments readily disclose. Professor Roger Clarke, a Canberra consultant in data surveillance and information privacy, regards the Hume Highway incident as an example of "function creep" - when technology, set up for one purpose, secretly ends up serving another purpose as well. And function creep, he says, is a way in which the "surveillance society" has sneaked under the public's guard.

"The social and political commentators have missed it, but what's more worrying is that young people have grown up with surveillance and have a different attitude to it," Clarke says. "They think life's like that."

Governments and transport authorities insist that such surveillance systems are totally benign. They are about road safety, keeping people alive, and managing increasing volumes of traffic more efficiently, they say. This isn't just soothing rhetoric - with around 1600 deaths on Australian roads last year alone, road safety is a huge issue - but at the same time we seem to have ceded our civil rights as motorists.

Cameron Murphy, president of the NSW Council for Civil Liberties, does not doubt that surveillance technology is about much more than simple traffic management.

"Most people are aware that speed cameras and red-light cameras are obviously there for infringement purposes," Murphy says. "But we are also aware that there's an extensive network of cameras that can track people from one end of the city to the other, along freeways and on main arterial roads.

"You should be able to go from A to B without the government monitoring you. If the prime motive is traffic management alone, then you don't have to survey one end of the freeway to the other - it doesn't add up. That's when it becomes an invasion of privacy ... Recording where people go, what time of day they travel. If there aren't appropriate controls, the data could be used for commercial purposes or by any other government agency."

Given the fear of terrorism and the heightened national security alert, the potential of some of the new "smart road" technologies is obvious. For instance, British firm Hills Numberplates has already devised so-called e-Plates, numberplates embedded with radio frequency identification (RFID) tags. These tags act as tracking devices that transmit a unique, encrypted ID code via silicon chips that cannot be seen or removed. Known as a silent technology, RFID is sometimes described as a sophisticated barcode because it can identify and track goods from a distance.

Hills Numberplates claims a single "reader" positioned at the roadside can identify dozens of vehicles fitted with an e-Plate, moving at any speed, at a distance of up to 100 metres. But will they catch on here? VicRoads has no plans to bring in e-Plates. However, the NSW Roads & Traffic Authority says they have certainly been up for discussion - though as yet there's no decision to introduce them.

"But as with everything of this nature, it's a case of watch this space," a spokesman says.

Transport authorities are also keeping an open mind about an electronic version of the vehicle identification number (VIN) that comes with every car. A Department of Transport and Regional Services spokesperson in Canberra says that while there are no plans "at this point in time" for an electronic VIN, that doesn't mean it won't happen.

Melbourne-based academic Professor Marcus Wigan, an adviser to the US Department of Transport, is also the Australian Privacy Foundation's spokesman on intelligent transport systems. He says e-VINs (which would transmit to a central location as cars pass specific points) are simply a more efficient way of managing the many regulatory aspects of the identity of vehicles. An e-VIN would certainly decimate the stolen car trade, but it would also obviously increase the ability of authorities to track cars and monitor daily travel routines.

The expression "intelligent transport systems" (ITS) is a catch-all phrase for the in-car electronics, smarter roads, satellite navigation technology, tolling systems and remote road monitoring being employed increasingly throughout the world - sometimes without limit.

Last September, as Hurricane Rita bore down on Texas, and hundreds of thousands of motorists fleeing the Houston area became trapped in a 200-kilometre traffic jam in which cars were abandoned and people collapsed from heat exhaustion, officers from the state's highway system were reportedly scanning e-tags to make sure evacuees had paid their tolls.

Meanwhile, London's Independent newspaper reported late last month that the United Kingdom was about to become the first country in the world where all motorists would be monitored by a vast network of cameras that would read the licence plates of every passing car. Neither the Home Office nor the British police denied the story, or the paper's claim that the ultimate plan was to build a huge database of vehicle movements so that police and security services could analyse the journeys of individual drivers.

And in the US, the Washington-based Intelligent Transportation Systems Joint Program Office - a powerful, 500-strong group of car manufacturers, technology companies and government interests - has reportedly spent more than $4 billion and almost 15 years developing a system of tracking and sensor technology that would collect data on the movements of every driver and public transport user. The stated aim of this system, known as the Integrated Network of Transportation Information, is to reduce the 40,000 or so annual road deaths in America by allowing government agencies to intervene directly between drivers, their cars and the road. And authorities want to have it in place within the next decade.

Whether or not they were designed for such purposes, what intelligent transport systems do is identify specific vehicles - and, therefore, their drivers.

The term first cropped up in Australia about 15 years ago. In 1992, an organisation called Intelligent Transport Systems Australia was set up in Melbourne, and today its membership base includes government, scientific, academic and car manufacturing groups. The group's executive director, Brent Stafford, says he expects that all new vehicles will be equipped with satellite navigation and telematics by 2010. And while he says he understands people's unease about such technologies, he can't see why such systems would be used to track Australians en masse, as seems to be the intent in Britain.

"It's quite easy to track the movements of every vehicle, but you'd have to ask, 'What for?'" says Stafford. "You'd also have to consider how much it would cost. ITS is the application of technology to transport. It's not the application of technology to security. The fact is, there'll be lots of Little Brothers looking after you, but no Big Brother spying on you."

Lachlan McIntosh, chief executive of the Australian Automobile Association, shares Stafford's view. "Why would you want to track everybody? And what would you do with all that data?" he asks.

When Good Weekend suggests to him that, given the uncertain times we live in, such surveillance options could be very attractive to government departments, he replies: "In France during World War II, everyone was tracked and monitored without these technologies.

I think surveillance comes and goes in society ... If there's a political will to monitor what everybody does, then it's likely to happen.

"In the end, there are a lot of benefits in monitoring where you are: the emergency response if you are to have an accident, for instance ... If, as you say, this will happen, and everyone had a monitoring device in their car that said they just had an accident, we may well save 100 or 200 lives a year. Okay, you may well have been going to Cronulla when you shouldn't have been, or maybe you had an unfortunate crash and nearly died, but you were saved because of the device. There are trade-offs in those discussions, and we often forget the benefits when we talk about the downside."

There are also advantages in being able to keep an eye on hazardous cargo or large sums of money, he adds. "We all want to know that if a cargo of ammonium nitrate goes missing, it can be tracked and found. Is that an intrusive activity on the driver of the truck? Well, maybe it is, but it's a security mechanism as well. Now, should you want to put surveillance on a particular car for some criminal activity, I imagine you would need a warrant and you would have to go to a magistrate to obtain it. So I would think Australians would want to ensure that they are protected through our court system against the undue use of surveillance."

People have to be informed about the benefits of the new technology, what the implications are and what the risks are, he adds. "As long as we have that sort of reasonably informed debate in Australia, I think we're likely to want to adopt the latest technology."

But is there debate? Dr Peter Chen, a political scientist who lectures in communications at the National Centre for Australian Studies at Monash University, says Australians tend to be relatively passive when it comes to such matters.

"While we like to tell ourselves that we have a healthy disregard for government, it's total fiction. We're very accepting of increased state security and surveillance for whatever reason," Chen believes. And when governments talk up safety as a way of getting more surveillance systems under the wire without causing public alarm, we generally accept official reasoning.

"That's the argument that's always used," says Chen. "No government ever says we're introducing wide-scale surveillance for anything but notions of public safety, and while the paranoid concerns of some people are somewhat overstated, systematic surveillance technologies are very compelling tools for governments of all persuasions, and tend to inevitably lead to the expansion of their use into other areas of public policy."

Remote surveillance, like static cameras and portable speed cameras, is cheap, too; much cheaper than human surveillance. "This was a key argument in the government's support for electronic tagging of terrorist suspects late last year: surveillance technologies are cheaper than policing," he says.

Police in NSW recently began using high-tech scanning units that employ automatic numberplate recognition (ANPR) technology to "read" the registration of passing vehicles and check them against an RTA database, as a way of detecting stolen and unregistered vehicles. Victoria Police trialled the technology, too, but has opted instead for mobile data terminals linked to the main police computer system, from which police can also access the VicRoads registration database. Seven hundred of these terminals are now being fitted to police cars, motorbikes, boats and helicopters by the Victorian Department of Justice.

Paul Chadwick, the Victorian Privacy Commissioner, wrote about ANPR technology during the trial. The systems, he pointed out, can be linked to existing surveillance camera systems, "so multiplying the 'eyes' of the State, and can be linked to a variety of databases, so expanding the State's 'memory'".

Meanwhile, the ordinary motorist, blithely driving across town or to a lunch in the country, should think twice about e-tags - those small, wireless electronic transponders attached to the windscreen that collect information about a car's movements and charge the owner a toll.

The e-tag revolution kicked off in Melbourne in 2000 with the opening of the privately operated, 22-kilometre CityLink, one of the world's first automated, fully electronic toll roads. In Sydney, both the controversial Cross City Tunnel and the recently opened Westlink M7 are also fully automated. This means that toll-road operators, whether they're government or private companies, can collect personal information such as your vehicle registration, driver's licence number, credit card details, name and address and your pattern of travel.

And that's a concern to lawyer Anna Johnston, a former NSW deputy privacy commissioner who's now the chair of the Australian Privacy Foundation. As she notes, drivers on these toll roads now have no choice but to identify themselves every time they use them. "I don't want to indulge in conspiracy theories, or say that we have reached that 'Big Brother' point," she says, "but there is a danger we are sleepwalking into a situation where more and more of our information can be logged, tracked, profiled and matched in ways that haven't really been contemplated in the past. That may not be the intention at the time a new technology is introduced - but of course with each new technology, with each new chipping-away at our privacy, it makes the next step so much easier."

Johnston's foundation campaigned against a law passed in NSW last May, which allows the RTA to issue photo identity cards to non-drivers over 16 years of age (VicRoads has no plans to introduce the voluntary scheme).

"We weren't against the concept of a photo ID card for non-drivers - there's a need for it, clearly - but we suggested an alternative way to develop it, so that it didn't result in one database being held by one agency covering the entire population, whose details get printed on a card which is both unique and universal. All that, of course, is like a national ID card, which Australians rejected in 1987."

The bill didn't limit the type of information that could be collected and stored, Johnston says, and the legislation specifically allowed the RTA to put the two databases (driver and non-driver) together. She's concerned the latter will eventually happen.

However, both the RTA and a spokesman for the NSW Roads Minister, Joe Tripodi, assured Good Weekend that the photocard database would be kept separate from other databases within the authority, and that there would be separate databases for drivers and non-drivers. In a statement, the RTA also said that databases kept on NSW motorists are not integrated, for privacy reasons, and that access to one database doesn't automatically mean access to another.

The inevitability of more privately run, cashless toll roads, and a more widespread user-pays road system means there'll be more databases and more information stored on motorists. Privacy laws protect access to all databases, although privacy advocates tend to be lukewarm about their effectiveness.

"You get principles that sound great in theory, like, 'This information should only be used for the purpose for which it's collected, or with your consent', and people say, 'Oh good'," says Nigel Waters of the Australian Privacy Foundation. "Then you look at the fine print where it says, 'Except in emergencies, for law enforcement and a whole raft of other exemptions.'"

But the acting Privacy Commissioner for NSW, John Dickie, argues the Privacy Act is not without teeth. "Government departments and agencies are subject to it. People can't just wander off and get around things - [though] if there is a serious crime, all bets are off," he says.

Four years ago, a former employee of Transurban, the company that operates CityLink, admitted in court that he had passed on the credit-card details of more than 8000 CityLink customers to cyber thieves, who then used them for an internet spending spree. A subsequent review of Transurban's information handling practices by the Office of the Federal Privacy Commissioner found Transurban needed to take steps to reduce the risk of further privacy breaches. The FPC won't detail what those measures involved.

A spokesman says there were no fundamental problems and that Transurban merely needed to "enhance" existing systems.

Meanwhile, Transurban has told Good Weekend that it takes the protection of personal information seriously, and that the manner in which it manages the use and disclosure of personal information goes beyond obligations imposed by state and federal privacy legislation. The information it collects on its database is used only for collecting tolls and enforcing toll collection, isn't available to other organisations, and is only made available to police or to an authorised government body once there's a properly authorised written request.

It's not just toll-road operators who are amassing huge amounts of data on private citizens. In what could almost be called privatised intelligence gathering, the outsourcing of traffic management systems to private-sector organisations means more databases still. One such organisation is Tenix, the contractor employed by Victoria Police to operate its speed cameras - and which wrongly fined more than 100 motorists last July after the wrong speed limit was entered into the machine by an operator.

"I guess if there's a concern about the private-sector organisations holding increasing amounts of data, it's, 'Where are they holding it, how secure is it, and what purpose are they putting it to?'" says Monash's Peter Chen, who believes we will soon be talking about "data laundering" the way we now talk about money laundering. "I think it's safe to say that governments around the world, not just in Australia, have been lousy at regulating the movement of data about members of the public held by private-sector organisations.

"We have privacy laws which are relatively tight, but ... if you put a large chunk of the general surveillance system data into private hands, the company that picks up that contract will undertake that work in the most effective and efficient way for their profitability. And that might mean warehousing and processing data offshore, outside the legal jurisdiction of Australian governments. If I were a car company, I'd be very interested in finding out about the sort of people who drive a lot, who they are, what are their characteristics. If that information was held in a country with

poor data security legal provisions, then data could be sold, resold or 'stolen'. That's not a conspiracy theory view. It happens all the time. Large amounts of data get 'lost' in transit every year around the world."

Marcus Wigan points out that no one "owns" the information stored about them - so there's very little redress for consumers if their data is misused. "There's no such thing as intellectual property when it comes to information about you," he says. Nevertheless, he cautions against paranoia over intelligent transport systems, even though he has his own concerns about the data building up as a result of new technologies.

"The rules we have to manage that information are reasonably good, but not so good as to handle a situation of future cross-linkages between all those databases," he says. "So if we have [someone's] entire historical records on a range of individual databases, and at some point, for administrative convenience, a link is drawn between them, then the result is a complete history of locations, times, events of many different kinds that suddenly becomes available as a single resource. That's a quantum leap.

"Your vehicle will have had its numberplate [photographed] various times, your e-tag will have been caught - you only have to have one identification token transferred between two or more agencies for an amazing degree of record linkage with other sources of information about you and your activities over a considerable period.

"The ability to manage this is improving incredibly quickly. Once this is achieved and it's a few years away yet - we suddenly get a retrospective loss of privacy of an enormous order [and] ITS systems become surveillance systems.

"I'm not saying they'll be used in that way," Wigan adds. "I'm saying the potential for that to occur ... would then become a low-cost, low-effort issue. We need to use the time until all this is in place to educate and earn the trust of the community to secure the very real benefits of intelligent transport systems."

Published in the Good Weekend on January 28, 2006

Attachments

Several reports were sent separately that have background on the bridge issue and the issues of Peak Traffic:

the 2005 Hirsch Report prepared for US Department of Energy

International Energy Agency, Saving Oil in a Hurry, 2005

US Department of Energy, Future U.S. Highway Energy Use: A Fifty Year Perspective, May 3, 2001

Richard Heinberg, Powerdown (introduction)

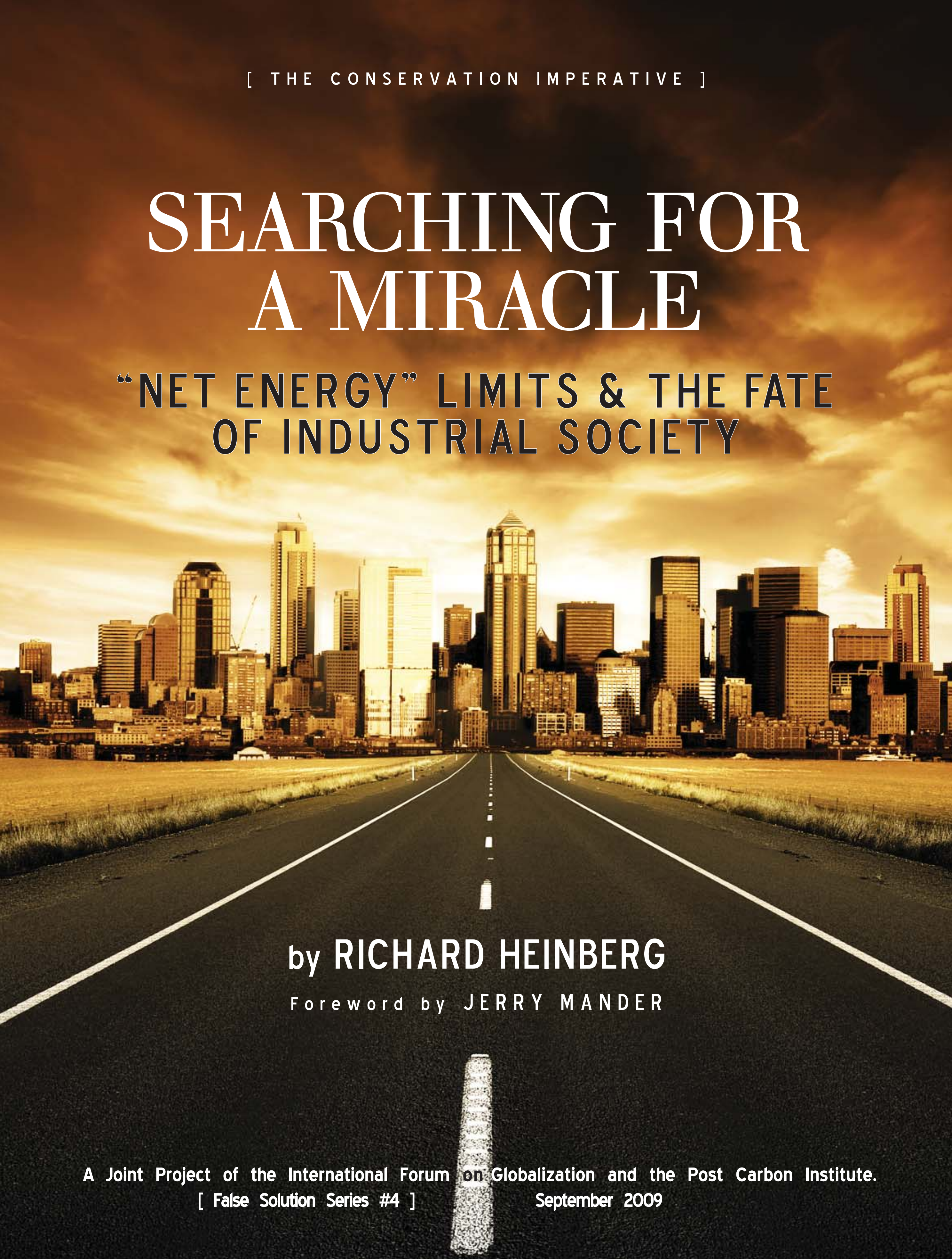
Business Week admits Peak Traffic is here, gas price increases are permanent, suburbia is winding down"

"Peak Traffic"
Peak Traffic: Planning NAFTA Superhighways at the End of the Age of Oil
www.road-scholar.org/peak-traffic.html

Behind enemy lines with the granola commandos
Published in Detroit Metro Times, 1993.
article about toxic waste used to power cement kilns

"Crude Oil: the supply outlook" report to the Energy Watch Group, October 2007

"Scientific American report" The End of Cheap Oil (March 1998)



[THE CONSERVATION IMPERATIVE]

SEARCHING FOR A MIRACLE

"NET ENERGY" LIMITS & THE FATE OF INDUSTRIAL SOCIETY

by RICHARD HEINBERG

Foreword by JERRY MANDER

A Joint Project of the International Forum on Globalization and the Post Carbon Institute.
[False Solution Series #4] September 2009

SEARCHING FOR A MIRACLE

'Net Energy' Limits & the Fate of Industrial Society

Acknowledgments

This document could not have been produced without the great help of several people. I particularly want to thank Prof. Charles Hall of Syracuse University, who has been a pioneer in developing the concept of "net energy," (Energy Returned on Energy Invested) that is at the heart of this report. We also drew directly from his published research in several aspects of the document. Jerry Mander and Jack Santa Barbara of the International Forum on Globalization helped conceive of this project several years ago and stayed involved throughout, reading several drafts, and offering detailed editing, shaping and writing suggestions. Dr. David Fridley, Staff Scientist at Lawrence Berkeley National Laboratory, read a later draft and gave valuable technical advice. Suzanne Doyle provided needed research and fact checking, and drafted the footnotes as well as several paragraphs. Alexis Halbert and Alina Xu of the IFG gathered many of the research materials on net energy, and engaged in some original research, and Victor Menotti of IFG offered important information on the state of climate negotiations. A special appreciation also goes to Asher Miller, my very supportive colleague, and ED of Post Carbon Institute. My profound thanks to all. Finally, I must acknowledge the pioneers who first understood the many profound dimensions of the relationships between energy and society; without their prior work this document could not even have been imagined: Frederick Soddy, Howard Odum, and M.King Hubbert. —Richard Heinberg

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Diagrams, Tables, and other research: Suzanne Doyle

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Cover Photo: iStock

Printer: ChromaGraphics

Funding Support:

We offer very special thanks to the Max and Anna Levinson Foundation and the Santa Barbara Family Foundation for their very generous financial support for IFG's "False Solutions" publications project.

CONTENTS

ISTOCK

Tokyo. Powered by imported oil and gas, combined with nuclear and coal. Japan is world's 3rd largest importer of oil and gas (after U.S. and China) and 4th largest user of energy (after U.S., China, Russia.) Fierce competition among industrial nations for remaining supplies, especially from Africa, South America, and the middle East, creates a precarious geopolitical situation. Japan may turn in future to more nuclear.

ISTOCK

As fossil fuels' supply dwindles and becomes more costly and polluting, renewed attention is on nuclear, and a theoretical "4th generation" of safer technology. But, as with proposed "clean coal" technology, "new nuclear" remains in the realm of scientific imagination, with high odds against it, and terrible downside potential. Problems of safe production, transport, waste disposal, ballooning costs, and limits of uranium supply are not nearly resolved. And nuclear's "net energy" ratio—the amount of energy produced vs. the amount expended to produce it—is low, putting it squarely into the category of "false solution."

FOREWORD: WHICH WAY OUT?

by Jerry Mander

INTERNATIONAL FORUM ON GLOBALIZATION

THIS LANDMARK REPORT by Richard Heinberg is #4 in the False Solutions series published since 2006 by the International Forum on Globalization.

Prior reports include "The False Promise of Biofuels," by IFG board member Jack Santa Barbara, which was first to predict what was confirmed a year later in dire studies from the Organization of Economic Cooperation and Development (OECD) and the United Nations—that the mad rush toward biofuels, especially corn ethanol, well underway by 2006, would cause more global environmental, agricultural and hunger problems, than it could ever begin to solve.

Despite this, U.S. policy continues to favor subsidizing industrial biofuels.

A second publication in the series, produced in partnership with the Institute for Policy Studies, was "The Manifesto on Global Economic Transitions"—a collective effort among 50 IFG Board and Associate Members. It is essentially a draft roadmap for the mandatory transformation of industrial society in recognition of limits imposed by planetary carrying capacities.

The third report, "The Rise and Predictable Fall of Globalized Industrial Agriculture," was written by former IFG executive director, Debbie Barker. That report shredded the expensively advertised notions that industrial agriculture systems are the best way "to feed a hungry world." The opposite is actually the case. The publication exposed and amplified a myriad of little-recognized connections of industrial farming to advancing hunger, global migrations, and climate change, among many other deadly effects. All of these publications are now in wide distribution.

The report which follows here, "Searching for a Miracle: 'Net Energy' Limits, & the Fate of Industrial Society," by our longtime friend and colleague Richard Heinberg, an associate member of IFG and senior fellow of the Post Carbon Institute, is the first to use the newly emerging techniques of "life cycle technology assessment," and in particular "net energy" analyses, for in-depth comparisons among all presently dominant and newly touted "alternative" energy schemes. These include all the major renewable systems currently being advocated. For the first time we are able to fully realize the degree to which our future societal options are far more limited than we thought.

With fossil fuels fast disappearing, and their continuing supplies becoming ever more problematic and expensive, hopes have turned to renewable sources that we ask to save "our way of life" at more or less its current level. Alas, as we will see, the "net energy" gain from all alternative systems—that is, the amount of energy produced, compared with the amount of energy (as well as money and materials) that must be invested in building and operating them—is far too small to begin to sustain industrial society at its present levels. This is very grim news, and demands vast, rapid adjustments by all parties, from governments to industries and even environmental organizations, that thus far are not clearly in the offing. There are, however, viable pathways forward, most importantly and urgently the need for a wide-ranging push for conservation; it is only a question of realism, flexibility, *dedication, and more than a little humility. Our beloved "way of life" must be reconsidered and more viable alternatives supported.*

THE WRONG TREE

We observe daily the tragic, futile official processes that continue to unfold among national governments, as well as global political and financial institutions, as they give lip service to mitigating climate change and the multiple advancing related global environmental catastrophes. Those crises include not only climate disruption, and looming global fossil fuels shortages, but other profound depletions of key resources—fresh water, arable soils, ocean life, wood, crucial minerals, biodiversity, and breathable air, etc. All these crises are results of the same sets of values and operating systems, and all are nearing points of extreme urgency.

Even our once great hopes that world governments would rally to achieve positive collective outcomes in some arenas; for example, at the United Nations climate change talks in Copenhagen, as well as other venues, are proving sadly fatuous. But certain things are ever-more clear: Global institutions, national governments, and even many environmental and social activists are barking up the wrong trees. Individually and as groups, they have not faced the full gravity and meaning of the global energy (and resource) conundrums. They continue to operate in most ways out of the same set of assumptions that we've all had for the past century—that fundamental systemic changes will not be required; that our complex of problems can be cured by human innovation, ingenuity, and technical efficiency, together with a few smart changes in our choices of energy systems.

Most of all, the prevailing institutions continue to believe in the primacy and efficacy of economic growth as the key indicator of systemic well-being, even in light of ever-diminishing resources. It will not be necessary, according to this dogma, to come to grips with the reality that ever-expanding economic growth is actually an absurdity in a finite system, preposterous on its face, and will soon be over even if activists do nothing to oppose it. Neither does the mainstream recognize that economic systems, notably capitalism, that *require* such endless growth for their own viability may themselves be doomed in the not very long run. In fact, they are already showing clear signs of collapse. As to any need for substantial changes in personal lifestyles, or to control and *limit* material consumption habits? Quite the opposite is being pushed—increased car sales, expanded "housing starts," and increased industrial production remain the focused goals of our economy, even under Mr. Obama, and are still celebrated when/if they occur, without thought of environmental consequences. No alterations in conceptual frameworks are encouraged to appreciate the now highly visible limits of nature, which is both root source of all planetary benefits, and inevitable toxic sink for our excessive habits.

In this optimistic though self-deluding dominant vision, there is also dedicated avoidance of the need for any meaningful *redistribution* of the planet's increasingly scarce remaining natural resources toward more equitable arrangements among nations and peoples—to at least slightly mitigate centuries of colonial and corporate plunder of the Third World. And on the similarly ignored question of the continued viability of a small planet that may soon need to support 8-10 billion people? Some actually say it's a *good* thing. We should think of these billions as new consumers who may help enliven economic growth, so goes that argument. But only if we find a few more planets nearby, perhaps in a parallel universe somewhere, bursting with oil, gas, water, minerals, wood, rich agricultural lands, and a virginal atmosphere.

The scale of denial is breathtaking. For as Heinberg's analysis makes depressingly clear, *there will be NO combination of alternative energy solutions that might enable the long term continuation of economic growth, or of industrial societies in their present form and scale.* Ultimately the solutions we desperately seek will not come from ever-greater technical genius and innovation. Far better and potentially more successful pathways can only come from a sharp turn to goals, values, and practices that emphasize conservation of material and energy resources, localization of most economic frameworks, and gradual population reduction to stay within the carrying capacities of the planet.

THE PARTY'S OVER

The central purpose of all of our *False Solution* documents, including this one, is to assert that this whole set of assumptions upon which our institutions have hung their collective hats, is tragically inaccurate, and only serves to delay, at a crucial moment, a major reckoning that must be understood immediately.

We are emphatically *not* against innovations and efficiencies where they can be helpful. But we are against the grand delusion that they can solve all problems, and we are against the tendency to ignore overarching inherent systemic limits that apply to energy supply, materials supply, and the Earth itself. For example, the grandest techno-utopian predictions at large today, such as "clean coal," via carbon sequestration, and "clean nuclear," via a new "safe 4th generation of reactor design," have already been revealed as little more than the wild fantasies of energy industries, as they peddle talking points to politicians to whom, on other days, they also supply with campaign cash. There is no persuasive evidence that clean coal, still in the realm of science fiction, will *ever* be achieved. Most likely it will occupy the same pantheon of technological fantasy as nuclear fusion, not to say human teleportation. In any case, the entire argument for clean coal, however absurd, still ignores what happens to the places from where it comes. Visit Appalachia sometime—now virtually desertified from mountain top removal, and its rivers poisoned to get at that soon-to-be "clean" coal. Clean nuclear offers similar anomalies—no currently contemplated solution for waste disposal is anywhere near practical—even if uranium supplies were not running out nearly as quickly as oil. To speak of nuclear as "clean" or "safe" is a clear sign of panic while, vampire-like, it's permitted to again rise from its grave.

Okay, we know that some technological "progress" is useful, especially among renewable energy alternatives. Systemic transformations toward a highly touted new complex mix of "renewable" energy systems such as wind, solar, hydro, biomass, wave and several others, will certainly be positive, and together they could make meaningful contributions, free of many of the negative environmental impacts that fossil fuels have brought.

But, as this report exquisitely explains, as beneficial as those shifts may be, they will inevitably fall far short. *They will never reach the scale or capacity to substitute for a fossil fuel system that, because of its (temporary) abundance and cheapness, has addicted industrial nations to a 20th century production and consumption spree that landed us, and the whole world, into this dire situation*. As Richard Heinberg has so eloquently said before, and used as the title of one his very important books, "the party's over."

So, those limitless supplies turned out not to be limitless, or cheap, (or any longer efficient), and we are left with only one real option: to face the need for a thorough systemic transformation of our entire society to one that emphasizes *less* consumption of material resources and energy (conservation), less globalization (shipping resources and products back and forth wastefully across oceans and continents), and *more* localization which has inherent efficiencies and savings from the mere fact of local production and use, and far less processing and shipping. Such changes must be combined with achieving lower population in all global sectors, and the fostering of an evolution of personal, institutional and national values that recognize (even celebrate) the ultimate limits of the earth's carrying capacities, presently being dramatically exceeded. None of that vision has infected the Copenhagen processes, nor those of the U.S. Congress, nor debates in national parliaments; anything short of that is just a self-protective, self-interested smoke screen, or, sheer denial of the realities at hand.

THE NET ENERGY FACTOR

Richard Heinberg's report makes its case by a methodical examination and *comparison* of many of the most important features inherent to the key energy systems of our time. His detailed summaries include "life cycle assessments" of the currently dominant systems such as oil, gas, coal, and nuclear—the very systems which built industrial society, and brought us to this grave historical moment. These systems are now each suffering advancing supply shortages and increased costs, making their future application dubious. Heinberg then explores and compares all the alternative systems now being hotly promoted, like wind, solar, hydro, geothermal, biomass and biofuels, incineration, wave energy and others. He delineates ten aspects of each system, including everything from direct monetary cost (*can we afford it?*), as well as "scalability" (*will its benefits apply at a meaningful volume?*). He also includes environmental impacts in the formula; the location of the resources; their reliability (*the wind doesn't blow all the time and the sun doesn't shine*); density—how compact is the source per unit?; transportability, etc.

Most important is the tenth standard that Heinberg lists—and the bulk of this document is devoted to it: "net energy," or, the Energy Returned on Energy Invested (EROEI). Heinberg explores this revolutionary analytic terrain thoroughly, basing his reportage on the groundbreaking research of leading scientists, notably including Charles Hall of Syracuse University, who has been the pioneer explorer of the full import of "net energy" to the future of industrialism and economic growth.

What is revealed from this process is that the once great advantages of fossil fuel systems, which in their heyday were able to produce enormous quantities of cheap energy *outputs* with relatively little investment of energy *inputs* or dollar investments—Heinberg puts the EROEI ratio at about 100:1—can no longer approach that level. And, of course, they continue to ravage the planet. Meanwhile, the highly promising alternative energy systems, which in most respects are surely far cleaner than fossil fuels, cannot yield net energy ratios that are anywhere near what was possible with fossil fuels. In other words, they require for their operation a significant volume of energy *inputs* that bring their energy *outputs* to a very modest level. Too modest, actually, to be considered a sufficient substitute for the disappearing fossil fuels. In fact, as Heinberg notes, there is no combination of alternative renewables that can compete with the glory days of fossil fuels, now ending. So, what does this portend for modern society? Industrialism? Economic growth? Our current standards of living? All prior assumptions are off the table. Which way now? Systemic change will be mandatory.

Of course, there is a huge segment of the grassroots activist world that already instinctively understood all this some time ago, and has not waited for governments, separately or in collaboration with others, to do the right thing. The world is now bursting with examples on every continent of enthusiastic efforts to transform communities into locally viable and sustainable economic systems. We see a virtual renaissance of local food systems, thus replacing the supplies of the industrial agriculture machine that often ships from across thousands of miles of land or ocean. And this burgeoning movement is directly supported by a parallel movement toward re-ruralization. We also see extraordinary efforts to limit the power of global corporations operating in local contexts. There is a growing effort by communities to assert control over their own local commons; to resist privatization of public services; and to return to local production values in manufacturing and energy systems so that conservation is placed ahead of consumption. A myriad other efforts also seek to affirm local sovereignty.

