German Aviation Research Society
"Aviation and the Environment"

How to fly without kerosene?

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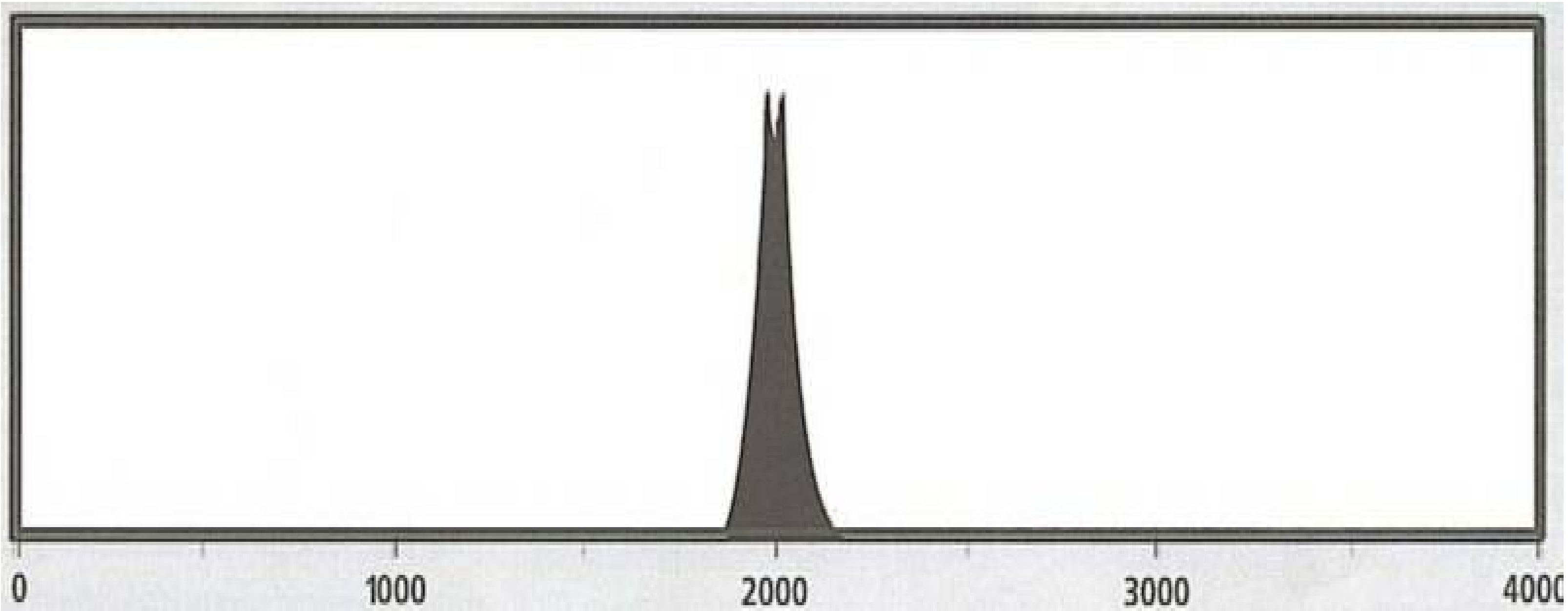
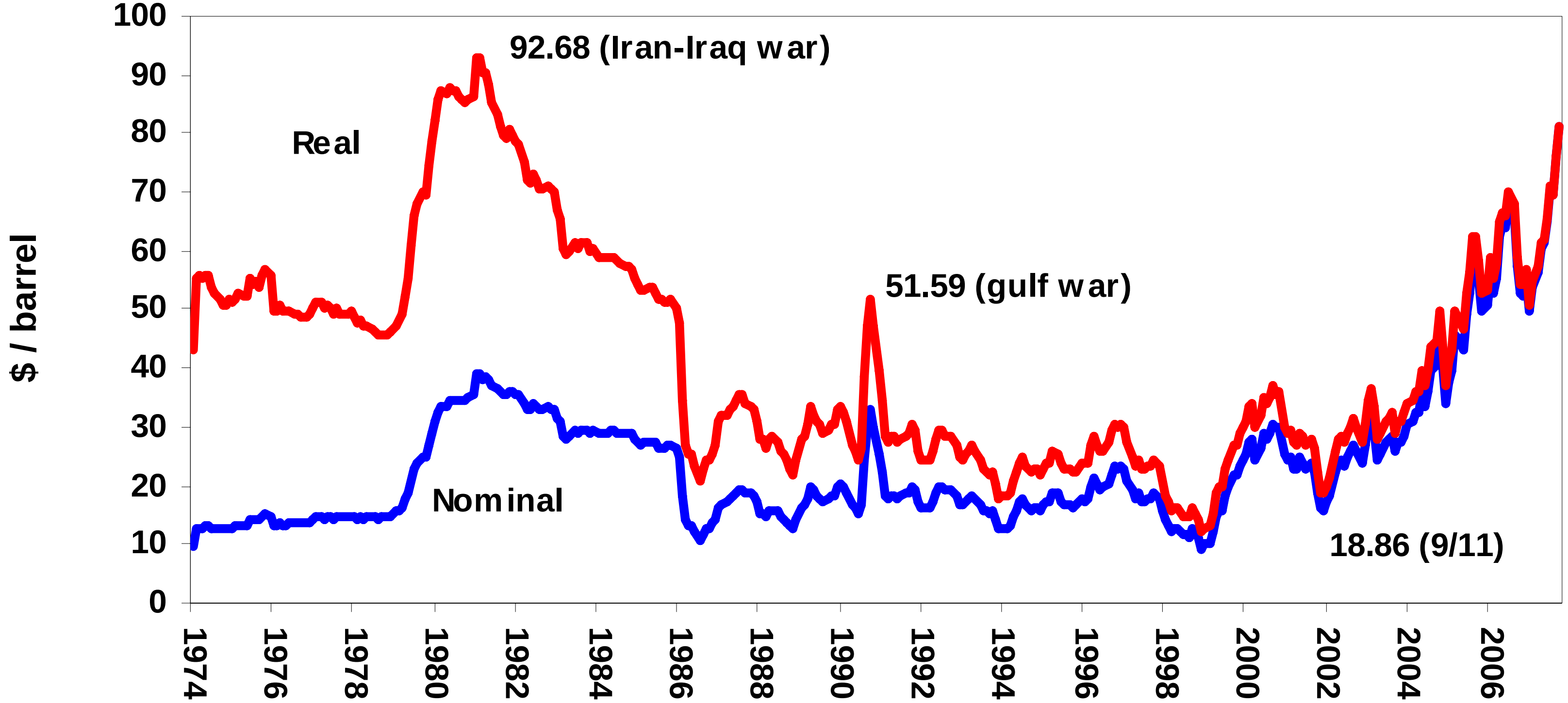
Agenda

