

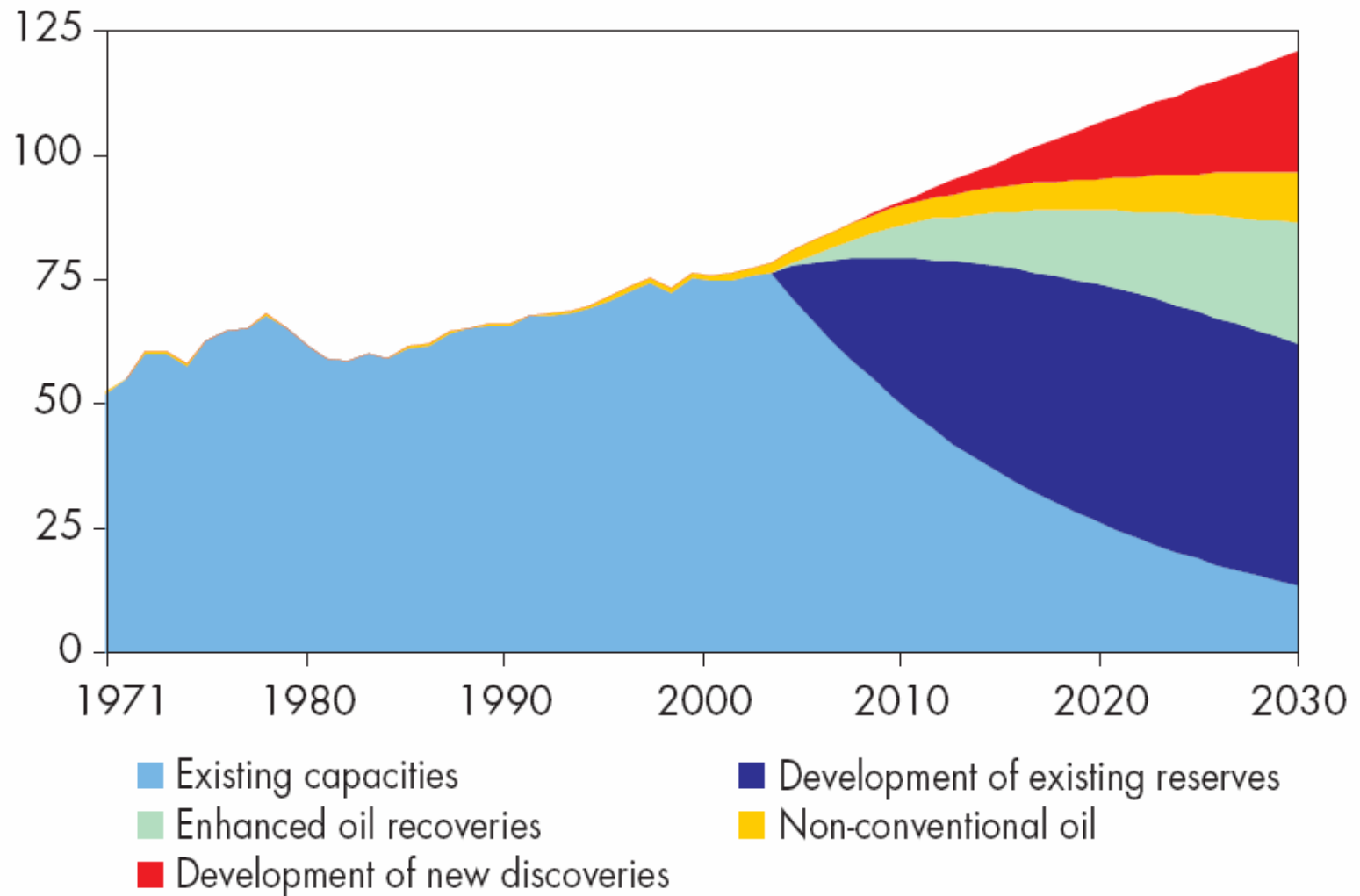
Preparing Hamilton for energy constraints

Richard Gilbert

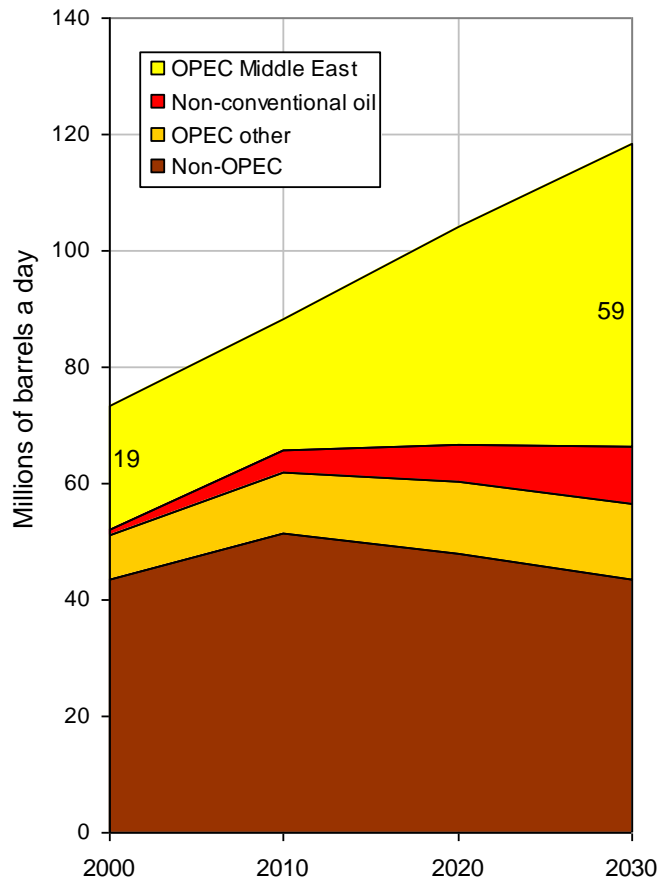
Presentation to the
Greater Toronto Transportation Conference
September 23, 2005

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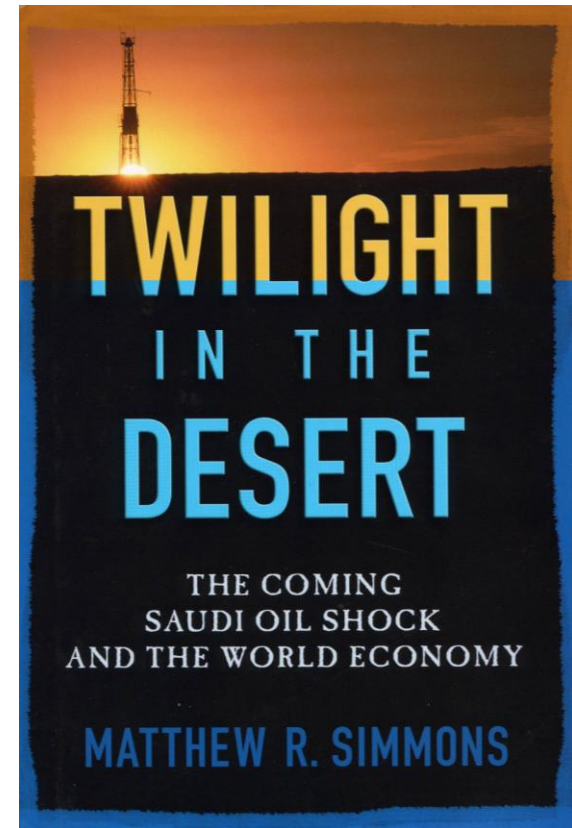
IEA's view of World oil production by source, 1971-2030 (in millions of barrels per day)



