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Comments of the Staff of the Oregon Public Utility Commission RE: The Northwest Power and Conservation Council's Preliminary Draft Fuel Prices for The Sixth Power Plan November 14, 2008

These are comments of the staff of the Oregon Public Utility Commission and do not necessarily reflect the views of any Commissioner.

Summary
The NWPCC draft Sixth Plan forecast of natural gas prices is improved over the forecasts used in the Fifth Plan. As in past plans the NWPCC has done an outstanding job of estimating the relationships among natural gas prices. Still, there are some issues to resolve.

It is surprising that the draft NWPCC high case price forecast for crude oil for 2030 is only $120 per barrel. Most oil experts predict world petroleum liquids production[1] will begin to decline between 2012 and 2018. Some say the peak is only 2-to-5 years away. It is unclear why this possibility was ignored.

There is two page summary of the likely magnitude of peak oil problems at http://thehill.com/op-eds/the-biggest-oil-problem-2008-10-07.html (*See* below as Appendix A).

The article states:

> *In 2005 the Swedish Royal Academy noted that 54 out of 65 of the largest oil producing countries were in decline, so it is not difficult to comprehend that world oil production will decline before long. World oil production has been relatively flat since 2004.*

When world oil production declines, a crude oil price of several hundred dollars per barrel is likely.[2] Because the draft NWPCC high case 2030 wellhead natural gas price of $10 per MMBtu

[1] In these comments oil is defined as all petroleum liquids, including ethanol and natural gas liquids.
[2] This assumes worldwide petroleum demand stays high and viable alternatives to oil (renewables, coal-to-liquids, etc) are not widely deployed by 2020.

is consistent with its high case oil price, this also raises questions about the reasonableness of the draft NWPCC natural gas price forecasts for 2020 and 2030.

OPUC staff finds the draft NWPCC 2010 medium natural gas forecast to be reasonable, given the likelihood of a U.S. economic recession in 2009 and perhaps continuing through 2010. The high price case does not encompass a reasonable range of likely prices. Based on a likely connection between oil and natural gas prices and likely future prices for oil, the NWPCC draft forecasts for 2020 and 2030 are unreasonably low.

Proposed Alternative Forecast

	Low	Medium Low	Medium	Medium High	High
2020	$5.00	$9.50	$14.00	$17.50	$21.00
2030	$7.50	$10.75	$14.00	$17.50	$21.00

Oct. 13, 2008
NWPCC Draft Forecast

	Low	Medium Low	Medium	Medium High	High
2007			$6.06		
2010	$6.50	$7.00	$7.50	$8.20	$9.00
2020	$4.50	$5.50	$7.25	$8.25	$9.25
2030	$5.00	$6.50	$7.65	$8.50	$10.00

(From the "Alt-Forecast" worksheet of "NWPCC-Nat-Gas-Data.xls" -- attached. Copies of other worksheets are in Appendix B)

2010 Natural Gas Price Forecasts
While not intended to capture short-term variations in prices, the draft NWPCC 2010 gas price forecasts may not encompass a reasonable range of trend possibilities. NWPCC's wellhead high case for 2010 is $9.00 (2006$). At 3 percent inflation for 2006-to-2008, this is $9.55 in 2008 dollars. U.S. wellhead prices were above this level for three months this year and for the last three months of 2005. The NWPCC should consider raising the high case forecast for 2010 to at least $10 (2006$) (Unless otherwise noted all statistics are from the U.S. Dept. of Energy, Energy Information Agency.)

Summary of Proposed 2020 Forecasts
Because they are close substitutes for non-transportation energy uses, the MMBtu prices for oil and gas tend to move together. Over the period 1986 to 2007, the ratio of the U.S. wellhead natural gas price and the West-Texas-Intermediate (WTI) crude oil price was 40-to-91 percent

with an average of 63 percent. The ratios for 2006 and 2007 were 56 and 51 percent. This is shown in the "WTI-WNG-History" worksheet in Appendix B.[3]

If, beginning in the next decade, world oil production declines significantly, WTI crude oil prices in 2020 could reach $300 per barrel (2006$). This implies a high case regular gasoline price of $9 per gallon (2006$) (*See* the "Oil-Gasoline" worksheet in Appendix B). The corresponding wellhead natural gas price is $21 per MMBtu (2006$) if natural gas is 40 percent of the energy price of WTI crude. With lags in the conversion to natural gas, the wellhead/WTI price ratio might be as low as 40 percent, the low end of the historical range. Based on a more conservative 2020 oil price forecast, a wellhead price of $21 also corresponds to a crude oil price of $190 per bbl and a gas-oil ratio of 63 percent, the historical average (*See* the "NG-Oil-Prices" worksheet in Appendix B). The NWPCC implicit ratio of wellhead to WTI prices for its high case 2030 forecast is 48 percent.

A more likely scenario for 2020 is $200 per bbl for WTI crude oil. This corresponds to a regular gasoline price of $6.25 per gallon. Compared to the proposed high case scenario, this scenario assumes slower economic growth, stronger demand responses to high petroleum and natural gas prices, growing North American natural gas production and flat world petroleum production through 2020. A wellhead/WTI ratio of 40 percent and $200 per barrel implies a medium case wellhead natural gas price of $14 per MMBtu (2006$). A wellhead price of $14 also corresponds to a crude oil price of $130 per bbl and a gas-oil price ratio of 63 percent, the historical average. (*See* the "NG-Oil-Prices" worksheet in Appendix B).

Staff's proposed low case natural gas price for 2020 is $5.00 per MMBtu (2006$). This is possible if world oil production grows though 2020 and there is little growth in the world economy between 2010 and 2020. This would correspond to a WTI crude price of $50 and a wellhead/WTI price ratio of 58 percent. (*See* the "NG-Oil-Prices" worksheet in Appendix B). The proposed medium-high forecast for 2020 is intermediate between the medium and the high. Similarly, the medium-low is intermediate between the medium and the low.

Summary of Proposed 2030 Forecasts

If oil production peaks between 2010 and 2013, one possibility is that the wellhead natural gas price declines from 2020 to 2030 as new technologies and substitutes to fossil fuels emerge. If production peaks after 2020 then prices will likely rise from 2020 to 2030. The proposed medium, medium-high and high price forecasts for 2030 are the same as for 2020 because it is uncertain when world petroleum production will begin to decline. Due to supply and demand responses, sustained prices well above $300 per WTI barrel and $21 per wellhead MMBtu seem unlikely either for 2020 or 2030. For WTI prices to be the same in 2030 as 2020 the decline in world oil demand over this period would have to keep pace with the decline rate of world oil production.

[3] NWPCC crude oil prices are the U.S. composite refinery acquisition (RAC) costs. The West-Texas Intermediate (WTI) crude oil price tends to be about 10 percent above the RAC price. WTI price is used here because it is a consistent grade of crude oil. The quality of crudes in the RAC average can change over time as refineries upgrade to handle heavier crude oil inputs. This could introduce a bias in trend analyses.

