Scenarios background assumptions (external factors of influence)

- **Overview of external factors relevant for aviation development**
- **Overview of factors and the consideration within the scenario quantification**
- **Congruence with IPCC SRES scenarios**
- **Excerpt of assumptions about external factors**
- **Comparison and ranges of assumptions made in other studies**

Short description of CONSAVE scenarios

1.1 Unlimited Skies: This scenario assumes a very high air transport demand highlighting the challenges ahead for the global aviation industry.

1.2 Regulatory Push & Pull: The (hypothetical) ”unconstrained” demand of this scenario is the same as in Unlimited Skies above. However, a number of constraints as well as regulatory actions addressing those are likely to dampen the effect on global transport volume.

2 Fractured World: This fractured world scenario assumes an absolute decline in international flights and the second lowest GDP-air transport elasticity of all scenarios considered. The available scenario literature provides no equivalent example, making this scenario quantification highly interesting but also challenging.

3 Down to Earth: This scenario of significant lifestyle changes (high environmental consciousness) postulates an entire decoupling of air transport from GDP growth.

Scenario Drivers	Unlimited Skies	Regulatory Push & Pull	Fractured World	Down to Earth
Regional disparities	↘	↘	↗	↘
Social values	↘	→	↘	↗
Role/Level of Governance	↘	→	global ↘ regional ↗	↗
Environmental consciousness (public)	↘	→	global ↘ regional ≈	↗
Environmental policies	↘	→	global ↘ regional ≈	↗
Resources availability	↗	→	global ↘ regional ≈	→
Technology development (i.e. Computer + Bioscience)	↗	↗	≈	↗
Communication options	↗	↗	global ↘ regional ≈	↗
Transport demand in general	↗	↗	global ↘ regional ≈	↘
Air Transport Demand	↗	↗	global ↘ regional ≈	↘

Key fields, factors, features, and constraints addresses in CONSAVE 1/2

	Key fields	Addressed in Background-Scenario storylines	Addressed in Aviation Scenario description	Quantified as Input for the AERO-Model	Challenges, Constraints studied
I	Demography	Population		Global + regional Population	
II	Macro economics	Economic Development		Global + regional GDP	
		Regional Disparities			
III	Energy /Resources	Resources	(Part of Aviation Costs)	Energy Use	Availability+ Price
				Oil Prod. Peak	Price to Cryoplane Technology
				Energy Price	
IV	Social Trends / Mobility Patterns	Social Trends	Mobility Patterns		Mobility Pattern
					Global Conflicts
V	Transport	Transport	Gen. Transport Development		
			Transport + IT Technology		
VI	Aviation Effects on Ecology	Environment	Environmental Impacts of Aviation		Environmental Impacts
			Environmental Regulation		

Key fields, factors, features, and constraints addresses in CONSAVE 2/2

	Key fields	Addressed in Background-Scenario storylines	Addressed in Aviation Scenario description	Quantified as Input for the AERO-Model	Challenges, Constraints studied
VII	Technology	Technology	Aviation Technology	Various Technical	Lag of Standardisation
		Communication Technology		Assumptions	Maintenance costs
				Cryoplane Intro. Year	
				New Aircraft Price	
				Surface competition	
VIII	Policy /Regulations	Governance	(Part of Environ. Impacts)	Var. Taxes + Charges	Regulations
IX	Air Transport - Supply	Air Transportation	Air Transport - Gen. Supply	Crew needed	
			Airport and ATM	Detour Factor	Infrastructure Capacity
			Safety and Security	Security (as Tax)	Security
			Air Transport Market	Target Profits	
				Load factor	
				Aircraft crap value	
				Interest Rate	
			Aviation Costs	Volume costs	
				Crew salaries	
X	Air Transport - Demand	Air Transportation	Air Transport - Demand	Autonomous Growth	Saturation
				Elasticities	

Overview of the assumed shaping factors

Background	Unlimited Skies	Regulatory Push & Pull	Fractured World	Down to Earth
Population	8,7 Billion		11,3 Billion	8,7 Billion
World GDP	180 Trillion $	175 Trillion $	82 Trillion $	136 Trillion $
GDP growth	3.9 % p. a.	3.8 % p. a.	2,3 % p. a.	2,5 % p. a.
Income per capita (10^3 1990 US $ per capita)	20,7	20,1	7,2	15,6
Corresponding IPCC scenario	SRES A1G	SRES A1T	SRES A2	SRES B1

*World GDP in RPP was reduced by 3% to be consistent with storylines.
Except this all other background assumptions are in accordance with the SRES scenarios of the Intergovernmental Panel on Climate Change (IPCC 1999).

CONSAVE scenarios vs. IPCC/SRES scenarios

There is good congruence between the CONSAVE aviation storylines and those of IPCC-SRES in terms of demographic and economic development.