- Introduction
- Peak oil and future oil prices
- Short-term impact of soaring kerosene prices
- Alternatives to kerosene as jet fuel

“The Flame in the Darkness”

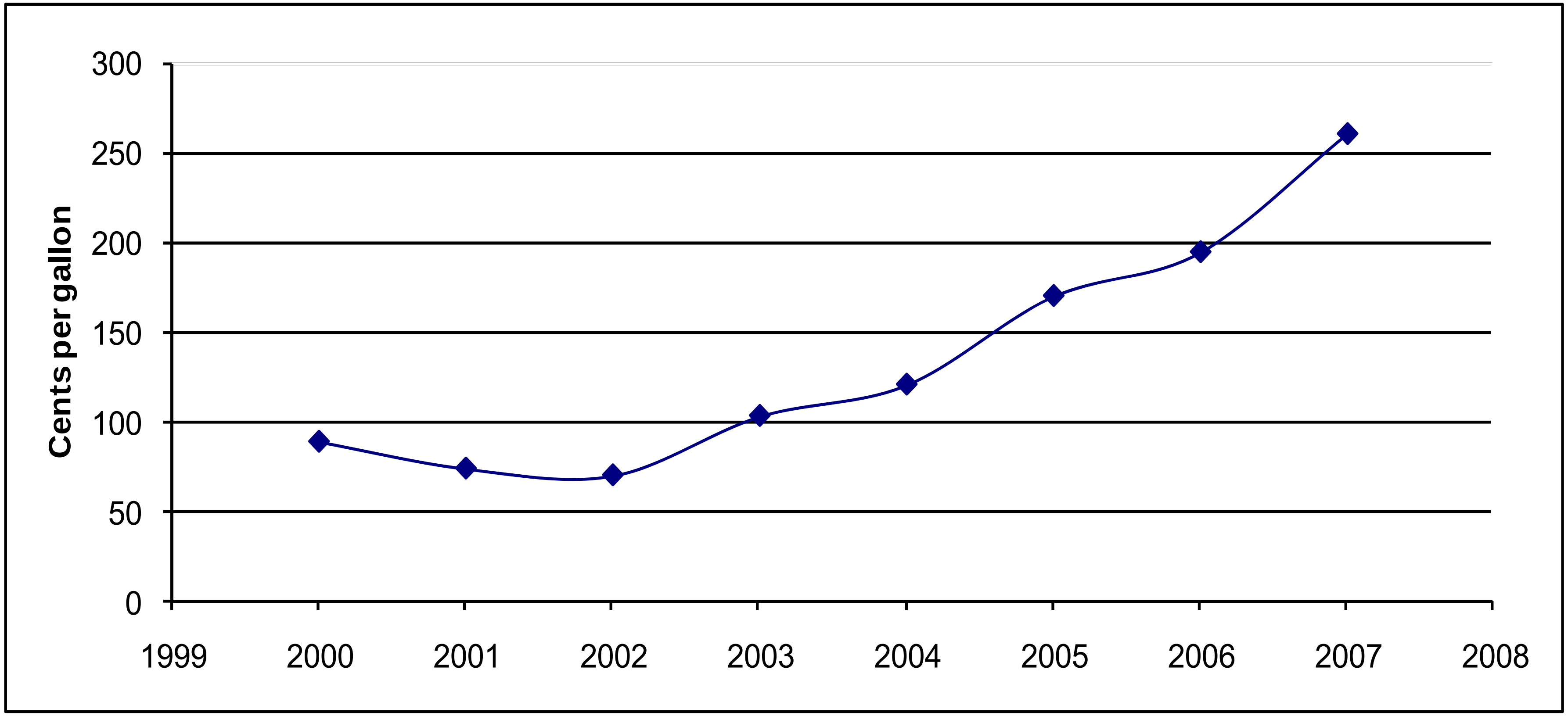


Real and nominal oil prices, 1974-2007



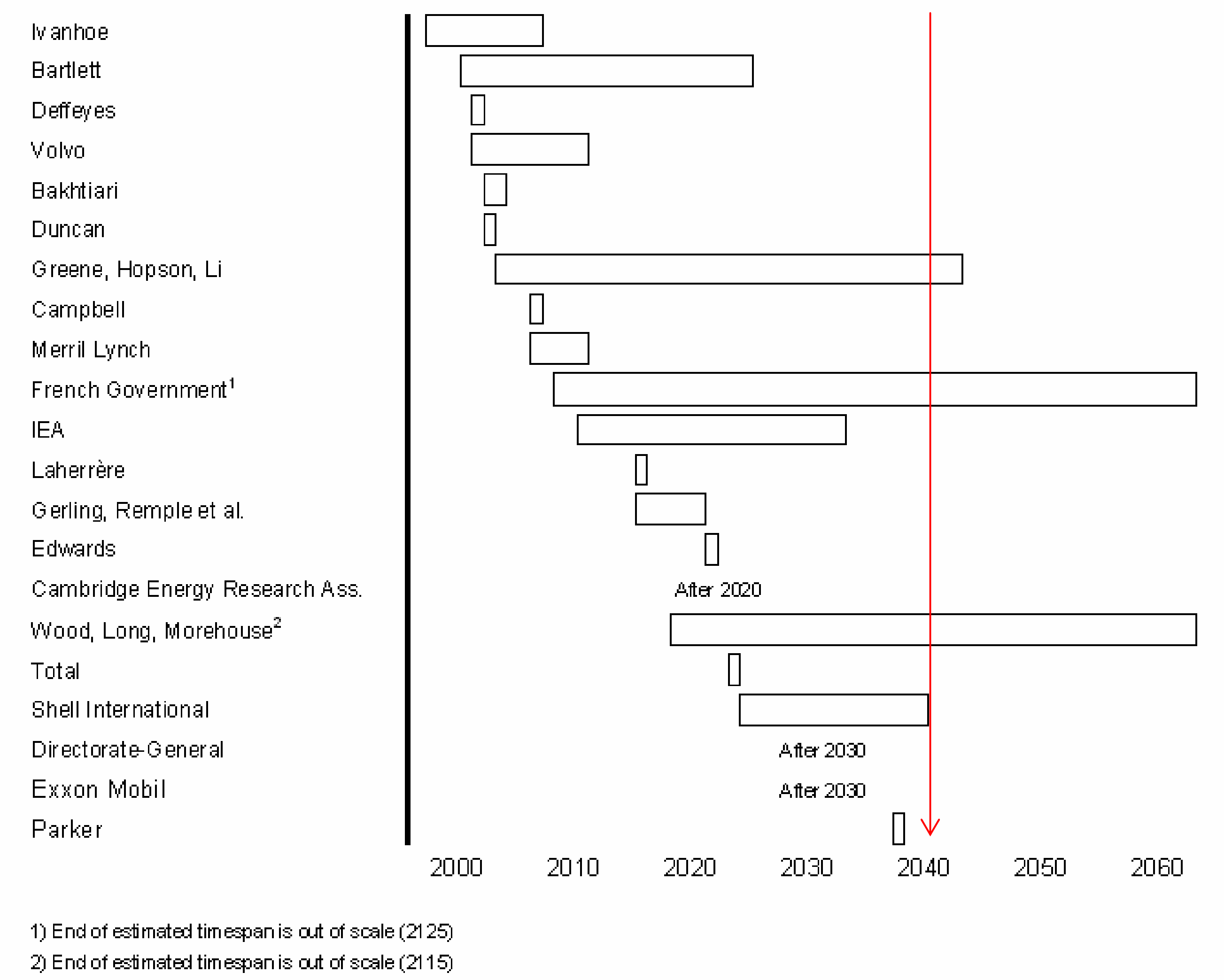
Source: EIA

Kerosene-type jet fuel prices in Rotterdam 1999-2007



Source: EIA

Estimates of the timing of peak oil



Source: GAO

Cause-and-effect chain of higher oil prices

Crude oil price up

Kerosene price up

Fuel costs up

Air fares or fuel surcharges up

Air travel demand down

AF-KLM fuel hedging policy

	2007-08	2008-09	2009-10	2010-11
Forecasted spot price (Brent, $/barrel)	79	83	79	78
Hedged consumption (%)	77	67	51	31
Average hedged price (Brent, $/barrel)	62	61	68	69
Final average price (Brent, $/barrel)	66	68	73	75

Source: Air France-KLM hedging policy for fuel expenditure (26th October 2007)

Exemplary routes investigated (Scheelhaase, Grimme and Schaefer 2007)

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	Route (Carrier)	HHN-STN (FR)	FRA-LHR (LH)	FRA-SIN (LH)
Operational data	Distance flown	572	695	10,603
	Aircraft type	B 737-800	A 321-100	A 340-300
	No. of seats	189	182	247
	Avg. seat load factor	76.1%	66.9%	80.5%
	Avg. no. of passengers	144	122	199
	Fuel consumption (liter kerosene)	3,250	4,125	107,500