The proposed 2030 low case wellhead forecast is $7.50 per MMBtu. This corresponds to a WTI price of $75 per bbl and a gas-oil price ratio of 58 percent. The medium-low case forecast for 2030 is intermediate between the medium and the low forecasts.

Summary of Rationale for 2020 and 2030

While the short term North American natural gas outlook is positive, the longer term outlook is uncertain. U.S. natural gas prices appear to be increasingly linked to world oil prices. There is a good review of worldwide natural gas markets by the International Energy Agency at http://www.iea.org/Textbase/npsum/gasmarket2008SUM.pdf and included below as Appendix C. The report notes:

> *Regional gas markets are on their way to globalization. This trend seems irreversible, and impacts even the remotest and the most independent markets, at least marginally.*

A key link between world oil prices and North American natural gas prices is liquefied natural gas (LNG).

LNG and Natural Gas Markets

For the months that the U.S. is a net importer of LNG, the Henry Hub prices must roughly equal Atlantic Basin LNG prices. Otherwise, LNG cargos will go elsewhere. Atlantic and Pacific Basin LNG prices are becoming linked. Trinidad or West African FOB LNG prices will equal delivered Japanese or Chinese LNG prices less the cost of LNG transport. Most Japanese LNG contracts are pegged at 90 percent of the crude oil price. This year Japan was paying as much as $20 per MMBtu for LNG for short-term supplies. Most energy analysts expect the U.S. will continue to need to import at least some LNG sometime in the near future into the Gulf Coast.

An even stronger link between oil and Northwest natural gas prices would occur if the proposed LNG export terminal from British Columbia were built (*See* http://www.kitimatlng.com/code/navigate.asp?Id=2). If the ratio of U.S. wellhead prices to WTI crude were near or below 40 percent, there would be strong economic incentive to build North American LNG export terminals. Once built, they would drive Northwest natural gas prices toward Asian LNG prices less the cost of LNG liquefaction and cross-Pacific transportation.

Even without the influence of LNG on North American natural gas markets, there are other forces that tend to keep the ratio of the wellhead and WTI price within its historical range.

Market Connections between Oil and Natural Gas

Oil and natural gas are close substitutes for many residential, commercial and industrial applications. Fuel switching occurs when there are sustained differences in fuel prices. Swapping out equipment generally occurs when it needs to be replaced. From 1972 though 1996 the price for residential natural gas averaged 74 percent of the residential price of heating oil. Over that period the ratio of residential use of natural gas and heating oil rose from 263 percent to 582 percent. From 1997 through 2005 the residential NG/oil price ratio averaged 91 percent

and the NG/oil use ratio was roughly stable with an average of 573 percent. (*See* the Res-Use and Res-Prices worksheets in Appendix B).

If the wellhead/WTI price ratio goes down to 40 percent, that would be below the 1986-1996 period when it averaged 53 percent. If so, this would likely begin a new cycle of fuel switching to natural gas. This would add to U.S. natural gas demand and would raise its price.

There are still significant opportunities to switch U.S. stationary oil use to natural gas. About 18 percent of U.S. oil use is for stationary uses where natural gas is a good a substitute (*See* the "US-Petrol" worksheet in Appendix B). While a relatively small fraction of petroleum use, this 7.4 quadrillion Btus could add up to 31 percent to natural gas use. Even shifting 5 percent of this oil use annually would increase natural gas use by 1.5 percent per year. U.S. natural gas use, including power generation, grew only 0.2 percent per year for the period 1997 to 2007.

The ability to substitute natural gas for transportation fuels is weaker but could play a significant role after 2020. This could occur through use of compressed natural gas (CNG) in vehicles and natural gas generation for electric or plug-in hybrid vehicles.

North American natural gas prices are also linked to oil markets through production and refining of oil sands in Canada. Natural gas is used to heat oil sands to produce bitumen. It is also used to produce hydrogen for the hydro-catalytic refining of bitumen into retail products. When the price of oil rises, so does the demand for natural gas to produce and refine bitumen. If oil sand production shifts to using petroleum coke, this link would be broken.

Crude Oil Prices

> *said the Queen. "Now, here you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that."* Lewis Carroll, *Through the Looking Glass*

Oil and natural gas differ from most other commodities. Because of depletion, it takes an increasing amount of effort to maintain constant production. Perpetual exponential growth of consumption is impossible. We have consumed roughly half of the conventional oil that will ever be found.

There is a good primer on peak oil at http://www.energybulletin.net/primer. The future is unlikely to resemble the 1970s and 1980s. Back then, there was a long list of countries with undeveloped oil resources.

Today, there is a declining list of countries that might increase oil exports to meet growing demand. For total exports to increase, these countries would have to make up for countries with declining production and for countries where demand is growing faster than production. Other than members of the Organization for Petroleum Exporting Countries (OPEC), the U.S. Dept. of Energy's *Annual Energy Outlook – 2008* lists only three countries that might increase conventional oil exports: Brazil, Azerbaijan, and Kazakhstan (page 5). These three countries

produced only 5 percent of the world's oil production in 2007. Notably absent from the list is Russia, which appeared on the list in the 2007 report.

Including Brazil on this list is questionable. In 2007, Brazil's oil use still exceeded its production. Much of Brazilian oil reserves are offshore under salt beds. It is difficult to estimate the size of these reserves as some deposits are very deep and hot. It is unclear if all the estimated reserves can be developed with current technology.

These three countries are a weak counterweight to declining exports from the North Sea, Mexico, Russia, Indonesia and many other countries. Since 2005, Indonesia has been a net importer and is no longer a member of OPEC. Canada and Venezuela have large oil sand deposits, but these can add only a few million barrels per day of production before 2020 due to huge infrastructure requirements.

This leaves it to OPEC countries to match growing world oil demand. OPEC is a cartel designed to restrict supply. This is not reassuring.

Many have questioned OPEC's claims of proved reserves. OPEC's claims have not been independently verified. OPEC countries have a strong incentive to overstate reserves as OPEC production quotas are based on claims of proved reserves. The BBC reported that

> *As a result in 1985 Kuwait revised its reserve estimates by 50% overnight. It was soon followed by United Arab Emirates, Iran, and Iraq. In 1988 Saudi Arabia became the last to join the revised reserve estimates party, adding a whopping 88 bn barrels.* (http://news.bbc.co.uk/1/hi/business/4681935.stm)

Since then, updates of the remaining Saudi reserves have been sporadic.

Saudi Arabia produced 10.2 million barrels per day in 2007. This was down from its 2005 production of 11.1 Mbpd. This July, *Business Week* reported that

> *The Saudis say they can ramp up production to 12.5 million barrels a day. But a field-by-field breakdown obtained by* BusinessWeek *shows that's not likely. …*
> *Three industry analysts in the U.S. said the document's overall conclusion—that the Saudis cannot sustain higher than 12 million barrels a day maximum production for the next few years—appeared to be reasonable.* (http://www.businessweek.com/bwdaily/dnflash/content/jul2008/db2008079_865368.htm?campaign_id=rss_daily).