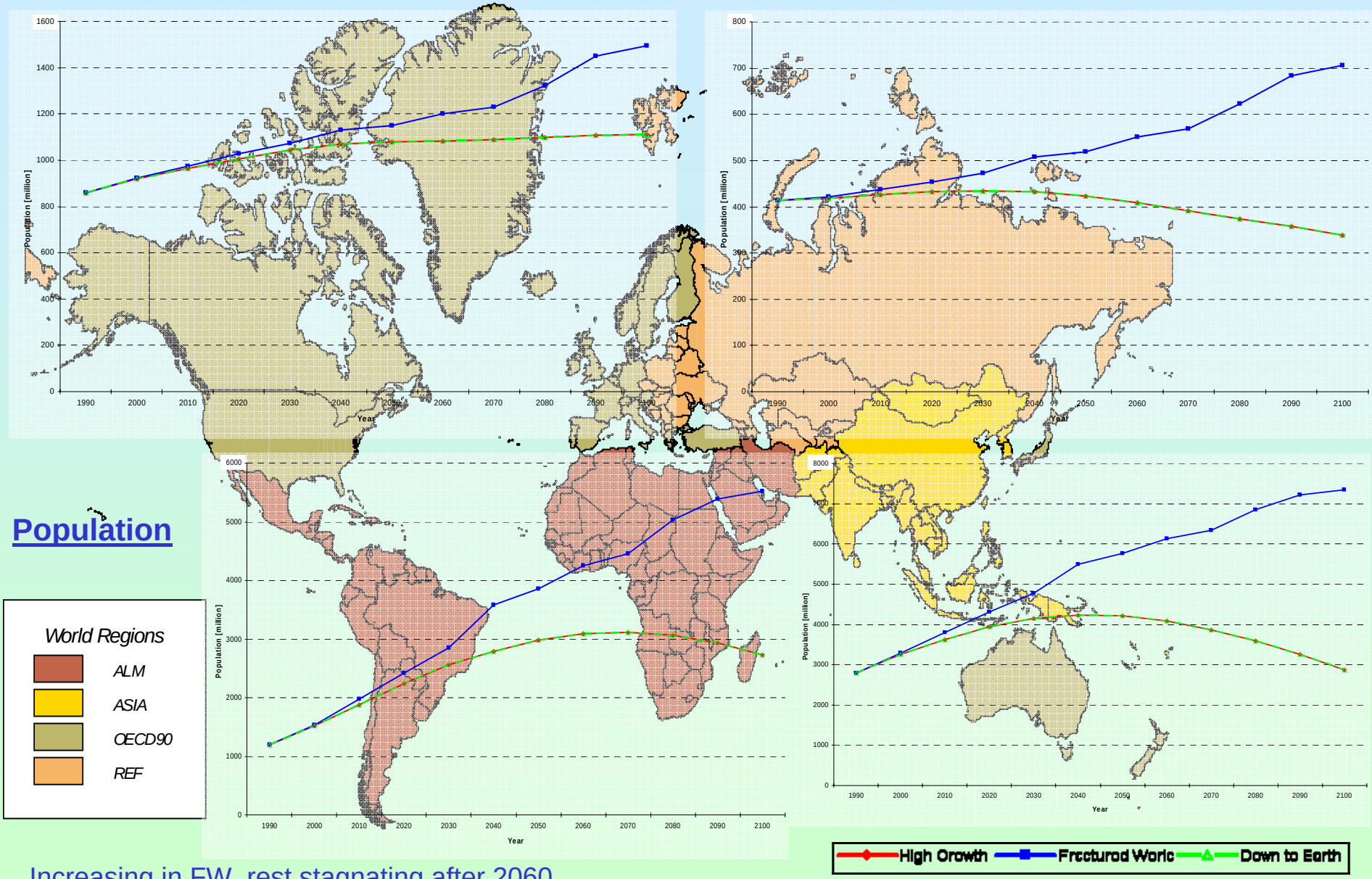
Population:
High growth (2 scenarios): SRES A1
Fractured World: SRES A2
Down to Earth: SRES B1 (identical to A1)
(Dynamics as Usual (2 scenarios): SRES B2)

GDP:
High growth (2 scenarios): SRES A1
Fractured World: SRES A2
Down to Earth: SRES B1
(Dynamics as usual (2 scenarios): SRES B2)

Resource and Energy Availability
With exception of one scenario (Fractured World), there is also good agreement between the SRES scenarios and the CONSAVE scenarios with respect to growth in energy demand, resource availability and (to a lesser extent on) resulting energy prices.

