Sustaining the Auto Industry through Ecology

Richard Gilbert

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Enquiries to Richard Gilbert at richardgilbert@sympatico.ca or 416 923 8839

What is 'ecology'?

The term is used in two ways:

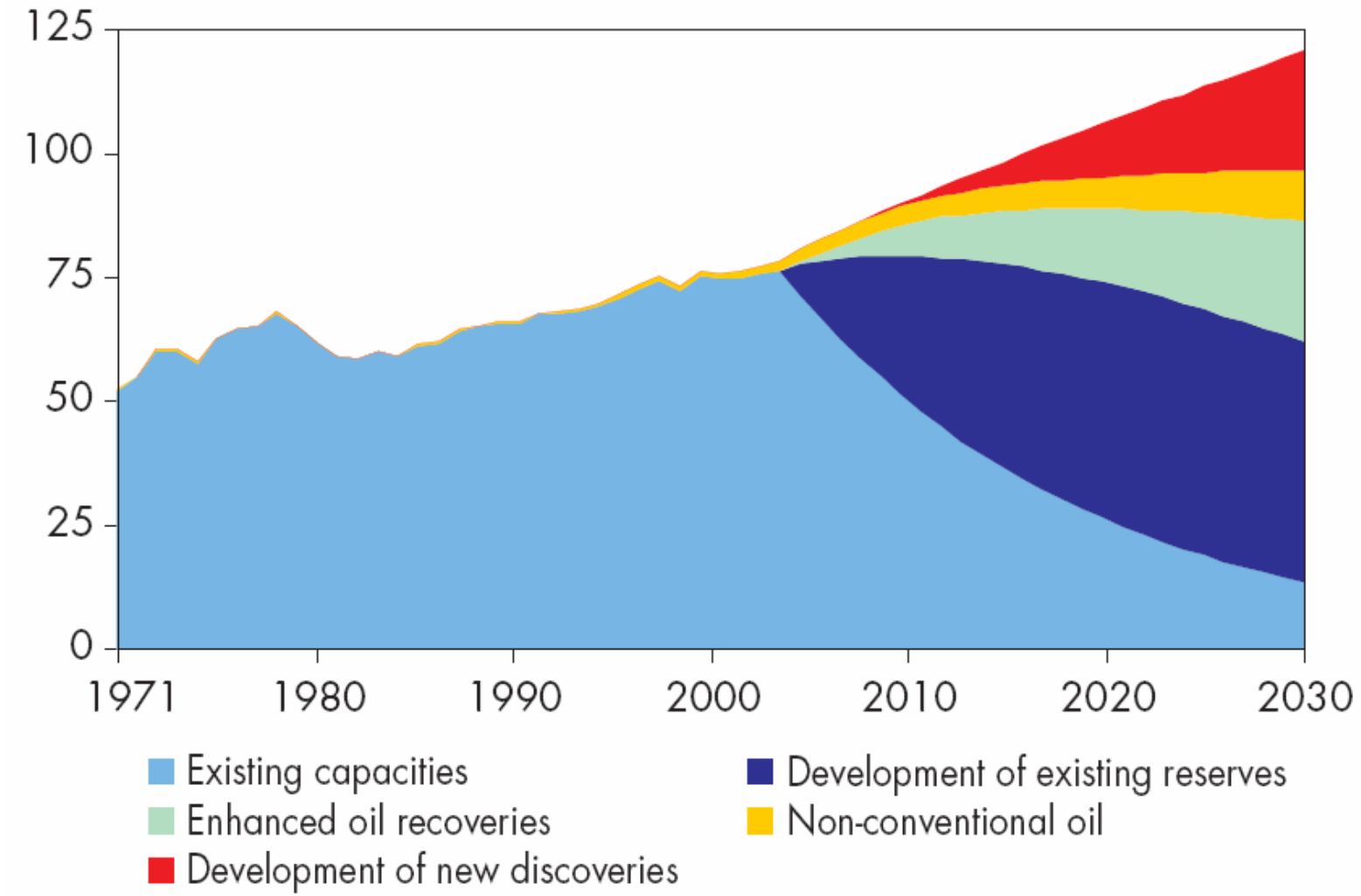
- To refer to the branch of biology concerned with the relations between organisms and their environment.

- To refer to the environment as it relates to living organisms (e.g., the ecology of the turtle).

Ecology is mostly about energy

- Organisms need usable energy for life.
- A key consideration in any ecological analysis is whether and how a species' environment provides enough energy, particularly for offspring.
- Similarly, a prime concern for the auto industry should be whether its offspring will have enough energy.
- If the usual energy is found to be in short supply, adaptation may be necessary to ensure survival of the species.

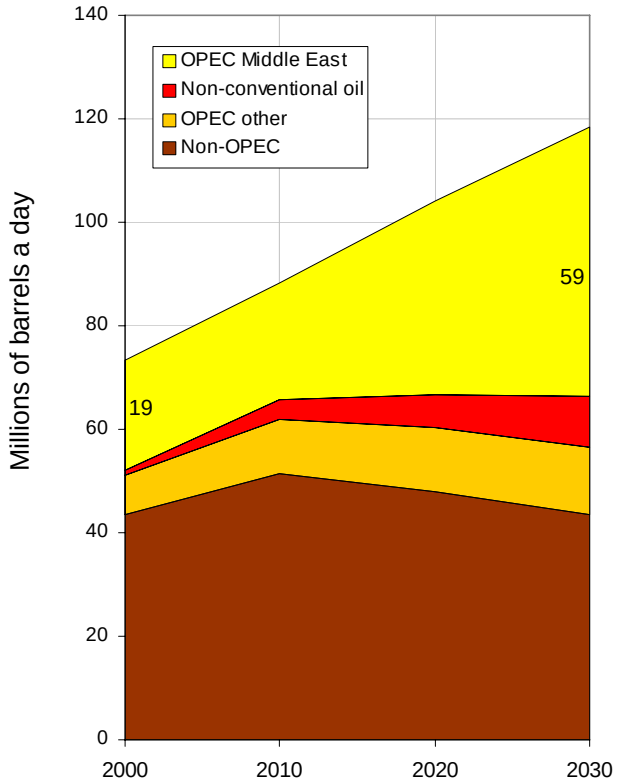
Here's what may be the most authoritative projection of consumption, and where could come from