Experts debate whether Saudi Arabia can maintain production in the 10-to-12 Mbpd range past 2013 or whether production will begin to decline. Significant increases seem unlikely.

A consensus is emerging that it is unlikely the Saudi national oil company, Saudi Aramco, will make the investments necessary to stave off a significant decline beginning in 2014. If Saudi

Aramco is going to have increased production on-line in 2014, it would have had to announce the projects by now. It has not.[4]

Some believe this lack of announced projects is because resources are not available. For a sample of this view, see an excerpt of Dave Cohen's July 16, 2008 article in Appendix D. Others believe the Saudis will not invest because lack of production post-2014 and very high prices are in its interest. What has changed is the Saudis no longer need to fear the competitive threat of non-OPEC production. If its market share is solid, why should OPEC hurry to produce the oil. The impact on the price of oil is the same, regardless of the reason.

Similarly, Iranian production is declining while its domestic use grows. Whether this is due internal incompetence, smart monopoly behavior, or resource constraints is not clear. It is clear that production dropped from 4.2 Mbpd in 2005 to 4.0 in 2007. It is forecast that Iranian exports will fall to zero by 2014 or 2015 (*See* Appendix E). Together, Iran and Saudi Arabia produced 17 percent of the world's oil in 2007.

The high oil prices of 2008 may spur increased drilling for the next 5 years, as in the U.S. in the 1970s. This might lead to small increases in world production though 2013. It is not likely to significantly push back the date when world production begins to decline. Most oil experts expect this to occur between 2012 and 2018. The decline rate is likely to be 2-to-4 percent per year within a decade of the peak.

While gasoline prices over $3 have reduced U.S. driving, higher prices will be needed for further reductions. Britain, which charges a flat $3.77 per gallon in fuel duty and imposes a 17.5 percent consumption tax on the total price, had flat petroleum use from 1993 through 2006. The U.S. consumes about 40 percent of the world gasoline supply and 25 percent of all petroleum products.

With flat or declining world petroleum production and growing oil use in Asia, only U.S. gasoline prices between $5 and $10 per gallon will be sufficient to equate demand and supply. This implies WTI oil prices of hundreds of dollars per barrel (2006$) by 2020, absent a decade-long worldwide recession and/or aggressive conservation. Nine dollars a gallon for gasoline corresponds to a WTI crude oil price of around $300 per barrel (*See* the "Gasoline-Oil" worksheet in Appendix B). Even this level may not be enough to equate world supply and demand, after world production begins to decline.

The recent drop in world oil prices is likely due to increased world oil production and reduced demand. Production the first seven months of 2008 was about 1.4 Mbpd above the 2007 average while use dropped by roughly 0.2 Mbpd. The net difference was 2 percent of oil supply.

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[4] For a public list of announced Saudi projects see:
http://www.saudiaramco.com/irj/go/km/docs/SaudiAramcoPublic/FactsAndFigures/F%26F2006/ProjectsTimeLine.pdf .
For a detailed look at the impact of production from projects scheduled to come on-line before 2012 see:
http://theoildrum.com/node/4201 .

Virtually all the production gain was from the Persian Gulf region. Demand has declined from reduced driving in response to high prices and the economic slowdown. The large price effect demonstrates sensitivity of oil prices to small changes in the supply-demand balance.

Transportation fuel alternatives and more efficient vehicles are unlikely to have large impact before 2020. It takes that long to turn over the capital stock of vehicles and the factories that make vehicles and alternative fuels. Slow vehicle turnover will limit the impact of plug-in hybrids and other electric vehicles before 2020. Coal-to-liquid facilities are not commercial and will not play a significant role before 2020. Biodiesel and ethanol will have limited impact because of the small fraction of light-duty diesel and E-85 vehicles. Retrofits of vehicles to use compressed natural gas have had difficulties. The majority of near-term reductions in use will have to come from less driving.

Peak oil is difficult to address because the U.S. and the world get a large fraction of their primary energy from petroleum. No other primary fuel is waiting to fill the gap for liquid fuels. In 2005, the latest data available, natural gas was 23 percent of world primary energy supply. Petroleum was 37 percent. For the U.S., natural gas and petroleum provided 23 and 39 percent, respectively, of the primary energy in 2007.

North American Natural Gas

Natural gas also faces depletion problems. There are new natural gas deposits to be developed, but these must overcome declines at existing fields. Decline rates for gas deposits are higher than for oil. For most deposits there is no such thing as enhanced gas recovery. It is seldom possible to inject water, steam or CO_2 into gas deposits to increase production.

Still, North American natural gas production may increase. This will likely push the wellhead/WTI price ratio to near its historical minimum.

Speaking at the 17th Annual Pacesetters Energy Conference in Greenwich, CT, IHS industry-relations Vice President Pete Stark told participants that shale has quickly overtaken other unconventional in the gas market. It is now a vital building block in U.S. energy supplies. The United States now is "increasingly reliant" on gas shale, he said.

Based on an analysis by Cambridge Energy Research Associates, an HIS company, the growth in U.S. gas supply will "certainly be driven by unconventional reservoirs," said Stark. "And even more solid is to look at the projected contribution for gas shales through 2017, and there is the potential for huge increases in U.S. gas production coming from these shales."

That is the “up side” for shale and other unconventional natural gas. There is a “down side,” as well, however. While the recent production increase is indisputable, not everyone is convinced the additional supplies can last for decades. “The jury is still out how big shale is going to be,” said Robert Ineson, a natural gas analyst at Cambridge Energy Research Associates. Also, it’s not yet clear how quickly shale and other unconventional wells will decline. All we know for sure is that production from such wells declines more quickly than conventional wells. Also,

some warn that by expanding “hydraulic fracturing” of shale, America strikes a Faustian bargain: It gains new energy reserves, but it consumes and may pollute critical water resources.

APPENDIX A

From http://thehill.com/op-eds/the-biggest-oil-problem-2008-10-07.html

The Biggest Oil Problem

By Dr. Robert L. Hirsch

Posted: 10/07/08 06:42 PM [ET]

It is impossible to substantially impact current high oil prices for more than a very short time, but it is possible to begin to impact our biggest oil problem. Time is of the essence, because looming in the relatively near future is the challenge of world oil production going into decline. When that happens, oil shortages will ensue, oil prices will skyrocket, and the associated economic pain will be much worse than what people are experiencing today.

Oil provides the energy for most transportation worldwide, and almost all material things that we use and consume come to us via our oil-fueled transportation system. Worldwide, the volumes of oil consumed are enormous, so when world oil production decline begins, the economic consequences will be dire.

