

NRC-CNRC

From *Discovery*
to *Innovation...*



Canada and the Coming Energy Transition

Future of Food Conference

Nelson, BC

November 13, 2007

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National Research
Council Canada

Conseil national
de recherches Canada

Canada

Outline

- Premise
- A view of world energy use
- Define the energy challenge
- Energy basics
- Oil basics and peak oil
- Energy complexities
- Quotes

Premise

- 1) Uncertainty in oil supply market**
- 2) projected world demand increase**
- 3) risk of unprecedented economic and social consequences**
- 4) Oil powers the engine of our economic trade and agriculture systems**
- 5) The risk warrants a proactive approach to begin buffering our communities to the loss of cheap oil**

A view of world energy use

All energy types: electrical, nuclear, coal, oil, natural gas, solar, wind, hydro, etc.

- 447 quadrillion BTU (2004)
- 559 quadrillion BTU (2015)
- 702 quadrillion BTU (2030)
- **Where will growth of 64% come from?**

Just think of a BTU as a unit of energy accounting

A quadrillion is 1,000,000,000,000,000

Or a billion millions!!!

Context - 45 million tons of coal

A pile of coal 10 feet tall by 1 mile wide by 3.3 miles long

At 60 mph it would take 9 minutes to drive around the pile

A view of world energy use

- Not all growth is equal most will come from developing economies



- non-OECD Asia region 3.2% annually
- Doubles from 2004 → 2030

Sources of primary energy

Short Term Renewable Sources

- Solar Photovoltaic
- Solar thermal
- Wind
- Hydro
- Tidal
- Wave
- Geothermal
- Biomass

Renewable on daily basis except for biomass

Longer Term Renewable Sources

- Coal
- Oil
- Natural gas

Time line for renewal is millions of years!



Carriers of energy

- Ethanol from crops
- Methanol
- Hydrogen
- Electricity

These act as conduits for sources of energy but without a source they cannot be produced!

Oil basics

- Barrel of oil = 42 gallons = 159 L
- World uses 84.5 (mbpd) million barrels per day
 - 3,500,000,000,000 gallons/day
 - 1000 barrels per second
- US 20.6 million barrels/day # 1 user in the world
- Canada uses 2.2 million barrels/day #7
- Oil is a dynamically traded commodity
 - Some buffering by strategic petroleum reserves