Among the most exciting expressions of these tendencies has been the birth and spread of an international "Transition Towns" movement. Originally launched a few years ago in southwest England, it has helped stimulate literally thousands of similar efforts in local communities, including hundreds in the U.S. All are trying to go back to the drawing board to convert all operating systems toward active conservation efforts that minimize material and energy flow-through, protecting scarce resources, while moving toward energy and production systems that are cognizant of and reactive to an entirely alternative set of values.

So far, this is not yet threatening to the larger machines of industrialism and growth, nor to the primacy of corporate power, but time is definitely on the side of such movements. It behooves us all to align ourselves with them. In this case, it is mandatory that we build and take action at the local grassroots level, while also demanding change from our governing institutions, locally, nationally and internationally. But in any case, as the document you are about to read helps make exquisitely clear, the status quo will not survive.

GIGIE CRUZ/GAIA

One hidden underbelly of a global economy, dependent on growth and consumption; this roadway runs through miles of trash and waste fields outside Manila. Similar landscapes of waste and pollution are found today in every modern country with one of the world's largest just outside New York.

ISTOCK

Some nations want to expand off-shore drilling, despite threats of spills to oceans, beaches, reefs, and sealife. Increased hurricane dangers from climate change make safety of these platforms ever-more doubtful, and raise chances of future Katrina-like collapses. Meanwhile, oil production also suffers overall declining rates of "net energy" and is far less viable than in its heyday. (See chapter three.)

One

OVERVIEW

THIS REPORT IS INTENDED as a non-technical examination of a basic question: *Can any combination of known energy sources successfully supply society's energy needs at least up to the year 2100?* In the end, we are left with the disturbing conclusion that *all* known energy sources are subject to strict limits of one kind or another. Conventional energy sources such as oil, gas, coal, and nuclear are either at or nearing the limits of their ability to grow in annual supply, and will dwindle as the decades proceed—but in any case they are unacceptably hazardous to the environment. And contrary to the hopes of many, there is no clear practical scenario by which we can replace the energy from today's conventional sources with sufficient energy from *alternative* sources to sustain industrial society at its present scale of operations. To achieve such a transition would require *(1)* a vast financial investment beyond society's practical abilities, *(2)* a very long time—too long in practical terms—for build-out, and *(3)* significant sacrifices in terms of energy quality and reliability.

Perhaps the most significant limit to future energy supplies is the "net energy" factor—the requirement that energy systems yield more energy than is invested in their construction and operation. There is a strong likelihood that future energy systems, both conventional and alternative, will have higher energy input costs than those that powered industrial societies during the last century. We will come back to this point repeatedly.

The report explores some of the presently proposed energy transition scenarios, showing why, up to this time, most are overly optimistic, as they do not address all of the relevant limiting factors to the expansion of alternative energy sources. Finally, it shows why energy conservation (using less energy, and also less resource materials) combined with humane, gradual population decline must become primary strategies for achieving sustainability.

* * *

The world's current energy regime is unsustainable. This is the recent, explicit conclusion of the International Energy Agency[1], and it is also the substance of a wide and growing public consensus ranging across the political spectrum. One broad segment of this consensus is concerned about the climate and the other environmental impacts of society's reliance on fossil fuels. The other is mainly troubled by questions regarding the security of future supplies of these fuels—which, as they deplete, are increasingly concentrated in only a few countries.

To say that our current energy regime is unsustainable means that it cannot continue and must therefore be replaced with something else. However, replacing the energy infrastructure of modern industrial societies will be no trivial matter. Decades have been spent building the current oil-coal-gas infrastructure, and trillions of dollars invested. Moreover, if the transition from current energy sources to alternatives is wrongly managed, the consequences could be severe: there is an undeniable connection between per-capita levels of energy consumption and economic well-being.[2] A failure to supply sufficient energy, or energy of sufficient quality, could undermine the future welfare of humanity, while a failure to quickly make the transition away from fossil fuels could imperil the Earth's vital ecosystems.

Nonetheless, it remains a commonly held assumption that alternative energy sources capable of substituting for conventional fossil fuels are readily available—whether fossil (tar sands or oil shale), nuclear, or a long list of renewables—and ready to come on-line in a bigger way. All that is necessary, according to this view, is to invest sufficiently in them, and life will go on essentially as it is.

But is this really the case? Each energy source has highly specific characteristics. In fact, it has been the characteristics of our present energy sources (principally oil, coal, and natural gas) that have enabled the building of a modern society with high mobility, large population, and high economic growth rates. Can alternative energy sources perpetuate this kind of society? Alas, we think not.

While it is possible to point to innumerable successful alternative energy production installations within modern societies (ranging from small home-scale photovoltaic systems to large "farms" of three-megawatt wind turbines), it is not possible to point to more than a very few examples of an entire modern industrial nation obtaining the bulk of its energy from sources other than oil, coal, and natural gas. One such rare example is Sweden, which gets most of its energy from nuclear and hydropower. Another is Iceland, which benefits from unusually large domestic geothermal resources, not found in most other countries. Even in these two cases, the situation is more complex than it appears. The construction of the infrastructure for these power plants mostly relied on fossil fuels for the mining of the ores and raw materials, materials processing, transportation, manufacturing of components, the mining of uranium, construction energy, and so on. Thus for most of the world, a meaningful energy transition is still more theory than reality.

But if current primary energy sources are unsustainable, this implies a daunting problem. The transition to alternative sources *must* occur, or the world will lack sufficient energy to maintain basic services for its 6.8 billion people (and counting).

Thus it is vitally important that energy alternatives be evaluated thoroughly according to relevant criteria, and that a staged plan be formulated and funded for a systemic societal transition away from oil, coal, and natural gas and toward the alternative energy sources deemed most fully capable of supplying the kind of economic benefits we have been accustomed to from conventional fossil fuels.

By now, it is possible to assemble a bookshelf filled with reports from nonprofit environmental organizations and books from energy analysts, dating from the early 1970s to the present, all attempting to illuminate alternative energy transition pathways for the United States and the world as a whole. These plans and proposals vary in breadth and quality, and especially in their success at clearly identifying the factors that are limiting specific alternative energy sources from being able to adequately replace conventional fossil fuels.

It is a central purpose of this document to systematically review key limiting factors that are often left out of such analyses. We will begin that process in the next section. Following that, we will go further into depth on one key criterion: *net energy*, or *energy returned on energy invested* (EROEI). This measure focuses on the key question: All things considered, how much more energy does a system produce than is required to develop and operate that system? What is the ratio of energy *in* versus energy *out*? Some energy "sources" can be shown to produce little or no *net* energy. Others are only minimally positive.

Unfortunately, as we shall see in more detail below, research on EROEI continues to suffer from lack of standard measurement practices, and its use and implications remain widely misunderstood. Nevertheless, for the purposes of large-scale and long-range planning, net energy may be the most vital criterion for evaluating energy sources, as it so clearly reveals the tradeoffs involved in any shift to new energy sources.

This report is not intended to serve as a final authoritative, comprehensive analysis of available energy options, nor as a plan for a nation-wide or global transition from fossil fuels to alternatives. While such analyses and plans are needed, they will require institutional resources and ongoing reassessment to be of value. The goal here is simply to identify and explain the primary criteria that should be used in such analyses and plans, with special emphasis on *net energy,* and to offer a cursory evaluation of currently available energy sources, using those criteria. This will provide a general, preliminary sense of whether alternative sources are up to the job of replacing fossil fuels; and if they are not, we can begin to explore what might be the fall-back strategy of governments and the other responsible institutions of modern society.

As we will see, the fundamental disturbing conclusion of the report is that there is little likelihood that either conventional fossil fuels or alternative energy sources can reliably be counted on to provide the amount and quality of energy that will be needed to sustain economic growth—or even current levels of economic activity—during the remainder of the current century.

This preliminary conclusion in turn suggests that a sensible transition energy plan will have to emphasize energy conservation above all. It also raises questions about the sustainability of growth *per se*, both in terms of human population numbers and economic activity.

MALCOLM LINTON/LIAISON

As in South America, Africa's oil resources are a target for corporate giants like Shell. Indigenous communities are invaded by massive infrastructures in their forests and waters, bringing oil spills, forced removals, and military actions. In the Niger delta, where this warning sign turns away people from docks, nearly full-scale war has broken out between resisting indigenous groups, such as the Ogoni people, and global oil companies, seeking control of traditional lands.

GLOSSARY OF TERMS

CCS: Carbon Capture and Storage. When applied to coal, this still somewhat hypothetical set of technologies is often referred to as "clean coal." Many energy experts doubt that CCS can be deployed on a significant scale.

Carbon Dioxide, or CO_2: A colorless, odorless, incombustible gas, that is formed during respiration, combustion, and organic decomposition. Carbon dioxide is a minor natural constituent of Earth's atmosphere, but its abundance has increased substantially (from 280 parts per million to 387 ppm) since the beginning of the Industrial Revolution due to the burning of fossil fuels. CO_2 traps heat in Earth's atmosphere; as the concentration of the gas increases, the planet's temperature rises.

DDGS: Distillers Dried Grains with Solubles. A byproduct of producing ethanol from corn, DDGS is typically used as livestock feed.

Efficiency: The ratio between the useful *output* of an energy *conversion* machine and the *input*, in energy terms. When the useful output of conversion increases relative to input, the machine is considered more energy efficient. Typically *efficiency* applies to machines that use energy to do work (like cars or household electrical devices), or that convert energy from one form to another (like coal-burning power plants that make electricity). *Efficiency* differs from *EROEI* (see below), which typically describes the ratio between the broader energy inputs and outputs of an energy *production* system, such as a coalmine, a wind farm, or an operating oilfield. The distinction can be confusing, because sometimes both *efficiency* and *EROEI* can be applied to different aspects of the same energy system. For example, *efficiency* is used to describe the input/output of a photovoltaic solar panel (in terms of how much of the energy of sunlight is converted to electricity), while *EROEI* describes how much useful energy the panel will produce as compared to the amount of energy required to build and maintain it.

EGS: Enhanced Geothermal System. This refers to a fledgling technology that employs equipment developed by the oil and gas industry to pipe water deep below the surface, where the natural heat of Earth's crust turns it to steam that can turn a turbine.

EIA: Energy Information Administration, a branch of the U.S. Department of Energy.

Electricity: Energy made available by the flow of electric charge through a conductor.

Embodied energy: the available energy that was used in the work of making a product. This includes the activities needed to acquire natural resources, the energy used manufacturing and in making equipment and in other supporting functions—i.e., direct energy plus indirect energy.

Energy: The capacity of a physical system to do work, measured in joules or ergs. (See expanded definition, next page.)

Energy carrier: A substance (such as hydrogen) or phenomenon (such as electric current) that can be used to produce mechanical work or heat or to operate chemical or physical processes. In practical terms, this refers to a means of conveying energy from ultimate source to practical application. Our national system of electricity generating plants and power lines serves this function: it converts energy from coal, natural gas, uranium, flowing water, wind, or sunlight into a common carrier (electricity) that can be made widely available to accomplish a wide array of tasks.

EROEI: "Energy Returned on Energy Invested," also known as EROI (energy return on investment), is the ratio of the amount of usable energy acquired from a particular energy resource to the amount of energy expended to obtain that energy resource. Not to be confused with *efficiency* (see above).

Feed-in tariff: An incentive structure to encourage the adoption of renewable energy through government legislation. Regional or national electricity utilities become obligated to buy renewable electricity (from renewable sources such as solar photovoltaics, wind power, biomass, hydropower, and geothermal power) at constant, above-market rates set by the government.

Food energy: The amount of chemically stored energy present in food, usually measured in kilocalories (often written simply as "calories"). All animals require a minimum periodic intake of food energy—as well as water and an array of specific nutrients (vitamins and minerals).

GHG: Greenhouse gases.

Horsepower: A unit of power originally intended to measure and compare the output of steam engines with the power output of draft horses. The definition of a horsepower unit varies in different applications (e.g., for rating boilers or electric motors); however, the most common definition, applying primarily to electric motors, is: a unit of power equal to 746 watts. Where units of horsepower are used for marketing consumer products, measurement methods are often designed by advertisers to maximize the magnitude of the number, even if it doesn't reflect the realistic capacity of the product to do work under normal conditions.

IEA: International Energy Agency. Headquartered in Paris, the IEA was created by the OECD nations after the oil shock of 1973 to monitor world energy supplies.

IGCC: Integrated Gasification Combined Cycle, an advanced type of coal power plant in which coal is brought together with water and air under high heat and pressure to produce a gas—synthesis gas (syngas), composed primarily of hydrogen and carbon monoxide — along with solid waste. It then removes impurities from the syngas before it is combusted.

IPCC: Intergovernmental Panel on Climate Change, a scientific body tasked to evaluate the risk of climate change caused by human activity. The panel was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP). The IPCC shared the 2007 Nobel Peace Prize with Al Gore.

Joule: A unit of electrical energy equal to the work done when a current of one ampere passes through a resistance of one ohm for one second.

Mb/d: Millions of barrels per day.

Photovoltaic (PV): Producing a voltage when exposed to radiant energy (especially sunlight).

Net energy (sometimes referred to as Net Energy Gain or NEG): A concept used in energy economics that refers to the ratio between the energy expended to harvest an energy source and the amount of energy gained from that harvest.

Power: The rate of doing work, measured in watts (joules per second). (See Horsepower above.)

Transesterification: A process that converts animal fats or more commonly plant oils into biodiesel. In more technical terms: the reaction of a triglyceride (fat/oil) with an alcohol to form esters (a class of organic compounds formed from an organic acid and an alcohol) and glycerol (glycerine). The reaction is often catalyzed by the addition of a strong alkaline like sodium hydroxide (lye). The products of the reaction are mono-alkyl ester (biodiesel) and glycerol.

Trombe wall: A typical feature of passive solar design, a trombe wall is a very thick, south-facing wall that is painted black and made of a material that absorbs a lot of heat. A pane of glass or plastic glazing, installed a few inches in front of the wall, helps hold in the heat. The wall heats up slowly during the day. Then as it cools gradually during the night, it gives off its heat inside the building.

UCG: Underground coal gasification. Where practical, this technology could gasify coal more cheaply than above-ground IGCC power plants (gasification of coal is a stage in CCS, see above).

Watt: A unit of power equal to 1 joule per second.

> **Watt-hour:** A unit of energy equal to the power of one watt operating for one hour.
>
> **Kilowatt (KW):** Thousand watts.
>
> **KWH:** Thousand watt-hours.
>
> **Megawatt (MW):** Million watts.
>
> **MWH:** Million watt-hours.
>
> **Gigawatt (GW):** Billion watts.
>
> **GWH:** Billion watt-hours.
>
> **Terawatt (TW):** Trillion watts.
>
> **TWH:** Trillion watt-hours.

Work: The transfer of energy from one physical system to another, especially the transfer of energy to a body by the application of a force that moves the body in the direction of the force. It is calculated as the product of the force and the distance through which the body moves and is expressed in joules, ergs, and foot-pounds.

WHAT IS "ENERGY"?

Energy is often defined as "the capacity of a physical system to do work," while work is said to be "force times distance traveled." But these definitions quickly become circular, as no one has seen "force" or "energy" apart from the effect that they have upon matter (which itself is difficult to define in the final analysis).

However hard it may be to define, we know that energy is the basis of everything: without it, nothing happens. Plants don't grow, cars don't move, and our homes get uncomfortably cold in the winter. Physicists may discuss energy in relation to stars and atoms, but energy is equally important to ecosystems and human economies: without sources of energy, living things die and economies grind to a halt.

Throughout history, most of the energy that humans have used has come to them in the form of food—the energy of sunlight captured and stored in plants (and in animals that eat plants). At the same time, humans have exerted energy, mostly by way of their muscles, in order to get what they wanted and needed, including food. It was essential that they harvested more food-energy than they expended in striving for it; otherwise, starvation resulted.

With animal domestication, primary energy still came by way of food, but much of that food (often of a sort that people couldn't eat) was fed to animals, whose muscles could be harnessed to pull plows, carts, and chariots.

People have also long used non-food energy by burning wood (a store of solar energy) for heat.

More recently, humans have found ways to "digest" energy that millions of years ago was chemically stored in the form of fossil fuels—"digesting" it not in their stomachs, but in the engines of machines that do work that human or animal muscles used to do; indeed, we have invented machines to do far more things than we were capable of previously, including work that human muscles could never do. Because fossil fuels represent energy stored in a more concentrated form than is found in the food we eat; because we can use fuel to power a great variety of machines; and because it has been possible to harvest fossil fuels in enormous and growing quantities, humankind has been able to build an interconnected global economy of unprecedented scope. However, fossil fuels are by their very nature finite, depleting resources. So, during recent decades enormous and increasing interest has been paid to the development of non-fossil, "alternative" energy sources.

Today, when we discuss national or global energy problems, we are mostly concerned about the energy for our machines. Most of the energy that humans use is still, in essence, solar energy—sunlight captured in food crops or forests; ancient sunlight stored in fossil fuels; sunlight heating air and fanning winds whose power can be harnessed with turbines; or sunlight transformed directly into electricity via photovoltaic panels. However, some non-solar forms of energy are also now available to us: tidal power captures the gravitational influence of the Moon and other celestial bodies; geothermal power uses Earth's heat, and nuclear power harnesses the energy given off by the decay of radioactive elements.

Even though we use more energy sources today than our ancestors did, and we use them in more ingenious and impressive ways, one vitally important principle still applies today as in the past, when our energy concerns had more directly to do with sunlight, green plants, and muscles: we must still expend energy to obtain energy, and our continued success as a species very much depends on our ability to obtain more energy from energy-harvesting efforts than we spend in those efforts.

LOU DEMATTEIS

Here's one benefit of the maze of pipelines and infrastructures driven through indigenous homelands in the Amazon; a daring new game for a young indigenous boy.

ISTOCK

The leading sources of CO_2 emissions in the U.S. are coal-fired power plants like this one. There are increased efforts to regulate major greenhouse gas polluters, and new emphases on developing so-called "clean coal" technologies of carbon capture and "sequestration" (burial). But the benefits of these measures are uncertain, and sequestration is in its infancy. As with nuclear waste, the question becomes: how long can buried coal gases stay buried? That aside, most U.S. coal now comes from mountain-top removal mining (see back cover and chapter four) which is transforming the glorious mountains of several states into wastelands, and will never qualify as "clean." In any case, coal reserves are far lower than have been reputed, making long term viability doubtful.

Two

NINE KEY CRITERIA: COMPARING ENERGY SYSTEMS AND THEIR LIMITS

In evaluating energy sources, it is essential first to give attention to the criteria being used. Some criteria give us good information about an energy source's usefulness for specific applications. For example, an energy source like oil shale that is a solid material at room temperature and has low energy density per unit of weight and volume is highly unlikely to be good as a transport fuel unless it can first somehow profitably be turned into a liquid fuel with higher energy density (i.e., one that contains more energy per unit of weight or volume). Other criteria gauge the potential for a specific energy source to power large segments of an entire society. Micro-hydro power, for example, can be environmentally benign, but its yield cannot be sufficiently increased in scale to provide a significant portion of the national energy budget of the U.S. or other industrial countries.

In general, it is important to identify energy sources that are capable of being scaled up to produce large quantities of energy, that have high economic utility, and that have minimal environmental impacts, particularly those impacts having to do with land use and water requirements, as well as with greenhouse gas emissions. Only sources that pass these tests are capable of becoming our future *primary* energy sources—that is, ones capably of supplying energy on the scale that fossil fuels currently do.

The economic utility and scalability of any energy source are determined by three main factors: the size of the resource base, the energy density of the resource itself, and the quantity and nature of other resources and infrastructures needed to process and employ the energy source in question.

Economist Douglas Reynolds, in a paper discussing the energy density of energy sources (which he terms "energy grade"), writes:

> Energy is the driving force behind industrial production and is indeed the driving force behind any economic activity. However, if an economy's available energy resources have low grades, i.e. low potential productivity, then new technology will not be able to stimulate economic growth as much. On the other hand, high-grade energy resources could magnify the effect of technology and create tremendous economic growth. High-grade resources [i.e., ones that have high energy density] can act as magnifiers of technology, but low-grade resources can dampen the forcefulness of new technology. This leads to the conclusion that it is important to emphasize the role of the inherent nature of resources in economic growth more fully. [3]

But economic utility is not the only test an energy source must meet. If there is anything to be learned from the ongoing and worsening climate crisis, it is that the environmental impacts of energy sources must be taken very seriously indeed. The world cannot afford to replace oil, coal, and gas with other energy sources that might pose a survival challenge to future generations.

So here, then, are nine energy evaluation criteria. In the section following this one, we will describe a tenth, net energy.

1. Direct Monetary Cost

This is the criterion to which most attention is normally paid. Clearly, energy must be affordable and competitively priced if it is to be useful to society. However, the immediate monetary cost of energy does not always reflect its *true* cost, as some energy sources may benefit from huge hidden state subsidies, or may have externalized costs (such as grave environmental impacts that later need correction). The monetary cost of energy resources is largely determined by the other criteria listed below.

The cost of energy typically includes factors such as the costs of resource extraction and refining or other resource modification or improvement, and transport. The repayment of investment in infrastructure (factories for building solar panels; nuclear power plants; refineries; and power lines, pipelines, and tankers) must also inevitably be reflected in energy prices.

However, prices can also be skewed by subsidies or restrictions of various kinds—including tax breaks to certain kinds of energy companies, pollution regulations, government investment in energy research and development, and government investment in infrastructure that favors the use of a particular kind of energy.

2. Dependence on Additional Resources

Very few energy sources come in an immediately useable form. One such example: Without exerting effort or employing any technology we can be warmed by the sunlight that falls on our shoulders on a spring day. In contrast, most energy sources, in order to be useful, require some method of gathering, mining, or processing fuels and then converting the resulting energy. In turn this usually entails some kind of apparatus, made of some kind of additional materials (for example, oil-drilling equipment is

TABLE 1A: TODAY'S ENERGY COST

Cost of existing power generation (cents per kWh)

Coal	2 to 4
Natural gas	4 to 7
Hydropower	1
Nuclear	2.9
Wind	4.5 to 10
Biomass power	4 to 9
Solar PV	21 to 83
Geothermal	10
Solar thermal	6 to 15
Tidal	10
Wave	12

Table 1A. These are approximate costs of production for eleven energy sources. (Residential electricity consumers typically pay from $.10 to $.20 per kWh.) Source: U.S. Federal Regulatory Commission, 2007.[4]

TABLE 1B: COST OF NEW ENERGY

Cost of new energy ($/kW)

Coal	1900-5800
Natural gas	500-1500
Hydropower	NA
Nuclear	4500-7500
Wind	1300-2500
Biomass power	NA
Solar PV	3900-9000
Geothermal	2600-3500
Solar thermal	3000-5000
Tidal	NA
Wave	NA

Table 1B. "New generation" refers to the infrastructure cost of introducing the capacity to produce one kilowatt on an ongoing basis; it does not refer to the cost of the actual generated power per kilowatt hour. Source: U.S. Federal Regulatory Commission, 2007.[5]

made from steel and diamonds). And sometimes the extraction or conversion process uses additional resources (for example, the production of synthetic diesel fuel from tar sands requires enormous quantities of water and natural gas, and the production of biofuels requires large quantities of water). The amount or scarcity of the added materials or resources, and the complexity and cost of the various apparatuses required at different stages, thus constitute important limiting factors on most modes of energy production.

The requirements for ancillary resources at early stages of production, in order to yield a given quantity of energy, are eventually reflected in the price paid for the energy. But this is not always or entirely the case. For example, many thin-film photovoltaic panels incorporate materials such as gallium and indium that are non-renewable and rare, and that are being depleted quickly. While the price of thin-film PV panels reflects and includes the current market price of these materials, it does not give much indication of future limits to the scaling up of thin-film PV resulting from these materials' scarcity.

3. Environmental Impacts

Virtually all energy sources entail environmental impacts, but some have greater impacts than others. These may occur during the acquisition of the resource (in mining coal or drilling for oil, for example), or during the release of carbon energy from the resource (as in burning wood, coal, oil, or natural gas). Other impacts occur in the conversion of the energy from one form to another (as in converting the kinetic energy of flowing water into electricity via dams and hydro-turbines); or in the potential for catastrophic events, as with nuclear energy production; or in waste disposal problems. Others may be intrinsic to the production process, such as injury to forests or topsoils from various forms of biofuels production.

Some environmental impacts are indirect and subtle. They can occur during the manufacture of the equipment used in energy harvesting or conversion. For example, the extraction and manipulation of resources used in manufacturing solar panels may entail significantly more environmental damage than the operation of the panels themselves.

AMAZON WATCH

4. Renewability

If we wish our society to continue using energy at industrial rates of flow not just for years or even decades into the future, but for centuries, then we will require energy sources that can be sustained more or less indefinitely. Energy resources like oil, natural gas, and coal are clearly non-renewable because the time required to form them through natural processes is measured in the tens of millions of years, while the quantities available will only be able to power society, at best, for only a few decades into the future at current rates of use. In contrast, solar photovoltaic and solar thermal energy sources rely on sunlight, which for all practical purposes is not depleting and will presumably be available in similar quantities a thousand years hence.

It is important to repeat once again, however, that the *equipment* used to capture solar or wind energy is not itself renewable, and that scarce, depleting, non-renewable resources and significant amounts of energy may be required to manufacture much crucial equipment.

Some energy sources *are* renewable yet are still capable of being depleted. For example, wood can be harvested from forests that regenerate themselves; however, the *rate* of harvest is crucial: if over-harvested, the trees will be unable to re-grow quickly enough and the forest will shrink and disappear.

Even energy sources that are renewable and that do not suffer depletion are nevertheless limited by the size of the resource base (as will be discussed next).

5. Potential Size or Scale of Contribution

Estimating the potential contribution of an energy source is obviously essential for macro-planning purposes, but such estimates are always subject to error—which can sometimes be enormous. With fossil fuels, amounts that can be reasonably expected to be extracted and used on the basis of current extraction technologies and fuel prices are classified as *reserves*, which are always a mere fraction of *resources* (defined as the total amount of the substance present in the ground). For example, the U.S. Geological Survey's first estimate of national coal reserves, completed in 1907, identified 5000 years' worth of supplies. In the decades since, most of those "reserves" have been reclassified as "resources." Reserves are downgraded to resources when new limiting factors are taken into account, such as (in the case of coal) seam thickness and depth, chemical impurities, and location of the deposit.

Today, only 250 years' worth of useable U.S. coal supplies are officially estimated to exist—a figure that is still probably much too optimistic (as the National Academy of Sciences concluded in its 2007 report, *Coal: Research and Development to Support National Energy Policy*).

On the other hand, reserves can sometimes grow as a result of the development of new extraction technologies, as has occurred in recent years with U.S. natural gas supplies: while the production of conventional American natural gas is declining, new underground fracturing technologies have enabled the recovery of "unconventional" gas from low-porosity rock, significantly increasing the national natural gas production rate and expanding U.S. gas reserves.

The estimation of reserves is especially difficult when dealing with energy resources that have little or no extraction history. This is the case, for example, with methane hydrates, regarding which various experts have issued a very wide range of estimates of both total resources and extractable future supplies. The same is also true of oil shale, and to a lesser degree tar sands, which have limited extraction histories.

Estimating potential supplies of renewable resources such as solar and wind power is likewise problematic, as many limiting factors are often initially overlooked. With regard to solar power, for example, a cursory examination of the ultimate resource is highly encouraging: the total amount of energy absorbed by Earth's atmosphere, oceans, and land masses from sunlight annually is approximately 3,850,000 exajoules (EJ)—whereas the world's human population uses currently only about 498 EJ of energy per year from all sources combined[6], an insignificant fraction of the previous figure. However, the factors limiting the amount of sunlight that can potentially be put to work for humanity are numerous, as we will see in more detail below.

Consider the case of methane harvested from municipal landfills. In this instance, using the resource provides an environmental benefit: methane is a more powerful greenhouse gas than carbon dioxide, so harvesting and burning landfill gas (rather than letting it diffuse into the atmosphere) reduces climate impacts while also providing a local source of energy. If landfill gas could power the U.S. electrical grid, then the nation could cease mining and burning coal. However, the potential size of the landfill gas resource is woefully insufficient to support this. Currently the nation derives about 11 billion kWh per year from landfill gas for commercial, industrial, and electric utility uses. This figure could probably be doubled if more landfills were tapped.[7] But U.S. electricity consumers use close to 200 times as much energy as that. There is another wrinkle: If society were to become more environmentally sensitive and energy efficient, the result would be that the amount of trash going into landfills would decline—and this would reduce the amount of energy that could be harvested from future landfills.

6. Location of the Resource

The fossil fuel industry has long faced the problem of "stranded gas"—natural gas reservoirs that exist far from pipelines and that are too small to justify building pipelines to access them. Many renewable resources often face similar inconveniences and costs caused by distance.

The locations of solar and wind installations are largely dictated by the availability of the primary energy source; but often, sun and wind are most abundant in sparsely populated areas. For example, in the U.S. there is tremendous potential for the development of wind resources in Montana and North and South Dakota; however, these are three of the least-populous states in the nation. Therefore, to take full advantage of these resources it will be necessary to ship the energy to more populated regions; this will typically require building new high-capacity long distance power lines, often at great expense, and causing sometimes severe environmental impacts. There are also excellent wind resources offshore along the Atlantic and Pacific coasts, nearer to large urban centers. But taking advantage of these resources will entail building and operating turbines in deep water and connecting them to the grid onshore—not an easy task. Similarly, the nation's best solar resources are located in the Southwest, far from population centers in the Northeast.

Thus, taking full advantage of these energy resources will require more than merely the construction of wind turbines and solar panels: much of the U.S. electricity grid will need to be reconfigured, and large-capacity, long-distance transmission lines will need to be constructed. Parallel challenges exist for other countries.

7. Reliability

Some energy sources are continuous: coal can be fed into a boiler at any desired rate, as long as the coal is available. But some energy sources, such as wind and solar, are subject to rapid and unpredictable fluctuations. Wind sometimes blows at greatest intensity at night, when electricity demand is lowest. The sun shines for the fewest hours per day during the winter—but consumers are unwilling to curtail electricity usage during winter months, and power system operators are required to assure security of supply throughout the day and year.

Intermittency of energy supply can be managed to a certain extent through storage systems—in effect, batteries. However, this implies yet further infrastructure costs as well as energy losses. It also places higher demands on control technology. In the worst instance, it means building much more electricity generation capacity than would otherwise be needed.[8]

8. Energy Density

A. Weight (or Gravimetric) Density

This refers to the amount of energy that can be derived from a standard weight unit of an energy resource.

For example, if we use the megajoule (MJ) as a measure of energy and the kilogram (kg) as a measure of weight, coal has about 20 to 35 MJ per kg, while natural gas has about 55 MJ/kg, and oil around 42 MJ/kg. (For comparison's sake, the amount of food that a typical weight-watching

American eats throughout the day weighs a little over a kilogram and has an energy value of about 10 MJ, or 2400 kilocalories.)

However, as will be discussed in more detail below, an electric battery typically is able to store and deliver only about 0.1 to 0.5 MJ/kg, and this is why electric batteries are problematic in transport applications: they are very heavy in relation to their energy output. Thus electric cars tend to have limited driving ranges and electric aircraft (which are quite rare) are able to carry only one or two people.

Consumers and producers are willing to pay a premium for energy resources with a higher energy density by weight; therefore it makes economic sense in some instances to convert a lower-density fuel such as coal into a higher-density fuel such as synthetic diesel, even though the conversion process entails both monetary and energy costs.

B. Volume (or Volumetric) Density

This refers to the amount of energy that can be derived from a given volume unit of an energy resource (e.g., MJ per liter).

Obviously, gaseous fuels will tend to have lower volumetric energy density than solid or liquid fuels. Natural gas has about .035 MJ per liter at sea level atmospheric pressure, and 6.2 MJ/l when pressurized to 200 atmospheres. Oil, though, can deliver about 37 MJ/l.

In most instances, weight density is more important than volume density; however, for certain applications the latter can be decisive. For example, fueling airliners with hydrogen, which has high energy density by weight, would be problematic because it is a highly diffuse gas at common temperatures and surface atmospheric pressure; indeed a hydrogen airliner would require very large tanks even if the hydrogen were super-cooled and highly pressurized.

The greater ease of transporting a fuel of higher volume density is reflected in the fact that oil moved by tanker is traded globally in large quantities, while the global tanker trade in natural gas is relatively small. Consumers and producers are willing to pay a premium for energy resources of higher volumetric density.

C. Area density

This expresses how much energy can be obtained from a given land area (e.g., an acre) when the energy resource is in its original state. For example, the area energy density of wood as it grows in a forest is roughly 1 to 5 million MJ per acre. The area grade for oil is usually tens or hundreds of millions of MJ per acre where it occurs, though oilfields are much rarer than forests (except perhaps in Saudi Arabia).

Area energy density matters because energy sources that are already highly concentrated in their original form generally require less investment and effort to be put to use. Douglas Reynolds makes the point:

> If the energy content of the resource is spread out, then it costs more to obtain the energy, because a firm has to use highly mobile extraction capital [machinery], which must be smaller and so cannot enjoy increasing returns to scale. If the energy is concentrated, then it costs less to obtain because a firm can use larger-scale immobile capital that can capture increasing returns to scale.[9]

Thus energy producers will be willing to pay an extra premium for energy resources that have high area density, such as oil that will be refined into gasoline, over ones that are more widely dispersed, such as corn that is meant to be made into ethanol.

9. Transportability

The transportability of energy is largely determined by the weight and volume density of the energy resource, as discussed above. But it is also affected by the state of the source material (assuming that it is a substance)—whether it is a solid, liquid, or gas. In general, a solid fuel is less convenient to transport than a gaseous fuel, because the latter can move by pipeline (pipelines can transport eight times the volume with a doubling of the size of the pipes). Liquids are the most convenient of all because they can likewise move through hoses and pipes, and they take up less space than gases.