This problem is often called “peak oil.” It’s not a theory, as some pejoratively suggest. Production from all conventional oil fields reaches a maximum and then goes into a long decline. The fact that countries with many oil fields experience production declines is thus understandable.

U.S. oil production peaked in 1970 and has been in decline ever since. The same happened in the U.K., Norway, Indonesia and Mexico, to name a few. In 2005 the Swedish Royal Academy noted that 54 out of 65 of the largest oil producing countries were in decline, so it is not difficult to comprehend that world oil production will decline before long.

World oil production has been relatively flat since 2004. Production has been on a fluctuating plateau for roughly four years after decades of rising in sync with growing world GDP. The flattening of world oil production happened despite huge increases in oil prices and significant advances in technology, which economists expected would lead to greater supply.

The problem is that oil production depends largely on geological factors and secondarily on human efforts. To many analysts, the plateauing of world oil production is a harbinger of the impending production decline, meaning that fewer and fewer barrels will be available each ensuing year until dramatic action takes hold — action that has yet to be seriously contemplated, let alone initiated. As we contemplate the future, it is not hard to envision gasoline prices above $10 per gallon and a government rationing program started sometime thereafter.

There are a multitude of actions that will help us cushion the economic shock that will accompany world oil production declines. Recent analysis indicates that all reasonable options will have to be pursued in parallel.

Conservation and energy efficiency will be extremely important, but even with the highest priority, they cannot impact on a large scale for more than a decade, because of the huge size of the world's fleets of cars, trucks, planes, ships, power plants, and so forth.

These fleets have very long lifetimes, represent huge investments, and cannot be replaced quickly. Unless we are willing to drastically curtail our economic activities — committing ourselves to an ever-deepening recession, we must provide our transportation fleets with oil or oil substitutes for decades while we replace them with technologies that are not dependent on liquid fuels.

Given wartime priority, much more than a decade, and huge investments, the following options can help the U.S. to overtake runaway world oil production declines: Intensive conservation and energy efficiency, enhanced oil recovery, offshore drilling and opening the Arctic National Wildlife Refuge, coal-to-liquids, biomass and shale oil. Elsewhere, some of these same options will have to be pursued along with opportunities not open in the U.S., such as heavy oil / oil sands and gas-to-liquids.

Instead of facing these issues squarely and realistically, much of the current energy dialogue is focused on finding a single "silver bullet." People argue about various technological shortcomings. What is seldom recognized is that all energy options have their strengths and weaknesses, so compromises will be essential to minimize the deeply negative economic consequences of doing nothing.

The error that many make in proposing "energy" solutions is to ignore the fundamental differences between liquid fuels and other energy forms. The world's fleets of liquid-fuel-consuming machinery represent on the order of $100 trillion in investment with lifetimes measured in decades. It is humanly and economically impossible to dramatically change those fleets as quickly as oil production is likely to decline, so liquid fuels of one sort or another must be provided until the world phases over to technologies that depend on other, more sustainable energy forms.

The good news is that plug-in hybrid and pure electric vehicles are close to commercial readiness and could displace current vehicles, but that cannot happen quickly under the best of conditions. On the other hand, there is nothing on the drawing boards to replace liquid-fueled airplanes.

What is needed is 1) broad-scale energy education and a serious, open, non-partisan discussion of what growing oil shortages will mean to our economy, 2) a serious, urgent plan for mitigation, and 3) a national priority to press ahead. We can dramatically impact with existing technologies, while we simultaneously phase into a more sustainable energy future.

Hirsch is senior energy adviser at Management Information Services Inc. He has had a long career in most aspects of energy in industry, the federal government and the non-profit sector. He is past chairman of the Board on Energy and Environmental Systems at The National Academies and lead author of the "The Hirsch Report" — formally known as Peaking of World Oil Production: Impacts, Mitigation and Risk Management — sponsored by the Department of Energy.

APPENDIX B
Copies of Worksheets from "NWPCC-Nat-Gas-Data.xls"

Alt-Forecast Worksheet is on page 2, above

NYMEX-2010 worksheet

Henry Hub Natural Price 2010
Oct 21, 2008 NYMEX futures for

Henry Hub for 2010 calendar	**2006$**	**2010$**
year un-weighted average =	**$6.69**	**$7.83**
Jan-10		8.334
Feb-10		8.334
Mar-10		8.139
Apr-10		7.414
May-10		7.374
Jun-10		7.459
Jul-10		7.559
Aug-10		7.639
Sep-10		7.669
Oct-10		7.744
Nov-10		8.009
Dec-10		8.309

	If Inflation =	4%	NYMEX on Oct, 21, 2008	
2010	2006$	$6.69	2010$	$ 7.83
NWPPC	2006$	$8.15		

http://www.nwppc.org/library/2008/2008-13.pdf

WTI-WNG-History worksheet

Historical Relationship WTI Crude Oil and U.S Wellhead Natural Gas Prices

WTI from http://tonto.eia.doe.gov/dnav/pet/hist/rwtca.htm
US NG Wellhead from http://tonto.eia.doe.gov/dnav/ng/hist/n9190us3a.htm

	Nominal Dollars	Ratio Range		Lowest Highest		
	US WTI $/BBL	US WTI $/MMBtu	Nat Gas US Wellhead $/MMBtu	NG Oil Ratio	Avg 1987-1996 Ratio	Avg 1997-2005 Ratio
1986	$15.05	$2.59	$1.94	75%	53%	75%
1987	$19.20	$3.31	$1.67	50%		
1988	$15.97	$2.75	$1.69	61%		
1989	$19.64	$3.39	$1.69	50%		
1990	$24.53	$4.23	$1.71	40%		
1991	$21.54	$3.71	$1.64	44%		
1992	$20.58	$3.55	$1.74	49%		
1993	$18.43	$3.18	$2.04	64%		
1994	$17.20	$2.97	$1.85	62%		
1995	$18.43	$3.18	$1.55	49%		
1996	$22.12	$3.81	$2.17	57%		
1997	$20.61	$3.55	$2.32	65%		
1998	$14.42	$2.49	$1.96	79%		
1999	$19.34	$3.33	$2.19	66%		
2000	$30.38	$5.24	$3.68	70%		
2001	$25.98	$4.48	$4.00	89%		
2002	$26.18	$4.51	$2.95	65%		
2003	$31.08	$5.36	$4.88	91%		
2004	$41.51	$7.16	$5.46	76%		
2005	$56.64	$9.77	$7.33	75%		
2006	$66.05	$11.39	$6.40	56%		
2007	$72.34	$12.47	$6.39	51%		
Avg.				**63%**		

NG-Oil-Prices worksheet

Indicates an input parameter

Discussed in text

Hypothetical Natural Gas at 50% of Oil Price
5.8 MMBtu per Barrel

Oil Price $/BBL	Oil Price $/MMBtu	Nat Gas $/MMBtu
$75.00	$12.93	$6.47
$100.00	$17.24	$8.62
$125.00	$21.55	$10.78
$150.00	$25.86	$12.93
$175.00	$30.17	$15.09
$200.00	$34.48	$17.24
$225.00	$38.79	$19.40
$250.00	$43.10	$21.55
$275.00	$47.41	$23.71
$300.00	$51.72	$25.86