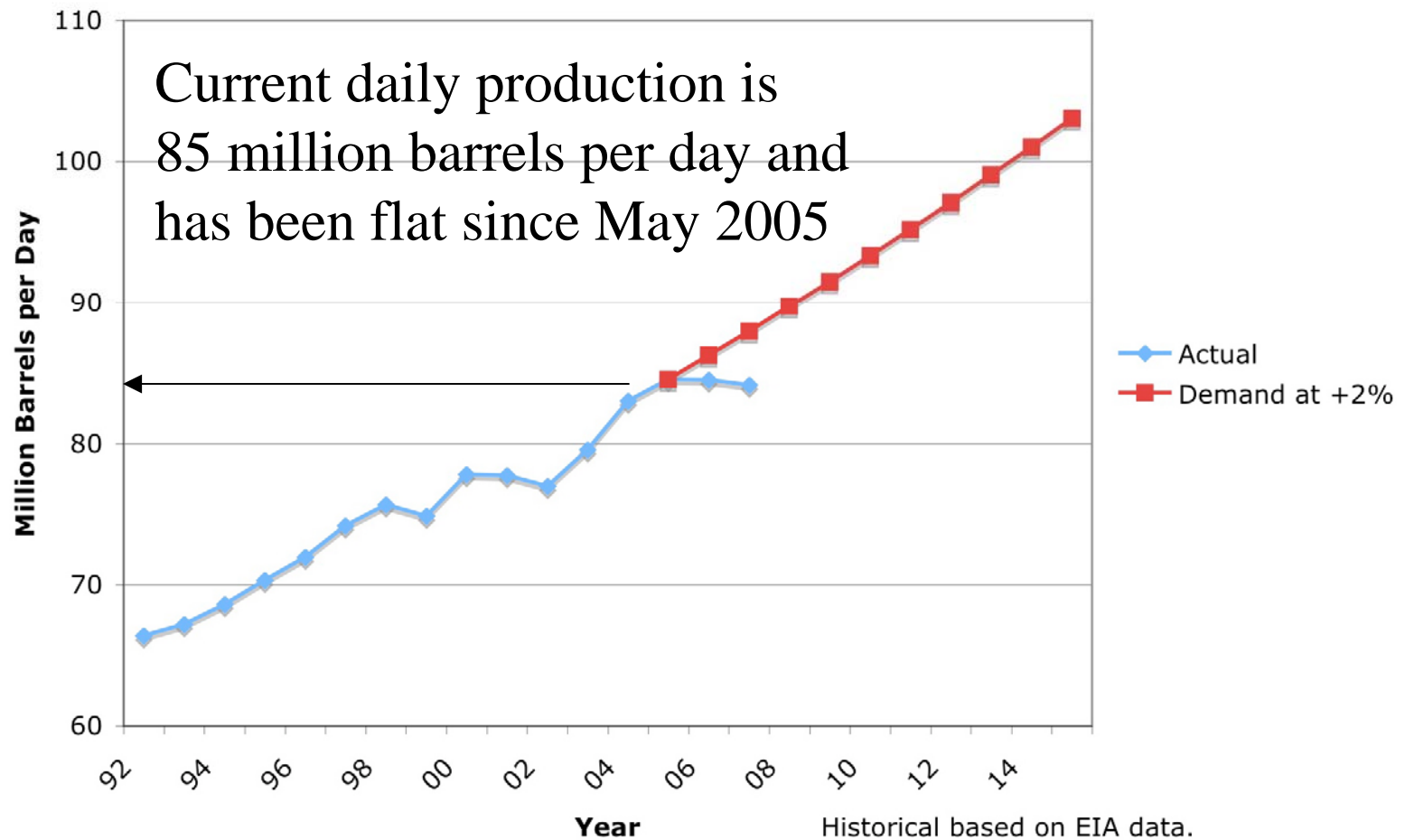


1 barrel = 42 gallons



Oil basics

Figure 3: World Oil Production and Expected Future Demand



Canadian Oil

\$50 billion in Tar sand investment



Canada a leader in the world

#7 oil user 2.2 mbpd

#15 oil exporter 1.1 mbpd

Conventional oil production is in decline

Canada produces 3.3 million barrels/day

What is the concept of peak oil?

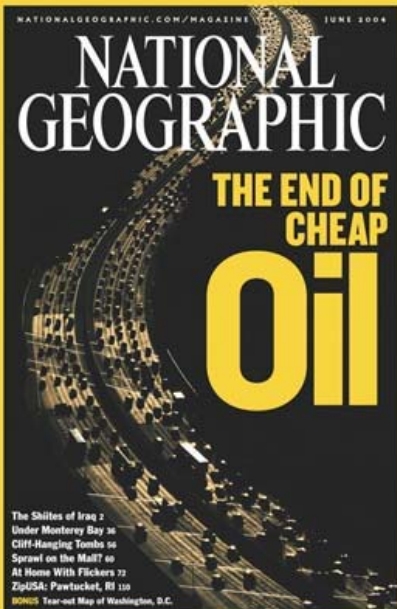
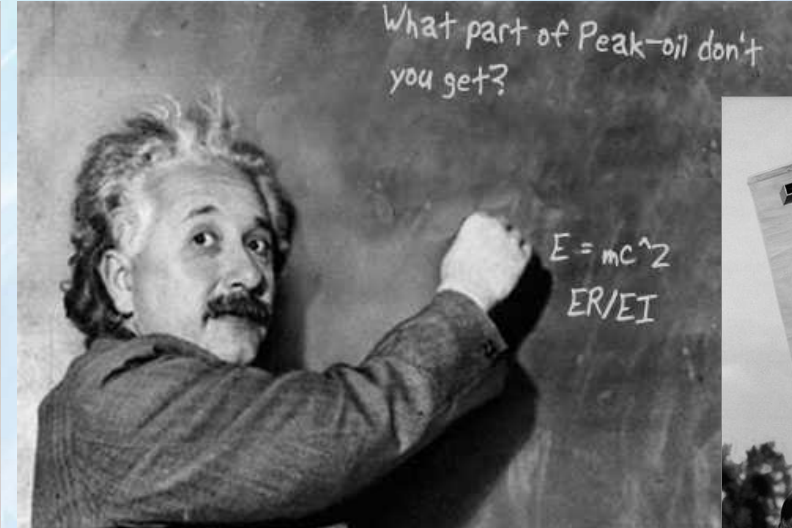
WORLD-WATCH