Some energy sources cannot be classified as solid, liquid, or gas: they are energy fluxes. The energy from sunlight or wind cannot be directly transported; it must first be converted into a form that can—such as hydrogen or electricity.

Electricity is highly transportable, as it moves through wires, enabling it to be delivered not only to nearly every building in industrialized nations, but to many locations within each building.

Transporting energy always entails costs—whether it is the cost of hauling coal (which may account for over 70 percent of the delivered price of the fuel), the cost of building and maintaining pipelines and pumping oil or gas, or the cost of building and maintaining an electricity grid. Using the grid entails costs too, since energy is lost in transmission. These costs can be expressed in monetary terms or in energy terms, and they must also be included in calculations to determine net energy gains or losses, as we will be discussing in detail in the next section.

It is arguable that net energy should simply be presented as tenth in this list of limiting energy factors. However, we believe this factor is so important as to deserve a separate discussion.

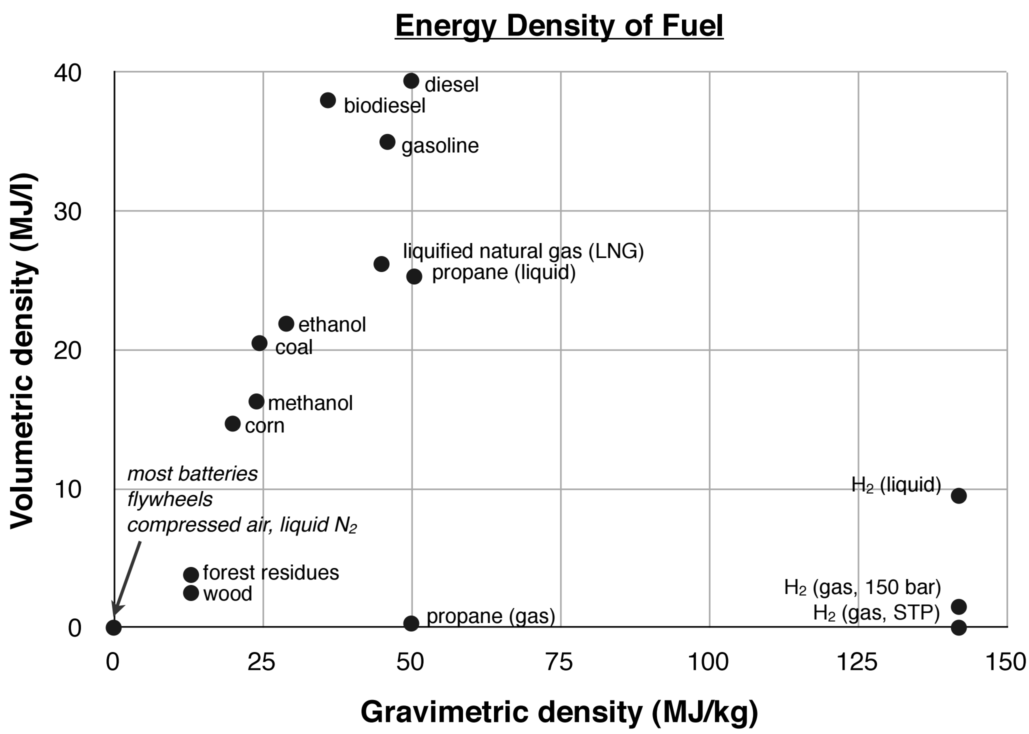


DIAGRAM 1: VOLUMETRIC AND GRAVIMETRIC DENSITY OF FUELS. *A hypothetical fuel with ideal energy density characteristics would occupy the upper right-hand corner of the diagram. Energy sources appearing in the lower left-hand corner have the worst energy density characteristics. H2 refers to hydrogen—as a super-cooled liquid, as a pressurized gas, and at "standard temperature and pressure."*

TEDDER

Possibly most promising among alternative renewable energies is windpower, already in wide use in northern Europe and parts of the U.S. "Net energy" for wind production tends to be higher than competitors, and potential future U.S. volume is substantial. A major problem is intermittency—wind does not always blow. Another is location and the need to cheaply transport the energy via power lines over long distances. Promising as it is, the total potential of wind, even combined with other alternative sources, remains below the level needed to sustain the present scale of industrial society. (See chapters two and three.)

Three

THE TENTH CRITERION: "*NET ENERGY*" (EROEI)

As already mentioned, *net energy* refers to the ratio of the amount of energy produced to the amount of energy expended to produce it. Some energy must always be invested in order to obtain any new supplies of energy, regardless of the nature of the energy resource or the technology used to obtain it. Society relies on the net energy surplus gained from energy-harvesting efforts in order to operate all of its manufacturing, distribution, and maintenance systems.

Put slightly differently, net energy means the amount of useful energy that's left over after the amount of energy invested to drill, pipe, refine, or build infrastructure (including solar panels, wind turbines, dams, nuclear reactors, or drilling rigs) has been subtracted from the total amount of energy produced from a given source. If ten units of energy are "invested" to develop additional energy sources, then one hopes for 20 units or 50 or 100 units to result. "Energy out" must exceed "energy in," by as much as possible. Net energy is what's left over that can be employed to actually do further work. It can be thought of as the "profit" from the investment of energy resources in seeking new energy.

RETURNS ON INVESTMENTS (EROEI)

The net energy concept bears an obvious resemblance to a concept familiar to every economist or businessperson—*return on investment,* or *ROI.* Every investor knows that it takes money to make money; every business manager is keenly aware of the importance of maintaining a positive ROI; and every venture capitalist appreciates the potential profitability of a venture with a high ROI. Maintaining a positive *energy return on energy invested* (EROEI) is just as important for energy producers, and for society as a whole. (Some writers, wishing to avoid redundancy, prefer the simpler EROI; but since there is a strong likelihood for some readers to assume this means *energy returned on money invested*, we prefer the longer and more awkward term). The EROEI ratio is typically expressed as production per single unit of input, so 1 serves as the denominator of the ratio (e.g., 10/1 or 10:1). Sometimes the denominator is simply assumed, so it may be noted that the EROEI of the energy source is 10—meaning, once again, that ten units of energy are yielded for every one invested in the production process. An EROEI of less than 1—for example, .5 (which might also be written as .5/1 or .5:1) would indicate that the energy being yielded from a particular source is only half as much as the amount of energy being invested in the production process. As we will see, very low net energy returns may be expected for some recently touted new energy sources like cellulosic ethanol. And as we will also see, the net energy of formerly highly productive sources such as oil, and natural gas, which used to be more than 100:1, have steadily declined to a fraction of that ratio today.

Sometimes energy return on investment (EROEI) is discussed in terms of "energy payback time"—i.e., the amount of time required before an energy-producing system (such as an array of solar panels) will need to operate in order to produce as much energy as was expended to build and install the system. This formulation makes sense for systems (such as PV panels) that require little or nothing in the way of ongoing operational and maintenance costs once the system itself is in place.

REPLACEMENT OF HUMAN ENERGY

If we think of net energy not just as it impacts a particular energy production process, but as it impacts society as a whole, the subject takes on added importance.

When the net energy produced is a large fraction of total energy produced (for example, a net energy ratio of 100:1), this means that the great majority of the total energy produced can be used for purposes other than producing more energy. A relatively small portion of societal effort needs to be dedicated to energy production, and most of society's efforts can be directed toward activities that support a range of specialized occupations not associated with energy production. This is the situation we have become accustomed to as the result of having a century of access to cheap, abundant fossil fuels—all of which offered relatively high energy-return ratios for most of the 20th century.

On the other hand, if the net energy produced is a small fraction of total energy produced (for example a ratio of 10:1 or less), this means that a relatively large portion of available energy must be dedicated to further energy production, and only a small portion of society's available energy can be directed toward other goals. This principle applies regardless of the type of energy the society relies on—whether fossil energy or wind energy or energy in the form of food crops. For example, in a society where energy (in the form of food calories) is acquired principally through labor-intensive agriculture—which yields a low and variable energy "profit"—most of the population must be involved in farming in order to provide enough energy profit to maintain a small hierarchy of full-time managers, merchants, artists, government officials, soldiers, beggars, etc., who make up the rest of the society and who spend energy rather than producing it.

HEYDAY FOR FOSSIL FUELS

In the early decades of the fossil fuel era (the late 19th century through most of the 20th century), the quantities of both total energy *and* net energy that were liberated by mining and drilling for these fuels was unprecedented. It was this sudden abundance of cheap energy that enabled the growth of industrialization, specialization, urbanization, and globalization, which have dominated the past two centuries.

In that era it took only a trivial amount of effort in exploration, drilling, or mining to obtain an enormous energy return on energy invested (EROEI). At that time, the energy industry understandably followed the best-first or "low-hanging fruit" policy for exploration and extraction. Thus the coal, oil, and gas that were highest in quality and easiest to access tended to be found and extracted preferentially. But with every passing decade the net energy (as compared to total energy) derived from fossil fuel extraction has *declined* as energy producers have had to prospect in more inconvenient places and to rely on lower-grade resources. In the early days of the U.S. oil industry, for example, a 100-to-one energy profit ratio was common, while it is now estimated that current U.S. exploration efforts are declining to an average one-to-one (break-even) energy payback rate[10].

In addition, as we will see in some detail later in this report, currently advocated alternatives to conventional fossil fuels generally have a much lower EROEI than coal, oil, or gas did in their respective heydays. For example, industrial ethanol production from corn is now estimated to have at best a 1.8:1 positive net energy balance[11]; it is therefore nearly useless as a primary energy source. (It is worth noting parenthetically that the calculation cited for ethanol may actually overstate the net energy gain of industrial ethanol because it includes the energy value of a production byproduct—distillers dried grains with solubles (DDGS), which can be fed to cattle—in the "energy out" column; but if the focus of the analysis is simply to assess the amount of energy used to produce one unit of corn ethanol, and the value of DDGS is thus disregarded, the EROEI is even lower, at 1.1, according to the same study.)

HOW EROEI SHAPES SOCIETY

As mentioned earlier, if the net energy profit available to society declines, a higher percentage of society's resources will have to be devoted directly to obtaining energy, thus increasing its cost. This means that less energy will be available for all of the activities that energy makes possible.

Net energy can be thought of in terms of the number of people in society that are required to engage in energy production, including food production. If energy returned exactly equals energy invested (EROEI = 1:1), then everyone must be involved in energy production activities and no one can be available to take care of society's other needs.

In pre-industrial societies, most of the energy collected was in the form of food energy, and most of the energy expended was in the form of muscle power (in the U.S., as recently as 1850, over 65 percent of all work being done was muscle-powered, versus less than 1 percent today, as fuel-fed machines do nearly all work). Nevertheless, exactly the same net-energy principle applied to these food-based energy systems as applies to our modern economy dominated by fuels, electricity, and machines. That is, people were harvesting energy from their environment (primarily in the form of food crops rather than fossil fuels), and that process itself required the investment of energy (primarily through the exertion of muscle power); success depended on the ability to produce more energy than was invested.

When most people were involved in energy production through growing or gathering food, societies were simpler by several measurable criteria: there were fewer specialized full-time occupations and fewer kinds of tools in use.

Archaeologist Lynn White once estimated that hunter-gatherer societies operated on a ten-to-one net energy basis (EROEI = 10:1).[12] In other words, for every unit of effort that early humans expended in hunting or wild plant gathering, they obtained an average of ten units of food energy in return. They used the surplus energy for all of the social activities (reproduction, child rearing, storytelling, and so on) that made life sustainable and rewarding.

Since hunter-gatherer societies are the simplest human groups in terms of technology and degree of social organization, 10:1 should probably be regarded as the minimum sustained average societal EROEI required for the maintenance of human existence (though groups of humans have no doubt survived for occasional periods, up to several years in duration, on much lower EROEI).

The higher complexity of early agrarian societies was funded not so much by increased EROEI as by higher levels of energy investment in the form of labor (farmers typically work more than hunters and gatherers) together with the introduction of food storage, slavery, animal domestication, and certain key tools such as the plow and the yoke. However, the transition to industrial society, which entails much greater levels of complexity, could only have been possible with both the higher total energy inputs, and the much higher EROEI, afforded by fossil fuels.

EROEI LIMITS ENERGY OPTIONS

Both renewable and non-renewable sources of energy are subject to the net energy principle. Fossil fuels become useless as energy sources when the energy required to extract them equals or exceeds the energy that can be derived from burning them.

This fact puts a physical limit to the portion of resources of coal, oil, or gas that should be categorized as reserves, since net energy will decline to the break-even point long before otherwise extractable fossil energy reserves are exhausted.

Therefore, the need for society to find replacements for fossil fuels may be more urgent than is generally recognized. Even though large amounts of fossil fuels remain to be extracted, the transition to alternative energy sources must be negotiated while there is still sufficient net energy available to continue powering society while at the same time providing energy for the transition process itself.

Net energy may have a direct effect on our ability to maintain industrial society at its present level. If the net energy for all combined energy sources declines, increasing constraints will be felt on economic growth, but also upon new adaptive strategies to deal with the current climate and energy crises. For example, any kind of adaptive energy transition will demand substantial new investments for the construction of more energy-efficient buildings and/or public transport infrastructure. However, such requirements will come at the same time that substantially more investment will be needed in energy production systems. Societies may simply be unable to adequately fund both sets of needs simultaneously. Noticeable symptoms of strain would include rising costs of bare necessities and a reduction in job opportunities in fields not associated with basic production. Supplying the energy required simply to maintain existing infrastructure, or to maintain aspects of that infrastructure deemed essential, would become increasingly challenging.

EROEI: DISTINCT FROM EFFICIENCY

The EROEI of energy *production* processes should not be confused with the efficiency of energy *conversion* processes, i.e., the conversion of energy from fossil fuel sources, or wind, etc., into useable electricity or useful work. Energy conversion is always less than 100 percent efficient—some energy is invariably wasted in the process (energy cannot be destroyed, but it can easily be dissipated so as to become useless for human purposes)—but conversion processes are nevertheless crucial in using energy. For example, in an energy system with many source inputs, common *energy carriers* are extremely helpful. Electricity is currently the dominant energy carrier, and serves this function well. It would be difficult for consumers to make practical use of coal, nuclear energy, and hydropower without electricity. But *conversion* of the original source energy of fossil fuels, uranium, or flowing water into electricity entails an energy cost. It is the objective of engineers to reduce that energy cost so as to make the conversion as efficient as possible. But if the energy source has desirable characteristics, even a relatively high conversion cost, in terms of "lost" energy, may be easily borne. Many coal power plants now in operation in the U.S. have an energy conversion efficiency of only 35 percent.

Similarly, some engines and motors are more efficient than others in terms of their ability to turn energy into work.

EROEI analysis does not focus on conversion efficiency *per se*, but instead takes into account all reasonable costs on the "energy invested" side of the ledger for energy *production* (such as the energy required for mining or drilling, and for the building of infrastructure), and then weighs that total against the amount of energy being delivered to accomplish work.

Because this report is a layperson's guide, we cannot address in any depth the technical process of calculating net energy.

NET ENERGY EVALUATION: IMPRECISE BUT ESSENTIAL FOR PLANNING

The use of net energy or EROEI as a criterion for evaluating energy sources has been criticized on several counts.[13] The primary criticism centers on the difficulty in establishing system boundaries that are agreeable to all interested parties, and that can easily be translated from analyzing one energy source to another. Moreover, the EROEI of some energy sources (such as wind, solar, and geothermal) may vary greatly according to the location of the resources versus their ultimate markets. Advances in the efficiency of supporting technology can also affect net energy. All of these factors make it difficult to calculate figures that can reliably be used in energy planning.

This difficulty only increases as the examination of energy production processes becomes more detailed: Does the office staff of a drilling company actually *need* to drive to the office to produce oil? Does the kind of car matter? Is the energy spent filing tax returns actually necessary to the manufacture of solar panels? While such energy costs are usually not included in EROEI analysis, some might argue that all such ancillary costs should be factored in, to get more of a full picture of the tradeoffs.[14]

Yet despite challenges in precisely accounting for the energy used in order to produce energy, net energy factors act as a real constraint in human society, regardless of whether we ignore them or pay close attention to them, because EROEI will determine if an energy source is able successfully to support a society of a certain size and level of complexity. Which alternative technologies have sufficiently high net energy ratios to help sustain industrial society as we have known it for the past century? Do any? Or does a combination of alternatives? Even though there is dispute as to exact figures, in situations where EROEI can be determined to be very low we can conclude that the energy source in question cannot be relied upon as a primary source to support an industrial economy.

Many criticisms of net energy analysis boil down to an insistence that other factors that limit the efficacy of energy sources should also be considered. We agree. For example, EROEI does not account for limits to *non-energy* inputs in energy production (such as water, soil, or the minerals and metals needed to produce equipment); it does not account for undesirable non-energy outputs of the energy production process—most notably, greenhouse gases; it does not account for energy quality (the fact, for example, that electricity is an inherently more versatile and useful energy delivery medium than the muscle power of horses); and it does not reflect the scalability of the energy source (recall the example of landfill gas above).

Energy returns *could* be calculated to include the use of non-energy inputs—e.g., Energy Return on *Water* Invested, or Energy Return on *Land* Invested. As net energy declines, the energy return from the investment of non-energy inputs is also likely to decline, perhaps even faster. For example, when fuel is derived from tar sands rather than from conventional oil fields, more land and water are needed as inputs; there is an equivalent situation when substituting biofuels for gasoline. Once society enters a single-digit average EROEI era, i.e., less than 10:1 energy output vs. input, a higher percentage of energy *and* non-energy resources (water, labor, land, and so on) will have to be devoted to energy production. This is relevant to the discussion of biofuels and similar low energy-gain technologies. At first consideration, they may seem better than fossil fuels since they are produced from renewable sources, but they use non-renewable energy inputs that have a declining net yield (as higher-quality resources are depleted). They may require large amounts of land, water, and fertilizer; and they often entail environmental damage (as fossil fuels themselves do). All proposed new sources of energy should be evaluated in a framework that considers these other factors (energy return on water, land, labor, etc.) as well as net energy.[15] Or, conceivably, a new multi-faceted EROEI could be devised.

In any case, while net energy is not the only important criterion for assessing a potential energy source, this is not a valid reason to ignore it. EROEI is a necessary—though not a complete—basis for evaluating energy sources. It is one of *five* criteria that we believe should be regarded as having make-or-break status. The other critical criteria, already discussed in Part I. above, are: renewability, environmental impact, size of the resource, and the need for ancillary resources and materials. If a potential energy source cannot score well with all five of these criteria, it cannot realistically be considered as a future primary energy source. Stated the other way around, a potential primary energy source can be disqualified by doing very poorly with regard to just one of these five criteria.

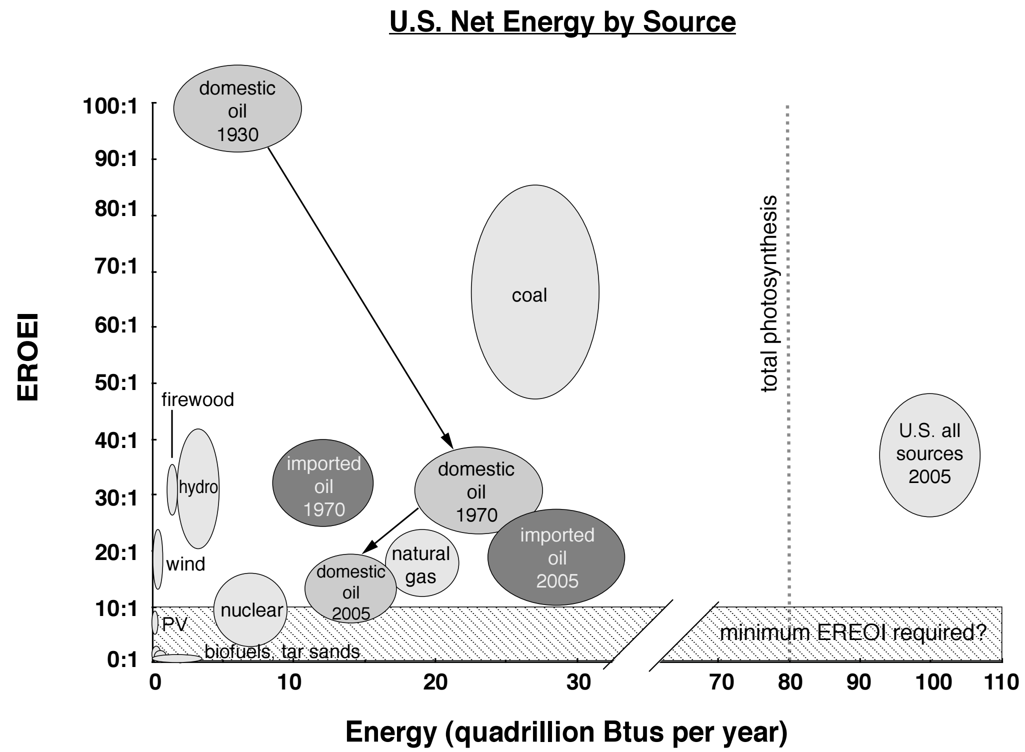


DIAGRAM 2: THE NET ENERGY (AND MAGNITUDE OF CONTRIBUTION) OF U.S. ENERGY SOURCES

This "balloon graph" of U.S. energy supplies developed by Charles Hall, Syracuse University, represents net energy (vertical axis) and quantity used (horizontal axis) of various energy sources at various times. Arrows show the evolution of domestic oil in terms of EROEI and quantity produced (in 1930, 1970, and 2005), illustrating the historic decline of EROEI for U.S. domestic oil. A similar track for imported oil is also shown. The size of each "balloon" represents the uncertainty associated with EROEI estimates. For example, natural gas has an EROEI estimated at between 10:1 and 20:1 and yields nearly 20 quadrillion Btus (or 20 exajoules). "Total photosynthesis" refers to the total amount of solar energy captured annually by all the green plants in the U.S. including forests, food crops, lawns, etc. (note that the U.S. consumed significantly more than this amount in 2005). The total amount of energy consumed in the U.S. in 2005 was about 100 quadrillion Btus, or 100 exajoules; the average EROEI for all energy provided was between 25:1 and 45:1 (with allowance for uncertainty). The shaded area at the bottom of the graph represents the estimated minimum EROEI required to sustain modern industrial society: Charles Hall suggests 5:1 as a minimum, though the figure may well be in the range of 10:1.[16]

RODRIGO BUENDIA/AFP/GETTY IMAGES

In the Ecuadorian and Peruvian Amazon, indigenous people such as the Achuar, are routinely confronted with oil spills in rivers (such as this one), and runoffs into lakes and forests; pipelines shoved through traditional lands, oil fires, gas excursions, waste dumping, smoke, haze and other pollutants as daily occurrences, leading to very high cancer rates, and community breakdowns similar to those in the Niger delta, Indonesia and elsewhere. Achuar communities have been massively protesting, and recently successful lawsuits against Chevron and Texaco have made international headlines.

USAF ARCHIVES

This giant photovoltaic array—70,000 panels on 140 acres of Nellis Airforce base in Nevada—leads sci-fi types to fantasize much larger arrays in space, or mid-ocean, but solar comes in all sizes. Other kinds of systems include "concentrating solar thermal" and passive solar, as used in many private homes. With sunlight as the resource, planetary supply is unlimited. But, it's intermittent on cloudy days, and often seasonally, reducing its reliability as a large scale primary energy, compared to operator-controlled systems like coal, gas, or nuclear. Other limits include materials costs and shortages and relatively low "net energy" ratios.

Four

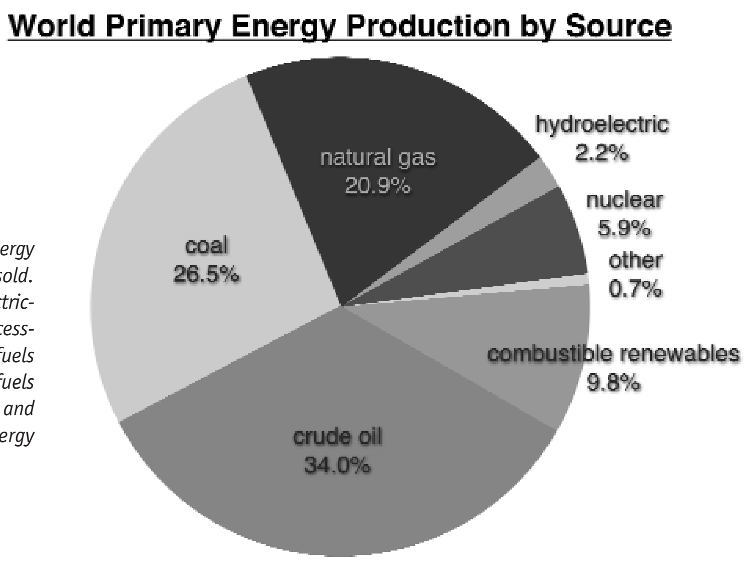
ASSESSING & COMPARING EIGHTEEN ENERGY SOURCES

IN THIS CHAPTER, we will discuss and compare in further detail key attributes, both positive and negative, of eighteen specific energy sources. The data on net energy (EROEI) for most of these are drawn largely from the work of Dr. Charles Hall, who, together with his students at the State University of New York in Syracuse, has for many years been at the forefront of developing and applying the methodology for calculating energy return ratios.[17]

We will begin by considering presently dominant energy sources, case-by-case, including oil, coal, and gas so that comparisons can be made with their potential replacements. After fossil fuels we will explore the prospects for various non-fossil sources. Altogether, eighteen energy sources are discussed in this section, listed approximately in the order of the size of their current contribution to world energy supply.

DIAGRAM 3: WORLD PRIMARY ENERGY PRODUCTION BY SOURCE.

This chart refers to commercial energy sources, produced to be bought and sold. This includes transportation fuels, electricity, and energy used in industrial processes, but not traditional or distributed fuels like firewood or off-grid PV. 'Other' fuels include commercial geothermal, wind and photovoltaic power. Source: Energy Information Administration[18].



1. OIL

ANACORTES REFINERY WALTER SIEGMUND

As the world's current largest energy source, oil fuels nearly all global transportation—cars, planes, trains, and ships. (The exceptions, such as electric cars, subways and trains, and sailing ships, make up a statistically insignificant portion of all transport). Petroleum provides about 34 percent of total world energy, or about 181 EJ per year. The world currently uses about 75 million barrels of crude oil per day, or 27 billion barrels per year[19], and reserves amount to about one trillion barrels (though the figure is disputed).

PLUS: Petroleum has become so widely relied upon because of several of its most basic characteristics: It is highly transportable as a liquid at room temperature and is easily stored. And it is energy dense—a liter of oil packs 38 MJ of chemical energy, as much energy as is expended by a person working two weeks of 10-hour days.[20]

Historically, oil has been cheap to produce, and can be procured from a very small land footprint.

MINUS: Oil's downsides are as plain as its advantages.

Its negative environmental impacts are massive. Extraction is especially damaging in poorer nations such as Ecuador, Peru, and Nigeria, where the industry tends to spend minimally on the kinds of remediation efforts that are required by law in the U.S.; as a result, rivers and wetlands are poisoned, air is polluted, and indigenous people see their ways of life devastated.

Meanwhile, burning oil releases climate-changing carbon dioxide (about 800 to 1000 lbs of CO_2 per barrel[21], or 70 kg of CO_2 per GJ), as well as other pollutants such as nitrogen oxides and particulates.

Most importantly, oil is non-renewable, and many of the world's largest oilfields are already significantly depleted. Most oil-producing nations are seeing declining rates of extraction, and future sources of the fuel are increasingly concentrated in just a few countries—principally, the members of the Organization of Petroleum Exporting Countries (OPEC). The geographic scarcity of oil deposits has led to competition for supplies, and sometimes to war over access to the resource. As oil becomes scarcer due to depletion, we can anticipate even worse oil wars.[22]

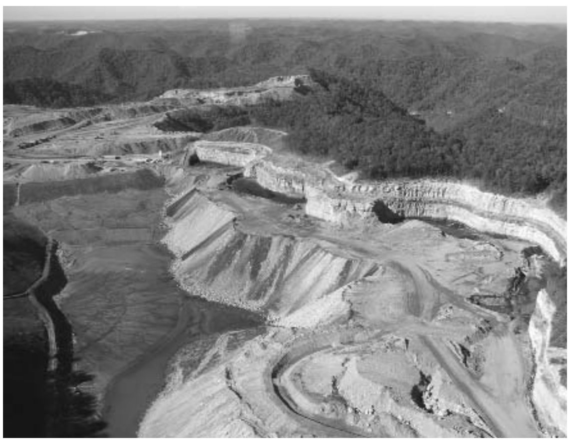
EROEI: The net energy (compared to gross energy) from global oil production is difficult to ascertain precisely, because many of the major producing nations do not readily divulge statistics that would make detailed calculations possible. About 750 joules of energy are required to lift 15 kg of oil 5 meters—an absolute minimum energy investment for pumping oil that no longer simply flows out of the ground under pressure (though much of the world's oil still does). But energy is also expended in exploration, drilling, refining, and so on. An approximate total number can be derived by dividing the energy produced by the global oil industry by *the energy equivalent of the dollars spent* by the oil industry for exploration and production (this is a rough calculation of the amount of energy used in the economy to produce a dollar's worth of goods and services). According to Charles Hall, this number—for oil and gas together—was about 23:1 in 1992, increased to about 32:1 in 1999, and has since declined steadily, reaching 19:1 in 2005. If the recent trajectory is projected forward, the EROEI for global oil and gas would decline to 10:1 soon after 2010. Hall and associates find that for the U.S. (a nation whose oil industry investments and oil production statistics are fairly transparent), EROEI at the wellhead was roughly 26:1 in 1992, increased to 35:1 in 1999, and then declined to 18:1 in 2006.[23]

It is important to remember that Hall's 19:1 estimate for the world as a whole is an average: some producers enjoy much higher net energy gains than others. There are good reasons to assume that most of the high-EROEI oil producers are OPEC-member nations.

PROSPECTS: As mentioned, oil production is in decline in most producing countries, and nearly all the world's largest oilfields are seeing falling production. The all-time peak of global oil production probably occurred in July, 2008 at 75 million barrels per day.[24] At the time, the per-barrel price had skyrocketed to its all-time high of $147. Since then, declining demand and falling price have led producing nations to cut back on pumping. Declining price has also led to a significant slowing of investment in exploration and production, which virtually guarantees production shortfalls in the future. It therefore seems unlikely that the July 2008 rate of production will ever be exceeded.

Declining EROEI and limits to global oil production will therefore constrain future world economic activity unless alternatives to oil can be found and brought on line extremely rapidly.

2. COAL


VIVIAN STOCKMAN/OHIO VALLEY ENVIRONMENTAL COALITION

The Industrial Revolution was largely made possible by energy from coal. In addition to being the primary fuel for expanding manufacturing, it was also used for space heating and cooking. Today, most coal is burned for the production of electricity and for making steel.

Coal has been the fastest-growing energy source (by quantity) in recent years due to prodigious consumption growth in China, which is by far the world's foremost producer and user of the fuel. The world's principal coal deposits are located in the U.S., Russia, India, China, Australia, and South Africa. World coal reserves are estimated at 850 billion metric tons (though this figure is disputed), with annual production running at just over four billion tons. Coal produces 134.6 EJ annually, or 27 percent of total world energy. The U.S. relies on coal for 49 percent of its electricity and 23 percent of total energy.[25]

Coal's energy density by weight is highly variable (from 30 MJ/kg for high-quality anthracite to as little as 5.5 MJ/kg for lignite).

PLUS: Coal currently is a cheap, reliable fuel for the production of electricity. It is easily stored, though bulky. It is transportable by train and ship (transport by truck for long distances is rarely feasible from an energy and economic point of view).

MINUS: Coal has the worst environmental impacts of any of the conventional fossil fuels, both in the process of obtaining the fuel (mining) and in that of burning it to release energy. Because coal is the most carbon-intensive of the conventional fossil fuels (94 kg of CO_2 are emitted for every GJ of energy produced), it is the primary source of greenhouse gas emissions leading to climate change, even though it contributes less energy to the world economy than petroleum does.

Coal is non-renewable, and some nations (U.K. and Germany) have already used up most of their original coal reserves. Even the U.S., the "Saudi Arabia of coal," is seeing declining production from its highest-quality deposits.

EROEI: In the early 20th century, the net energy from U.S. coal was very high, at an average of 177:1 according to one study[26], but it has fallen substantially to a range of 50:1 to 85:1. Moreover, the decline is continuing, with one estimate suggesting that by 2040 the EROEI for U.S. coal will be 0.5:1[27].

PROSPECTS: While official reserves figures imply that world coal supplies will be sufficient for a century or more, recent studies suggest that supply limits may appear globally, and especially regionally, much sooner. According to a 2007 study by Energy Watch Group of Germany, world coal production is likely to peak around 2025 or 2030, with a gradual decline thereafter. China's production peak could come sooner if economic growth (and hence energy demand growth) returns soon. For the U.S., coal production may peak in the period 2030 to 2035.

New coal technologies such as carbon capture and storage (CCS) could theoretically reduce the climate impact of coal, but at a significant economic and energy cost (by one estimate, up to 40 percent of the energy from coal would go toward mitigating climate impact, with the other 60 percent being available for economically useful work; there would also be an environmental cost from damage due to additional mining required to produce the extra coal needed to make up for the energy costs from CCS). [28]

Coal prices increased substantially in 2007-2008 as the global economy heated up, which suggests that the existing global coal supply system was then near its limit. Prices have declined sharply since then as a result of the world economic crisis and falling energy demand. However, prices for coal will almost certainly increase in the future, in inflation- or deflation-adjusted terms, as high-quality deposits are exhausted and when energy demand recovers from its lowered level due to the current recession.