IEA's view of World oil production by source, 2000-2030

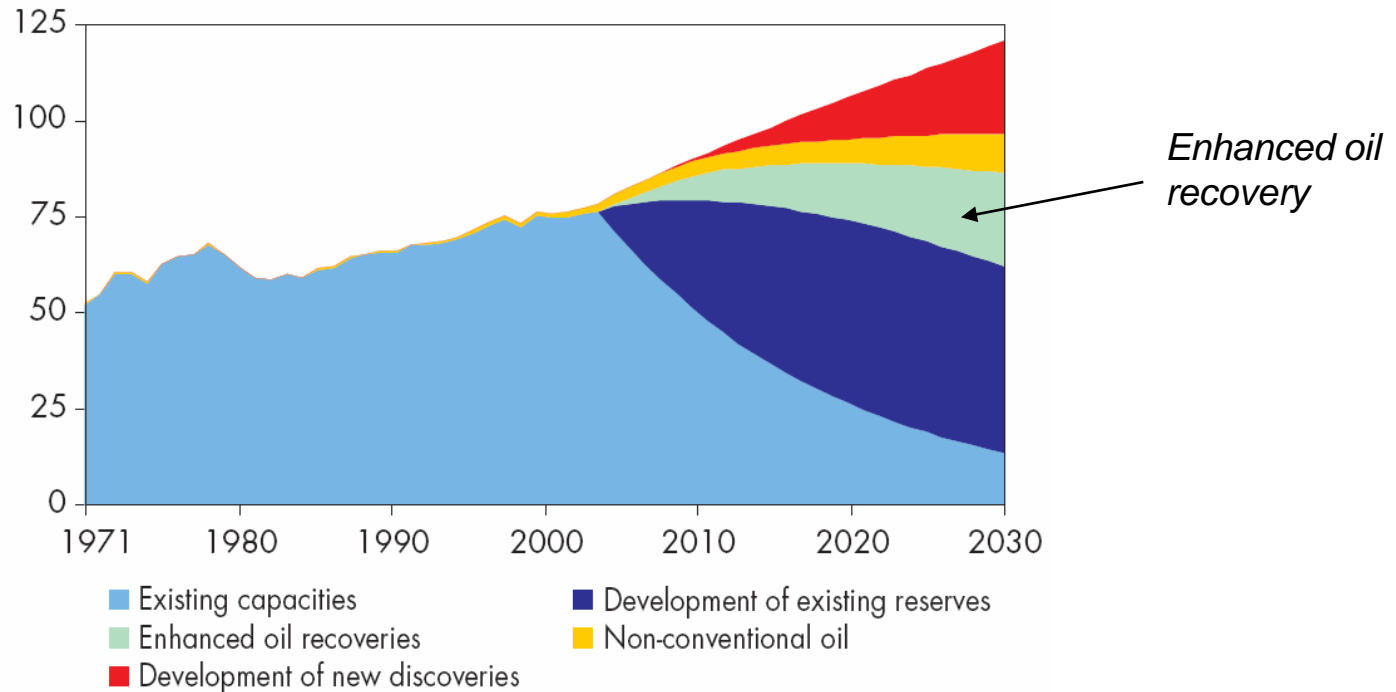


But, Simmons says, there is doubt as to whether Saudi Arabia can even maintain the current production of 9.5 mb/d.



IEA: "Of the projected 31 mb/d rise in world oil demand between 2010 and 2030, 29 mb/d will come from OPEC Middle East ... Saudi Arabia, Iraq, and Iran are likely to contribute most of the increase."

Enhanced oil recoveries (reserve growth) is the other main place IEA says the oil is coming from



In theory this is plausible. Better technology allows us to make more of reserves now than when they were discovered. But, probably offset by initial over-reporting. Shell is the best known. This company wrote down reserves four times in 2004-2005, reducing its total by 22%. BUT.....

Shell was not even included in a recent list of the world's top 20 oil companies (by reserves)

Oil's rich list			
Top 20 oil companies, by reserves, 2003			
		State ownership, %	m barrels
Saudi Aramco	Saudi Arabia	100	259,400
NIOC	Iran	100	125,800
INOC	Iraq	100	115,000
KPC	Kuwait	100	99,000
PDV	Venezuela	100	77,800
Adnoc	UAE	100	55,200
Libya NOC	Libya	100	22,700
NNPC	Nigeria	100	21,200
Pemex	Mexico	100	16,000
Lukoil	Russia	8	16,000
Gazprom	Russia	73	13,600
Exxon Mobil	US	-	12,900
Yukos*	Russia	-	11,800
PetroChina	China	90	11,000
Qatar Petroleum	Qatar	100	11,000
Sonatrach	Algeria	100	10,500
BP	Britain	-	10,100
Petrobras	Brazil	32	9,800
Chevron Texaco†	US	-	8,600
Total	France	-	7,300

* Now in effect controlled by government
† Does not include newly acquired Unocal

Source: *Petroleum Intelligence Weekly*

Source: *The Economist*
(April 28, 2005)

The Economist
forgot to include
Shell. It fits
in about
here

Almost all of the oil in the world is controlled by government-owned companies, who play games with data.