Resource availability (peak of world oil production):
High growth, unconstrained (”Unlimited Skies”): SRES A1G (2080)
High growth, constrained (”Regulatory Push & Pull”): SRES A1T (2050)
Fractured world: SRES A2 with modifications Down to Earth: SRES B1 (2020)
(Dynamics as Usual (two scenarios): SRES B2 (2030-2040))

Energy prices, especially oil.
The unconstrained CONSAVE scenario will largely rely on the scenarios of energy prices as reported in the SRES report. For the constrained scenario “Regulatory Push & Pull” (not treated in IPCC SRES), additional price mark-ups are necessary.



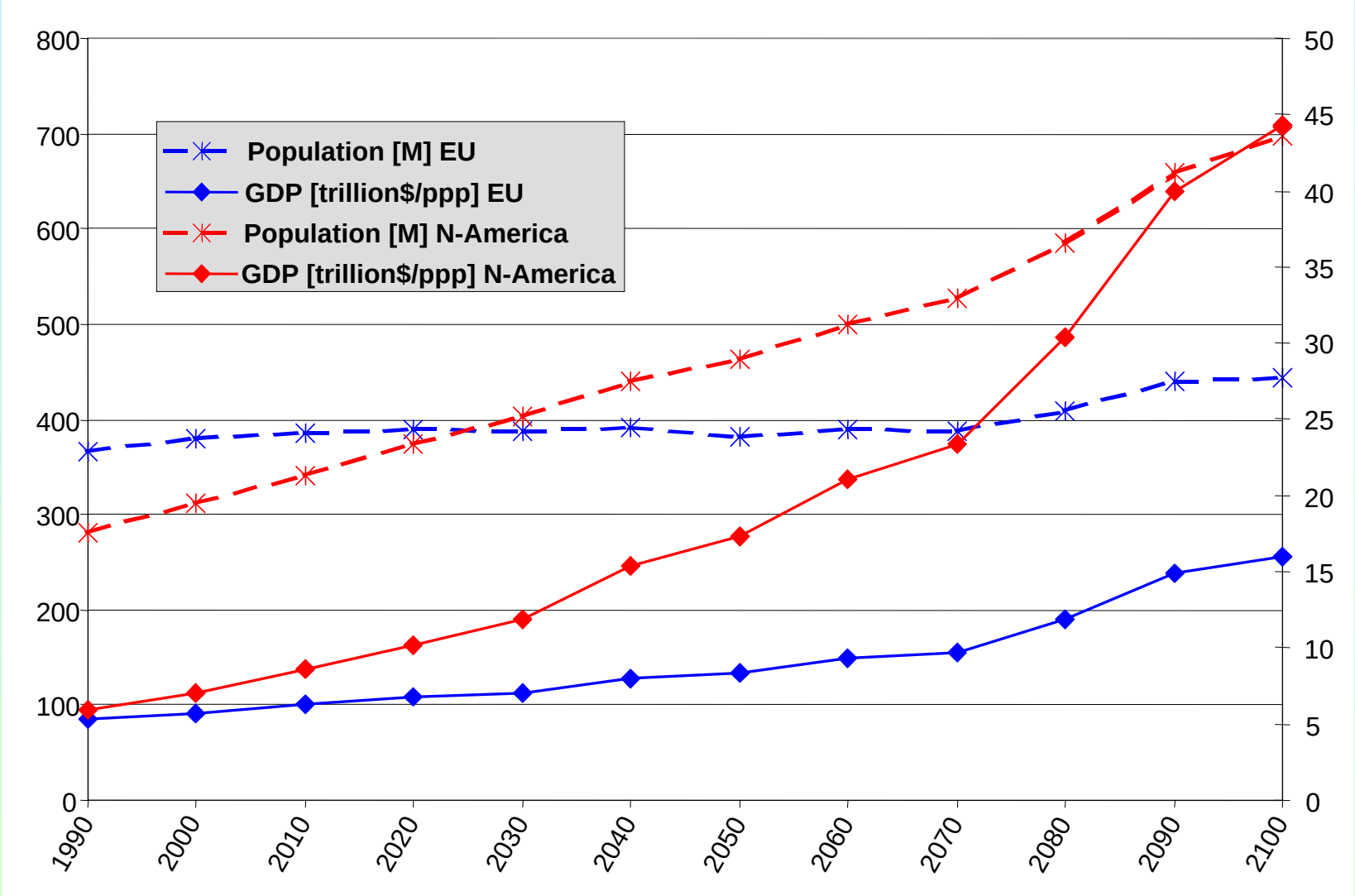
Population

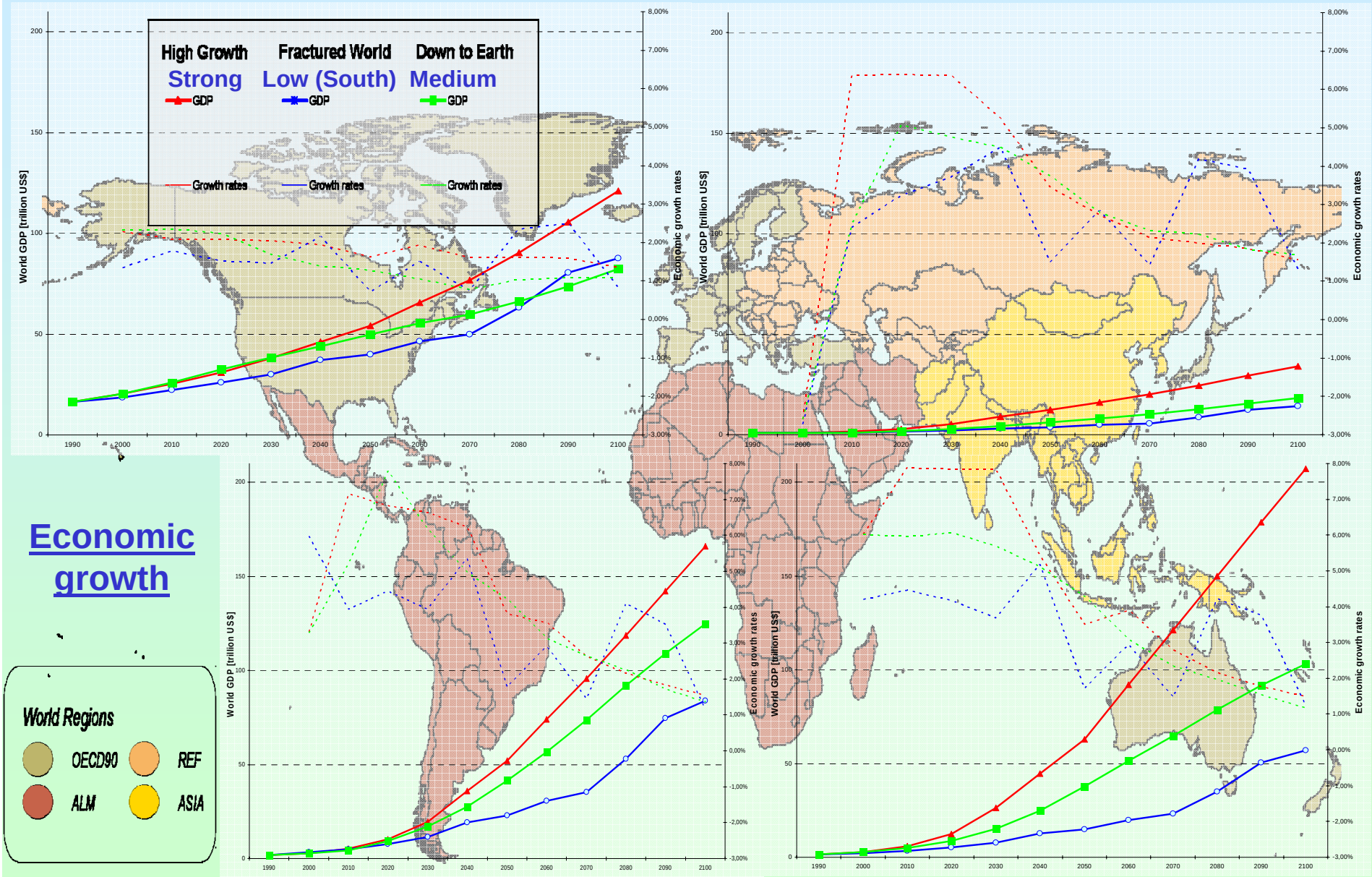
World Regions

- *ALM*
- *ASIA*
- *OECD90*
- *REF*

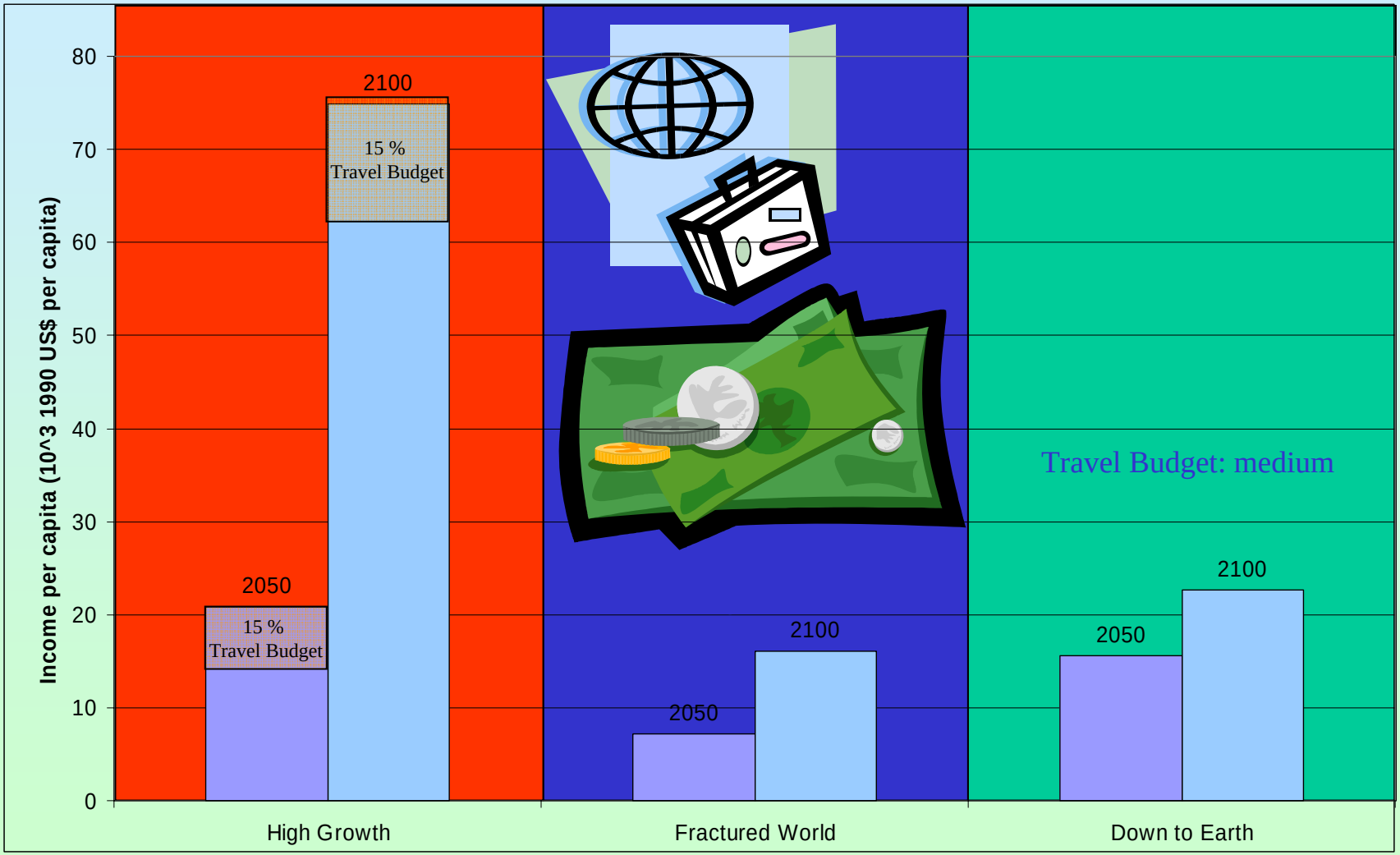
Increasing in FW, rest stagnating after 2060