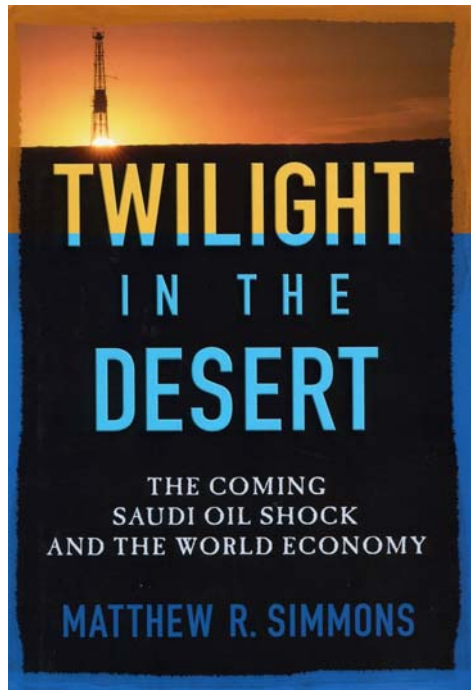
Source: *World Energy Outlook 2004*, International Energy Agency

IEA says almost all of the 'conventional' oil—existing reserves, new discoveries, enhanced recovery—will come from the Middle East

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



Simmons says there is doubt 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." On April 10, 2006, according to *Platts Oilgram News,* Saudi Aramco, announced that its "composite decline rate of producing fields" is 2%/year, after "remedial actions and the development of new fields".

The decline in production may have begun

MONDAY, JUNE 5, 2006

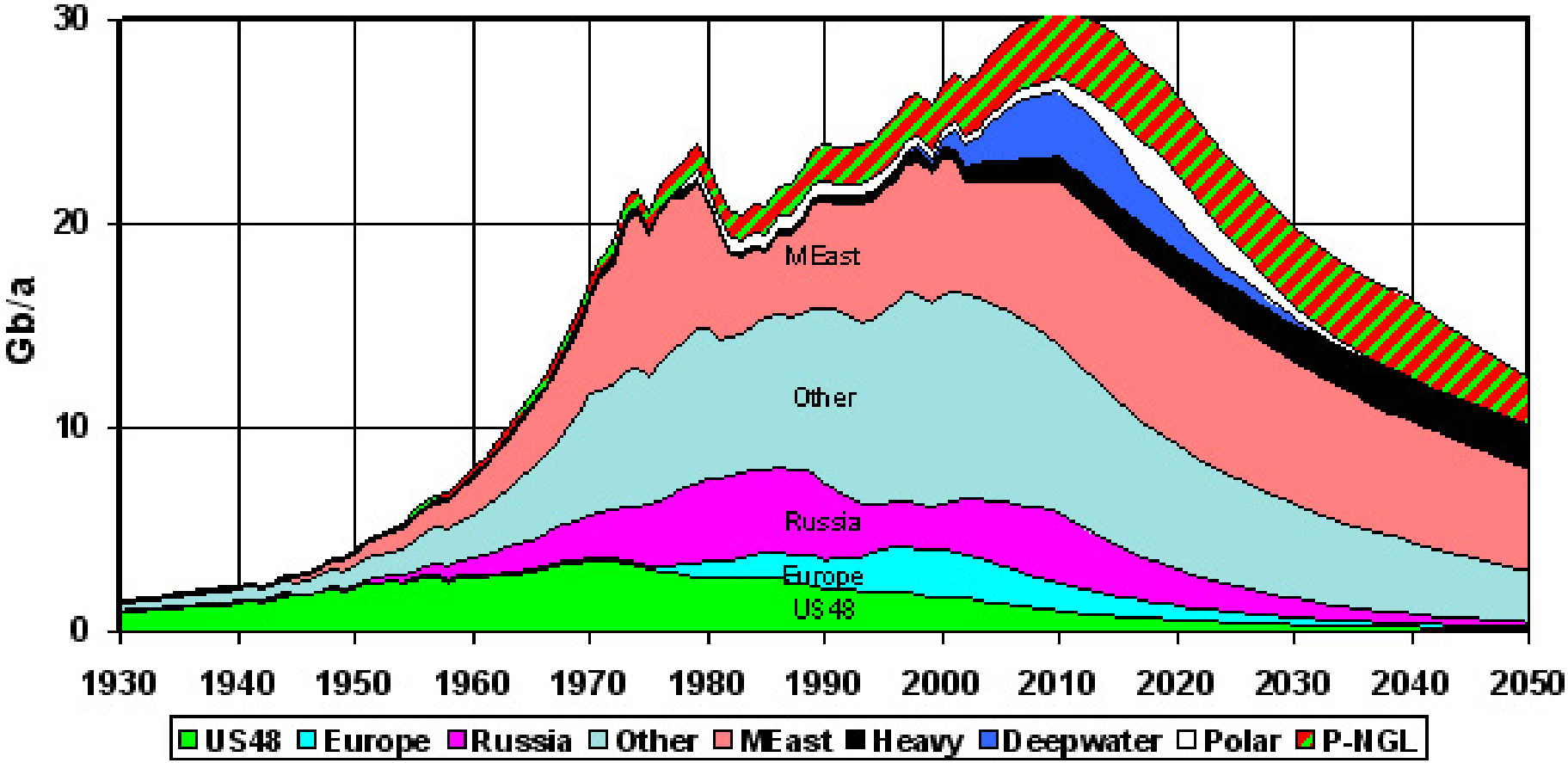
THE WALL STREET JOURNAL.®

PETROLEUM

Saudi minister acknowledges crude oil output has fallen

The article explains April's decline in Saudi production from 9.5 to 9.1 million barrels/day as "drop in demand". This could be correct.