Here are the official reports on OPEC Middle East reserves

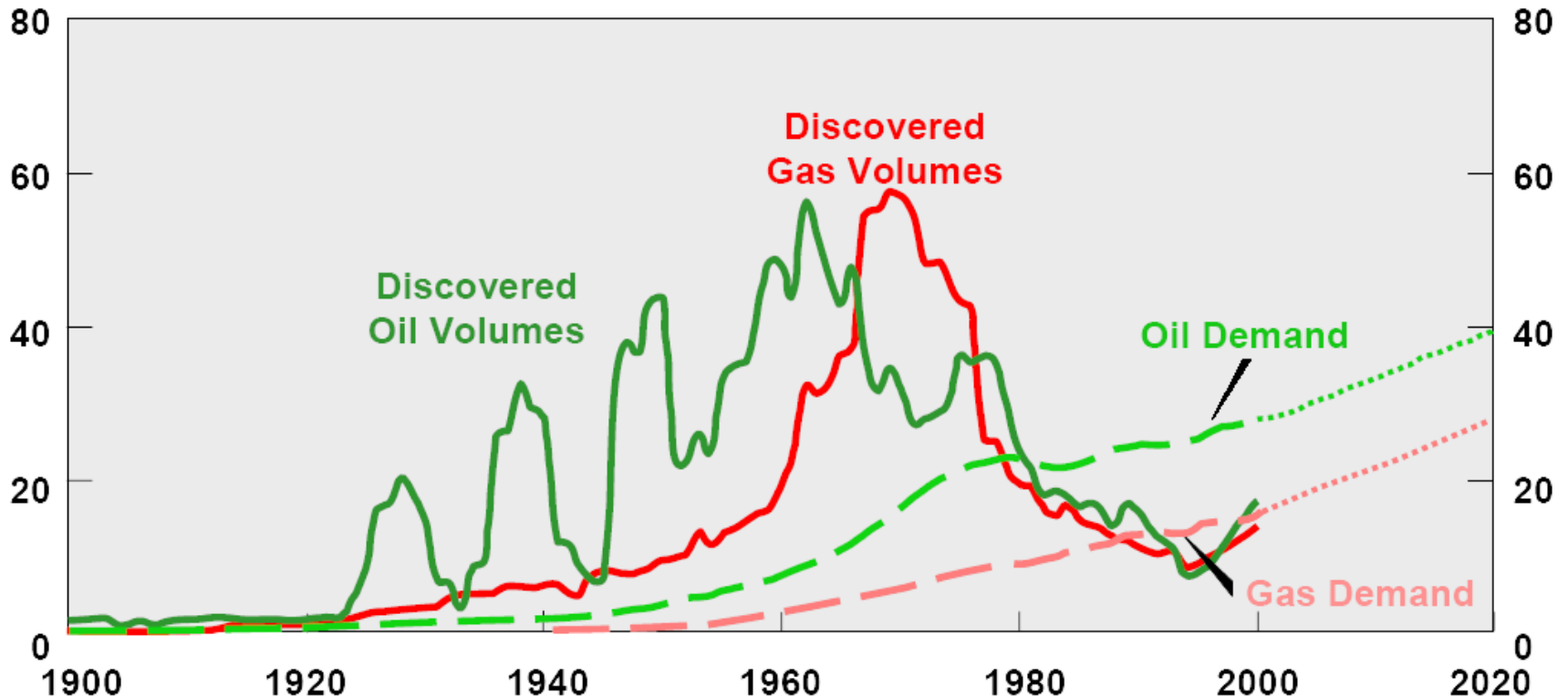
	A. Dhabi	Iran	Iraq	Kuwait	N. Zone	S. Arabia	Venezuela
1980	28	58	31	65	6.1	163	18
1981	29	58	30	66	6.0	165	18
1982	31	57	30	65	5.9	164	20
1983	31	55	41	64	5.7	162	22
1984	30	51	43	64	5.6	166	25
1985	31	49	45	90	5.4	169	26
1986	30	48	44	90	5.4	169	26
1987	31	49	47	92	5.3	167	25
1988	92	93	100	92	5.2	167	56
1989	92	93	100	92	5.2	170	58
1990	92	93	100	92	5.0	258	59
1991	92	93	100	95	5.0	259	59
1992	92	93	100	94	5.0	259	63
1993	92	93	100	94	5.0	259	63
1994	92	89	100	94	5.0	259	65
1995	92	88	100	94	5.0	259	65
1996	92	93	112	94	5.0	259	65
1997	92	93	113	94	5.0	259	72
1998	92	90	113	94	5.0	259	73
1999	92	90	113	94	5.0	261	73
2000	92	90	113	94	5.0	261	77
2001	92	90	113	94	5.0	261	78
2002	92	90	113	94	5.0	259	78
2003	92	126	115	97	5.0	259	78
2004	92	126	115	99	5.0	259	77

Source: Colin Campbell,
ODAC, Edinburgh, (April 25, 2005)

It's hard to believe
these figures bear
much relation to
reality. And yet this
is what IEA
projections have to
be based on.

World discovery of and demand for oil and natural gas, 1900-2000, and projected potential demand until 2020