Volume 19, Number 1 Vision for a Sustainable World January/February 2006

Peak Oil

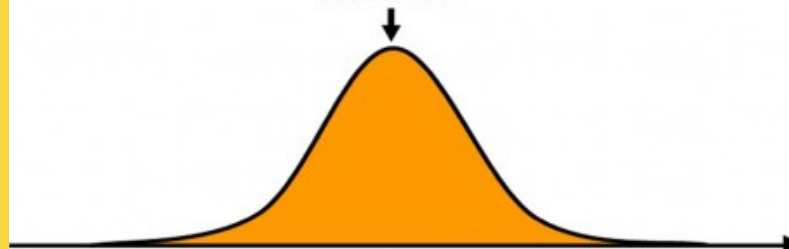
Five Easy Pieces:

- » Kjell Aleklett
- » Red Cavaney
- » Christopher Flavin



Wake up!!!

We are here



Peak Oil

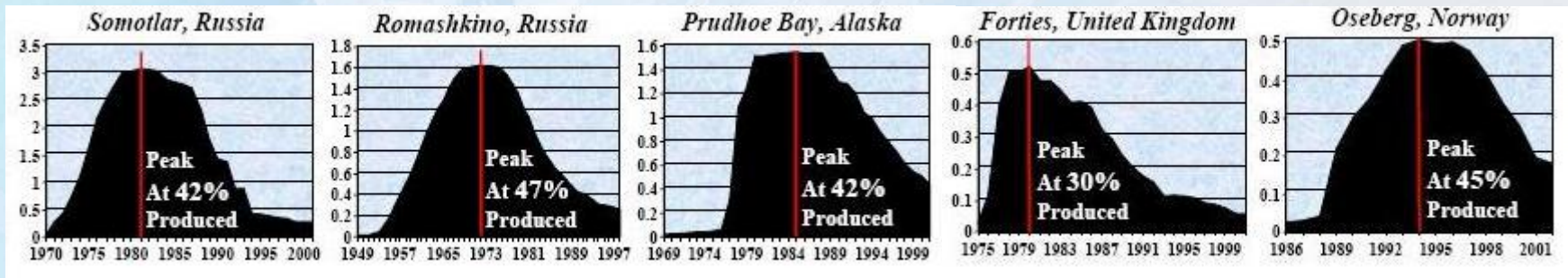


What is the concept of peak oil?

- Great news we are not running out of oil!
 - We are running out of cheap oil
 - 1.25 trillion barrels left in the ground
 - Non-transparent OPEC proved reserve estimates are a source of concern
 - 1.11 trillion barrels already consumed
 - 30 billion barrels per year produced (42 years left)
 - 1000 barrels a second!

What is the concept of peak oil?

- Will not peak and decline when half of the oil is used up
 - We don't know exactly what the world's recoverable reserves are (reserves versus resources uncertain)
 - Producing countries may not extract in an unconstrained way (Peak exports)
 - Inflation and unstable political environment erodes investment
 - Geopolitical events (war and local insurgency)