Increases in fuel costs and ticket prices

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	Route (Carrier)	HHN-STN (FR)	FRA-LHR (LH)	FRA-SIN (LH)
Fuel costs (c_{pax})	AF-KLM base	12.6	18.9	302.6
	α = 0.67	14.9	22.3	356.5
	α = 0	21.9	32.8	524.0
Fuel costs (€/PAX)	AF-KLM base	8.7	13.0	208.7
	α = 0.67	10.3	15.4	245.9
	α = 0	15.1	22.6	361.4
	Avg. ticket price (per sector, €/PAX)	44	136	602
Abs. price increase (€/PAX)	α = 0.67	1.6	2.4	37.2
	α = 0	6.4	9.6	152.7
Rel. price increase	α = 0.67	3.6%	1.8%	6.2%
	α = 0	14.5%	7.1%	25.4%

Airline‘s future fuel costs (1)

$$C = ([\alpha \cdot p_h + (1-\alpha) \cdot p_s] + c_r) / 159$$

C	Future fuel costs ($/liter kerosene)
α	Share of fuel consumption hedged (%)
p_h	Average hedged crude oil price ($/barrel)
p_s	Future spot crude oil price ($/barrel)
c_r	Gross refiner margin ($/barrel)

Airline's future fuel costs (2)

$$c_{pax} = C \cdot \frac{k}{n}$$

c_{pax}	Future fuel costs per passenger ($/PAX)
C	Future fuel costs ($/liter kerosene)
k	Fuel consumption per flight (liter kerosene)
n	Avg. passenger number per flight (PAX)

Changes in demand
(Gillen, Morrison, Stewart 2004)

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Route (Carrier)	HHN-STN (FR)	FRA-LHR (LH)	FRA-SIN (LH)
Avg. price elasticity, business	-0.7	-0.7	-0.265
Avg. price elasticity, leisure	-1.52	-1.52	-1.04
Share of business travellers	25%	50%	50%
Relative price increase for α = 0.67	3.6%	1.8%	6.2%
Relative price increase for α = 0	14.5%	7.1%	25.4%
Change in demand for α = 0.67	-4.7%	-2.0%	-4.0%
Change in demand for α = 0	-19,1%	-7,9%	-16,6%

The future of aviation?

Measures to save kerosene and kerosene substitutes

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Short-term	Long-term
✈ Shorter air routes	✈ Alternative fuels
✈ Carrying less minimum fuel	✈ Fuel cells (all-electric aircraft)
✈ Increased fuel blending	✈ Blended wing airliner
✈ Shorter sector lengths	✈ Solar power
✈ Modern fleet	
✈ Increased load factors	
✈ More efficient ground operations	

Assessment of alternatives to kerosene as jet fuel

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		High energy content	Safety criteria	Environmentally clean	Global availability and costs	Short-term availability
Synthetic kerosene	BTL	o	+	+	o	+
	CTL	o	+	-	o	+
	GTL	o	+	-	o	+
Hydrogen		+	?	+	-	-
Biofuels		-	-	o	+	+
Fuel cells		-	+	+	o	-

Hydrogen-powered aircraft (Cryoplane)

Conclusions (1)

- Air traffic growth constrained by scarcity of kerosene will be much lower – and may even be negative – than unconstrained air traffic growth
- Services offered by low cost carriers and long-haul services will be most adversely affected by higher fuel prices
- Soaring fuel prices may also influence the typical air service pattern (e.g. revival of turboprops)
- Aviation industry and politicians better face the implications of finite oil resources

Conclusions (2)

- Peak oil may soon eclipse the global warming debate in commercial aviation
- High fuel prices influence commercial aviation in the same direction as intended by EU emission trading system (ETS)
- The impact of soaring fuel prices is likely to exceed the impact of ETS

Is ETS actually needed in view of finite oil resources that may restrict or even terminate air traffic growth?

Thank you for your attention!

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