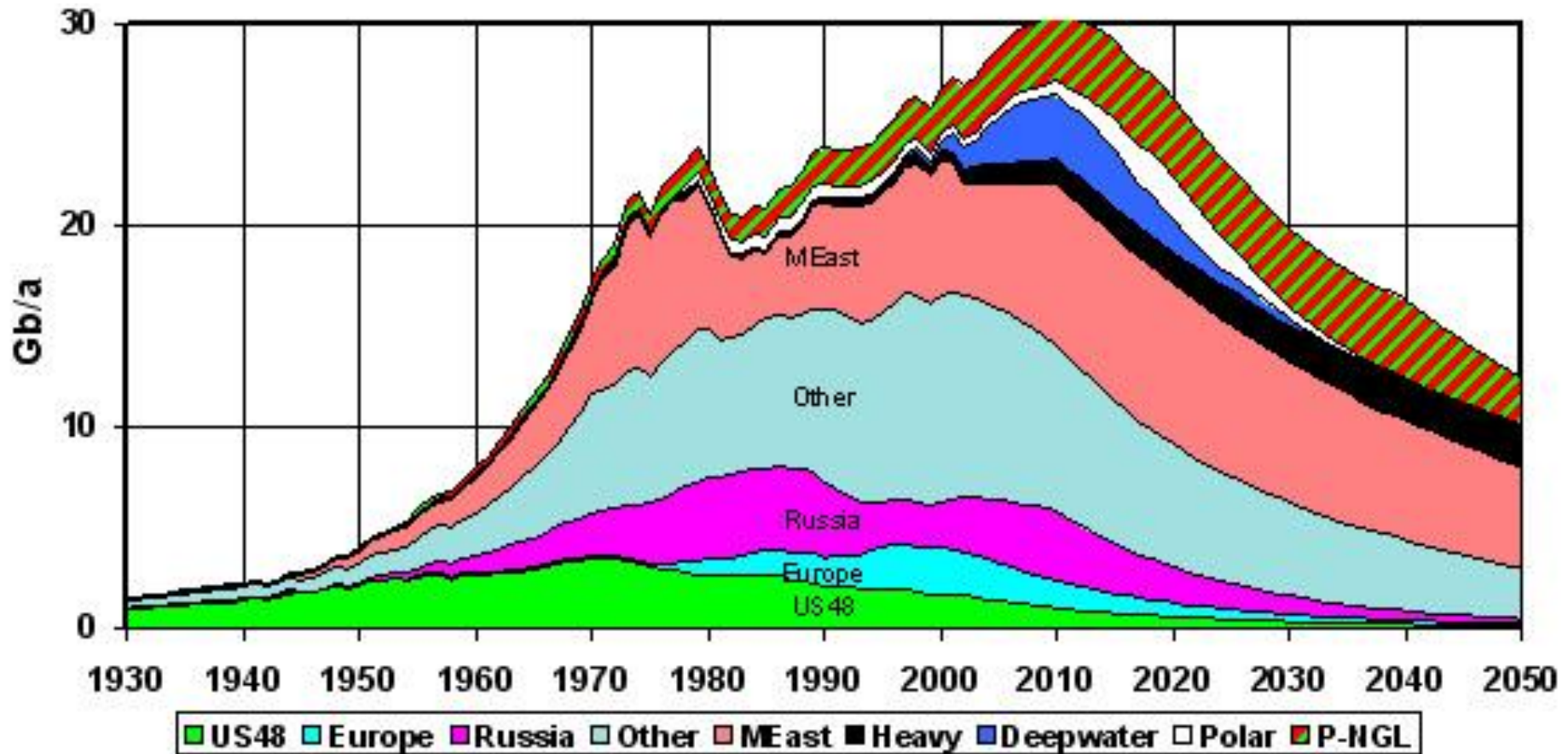
Billions of Oil-Equivalent Barrels



Source: Exxon Mobile Corporation

We haven't been finding the fuel we need to sustain what we depend on. In this decade, we are using more natural gas than we are discovering, and very much more oil.

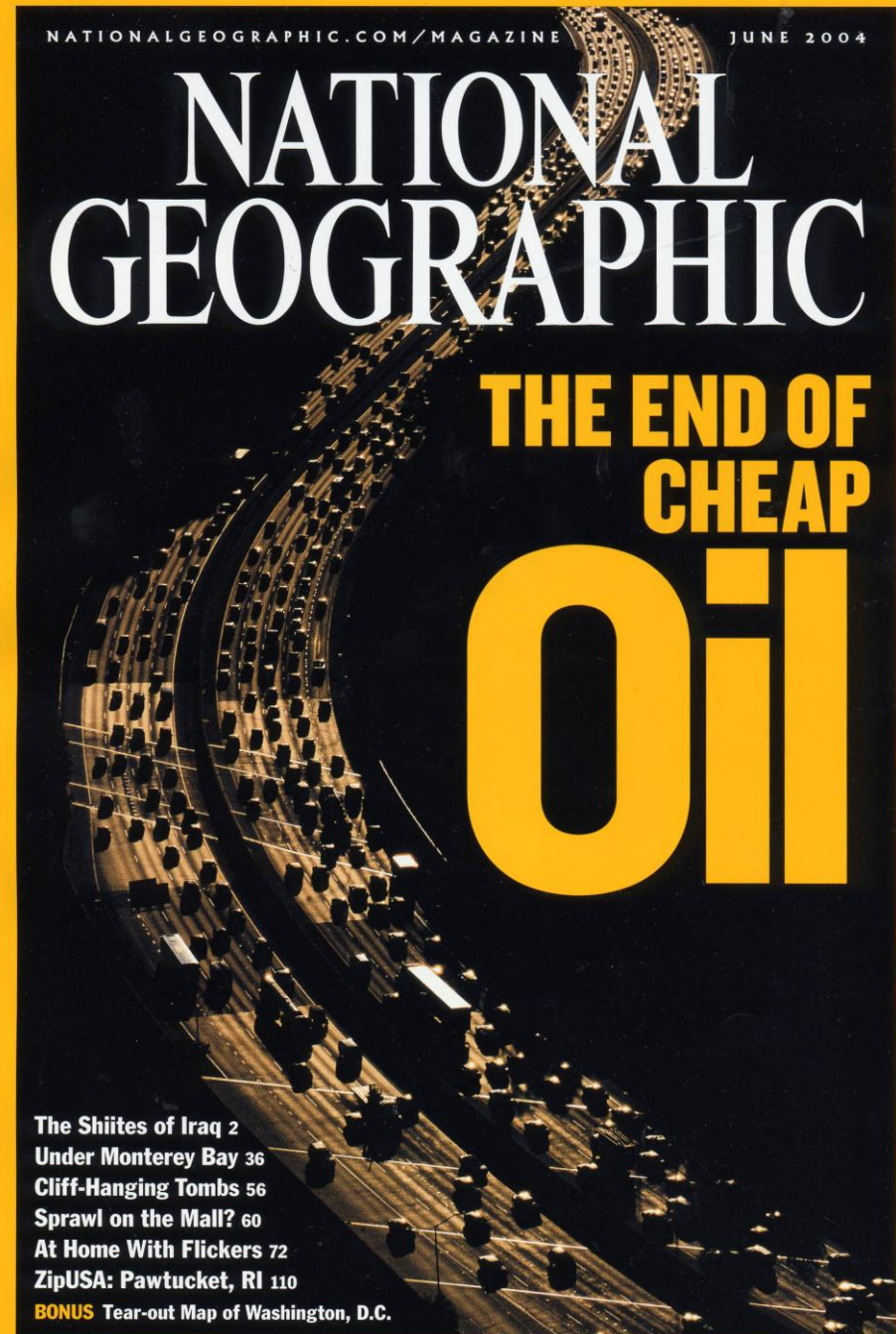
World production of regular oil by region, non-conventional oil, and natural gas liquids, actual and estimated, billions of barrels per year, 1930-2050



Source: Uppsala Hydrocarbon Depletion Group

Production of crude oil and equivalents—which provide >95% of transport fuels worldwide—may peak in 2012, which will mean very high prices unless consumption falls first.

The National Geographic cover of June 2004 echoed the title of a 1998 *Scientific American* article by geologists Colin Campbell and Jean Laherrère that was initially dismissed as yet another oil scare but is now seen as a seminal step in our understanding of the future availability of oil (and natural gas).



Four points from a paper by Denmark's Klaus Illum

(at http://www.ida.dk/oilconference/Oil-based_Technology_and_Economy.pdf)

1. There will be a peak in world oil production.
2. If peak later than about 2020 is possible, which is far from clear, it will be achieved only by making huge investments, which may well be wasted.
3. An earlier peak will be “less unfortunate” for humanity than a later peak.
4. Governments should work to ensure that the peak in oil **use** occurs before the peak in oil production.

IEA is moving towards Illum's perspective

1. There will be an unusual special issue of *World Energy Outlook* in November 2005.
2. In an interview published in *Le Monde*, September 19, 2005, Fatih Birol, IEA's Director of Economic Studies, spoke to an impending peak in oil production, and argued for massive conservation and substitution.
3. He said, "Le pétrole, c'est comme une petite amie, vous savez depuis le début de votre relation qu'elle vous quittera un jour. Pour qu'elle ne vous brise pas le coeur, mieux vaut la quitter avant qu'elle ne vous quitte." [Oil is like a girlfriend. You know from the outset of your relationship she will leave you one day. So that she doesn't break your heart, it's better you leave her before she leaves you.]