Hypothetical Natural Gas at 63% of Oil Price
5.8 MMBtu per Barrel

Oil Price $/BBL	Oil Price $/MMBtu	Nat Gas $/MMBtu
$75.00	$12.93	$8.15
$100.00	$17.24	$10.86
$130.00	$22.41	$14.12
$155.00	$26.72	$16.84
$180.00	$31.03	$19.55
$190.00	$32.76	$20.64
$215.00	$37.07	$23.35
$240.00	$41.38	$26.07
$265.00	$45.69	$28.78
$290.00	$50.00	$31.50

Hypothetical Natural Gas at 40% of Oil Price
5.8 MMBtu per Barrel

Oil Price $/BBL	Oil Price $/MMBtu	Nat Gas $/MMBtu
$50.00	$8.62	$3.45
$75.00	$12.93	$5.17
$100.00	$17.24	$6.90
$125.00	$21.55	$8.62
$150.00	$25.86	$10.34
$175.00	$30.17	$12.07
$200.00	$34.48	$13.79
$225.00	$38.79	$15.52
$250.00	$43.10	$17.24
$275.00	$47.41	$18.97
$300.00	$51.72	$20.69

Wellhead Nat Gas Forecast Low Case	Implied NG/Oil ratio @ oil price	
$5.00	58%	2020
$7.50	58%	2030

NWPCC High Case 2030

RAC Crude $/BBL	WTI Crude $/BBL	WTI Crude $/MMBtu
$120.00	$132.36	$20.69

Wellhead Nat. Gas $/MMBtu	Ratio NG Wellhead to WTI
$10.00	48%

Res-Use Worksheet
Trillion Btu

Residential Sector Energy Consumption Estimates, 1960-2005, United States

Year	Coal	Natural Gas		Petroleum					
				Distillate Fuel	Kerosene	LPG		Total	
1960	578	3,212		1,568	354	343		2,265	
1961	527	3,362		1,610	372	351		2,332	
1962	515	3,600		1,688	371	383		2,441	
1963	434	3,695		1,683	366	410		2,459	
1964	375	3,900		1,632	322	421		2,375	
1965	348	4,019		1,713	334	434		2,481	
1966	345	4,260		1,693	317	461		2,471	
1967	296	4,440		1,778	295	483		2,557	
1968	261	4,578		1,847	319	519		2,685	
1969	245	4,864	NG-Oil	1,838	311	590		2,739	
1970	207	4,953	Use	1,878	298	579		2,755	
1971	171	5,092	Ratio	1,897	295	585		2,777	
1972	115	5,257	263%	1,996	271	628		2,895	
1973	94	5,001	250%	2,003	227	595		2,825	
1974	82	4,898	266%	1,844	184	546		2,573	
1975	62	5,024	278%	1,807	161	528		2,495	
1976	59	5,149	259%	1,987	184	549		2,720	
1977	57	4,914	246%	1,994	167	533		2,695	
1978	49	4,987	256%	1,951	153	516		2,620	
1979	38	5,052	311%	1,626	133	355		2,114	
1980	31	4,855	369%	1,316	107	325		1,748	
1981	30	4,652	406%	1,147	85	311		1,543	
1982	32	4,751	452%	1,050	95	296		1,441	
1983	31	4,515	489%	924	85	352		1,362	
1984	40	4,685	429%	1,091	88	290		1,468	
1985	39	4,566	418%	1,092	159	327		1,578	
1986	41	4,432	399%	1,111	121	323		1,556	
1987	38	4,436	384%	1,156	119	360		1,634	
1988	37	4,757	400%	1,190	144	356		1,690	
1989	31	4,926	425%	1,160	117	402		1,679	
1990	31	4,519	462%	978	64	365		1,407	
1991	25	4,684	504%	930	72	389		1,392	
1992	26	4,820	492%	980	65	382		1,427	
1993	26	5,098	523%	974	76	399		1,448	
1994	21	4,981	519%	960	65	395		1,420	
1995	17	4,984	551%	905	74	404		1,383	
1996	16	5,391	582%	926	89	473		1,488	

Res-Use Worksheet (cont.)

Residential Sector Energy Consumption Estimates, 1960-2005, United States								
			Petroleum					
Year	Coal	Natural Gas	Distillate Fuel		Kerosene	LPG		Total
Trillion Btu								
drop 1973 to 1997				1,129				
			Ratio NG/Dist.					
1997	16	5,125	586%	874	93	461		1,428
1998	12	4,671	605%	772	108	434		1,314
1999	14	4,857	587%	828	111	534		1,473
2000	11	5,100	564%	905	95	564		1,563
2001	11	4,902	540%	908	95	535		1,539
2002	12	4,994	581%	860	60	543		1,463
2003	12	5,231	578%	905	70	564		1,539
2004	13	4,970	538%	924	85	532		1,541
2005	9	4,960	581%	854	84	517		1,455
Average 1997-2005			573%	870				

Res-Prices Worksheet

Table 2. Residential Sector Energy Price Estimates by Source, 1970-2005, United States