Here's the best estimate of when the world peak in liquid hydrocarbon production will occur: about 2012 (black area is oil sands)



Source: Uppsala Hydrocarbon Depletion Group, 2005

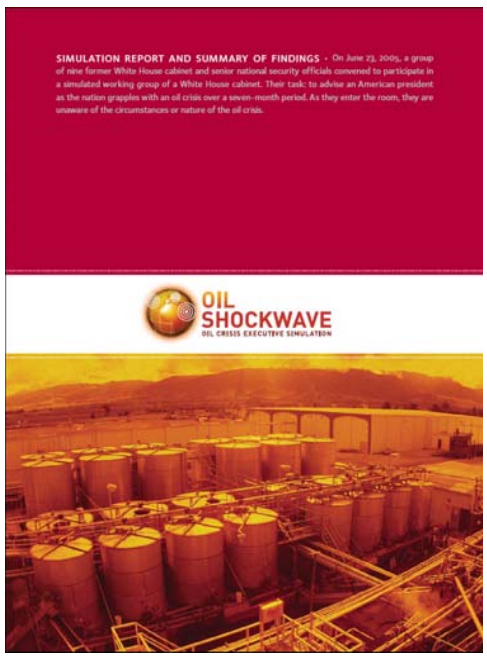
An updated analysis by Colin Campbell puts the peak in production of conventional oil in 2005 and the peak production of all liquid hydrocarbons in 2010 (ASPO newsletter, April 2006)

Small shortfalls can mean big price increases: 1

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

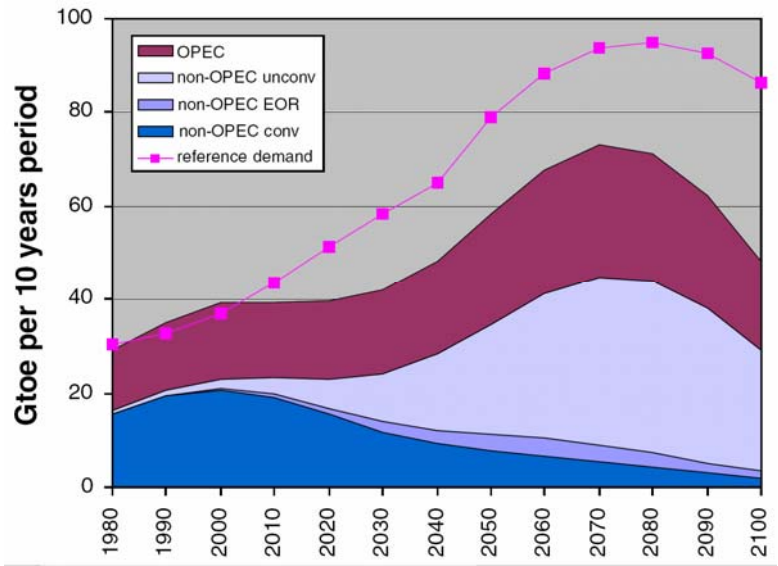
	Shortfall in crude oil supply			
	0%	5%	10%	15%
Resulting increase in crude oil price	0%	30%	200%	550%
Crude oil price per barrel (US$)	$50	$65	$150	$320
Resulting gasoline pump price (Can$/litre)	$0.85	$1.00	$1.50	$2.50