Hamilton's challenge

1. The City is in the middle of an extraordinarily complex planning exercise addressing at least: (i) economic development (30% fewer jobs than workers); (ii) anticipated population growth from 525,000 in 2005 to near 700,000 by 2031; and (iii) provincial Smart Growth plans positioning downtown Hamilton as a growth node.
2. Several citizens have complained that the planning exercise is not realistic about energy futures, particularly the possibility of 'peak oil'.
3. City Council has asked for a report on whether and how considerations of 'peak oil', i.e., energy constraints, might be accommodated in the planning processes.

Approach

1. Transport fuels can rise to about \$2.50/litre and not much will change.
2. Choose \$4/L as the price point associated with likely radical changes in transport, land use, and energy supply. (Also, \$2/cubic metre for natural gas; current retail price is near \$0.40, soon to rise above \$0.50.)
3. If odds of \$4/L (today's dollars) happening in planning period (to 2031) are less than 25%, recommend take no action. If odds are 25-50%, change planning processes but not giving energy front and centre place. If odds are >50%, energy use and production become main focus of all planning.
4. The last scenario (>50%) is being selected.

Crude oil prices and pump prices

Based on analysis for the U.S. by the Brookings Institution

	Shortfall in crude oil supply			
	0%	5%	10%	15%
Resulting increase in crude oil price	0%	30%	200%	550%
Crude oil price per barrel (US\$)	\$50	\$65	\$150	\$320
Resulting gasoline pump price (Can\$/litre)	\$0.85	\$1.00	\$1.50	\$2.50

SIMULATION REPORT AND SUMMARY OF FINDINGS - On June 23, 2005, a group of nine former White House cabinet and senior national security officials convened to participate in a simulated working group of a White House cabinet. Their task: to advise an American president as the nation grapples with an oil crisis over a seven-month period. As they enter the room, they are unaware of the circumstances or nature of the oil crisis.

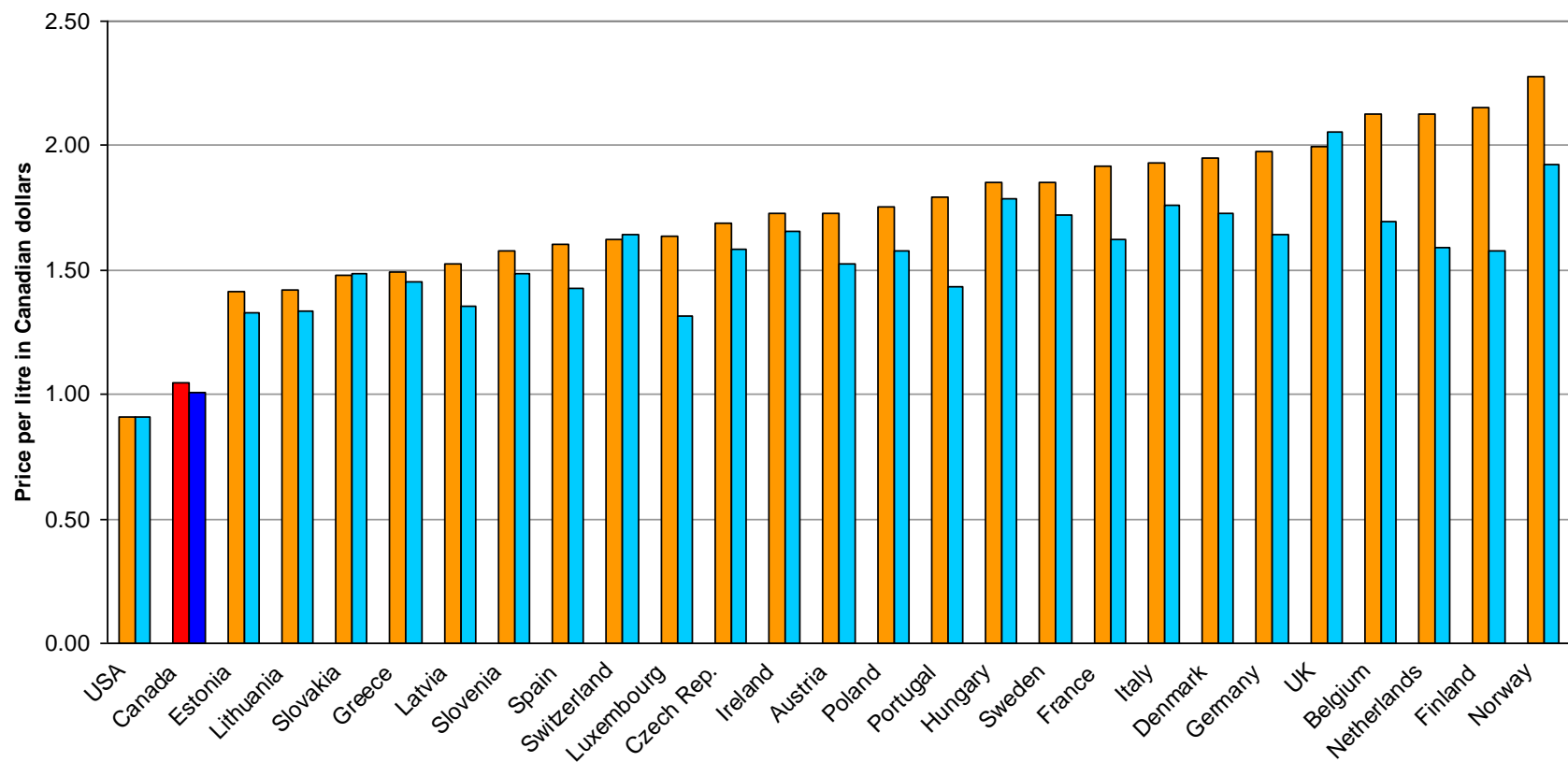


However, the U.S. National Commission on Energy Policy concluded in June 2005 that a “4 percent global shortfall in daily supply results in a 177 percent increase in the price of oil (from \$58 to \$161 per barrel).