Year	Primary Energy										
	Coal		Natural Gas		Petroleum						Wood
					Distillate	Kerosene	LPG		Total		
	Prices in Nominal Dollars per Million Btu										
1970	1.14		1.06	Ratio	1.39	1.54	2.12		1.56		0.66
1971	1.22		1.12	Oil/NG	1.46	1.59	2.09		1.61		0.69
1972	1.27		1.18	80%	1.47	1.59	2.18		1.63		0.69
1973	1.2		1.26	75%	1.69	1.87	3.62		2.11		0.8
1974	2.2		1.42	54%	2.61	2.93	3.73		2.87		1.24
1975	2.45		1.67	61%	2.74	3.14	4.02		3.04		1.31
1976	2.41		1.94	66%	2.94	3.32	4.39		3.26		1.39
1977	2.53		2.3	69%	3.32	3.78	4.89		3.66		1.57
1978	2.59		2.52	72%	3.51	4.04	4.75		3.79		1.64
1979	2.69		2.92	58%	5.04	5.56	6.59		5.33		2.35
1980	2.9		3.6	51%	7.02	8.32	7.92		7.26		3.1
1981	3.56		4.19	49%	8.63	10.53	8.34		8.68		3.79
1982	3.65		5.05	60%	8.38	10.47	9.24		8.69		3.82
1983	3.16		5.88	73%	8.11	7.64	9.46		8.43		3.57
1984	3.4		5.95	72%	8.25	7.9	9.45		8.47		3.85
1985	3.26		5.94	75%	7.93	7.9	9.1		8.17		3.71
1986	3.12		5.67	89%	6.36	6.37	8.57		6.82		2.97
1987	2.74		5.39	89%	6.06	6.44	8.64		6.66		2.87
1988	2.61		5.32	87%	6.12	6.31	8.45		6.63		2.9
1989	2.64		5.47	81%	6.76	6.19	10.38		7.59		3.2
1990	3.01		5.63	70%	8.01	7.46	10.94		8.75		3.59
1991	3.1		5.66	74%	7.68	7.09	10.94		8.56		3.44
1992	2.89		5.73	82%	7.02	6.36	10.39		7.89		3.14
1993	3.02		5.99	87%	6.85	5.89	10.25		7.73		3.03
1994	2.67		6.23	94%	6.66	6.05	10.89		7.81		2.94
1995	2.58		5.89	90%	6.52	5.74	10.85		7.75		2.88
1996	2.53		6.16	82%	7.47	6.33	12.25		8.92		3.3
Avg 1972-1996				74%							
1997	2.48		6.75	91%	7.44	6.29	12.21		8.9		3.23
1998	2.46		6.61	103%	6.44	5.25	11.09		7.88		2.8
1999	2.37		6.5	98%	6.64	5.73	10.92		8.12		2.89
2000	2.24		7.64	77%	9.95	9.13	14.52		11.55		4.33
2001	2.93		9.42	99%	9.48	8.81	15.83		11.65		4.22
2002	2.59		7.71	89%	8.65	8.26	13.41		10.4		3.85
2003	2.46		9.23	89%	10.32	9.83	15.78		12.3		4.6
2004	3.03	[R]	10.52	89%	11.77	11.33	17.88	[R]	13.86	[R]	5.25
2005	3.46		12.34	79%	15.53	14.76	20.61		17.29		6.92
Avg 1997-2005				91%							

US-Petrol Worksheet

2007 U.S. NG & Petroleum Use

Quadrillion Btu	Total Petrol	NG a substitute	
Transportation	27.72	?	
Residential	1.28	1.28	Stationary
Commercial	0.63	0.63	for which
Industrial	9.52	4.70	NG is a sub:
Electric Generation	0.66	0.66	% of total
Total Petrol	39.82	7.28	18%
US Nat Gas Use	23.64		
% of NG		31%	

Industrial

Thou. BBL	2007	NG Not a Substitute
Asphalt	179,005	
Distillate	219,014	
Kerosene	3,015	
LPG	579,804	
Lubricants	25,378	
Gasoline	69,232	
Pet-Coke	150,940	
Residual	39,960	
Other	579,207	
Total	1,845,555	
NG Subst.	911,025	
% of Total	49.4%	

Margin-History Worksheet

Refiner Acquisition Cost
WTI Crude Cost
and Gasoline Margin

Nominal $ per BBL											
US Composite Refiner Acquisition Cost	1997 $19.04	1998 $12.52	1999 $17.51	2000 $28.26	2001 $22.95	2002 $24.10	2003 $28.53	2004 $36.98	2005 $50.24	2006 $60.24	2007 $67.94
WTI Crude Cost	$20.61	$14.42	$19.34	$30.38	$25.98	$26.18	$31.08	$41.51	$56.64	$66.05	$72.34
WTI-minus-RAC	$1.57	$1.90	$1.83	$2.12	$3.03	$2.08	$2.55	$4.53	$6.40	$5.81	$4.40
WTI/RAC ratio	108%	115%	110%	108%	113%	109%	109%	112%	113%	110%	106%
Average Ratio	110%										

Nominal $ per BBL											
Reg. gasoline ($/gal)	$1.19	$1.02	$1.12	$1.46	$1.38	$1.31	$1.52	$1.81	$2.24	$2.53	$2.77
WTI ($/gal)	$0.49	$0.34	$0.46	$0.72	$0.62	$0.62	$0.74	$0.99	$1.35	$1.57	$1.72
Implicit Margin on WTI	$0.70	$0.68	$0.66	$0.74	$0.76	$0.69	$0.78	$0.82	$0.89	$0.96	$1.05
RG Margin (2006$/gal)	$0.84	$0.81	$0.78	$0.84	$0.86	$0.76	$0.85	$0.87	$0.92	$0.96	$1.02
WTI (2006$/gal)	$0.59	$0.41	$0.54	$0.83	$0.69	$0.69	$0.80	$1.05	$1.39	$1.57	$1.68

A regression of Reg. Gas margin on WTI
(used in "Gasoline-Oil" Worksheet)

In 2006$ per gal.	Mar-gin	equals	0.712		plus	0.162	times	WTI			
Predicted Margin	$0.81	$0.78	$0.80	$0.85	$0.83	$0.82	$0.84	$0.88	$0.94	$0.97	$0.98
Actual Margin	$0.84	$0.81	$0.78	$0.84	$0.86	$0.76	$0.85	$0.87	$0.92	$0.96	$1.02
Prediction Error	$0.03	$0.03	($0.03)	($0.00)	$0.03	($0.06)	$0.00	($0.01)	($0.02)	($0.01)	$0.04

Personal Consumption. Expenditure Deflator	1997 95.1	1998 96.0	1999 97.6	2000 100.0	2001 102.1	2002 103.5	2003 105.6	2004 108.4	2005 111.6	2006 114.7	2007 117.7
US-BEA 2006 base	83.0	83.7	85.1	87.2	89.0	90.3	92.1	94.5	97.3	100.0	102.6
1997-2007 Infla-tion	2.1%										

Gasoline-Oil Worksheet

Relationship Between Crude Oil and Gasoline Prices

2006$

WTI Oil Price $/BBL	WTI Oil Price $/GAL	Gasoline Margin* $/GAL	Gasoline Price $/GAL
$50	$1.19	$0.91	$2.10
$100	$2.38	$1.10	$3.48
$150	$3.57	$1.29	$4.86
$200	$4.76	$1.49	$6.25
$250	$5.95	$1.68	$7.63
$300	$7.14	$1.87	$9.01
$350	$8.33	$2.06	$10.40
$400	$9.52	$2.26	$11.78

* Margin based on regression of 1997 to 2007 data.

APPENDIX C

IEA Natural Gas Market Review 2008 • *Executive summary*

http://www.iea.org/Textbase/npsum/gasmarket2008SUM.pdf

2007: Demand and prices continue to rise

Over 2007 and into the first half of 2008, natural gas prices continued to rise in all IEA markets. Tight supplies, unprecedented oil prices, demand growth in established as well as new markets, and delayed investment were amongst the causes of this steady upward trend. While the weakening United States dollar cushioned these price increases somewhat in 2007, at least in euro and yen terms, continuing upward pressure in 2008 is translating into further significant price rises everywhere. Price levels, however, still vary between markets as a result of particular regional and national characteristics, despite the increasing mobility of LNG cargoes.