Small shortfalls can mean big price increases: 2

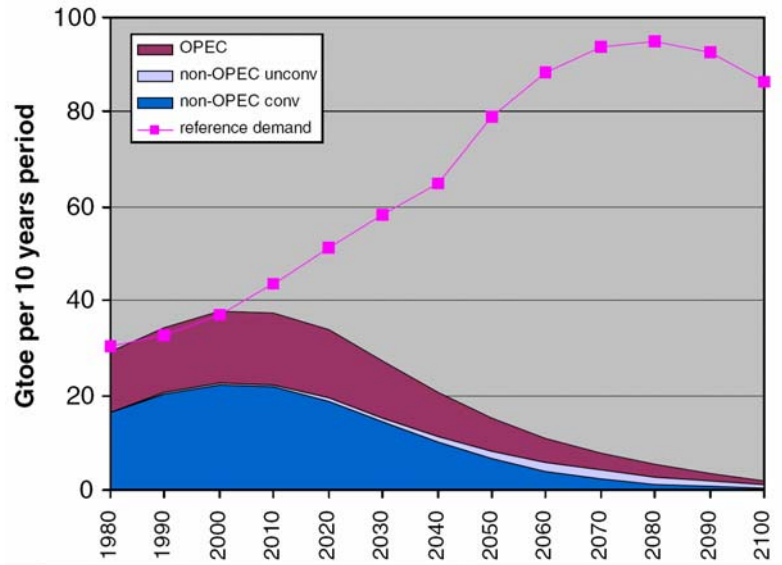


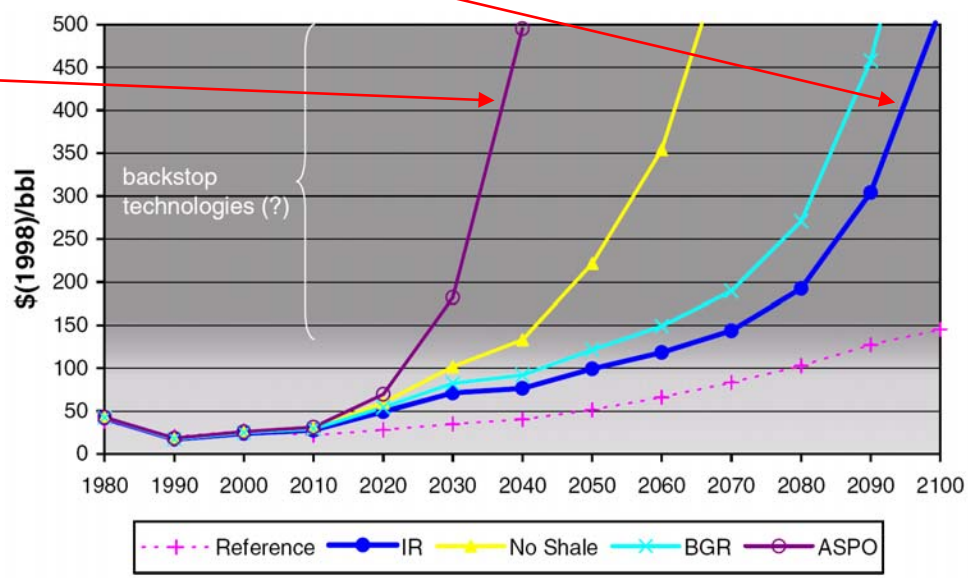
The U.S. National Commission on Energy Policy concluded in June 2005 that a "4 percent global shortfall in daily supply results in a 177 percent increase in the price of oil" (from $58 to $161 per barrel).

Small shortfalls can mean big price increases: 3



This is another estimate pointing to huge oil price increases, even if production were to double, however implausibly, largely through massive extraction from oil sands and shale. The authors noted, "In reality …such high prices would very likely lead to substantial long-run changes on the demand side … and are therefore rather unrealistic …"

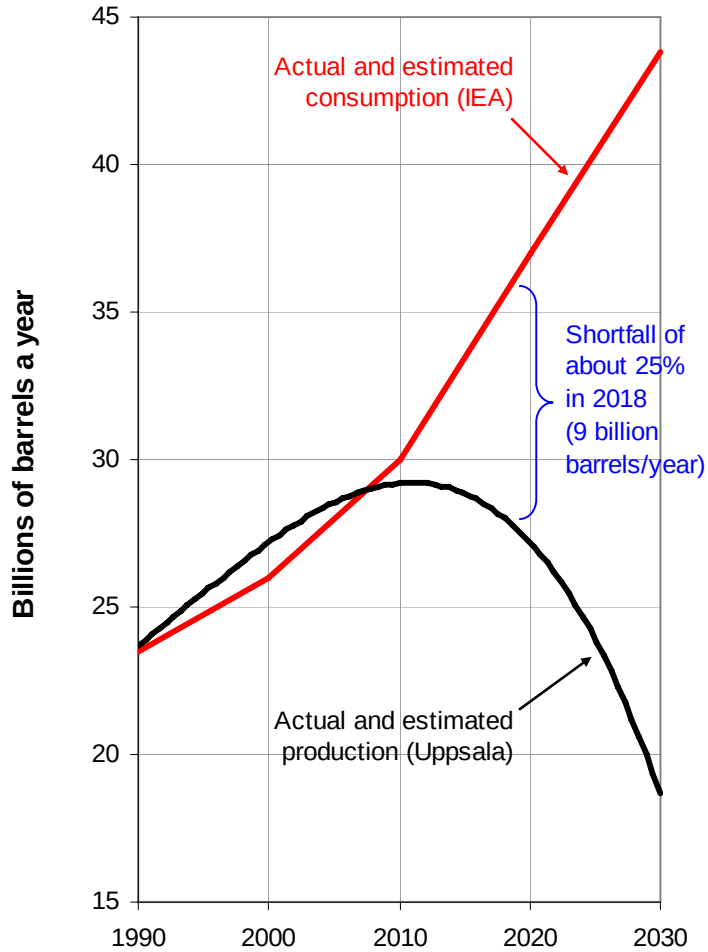




Source of the charts on this slide: Rehrl & Friedrich, 2006

The possibility of fourfold increases in pump prices

- The IEA projection of world consumption and the Uppsala University analysis of production together suggest that in 2018 there could be an oil production shortfall of about 25%.
- Using the second of the above analyses of the impact of shortfall on price, this translates into an eight-fold increase in oil's 'wholesale' price (i.e., to US$500-600/barrel).
- High prices force down potential demand; and pump prices vary less than crude oil prices (distribution costs, taxes).
- Nevertheless, it may be reasonable to assume that pump prices of transport fuels will be four times higher in 2018 than they are now.



Four-dollar gasoline is an optimistic perspective

1. One outcome of the end of cheap oil could be a 'hard landing' into economic depression and widespread dislocation.

2. 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'.

3. A reasonably stable $4/L also implies an orderly process whereby the long decline in production of oil is being matched by progressively more efficient use and by a measured transition to use of other fuels.

4. $4/L is also optimistic in that it is a large enough increase to effect real change in how energy is used and produced.