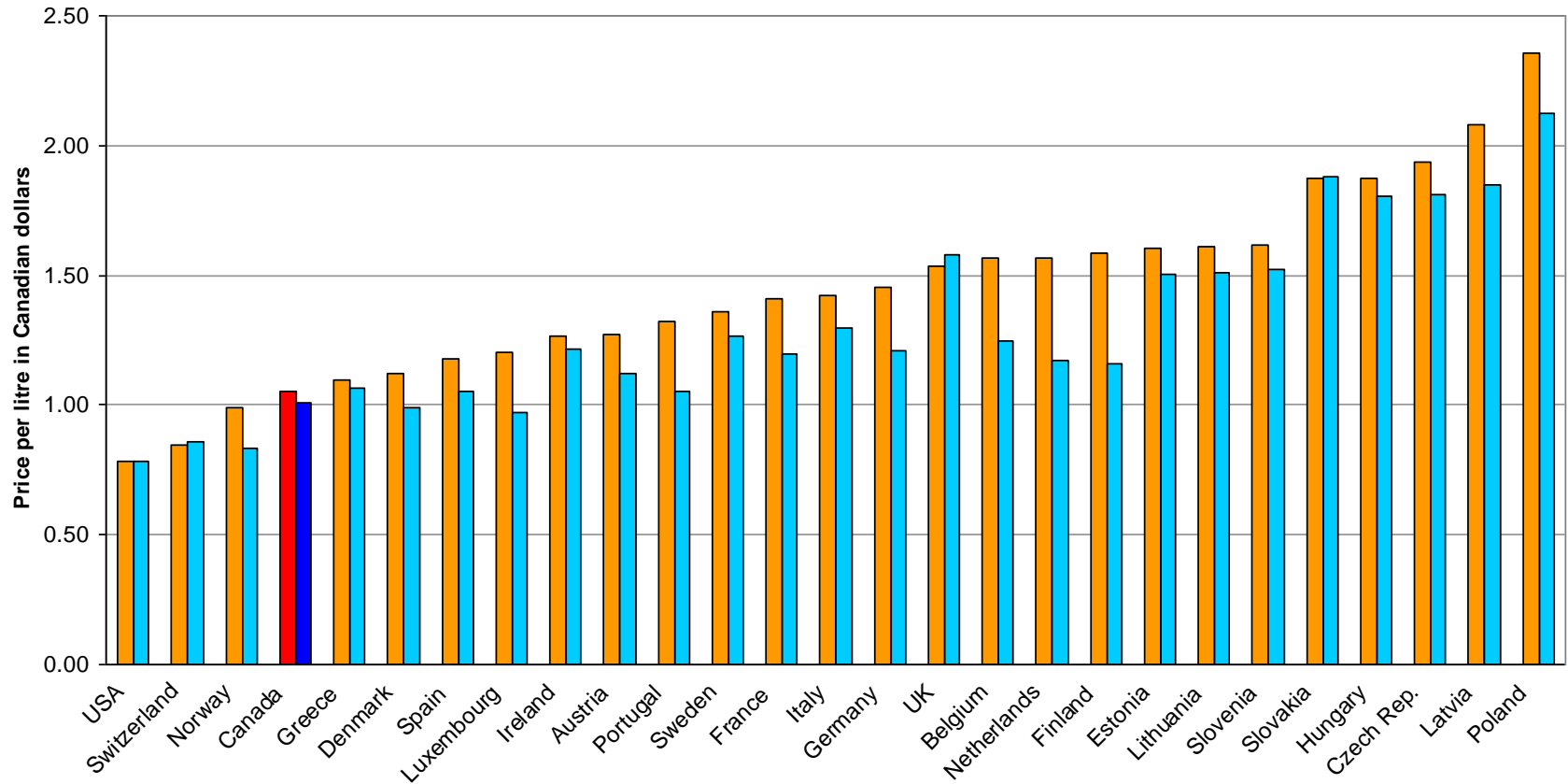
[See www.energycommission.org/ewebeditpro/items/O82F6801.pdf.]



Gasoline (cheapest posted) and diesel fuel, September 19-20, 2005, ranked by gasoline price, using official exchange rates for this period



Gasoline (cheapest posted) and diesel fuel, September 19-20, 2005, ranked by gasoline price, using purchasing power parity (based on McDonald's hamburger price in June 2005)



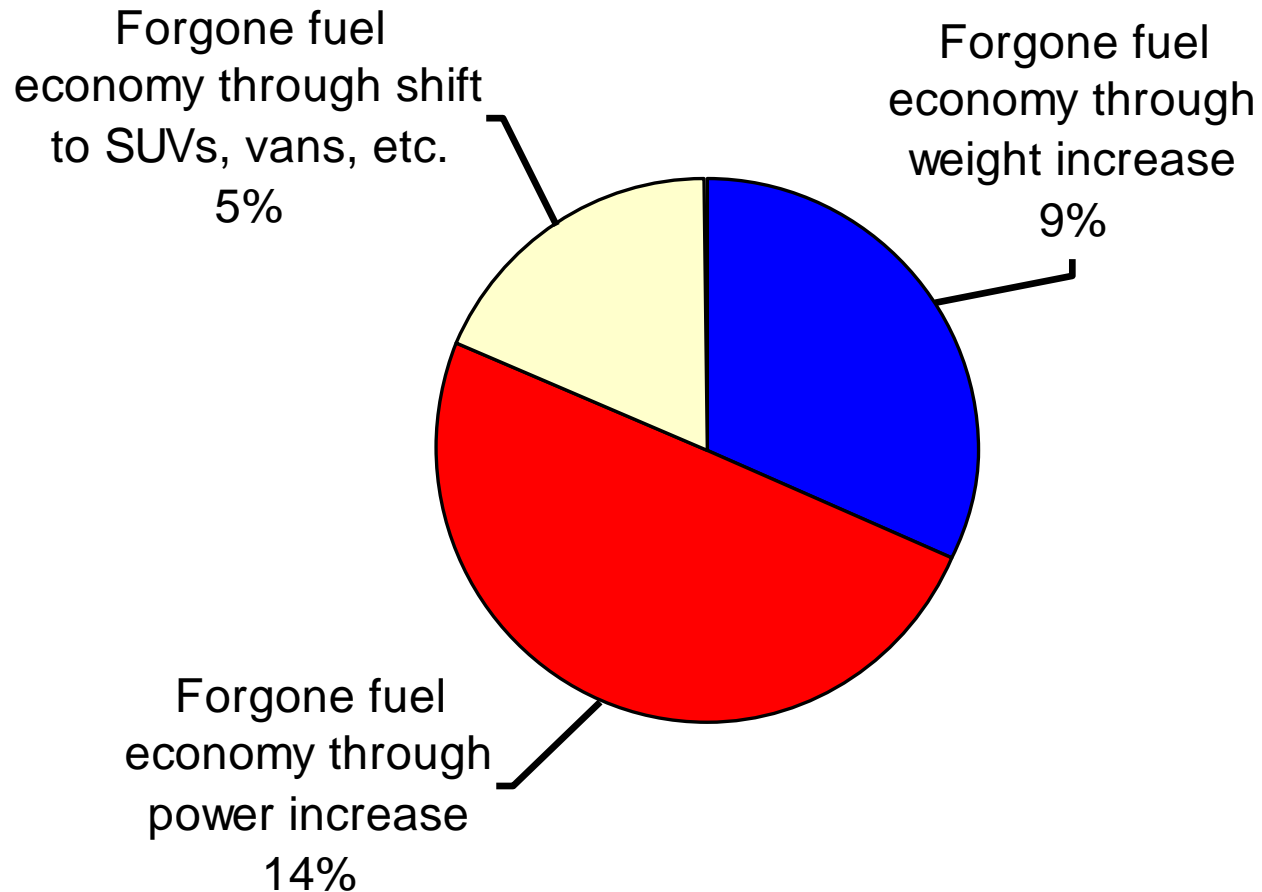
Four-dollar gasoline is an optimistic perspective

1. Cheap energy is so important for our way of living, large increases in energy prices could be devastating.
2. An entirely possible outcome of the end of cheap oil (and natural gas) could be a 'hard landing' into economic depression and widespread dislocation.
3. Projecting a reasonably stable price of \$4/L implies that there is still demand for oil, i.e., economic and social life are continuing, albeit within a different framework. \$4/L implies a 'soft landing'.
4. A reasonably stable \$4/L also implies an orderly process whereby the long gradual decline in production of oil (and natural gas) is being matched by progressively more efficient use and by a measured transition to use of other fuels.