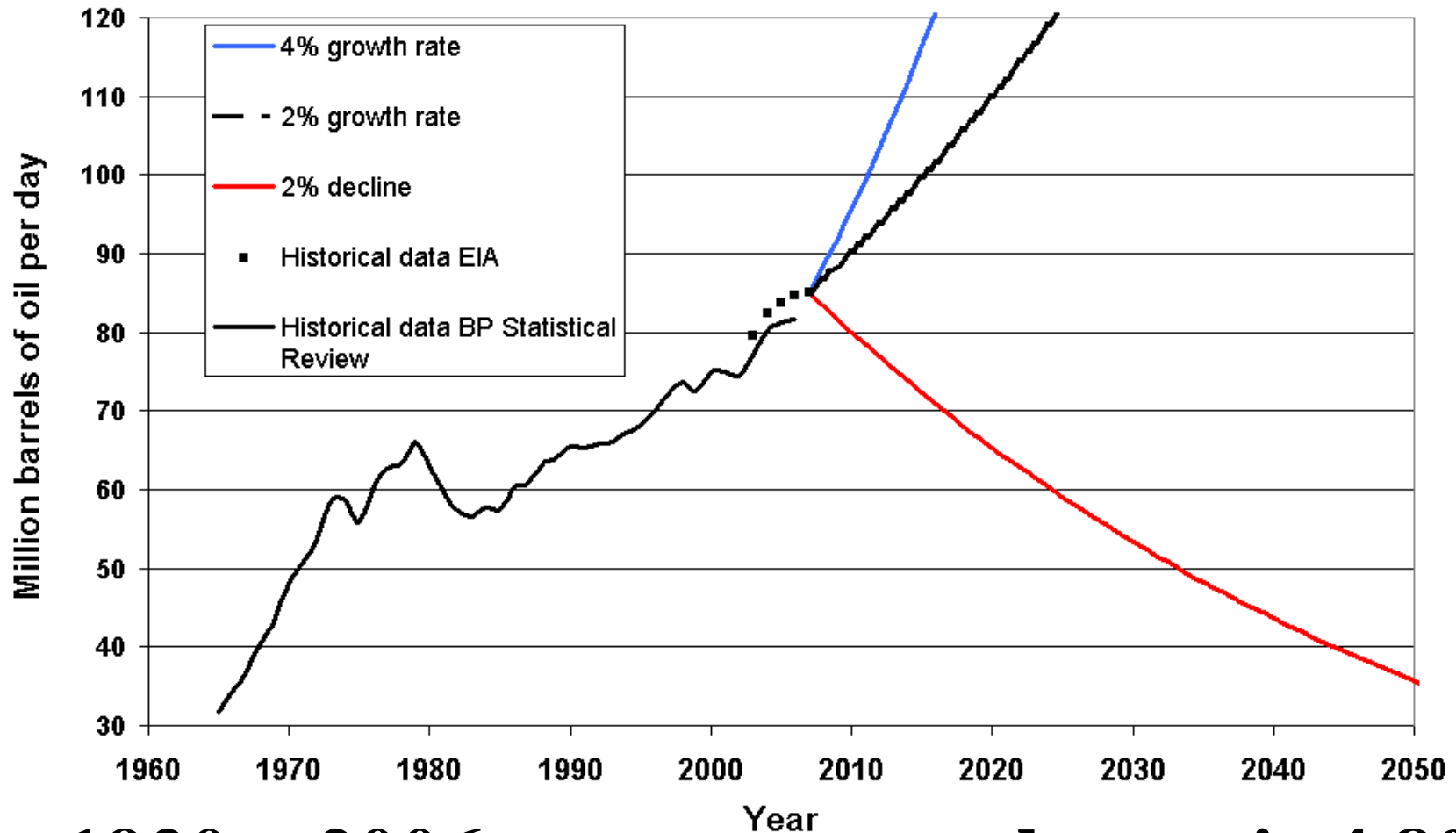
Oil as a dynamic system

- Just in time supply
- 4% annual decrease means 20 mbpd needed just to break even by 2015
- Saudi Arabia only supplies 10 mbpd!
- Unconventional production could be ramped up to 5 mbpd by 2015 with focused effort
- We need 3.3 mbpd added yearly of new capacity just to remain flat
- It took us 140 years to go through the 1st trillion the next trillion will take less than 30

The world is running to stay in place!



Oil where do we stand?