3. NATURAL GAS

GAS FLARE AT NATURAL GAS PLANT ISTOCK

Formed by geological processes similar to those that produced oil, natural gas often occurs together with liquid petroleum. In the early years of the oil industry, gas was simply flared (burned at the wellhead); today, it is regarded as a valuable energy resource and is used globally for space heating and cooking; it also has many industrial uses where high temperatures are needed, and it is increasingly burned to generate electricity. Of the world's total energy, natural gas supplies 25 percent; global reserves amount to about 6300 trillion cubic feet, which represents an amount of energy equivalent to 890 billion barrels of oil.[29]

PLUS: Natural gas is the least carbon-intensive of the fossil fuels (about 53 kg CO_2 per GJ). Like oil, natural gas is energy dense (more so by weight than by volume), and is extracted from a small land footprint. It is easily transported through systems of pipelines and pumps, though it cannot be transported by ship as conveniently as oil, as this typically requires pressurization at very low temperatures.

MINUS: Natural gas is a hydrocarbon fuel, which means that burning it releases CO_2 even if the amounts are less than would be the case to yield a similar amount of energy from coal or oil. Like oil, natural gas is non-renewable and depleting. Environmental impacts from the production of natural gas are similar to those with oil. Recent disputes between Russia, Ukraine, and Europe over Russian natural gas supplies underscore the increasing geopolitical competition for access to this valuable resource. International transport and trade of liquefied natural gas (LNG) entails siting and building offloading terminals that can be extremely hazardous.

EROEI: The net energy of global natural gas is even more difficult to calculate than that of oil, because oil and gas statistics are often aggregated. A recent study that incorporates both direct energy (diesel fuel used in drilling and completing a well) and indirect energy (used to produce materials like steel and cement consumed in the drilling process) found that as of 2005, the EROEI for U.S. gas fields was 10:1.[30] However, newer "unconventional" natural gas extraction technologies (coal-bed methane and production from low-porosity reservoirs using "fracing" technology) probably have significantly lower net energy yields: the technology itself is more energy-intensive to produce and use, and the wells deplete quickly, thus requiring increased drilling rates to yield equivalent amounts of gas. Thus as conventional gas depletes and unconventional gas makes up a greater share of total production, the EROEI of natural gas production in North America will decline, possibly dramatically.

PROSPECTS: During the past few years, North America has averted a natural gas supply crisis as a result of the deployment of new production technologies, but it is unclear how long the reprieve will last given the (presumably) low EROEI of these production techniques and the fact that the best unconventional deposits, such as the Barnett shales of Texas, are being exploited first. European gas production is declining and Europe's reliance on Russian gas is increasing—but it is difficult to tell how long Russia can maintain current flow rates.

In short, while natural gas has fewer environmental impacts than the other fossil fuels, especially coal, its future is clouded by supply issues and declining EROEI.

4. HYDROPOWER

RIO PARANAIBA DAM, PORTUGAL

MURILOIF

Hydropower is electric current produced from the kinetic energy of flowing water. Water's gravitational energy is relatively easily captured, and relatively easily stored behind a dam. Hydro projects may be enormous (as with China's Three Gorges Dam) or very small ("microhydro") in scale. Large projects typically involve a dam, a reservoir, tunnels, and turbines; small-scale projects usually simply employ the "run of the river," harnessing energy from a river's natural flow, without water storage.

Hydropower currently provides 2,894 Terawatt hours (TWh) of electricity annually worldwide, and about 264 TWh in the U.S.; of all *electrical* energy, hydropower supplies 19 percent worldwide (with 15 percent coming from large hydropower), and 6.5 percent in the U.S. This represents 6 percent of total energy globally and 3 percent nationally.[31]

PLUS: Unlike fossil energy sources, with hydropower most energy and financial investment occurs during project construction, while very little is required for maintenance and operations. Therefore electricity from hydro is generally cheaper than electricity from other sources, which may cost two to three times as much to generate.

MINUS: Energy analysts and environmentalists are divided on the environmental impacts of hydropower. Proponents of hydropower see it as a clean, renewable source of energy with only moderate environmental or social impacts. Detractors of hydropower see it as having environmental impacts as large as, or larger than, those of some conventional fossil fuels. Global impacts include carbon emissions primarily during dam and reservoir construction and methane releases from the drowned vegetation. Regional impacts result from reservoir creation, dam construction, water quality changes, and destruction of native habitat. The amount of carbon emissions produced is very site-specific and substantially lower than from fossil fuel sources. Much of the debate about hydropower centers on its effects on society, and whether or not a constant supply of water for power, irrigation, or drinking justifies the occasional requirement to relocate millions of people. Altogether, large dam and reservoir construction projects have required relocations of about 40 to 80 million people during the last century. Dam failure or collapse is also a risk in some cases, especially in China.

EROEI: Hydropower's EROEI ranges roughly from 11.2:1 to 267:1, varying enormously by site. Because hydropower is such a variable resource, used in many different geographical conditions and involving various technologies, one generalized EROEI ratio cannot describe all projects. The EROEI for favorable or even moderate sites can be extremely high, even where environmental and social impacts are severe.

PROSPECTS: Globally, there are many undeveloped dam sites with hydropower potential, though there are few in the U.S., where most of the best sites have already been developed. Theoretically, hydropower could be accessible at some level to any population near a constant supply of flowing water.

The International Hydropower Association estimates that about one-third of the realistic potential of world hydropower has been developed. In practice, the low direct investment cost of fossil fuels, combined with the environmental and social consequences of dams, have meant that fossil fuel-powered projects are much more common.

Dams have the potential to produce a moderate amount of additional, high-quality electricity in less-industrialized countries, but continue to be associated with extremely high environmental and social costs. Many authors see "run-of-river" hydropower (in which dams are not constructed) as the alternative future, because this does away with the need for massive relocation projects, minimizes the impacts on fish and wildlife, and does not release greenhouse gases (because there is generally no reservoir), while it retains the benefits of a clean, renewable, cheap source of energy. However, the relatively low power density of this approach limits its potential.

5. NUCLEAR

Electricity from controlled nuclear fission reactions has long been a highly contentious source of energy. Currently, 439 commercial power-generating reactors are operating worldwide, 104 of them in the U.S. Collectively they produced 2,658 TWh world-wide in 2006, and 806 TWh in the U.S. This represents about 6 percent of world energy, 8 percent of all energy consumed in the U.S., and 19 percent of U.S. electricity.[32]

All commercial reactors in the U.S. are variants of light water reactors. Other designs continue to be subjects of research.

PLUS: Nuclear electricity is reliable and relatively cheap (with an average generating cost of 2.9 cents per kW/h) once the reactor is in place and operating. In the U.S., while no new nuclear power plants have been built in many years, the amount of nuclear electricity provided has grown during the past decade due to the increased efficiency and reliability of existing reactors.

The nuclear cycle emits much less CO_2 than the burning of coal to produce an equivalent amount of energy (though it is important to add that uranium mining and enrichment, and plant construction, still entail considerable carbon emissions). This reduced CO_2 emission rate has led some climate protection spokespeople to favor nuclear power, at least as a temporary bridge to an "all-renewable" energy future.

MINUS: Uranium, the fuel for the nuclear cycle, is a *not* a renewable resource. The peak of world uranium production is likely to occur between 2040 and 2050[33], which means that nuclear fuel is likely to become more scarce and expensive during the next few decades. Already, the average grade of uranium ore mined has declined substantially in recent years as the best reserves have been depleted. Recycling of fuel and the employment of alternative nuclear fuels are possible, but the needed technology has not been adequately developed.

Nuclear power plants are extremely costly to build, so much so that unsubsidized nuclear plants are not economically competitive with similar-sized fossil-fuel plants. Government subsidies in the U.S. include: *(1)* those from the military nuclear industry, *(2)* non-military government subsidies, and *(3)* artificially low insurance costs. New power plants also typically entail many years of delay for design, financing, permitting, and construction.

The nuclear fuel cycle also brings substantial environmental impacts, which may be even greater during the mining and processing stages than during plant operation even when radiation-releasing accidents are taken into account. Mining entails ecosystem removal, the release of dust, the production of large amounts of tailings (equivalent to 100 to 1,000 times the quantity of uranium extracted), and the leaching of radiation-emitting particles into groundwater. During plant operation, accidents causing small to large releases of radiation can impact the local environment or much larger geographic areas, potentially making land uninhabitable (as occurred with the explosion and radiation leakage in the Chernobyl reactor in the former Soviet Union in 1986).

Storage of radioactive waste is also highly problematic. High-level waste (like spent fuel) is much more radioactive and difficult to deal with than low-level waste, and must be stored onsite for several years before transferal to a geological repository.

So far, the best-known way to deal with waste, which contains doses of radiation lethal for thousands of years, is to store it in a geological repository, deep underground. The long-proposed site at Yucca Mountain in Nevada, the only site that has been investigated as a repository in the U.S., has recently been canceled. Even if the Yucca Mountain site had gone ahead, it would not have been sufficient to store the U.S. waste already awaiting permanent storage. More candidate repository sites will need to be identified soon if the use of nuclear power is to be expanded in the U.S. Even in the case of ideal sites, over thousands of years waste could leak into the water table. The issue is controversial even after extremely expensive and extensive analyses by the Department of Energy.

Nearly all commercial reactors use water as a coolant. As water cools the reactor, the water itself becomes warmed. When heated water is then discharged back into lakes, rivers, or oceans the resultant heat pollution can disrupt aquatic habitats.

During the 2003 heat wave in France, several nuclear plants were shut because the river water was too hot. And in recent years, a few reactors have had to be shut down due to water shortages, highlighting a future vulnerability of this technology in a world where over-use of water and extreme droughts from climate change are becoming more common.

Reactors must not be sited in earthquake-prone regions due to the potential for catastrophic radiation release in the event of a serious quake. Nuclear reactors are often cited as potential terrorist targets and as potential sources of radioactive materials for the production of terrorist "dirty bombs."

EROEI: A review by Charles Hall *et al.*[34] of net energy studies of nuclear power that have been published to date found the information to be "idiosyncratic, prejudiced, and poorly documented." The largest issue is determining what the appropriate boundaries of analysis should be. The review concluded that the most reliable EROEI information is quite old (showing results in the range of 5 to 8:1), while newer information is either highly optimistic (15:1 or more) or pessimistic (low, even less than 1:1). An early study cited by Hall indicated that the high energy inputs during the construction phase are one of the major reasons for the low EROEI—which also means there are substantial greenhouse gas (GHG) emissions during construction.


NUCLEAR WASTE STORAGE FACILITY, YUCCA MT, NEVADA M.KNIAZKOV/GETTY IMAGES

PROSPECTS: The nuclear power industry is set to grow, with ten to twenty new power plants being considered in the U.S. alone. But the scale of growth is likely to be constrained mostly for reasons discussed above.

Hopes for a large-scale deployment of new nuclear plants rest on the development of new technologies: pebble-bed and modular reactors, fuel recycling, and the use of thorium as a fuel. The ultimate technological breakthrough for nuclear power would be the development of a commercial fusion reactor. However, each of these new technologies is problematic for some reason. Fusion is still decades away and will require much costly research. The technology to extract useful energy from thorium is highly promising, but will require many years and expensive research and development to commercialize. The only breeder reactors in existence are either closed, soon to be closed, abandoned, or awaiting re-opening after serious accidents. Examples of problematic breeders include BN-600 (in Russia, which will end its life by 2010); Clinch River Breeder Reactor (in the U.S., construction abandoned in 1982 because the U.S. halted its spent-fuel reprocessing program thus making breeders pointless); Monju (in Japan, being brought online again after a serious sodium leak and fire in 1995); and Superphénix (in France, closed in 1998). Therefore, realistically, nuclear power plants constructed in the short and medium term can only be incrementally different from current designs.

In order for the nuclear industry to grow sufficiently so as to replace a significant portion of energy now derived from fossil fuels, scores if not hundreds of new plants would be required, and soon. Given the expense, long lead-time entailed in plant construction, and safety issues, the industry may do well merely to build enough new plants to replace old ones that are nearing their retirement and decommissioning.

Hall *et al.* end their review of nuclear power by stating: "In our opinion we need a very high-level series of analyses to review all of these issues. Even if this is done, it seems extremely likely that very strong opinions, both positive and negative, shall remain. There may be no resolution to the nuclear question that will be politically viable."

6. BIOMASS

BEDOUIN COOKING, EYGPT

ISTOCK

Consisting of wood and other kinds of plant materials, as well as animal dung, various forms of biomass still account annually for about 13 percent of the world's total energy consumption and are used by up to 3 billion people for cooking and heating.[35] (Note: Most official comparative tallies of energy from various sources, such as those from the IEA and EIA, omit the contribution of "traditional" or noncommercial biomass usage; since these official sources are cited repeatedly herein, the careful reader will find that adding the 13 percent contribution of biomass to the percentage figures for other energy sources yields a total that is greater than 100 percent. The only remedy for this in the present text would have been the re-calculation of statistics from the official sources, but that would merely have added a different potential source of confusion.)

Nontraditional "new" forms of biomass usage generally involve converting wood, crops, manures, or agricultural "waste" products into liquid or gaseous fuel (see ethanol and biodiesel, below), using it to generate electricity, or using it to cogenerate heat and electricity. World electric power generation from biomass was about 183 TWh in 2005 from an installed capacity of 40 GW, with 27 percent of this coming from biogas and municipal solid waste.[36]

Wood fuels presently account for 60 percent of global forest production (most of the remaining 40 percent is used for building materials and paper) and, along with agricultural residues (such as straw), contribute 220 GWh for cooking and heating energy. Forests are a huge renewable resource, covering 7 percent of the Earth's surface, but net deforestation is occurring around the globe, especially in South America, Indonesia, and Africa.[37] Deforestation is caused mostly by commercial logging and clearing of land for large-scale agriculture, *not* by traditional wood gathering, which is often sustainably practiced. However, in many areas wood use and population pressure are leading to deforestation and even desertification.

Cogeneration or Combined Heat and Power (CHP) plants can burn fossil fuels or biomass to make electricity and are configured so that the heat from this process is not wasted but used for space or water heating. Biomass CHP is more efficient at producing heat than electricity, but can be practical on both counts if there is a local source of excess biomass and a community or industrial demand nearby for heat and electricity. Biomass plants are being built in the U.S., in northern Europe, and also in Brazil (where they are associated with the sugar processing industry). The rate of growth of biopower has been around 5 percent per year over the last decade.[38] Biomass power plants are only half as efficient as natural gas plants and are limited in size by a fuelshed of around 100 miles, but they provide rural jobs and reliable base-load power (though in temperate climates biomass availability is seasonal, and biomass storage is particularly inefficient with high rates of loss).[39]

Biomass conversion technologies (as opposed to direct use via burning) can be divided into three categories. *Biochemical* methods use fermentation and decomposition to create alcohols (primarily ethanol) and landfill gas. Oil extracted from plants, animals or algae can be converted *chemically* into biodiesel. In *thermochemical* processes, biomass is heated (pyrolized) and broken down into carbon and flammable syngases or bio-oil (depending on the speed and temperature of pyrolysis and the feedstock). Bio-oil can be used like fuel oil or refined into biodiesel, while syngas has properties similar to natural gas. There is growing interest in using thermochemical processes to make biofuels, since the leftover carbon (called biochar) can be added to farm fields to improve soil fertility and sequester carbon.[40]

The biochemical process of decay in the absence of oxygen produces biogas, which occurs naturally in places where anaerobic decay is concentrated, like swamps, landfills, or cows' digestive systems. Industrial manufacture of biogas uses bacteria to ferment or anaerobically digest biodegradable material, producing a combustible mixture consisting of 50 to 75 percent methane plus other gases.[41] Biogas can be used like natural gas and burned as fuel in anything from a small cookstove to an electricity plant. Small-scale biogas is utilized all over the world, both in households and for industry.

Biogas can be produced on an industrial scale from waste materials, but it is difficult to find estimates of the possible size of this resource. The National Grid in the U.K. has suggested that waste methane can be collected, cleaned and added to the existing U.K. natural gas pipeline system. That agency estimates that if all the country's sewage, food, agriculture and manufacturing biowastes were used, half of all U.K. residential gas needs could be met. Burning biogas for heat and cooking offers 90 percent energy conversion efficiency, while using biogas to generate electricity is only 30 percent efficient.[42]

PLUS: Biomass is distributed widely where people live. This makes it well suited for use in small-scale, region-appropriate applications where using local biomass is sustainable. In Europe there has been steady growth in biomass CHP plants in which scrap materials from wood processing or agriculture are burned, while in developing countries CHP plants are often run on coconut or rice husks. In California, dairy farms are using methane from cow manure to run their operations. Biogas is used extensively in China for industry, and 25 million households worldwide use biogas for cooking and lighting.[43]

Burning biomass and biogas is considered to be carbon neutral, since unlike fossil fuels these operate within the biospheric carbon cycle. Biomass contains carbon that would ordinarily be released naturally by decomposition or burning to the atmosphere over a short period of time. Using waste sources of biogas like cow manure or landfill gas reduces emissions of methane, a greenhouse gas twenty-three times more potent than carbon dioxide.

MINUS: Biomass is a renewable resource but not a particularly expandable one. Often, available biomass is a waste product of other human activities, such as crop residues from agriculture, wood chips, sawdust and black liquor from wood products industries, and solid waste from municipal trash and sewage. In a less energy-intensive agricultural system, such as may be required globally in the future, crop residues may be needed to replenish soil fertility and will no longer be available for power generation. There may also be more competition for waste products in the future, as manufacturing from recycled materials increases.

Using biomass for cooking food has contributed to deforestation in many parts of the world and it is associated with poor health and shortened lifespans, especially for women who cook with wood or charcoal in unvented spaces. Finding a substitute fuel or increasing the efficiency of cooking with wood is the goal of programs in India, China and Africa.[44] In order to reduce greenhouse gas emissions, it is probably more desirable to re-forest than to use wood as fuel.

EROEI: Energy return estimates for biomass are extremely variable. Biomass is generally more efficiently used for heat than for electricity, but electricity generation from biomass can be energetically favorable in some instances. Biogas is usually made from waste materials and utilizes decomposition, which is a low energy-input process, so it is inherently efficient. Regarding the EROEI of ethanol and biodiesel, see below.

PROSPECTS: Wood, charcoal, and agricultural residues will almost certainly continue to be used around the world for cooking and heating. There is a declining amount of biomass-derived materials entering the waste stream because of increased recycling, so the prospect of expanding landfill methane capture is declining. Use of other kinds of biogas is a potential growth area. Policies that support biogas expansion exist in India and especially in China, where there is a target of increasing the number of household-scale biogas digesters from an estimated 1 million in 2006 to 45 million by 2020.

7. WIND POWER

TRADITIONAL WINDMILL IN THE NETHERLANDS / QUISTNIX

One of the fastest-growing energy sources in the world, wind power generation expanded more than five-fold between 2000 and 2007. However, it still accounts for less than 1 percent of the world's electricity generation, and much less than 1 percent of total energy. In the U.S., total production currently amounts to 32Twh, which is 0.77 percent of total electricity supplied, or 0.4 percent of total energy.

Of all new electricity generation capacity installed in the U.S. during 2007 (over 5,200 MW), more than 35 percent came from wind. U.S. wind energy production has doubled in just two years. In September 2008, the U.S. surpassed Germany to become the world leader in wind energy production, with more than 25,000 MW of total generating capacity. [45] (Note: In discussing wind power, it is important to distinguish between nameplate production capacity—the amount of power that theoretically could be generated at full utilization—and the actual power produced: the former number is always much larger, because winds are intermittent and variable.)

Wind turbine technology has advanced in recent years, with the capacity of the largest turbines growing from 1 MW in 1999 to up to 5 MW today. The nations currently leading in installed wind generation capacity are the United States, Germany, Spain, India, and China. Wind power currently accounts for about 19 percent of electricity produced in Denmark, 9 percent in Spain and Portugal, and 6 percent in Germany and the Republic of Ireland. In 2007-2008 wind became the fastest-growing energy source in Europe, in quantitative as well as percentage terms.

PLUS: Wind power is a renewable source of energy, and there is enormous potential for growth in wind generation: it has been estimated that developing 20 percent of the world's wind-rich sites would produce seven times the current world electricity demand.[46] The cost of electricity from wind power, which is relatively low, has been declining further in recent years. In the U.S. as of 2006, the cost per unit of energy production capacity was estimated to be comparable to the cost of new generating capacity for coal and natural gas: wind cost was estimated at $55.80 per MWh, coal at $53.10/MWh, and natural gas at $52.50 (however, once again it is important with wind power to stress the difference between nameplate production capacity and actual energy produced).[47]

MINUS: The uncontrolled, intermittent nature of wind reduces its value when compared to operator-controlled energy sources such as coal, gas, or nuclear power. For example, during January 2009 a high pressure system over Britain resulted in very low wind speeds combined with unusually low temperatures (and therefore higher than normal electricity demand). The only way for utility operators to prepare for such a situation is to build extra generation capacity from other energy sources. Therefore, adding new wind generating capacity often does not substantially decrease the need for coal, gas, or nuclear power plants; it merely enables those conventional power plants to be used less while the wind is blowing. However, this creates the need for load-balancing grid control systems.

Another major problem for wind generation is that the resource base is often in remote locations. Getting the electricity from the local point-of-generation to a potentially distant load center can be costly. The remoteness of the wind resource base also leads to increased costs for development in the case of land with difficult terrain or that is far from transportation infrastructure.

Being spread out over a significant land area, wind plants must compete with alternative development ideas for these land resources, especially where multiple simultaneous usages are impossible.

The dramatic cost reductions in the manufacture of new wind turbines over the past two decades may slow as efficiencies are maximized and as materials costs increase.

Though wind turbines have been generally accepted by most communities, there has been concern about "visual pollution" and the turbines' danger to birds.

EROEI: The average EROEI from all studies worldwide (operational and conceptual) was 24.6:1. The average EROEI from just the operational studies is 18.1:1. This compares favorably with conventional power generation technologies.[48]

In the U.S., existing wind power has a high EROEI (18:1), though problems with electricity storage may reduce this figure substantially as generating capacity grows. EROEI generally increases with the power rating of the turbine, because *(1)* smaller turbines represent older, less efficient technologies; *(2)* larger turbines have a greater rotor diameter and swept area, which is the most important determinant of a turbine's potential to generate power; and *(3)* since the power available from wind increases by the cube of an increase in the wind speed, and larger turbines can extract energy from winds at greater heights, wind speed and thus EROEI increase quickly with the height of the turbine.

The net energy ratio for wind power can range widely depending on the location of a turbine's manufacture and installation, due to differences in the energy used for transportation of manufactured turbines between countries, the countries' economic and energy structure, and recycling policies. For example, production and operation of an E-40 turbine in coastal Germany requires 1.39 times more energy than in Brazil. The EROEI for sea-based turbines is likely to be lower due to maintenance needs resulting from the corrosive effects of sea spray.

PROSPECTS: Wind is already a competitive source of power. For structural reasons (its long-term cost of production is set by financing terms upon construction and does not vary in the short term), wind benefits from *feed-in tariffs* to protect it from short-term electricity price fluctuations; but overall it will be one of the cheapest sources of power as fossil fuels dwindle—and one with a price guaranteed not to increase over time. In the E.U. its penetration is already reaching 10 to 25 percent in several nations; prospects in the U.S. are in some ways better, as growth is not limited by the geographical constraints and population density found in Europe (with more land covered by cities, that leaves fewer good sites for turbines).

Intermittency can be dealt with to some extent, as the European experience shows, by a combination of smart grid management and infrequent use of the existing fossil-fuel-fired capacity; even though a large amount of thermal power generation capacity will still be required, less coal and gas will need to be burned. Nevertheless, until windmill power can mine ores, produce cement, and make steel and alloys and the machine tools to make components, then wind turbine costs are going to be highly connected to fossil fuel prices, and those costs will impact power prices.

In the U.S., substantial further development of wind power will require significant investment in upgrading the national electricity grid.

8. SOLAR PHOTOVOLTAICS (PV)

Photovoltaic (PV) cells generate electricity directly from sunlight. PV cells usually use silicon as a semiconductor material. Since an enormous amount of energy is transmitted to the Earth's surface in the form of solar radiation, tapping this source has great potential. If only 0.025 percent of this energy flow could be captured, it would be enough to satisfy world electricity demand.

In 2006 and 2007, photovoltaic systems were the fastest growing energy technology in the world (on a percentage basis), increasing 50 percent annually. At the beginning of 2008, world PV installed capacity stood at 12.4 GW.

The goals of PV research are primarily to *(1)* increase the efficiency of the process of converting sunlight into electricity (the typical efficiency of an installed commercial single-crystalline silicon solar panel is 10 percent, meaning that only 10 percent of the energy of sunlight is converted to electrical energy, while 24.7 percent efficiency has been achieved under laboratory conditions); and *(2)* decrease the cost of production (single-crystalline silicon panels average $3.00 per watt installed, while new photovoltaic materials and technologies, especially thin-film PV materials made by printing or spraying nanochemicals onto an inexpensive plastic substrate, promise to reduce production costs dramatically, though usually at a loss of efficiency or durability).[49]

PLUS: The solar energy captured by photovoltaic technology is renewable—and there is a lot of it. The cumulative average energy irradiating a square meter of Earth's surface for a year is approximately equal to the energy in a barrel of oil; if this sunlight could be captured at 10 percent efficiency, 3,861 square miles of PV arrays would supply the energy of a billion barrels of oil. Covering the world's estimated 360,000 square miles of building rooftops with PV arrays would generate the energy of 98 billion barrels of oil each year.

The price for new installed PV generating capacity has been declining steadily for many years.

Unlike passive solar systems, PV cells can function on cloudy days.[50]

MINUS: The functionality of PV power generation varies not only daily, but also seasonally with cloud cover, sun angle, and number of daylight hours. Thus, as with wind, the uncontrolled, intermittent nature of PV reduces its value as compared to operator-controlled energy sources such as coal, gas, or nuclear power.

Sunlight is abundant, but diffuse: its area density is low. Thus efforts to harvest energy from sunlight are inevitably subject to costs and tradeoffs with scale: for example, large solar installations require suitable land, water for periodic cleaning, roads for access by maintenance vehicles, and so on.

Some of the environmental impacts of manufacturing PV systems have been analyzed by Alsema *et al.* and compared to the impacts of other energy technologies.[51] This study found PV system CO_2 emissions to be greater than those for wind systems, but only 5 percent of those from coal burning. A potential impact would be the loss of large areas of wildlife habitat if really large industrial-scale solar arrays were built in undeveloped desert areas.

EROEI: Explicit net energy analysis of PV energy is scarce. However, using "energy pay-back time" and the lifetime of the system, it is possible to determine a rough EROEI. From a typical life-cycle analysis performed in 2005, Hall *et al.* calculated an EROEI of 3.75:1 to 10:1.[52]

Some of these EROEI values are likely to change as research and development continue. If present conditions persist, EROEI may decline since sources of silicon for the industry are limited by the production capacity of semiconductor manufacturers.

PROSPECTS: Despite the enormous growth of PV energy in recent years, the incremental increase in oil, gas, or coal production during a typical recent year has exceeded all existing photovoltaic energy production. Therefore if PV is to become a primary energy source, the rate of increase in capacity will need to be even greater than is currently the case.

Because of its high up-front cost, a substantial proportion of installed PV has been distributed on home roofs and in remote off-grid villages, where provision of conventional electricity sources would be impractical or prohibitively expensive. Commercial utility-scale PV installations are now appearing in several nations, partly due to the lower price of newer thin-film PV materials and changing government policies.[53]

The current economic crisis has lowered the rate of PV expansion substantially, but that situation could be reversed if government efforts to revive the economy focus on investment in renewable energy.

However, if very large and rapid growth in the PV industry were to occur, the problem of materials shortages would have to be addressed in order to avert dramatic increases in cost. Materials in question—copper, cadmium-telluride (CdTe), and copper-indium-gallium-diselenide (CIGS)—are crucial to some of the thin-film PV materials to which the future growth of the industry (based on lowering of production costs) is often linked. With time, PV production may be constrained by lack of available materials, the rate at which materials can be recovered or recycled, or possibly by competition with other industries for those scarce materials. A long-term solution will hinge on the development of new PV materials that are common and cheap.

Concentrating PV, which uses lenses to focus sunlight onto small, highly efficient silicon wafers, is achieving ever-lower costs and ever-higher efficiencies, and could be competitive with coal, nuclear, and natural gas power generation on an installed per-watt capacity basis within just a few years. Nevertheless, this technology is still in its infancy and even if it can be developed further the problem of intermittency will remain.

9. ACTIVE (CONCENTRATING) SOLAR THERMAL

This technology typically consists of installations of mirrors to focus sunlight, creating very high temperatures that heat a liquid which turns a turbine, producing electricity. The same power plant technology that is used with fossil fuels can be used with solar thermal since the focusing collectors can heat liquid to temperatures from 300°C to 1000°C. Fossil fuel can be used as a backup at night or when sunshine is intermittent.

There is a great deal of interest and research in active solar thermal and a second generation of plants is now being designed and built, mostly in Spain. Worldwide capacity will soon reach 3 GW.

PLUS: Like PV, active solar thermal makes use of a renewable source of energy (sunlight), and there is enormous potential for growth. In the best locations, cost per watt of installed capacity is competitive with fossil-fuel power sources. Solar thermal benefits from using already mature power plant

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technology and needs less land than a photovoltaic array of the same generating capacity.

MINUS: Again like PV, concentrating solar thermal power is intermittent and seasonal. Some environmental impacts are to be expected on the land area covered by mirror arrays and during the construction of transmission lines to mostly desert areas where this technology works best.

EROEI: The energy balance of this technology is highly variable depending on location, thus few studies have been done. In the best locations (areas with many sunny days per year), EROEI is likely to be relatively high.

PROSPECTS: There is considerable potential for utility-scale deployment of concentrating solar thermal power. Some analysts have even suggested that all of the world's energy needs could be filled with electrical power generated by this technology. This would require covering large areas of desert in the southwestern U.S., northern Africa, central Asia, and central Australia with mirrors, as well as constructing high-power transmission lines from these remote sites to places where electricity demand is highest. Such a project is possible in principle, but the logistical hurdles and financial costs would be daunting. Moreover, some intermittency problems would remain even if the sunniest sites were chosen.

Leaving aside such grandiose plans, for nations that lie sufficiently close to the equator this appears to be one of the most promising alternative sources of energy available.[54]

Recently a startup project called Desertec has proposed raising an estimated $570 billion for the construction of an enormous active solar thermal installation in the Sahara Desert to supply 15 percent of Europe's electricity needs.Concentrating solar thermal plants in Spain are now testing a heat storage module,[55] which can maintain power delivery during nights and perhaps longer periods of low sunshine. Since thermal energy is much cheaper to store than electricity, this could represent an advantage over wind or PV power if the Spanish tests are successful.

10. PASSIVE SOLAR


SOLAR WINDOWS

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This simple approach consists of capturing and optimizing natural heat and light from the sun within living spaces without the use of collectors, pumps, or mechanical parts, thus reducing or eliminating the need for powered heating or lighting. Buildings are responsible for a large percentage of total energy usage in most countries, and so passive solar technologies are capable of offsetting a substantial portion of energy production and consumption that might otherwise come from fossil fuels. A passive solar building is designed *(1)* to maintain a comfortable average temperature, and *(2)* to minimize temperature fluctuations. Such a building usually takes more time, money, and design effort to construct, with extra costs made up in energy savings over time.

Passive solar heating takes three dominant forms: glazing surfaces to help capture sunlight; *trombe walls*, and other features for heat storage; and insulation to maintain relatively constant temperatures. Other important factors include orienting the long side of the building toward the sun, determining the appropriate sizing of the mass required to retain and slowly release accumulated heat after the sun sets, and determining the size of the trombe wall necessary to heat a given space. (Of course, the size of the entire building is also an issue—a passive solar design for a monster home makes no sense.)

Other passive uses of sunlight in buildings include passive solar cooling and daylighting (using windows and openings to make use of natural light).

PLUS: Depending on the study, passive solar homes cost less than, the same as, or up to 5 percent more than other custom homes; however, even in the latter case the extra cost will eventually pay for itself in energy savings.A passive solar home can only provide heat for its occupants, not extra electricity, but if used on all new houses passive systems could go a long way toward replacing other fuels.

Incorporating a passive solar system into the design of a new home is generally cheaper than fitting it onto an existing home. A solar home "decreases cooling loads and reduces electricity consumption, which leads to significant decline in the use of fossil fuels."[56] Passive solar buildings, in contrast to buildings with artificial lighting, may also provide a healthier, more productive work environment.

MINUS: Limitations to passive solar heating can include inappropriate geographic location (clouds and colder climates make solar heating less effective), and the relative difficulties of sealing the house envelope to reduce air leaks while not increasing the chance of pollutants becoming trapped inside. The heat-collecting, equator-facing side of the house needs good solar exposure in the winter, which may require spacing houses further apart and using more land than would otherwise be the case.

EROEI: Strictly speaking, it is not appropriate to use EROEI calculations in this instance since there is no "energy out" for the equation. Passive solar design is essentially a matter of using the "free energy" of nature to replace other forms of energy that would otherwise need to be used for heating and lighting. It is extremely site-specific, and architects rarely obtain quantitative feedback on systems they have designed, so determining general figures for savings is difficult (but a range from 30 to 70 percent is typical). If the system is built into the house from the beginning, then energy savings can be obtained with few or no further investments.

PROSPECTS: Designing buildings from the start to take advantage of natural heating and lighting, and to use more insulation and solar mass, has tremendous potential to reduce energy demand. However, in many cases high-efficiency buildings require more energy for construction, (construction energy is not generally considered in savings calculations, which are typically done only on operational energy).