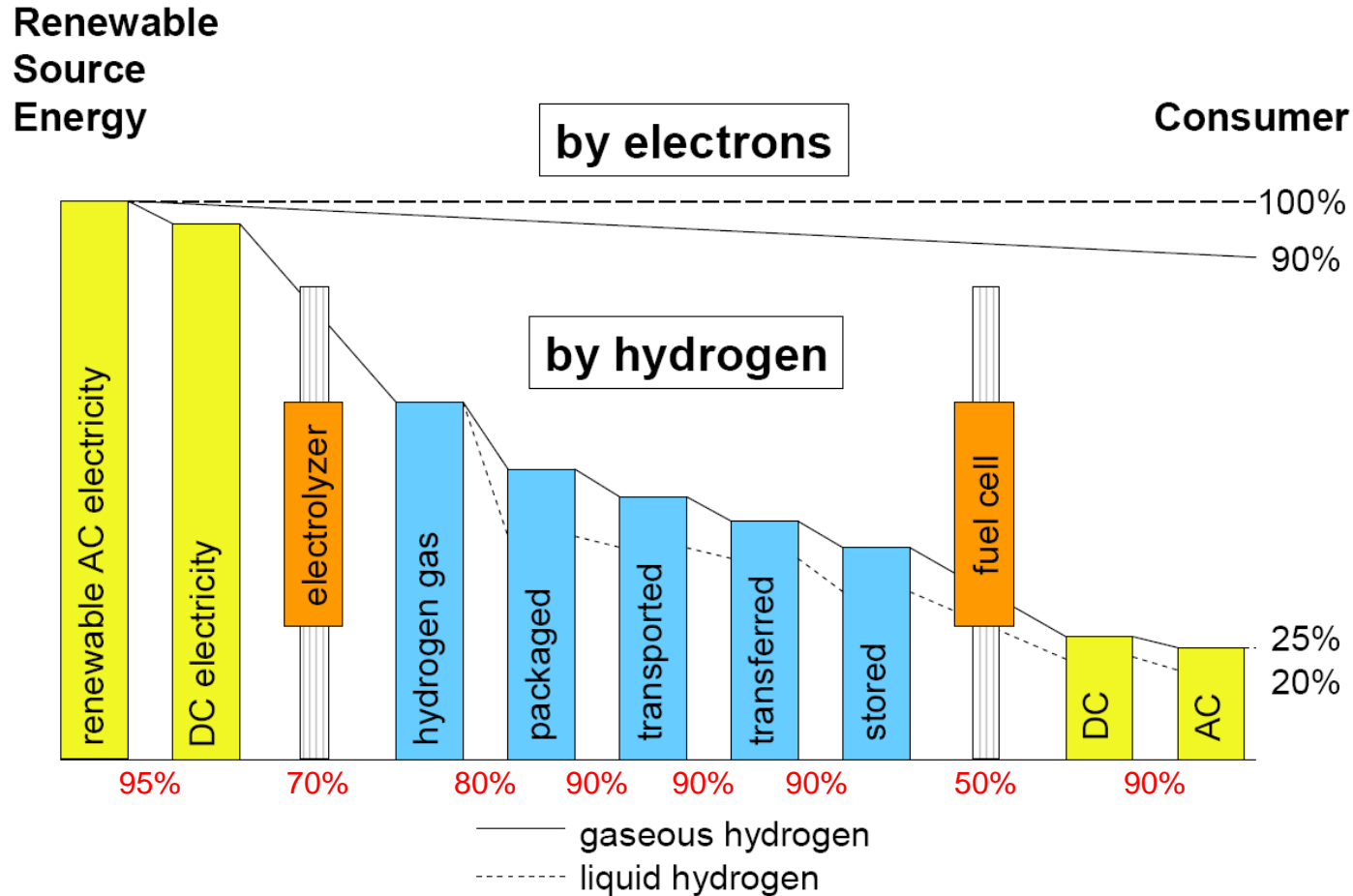
Factors for consideration re. \$4/L (and \$2/m³)

1. There will be a substantial move towards electric vehicles (already happening with hybrids and plug-in hybrids).
2. Grid-connected vehicles will prevail, including trolley trucks, transit, personal vehicles, and things in between.
3. Settlements will become denser UNLESS lower density comes with energy (electricity) and food production.
4. Transit (including PRT) can serve much lower densities if there are fewer cars.
5. Buildings can generally produce 50% more electricity than they use, chiefly from roof and wall solar panels, although timing is a problem.

Components of 28 per cent forgone fuel economy, US, 1998-2004



Transport of renewable electricity by hydrogen and electrons (why the hydrogen fuel cell future won't work)



Approximate efficiencies
of processes are in red.

Source: Bossel (2005)

What are grid-connected (tethered) vehicles?

- Electrically driven vehicles that get their motive energy while moving from an overhead wire(s) or third rail rather than from an on-board source.
- They have **high 'wire-to-wheel' fuel efficiency** for four reasons:
 - >95% of applied energy is converted to traction
 - electric motors are lighter than internal combustion engines (ICEs)
 - constant torque at all speeds means no oversizing
 - there is no fuel to carry.
- Overall efficiency and environmental impacts depend on the distribution system (perhaps a 10% loss) and the primary fuel source, which can range from inefficient and dirty (e.g., coal) to efficient and clean (e.g., sun and wind).
- Grid-connected systems can **use a wide range of fuels and switch among them without disrupting transport activity**, allowing smooth transitions towards sustainable transport.