(Exogenous) scenario - Example: Fractured World

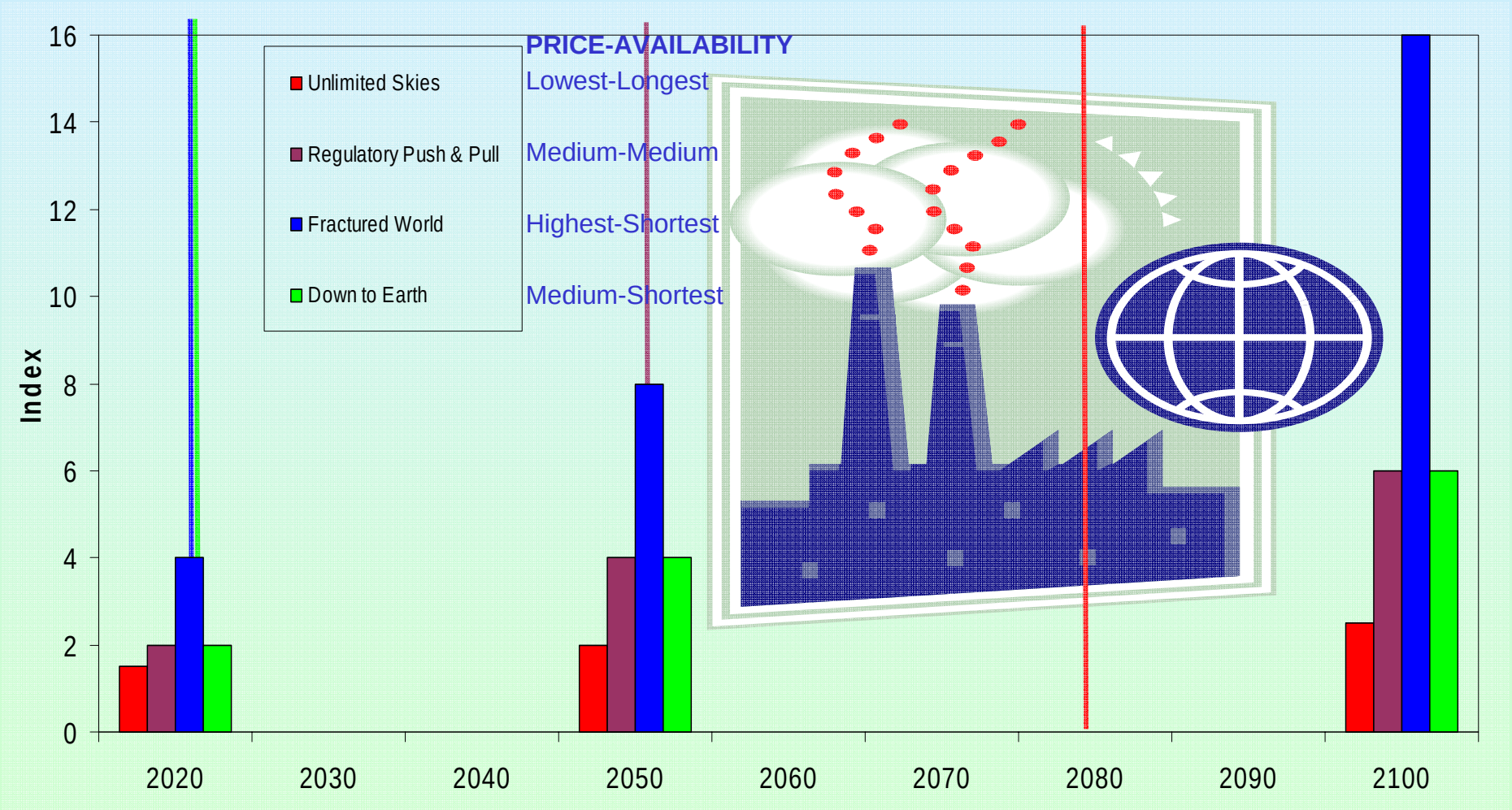



High Growth
Strong
GDP
Growth rates
Fractured World
Low (South)
GDP
Growth rates
Down to Earth
Medium
GDP
Growth rates
World GDP [trillion US$]
Economic growth rates
Economic growth
World Regions
OECD90
REF
ALM
ASIA

