‘Mankind was destined to live on the edge of perpetual disaster. We are mankind because we survive. We do it in a half-assed way – but we do it’

- James Michener

(From a plaque on the Writers’ Walk, Circular Quay, Sydney)
IT’S LATE, AUSTRALIA!
How long until you wake up?

First call: Uppsala 2002
Then: Rimini, Pisa, Denver, Boston, Cork, Houston, ...

During six long years: what’s changed?
While Australia slept:

2002

Discovery rates continue decades-long fall

Calculations suggest reserves can’t meet demand projections

Some recognition of political, investment risk in developing resources
While Australia slept:

2002

Discovery rates continue decades-long fall

Calculations suggest reserves can’t meet demand projections

Some recognition of political, investment risk in developing resources

2008

No improvement in resource situation

New, more accurate, calculations of supply define earlier peak more clearly

Political will to increase supply clearly absent; prices not stimulating investment to increase supply
We’ve carried on burning up oil ....

Oil consumption per capita

Consumption per capita 2007
Tonnes

... buying from those who have lots

Who has the oil?
‘Business as Usual’ Demand Growth

How will restricted supply / higher prices alter these?
The size of the problem!

World Demand

Required New Production

Existing Field
Decline ~ 4 - 6%

Existing Production

MOEBD

World Demand

Required New Production

Existing Field
Decline ~ 4 - 6%

Existing Production

ExxonMobil
There are three problems:

Geology
Investment
Policy of main producers

These, taken together, make the future of oil very difficult

Fatih Birol
Chief Economist
In your dreams ....

‘The explorers will fix it; there’s lots of oil out there - think of Jack and Tupi; add in the OCS and ANWR’

‘Worldwide reserves/production ratio is still 40:1; there’s lots of time to find other energy sources’

‘Technology will deal with it: add just 10% to recovery efficiency and we’re fine’
Discoveries – the trend continues!
The R/P Myth

1. Reservoirs don't do this:

2. .... but this:

Each field’s prodn. rate declines after ~ 50% of reserves produced
Total prodn. rate not constant, declines ~ 4%/ year.
After 40 years, rate is ~ 20% of original

3. So production from known fields will look like this:
Effects of New Technology

Little indication that recovery efficiency is increasing in established fields.

Main benefits seem to be in dealing with unexpected problems and in finding small accumulations.
We’re trying harder, but ....!

Source: BP, Baker Hughes

**World and US Rig Usage**

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Rigs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>500</td>
</tr>
<tr>
<td>2002</td>
<td>1000</td>
</tr>
<tr>
<td>2004</td>
<td>1500</td>
</tr>
<tr>
<td>2006</td>
<td>2000</td>
</tr>
<tr>
<td>2008</td>
<td>2500</td>
</tr>
</tbody>
</table>

**World Oil Production**

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Prodn. Rate (mm b/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>60</td>
</tr>
<tr>
<td>1999</td>
<td>70</td>
</tr>
<tr>
<td>2001</td>
<td>80</td>
</tr>
<tr>
<td>2003</td>
<td>80</td>
</tr>
<tr>
<td>2005</td>
<td>80</td>
</tr>
<tr>
<td>2007</td>
<td>80</td>
</tr>
</tbody>
</table>
Some things aren’t changing....


come on, when I was your age, I had to walk six miles through snow to get to school...

so, your parents couldn't afford gas either...
... others are ...
... but not as we had expected
If it looks like a peak – and it feels like a peak – then ....!
If it looks like a peak .....
Predicted World Production
The Problem – and part of the Solution?

Energy Growth Relative to GDP Growth

OECD

Ratio of energy : GDP growth

Non-OECD

10-year average

Prices wake us up

US Gasoline Consumption Growth

Source: EIA
© BP 2008
Rationing: A forced solution

Queuing for diesel at a Sinopec station in South China, Apr. 2008

Waiting in line for gas when Grangemouth refinery workers were on strike, Apr. 2008

Source: 13D Research, NY
Evaluating Alternative Energy Sources

Must consider

Technical Readiness, Scaling
Financial Viability
Energy Return
Environmental Impact
Longevity
Energy return: A Vital Criterion

- Source: C.A.S. Hall, C. Cleveland
Filling Medium-term Energy Gap

Clear that economic supply from ‘sustainables’ will be too small to fill short to medium-term gap

Only candidates to fill gap in this period

- Unconventional Fossil Fuels
  - Oil from Shale or Tar Sands
  - Gas-to-Liquids, Coal-to-Liquids

- Coal – with CCS

- Natural Gas

- Nuclear

- but contributions needed from all sources!
Liquid Energy: Tar Sands

Huge resource in Canada, Venezuela (resource 2-3 times world oil resource); also Russia, Middle East

Recover oil by mining/retorting or *in situ* heating

Huge water (3-10 bbl/bbl) and gas (1 mscf/bbl) demands and cost inflation, environmental concerns (water and spent sand) slowing development

Targets will not be met; long term possibility
Liquid Energy: Oil ‘Shales’

Marls with particles of immature hydrocarbons
Trillions of barrels in west US, NE Australia, Brazil, China

Recover oil by mining/retorting or heating *in situ*

Environmental problems: water demand (3 bbl/bbl)
and disposal, shale disposal (2 ton/bbl), high CO2

Commercial tests: Exxon (1980s), Queensland (2001), Estonia; now by Shell and others in Colorado

At best, a long term solution
Liquid Energy: Gas-to-Liquids

Direct Process: energy intensive and difficult to control – no commercial application yet

Complex Indirect Process: converts $\text{CH}_4$ to syngas, then to longer-chain HCs. Used for strategic reasons (S. Africa) or stranded gas (NZ, Malaysia)

New Exxon plant built in Qatar but plans for others dropped in favour of LNG exports

Long term potential if gas supply allows
Liquid Energy: Coal-to-Liquids

Established process; S. Africa uses since 1955, now source for 30% of its petrol/diesel

Rising coal prices, x3 in year, impact economics

Environmental problems: water use (10 bbl/bbl), CO2 output (50 lb/gal. v 27 lb/gal. for refinery)

CCS could reduce CO2 output (to 20 lb/gal)

Potential source, if CCS developed
Other possible liquid HC sources

Biofuels

First generation
  Sugar, starch, vegetable oils
  Limited by competition with food usage

Second generation
  Cellulosic, non-food
  Awaits technical breakthrough

Third generation
  Biodegradable fuels from algae
  Some medium term potential?
A Plant in your Tank?

Algae produce 30 x energy/area of other crops. Grow on marginal land, saline water

Long running pilot in US until 1996; limited operations now in New Zealand and US

Need to find strain with high oil/mass ratio, fast growing and easy to harvest

Trials involve both open systems (sewage ponds) and closed (polytubing and CO2)
“OK, it’s agreed – we announce that to do nothing is not an option and then we wait and see how things pan out”

(from ‘Private Eye’)
The End