1920 – 2006 average growth rate is 4.8%

Oil end uses in the USA

U.S. Oil Use By Sector



Electricity
1%

Residential
7%

Industrial
23%

Transportation
69%

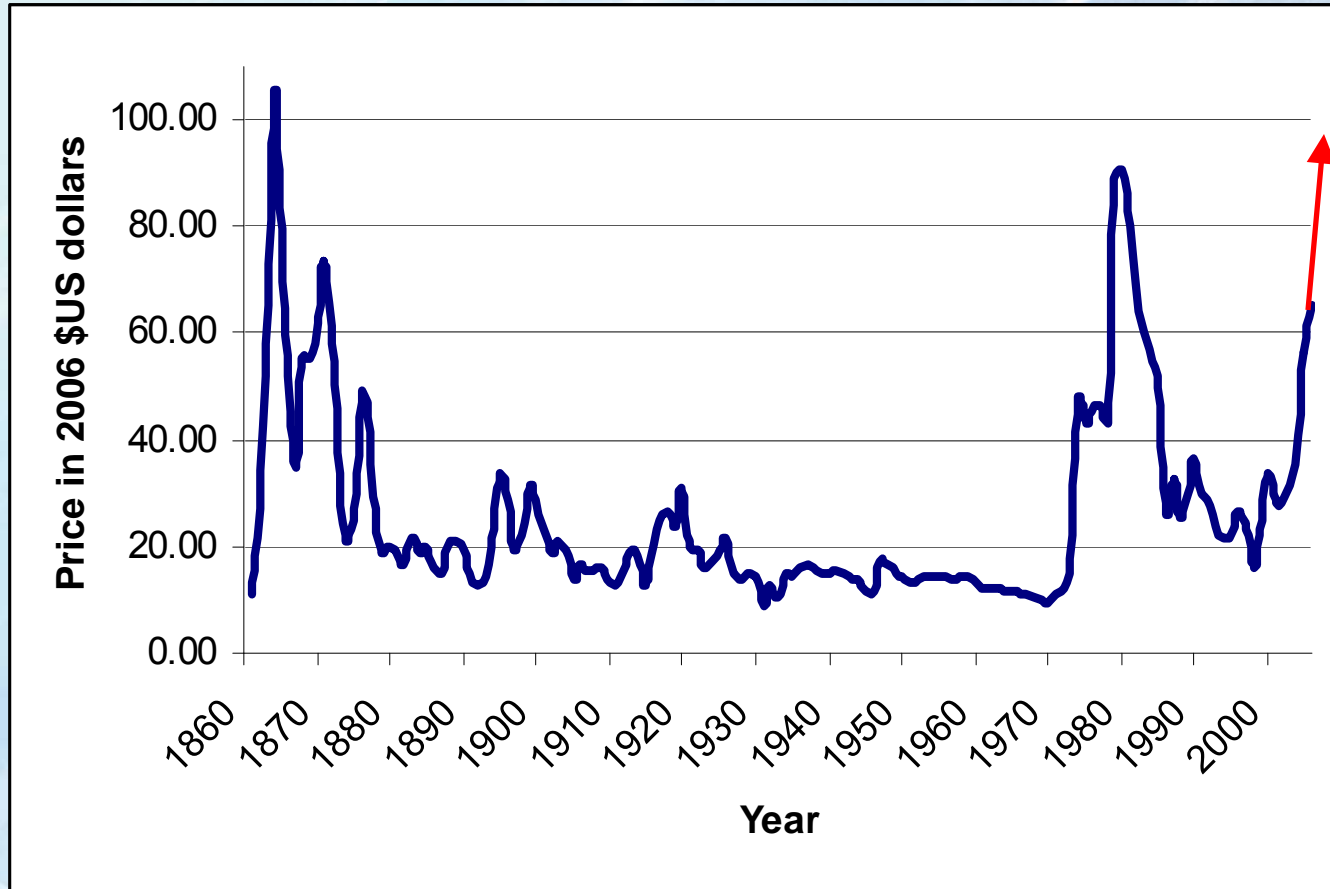


5% of the world
population
uses 25% of the oil!

Data are for 2005.

Source: Energy Information Administration, *Annual Energy Outlook 2005*

Oil – historical pricing



OPEC can't provide a price cushion anymore

Can't we move on?

- Un-conventional oil and gas
- Hydrogen and fuel cells
- Nuclear energy
- Bio-fuels
- Wind energy
- Solar energy
- Tidal energy
- Run of the river

The simple fact is that the other options are just not as good!



Energy metrics to think about

- Location - resources are not always where needed
- Economics
- Access – Geopolitics and resource nationalism
 - Remaining oil isn't all ours to buy
 - National Oil companies not International Oil companies are running the show
 - 1970s 93% IOC now 20% IOC
- Environmental challenges
 - Water – coal bed methane, tar sands
 - Carbon dioxide management
- Energy return on investment – lower energy density or diminishing returns
- Intermittency of supply
- Sector use

Resource extraction – easiest first hardest last

hardest

Oil shale

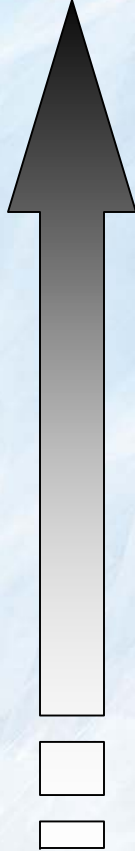
Coal to liquids

Tar sands

Deep water drilling

Isolated small pools of oil

Large lakes of high pressure oil



easiest



Government response?