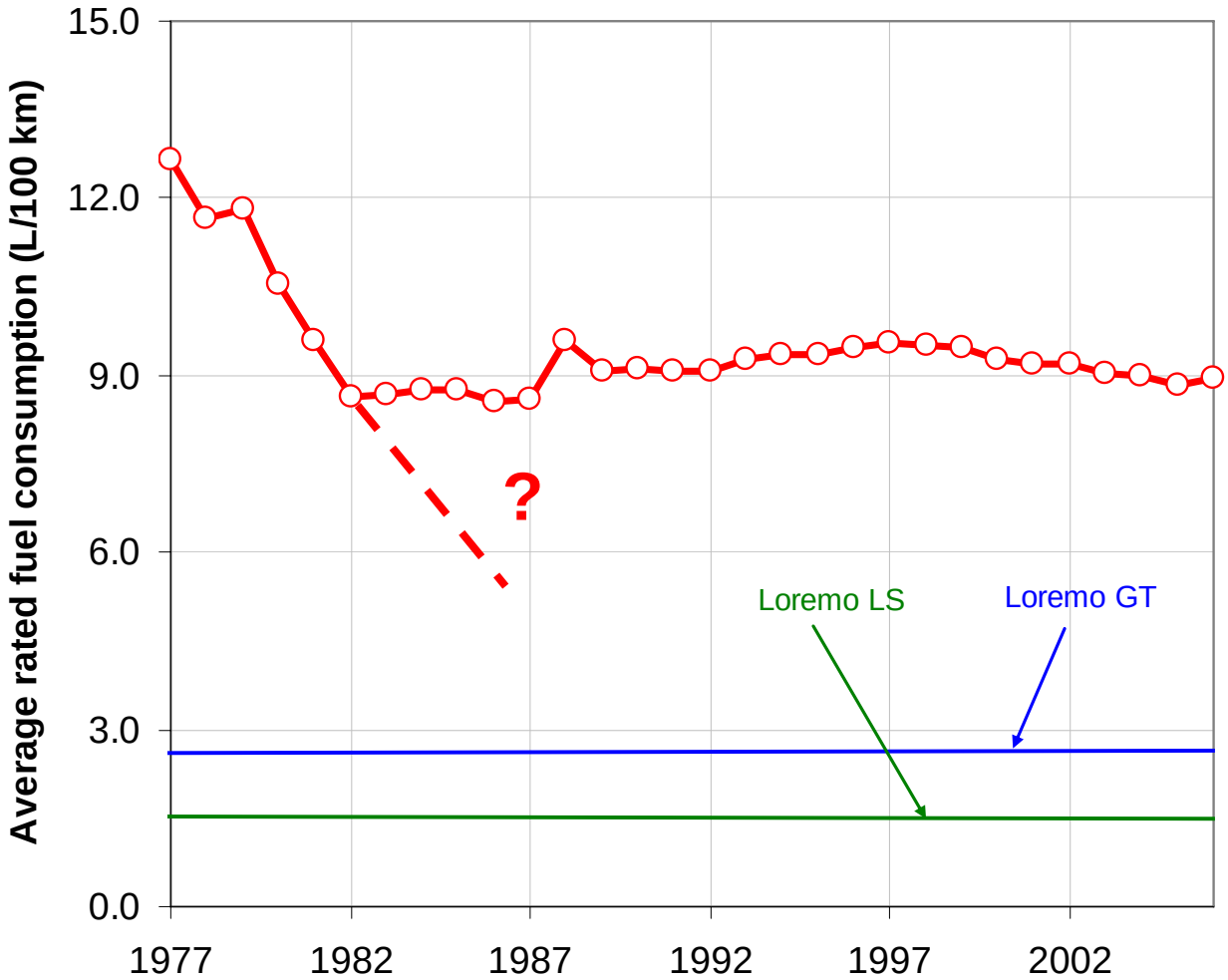
Adaptations to expensive oil: 1. Very efficient ICE vehicles

Loremo
simple. clever. fun

Data	Loremo LS	Loremo GT
Engine	2-cylinder turbodiesel	3-cylinder turbodiesel
Output	15 kW / 20 HP	36 kW / 50 HP
Max. speed	160 km/h	220 km/h
Acceleration	20 sec. (0-100km/h)	9 sec. (0-100km/h)
Transmission	5-gear manual transmission	5-gear manual transmission
Drive	midship/rear wheel drive	midship/rear wheel drive
Consumption	1,5 l/100 km	2,7 l/100 km
Fuel range	1.300 km (20-l-tank)	800 km (20-l-tank)
Weight	450 kg	470 kg
Drag	Cw=0,20; Cw×A=0,22 m²	Cw=0,20; Cw×A=0,22 m²
Seats	2+2	2+2
Dimensions	384cm x 136cm x 110cm (l x w x h)	384cm x 136cm x 110cm (l x w x h)
Price	< 11.000 Euro	< 15.000 Euro
Standard	airbags, particle filter, radio	airbags, particle filter, radio
Extras	dashboard computer, air condition, MP3 player, navigation system	dashboard computer, air condition, MP3 player, navigation system

Current new light-duty vehicles sold in Canada have an average rating of 9.0 L/100 km.

Trends in fuel consumption by new Canadian light-duty vehicles



Source for fuel consumption trends: 1977-1998, Schingh et al. (2000); 1991-2006, Reilly-Rowe (2005)

Current headlines about downsizing can be misleading

National Post, June 6, 2006

AUTOMOTIVE

Canadians buy small as gas prices go big

Entry-level strong focus

BY NICOLAS VAN PRAET

More than half of new auto buyers in Canada are consistently snapping up the smallest and cheapest cars and trucks as high gasoline prices change their purchasing habits.

The trend toward buying entry-level vehicles — including subcompact and compact cars, small pickup trucks, and compact sport utility vehicles — has been slowly gaining steam for about seven years. Last year, there were several months in which researchers noted more than 50% of new buyers in Canada picked entry-level vehicles.

But now a steady majority of new buyers in this country are purchasing them, says leading industry research firm DesRosiers Automotive Consultants Inc.

DesRosiers's most recent figures found nearly 55% of Canadians bought an entry-level vehicle in April. That excludes fleet sales.

"This is huge," Dennis DesRosiers said. "From my perch, it's clearly an indication that consumers are reacting to gas prices."

See CARS on Page FP5

Ford Ranger sales rise 124.2% in first four months of 2006.