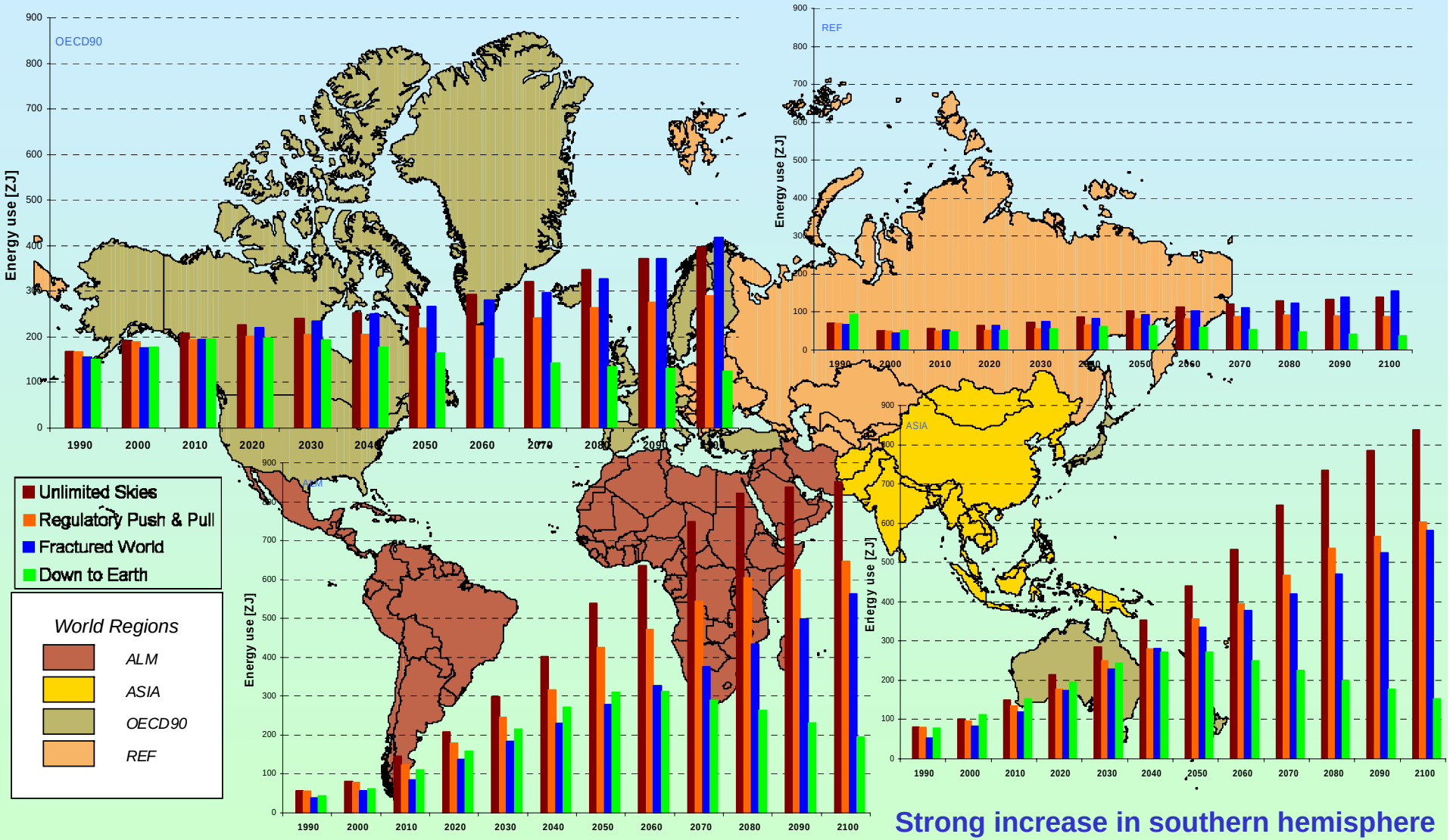
Income per capita and travel budget



Energy prices (and peak of oil production)