- Key alternative technologies only supply about 1% of U.S. consumption of petroleum products...by 2015 only displace the equivalent of 4%
- There is no coordinated federal strategy for reducing uncertainty about the peak's timing or mitigating its consequences
- An imminent peak and sharp decline in oil production could cause a world wide recession



GAO

U.S. Government Accountability Office

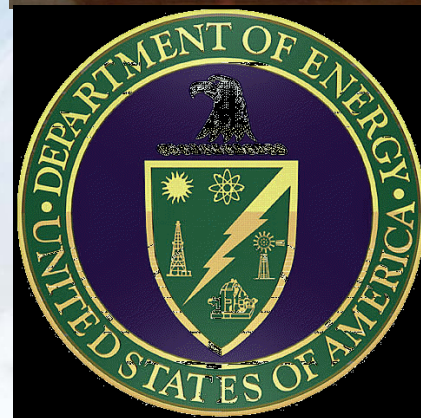
Crude oil Uncertainty about Future Oil Supply makes it Important to Develop a Strategy For Addressing a Peak and Decline in Oil Production – GAO-07-283 February 2007

Government response?

“Even with all the technical expertise the world could offer and all the political will it could muster, eventually, we will run out of oil. And, even before then, the price of a dwindling supply will be prohibitive. At present, our world is overly focused on, and overly dependent upon, one source of energy. And that path is unsustainable.”

Samuel W. Bodman US Secretary of Energy

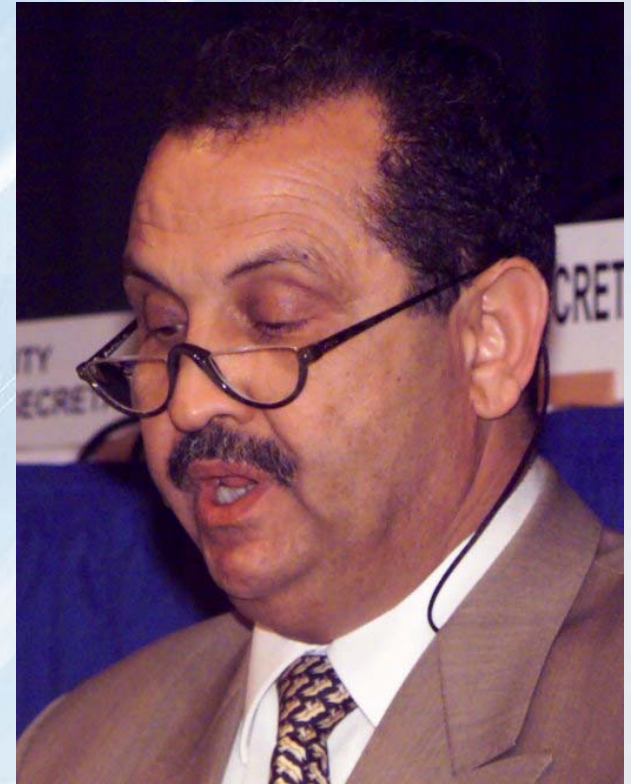
speech given Middle East Institute's 60th Anniversary Conference November 13, 2006



OPEC response?

“most would appear to agree that peak oil output is not very far away for all of us. It could take place sometime within the next decade or so, which in fact means that **there is not much time left** for a world economy to be driven largely by oil.”

~ Dr Shokri Ghanem



Chairman of the People's Committee, the National Oil Corporation (NOC)
of Libya quoted

In OPEC Bulletin November-December 2006 pg. 60



Saudi response?

“Reserves are confused and in fact inflated. Many of the so called reserves are in fact resources. They’re not delineated, they’re not accessible, they’re not available for production”.

أرامكو السعودية
Saudi Aramco



**Sadad al-Huseini –
former head of exploration and
production at Saudi Aramco**

OECD response?

“...oil production from non-OPEC producers will reach a peak before starting to decline...at the same time the peak of the economic expansion phase of China will take place. The two events will coincide: the explosion of the growth of the Chinese demand, and the fall in production of non-OPEC oil.

Fatih Barol - Economic Director of Studies of the
INTERNATIONAL ENERGY AGENCY

Quoted in LeMonde June 27, 2007





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From *Discovery*
to *Innovation...*

Thanks for your attention

Questions can be directed to

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