Until now, higher up-front construction costs have discouraged mass-scale deployment of passive solar homes in most countries. Higher energy prices will no doubt gradually alter this situation, but quicker results could be obtained through shifts in building regulations and standards, as has been shown in Germany. There, the development of the voluntary Passivhaus standard has stimulated construction and retrofitting of more than 20,000 passive houses in northern Europe.[57] The Passivhaus is designed to use very little energy for heating. Passive solar provides space heating, and superinsulation and controlled outdoor air exchange (usually with heat exchanger) reduces heat loss.

Buildings in industrialized nations have generally become more efficient in recent years; however declines in averaged energy use per square foot have generally been more than offset by population growth and the overbuilding of real estate (the average size of buildings has grown), so that the total amount of energy used in buildings has continued to increase. Thus, population and economic growth patterns need to be part of the "green building" agenda, along with the increasing use of passive solar design elements.[58]

11. GEOTHERMAL ENERGY

Derived from the heat within the Earth, geothermal energy can be "mined" by extracting hot water or steam, either to run a turbine for electricity generation or for direct use of the heat. High-quality geothermal energy is typically available only in regions where tectonic plates meet and volcanic

GEOTHERMAL BOREHOUSE, ICELAND/ LYDUR SKULASON

and seismic activity are common. Low-temperature geothermal direct heat can be tapped anywhere on Earth by digging a few meters down and installing a tube system connected to a heat pump.

Currently, the only places being exploited for geothermal electrical power are where hydrothermal resources exist in the form of hot water or steam reservoirs. In these locations, hot groundwater is pumped to the surface from two to three km deep wells and used to drive turbines. One example: The Geysers installation in Northern California, occupying 30 square miles along the Sonoma and Lake County border, comprises the world's largest complex of geothermal power plants. The fifteen power plants there have a total net generating capacity of about 725 MW of electricity—enough to power 725,000 homes, or a city the size of San Francisco. The Geysers meets the typical power needs of Sonoma, Lake, and Mendocino counties, as well as a portion of the power needs of Marin and Napa counties.

Power can also be generated from hot dry rocks by pumping turbine fluid (essentially water) into them through three to ten km deep boreholes. This method, called Enhanced Geothermal System (EGS) generation, is the subject of a great deal of research, but no power has been generated commercially using EGS. If perfected, EGS could enable geothermal power to be harvested in far more places than is currently practical.

In 2006, world geothermal power capacity was about 10 GW.[59] Annual growth of geothermal power capacity worldwide has slowed from 9 percent in 1997 to 2.5 percent in 2004.

However, the use of direct heat using heat pumps or piped hot water has been growing 30 to 40 percent annually, particularly in Europe, Asia, and Canada.[60] (This is a fundamentally different technology from geothermal electricity production, even though the basic resource—heat from the Earth—is the same.)

PLUS: Geothermal power plants produce much lower levels of carbon emissions and use less land area as compared to fossil fuel plants. They can also run constantly, unlike some other renewable energy systems, such as wind and solar.

Geothermal direct heat is available everywhere (and geothermal heat pumps are among the few non-fossil fuel options for space heating), although it is less cost-effective in temperate climates. Countries rich in geothermal resources (such as Sudan, Ethiopia, Colombia, Ecuador, much of the Caribbean, and many Pacific islands) could become less dependent on foreign energy.

MINUS: In addition to geography and technology, high capital cost and low fossil fuel prices are major limiting factors for the development of geothermal electricity production. Technological improvements (especially the further development of EGS) are necessary for the industry to continue to grow. Water can also be a limiting factor, since both hydrothermal and dry rock systems consume water.

The sustainability of geothermal power generating systems is a cause of concern. Geothermal resources are only renewable if heat removal is balanced by natural replenishment of the heat source. Some geothermal plants have seen declines in temperature, most probably because the plant was oversized for the local heat source.

There is likely to be some air, water, thermal, and noise pollution from the building and operation of a geothermal plant, as well as solid waste buildup and the possibility of induced seismic activity near it.

EROEI: The calculated net energy for hydrothermal power generation has ranged, depending on the researcher, from 2:1 to 13:1. This discrepancy reflects differences in efficiency due to site characteristics and the lack of a unified methodology for EROEI analysis, as well as disagreements about system boundaries, quality-correction, and future expectations.[61]

There are no calculations of EROEI values for geothermal direct heat use, though for various reasons it can be assumed that they are higher than those for hydrothermal electrical power generation. As a starting point, it has been calculated that heat pumps move three to five times the energy in heat that they consume in electricity.

PROSPECTS: There is no consensus on potential resource base estimates for geothermal power generation. Hydrothermal areas that have both heat and water are rare, so the large-scale expansion of geothermal power depends on whether EGS and other developing technologies will prove to be commercially viable. A 2006 MIT report estimated U.S. hydrothermal resources at 2,400 to 9,600 EJ, while dry-heat geothermal resources were estimated to be as much as 13 million EJ.[62]

Until EGS is developed and deployed, limited hydrothermal resources will continue to be important regionally.

Meanwhile, direct geothermal heat use via heat pumps provides one of the few available alternatives to the use of fossil fuels or wood for space heating, and is therefore likely to see an increased rate of deployment in colder climates.

12. ENERGY FROM WASTE

LANDFILL, U.K.

ISTOCK

Trash can be burned to yield energy, and methane can be captured from landfills. All told, the world derives over 100 TWh of electricity, and an even greater amount of useful heat energy, from waste, amounting to about 1 percent of all energy used globally.

In the U.S., 87 trash incinerating generation plants produce about 12.3 TWh of electricity per year. Municipal waste is also burned for power in Europe; Taiwan, Singapore, and Japan incinerate 50 to 80 percent of their waste. There are 600 incineration plants producing energy worldwide. However, the practice is mostly restricted to high-income countries because such plants are expensive to operate and the waste stream in low-income nations typically has low calorific value. One estimate for total energy produced is 450 TWh, but this includes heat energy as well as electricity.[63]

The capture of landfill gas yields 11 TWh of electricity and 77 billion cubic feet of gas for direct use annually in the U.S. (from 340 out of a total of 2,975 landfills).[64] In Europe, landfill gas provides 17 TWh of electricity as well as heat energy, for a total of 36.3 TWh of biogas energy; there, recovery of biogas is now mandatory.

PLUS: Industrial waste products contain embodied energy; thus efforts to recover that energy can be thought of as a way of bringing greater efficiency to the overall industrial system. Energy production from waste does not entail the extraction of more natural resources than have already been used in the upstream activities that generated the waste (other than the resources used to build and operate the waste-to-energy plants themselves).

MINUS: Waste incineration releases into the environment whatever toxic elements are embodied in the waste products that are being burned—including dioxin, one of the most deadly compounds known. Moreover, incinerators emit more CO_2 per unit of energy produced than coal-fired, natural-gas-fired, or oil-fired power plants.

If energy efficiency is the goal, a better systemic solution to dealing with wastes would be to minimize the waste stream. Moreover, a zero-waste approach is one of the fastest, cheapest, and most effective strategies to protect the climate and the environment: significantly decreasing waste disposed in landfills and incinerators could reduce greenhouse gases by an amount equivalent to the closing of one-fifth of U.S. coal-fired power plants. However, if economic activity continues to decline, as a result of slower economic growth, less waste will be produced, one of the up-sides of financial decline.

EROEI: Little information is available on the net energy from waste incineration or landfill gas capture. If system boundaries are narrowly drawn (so that only direct energy costs are included), the EROEI from landfill gas capture is likely to be high. EROEI from trash incineration is likely to decline as more investment is directed toward preventing toxic materials from being released from burners.

PROSPECTS: If and when zero-waste policies are more generally adopted, the amount of waste available to be burned or placed into landfills will decline dramatically. Therefore waste-to-energy projects should not be regarded as sustainable over the long term, nor should this energy source be regarded as being scalable—that is, it is unlikely to be dramatically increased in overall volume.

13. ETHANOL

Ethanol is an alcohol made from plant material—usually sugar cane or corn—that is first broken down into sugars and then fermented. It has had a long history of use as a transportation fuel beginning with the Model T Ford. In 2007, 13.1 billion gallons of ethanol were produced globally. Thirty-eight percent of this was produced from sugar cane in Brazil, while another 50 percent was manufactured from corn in the U.S.[65] There has been a high rate of growth in the industry, with a 15 percent annual increase in world production between 2000 and 2006. Ethanol can be substituted for gasoline, but the total quantity produced is still only a small fraction of the 142 trillion gallons of gasoline consumed in the U.S. each year.[66]

Ethanol can be blended with gasoline and used in existing cars in concentrations of up to 10 percent. For percentages higher than this, engine modifications are needed since ethanol is more corrosive than gasoline. New cars are already being manufactured that run on 100 percent ethanol, on the 25/75 ethanol/gasoline "gasohol" blend used in Brazil, or the 85/15 ("E85") blend found in the United States.

Corn ethanol has become highly controversial because of problems associated with using a staple food plant such as corn as a fuel, and the resulting


ETHANOL PLANT, SOUTH DAKOTA ISTOCK

diversion of huge amounts of land from food production to fuel production. Another problem is that ethanol plants are themselves usually powered by fossil fuels.[67] However, there is now growing interest in making ethanol from non-food plant materials like corn stover, wheat chaff, or pine trees. One potential feedstock is the native prairie plant switchgrass, which requires less fossil fuel input for cultivation than corn. However, making cellulosic ethanol out of these non-food feedstocks is a technology in its infancy and not yet commercialized.

Potential ethanol resources are limited by the amount of land available to grow feedstock. According to the Union of Concerned Scientists (UCS), using all of the corn grown in the U.S. with nothing left for food or animal feed would only displace about 15 percent of U.S. gasoline demand by 2025.[68] Large-scale growing of switchgrass or other new cellulose crops would require finding very large acreages on which to cultivate them, also aggravating shortages of agricultural lands.

PLUS: Ethanol has the portability and flexibility of oil and can be used in small amounts blended with gasoline in existing vehicles. The distribution infrastructure for gasoline could be gradually switched over to ethanol as new cars that run on higher ethanol concentrations are phased in, though current pipelines would eventually have to be replaced as ethanol is highly corrosive.

Cellulosic ethanol is widely considered to be a promising energy source since it has potentially less environmental impact with respect to land use and lifecycle greenhouse gas emissions than fossil fuels. The UCS reports that it has the potential to reduce greenhouse gas emissions by 80 to 90 percent compared to gasoline.[69] However, this conclusion is disputed, and there are still serious technical problems with producing cellulosic ethanol on a commercial scale.

MINUS: There are approximately 45 MJ per kilogram contained in both finished gasoline and crude oil, while ethanol has an energy density of about 26 MJ per kilogram and corn has only 16 MJ per kilogram. In general, this means that large amounts of corn must be grown and harvested to equal even a small portion of existing gasoline consumption on an energy-equivalent level, which will undoubtedly expand the land area that is impacted by the production process of corn-based ethanol.

Increases in corn ethanol production may have helped to drive up the price of corn around the world in 2007, contributing to a 400 percent rise in the price of tortillas in Mexico.[70] Ethanol and other biofuels now consume 17 percent of the world's grain harvest.

There are climate implications to corn ethanol production as well. If food crops are used for making transportation fuel rather than food, more land will have to go into food production somewhere else. When natural ecosystems are cleared for food or ethanol production, the result is a "carbon debt" that releases 17 to 420 times more CO_2 than is saved by the displacement of fossil fuels.[71] The situation is better when dealing with existing cropland, but not much: Since fossil fuels are necessary for growing corn and converting it into ethanol, the finished fuel is estimated to offer only a 10 to 25 percent reduction in greenhouse gas emissions as compared to gasoline,[72] though even this level of reduction is questionable, as it relies on calculations involving DDGS; considering only liquid fuels, there is likely less or no greenhouse gas reduction. Corn ethanol also uses three to six gallons of water for every gallon of ethanol produced and has been shown to emit more air pollutants than gasoline.

EROEI: There is a range of estimates for the net energy of ethanol production since EROEI depends on widely ranging variables such as the energy input required to get the feedstock (which is high for corn and lower for switchgrass and cellulose waste materials) and the nature of the process used to convert it to alcohol.

There is even a geographic difference in energy input depending on how well suited the feedstock crop is to the region in which it is grown. For example, there is a definite hierarchy of corn productivity by state within the U.S.: in 2005, 173 bushels per acre (10,859 kg/ha) were harvested in Iowa, while only 113 bushels per acre were harvested in Texas (7,093 kg/ha). This is consistent with the general principle of "gradient analysis" in ecology, which holds that individual plant species grow best near the middle of their gradient space; that is near the center of their range in environmental conditions such as temperature and soil moisture. The climatic conditions in Iowa are clearly at the center of corn's gradient space. Statistics suggest that corn production is also less energy-intensive at or near the center of corn's gradient space.[73] This would imply a diminishing EROEI for ethanol production as the distance from Iowa increases, meaning that the geographic expansion of corn production will produce lower yields at higher costs. Indeed, ethanol production in Iowa and Texas yield very different energy balances, so that in Iowa the production of a bushel of corn costs 43 MJ, while in Texas it costs 71 MJ.

Calculated net energy figures for corn ethanol production in the U.S. range from less than 1:1 to 1.8:1.[74]

Ethanol from sugar cane in Brazil is calculated to have an EROEI of 8:1 to 10:1, but when made from Louisiana sugar cane in the U.S., where growing conditions are worse, the EROEI is closer to 1:1.[75] Estimates for the projected net energy of cellulose ethanol vary widely, from 2:1 to 36:1.[76] However, such projections must be viewed skeptically, given the absence of working production facilities.

These EROEI figures differ largely because of co-product crediting (i.e., adding an energy return figure to represent the energy replacement value of usable by-products of ethanol production—principally DDGS). In the USDA's figures for energy use in ethanol production, EROEI is 1.04 prior to the credits. But some analysts argue that co-product crediting is immaterial to the amount of energy required to produce ethanol. Distillation is highly energy intensive, and even more so in the case of cellulosic ethanol because the initial beer concentration is so low (about 4 percent compared to 10 to 12 percent for corn). This dramatically increases the amount of energy needed to boil off the remaining water. At absolute minimum, 15,000 BTU of energy are required in distillation alone per gallon of ethanol produced (current corn ethanol plants use about 40,000 BTU per gallon). This sets the limit on EROEI. If distillation were the only energy input in the process, and it could be accomplished at the thermodynamic minimum, then EROEI would be about 5:1. But there are other energy inputs to the process and distillation is not at the thermodynamic minimum.

Sugar cane EROEI estimates and cellulosic estimates that are frequently cited exclude non-fossil fuel energy inputs. For example, 8 to 10:1 EROEI numbers for the production of ethanol from sugar cane in Brazil exclude all bagasse (dry, fibrous residue remaining after the extraction of juice from the crushed stalks of sugar cane) burned in the refinery—which is clearly an energy input, though one that is derived from the sugar cane itself. Cellulosic ethanol EROEI estimates often assume that the lignin recovered from biomass is sufficient not only to fuel the entire plant, but to export 1 to 2 MJ of electricity per liter of ethanol produced (which is then credited back to the ethanol). However, this assumption is based on a single lab study that has not been replicated. The questions of whether these non-fossil energy inputs should be included or excluded in net energy calculations, and how such inputs should be measured and evaluated, are contested.

PROSPECTS: Ethanol's future as a major transport fuel is probably dim except perhaps in Brazil, where sugar cane supplies the world's only economically competitive ethanol industry. The political power of the corn lobby in the United States has kept corn ethanol subsidized and has kept investment flowing, but the fuel's poor net energy performance will eventually prove it to be uneconomic. The technical problems of processing cellulose for ethanol may eventually be overcome, but land use considerations and low EROEI will likely limit the scale of production.

14. BIODIESEL

BIODIESEL BUS, BARCELONA

This is a non-petroleum-based diesel fuel made by *transesterification* of vegetable oil or animal fat (tallow)—a chemical treatment to remove glycerine, leaving long-chain alkyl (methyl, propyl, or ethyl) esters. Biodiesel can be used in unmodified diesel engines either alone, or blended with conventional petroleum diesel. Biodiesel is distinguished from straight vegetable oil (SVO), sometimes referred to as "waste vegetable oil" (WVO), "used vegetable oil" (UVO), or "pure plant oil" (PPO). Vegetable oil can itself be used as a fuel either alone in diesel engines with converted fuel systems, or blended with biodiesel or other fuels.

Vegetable oils used as motor fuel or in the manufacture of biodiesel are typically made from soy, rape seed ("canola"), palm, or sunflower. Considerable research has been devoted to producing oil for this purpose from algae, with varying reports of success (more on that below).

Global biodiesel production reached about 8.2 million tons (230 million gallons) in 2006, with approximately 85 percent of production coming from the European Union, but with rapid expansion occurring in Malaysia and Indonesia.[77]

In the United States, average retail (at the pump) prices, including Federal and state fuel taxes, of B2/B5 are lower than petroleum diesel by about 12 cents, and B20 blends are the same as petrodiesel. B99 and B100 generally cost more than petrodiesel except where local governments provide a subsidy. (The number following "B" in "B20," "B99," etc., refers to the percentage of biodiesel in the formulation of the fuel; in most instances, the remaining percentage consists of petroleum diesel. Thus "B20" fuel consists of 20 percent biodiesel and 80 percent petroleum diesel.)

PLUS: Biodiesel's environmental characteristics are generally more favorable than those of petroleum diesel. Through its lifecycle, biodiesel emits one fifth the CO_2 of petroleum diesel, and contains less sulfur. Some reports suggest that its use leads to longer engine life, which presumably would reduce the need for manufacturing replacement engines.[78] When biodiesel is made from waste materials like used vegetable oil, the net environmental benefits are more pronounced.

MINUS: The principal negative impact of expanding biodiesel production is the need for large amounts of land to grow oil crops. Palm oil is the most fruitful oil crop, producing 13 times the amount of oil as soybeans, the most-used biodiesel feedstock in the United States. In Malaysia and Indonesia, rainforest is being cut to plant palm oil plantations, and it has been estimated that it will take 100 years for the climate benefits of biodiesel production from each acre of land to make up for the CO_2 emissions from losing the rainforest.[79] Palm oil production for food as well as fuel is driving deforestation across Southeast Asia and reducing rainforest habitat to the point where larger animal species, such as the orangutan, are threatened with extinction.[80] Soybean farming in Brazil is already putting pressure on Amazonian rainforests. If soybeans begin to be used extensively for biofuels this pressure will increase.

EROEI: The first comprehensive comparative analysis of the full life cycles of soybean biodiesel and corn grain ethanol has concluded that biodiesel has much less of an impact on the environment and a much higher net energy benefit than corn ethanol, but that neither can do much to meet U.S. energy demand.[81] Researchers tracked all the energy used for growing corn and soybeans and converting the crops into biofuels. They also examined how much fertilizer and pesticide corn and soybeans required and the quantities of greenhouse gases, nitrogen oxides, phosphorus, and pesticide pollutants each released into the environment. The study showed a positive energy balance for both fuels; however, the energy returns differed greatly: soybean biodiesel currently returns 93 percent more energy than is used to produce it (1.93:1), while corn grain ethanol provides, according to this study, only 25 percent more energy (1.25:1). When discussing such distinctions, it is important to recall that industrial societies emerged in the context of energy returns in the double digits—50:1 or more, meaning fifty times as much energy yielded as invested.

Other researchers have claimed that the net energy of soybean biodiesel has improved over the last decade because of increased efficiencies in farming, with one study calculating an EROEI of 3.5:1.[82] Palm oil biodiesel has the highest net energy, calculated by one study at 9:1.[83]

PROSPECTS: There are concerns, as with ethanol, that biodiesel crops will increasingly compete with food crops for land in developing countries and raise the price of food. The need for land is the main limitation on expansion of biodiesel production and is likely to restrict the potential scale of the industry.[84] Water is also a limiting factor, given that world water supplies for agricultural irrigation are already problematic.

Biodiesel can also be made from algae, which in turn can be grown on waste carbon sources, like the CO_2 scrubbed from coal-burning power plants or sewage sludge. Saltwater rather than freshwater can be used to grow the algae, and there is optimism that this technology can be used to produce significant amounts of fuel. However, the process is still in a developmental stage. Limiting factors may be the need for large closed bioreactors, water supply, sunshine consistency, and thermal protection in cold climates.[85]

Biodiesel from waste oil and fats will continue to be a small and local source of fuel, while algae-growing shows promise as a large-scale biodiesel technology only if infrastructure and maintenance costs can be minimized.

15. TAR SANDS

Sometimes called "oil sands," this controversial fossil fuel consists of bitumen (flammable mixtures of hydrocarbons and other substances that are components of asphalt and tar) embedded in sand or clay.

OIL SANDS OPEN PIT MINING

IEN EARTH

The resource is essentially petroleum that formed without a geological "cap" of impervious rock (such as shale, salt, or anhydrite) being present to prevent lighter hydrocarbon molecules from rising to the surface, and that therefore volatized rather than remaining trapped underground.

Tar sands can be extracted through an *in situ* underground liquefaction process by the injection of steam, or by mining with giant mechanized shovels. In either case, the material remains fairly useless in its raw state, and requires substantial processing or upgrading, the finished product being referred to as "syncrude."

The sites of greatest commercial concentration of the resource are in Alberta, Canada and the Orinoco Basin of Venezuela (where the resource is referred to as heavy oil). Current production of syncrude from operations in Canada amounts to about 1.5 million barrels per day, which accounts for 1.7 percent of total world liquid fuels production, or a little less than 0.7 percent of total world energy. Reserves estimates range widely, from less than 200 billion barrels of oil equivalent up to 1.7 trillion barrels in Canada; for Venezuela the most-cited reserves estimate of extra heavy crude is 235 billion barrels, though in both cases it is likely that a large portion of what has been classified as "reserves" should be considered unrecoverable "resources" given the likelihood that deeper and lower-quality tar sands will require more energy for their extraction and processing than they will yield.

PLUS: The only advantages of tar sands over conventional petroleum are that *(1)* large amounts remain to be extracted, and *(2)* the place where the resource exists in greatest quantity (Canada) is geographically close and politically friendly to the country that imports the most oil (the U.S.).

MINUS: Tar sands have all of the negative qualities associated with the other fossil fuels (they are nonrenewable, polluting, and climate-changing), but in even greater measure than is the case with natural gas or conventional petroleum. Tar sands production is the fastest-growing source of Canada's greenhouse gas emissions, with the production and use of a barrel of syncrude ultimately doubling the amount of CO_2 that would be emitted by the production and use of a barrel of conventional petroleum. Extraction of tar sands has already caused extensive environmental damage across a broad expanse of northern Alberta.

All of the techniques used to upgrade tar sands into syncrude require other resources. Some of the technologies require significant amounts of water and natural gas—as much as 4.5 barrels of water and 1200 cubic feet (34 cubic meters) of natural gas for each barrel of syncrude.

As a result, syncrude is costly to produce. A fixed per-barrel dollar cost is relatively meaningless given recent volatility in input costs; however, it is certainly true that production costs for syncrude are much higher than historic production costs for crude oil, and compare favorably only with the higher costs for the production of a new marginal barrel of crude using expensive new technologies.

EROEI: For tar sands and syncrude production, net energy is difficult to assess directly. Various past net energy analyses for tar sands range from 1.5:1 to 7:1, with the most robust and recent of analyses suggesting a range of 5.2:1 to 5.8:1.[86] This is a small fraction of the net energy historically derived from conventional petroleum.

PROSPECTS: The International Energy Agency expects syncrude production in Canada to expand to 5 mb/d by 2030, but there are good reasons for questioning this forecast. The environmental costs of expanding production to this extent may be unbearable. Further, investment in tar sands expansion is now declining, with more than US$60 billion worth of projects having been delayed in the last three months of 2008 as the world skidded into recession. A more realistic prospect for tar sands production may be a relatively constant production rate, rising perhaps only to 2 or 3 million barrels per day.

16. OIL SHALE

If tar sands are oil that was "spoiled" (in that the shorter-chained hydrocarbon molecules have volatized, leaving only hard-to-use bitumen), oil shale (or kerogen, as it is more properly termed) is oil that was undercooked: it consists of source material that was not buried at sufficient depth or for long enough to be chemically transformed into the shorter hydrocarbon chains found in crude oil or natural gas.

Deposits of potentially commercially extractable oil shale exist in thirty-three countries, with the largest being found in the western region of the U.S. (Colorado, Utah, and Wyoming). Oil shale is used to make liquid fuel in Estonia, Brazil, and China; it is used for power generation in Estonia, China, Israel, and Germany; for cement production in Estonia, Germany, and China; and for chemicals production in China, Estonia, and Russia. As of 2005, Estonia accounted for about 70 percent of the world's oil shale extraction and use. The percentage of world energy currently derived from oil shale is negligible, but world resources are estimated as being equivalent to 2.8 trillion barrels of liquid fuel.[87]

PLUS: As with tar sands, the only real upside to oil shale is that there is a large quantity of the resource in place. In the U.S. alone, shale oil resources are estimated at 2 trillion barrels of oil equivalent, nearly twice the amount of the world's remaining conventional petroleum reserves.

MINUS: Oil shale suffers from low energy density, about one-sixth that of coal. The environmental impacts from its extraction and burning are very high, and include severe air and water pollution and the release of half again as much CO_2 as the burning of conventional oil. The use of oil shale for heat is far more polluting than natural gas or even coal. Extraction on a large scale in the western U.S. would require the use of enormous amounts of water in an arid region.

EROEI: Reported EROEI for oil produced from oil shale is generally in the range of 1.5:1 to 4:1[88]. Net energy for this process is likely to be lower than the production of oil from tar sands because of the nature of the material itself.

PROSPECTS: During the past decades most commercial efforts to produce liquid fuels from oil shale have ended in failure. Production of oil shale worldwide has actually declined significantly since 1980. While low-level production is likely to continue in several countries that have no other domestic fossil fuel resources, the large-scale development of production from oil shale deposits seems unlikely anywhere for both environmental and economic reasons.

17. TIDAL POWER

TIDAL POWER PLANT, RANCE RIVER, FRANCE   DANI

Generation of electricity from tidal action is geographically limited to places where there is a large movement of water as the tide flows in and out, such as estuaries, bays, headlands, or channels connecting two bodies of water.

The oldest tidal power technology dates back to the Middle Ages, when it was used to grind grain. Current designs consist of building a barrage or dam that blocks off all or most of a tidal passage; the difference in the height of water on the two sides of the barrage is used to run turbines. A newer technology, still in the development stage, places underwater turbines called tidal stream generators directly in the tidal current or stream.

Globally, there is about 0.3 GW of installed capacity of tidal power[89], most of it produced by the barrage built in 1966 in France across the estuary of the Rance River (barrages are essentially dams across the full width of a tidal estuary).

PLUS: Once a tidal generating system is in place, it has low operating costs and produces reliable, although not constant, carbon-free power.

MINUS: Sites for large barrages are limited to a few places around the world. Tidal generators require large amounts of capital to build, and can have a significant negative impact on the ecosystem of the dammed river or bay.

EROEI: No calculations have been done for tidal power EROEI as yet. For tidal stream generators this figure might be expected to be close to that of wind power (an average EROEI of 18:1) since the turbine technologies for wind and water are so similar that tidal stream generators have been described as "underwater windmills." However, tidal EROEI figures would likely be lower due to the corrosiveness of seawater and thus higher construction and maintenance energy use. The EROEI of barrage systems might be somewhat comparable to that of hydroelectric dams (EROEI in the range of 11.2:1 to 267:1), but will likely be lower since the former only generate power for part of the tidal cycle.

PROSPECTS: One estimate of the size of the global annual potential for tidal power is 450 TWh, much of it located on the coasts of Asia, North America, and the United Kingdom.[90] Many new barrage systems have been proposed and new sites identified, but the initial cost is a difficulty. There is often strong local opposition, as with the barrage proposed for the mouth of the River Severn in the U.K. Tidal stream generators need less capital investment and, if designed and sited well, may have very little environmental impact. Prototype turbines and commercial tidal stream generating systems are being tested around the world.

18. WAVE ENERGY

Designed to work offshore in deeper water, wave energy harvests the up-and-down, wind-driven motion of the waves. Onshore systems use the force of breaking waves or the rise and fall of water to run pumps or turbines.

The commonly quoted estimate for potential global wave power generation is about 2 TW[91], distributed mostly on the western coasts of the Americas, Europe, southern Africa, and Australia,

PELAMIS WAVE ENERGY CONVERTER, EUROPEAN MARINE ENERGY TEST CENTRE

where wind-driven waves reach the shore after accumulating energy over long distances. For current designs of wave generators the economically exploitable resource is likely to be from 140 to 750 TWh per year.[92] The only operating commercial system has been the 2.25 MW Agucadora Wave Park off the coast of Portugal. (However, this was recently pulled ashore, and it is not clear when it will be redeployed).

Research into wave energy has been funded by both governments and small engineering companies, and there are many prototype designs. Once the development stage is over and the price and siting problems of wave energy systems are better understood, there may be more investment in them. In order for costs to decrease, problems of corrosion and storm damage must be solved.

PLUS: Once installed, wave energy devices emit negligible greenhouse gases and should be cheap to run. Since the majority of the world's population lives near coastlines, wave energy is convenient for providing electricity to many. It may also turn out to provide an expensive but sustainable way to desalinate water.

MINUS: In addition to high construction costs, there are concerns about the environmental impact of some designs, as they may interfere with fishing grounds. Interference with navigation and coastal erosion are also potential problems. Wave energy fluctuates seasonally as well as daily, since winds are stronger in the winter, making this a somewhat intermittent energy source.

EROEI: The net energy of wave energy devices has not been thoroughly analyzed. One rough estimate of EROEI for the Portuguese Pelamis device is 15:1.[93]

PROSPECTS: Wave power generation will need more research, development, and infrastructure build-out before it can be fairly assessed. More needs to be understood about the environmental impacts of wave energy "farms" (collections of many wave energy machines) so that destructive siting can be avoided. The best devices will need to be identified and improved, and production of wave devices will need to become much cheaper.

OTHER SOURCES

In addition to the eighteen energy sources discussed above, there are some other potential sources that have been discussed in the energy literature, but which have not reached the stage of application. These include: ocean thermal (which would produce energy from the temperature differential between surface and deep ocean water), "zero-point" and other "free energy" sources (which are asserted to harvest energy from the vacuum of space, but which have never been shown to work as claimed), Earth-orbiting solar collectors (which would beam electrical energy back to the planet in the form of microwave energy), Helium 3 from the Moon (Helium 3 does not exist in harvestable quantities on Earth, but if it could be mined on the Moon and brought back by shuttle, it could power nuclear reactors more safely than uranium does), and methane hydrates (methane frozen in an ice lattice—a material that exists in large quantities in tundra and seabeds, but has never successfully been harvested in commercially signifiant quantities). Of these, only methane hydrate has any prospect of yielding commercial amounts of energy in the foreseeable future, and even that will depend upon significant technological developments to enable the collecting of this fragile material. Methanol and butanol are not discussed here because their properties and prospects differ little from those of other biofuels.

Thus, over the course of the next decade or two, society's energy almost certainly must come from some combination of the eighteen sources above. In the next section we explore some of the opportunities for combining various of these alternative energy options to solve the evolving energy crisis.

TABLE 2: COMPARING CURRENT FUEL SOURCES

	Annual electricity produced (TWh)	Reserves	EROEI
Fossil Fuels	11,455	finite	Coal 50:1 Oil 19:1 Natural gas 10:1

	Annual electricity produced (TWh)	Potential electricity production (TWh)	EROEI
Hydropower	2894	8680	11:1 to 267:1
Nuclear	2626	5300	1.1:1 to 15:1
Wind	160	83,000	18:1
Biomass power	218	NA	NA
Solar PV	8	2000	3.75:1 to 10:1
Geothermal	63	1000 – 1,000,000	2:1 to 13:1
Solar thermal	1	up to 100,000	1.6:1
Tidal	.6	450	~ 6:1
Wave	~ 0	750	15:1

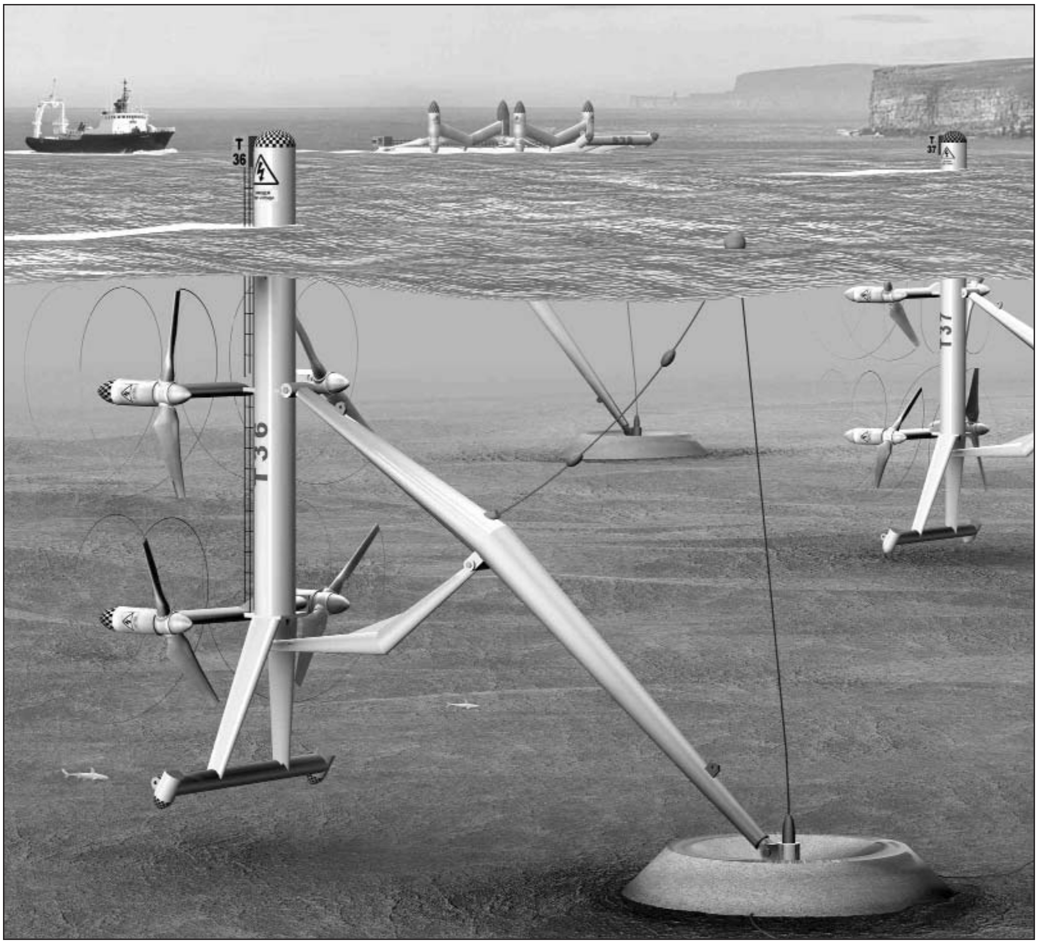
Table 2. Global annual electricity generation in terawatt-hours, estimated existing reserve or potential yearly production, and EROEI.[94] The largest current source of electricity (fossil fuels) has no long-term future, while the sources with the greatest potential are currently the least developed.