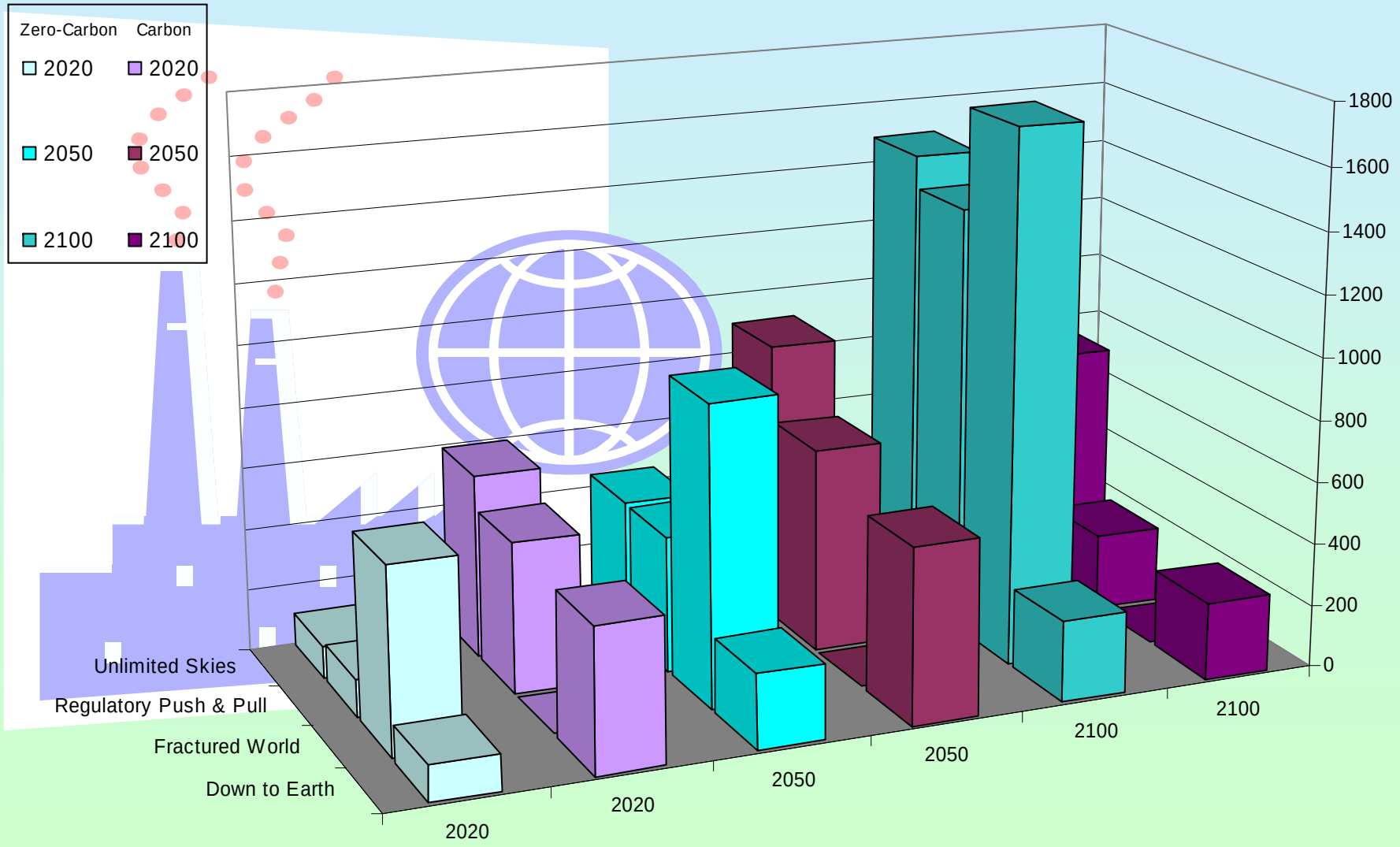


Amount of energy used in four CONSAVE scenarios