Rising prices have not curbed demand in consuming markets – in the United States, gas demand grew by 6.5% in 2007, with growth continuing into the first quarter of 2008 at around 4%, on the back of a cold winter. In Japan, growth in 2007 was 9%, continuing into 2008, as nuclear plant utilisation fell below 50%, and higher LNG imports helped fill the gap. In Europe, the pattern of previous warm winters continued, thus dampening growth in gas consumption. Despite this Turkey continued its strong growth, up 17% on 2006; gas use has doubled to 37 bcm since 2002. A return to more normal weather patterns in Europe in the early part of 2008 saw growth of over 8% in the first quarter of the year, most notably in Spain where demand increased 20% in the six months to April 2008.

Gas markets in a globalising context

Regional gas markets are on their way to globalisation. This trend seems irreversible, and impacts even the remotest and the most independent markets, at least marginally. More producing and consuming countries, growing dependence on external imports in OECD Europe, tighter balances, increasing volumes of spot and short-term LNG, and higher prices encourage global interactions. In the tight market context of 2007 and the beginning of 2008, spot and short-term LNG trade played a greater role in inter-regional market balancing, aligning prices for some regions at higher levels. In order to benefit from this globalising trend, more transparency on prices and flows, and more competitive internal markets are needed. Interregional competition will then improve global gas security in the long term.

Gas supply developments

On the OECD supply side, indigenous gas production in the United States appears to have responded significantly to higher prices, especially in late 2007 and 2008 while United Kingdom production continued its dramatic fall of nearly 10% per year.

Russia, OECD Europe's main source of gas imports, maintained production in 2007 at 2006 levels despite the continuing depletion of its traditional major producing fields. Independent producers also maintained production levels close to 2006 output. In June 2007, the Russian government passed an amendment to existing regulations intending to align domestic gas prices to net-back export prices by 2011. Coupled with a programme to reduce gas flaring and increase efficiency in gas use, this set of reforms is intended to free up more gas volumes to meet rising domestic demand and export requirements. However, in the context of inflationary pressures, price reform could be postponed.

In other exporting countries, LNG production capacity is set to grow rapidly, although not as quickly as anticipated in the past. Commissioning and production problems are appearing in new LNG liquefaction plants, delaying commercial deliveries of cargoes and causing concerns among consumers.

There was positive news in LNG supply with Equatorial Guinea and Norway joining the ranks of LNG exporters. Despite this, there has been a distinct lack of final investment decisions (FIDs) over the period since the 2007 Natural Gas Market Review. Positive announcements have come only from Angola, Australia and Algeria.

Delays and cancellations were a frequent feature of upstream gas development in 2007 and 2008, due notably to escalating engineering, procurement and construction costs. Moreover, in some producing countries, growing state involvement in the control of energy resources and their development continues to influence decision making.

Tensions concerning the allocation of resources between the domestic market and exports persist in Indonesia, Nigeria and in the Middle East and North Africa. Low domestic gas prices in many of these countries are leading to greater volumes of gas being consumed locally, often at greatly distorted prices, in efforts to diversify and strengthen the economy, in industries such as petrochemicals, water desalination and power generation. Low domestic prices also discourage upstream investment.

Similarly, domestic politics and economic development policies in some producing states hinder the necessary investment and technical know-how to capitalise on their resources. Government intervention and state appropriation of privately owned assets, coupled with complex financial arrangements, ensure that much of the gas reserves remain in the ground.

Investment in import infrastructure

An unprecedented major expansion is underway globally in regasification capacities, well in excess of LNG production capacity. Consequently, regasification capacity is likely to be underutilised relative to liquefaction but this likely excess capacity could be a source of flexibility. “Global” exchange of LNG cargoes is accelerating, particularly from the Atlantic to the Pacific region, facilitated by the changing business models of the LNG industry.

Pipeline infrastructure development in 2007 was marked by delays and increased costs of major projects; both the Nabucco and Nord Stream projects saw cost estimates increase by at least 50%. In North America, the Alaska pipeline was delayed, although the Rex Pipeline project is on time. In marked contrast to North American pipeline investment, investment in internal interconnections and in new supply projects in Europe continues to lag.

In LNG similar trends can be seen, with a significant amount of capacity being planned but not all projects actually proceeding. Major delays afflict many projects with some cancellations such as the Baltic LNG project announcement from Gazprom. The dearth of FID in new LNG projects since mid-2005 means that any major post-2012 expansion of capacity is more likely to slip toward 2015. Notwithstanding the massive expansion in LNG that will occur in the decade 2002 to 2012, the lag in LNG investment beyond 2012 is a concern for all gas users in both IEA and non-IEA markets.

Gas to power

Despite rising gas prices, gas-fired power exerts a major influence on demand for gas in both OECD and non-OECD countries. There was little in the way of new coal plant built outside of the developing world in 2007 and less than a handful of announcements in relation to new nuclear plant. In OECD countries,

especially in Europe, low capital costs, short leadtimes, and relatively light environmental footprints still make CCGT the low risk default option for new investments in power generation in an environment characterised by considerable regulatory uncertainty. In a number of oil and gas producing countries, namely in the Middle East and North Africa region, gas is emerging as the fuel of choice to meet rising electricity demand. In the major emerging economies of China and India the share of gas in the generation mix remains relatively small, but the volumes consumed can be significant in terms of global gas use and trade.

Gas security

While much of 2007 was crisis-free relative to other years, events in the first half of 2008 have served to remind us of the fragility of gas markets. In June 2008, an explosion at a gas supply hub in Western Australia reduced local gas supplies by 30% with significant implications. Earlier in 2008, a minor dispute between Turkmenistan and Iran resulted in gas shortfalls in Iran, holder of the world's third largest gas reserves. This incident had repercussions as far away as Greece and Turkey.

Role of new technology

Advances in technology to access new gas resources and find new ways of bringing gas to markets are essential to ensure additional supplies for a growing demand. Delivering greater efficiency in upstream and downstream sectors is a key objective of research and development to ensure gas market sustainability over the longterm. In a globalising gas market – one with rising prices, tight supply prospects and increasing environmental constraints – frontier gas resources will probably see their contribution to global gas supply grow in the future.

Appendix D

For the full article see
http://www.aspo-usa.com/index.php?option=com_content&task=view&id=415&Itemid=91

Peak oil is a done deal

by Dave Cohen 16 JULY 2008
It ain't over 'til the fat lady sings — anonymous
The fat lady is warming up — anonymous

[Note this article refers only to crude oil and crude oil condensate, it does not include natural gas liquids and other liquids.]

I now believe that the hypothesis of a near or medium-term peak in the world's oil supply is confirmed beyond any reasonable doubt. A shift in emphasis that speaks to reducing our demand for oil and examining alternatives to oil is now required. I will be taking that road in the future, leaving specific concerns about the oil supply behind.

Today's story briefly summarizes why I believe "peak oil" is a done deal. The forecast[1] below reflects my own view. This analysis does not necessarily reflect the view of *ASPO-USA*. Global oil (crude + condensate) production will peak at 76.5 ± 0.5 million barrels per day (b/d) in 2011, ± 1 year, with a probability of 80%. There is a 20% likelihood that output will peak at another level—not 76-77 million b/d—between 2009 and 2013.