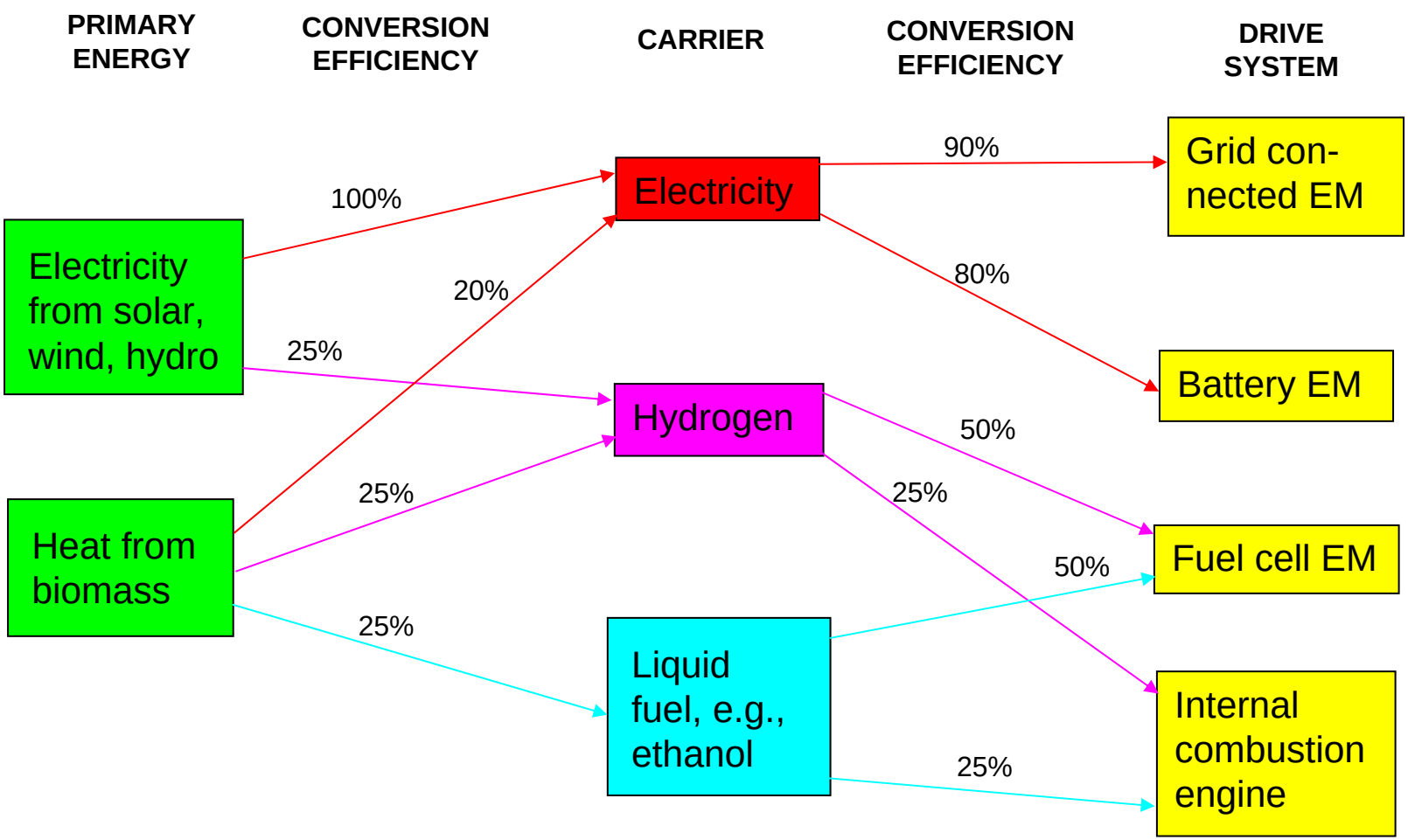
This article notes that "Small pickup trucks have seen the most dramatic increase in sales: a 54.1% rise in the first four months of 2006 over the same 2005 months. … Those gains have come at the expense of mid-sized vehicles." But, rated fuel use by the Ford Ranger is 8.7-12.3 L/100km, depending on configuration, which is *higher* than Ford's mid-sized vehicles (8.3-10.6 L/100km, according to model).

Adaptations to expensive oil: 2. Use coal or natural gas to make liquid fuel, or generate electricity

Issues:

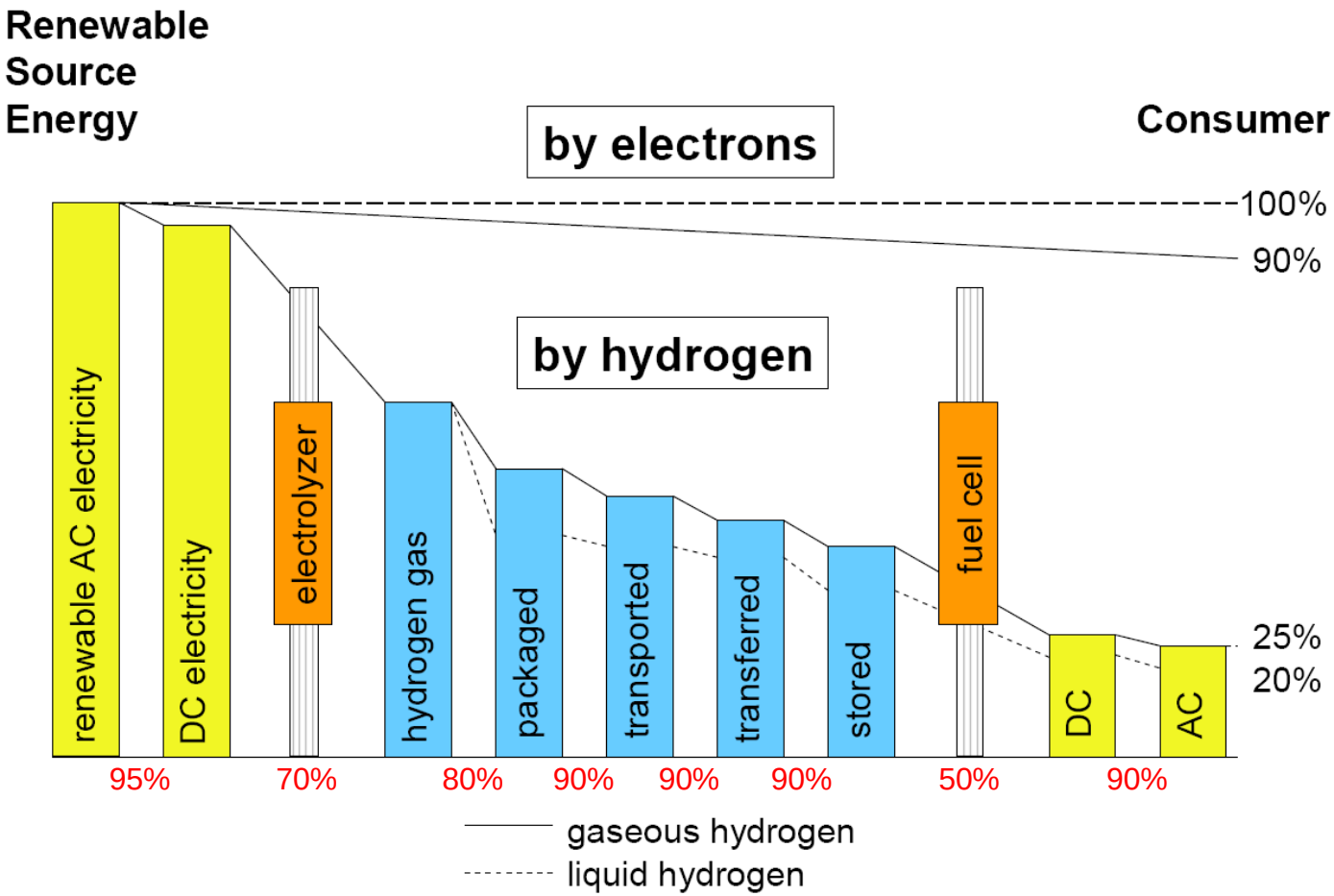
- Natural gas is peaking too (already in North America)
- Coal is carbon-rich, therefore much CO_2; sequestering is energy-intensive
- Electricity generation from coal or natural gas is <40% efficient (although improved with co-generation)
- Fischer-Tropsch process is well established (Germany, South Africa; now Qatar) but energy-intensive and, when coal is the basic fuel, polluting

Adaptations to expensive oil: 3. Renewable fuels



Indicated conversion efficiencies are rough estimates.
Better estimates (and sources) are being developed.

Why the hydrogen fuel cell future won't work (but grid-connected vehicles will)



Source: Bossel (2005)

Approximate efficiencies of processes (multiplicative) are in red.

Electricity is better for an energy-constrained world: 1. Comparison of ICE, Battery, and fuel cell drives

	ICE[1]	Battery[2]	Fuel cell[3]
Length (m)	4.25	4.49	4.17
Width (m)	1.76	1.77	1.76
Height (m)	1.46	1.45	1.65
Unladen weight (kg)	1,400	1,590	1,670
Seats	5	5	4
Drive (2 or 4 wheels)	2	4	2
Max torque (Nm)	340	518	272
Max power output (kW)	103	50	86
Max speed (km/h)	205	180	150
Range (km)[4]	980	250	430
Rate of use of energy at the vehicle (MJ/100km)	**197**[5]	**69**[6]	**124**[7]

1. 2005 Honda Civic 2.2 i-CTDi (Honda Motor Company, 2005a).
2. 2005 Mitsubishi Lancer Evolution MIEV (Mitsubishi Motors Corporation, 2006).
3. 2005 Honda ZC2 (Honda Motor Company, 2005b).
4. Assumes full fuel tanks and charged batteries run to exhaustion.
5. Based on the stated 5.1 L/100 km, at 38.7 MJ/L for diesel fuel.
6. As estimated by Bossel (2005b) from information provided in the Mitsubishi source about the batteries (95 Ah rating; 14.8 volts; 24 modules) and the indicated range.
7. Based on the stated storage capacity of 3.75 kg hydrogen (at 142 MJ/kg) and the indicated range.

Electricity is better for an energy-constrained world: 2. Comparison of ICE and grid-connected transit

Mode[1]	Average speed (km/h)[2]	Average occu-pancy (passen-gers/veh-icle)[3]	Energy use at the vehicle[3]			Fuel cost in U.S. cents[4]	
			Average, MJ per *vehicle*-kilometre	Range of MJ per *vehicle*-kilometre	Average, MJ per *pass-enger*-kilometre	Per MJ[4]	Per pass-enger-kilo-metre
Diesel bus	13.2	10.2	24.5	5.7-42.0	1.49	1.21	1.81
Trolley bus	7.9	13.3	11.3	9.1-20.0	0.53	1.98	1.04
Light rail[5]	15.9	23.2	18.1	9.1-34.1	0.49	1.98	0.96

1. All U.S. trolley bus fleets (four in total) and light rail fleets (26) are represented in the table, but only 154 out of the 525 diesel bus fleets providing local public transport service in the U.S. Excluded were bus fleets operated by the private sector, fleets for which other fuels were used as well as diesel fuel, and fleets for which there were evident data anomalies.
2. Speed and occupancy data refer to in-service vehicle-kilometres only.
3. Energy and thus cost data include all vehicle-kilometres (vkm), on average 13.9% higher than in-service vkm for diesel buses, 3.1% higher for trolley buses, and 1.9% higher for light rail.
4. Fuel price/cost data are unweighted averages for 2004. The estimated per-MJ cost of diesel fuel is based on the average 'highway' price, i.e., 177.6 U.S. cents/U.S. gallon (46.9 ¢/L), which was likely higher than the (unknown) price paid by fleet operators. The estimated percentage cost of electricity is based on that reported to be paid for transport operation, i.e., 7.13 U.S. cents per kWh. Note that the average 'highway' price of diesel fuel per MJ in 2005 was 240.2 ¢/U.S. gallon, i.e., 35.2% higher than the average price in 2004. The average cost of electricity supplied for transport operation in 2005 is not known.
5. For light rail 'vehicle' means one carriage (car in North America). Thus, a two-car light-rail train counts here as vehicles. For diesel and trolley buses, each bus counts as one vehicle whether or not it is articulated.