TABLE 3. COMPARING LIQUID FUEL SOURCES

	Global production (million barrels/year)	Reserves (trillion barrels)	EROEI
Oil	27,000	1.2	19:1
Tar sands	548	3.3	5.2:1 to 5.8:1
Oil shale	1.6	2.8	1.5:1 to 4:1

	Global production (million barrels/year)	Potential production (million barrels/year)	EROEI
Ethanol	260	1175	0.5:1 to 8:1
Biodiesel	5	255	1.9:1 to 9:1

Table 3. Liquid fuels: Current global annual production, reserves, potential production, and EROEI.[95]



TIDAL STREAM PARTNERS: PROTOTYPE

Wave energy systems, such as depicted here, remain highly theoretical in practical terms. So far, the only operating commercial system is the Agucadora Wave Park off the coast of Portugal, recently pulled from service. Research continues, however, as wave energy releases no greenhouse gasses and for communities near shorelines it may yet prove practical, and with a high net energy potential. It could form a useful part of any mix of alternative renewable energy systems.

Five

TOWARD A FUTURE ENERGY MIX

A CURSORY EXAMINATION of our current energy mix yields the alarming realization that about 85 percent of our current energy is derived from three primary sources—oil, natural gas, and coal—that are non-renewable, whose price is likely to trend higher (and perhaps very steeply higher) in the years ahead, whose EROEI is declining, and whose environmental impacts are unacceptable. While these sources historically have had very high economic value, we cannot rely on them in the future. Indeed, the longer the transition to alternative energy sources is delayed, the more difficult that transition will be unless some practical mix of alternative energy systems can be identified that will have superior economic and environmental characteristics.

A process for designing an energy system to meet society's future needs must start by recognizing the practical limits and potentials of the available energy sources. Since *primary* energy sources (ones that are capable of replacing fossil fuels in terms of their percentage of the total energy supplied) will be the most crucial ones for meeting those needs, it is important to identify those first. Secondary sources (ones that are able to supply only a few percent of total energy) will also play their roles, along with "energy carriers" (forms of energy that make energy from primary sources more readily useful—as electricity makes the energy from coal useful in millions of homes).

A future primary energy source, at a minimum, must meet these make-or-break standards:

- It must be capable of providing a substantial amount of energy—perhaps a quarter of all the energy currently used nationally or globally;
- It must have a net energy yield of 10:1 or more;
- It cannot have unacceptable environmental (including climate), social, or geopolitical impacts (such as one nation gaining political domination over others); and
- It must be renewable.

A PROCESS OF ELIMINATION

Assuming that oil, natural gas, and coal will have rapidly diminishing roles in our future energy mix, this leaves fifteen alternative energy sources with varying economic profiles and varying environmental impacts. Since even the more robust of these are currently only relatively minor contributors to our current energy mix, this means our energy future will look very different from our energy present. The only way to find out what it might look like is to continue our process of elimination.

If we regard large contributions of climate-changing greenhouse gas emissions as a non-negotiable veto on future energy sources, that effectively removes tar sands and oil shale from the discussion. Efforts to capture and sequester carbon from these substances during processing would further reduce their already-low EROEI and raise their already-high production costs, so there is no path that is both economically realistic and environmentally responsible whereby these energy sources could be scaled up to become primary ones. That leaves thirteen other candidates.

Biofuels (ethanol and biodiesel) must be excluded because of their low EROEI, and also by limits to land and water required for their production. (Remember: We are not suggesting that any energy source cannot play *some* future role; we are merely looking first for primary sources—ones that have the potential to take over all or even a significant portion of the current role of conventional fossil fuels.)

Energy-from-waste is not scalable; indeed, the "resource" base is likely to diminish as society becomes more energy efficient.

That leaves ten possibilities: nuclear, hydro, wind, solar PV, concentrating solar thermal, passive solar, biomass, geothermal, wave, and tidal.

Of these, nuclear and hydro are currently producing the largest amounts of energy. Hydropower is not without problems, but in the best instances its EROEI is very high. However, its capacity for growth in the U.S. is severely limited—there are not enough available undammed rivers—and worldwide it cannot do more than triple in capacity. Nuclear power will be slow and expensive to grow. Moreover, there are near-term limits to uranium ores, and technological ways to bypass those limits (e.g., with thorium reactors) will require time-consuming and expensive research. In short, both hydrower and nuclear power are unlikely candidates for rapid expansion to replace fossil fuels.

Biomass energy production is likewise limited in scalability, in this case by available land and water, and by the low efficiency of photosynthesis. America and the world could still obtain more energy from biomass, and production of *biochar* (a form of charcoal, usually made from agricultural waste, used as a soil amendment) raises the possibility of a synergistic process that would yield energy while building topsoil and capturing atmospheric carbon (though some analysts doubt this because pyrolysis, the process of making charcoal, emits not only CO_2 but other hazardous pollutants as well). Competition with other uses of biomass for food and for low-energy input agriculture will limit the amount of plant material available for energy production. Realistically, given the limits mentioned, biomass cannot be expected to sustainably produce energy on the scale of oil, gas, or coal.

Passive solar is excellent for space heating, but does not generate energy that could be used to run transportation systems and other essential elements of an industrial society.

That leaves six sources: Wind, solar PV, concentrating solar thermal, geothermal, wave, and tidal—which together currently produce only a tiny fraction of total world energy. And each of these still has its own challenges—like intermittency or limited growth potential.

Tidal, wave power, and geothermal electricity generation are unlikely to be scalable; although geothermal heat pumps can be used almost anywhere, they cannot produce primary power for transport or electricity grids.

Solar photovoltaic power is still expensive. While cheaper PV materials are now beginning to reach the market, these generally rely on rare substances whose depletion could limit deployment of the technology. Concentrating PV promises to solve some of these difficulties; however, more research is needed and the problem of intermittency remains.

With good geographical placement, wind and concentrating solar thermal have good net energy characteristics and are already capable of producing power at affordable prices. These may be the best candidates for non-fossil primary energy sources—yet again they suffer from intermittency.

Thus there is no single "silver-bullet" energy source capable of replacing conventional fossil fuels directly—at least until the problem of intermittency can be overcome—though several of the sources discussed already serve, or are capable of serving, as secondary energy sources.

This means that as fossil fuels deplete, and as society reduces reliance on them in order to avert catastrophic climate impacts, we will have to use every available alternative energy source strategically. Instead of a silver bullet, we have in our arsenal only BBs, each with a unique profile of strengths and weaknesses that must be taken into account.

But since these alternative energy sources are so diverse, and our ways of using energy are also diverse, we will have to find ways to connect source, delivery, storage, and consumption into a coherent system by way of common energy carriers.

COMMON CARRIERS: ELECTRICITY AND HYDROGEN

While society uses oil and gas in more or less natural states (in the case of oil, we refine it into gasoline or distil it into diesel before putting it into our fuel tanks), we are accustomed to transforming other forms of energy (such as coal, hydro, and nuclear) into electricity—which is energy in a form that is easy and convenient to use, transportable by wires, and that operates motors and a host of other devices with great efficiency.

With a wider diversity of sources entering the overall energy system, the choice of an energy carrier, and its further integration with transportation and space heating (which currently primarily rely on fossil fuels directly), become significant issues.

For the past decade or so energy experts have debated whether the best energy carrier for a post-fossil fuel energy regime would be electricity or hydrogen.[96] The argument for hydrogen runs as follows: Our current transportation system (comprised of cars, trucks, ships, and aircraft) uses liquid fuels almost exclusively. A transition to electrification would take time, retooling, and investment, and would face difficulties with electricity storage (discussed in more detail below): moreover, physical limits to the energy density by weight of electric batteries would mean that ships, large trucks, and aircraft could probably never be electrified in large numbers. The problem is so basic that it would remain even if batteries were substantially improved.

Hydrogen could more effectively be stored in some situations, and thus might seem to be a better choice as a transport energy carrier. Moreover, hydrogen could be generated and stored at home for heating and electricity generation, as well as for fueling the family car.

However, because hydrogen has a very low energy density per unit of volume, storage is a problem in this case as well: hydrogen-powered airplanes would need enormous tanks representing a substantial proportion of the size of the aircraft, and automobiles would need much larger tanks as well.

Moreover, several technological hurdles must be overcome before fuel cells—which would be the ideal means to convert the energy of hydrogen into usable electricity—can be widely affordable. And since conversion of energy is never 100 percent efficient, converting energy from electricity (from solar or wind, for example) to hydrogen for storage before converting it back to electricity for final use will inevitably entail significant inefficiencies.

The problems with hydrogen are so substantial that many analysts have by now concluded that its role in future energy systems will be limited (we are likely never to see a "hydrogen economy"), though for some applications it may indeed make sense.

Industrial societies already have an infrastructure for the delivery of electricity. Moreover, electricity enjoys some inherent advantages over fossil fuels: it can be converted into mechanical work at much higher efficiencies than can gasoline burned in internal combustion engines, and it can be transported long distances much more easily than oil (which is why high-speed trains in Europe and Japan run on electricity rather than diesel).

But if electricity is chosen as a systemic energy carrier, the problems with further electrifying transport using renewable energy sources such as wind, solar, geothermal, and tidal power remain: how to overcome the low energy density of electric batteries, and how to efficiently move electricity from remote places of production to distant population centers?[97]

ENERGY STORAGE AND TRANSMISSION

The energy densities by weight of oil (42 megajoules per kilogram), natural gas (55 MJ/kg), and coal (20 to 35 MJ/kg) are far higher than those of any electricity storage medium currently available. For example, a typical lead-acid battery can store about 0.1 MJ/kg, about one-fifth of 1 percent of the energy-per-pound of natural gas. Potential improvements to lead-acid batteries are limited by chemistry and thermodynamics, with an upper bound of less than 0.7 MJ/kg.

Lithium-ion batteries have improved upon the energy density of lead-acid batteries by a factor of about 6, achieving around 0.5 MJ/kg; but their theoretical energy density limit is roughly 2 MJ/kg, or perhaps 3 MJ/kg if research on the substitution of silicon for carbon in the anodes is realized in a practical way. On the other hand, supplies of lithium are limited, and therefore not scaleable.

It is possible that other elements could achieve higher energy storage by weight. In principle, compounds of hydrogen-scandium, if they could be made into a battery, could achieve a limit of about 5 MJ/kg. Thus the best existing batteries get about 10 percent of what is physically possible and 25 percent of the demonstrated upper bound.

Energy can be stored in electric fields (via capacitors) or magnetic fields (with superconductors). While the best capacitors today store one-twentieth the energy of an equal mass of lithium-ion batteries, a new company called EEstor claims a ceramic capacitor capable of 1 MJ/kg. Existing magnetic energy storage systems store around 0.01 MJ/kg, about equal to existing capacitors, though electromagnets made of high-temperature superconductors could in theory store about 4 MJ per liter, which is similar to the performance of the best imaginable batteries.

Chemical potential energy (a property of the atomic or molecular structure of materials that creates the potential for energy to be released and converted into usable forms—as is the case with fossil fuels and other combustible matter) can be stored as inorganic fuel that is oxidized by atmospheric oxygen. Zinc air batteries, which involve the oxidation of zinc metal to zinc hydroxide, could achieve about 1.3 MJ/kg, but zinc oxide could theoretically beat the best imagined batteries at about 5.3 MJ/kg.

Once again, hydrogen can be used for storage. Research is moving forward on building-scale systems that will use solar cells to split water into hydrogen and oxygen by day and use a fuel cell to convert the gases to electricity at night.[98] However, as discussed above, this technology is not yet economical.[99]

Better storage of electricity will be needed at several points within the overall energy system if fossil fuels are to be eliminated. Not only will vehicles need efficient batteries, but grid operators relying increasingly on intermittent sources like wind and solar will need ways to store excess electricity at moments of over-abundance for times of peak usage or scarcity. Energy storage on a large scale is already accomplished at hydroelectric dams by pumping water uphill into reservoirs at night when there is a surplus of electricity: energy is lost in the process, but a net economic benefit is realized in any case. This practice could be expanded, but it is limited by the number and size of existing dams, pumps, and reservoirs. Large-scale energy storage by way of giant flywheels is being studied, but such devices are likely to be costly.

The situation with transmission is also daunting. If large amounts of wind and solar energy are to be sourced from relatively remote areas and integrated into national and global grid systems, new high-capacity transmission lines will be needed, along with robust two-way communications, advanced sensors, and distributed computers to improve the efficiency, reliability, and safety of power delivery and use.

For the U.S. alone, the cost of such a grid upgrade would be $100 billion at a minimum, according to one recent study.[100] The proposed new system that was the basis of the study would include 15,000 circuit miles of extremely high voltage lines, laid alongside the existing electric grid infrastructure, starting in the Great Plains and Midwest (where the bulk of the nation's wind resources are located) and terminating in the major cities of the East Coast. The cost of building wind turbines to generate the amount of power assumed in the study would add another $720 billion, spent over a fifteen-year period and financed primarily by utilities and investors.

Yet, this hypothetical project would enable the nation to obtain only 20 percent of its electricity from wind by 2024. If a more rapid and complete transition away from fossil fuels is needed or desired, the costs would presumably be much higher.

However, many energy analysts insist that long high-capacity power lines would *not* be needed for a renewable energy grid system: such a system would best take advantage of regional sources—off-shore wind in the U.S. Northeast, active solar thermal in the desert Southwest, hydropower in the Northwest, and biomass in the forested Southeast. Such a decentralized or "distributed" system would dispense not only with the need for costly high-capacity power line construction but would also avoid fractional power losses associated with long-distance transmission.[101] Still, problems remain: one of the advantages of a continent-scale grid system for renewables would be its ability to compensate for the intermittency of energy sources like wind and solar. If skies are overcast in one region, it is likely that the sun will still be shining or winds blowing elsewhere on the continent. Without a long-distance transmission system, there must be some local solution to the conundrum of electricity storage.

TRANSITION PLANS

As noted above, there is an existing literature of plans for transitioning U.S. or world energy systems away from fossil fuels. It would be impossible to discuss those plans here in any detail, except to remark that some of those proposals include nuclear power[102] while some exclude it[103]. And some see a relatively easy transition to solar and wind[104], while others do not[105].

The present analysis, which takes into account EROEI and other limits to available energy sources, suggests first that the transition is inevitable and necessary (as fossil fuels are rapidly depleting and are also characterized by rapidly declining EROEI), and that the transition will be neither easy nor cheap. Further, it is reasonable to conclude from what we have seen that a full replacement of energy currently derived from fossil fuels with energy from alternative sources is probably impossible over the short term; it may be unrealistic to expect it even over longer time frames.

The core problem, which is daunting, is this: How can we successfully replace a concentrated store of solar energy (i.e., fossil fuels, which were formed from plants that long ago bio-chemically captured and stored the energy of sunlight) with a *flux* of solar energy (in any of the various forms in which it is available, including sunlight, wind, biomass, and flowing water)?

It is not within the purpose of this study to design yet another detailed transition plan. Such exercises are useful, but inevitably decisions about how much of a hypothetical energy mix should come from each of the potential sources (wind, solar, geothermal, etc.) depend on projections regarding technological developments and economic trends. The final plan may consist of a complex set of scenarios, with increasing levels of detail adding to the document's value as an analytical tool; yet all too often real-world political and economic events turn such scenarios into forgotten pipe-dreams.

The actual usefulness of energy transition plans is more to show what is possible than to forecast events. For this purpose, even very simple exercises can sometimes be helpful in pointing out problems of scale. For example, the following three scenarios for world energy, which assume only a single alternative energy source using extremely optimistic assumptions, put humanity's future energy needs into a sobering cost perspective.[106]

Scenario 1: The World at American Standards. If the world's population were to stabilize at 9 billion by 2050, bringing the entire world up to U.S. energy consumption (100 quadrillion BTU annually) would require 6000 quads per year. This is more than twelve times current total world energy production. If we assume that the cost of solar panels can be brought down to 50 cents per watt installed (one tenth the current cost and less than the current cost of coal), an investment of $500 trillion would be required for the transition, not counting grid construction and other ancillary costs—an almost unimaginably large sum. This scenario is therefore extremely unlikely to be realized.

Scenario 2: The World at European Standards. Since Europeans already live quite well using only half as much energy as Americans, it is evident that a U.S. standard of living is an unnecessarily high goal for the world as a whole. Suppose we aim for a global per-capita consumption rate 70 percent lower than that in the United States. Achieving this standard, again assuming a population of 9 billion, would require total energy production of 1800 quads per year, still over three times today's level. Cheap solar panels to provide this much energy would cost $150 trillion, a number over double the current world annual GDP. This scenario is conceivable, but still highly unlikely.

Scenario 3: Current per-Capita Energy Usage. Assume now that current world energy usage is maintained on a per-capita basis. If people in less-industrialized nations are to consume more, this must be compensated for by reduced consumption in industrial nations, again with the world's population stabilizing at 9 billion. In this case, the world would consume 700 quads of energy per year. This level of energy usage, if it were all to come from cheap solar panels, would require $60 trillion in investment—still an enormous figure, though one that might be achievable over time. (Current average per-capita consumption globally is 61 gigajoules per year; in Qatar it is 899 GJ per year, in the U.S. it is 325 GJ per year, in Switzerland it is 156 GJ per year, and in Bangladesh it is 6.8 GJ per year. The range is very wide. If Americans were to reduce their energy use to the world average, this would require a contraction to less than one-fifth of current consumption levels, but this same standard would enable citizens of Bangladesh to increase their per-capita energy consumption nine-fold.)

Of course, as noted above, all three scenarios are extremely simplistic. On one hand, they do not take into account amounts of energy already coming from hydro, biomass, etc., which could presumably be maintained: it would not be necessary to produce all needed energy from new sources. But on the other hand, costs for grid construction and electrification of transport are not included. Nor are material resource needs accounted for. Thus on balance, the costs cited in the three scenarios are if anything probably dramatically understated.

The conclusion from these scenarios seems inescapable: unless energy prices drop in an unprecedented and unforeseeable manner, the world's economy is likely to become increasingly energy-constrained as fossil fuels deplete and are phased out for environmental reasons. It is highly unlikely that the entire world will ever reach an American or even a European level of energy consumption, and even the maintenance of current energy consumption levels will require massive investment.

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TABLE 4. ENERGY USE BY (SELECTED) COUNTRIES, 2006 *(Source: U.S. Energy Information Administration[107])*

COUNTRY	Per capita energy use (Million Btu)	Total energy use (Quadrillion Btu)
Afghanistan	0.6	0.018
Albania	34.3	0.123
Algeria	46.6	1.536
Angola	13.7	0.165
Argentina	79	3.152
Australia	276.9	5.611
Austria	187.2	1.534
Bangladesh	5	0.743
Belgium	265.1	2.751
Benin	4.9	0.039
Bolivia	24.2	0.218
Botswana	33.1	0.059
Brazil	51.2	9.635
Bulgaria	121.5	0.897
Burkina Faso	1.3	0.019
Burma (Myanmar)	5	0.236
Cambodia	0.7	0.01
Cameroon	5	0.088
Canada	427.2	13.95
Chad	0.3	0.003
Chile	77.6	1.254
China	56.2	73.808
Colombia	29.8	1.305
Congo (Kinshasa)	1.6	0.097
Costa Rica	43.6	0.178
Croatia	92.1	0.414
Cuba	35.1	0.399
Czech Republic	176.6	1.808
Denmark	161.3	0.879
Ecuador	31	0.42
Egypt	32.2	2.544
El Salvador	19.2	0.131
Estonia	175.2	0.232
Ethiopia	1.4	0.103
France	180.7	11.445
Germany	177.5	14.629
Ghana	7.1	0.159
Greece	139.1	1.487
Greenland	149.3	0.008
Guatemala	16.3	0.202
Guinea	2.4	0.023
Guyana	29.4	0.023
Haiti	3.3	0.028
Honduras	17.3	0.127
Hong Kong	167.7	1.164
Hungary	114.7	1.145
Iceland	568.6	0.17
India	15.9	17.677
Indonesia	17.9	4.149
Iran	118.2	7.686
Iraq	46.6	1.247
Ireland	173.4	0.704
Israel	123.5	0.848
Italy	138.7	8.069
Japan	178.7	22.786
Jordan	52.2	0.308
Kazakhstan	195.3	2.975
Kenya	5.6	0.202
Korea, North	41.1	0.949
Korea, South	193.4	9.447
Kuwait	469.8	1.136
Laos	3.6	0.023
Lebanon	53.3	0.207
Liberia	2.5	0.008
Libya	132	0.779
Lithuania	97	0.348
Madagascar	2.2	0.042
Malaysia	104.8	2.557
Mali	1.1	0.013
Mexico	68.5	7.357
Mongolia	33	0.096
Morocco	15.2	0.508
Mozambique	10.6	0.218
Namibia	29.3	0.06
Nepal	2.4	0.068
Netherlands	250.9	4.137
New Zealand	211.2	0.864
Nicaragua	12.8	0.071
Niger	1.3	0.017
Nigeria	7.8	1.023
Norway	410.8	1.894
Pakistan	14.2	2.298
Peru	21.6	0.613
Philippines	14.2	1.271
Poland	100.1	3.856
Qatar	1,023.3	0.906
Romania	75.2	1.678
Russia	213.9	30.386
Rwanda	1.4	0.013
Saudi Arabia	255	6.891
Senegal	6.9	0.084
Sierra Leone	2.8	0.017
Singapore	476.8	2.142
Solomon Islands	5.4	0.003
Somalia	1.2	0.01
South Africa	117.2	5.177
Spain	161.2	6.51
Sri Lanka	10.5	0.218
Sudan	4.8	0.185
Swaziland	15	0.017
Sweden	245.8	2.216
Switzerland	170.7	1.284
Syria	42.9	0.81
Taiwan	200.6	4.569
Tanzania	2.1	0.08
Thailand	57.9	3.741
Turkey	55.5	3.907
Uganda	1.2	0.035
Ukraine	125.9	5.871
United Arab Emirates	577.6	2.464
United Kingdom	161.7	9.802
United States	334.6	99.856
Uruguay	38.8	0.134
Venezuela	124.4	3.191
Vietnam	16.6	1.404
Yemen	12.4	0.267
Zambia	11.1	0.126
Zimbabwe	15	0.183


ANITA BOWEN

In many cities of the world, there's a renaissance in bicycle travel, and new public accommodations to bicyclists: pathways, car-free roads and parks, new rules of the road that favor bicycles, bike racks on public busses, bike cars on commute trains, etc. All seem small-scale compared to the immensity of the energy crisis, but they create a "can do" spirit, self-reliance, and a transformational ethic, so other conservation steps—emphasis on light rail, dedicated bus lanes, fees for cars downtown, higher parking rates—begin to be practical. And it's fun and healthy.

Six

THE CASE FOR CONSERVATION

THE CENTRAL ISSUE REMAINS—how to continue supplying energy in a world where resources are limited and declining. The solution becomes much easier if we find ways to proactively *reduce* energy demand. And that project in turn becomes easier if there are fewer of us wanting to use energy (that is, if population shrinks rather than continuing to increase).

Based on all that we have discussed, the clear conclusion is that the world will almost certainly have considerably less energy available to use in the future, not more, though (regrettably) this strong likelihood is not yet reflected in projections from the International Energy Agency or any other notable official source. Fossil fuel supplies will almost surely decline faster than alternatives can be developed to replace them. New sources of energy will in many cases have *lower* net energy profiles than conventional fossil fuels have historically had, and they will require expensive new infrastructure to overcome problems of intermittency, as we have discussed.

Moreover, the current trends toward declining energy demand, combined with falling investment rates for new energy supplies (especially for fossil fuels), resulting from the ongoing global economic crisis, are likely to continue for several years, thus complicating both a general recognition of the problem and a coordinated response.

How far will supplies fall, and how fast? Taking into account depletion-led declines in oil and natural gas production, a leveling off of energy from coal, and the recent shrinkage of investment in the energy sector, it may be reasonable to expect a reduction in global energy availability of 20 percent or more during the next quarter century. Factoring in expected population growth, this implies substantial *per-capita* reductions in available energy. These declines are unlikely to be evenly distributed among nations, with oil and gas importers being hardest hit, and with the poorest countries seeing energy consumption returning to pre-industrial levels (with energy coming almost entirely from food crops and forests and work being done almost entirely by muscle power).

Thus, the question the world faces is no longer *whether* to reduce energy consumption, but *how*. Policy makers could choose to manage energy unintelligently (maintaining fossil fuel dependency as long as possible while making poor choices of alternatives, such as biofuels or tar sands, and insufficient investments in the far more promising options such as wind and solar). In the latter case, results will be catastrophic. Transport systems will wither (especially ones relying on the most energy-intensive vehicles—such as airplanes, automobiles, and trucks). Global trade will contract dramatically, as shipping becomes more costly. And energy-dependent food systems will falter, as chemical input and transport costs soar. All of this could in turn lead to very high long-term unemployment and perhaps even famine.

However, if policy makers manage the energy downturn intelligently, an acceptable quality of life could be maintained in both industrialized and less-industrialized nations at a more equitable level than today; at the same time, greenhouse gas emissions could be reduced dramatically. This would require a significant public campaign toward the establishment of a new broadly accepted conservation ethic to replace current emphases on never-ending growth and over-consumption at both personal and institutional-corporate levels. We will not attempt here a full list of the needed shifts, but they might well include the following practical, engineering-based efforts:

- Immediate emphasis on and major public investment in construction of highly efficient rail-based transit systems and other public transport systems (including bicycle and pedestrian pathways), along with the redesign of cities to reduce the need for motorized human transport.[108]
- Research, development, and construction of electricity grid systems that support distributed, intermittent, renewable energy inputs.
- Retrofit of building stock for maximum energy efficiency (energy demand for space heating can be dramatically reduced through super-insulation of structures and by designing to maximize solar gain).[109]
- Reduction of the need for energy in water pumping and processing through intensive water conservation programs (considerable energy is currently used in moving water, which is essential to both agriculture and human health).[110]

As well, the following policy-based initiatives will be needed:

- Internalization of the full costs of energy to reflect its true price. Elimination of perverse energy subsidies, especially all upstream and production-side state support. Encourage government "feed-in tariffs" that favor ecologically sustainable renewable energy production.
- Application of the ten energy assessment criteria listed in this document to all energy technologies that are currently being proposed within the UN climate negotiations, for "technology transfer" from rich countries to poor.
- Re-localization of much economic activity (especially the production and distribution of essential bulky items and materials) in order to lessen the need for transport energy[111]; correspondingly, a reversal of the recent emphasis on inherently wasteful globalized economic systems.
- Rapid transition of food systems away from export oriented industrial production, toward more local production for local consumption, thus reducing mechanization, energy inputs, petro-chemicals and transport costs. Also, increased backing for permaculture, and organic food production. And, firm support for traditional local Third World farming communities in their growing resistance to industrial export agriculture.
- A major shift toward *re-ruralization*, i.e., creating incentives for people to move back to the land, while converting as much urban land as possible to sustainable food production, including substantial suburban lands currently used for decorative lawns and gardens.
- Abandonment of *economic growth* as the standard for measuring economic progress, and establishment of a more equitable universal standard of "sufficiency."
- Increase of reserve requirements on lending institutions to restrain rampant industrial growth until price signals are aligned to reflect full costs. Restrictions on debt-based finance.
- Development of indicators of economic health to replace the current GDP calculus with one that better reflects the general welfare of human beings.
- *Re-introduction* of the once popular "import substitution" (from the 1930s) model whereby nations determine to satisfy basic needs—food, energy, transport, housing, healthcare, etc.—*locally* if they possibly can, rather than through global trade.
- Establishment of international protocols on both energy assessment (including standards for assessing EROEI and environmental impacts) and also technology assessment. The latter should include full lifecycle energy analysis, along with the prin-

ciples of "polluter pays" and the "precautionary principle."

- Adoption of international depletion protocols for oil, gas and coal—mandating gradual reduction of production and consumption of these fuels by an annual percentage rate equal to the current annual depletion rate, as outlined in the present author's previous book, *The Oil Depletion Protocol*, so as to reduce fuel price volatility.
- Transformation of global trade rules to reward governments for, rather than restraining them from, protecting and encouraging the localization of economic production and consumption patterns.
- Aggressive measures for "demand-side management" that reduce overall energy needs, particularly for power grids. This would be part of a society-wide "powering down," i.e., a planned reduction in overall economic activity involving energy, transport and material throughputs, emphasizing conservation over new technology as the central solution to burgeoning problems.
- International support for women's reproductive and health rights, as well as education and opportunity, as important steps toward mitigation of the population crisis, and its impact on resource depletions.
- The return of control of the bulk of the world's remaining natural resources from corporations and financial institutions in the industrialized countries to the people of the less industrialized nations where those resources are located.

The goal of all these efforts must be the realization of a no-growth, *steady-state* economy, rather than a growth-based economy. This is because energy and economic activity are closely tied: without continuous growth in available energy, economies cannot expand. It is true that improvements in efficiency, the introduction of new technologies, and the shifting of emphasis from basic production to provision of services can enable some economic growth to occur in specific sectors without an increase in energy consumption. But such trends have inherent bounds. Over the long run, static or falling energy supplies must be reflected in economic stasis or contraction. However, with proper planning there is no reason why, under such circumstances, an acceptable quality of life could not be maintained.[113] For the world as a whole, this might entail the design of a deliberate plan for global redistribution of energy consumption on a more equitable basis, with industrial nations reducing consumption substantially, and less-industrial nations increasing their consumption somewhat in order to foster global "sufficiency" for all peoples. Such a formula might partly make up for centuries of colonial expropriation of the resources of the world's poor countries, a historical factor that had much to do with the rapid industrial growth of the wealthy resource-hunting countries during the past 150 years. Addressing this disparity might help provide the poorer countries a chance for survival, if not equity.

Here's some good news: A considerable literature exists on how people in recently affluent nations can reduce energy consumption while actually increasing levels of personal satisfaction and community resilience.[114] The examples are legion, and include successful community gardens, rideshare, job-share, and broad local investment and conservation programs, such as Jerry Mander briefly mentions in the Foreword, including most notably the Transition Towns movement that is now sweeping Europe and beginning in the U.S. as well.

While the subject is, strictly speaking, beyond the scope of this booklet, it must also be noted and underscored that global conservation efforts are and will be required with regard to *all* natural resources (not just energy resources). The Earth's supplies of high-grade ores are limited, and shortages of a wide range of minerals, including phosphorus, coltan, and zinc, are already occurring or expected within the next few decades if current consumption patterns continue. Deforestation, loss of topsoil due to erosion, and the (in many cases) catastrophic and irreversible decline of wild fish species in the oceans are also serious problems likely to undermine economic activity and human well-being in the years ahead. Thus, all standard operating assumptions about the future of industrial society are clearly open to doubt.

Societal adaptation to resource limits inevitably also raises the question of population. When population grows but the economy remains the same size, there are fewer economic goods available per person. If energy and material constraints effectively impose a cap on economic growth, then the only way to avert continuing declines in per-capita access to economic goods is to limit population by, for example, providing economic incentives for smaller families rather than larger ones (Note: in the United States larger families are now rewarded with lower taxes), as well as easy access to birth control, and support for poor women to obtain higher levels of education. Policy makers must begin to see population shrinkage as a goal, rather than an impediment to economic growth.

In his book *Energy at the Crossroads*[115], Vaclav Smil shows the relationship between per capita energy consumption and various indices of well-being. The data appear to show that well-being requires at least 50 to 70 GJ per capita per year. As consumption above that level slightly expands, a sense of well being also expands, but only up to about 100 GJ per capita, a "safety margin" as it were. Remarkably however, above and beyond that level of consumption, there is no increase in a sense of well being. In fact the more consumptive and wealthy we become, the less content and satisfied we apparently are. One wonders whether the effort needed to expand material wealth and consumption have their own built-in dissatisfactions in terms of challenges to free time, added daily pressures, reduced family contact, engagement with nature, and personal pleasures. North America's energy consumption is currently about 325 GJ per annum. Using these indices as goals, and with a general notion of the total amount of energy that will be available from renewable energy sources, it should then be possible to set a target for a population size and consumption levels that would balance these factors.