Public transit within cities

Montreal



Vehicle type	Fuel	Occupancy (pers./veh.)	Energy use (mJ/pkm)
Transit bus (U.S.)	Diesel	9.3	2.73
Trolleybus (U.S.)	Electricity	14.6	0.88
Light rail (streetcar)	Electricity	26.5	0.76
Heavy rail (subway)	Electricity		0.58

Calgary



Vancouver

Public transit between cities

Amtrak Acela at Boston South station

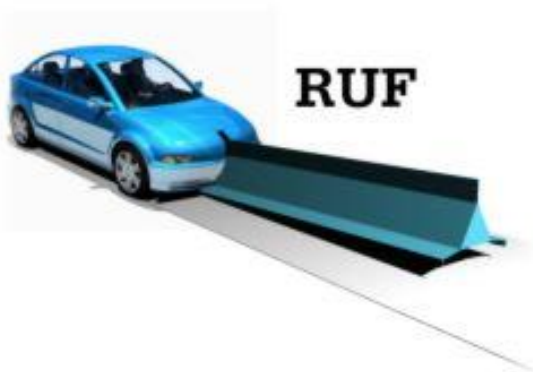


Vehicle type	Fuel	Occupancy (pers./veh.)	Energy use (mJ/pkm)
Intercity rail	Diesel		2.20
School bus	Diesel	19.5	1.02
Intercity bus	Diesel	16.8	0.90
Intercity rail	Electricity		0.64



German ICE

Düsseldorf Airport SkyTrain



Personal vehicles

Vehicle type	Fuel	Occupancy (pers./veh.)	Energy use (mJ/pkm)
SUVs, vans, etc.	Gasoline	1.70	3.27
Large cars	Gasoline	1.65	2.55
Small cars	Gasoline	1.65	2.02
Motorcycles	Gasoline	1.10	1.46
Fuel-cell car	Hydrogen	1.65	0.92
Hybrid electric car	Gasoline	1.65	0.90
Very small car	Diesel	1.30	0.89
Personal Rapid Transit	Electricity	1.65	0.49



Skyweb Express (Cincinnati concept)

Freight transport

Trolley truck operating at the Quebec Cartier iron ore mine, Lac Jeannine, 1970s



Vehicle type	Fuel	Energy use (mJ/tkm)
Truck	Diesel	0.45
Train	Diesel	0.20
Train	Electricity	0.06
Truck	Electricity	0.15?

Energy production will be a priority

1. Hamilton could become self-sufficient in electricity and produce substantial amounts of natural gas.
2. Every building can be an electricity generator. Also, wind turbines in agricultural areas and offshore, microhydro, and cogeneration. Also Deep Lake Water Cooling to help offset effects of global warming (20 km not Toronto's 5 km to 80-metre isobath, but no big problem).
3. Make Hamilton EFW centre for southern Ontario so that others pay Hamilton to take their energy. (But not one garbage truck enters Hamilton, and the plant is an air cleaner for half the year.)
4. Make Hamilton anaerobic digestion centre for south and south-west Ontario, with upgrading of biogas for natural gas grid.
5. Unused parts of the Stelco site would be ideal locations for EFW and digester plants.

Hamilton 'The Electric City'

1. In the 1880s, Hamilton was one of the first cities in the world to have widespread electric light—for streets, homes, and businesses. It was known as 'The Electric City'. Hamilton could again be 'The Electric City', in the forefront of the transition to electric transport and new electricity generation.
2. The port and the area between the port and the downtown could be a huge R&D centre and testbed for the coming energy-constrained world, with development of vehicle systems (e.g., PRT), building systems (e.g., geothermal), and small-scale electricity generation.
3. The current economic development focus is 'Aerotropolis', i.e., expansion of Hamilton Airport, chiefly for freight. This may not be a viable focus in a severely energy-constrained world. Also, lands near the airport are some of the best and most beautiful agricultural land in Ontario, and could be needed for food and energy production, and for recreation.

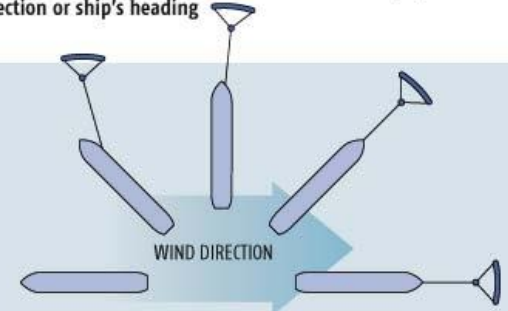
A return to wind? (Our transport future will be more like this than more air travel and freight movement)

A NEW AGE OF SAIL

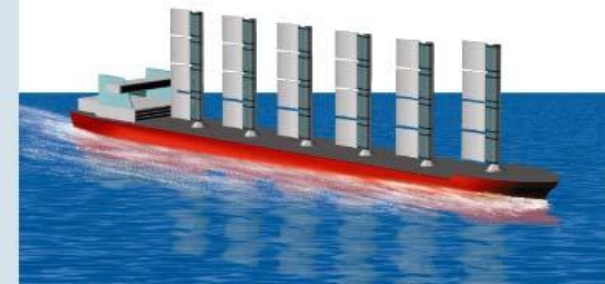
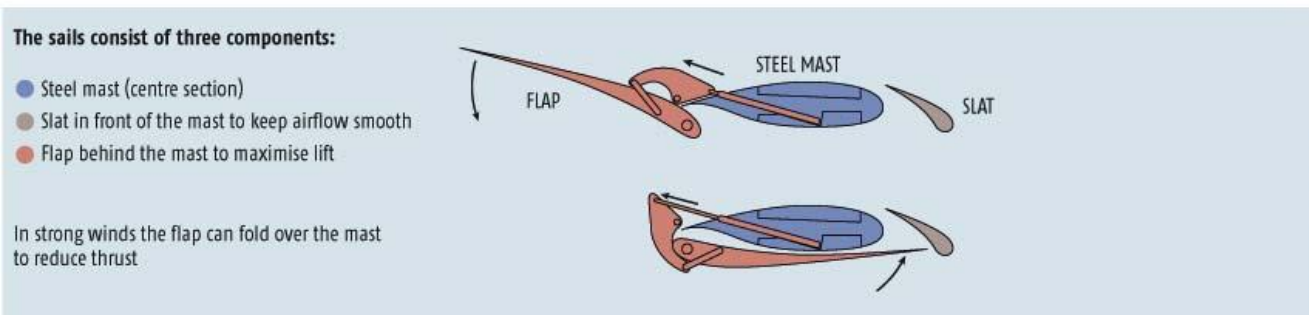
Flying a kite on a cargo ship should help reduce fuel consumption and improve stability. By making use of strong, steady winds at high altitude, a kite could outperform conventional sails.



SkySails' autopilot automatically adjusts the position of the kite to maximise thrust, whatever the wind strength, wind direction or ship's heading.



The sails on the Danish windship (right) are shaped like aerofoils to obtain the maximum amount of thrust from the wind.



Source: Hamer (2005)

Fuel is now >75% of shipping costs. Kites reduce fuel use by about a third. <3-year payback. Coming into use in 2006. Winched in to pass under the Burlington Skyway (to be used chiefly by grid-connected vehicles powered in part by massive wind turbines mounted on the Skyway and nearby).



Source: Economist September 17, 2005