Electricity is better for an energy-constrained world: 3. Comparison of modes and drives

Estimate for PRT may be too conservative. PRT vehicles would be much lighter than BEVs (thus much better uphill), could travel in trains, and would have very little stop-start.

Vehicle	MJ/pkm
ICE (Honda Civic)	1.31
ICE (Loremo LS)	0.33
ICE (Loremo GT)	0.62
FCV (Honda ZC2)	0.83
BEV (Mitsubishi)	0.46
GCV (estimated PRT)	0.43
ICE (U.S. diesel bus)	1.49
GCV (U.S. light rail)	0.49
GCV (U.S. trolley bus)	0.53
Note: Cars and PRT assume 1.5 persons per vehicle	

Sources: As for previous two slides, and Gustavsson (1995) for PRT

Why biofuels may not fill the liquid transport fuels gap

1. Ethanol and biodiesel have some role as substitutes for present transport fuels.

2. Ethanol production raises questions about required energy inputs and land requirements. The new Goldfield plant in Iowa uses about 100,000 tonnes of coal [!] a year to produce about 200 million litres of ethanol from about 4.7 million tonnes of corn—harvested from about 4,700 square kilometres of land. The energy inputs in the form of coal and fuel to move the corn to the plant amount to about 80% of the energy in the ethanol, and more energy is required for farming and other necessary activities.

3. There may be fewer questions with production of ethanol from cellulose (Ottawa-based Iogen Corp. is a world leader), using wood and other wastes.

4. But the land requirement question remains, and a new question: in an energy-constrained world in which fertilizer production is limited by oil and natural gas availability, will not waste materials be needed to replenish land?

5. It usually makes more sense to use biofuels to cogenerate electricity.

What are grid-connected vehicles (GCVs)?

- 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

Calgary

Vancouver

Public transit between cities

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

Amtrak Acela at Boston South station

German ICE

Note on Calgary-Edmonton High-Speed Rail

- Recent Van Horne Institute study (Shirocca Consulting) showed: With current fuel price regime, Calgary-Red Deer-Edmonton high-speed electric train (300 km/h; 90-min. C-E trip time; 10 return trips/weekday) would have revenues about $200 million/year, thus covering operating costs (about $120 million/year) and 75% of capital costs ($3.7 billion, or about $130 million/year).

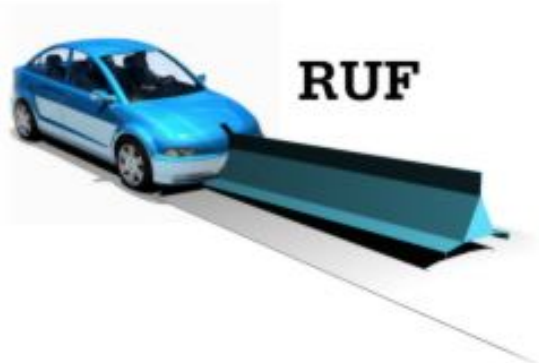
- What if fuel prices rise fourfold and fuel efficiency improves by 50% (air, train) and 100% (car)? Rail use rises to 45% of trips (from 22%). Also, (not in Van Horne estimate) total trips rise by 50% (same people travelling more, as for Paris-Lyon). Revenues now exceed costs by $25 million/year.

- Paris-Lyon TGV (400 km) has double-decked trains running 35 times a day (headways as low as 3-4 minutes, GPS-satellite managed).

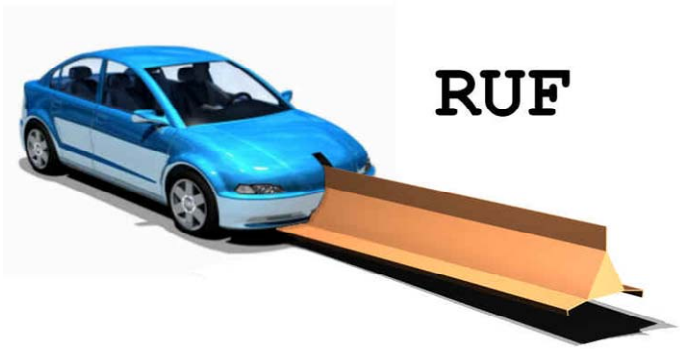
Personal vehicles

Düsseldorf Airport SkyTrain

Skyweb Express (Cincinnati concept)



More on PRT



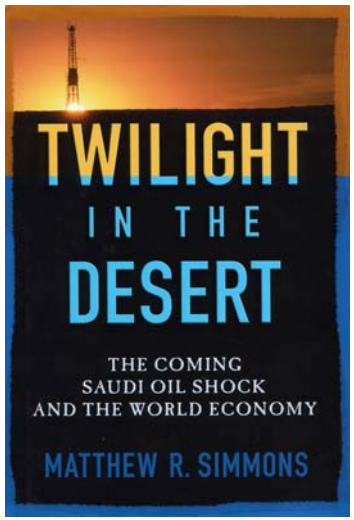
Freight transport

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?

Conclusions re. sustaining auto industry through ecology

- Focus on preparing for era of energy constraints
- Embrace future based on electric drives not ICEs
- Re-commit to battery-electric vehicles
- Above all, recognize the superiority of the grid-connected mode for an era of energy constraints with a high premium for use of renewable fuels; develop PRT systems



Thanks for your attention!