Energy conservation can take two fundamental forms: curtailment and efficiency. *Curtailment* describes situations where uses of energy are simply discontinued (for example, we can turn out the lights in rooms as we vacate them). *Efficiency* describes situations where less energy is used to provide an equivalent benefit (a related example would be the replacement of incandescent bulbs with compact fluorescents or LEDs). Efficiency is typically preferred, since few people want to give up tangible benefits, but efficiency gains are subject to the law of diminishing returns (the first ten percent gain may be cheap and easy, the next ten percent will be somewhat more costly, and so on), and there are always ultimate limits to possible efficiency gains (it is impossible to light homes at night or to transport goods with zero energy expenditure). Nevertheless, much could be achieved over the short term in energy efficiency across all sectors of the economy.

Curtailment of use is the quickest and cheapest solution to energy supply problems. Given the reality that proactive engagement with the inevitable energy transition has been delayed far too long, curtailment (rather than efficiency or replacement with alternative sources) will almost certainly need to occur, especially in wealthy nations. But even granting this, proactive effort will still be crucial, as planned and managed curtailment will lead to far less societal disruption than ad hoc, uplanned curtailment in the forms of electrical blackouts and fuel crises.

The transition to a steady-state economy will require a revision of economic theories and a redesign of financial and currency systems.[116] These efforts will almost certainly be required in any case if the world is to recover from the current economic crisis.

Realistic energy descent planning must begin at all levels of society. We must identify essential economic goods (obviously including food, water, shelter, education, and health care) and decouple these from discretionary consumption that in recent decades has been encouraged merely to stoke economic growth.

The UN negotiations on climate change leading up to the Copenhagen climate summit in December 2009, have presented an opportunity for the world to consider the centrality of energy conservation in cutting greenhouse gases, yet it is barely part of the official UN climate agenda. Much of the current policy discussion misguidedly focuses on expanding renewable energy sources, with little to no consideration of their ecological, economic, and practical limits. Energy efficiency is receiving increasing attention, but it must be seen as part of a clear conservation agenda aimed at reducing global demand for energy overall.

Surprisingly, a recent US-China memorandum of understanding on energy and climate listed conservation as its top bullet point among shared concerns. If the world's two largest energy consumers in fact believe this is their top priority, then it needs to come to the fore in global climate discussions.

However, the mandate of the UN climate talks does not include an official multilateral process to cooperate on energy descent. Negotiators increasingly express concern over energy supply issues but are without an international forum in which to address them.

The national security community appears now to take seriously threats related both to climate change and energy supply vulnerability. This could set a new context for post-Copenhagen international efforts to address these collective concerns so as to avoid violent conflict over depleting energy resources and climate disaster.

* * *

Our energy future will be defined by limits, and by the way we respond to those limits. Human beings can certainly live within limits: the vast majority of human history played out under conditions of relative stasis in energy consumption and economic activity; it is only in the past two centuries that we have seen spectacular rates of growth in economic activity, energy and resource consumption, and human population. Thus, a deliberate embrace of limits does not amount to the end of the world, but merely a return to a more normal pattern of human existence. We must begin to appreciate that the 20th century's highly indulgent, over-consumptive economic patterns were a one-time-only proposition, and cannot be maintained.

If the energy transition is wisely managed, it will almost certainly be possible to maintain, within this steady-state context, many of the benefits that our species has come to enjoy over the past decades—better public health, better knowledge of ourselves and our world, and wider access to information and cultural goods such as music and art.

As society adopts alternative energy sources, it will at the same time adopt new attitudes toward consumption, mobility, and population. One way or another, the transition away from fossil fuels will mark a turning point in history as momentous as the Agricultural Revolution or the Industrial Revolution.

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Peak Oil Review

Tom Whipple, Editor
Sharon Astyk, Commentary Editor

October 24, 2011

1. Oil and the Global Economy

For another week the global oil markets were largely driven by the prospects for settling the EU's sovereign debt crisis. The price rise which began in early October, taking Brent crude from $98 a barrel to the neighborhood of $112, continued through Wednesday when it became clear that negotiations between France and Germany over the debt crisis were at an impasse. Prices then fell with Brent closing out the week at $109.56 and NY oil at $87.40.

Although limited amounts of oil are now being exported from Libya, global markets remain tight, which is why OPEC is still averaging $108 a barrel for its oil. The death of Gadhafi last week brought to a close another chapter in the Arab uprising. The next few months will see whether the Libyans can form a government with enough strength to organize and provide security for oil production or whether disagreements among the various tribes, cities, and other factions will prevent Libyan oil exports from reaching significant levels in the next year or so. Some engineers are already talking about the damage that might have been done to the pressure of Libyan oil fields by the emergency shutdowns they underwent.

US commercial petroleum inventories fell by an unusually large 11 million barrels the week before last adding more credence to the IEA assertion that the world currently is burning more oil and other liquids than it is producing. Global stocks are still about 2.6 billion barrels so the drawdown can still go on for some time without much effect. Global oil prices have been trading over a $15 a barrel range centered on $110 since late spring. This price range is some $25 dollar a barrel higher than where oil traded for most of 2010 and is clearly exacting a toll on many economies.

The announcement that US combat forces will not be remaining in Iraq after the end of the year raises once again the question of whether the government will be able to provide sufficient security to allow major increases in oil production. Assassinations, bombings, and sabotage of oil facilities still take place on a regular basis. Increasing tensions in the region stemming from the Syrian, Bahraini, Yemeni, and Kurdish uprisings, and the numerous issues between Iran and many other states, all suggest that exploiting the world's last major deposit of cheap and easy to extract oil may not be all that easy.

A meeting of oil ministers in Paris last week provided the venue for a number of interesting assertions by senior officials of the IEA. The Agency believes that: the growth in oil demand would be "largely wiped out" by a double-dip recession; that the ongoing unrest in the Middle East might lead to underinvestment in oil production and higher prices in the year ahead; it is almost too late to limit global temperature increases to 2^{o} C.; the world is faced with a dire future in which the average global temperatures rise by more than 3.5 C unless there are major innovations to lower the cost of clean energy and lower carbon emissions; and that they see less potential for an oil price spike in the next few months than they did a few months ago due to slowing economies.

2. The EU debt crisis

Most observers agree that a quick settlement to the EU's sovereign debt crisis is vital to continued global economic stability. Unless a way is found to heal permanently the hemorrhaging of Greece's economy, the problem will spread to the major European banks that hold the Greek debt and from there to Spain, Italy, Belgium and eventually France. Even Wall Street is threatened due to the massive credit default swaps it holds on Europe's debt. Taken to the extreme, the situation could ultimately result in severe damage to the global banking system and a major world-wide depression. In such a situation the significance of peaking global oil supplies likely would be lost in the midst of plummeting demand for oil.

Europe's leaders clearly understand the danger of the situation and are scrambling to find a solution that is not easily coming. Greece's economy seems to be in a death spiral with its people unwilling to make the sacrifices demanded by the rest of the EU and its deficits continuing to grow. A split has developed between Germany and France which are the only Eurozone countries large enough to affect a bailout. France, whose banks are heavily invested in Greece and other threatened Eurozone economies and would be damaged, if not wiped out, by widespread defaults, is seeking to solve the problem with European and global money rather than using its government credit to support French banks.

Germany has already committed $290 billion to a bailout fund for Greece, Portugal, and Ireland, and its voters are tired of bailing out what they see as bad financial management by other Eurozone members. Berlin, under pressure from the parliament, is refusing to bail out what it considers to be poor loans made by banks in other counties. The search for a solution jumps around from large write downs in the bad debts to various schemes to inflate European Financial Stability Facility (EFSF). So far all proposals have serious problems and serious opposition which is why the problem continues to be pushed ahead despite the urgency of the situation.

Despite constant incantations of optimism from various European leaders, which serve to push up the equity markets and the price of oil, many observers believe the debt situation has become so massive and complex that it is insoluble on more than a temporary basis. While some agreement may be cobbled together in the next week or two, it seems likely the underlying problem will around is some form or other for many years.

3. US oil consumption

As the world's largest consumer of oil products, just what is happening to oil consumption in the United States is always of interest. A new study says US drivers will spend about $490 billion filling their gas tanks this year which will be up by more than $100 billion over 2010. Three years ago when average gasoline prices got over $4 a gallon, demand for gasoline fell by only 3 percent. These high gasoline prices have become a part of life and not just a brief up and down as in 2008. Despite oil prices that have been running 60-80 cents a gallon higher than last year, gasoline consumption is only down some 1.3 percent last month from September 2010.

It seems that most drivers can't or won't reduce their fuel consumption and are taking the extra $100 billion from other purchases. Many say they are cutting back on food expenditures as they have few other options. America seems to be running into an "elasticity wall" at which lifestyles and lack of alternative transportation choices are keeping Americans in their cars right down to the end of their resources.

The API is reporting that total US petroleum imports fell by nearly 10 percent in September reflecting a 5 percent increase in domestic production during the last four weeks over last year as well as the continuing drawdown in US stocks which were 5.3 percent lower than a year earlier. It is possible that the general tightness of the global market without Libyan production and various reductions in non-OPEC production is making it more difficult for US refiners to find crude to import.

The API is also reporting a surge in the demand for distillates in September which recently has been running nearly 6 percent higher than last year. As it is difficult to see an increase of this size being consumed by a moribund US economy, it is likely that much of the increased demand for distillates is being exported. US oil product exports this year are up 24 percent over 2010. With global conventional oil production flat, much of the increase in demand is being satisfied by natural gas liquids and ethanol which are not substitutes for distillates.

If current trends continue, it is likely that we are going to see increasingly higher prices for distillates – diesel, fuel oil, and jet fuels – and that the availability of these oil products may become an issue before that of gasoline.

4. Fracking for gas

There was news on the fracking front last week as new rules were issued to control fracking of natural gas shale. As shale gas has come to be seen in many quarters as the salvation for the nation's problems by providing clean cheap energy, jobs, and tax revenues, the new rules are likely to become controversial as the industry seeks to have them overturned.

The EPA announced that it will issue national shale wastewater rules under the Clean Water Act that will set standards that drillers must meet before sending water that has been extracted from fracked wells to waste water facilities for treatment. It currently is illegal to discharge untreated waste water from fracking into streams or bodies of water. This move is separate from an ongoing study of the effects of fracking on drinking water. The new rules are to come into force in 2014.

While New York's temporary ban on drilling ended last week, the new rules issued with the lifting of the ban will prove to be onerous for many drilling companies unless they are modified. The new rules, which are expected to come into force next year, establish buffer zones around waterways and aquifers that are as much as 20 times wider than those found in fracking-friendly Pennsylvania. The rules would prohibit drilling within 500 feet of the state's 18 primary aquifers, within 4000 feet of the NY City and Syracuse watersheds and within 2000 feet of rivers and streams. NY City is also proposing that drilling be banned within seven miles of the aged underground aqueducts that bring water to major cities.

Numerous drilling companies already hold leases on tens of thousands of acres that would be closed under the new rules. After a 90-day comment period, the new regulations could be finalized and new drilling permits could be issued by mid-2012.

Quote of the week

- "Most economists view the economic growth of the last century and a half as being fueled by ongoing technological progress. Without question, that progress has been most impressive. But there may also have been an important component of luck in terms of finding and exploiting a resource that was extremely valuable and useful but ultimately finite and exhaustible. It is not clear how easy it will be to adapt to the end of that era of good fortune."

-- James D. Hamilton

The Briefs (clips from recent *Peak Oil News* dailies are indicated by date and item #)

- California regulators have approved North America's first **cap-and-trade** program, setting limits on carbon emissions. The move represents the world's second-largest carbon control program after the European Union. (10/22, #14)
- U.S. officials have approved the first offshore oil-exploration plan submitted by **BP** since the Deepwater Horizon oil spill. (10/22, #17)

- Increasingly, **Iraq's** drive to expand its oil and natural gas industry, the country's economic lifeline, is becoming dependent on the government's ability to ensure security and, without US forces that looks to be a serious problem. (10/21, #8)
- **Lukoil** and its partners are poised to award a numerous contracts to international engineering and construction companies as it moves full speed ahead with development of its supergiant West Qurna Phase 2 in southern Iraq. (10/21, #9)
- **ExxonMobil, BP, and Eni** will spend around $100 billion to upgrade three oil fields in southern Iraq. About $50 billion would be spent to upgrade the big West Qurna Phase 1 oil field which is being developed by Exxon. The remaining $50 billion will be spent by BP and Eni to upgrade the Rumaila and Zubair oil fields, respectively. (10/20, #7)
- **Iraq** has agreed with oil majors to build a multi-billion-dollar oil field water injection plant in the south of the country, after disagreement over costs that suspended the project for months. (10/20, #8)
- **Iraq** is driving to build new oil refineries to increase capacity by 740,000 b/d as its postwar economy swells, part of a multibillion-dollar program under way across the Persian Gulf region. (10/20, #9)
- **Iraq's** crude oil production is expected to hit some 3 million b/d by the end of October from the current 2.9 million--the highest level reached since the US-led invasion in 2003. (10/18, #7)
- President **Chávez** of Venezuela declared on Thursday that he had beaten cancer, less than five months after revealing that he had undergone emergency surgery to remove a tumor while in seclusion in Cuba. (10/21. #11)
- **Statoil** announced its giant North Sea discovery Aldous Major South is estimated to contain double the volume compared with previous estimates. (10/21, #14)
- A Japanese industrial company aims to test a new **tidal power system** at an energy center in the north of Scotland. (10/21, #20)
- **India and Russia** signed deals to work closer with the IEA on energy matters. The International Energy Agency sponsored a meeting in Paris that focuses on energy security and sustainability, as well as closer engagement with non-member states. (10/20, #5)
- **Eni** has made a very large natural-gas discovery off the coast of Mozambique, big enough that it could turn the East African country into a major exporter of gas to Asia. (10/20, #11)
- China's largest **rare earths** producer is suspending production for a month in a move to force prices up. (10/18, #17) (10/20, #13)
- The **Gas Exporting Countries** Forum won't become a cartel like OPEC because it won't impose production quotas on its members, said Russia's Deputy Energy Minister Anatoly Yanovsky. (10/19, 6)
- Russian Prime Minister Putin has told his Japanese counterpart Yoshihiko Noda that Moscow hopes to advance **energy cooperation** with Tokyo in areas including LNG and possible electricity supplies to the gas- and power- hungry nation. (10/17, #16)
- **Japan** is considering revising plans to cut carbon dioxide emissions by 25 percent by 2020 due to a rethink of its energy future. The country is worried that it is spending too much on carbon credit programs. (10/19, #12)
- The **EU** is for the first time clearly questioning whether it should press ahead with long-term plans to cut greenhouse-gas emissions if other countries don't follow suit. This could herald a significant policy shift for a region that has been at the forefront of advocating action to combat climate change. (10/19, #17)

- A bill passed by the US Senate ensures the American public isn't in danger of **gas pipelines** "exploding under their feet," a California lawmaker said. (10/19, #14)
- US officials are trying to make sure the American coastline will be protected as **Cuba** begins drilling a deep water oil well later this year about 60 miles off the Florida Keys. (10/17, #8)
- **China's** hydropower output dropped 24.5 percent year-on-year to 56.87 billion kilowatt-hours (kwh) in September as a result of decreased runoff from major rivers. (10/17, #9)
- **BP** reached a $4 billion out-of-court settlement with Anadarko Petroleum Corp. to settle claims related to the deadly explosion and oil spill at a U.S. offshore drilling platform. (10/17, #13)
- Kinder Morgan Inc.'s agreement to buy El Paso Corp. (EP) for $21.1 billion, the energy industry's biggest transaction in more than a year, would create the largest natural-gas **pipeline network** in the U.S. (10/17, #15)

Commentary: Oil and the Economy

By Chris Martenson

(Note: Commentaries do not necessarily represent the position of ASPO-USA.)

By itself, the concept of having to get by on just a little bit less oil each year seems to be manageable enough. Some think that a steadily, or even sharply, rising price will merely reduce demand and promote exploration and that everything will more or less normally work itself out through well understood market mechanisms. Perhaps it will, but I think the odds are stacked against a smooth transition to a future of less net energy.

The critical fact is this: Because all money is loaned into existence, our economy requires perpetual growth to function. The purpose of this article is not to opine on whether this is a good or a bad system, but merely to describe it and the risks it carries by virtue of its design.

With constant economic growth, our money system is relatively happy; without growth, it becomes utterly despondent. Without constant economic growth, preferably in the range of 3% (or more!), the collective pile of debts cannot be serviced out of new growth and so they begin to default.

This is exactly the dynamic that has been exposed and now is in play in Europe and, if my guesses are correct, will soon visit the very core of the thin-air money machine, the US itself.

That’s the difference between growth and shrinkage in our world economy. Night and day. Life and death. If this strikes you as a rather fragile and unsustainable way to construct an economy, then you are not alone. After all, how can anything grow forever?

The key takeaway here is this: Our economy must grow in order to function.

Oil & the Economy

When I have the opportunity to present to and interact with people who are one the economic/financial side of the equation, they very rarely understand - truly understand - the energy side of the equation. You know, the not-so-subtle difference between total energy and net energy, and the fact that the first and second laws of thermodynamics have never been broken.

And in reverse, I often find that people in the energy camp do not really appreciate how the economy functions, and that it is really a complex system with multiple nested feedback loops predicated upon growth. In my view, each camp would benefit from spending a little bit more time in the other camp because both are really making some very profound assumptions.

The economic folks are assuming that energy will somehow be found and brought to market and the energy folks are assuming that the economy will be there to support their capital and technology-intensive efforts. Neither of these assumptions are very helpful if they help us overlook the potential disruption that declining net energy could unleash within our economy.

To return to the idea of our economy as a complex system for a minute. The field of complexity research is pretty robust and understands the basic principles of the coupling between energy flows and complexity. Whether the complex system being studied is a wave encountering the shore, a pile of sand, or an economy; the same fundamental rules seem to apply. Maintaining complexity requires energy while increasing complexity requires more energy.

At this point I have to confess that my earlier description of the economy was woefully narrow. Yes, it is a nested system with multiple feedback loops, but those in turn are interconnected with political, social and cultural systems, each of which are themselves complex systems. It is in the largest sense that we must consider the impact of declining net energy on the complexity and behaviors of our most critical systems.

To make things even more uncertain, another feature of complex systems is that they are inherently unpredictable. When an event might occur, or how big that event might be, are both unknowable, whether it is the size and timing next earthquake on an overdue fault or the vigor and demands of the social uprising we are talking about. Complex systems are frequently tightly coupled and little events cascade and become larger events; the so-called butterfly effect.

My view here is that a decline in net energy will disrupt the economy, and other interlocking systems, in ways that are both unknowable and larger than expected by most.

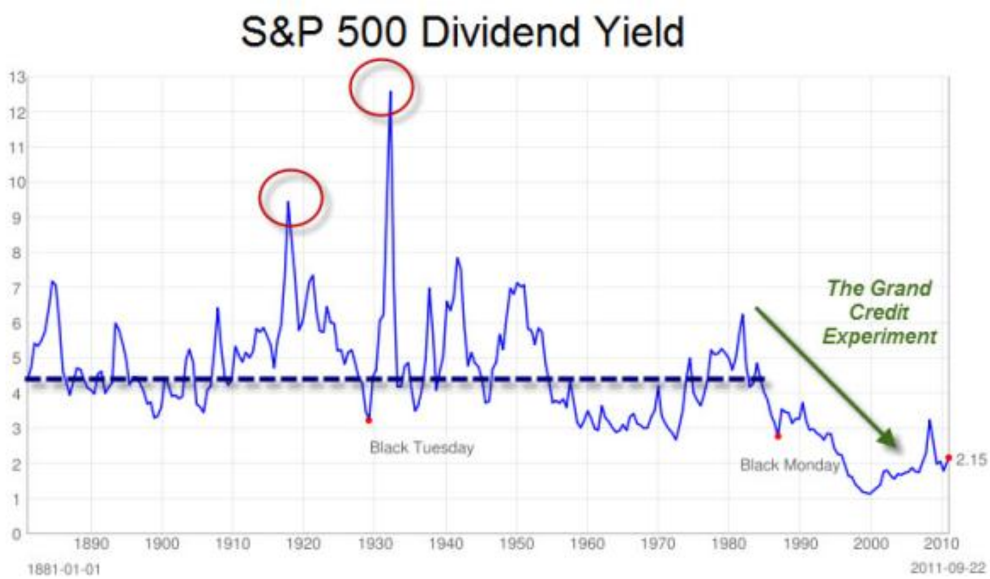
Six Inches Thick

Recently there was a revealing AP story about coal seams in Kentucky being chased that were only six inches thick. Revealing because it tells us a lot about where we are in the net energy story.

Those managing pensions with 30 year investment horizons should be thinking really hard about those six inch coal seams. They should ponder what it means that half of all the oil ever burned has been burned over the past 22 years and wonder about where the supplies will come from to fund the next 22 years.

In fact all of us should; what we assume to be the way the world works, and the way all of those interlocking complex systems function, is a very, very recent development historically speaking and can continue if, *and **only** If*, the amount of available surplus energy continues to grow.

This is not an idle concern, but one that will shape our futures by shaking our monetary and economic systems to the core. Such is the nature of complex systems starved of the requisite amount of energy required to both maintain and advance the current level of complexity.



The implications for stocks, bonds, and every other growth-dependent investment class are enormous. In aggregate they will fall in value. Whether dollars, euros or yen are depreciated or inflated in value does not matter, either way stocks and bonds will be worth less than they currently are because the growth premium will be reduced or eliminated.

(Source - http://www.multpl.com/s-p-500-dividend-yield/)

To make things just a little bit darker for equities today is the fact that from a historical perspective dividend yields are quite unattractive and reversion to the mean is the better bet:

Historically, truly compelling equity yields are in the vicinity of 10% but even the long term average is more than double the current yield. The two ways to bring the dividend yield back into the historical fold are for prices to fall by half or dividends to be doubled.

Unless a massive earnings binge is expected, which rising energy costs render difficult if not impossible, the 'fall by half' option is the more likely outcome. How could equities fall by half? One way would be to keep the dollar constant and let the prices fall. This is the more obvious method. The other way is to debase the currency and let the purchasing power of stocks erode by half while holding their nominal prices constant. If that sounds tricky, it is exactly what has happened over the prior thirteen years where the S&P is now trading at the exact same level it was back then. Inflation has been anything but absent over that same period and this is how printing money in the face of declining net energy (and an enormous credit bubble popping) will deliver to us smaller returns even as the tried and formerly true monetary levers are pulled and pulled again in search of a response we can recognize.

The bottom line here is that everything we think we know about investing and how the world works is challenged by the pesky reality of energy sources that are dwindling in both quantity and quality. The days of pulling magic monetary and fiscal levers and then having the resources magically appear are over. A new and more complex future has arrived.

Unfortunately the experience set of practically everyone currently with their hands on these levers does not extend to energy, physics, the laws of thermodynamics, or anything outside of the tidy but woefully incomplete world of economics.

Our job, then, is to assess for ourselves what the nature, duration, and size of the economic disruptions might be that result from steadily squeezing the available amount of net energy that all these complex systems are supported by.

Whatever the answer each person or entity arrives at, whether that is "there's nothing to worry about," or something dire, is perfectly fine as long as a comprehensive, data rich conversation and/or debate is held. The time for holding assumptions and beliefs is over. It is time to broaden our views, wander into the neighboring camps, and see what we can learn from each other.

Chris Martenson (@chrismartenson) speaks twice at the 2011 ASPO-USA Conference. First, Thursday Nov. 3 at the Congressional Auditorium inside the U.S. Capitol. Then later that afternoon in a session titled "Of Wells and Wall Street." Dr. Martenson is the author of a "The Crash Course: The Unsustainable Future of Our Economy, Energy and Environment" published by Wiley and now available in bookstores. His website, Chrismartenson.com, reaches a wide and growing audience of individuals interested in how to navigate the coming times with an eye towards preserving capital and mitigating risks.

The Olduvai Theory

Energy, Population, and Industrial Civilization

by Richard C. Duncan

Abstract

The Olduvai Theory states that the life expectancy of industrial civilization is approximately 100 years: circa 1930-2030. Energy production per capita *(e)* defines it. The exponential growth of world energy production ended in 1970 (Postulate 1 is verified). Average *e* will show no growth from 1979 through circa 2008 (Postulate 2 is confirmed from 1979 through 2003). The rate of change of *e* will go steeply negative circa 2008 (Postulate 3). World population will decline to about two billion circa 2050 (Postulate 4). A growing number of independent studies concur (see text).

[Key Words*: Olduvai Theory; Henry Adams; energy and population; exponential growth; permanent blackouts; overshoot and collapse.*]

Introduction

The Olduvai Theory states that the life expectancy of industrial civilization is approximately 100 years: circa 1930-2030. It is defined by the ratio of world energy production and population *(e)*. Four postulates follow:

1. The exponential growth of world energy production ended in 1970.
2. Average *e* will show no growth from 1979 to circa 2008.
3. The rate of change of *e* will go steeply negative circa 2008.
4. World population will decline proximate with *e*.

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This paper accomplishes four goals:

The first goal is to show that from 1893 through 1949 three distinguished scholars formulated a comprehensive Olduvai scenario.

The second goal is threefold: 1) electrical power is crucial end-use energy for industrial civilization;[1] 2) the big blackouts are inevitable; and 3) the proximate cause of the collapse of industrial civilization, if and when it occurs, will be that the electric power grids go down and never come back up.

I first presented the Olduvai Theory at an engineering conference entitled, "Science, Technology, and Society" (Duncan, 1989). My paper was well received and a lengthy discussion followed — even though I had no data to support it at the time. A few years later I had gathered eight (8) historical data points to backup the theory (Duncan, 1993). Three years after that I showed that it held up against the world energy and population data from 1950 to 1995 (Duncan, 1996). Next tested in 2000, the theory was supported by data from 1920 to 1999 (Duncan, 2000, 2001). The third goal of this paper is to extend this series of tests by using data from 1850 through 2003.

The fourth goal is twofold: 1) detail and describe the Olduvai Theory from 1930 to 2030, and 2) document that a growing number of studies concur with Postulate 4.

Three Scouts

> *There is no comprehensive substitute for oil in its high-energy density, ease of handling, myriad end-uses, and in the volumes in which we now use it. The peak of world oil production and then its irreversible decline will be a turning point in Earth history with worldwide impact beyond anything previously seen. And that event will surely occur within the lifetimes of most people living today.* (Youngquist, 2004)

An Olduvai scenario of industrial society was envisioned by historian Henry Adams in 1893, quantified by architect Frederick Ackerman in 1932, and graphed by geophysicist King Hubbert in 1949. A summary follows.

HENRY ADAMS, Historian (1838-1918) – great grandson of the second President and grandson of the sixth: I first became aware of Henry Adams' work in 2002 while reading David E. Nye's masterpiece *Electrifying America.*

Henry Adams defined energy broadly to include not only steam engines or electricity but also any force capable of organizing and directing people.

> *Adams concluded that electrification was part of a larger process of historical acceleration, which would lead to an inevitable social decline. … It seemed probable that the ultimate result of exploiting new energy systems would be the apocalyptic end of history itself.* (Nye, 1990, p. 142-3)

Adams' goal was to discover a succinct law of history as outlined in his book *The Education of Henry Adams* (Adams, 1907). It was at the Chicago World's Fair in 1893 where he first theorized that "forces totally new" – especially electric power and incandescent lighting – would "accelerate society into chaos and ruin."

> *The new American – the child of incalculable coal-power, chemical power, electric power, and radiating energy, as well as of new forces yet undetermined – must be a sort of god compared with any former creation of nature. … The new forces would educate. … The law of acceleration was definite … No scheme could be suggested to the new American, and no fault needed to be found, or complaint made; but the next great influx of new forces seemed near at hand, and its style of education promised to be violently coercive.* (Adams, 1907, Chap. 34)

Ernest Samuels (1973) edited Adams' book and forcefully summed it up.

> *Even in his own day he saw the eighteenth century American dream of unlimited opportunity and indefinite progress turning into a waking nightmare of the moral dilemmas of a capitalist society. He saw too that though science was indeed making tremendous advances in the conquest of Nature, winning every battle in that age-old contest, the odds were growing that a dehumanized mankind might lose the war.* (p. vii)

Henry Adams' farsightedness was and is amazing. He is buried in Rock Creek Cemetery in Washington, DC and his ideas are now resonating worldwide – but not yet in the U.S. capital.

FREDERICK LEE ACKERMAN**,** Architect (1878-1950): In 1919, Ackerman was a founding member of the Technical Alliance (later Technocracy Inc.). The group consisted of a broad spectrum of eminent professionals. In 1932 Ackerman published his seminal paper "The Technologist Looks at the Depression" wherein he – like Henry Adams before – observed that new energies were accelerating social change.

From about 4000 B.C.E. to 1750 C.E., Ackerman noted, the common welfare was limited to the work that man could do with his hands and a few crude tools.

Whence the Name 'Olduvai'?

Olduvai Gorge is an archaeological site in the eastern Serengeti Plains in northern Tanzania. The gorge is a very steep-sided ravine roughly 30 miles long and 295 ft. deep. Exposed deposits show rich fossil fauna, many hominid remains and items belonging to one of the oldest stone tool technologies, called Olduwan. The objects recovered date from 2,100,000 to 15,000 years ago.

The name of this premier site for studying the Stone Age has been taken to label the theory that industrial civilization will soon collapse and send humankind into precipitous decline.

Olduvai Gorge is best known as the site where, in 1959, the discoveries of Mary and Louis Leakey changed paleontology to focus on Africa, rather than Asia, as the region of human origins.

The Oxford Dictionary of Scientists (Oxford University Press, 1999) states: "Leakey's work has not only provided evidence for the greater age of humans but suggests that Africa, and not as was previously thought, Asia, may have been the original center of human evolution."

Social change, he concluded, involves a change in the techniques whereby people live.

> *We shall define as a "social steady state" any society in which the quantity [of energy expended] per capita … shows no appreciable change as a function of time. … On the other hand a society wherein … the average quantity of energy expended per capita undergoes appreciable change as a function of time is said to exhibit "social change." … Upon this basis we can measure quantitatively the physical status of any given social system. … The energy per capita [equals the] the total amount [of energy] expended divided by the population.* (Ackerman, 1932, p. 18-19)

Ackerman's Law is expressed by the ratio: e = Energy/Population.

It is important to acknowledge that in 1943 anthropologist Leslie A. White independently discovered what is now properly designated Ackerman's Law.[2]

M. KING HUBBERT, Geophysicist (1903-1989): In 1949 King Hubbert noted that world energy consumption per capita, e, after historically rising very gradually from about 2,000 to 10,000 kilogram calories per day, then increased to a much higher level in the 19th century. Further, he believed it possible for global society to maintain a high level of e indefinitely (later he labeled this "Course I"). But he also realized that society could permanently collapse back to "the agrarian level of existence" (later he labeled this "Course III").

Hubbert published sketches of Course III (overshoot and collapse) many times after 1949. And, although he kept the general shape of the curves the same, he successively decreased his estimate of when the peak of e would occur. Namely: In his original paper he put the peak of e in 2400 C.E. (Hubbert, 1949); in his next version he put the peak in 2360 C.E. (Hubbert, 1962); and in his final version he put the peak in 2150 C.E. (Hubbert, 1976). Thus between 1949 and 1976 Hubbert's "most dismal Course III" became successively bleaker by some 250 years.

The historical data through 2003 (shown later as curve 2, Figure 2) now rules out Hubbert's most optimistic Course I. This leaves global society with only two feasible futures: Course II (an orderly decline of e to a medium steady state) and Course III (collapse to the agrarian level of existence).

Linking the "scouts" together: Henry Adams in about 1915 gave the copyright to his book *Mont-San-Michele and Chartres* to the American Institute of Architects whereon they published it. At that time Frederick Ackerman was a distinguished member of the Institute. Further, both Frederick Ackerman and King Hubbert were close friends and prominent members of Technocracy Inc. Thus the intellectual chain linking Adams to Ackerman to Hubbert is complete.

Electromagnetic Civilization

> *For systems theorists the first message of their eerily smooth distribution curves is clear: big blackouts are a natural product of the power grid. The culprits that get blamed for each blackout – lax tree trimming, operators who make bad decisions – are actors in a bigger drama, their failings mere triggers for disasters that in some strange ways are predestined. In this systems-level view, massive blackouts are just as inevitable as the mega quake that will one day level much of Tokyo.* (Fairley, 2004)

This section stresses that 1) affordable electric power is crucial for modern living (all agree); 2) big blackouts are inevitable (power system engineers agree); 3) permanent blackouts are coming ("unthinkable").

1) King Kilowatt

Electricity is the most versatile and convenient end-use energy ever put to use by humanity. But one catch is that electricity is "everywhere and nowhere." Think of all the energized switches, outlets, and wires in an "empty" room plus the electromagnetic waves that pervade it at the speed of light (AM, FM, TV, cell phone, etc.). Then there is the vastly greater expanse of man-made electromagnetic energy that envelops the planet and radiates out into the Galaxy.[3]

Every power plant generates electromagnetic waves. From there they follow countless miles of high-voltage wave guides (commonly called "wires" or "lines") at near the speed of light to numerous customer loads: heaters, motors, telephones, lights, antennas, radios, televisions, fiber-optic systems, the

Internet, etc. We constantly "swim" through this sea of electromagnetic energy just as fishes swim through water. And, like water to fishes, this ethereal energy is vital to modern civilization.

By tallying the amount of primary energy used to generate electric power we find that electricity wins hands down as our most important end-use energy. To wit: I estimate that 7% of the world's oil is consumed by the electric power sector, 20% of the world's natural gas, 88% of the coal, and 100% each for nuclear and hydroelectric power. The result is that electric power accounts for 43% of the world's end-use energy compared to oil's 35%.