This estimate intentionally says nothing about the shape of the production curve after the peak. I stand by this forecast and will not be revising it in the future. A "peak oil" forecast examines the supply-side of the oil market, but reality dictates that high prices will affect demand. My estimate can thus be viewed as a "low price" or "reference" case that ignores the effects of rising prices. See the *Summary* for a brief discussion.

Saudi Aramco Update

Business Week published Saudi Oil: A Crude Awakening on Supply? on July 10, 2008. Steve LeVine's story should leave us with no doubt about what to expect from the Kingdom in coming years. Mysteriously, this story was not *Front Page News* in every media outlet all over the world.

Business Week received a "detailed document obtained from a person with access to Saudi oil officials." The new information simply confirms what I already knew, but independent confirmation helps us reach firm conclusions. PFC's Roger Diwan, a respected oil analyst, vetted the *Business Week* document.

The data describes Saudi maximum sustainable capacity (table above). Capacity remains around 12 million barrels per day (b/d) for the next 5 years. An important shift occurs which should give us all pause. One dramatic part of the data concerns a site called Ghawar, which has been the kingdom's workhorse field for decades. It shows the field producing 5.4 million barrels a day next year, but the volume then falling off rapidly, to 4.475 million daily barrels in 2013. "That's why Khurais is so important—to make up for that decrease," said the oil industry executive who released the data.

The long anticipated decline ("twilight") of Ghawar, the world's largest oil field, is reflected in the Saudi Light data (blue circle). If these numbers are accurate, Ghawar output declines 17% between 2009 and 2013. This works out to about 4%/year for each of the next 5 years. Production of "good

oil"—not Manifa heavy sour oil (gray circle)—to offset these declines is supposed to come from Shaybah.

Though 2014 is not included in the data, one of the fields listed—Shaybah—is to have a volume increase to 1 million barrels a day that year, from 750,000 barrels a day from 2009 to 2013, according to the oil executive.

Simple arithmetic tells us that additions from Shaybah after 2013 will not offset Ghawar declines for more than one year. *Business Week's* source indicates that 10.4 million b/d is Saudi Arabia's maximum *sustainable* production level between 2009-2013.

... [The middle part of the article is not reproduced here]

In Summary
I am now in a position to add up the production numbers arrived at above, but first I need to establish a baseline. I will use the EIA's data (here and here) for May, 2008. The EIA's 4-month average for 2008 is 74.325 million b/d. Saudi production in May was 9.4 million b/d, up 300,000 b/d from April. I will add those barrels to the 4-month average to obtain a baseline of 74.625 million b/d.

We can now add our additions to the baseline. The non-OPEC increment is 0.5 million b/d, the Saudi increment is 1 million b/d, and the rest of OPEC increment is 0.72 million b/d. Together, these yield 2.22 million b/d. Adding this to the baseline, we get 76.845 million b/d. If you look back at both of the IEA charts, you will see that OPEC capacity additions fall off considerably in 2011, while non-OPEC additions drop after 2009. My view is that after 2011, we will never surpass production levels achieved that year.

The oil price is rising quickly. The higher prices preceding the peak are now dampening demand in the United States and elsewhere in the OECD. However, subsidized consumption growth outside the OECD (China, etc.) is still soaking up demand reductions elsewhere. I can not predict future oil prices with any certainty, and I can not predict future oil demand with any certainty, although I have discussed these subjects at length in other columns.

Obviously, I can not predict the exact shape of the world oil production curve in the next 5 years. What I *can* do, however, is establish a ceiling for world oil production should demand remain strong going forward. That ceiling, now and forever, is likely to occur in 2011 somewhere between 76 and 77 million b/d.

We are so close to the peak now that quibbles about the numbers cited here do not matter. My familiarity with the oil industry justifies many of the "hidden assumptions" I've made and did not have time to discuss. If you remain unconvinced that a peak of world crude oil production is now almost upon us, nothing I could say further will persuade you in any case.

As I said at the top, this is my official forecast and I will not revise it in the future. I will note for the historical record that in July of 2008 few Americans have come to grips with the implications of a permanent peak in the world's oil supply despite the strong price signal we've seen for several years now. I have done all I could over the last few years to warn everyone about what's coming. My conscience is clear even as my concern remains high.

For me, the time has come to examine measures we might take in the post-peak world.
Contact the author at dave.aspo@gmail.com

Appendix E

Abstract

Roger Stern, **"The Iranian Petroleum Crisis and the United States National Security,"** *Proceedings of the National Academy of Sciences* 104, no. 1 (January 2, 2007): 377–82.

For the full article see: http://www.pnas.org/content/104/1/377.full

The U.S. case against Iran is based on Iran's deceptions regarding nuclear weapons development. This case is buttressed by assertions that a state so petroleum-rich cannot need nuclear power to preserve exports, as Iran claims. The U.S. infers, therefore, that Iran's entire nuclear technology program must pertain to weapons development. However, some industry analysts project an Irani oil export decline [e.g., Clark JR (2005) *Oil Gas J* 103(18):34–39]. If such a decline is occurring, Iran's claim to need nuclear power could be genuine. Because Iran's government relies on monopoly proceeds from oil exports for most revenue, it could become politically vulnerable if exports decline.

Here, we survey the political economy of Irani petroleum for evidence of this decline. We define Iran's export decline rate (*edr*) as its summed rates of depletion and domestic demand growth, which we find equals 10–12%. We estimate marginal cost per barrel for additions to Irani production capacity, from which we derive the "standstill" investment required to offset *edr*. We then compare the standstill investment to actual investment, which has been inadequate to offset *edr*. Even if a relatively optimistic schedule of future capacity addition is met, the ratio of 2011 to 2006 exports will be only 0.40–0.52.

A more probable scenario is that, absent some change in Irani policy, this ratio will be 0.33–0.46 with exports declining to zero by 2014–2015. Energy subsidies, hostility to foreign investment, and inefficiencies of its state-planned economy underlie Iran's problem, which has no relation to "peak oil."

Alternative to the NWPCC Natural Gas Forecast
U.S. Wellhead Natural Gas Price Forecasts (2006 Dollars Per Million Btu)

Proposed Alternative Forecast

	Low	Medium Low	Medium	Medium High	High
2020	$5.00	$9.50	$14.00	$17.50	$21.00
2030	$7.50	$10.75	$14.00	$17.50	$21.00

Oct. 13, 2008 NWPCC Draft Forecast

	Low	Medium Low	Medium	Medium High	High
2007			$6.06		
2010	$6.50	$7.00	$7.50	$8.20	$9.00
2020	$4.50	$5.50	$7.25	$8.25	$9.25
2030	$5.00	$6.50	$7.65	$8.50	$10.00