The critical role that electricity plays in the United States is likewise telling. Out of the total end-use energy consumed in each of the social sectors in 2003:

1) 0.2% was electricity in the Transportation sector,
2) 33.3% in the Industrial sector,
3) 65.9% in the Residential sector, and
4) 76.2% in the Commercial sector (EIA, 2004).

2) Big Blackouts Are Inevitable

The second catch is that electricity is generated, transmitted, and distributed by a complex, far-flung, costly, and fragile infrastructure.

The electric power networks are the largest, most complex machines ever constructed. They have been built, rebuilt, and interconnected over many decades with a baffling variety of hardware, software, standards, and regulations. The ravenous input nodes must be continuously fed with immense amounts of primary energy and then the output nodes deliver electromagnetic energy to myriad customer loads.

Between the input and output nodes are power plants, substations, and transmission and distribution lines and towers.

Inevitably the old equipment wears out or becomes obsolete so highly educated and skilled personnel are needed to maintain the grids.

Then there are power control centers that monitor and manage the generation, transmission, and distribution of electric power over local, regional, and super-regional areas. Each control center has numerous computers, databases, and special software to monitor and control the flow of power. Thoroughly trained and dedicated operators are essential to keep the grids going 24/7/365.

Much faster response times are provided by "protective relays" that instantly trip for abnormal conditions, such as short circuits on high-voltage power lines.

Thus, except for lightning strikes and tornadoes, it might seem that the power networks would always operate reliably, thus completely avoiding big blackouts.

But that is false. Power control specialists J. Apt and L. B. Lave (2004) have warned:

> *Data for the last four decades show that blackouts occur more frequently than theory predicts, and they suggest that it will become increasing expensive to prevent these low-probability, high-consequence events. The various proposed "fixes" are expensive and could even be counterproductive, causing future failures because of some unanticipated interaction.*

3) Permanent Blackouts Are Coming

The third catch, according to the Olduvai Theory, is that sooner or later the power grids will go down and never come back up.[4] The reasons are many.

The International Energy Agency (lEA, 2004) estimates that the cumulative worldwide energy investment funds required from 2003 to 2030 would be about $15.32 trillion (T, US 2000 $) allocated as follows:

1. Coal: $0.29T (1.9% of the total),
2. Oil: $2.69T (17.6%),
3. Gas: $2.69T (17.6%),
4. Electricity: $9.66T (63.1%).

Thus the lEA projects that the worldwide investment funds essential for electricity will be 3.7 times the amount needed for oil alone, and much greater than all of that required for oil, gas, and coal combined.

The OT says that the already debt-ridden nations, cities, and corporations will not be able to raise the $15.32 trillion in investment funds required by 2030 for world energy. (Not to mention the vastly greater investment funds required for agriculture, roads, streets, schools, railroads, water resources, sewer systems, and so forth.)

Furthermore, because of the rapidly rising cost of electricity, the increasingly impoverished customers won't be able to pay their electric bills. Worse yet, the really desperate ones will illegally wire directly to the low-voltage power lines, so without a wattmeter to record their usage they won't even have any bills to pay.

We will return to this pivotal topic later, but first I will use the most recent data now available to test OT Postulates 1 and 2.

World Energy and Population: the Basis

During the last two centuries we have known nothing but exponential growth and in parallel we have evolved what amounts to an exponential-growth culture, a culture so heavily dependent upon the continuance of exponential growth for its stability that it is incapable of reckoning with problems of no growth. (M. King Hubbert, 1976, p. 84)

The Olduvai Theory is based on time-series data of world energy production and population; all data are freely available on the Internet. The data are arrays of discrete numbers year-on-year, not continuous functions of time. Hence the difference calculus must be used, not the infinitesimal calculus. Postulates 1 and 2 require that we distinguish intervals of linear growth from those of exponential growth.[5, 6]

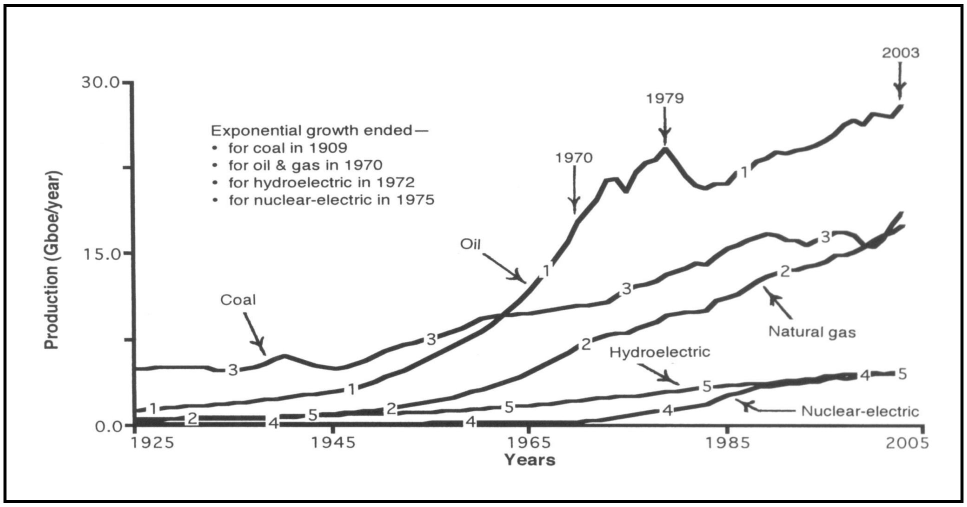

Figure 1. World production of the five major sources of energy. All curves are scaled in 'billion barrels of oil equivalent' (Gboe). Data sources: Romer (1985) for 1850-1964; British Petroleum (2004) for 1965-2003.

FIVE MAJOR SOURCES OF ENERGY

Our energy database for testing the OT ranges from 1850 through 2003 (Romer, 1985; British Petroleum, 2004). However it is more effective to focus on the years from 1925 through 2003 for world oil, natural gas, coal, nuclear, and hydroelectric energy production – Figure 1.[7]

Commercial oil production was underway before 1833 in the Chechen Republic (using shovel-dug wells; Iastratov, 2004). Hence, if we assume that it began in 1833 and grew exponentially up to 1850, then world oil production grew exponentially at an average of 8.8%/y during the 137-year interval from 1833 to 1970. After that production slowed to various linear rates of growth and decline from 1970 to 2003 (curve 1).

World natural gas production began in about 1880 and grew exponentially at 6.8%/y during the 90-year interval from 1880 to 1970. Thereafter it grew at a 2.7%/y linear rate from 1970 to 2003 (curve 2).

Coal was burned for cooking and space heating ever since the 12th Century, but it was not used for mechanical work until about 1700 (Savery's steam engine). Thus if we assume that it began in 1700 and grew exponentially up to 1850, then coal production grew exponentially at about 4.3%/y during the 209-year interval from 1700 to 1909. This was followed by several intervals of linear growth and decline from 1909 to 2003 (curve 3).

Nuclear-electric energy production began in 1955 (in Britain) and grew exponentially at 29.7%/y from 1955 to 1975. This was succeeded by three intervals of linear growth and decline from 1975 to 2003 (curve 4).

Hydroelectric energy production began in about 1890 (at Niagara Falls, USA) and grew exponentially at 15.4%/y from 1890 to 1912, followed by exponential growth at 3.6%/y from 1912 to 1972. Next came linear growth from 1972 to 2000 and decline from 2000 to 2003 (curve 5).

Testing Postulate 1 is facilitated by ranking the five sources of energy production by the duration of their intervals of exponential growth:

1. Coal grew exponentially for 209 years: 1700-1909.

2. Oil grew exponentially for 137 years: 1833-1970.

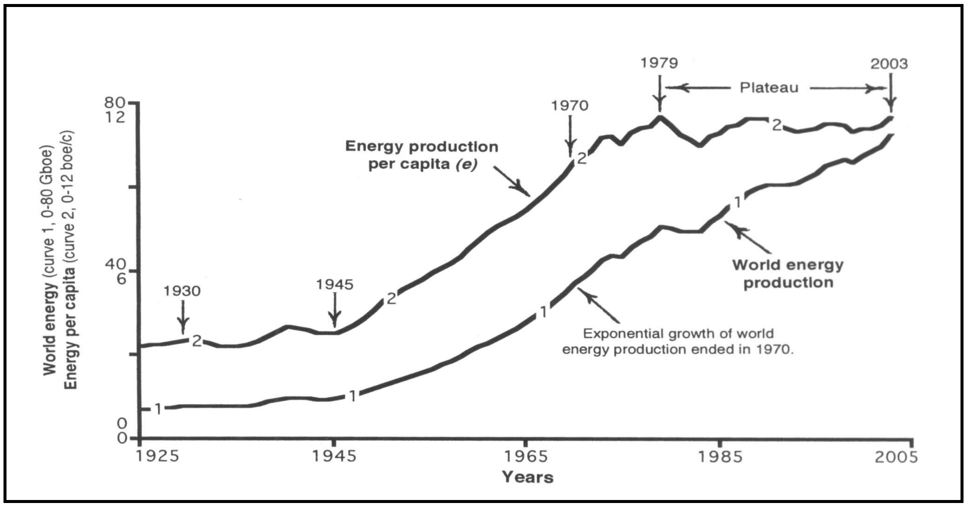

Figure 2. World energy production and energy production per capita. Data sources: 1) for energy – Romer (1985) for 1850-1964 and British Petroleum (2004) for 1965-2003; 2) for population – UN (2004) for 1850-1949 and USCB (2004) for 1950-2003.

3. Natural gas grew exponentially for 90 years: 1880-1970.

4. Hydroelectric energy grew exponentially for 82 years: 1890-1972.

5. Nuclear-electric energy grew exponentially for 20 years: 1955-1975.

Note well that none of the five sources of primary energy production grew exponentially after 1975. *Postulate 1 is partly verified (continued below).*

Q: So is exponential growth passé on this planet? My response: There is, I recognize, the possibility that world coal and/or nuclear-electric energy production could grow exponentially for very brief periods in the future, but that option does not exist for oil, natural gas, or hydroelectric energy production.

WORLD TOTAL ENERGY PRODUCTION AND ENERGY PRODUCTION PER CAPITA

By combining world oil, natural gas, coal, nuclear, and hydroelectric energy production (discussed above), we get the world total energy production. The portion from 1925 through 2003 is shown by curve 1, Figure 2.

World total energy production grew exponentially at about 4.6%/y from 1700 to 1909. Next it grew linearly at 2.2%/y from 1909 to 1930 and 1.5%/y from 1930 to 1945. Subsequently it surged exponentially at 5.5%/y from 1945 to 1970. This was followed by linear growth at 3.5%/y from 1970 to 1979. Thereafter world total energy production slowed to linear growth of about 1.5%/y from 1979 to 2003. *Postulate 1 is verified.*

World population is the essential other half of the energy-population matrix, but it is omitted from Figure 2 to avoid clutter. Described in numbers: World population grew linearly at an average of 0.5%/y from 1850 to 1909; 0.8%/y from 1909 to 1930; 1.0%/y from 1930 to 1945; 1.7%/y from 1945 to 1970; 1.8%/y from 1970 to 1979; and 1.5%/y from 1979 to 2003 (UN, 2004; USCB, 2004).

Comparing the foregoing numbers: World total energy production easily outpaced world population growth from 1700 to 1979, but then from 1979 through 2003 total energy production and population growth went dead even at 1.5%/y each.

World total energy production per capita, *e,* grew exponentially at 3.9%/y from 1700 to 1909. Thereafter it grew at linear rates of 1.4%/y from 1909 to 1930; 0.5%/y from 1930 to 1945; 3.7%/y from 1945 to 1970; 1.7%/y from 1970 to 1979; and 0.0%/y (i.e., zero net growth, called the 'Plateau') from 1979 to 2003 – curve 2, Figure 2.

Observe in Figure 2 that average *e* did not grow at all from 1979 to 2003. *Postulate 2 is confirmed from 1979 to 2003.*

The Olduvai Theory

Many industrialized nations are now growing rapidly and placing ever-greater demands on world resources. Many of those resources come from the presently underdeveloped countries. What will happen when the resource-supplying countries begin to withhold resources because they foresee the day when their own demand will require the available supplies? ... Will the developed nations stand by and let their economies decline while resources still exist in other parts of the world? Will a new era of international conflict grow out of pressures from resource shortage? (Forrester, 1971, p. 70)

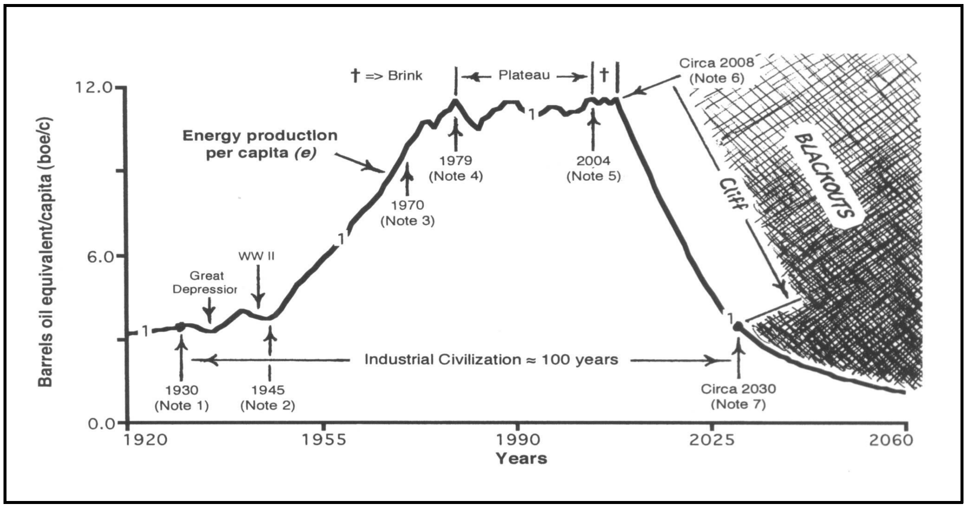

Figure 3. The Olduvai Theory: 1930-2030. Notes: (1) 1930 => Industrial civilization begins; (2) 1945 => Very strong growth begins; (3) 1970 => Growth begins to slow; (4) 1979 => The no-growth "Plateau" begins; (5) 2004 => The "Brink" begins; (6) Circa 2008 => The "Cliff" begins; and (7) Circa 2030 => Industrial civilization ends. Data sources: 1) for energy – Romer (1985) for 1850-1964, British Petroleum (2004) for 1965-2003, and Duncan (this paper) for 2004-2060; 2) for population—UN (2004) for 1850-1949, USCB (2004) for 1950-2004, and Duncan (this paper) for 2005-2060.

The Olduvai Theory states that the life expectancy of industrial civilization is approximately 100 years: circa 1930-2030. Ackerman's ("White's") Law defines it: *e = Energy/Population.* The duration of industrial civilization is measured by the time in years from when *e* reaches 30% of its maximum value to the time when *e* falls back to that value. The OT is illustrated in Figure 3.

Seven events: The 1st event in 1930 (Note 1, Figure 3) marks the beginning of industrial civilization where *e* first reached 30% of its maximum value. The 2nd event in 1945 (Note 2) marks the beginning of very fast growth. The 3rd event in 1970 (Note 3) marks the beginning of slower growth. The 4th event in 1979 (Note 4) marks the start of a rough *Plateau* of no growth. The 5th event in 2004 (Note 5) marks the beginning of the *Brink.* The 6th event circa 2008 (2006-2012, Note 6) marks the edge of the *Cliff* where *e* begins a precipitous decline. The 7th event circa 2030 (Note 7) is the "lagging 30% point" when *e* falls back to 30% of its maximum value. This puts the duration of industrial civilization at approximately 100 years.

Seven intervals: 1) From 1930 to 1945 *e* shows irregular growth during the Great Depression and World War II.[8] 2) The strong growth from 1945 to 1970 correlates with the strong growth in world oil and natural gas production. 3) The slowing growth of *e* from 1970 to 1979 reflects slackening oil production. 4) The rugged *Plateau* from 1979 to 2003 shows that energy production ran neck-in-neck with population growth. 5) The *Brink* from 2004 to circa 2008 represents the energy industry's struggle to keep up with rising demand. 6) The *Olduvai Cliff* from circa 2008 to 2030 correlates with a spreading epidemic of permanent blackouts. 7) From 2030 onward society approaches the agrarian level of existence.

The most reliable leading indicator of the OT Cliff event, if and when it happens, will be brownouts and rolling blackouts.

WORLD POPULATION SCENARIOS

The resource wars will run their courses, and populations will crash. The journey back to 'natural' levels of world population will not be a joyous one. Have policy-makers begun to grasp the scale of the problem that confronts

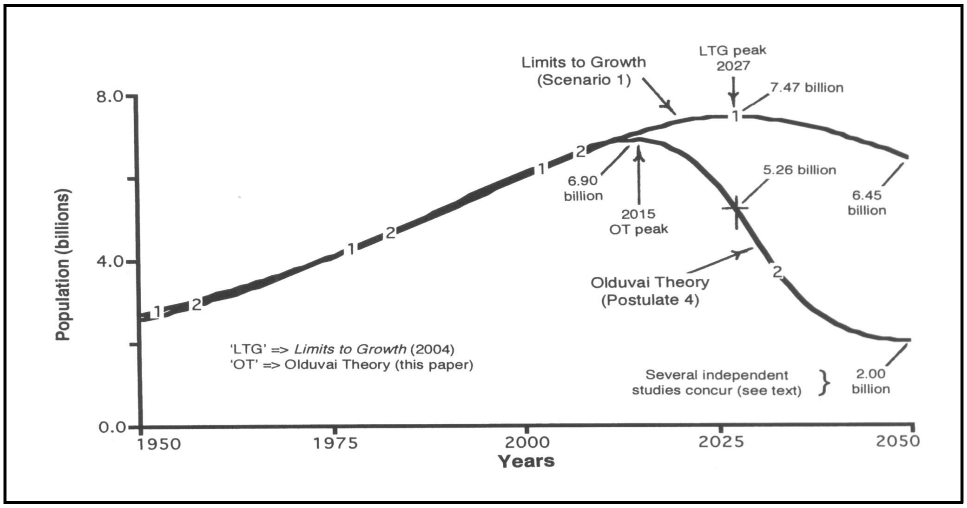

Figure 4. Two world population scenarios. Data sources: Curve 1—Meadows et al. (2004); Curve 2 – USCB (2004) for 1950-2004, and Duncan (this paper) for 2005-2050.

them? Are they still dazzled by the contention that rates of increase are slowing, not grasping that all the time the numbers are mounting up? (Stanton, 2003)

Two scenarios of world population are illustrated in Figure 4.[9] The first is based on a system dynamics model that was recently updated and tested with many alternative policies.[10] The second is based on some of my previous studies including nine forecasts of world oil production. Details follow.

1. Limits to Growth: The 30-Year Update (2004)

In 1970 The Club of Rome sponsored Phase One of the "Project on the Predicament of Mankind." Dr. Dennis Meadows of MIT directed a team of 17 scholars that worked for two years to complete it. "The study examined the five basic factors that determine, and therefore, ultimately limit, growth on this planet – population, agricultural production, natural resources, industrial production, and pollution."

Phase One of the study was published in *The Limits to Growth* (Meadows et al., 1972). That study was updated and published in *Beyond the Limits* (Meadows et al., 1992). In turn, the 1992 study was updated in 2002 and published in *Limits to Growth: The 30-Year Update* (Meadows et al., 2004).

The 30-year update is coded in 241 system dynamics equations. The main output of the model depicts 10 scenarios, and the key variables for each are plotted out over time. Depending on the assumptions, the LTG model can produce many different scenarios ranging from the deep impoverishment of society to a high level of human welfare extending far into the future.

Meadows et al. (2004) describe their reference scenario:

> *The world society proceeds in a traditional manner without any major deviation from the policies pursued during most of the twentieth century. Population and production increase until growth is halted by increasingly inaccessible nonrenewable resources. Ever more investment is required to maintain resource flows. Finally, lack of investment funds in the other sectors of the economy leads to declining output of both industrial goods and services. As they fall, food and health services are reduced, decreasing life expectancy and raising average death rates.* (p. 168-69; emphasis added)

The peak of world population in the LTG scenario occurs in 2027 at 7.47 billion people – curve 1, Figure 4. Note well that the "lack of investment funds" is cited as one of the primary causes of collapse.

Bottom line: The tone of *Limits to Growth: The 30-Year Update* is cautiously optimistic. The authors maintained in 2002 that there was still time for the world to achieve sustainability, but the course of society would have to be quickly changed. However by 2022 it will be too late. The 20-year delay in moving toward sustainability sends the world "on a turbulent, and ultimately unsuccessful path. Policies that were once adequate are no longer sufficient."

2. The Olduvai Theory and World Population

> *[As a result of permanent blackouts of electric power] the industries of all civilized countries would stop working, so that, with millions unemployed and with a total cut in the production of goods,*

unprecedented and incurable misery would occur, killing perhaps three-quarters of the population, and leaving the rest in a deplorable state. (Thirring, 1956, p. 135)

The data for testing OT Postulate 3 are not available at this writing. For the sake of discussion, however, I reserve Postulate 3 for later, and show that Postulate 4 (the Olduvai scenario for world population) is consistent with a growing number of autonomous studies.

The peak of world population in the OT scenario occurs in 2015 at 6.90 billion – curve 2, Figure 4. Notice that the OT scenario closely matches the LTG scenario up to 2012. Thereafter, however, the OT scenario diverges downward. Thus when the LTG scenario peaks in 2027 at 7.47 billion, the population in the Olduvai scenario has declined to 5.26 billion – the same value it had in 1990.

The differences increase over time. Namely: When the LTG scenario shows the world population at 6.45 billion in 2050, population in the OT scenario has fallen to 2.00 billion – the same value it had in 1925.

The differences between the LTG scenario and the OT scenario, I reason, occur mainly because the *Limits to Growth* model does not explicitly include world energy production, whereas the Olduvai Theory does (Duncan, 1989, 1993, 1996, 2000, 2001, 2003, 2004; Duncan & Youngquist, 1999).

Moreover, the Olduvai Theory specifies that permanent blackouts – each happening one-by-one, region-by-region, and spreading worldwide over time – will be the *proximate (direct, immediate)* cause of the collapse of industrial civilization. In contrast, the *Limits to Growth* model identifies many *ultimate (indirect, delayed)* causes of the collapse – especially the "lack of investment funds for industrial goods and services." Hence the LTG and OT scenarios are consistent and complementary.

The Olduvai scenario was neither first nor is it unique in projecting that world population could quickly decline to its pre-industrial level. Five examples follow.

In 1949 King Hubbert realized that the human population could collapse back to "the agrarian level of existence" ("Scenario III", discussed previously).

Austrian physicist Hans Thirring (1956) was, as far as I can tell, the first to recognize that the rapidly growing world population was increasingly vulnerable to the loss of electric power. His scenario (quoted above) suggests that permanent blackouts might kill "perhaps three-quarters of the [world's] population." Thus the widespread loss of electric power might cause the OT peak population of 6.90 billion in 2015 to fall to 1.73 billion in 2050.

According to Professor David Pimentel of Cornell University the world will have to adjust to lesser supplies of energy and food by a commensurate decrease in population. D. Pimentel and M. Pimentel (1996) state, "…the nations of the world must develop a plan to reduce the global population from near 6 billion to about 2 billion. If humans do not control their numbers, nature will."

Professor Richard Heinberg of the New College of California anticipates that oil and gas depletion will send prices of these fuels – along with the hydrocarbon-dependent fertilizers, pesticides, and herbicides – soaring. Hence without cheap energy, industrial agriculture will be able to feed only a fraction of the people it does now – perhaps less than two billion, roughly its pre-industrial level (reported by J. Attarian, 2003).

After reviewing an early draft of this paper, geologist Walter Youngquist (2004) wrote, "I doubt if population will be reduced to 2 billion or less by 2030 – you might want to modify that as the Third World will still have a lot living on a subsistence basis. I would move the 2 billion or so ultimate figure to year 2050 perhaps. By the way, the 2 billion is what others say is probably the limit in terms of a renewable natural resource economy – and the living is not likely to be as high as it is now."

To extend our survey, four widely circulated scenarios to 2050 tend to put the world population far above those mentioned above. Specifically, the US Census Bureau puts the world population in 2050 at 9.2 billion (USCB, 2004). In addition, the United Nations offers three population scenarios for 2050:10.6 billion [high], 8.9 billion [medium], and 7.4 [low] (UN, 2004).

All population scenarios – we point up – are speculation. Only time will tell.

History gives no precedent for the collapse of industrial (electromagnetic) civilization, but the consequences of the policy of exponential brinkmanship are clear (White, 1943; Thirring, 1956;

Youngquist, 1997, 1999; Stanton, 2003; and Bartlett et al., 2004).

The overshoot and collapse of industrial civilization was assured once humanity became dependent on the rapid exploitation of nonrenewable resources on a finite planet. Moreover our insatiable appetite for electric power has accelerated the collapse and steepened the decline (Adams, 1907; Duncan, 2000, 2001).

The Olduvai Theory is extensively discussed on the worldwide web – pro, con, and more. Search for "olduvai theory" to access the various sites and forums.

Conclusions

The Olduvai Theory states that the life expectancy of industrial civilization is approximately 100 years: circa 1930-2030. Ackerman's ("White's") Law defines it: $e = Energy/Population$. Four postulates follow:

1. The exponential growth of world energy production ended in 1970.
2. Average *e* will show no growth from 1979 to circa 2008.
3. The rate of change of *e* will go steeply negative circa 2008.
4. World population will decline proximate with *e*.

Henry Adams in 1893 envisioned that electric power would accelerate society into chaos and ruin. Frederick Ackerman in 1932 showed that social change could be quantified by *e*. King Hubbert graphed the shape of the *e* curve in 1949. Thus an Olduvai scenario existed before 1950.

None of the world's five major sources of primary energy has grown exponentially since 1975 (Figure 1). World total energy production has not grown exponentially since 1970 (curve 1, Figure 2). *Postulate 1 is verified.*

The average rate of growth of world energy production per capita *(e)* was zero from 1979 to 2003 (curve 2, Figure 2). *Postulate 2 is confirmed through 2003.*

Seventy-four (74) out of the approximately 100 years of the Olduvai Theory are now history (Figure 3). All of the data needed to test it are freely available on the worldwide web and updated annually. Rigorous tests are welcome.

The Olduvai scenario for world population peaks at 6.9 billion circa 2015 (curve 2, Figure 4). Thereafter the population declines to 2.0 billion in 2050 (Postulate 4). A growing number of independent studies concur (see text). ■

ACKNOWLEDGMENTS

Walter Youngquist has bestowed wise guidance and much scientific information over many years. Robert Hickerson, Alistair McCrone, John Attarian, David Pimentel, Virginia Abernethy, and David Burghardt have helped out in many ways. Colin Campbell, Ali Samsam Bakhtiari, Alan Hammaker, and Francis de Winter have provided valuable perspectives on diverse subjects. Richard Pelto's "Third Place Academy" has extended my horizons. Marvin Gregory has passed along a constant stream of useful information. Patrick McNally's keen questions have been very helpful. Ronald Angel has stressed computational rigor. John Greer has fostered localized rural communities. The web sites of Jay Hanson, Ronald Swenson, and Tom Robertson have bought forth many useful discussions and suggestions from around the world.

ENDNOTES

1. Hydrocarbons, of course, are the crucial source of primary energy for industrial civilization – as it now exists. However *if* we had abundant and affordable electric power from other sources, *then* civilization – in some form and at some population level – could continue indefinitely sans hydrocarbons.

2. "We have, in the above generalizations *the* law of cultural evolution: *Culture develops when the amount of energy harnessed by man per capita per year is increased; or the efficiency of the technological means of putting this energy to work is increased; or, as both factors are simultaneously increased"* (White, 1943). But as far as I know no one has ever quantified how world total energy efficiency has changed over time.

3. Engineers usually represent electromagnetic energy as waves. Physicists often represent it as particles. A coherent theory is lacking.

4. The OT says that permanent blackouts will be the instantaneous (direct) cause of collapse of industrial civilization. In contrast, the deeper causality will be a complex matrix of delayed feedback interactions, including: depletion of nonrenewable resources, lack of capital and operational investment funds, soil erosion, declining industrial and agricultural production, Peak Oil, global warming, pollution, deforestation, falling aquifers, unemployment, resource wars, and pandemic diseases – to name just a few.

5. For exponential growth the year-on-year incremental changes must be positive and exponential; for exponential decline they must be negative and exponential.

6. The exponential doubling time ('DT' in years) is approximately equal to *69.3/PctG* where *'PctG'* is the average percent growth per year (Bartlett et al., 2004, p. 396).

7. One boe = 5.46 million Btu (heat value).

8. Worthy of note in Figure 3 is how clearly the plot of Ackerman's Law *(e)* reveals the Great Depression and World War II.

9. By definition, all scenario curves, dates, and scales are approximate.

10. System dynamics is a methodology for studying, testing, and managing complex, nonlinear, feedback systems, such as one finds in business and other social systems. See: www.albany.edu/cpr/sds.

DEFINITIONS

"Scenario" means an outline for any series of events – real, imagined, or tutorial. "Circa" indicates an approximate year. "Oil" means crude oil and natural gas liquids. "Total energy" means the world's five major sources of commercial energy combined: oil, natural gas, coal, hydroelectricity, and nuclear-electricity. "*e*" means energy production per capita. Energy "production" and "consumption" mean the same thing. (Although energy is neither produced nor consumed, these terms are common in the industry.) "%/y" means percent per year. "b" means barrels of oil. "boe" means barrels of oil equivalent. "G" means billion (10^9). "T" means trillion (10^{12}). "Industrial civilization," "electromagnetic civilization," and "modern civilization" all mean the same thing. "C.E." means Common Era; "B.C.E." means Before Common Era. "Brinkmanship" means the policy of pursuing a hazardous course to the brink of catastrophe.

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New GAO Peak Oil Report Provides Urgent Call to Action: U.S. Vulnerable and the Government Unprepared for Unacceptably High Risks of Oil Supply Shock

Washington, DC - Congressmen Roscoe Bartlett (R-MD) and Tom Udall (D-NM), co-chairmen of the Congressional Peak Oil Caucus, held a Capitol Hill news conference with Mark E. Gaffigan of the U.S. Government Accountability Office (GAO) on Thursday, March 29, 2007 to discuss the release of an embargoed GAO report that revealed the United States is *particularly vulnerable* and the United States federal government is *unprepared* to respond to severe consequences from increasing and unacceptable risks of significant disruptions to oil supplies from peak oil and other above ground political and economic factors. "CRUDE OIL - Uncertainty about Future Oil Supply Makes It Important to Develop a Strategy for Addressing a Peak and Decline in Oil Production," (GAO-07-283) is now available for downloading from the GAO website: www.gao.gov.

The report reaffirmed that peak oil is inevitable. It is the point of maximum oil production followed by irreversible declines for oil fields, regions, countries and eventually the world. The report found most experts project a peak and subsequent decline in world oil production could occur ***without warning*** any time between now and 2040. The quality and availability of data concerning oil reserves and production capabilities makes projections uncertain. In addition, significant above ground political and economic risks to increasing world production are detailed affecting a large majority of world reserves. Coupled with rising demand, these factors show increasing risks of significant disruption to oil supplies. The report found no focus, coordination or plans by the federal government to prepare for peak oil or other potential supply disruptions.

Congressman Roscoe Bartlett said, "This GAO peak oil report is a clarion call for leadership at the highest level of our country to avert an energy crisis unlike any the world has ever before experienced and one that we know could happen at any time. Only the President can rally the country to take the urgent steps necessary. Potential alternatives to oil are extremely limited. Technology won't save us without time and money to develop and scale them up."

Congressman Tom Udall said, “Today’s report once again emphasizes our need to prepare for peak oil by implementing forward-thinking approaches and advance initiatives that will move our nation toward greater energy stability and independence. Practical legislation coupled with a concerted focus on conservation, higher fuel efficiency standards, energy saving buildings and appliances, revival of passenger and freight rail, expanded research into and use of biofuels will make the difference. I wholeheartedly believe in the ingenuity and intelligence of our countrymen and women to achieve these ambitious goals.”

Projecting future oil supplies is highly uncertain, in part, because the Organization of Petroleum Exporting Countries (OPEC) controls most of the estimated world oil reserves, but its estimates of reserves are not verified by independent auditors. In addition, four countries—Iran, Iraq, Nigeria, and Venezuela hold one-third of proven oil reserves and are considered at high risk for political disruption.. Countries with medium or high levels of political risk contained 63 percent of proven worldwide oil reserves. According to GAO’s analysis, “85 percent of the world’s proven oil reserves are in countries with medium-to-high investment risk or where foreign investment is prohibited.”

“A number of studies [GAO] reviewed indicate that most of the U.S. recessions in the post-World War II era were preceded by oil supply shocks and the associated sudden rise in oil prices. Ultimately, however, the consequences of a peak and permanent decline in oil production could be even more prolonged and severe than those of past oil supply shocks. Because the decline would be neither temporary nor reversible, the effects would continue until alternative transportation technologies to displace oil became available in sufficient quantities at comparable costs.”

The United States and the transportation sector are identified as particularly vulnerable to disruptions and dislocations from peak oil. “In the United States, alternative transportation technologies have limited potential to mitigate the consequences of a peak and decline in oil production, at least in the near term, because they face many challenges that will take time and effort to overcome… Development and widespread adoption of the seven alternative fuels and advanced vehicle technologies [GAO] examined will take time, and significant challenges will have to be overcome, according to DOE.”

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