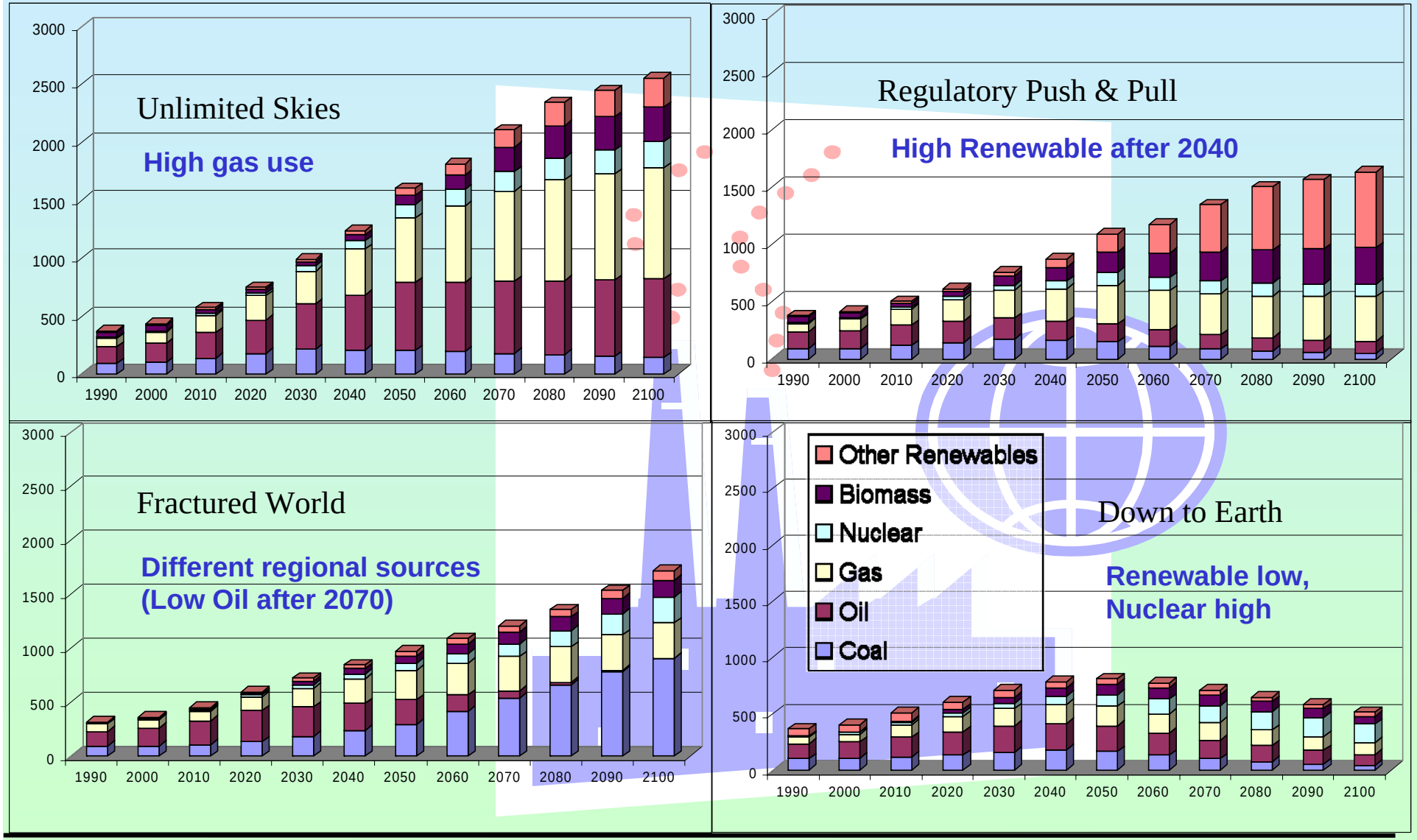


Strong increase in southern hemisphere

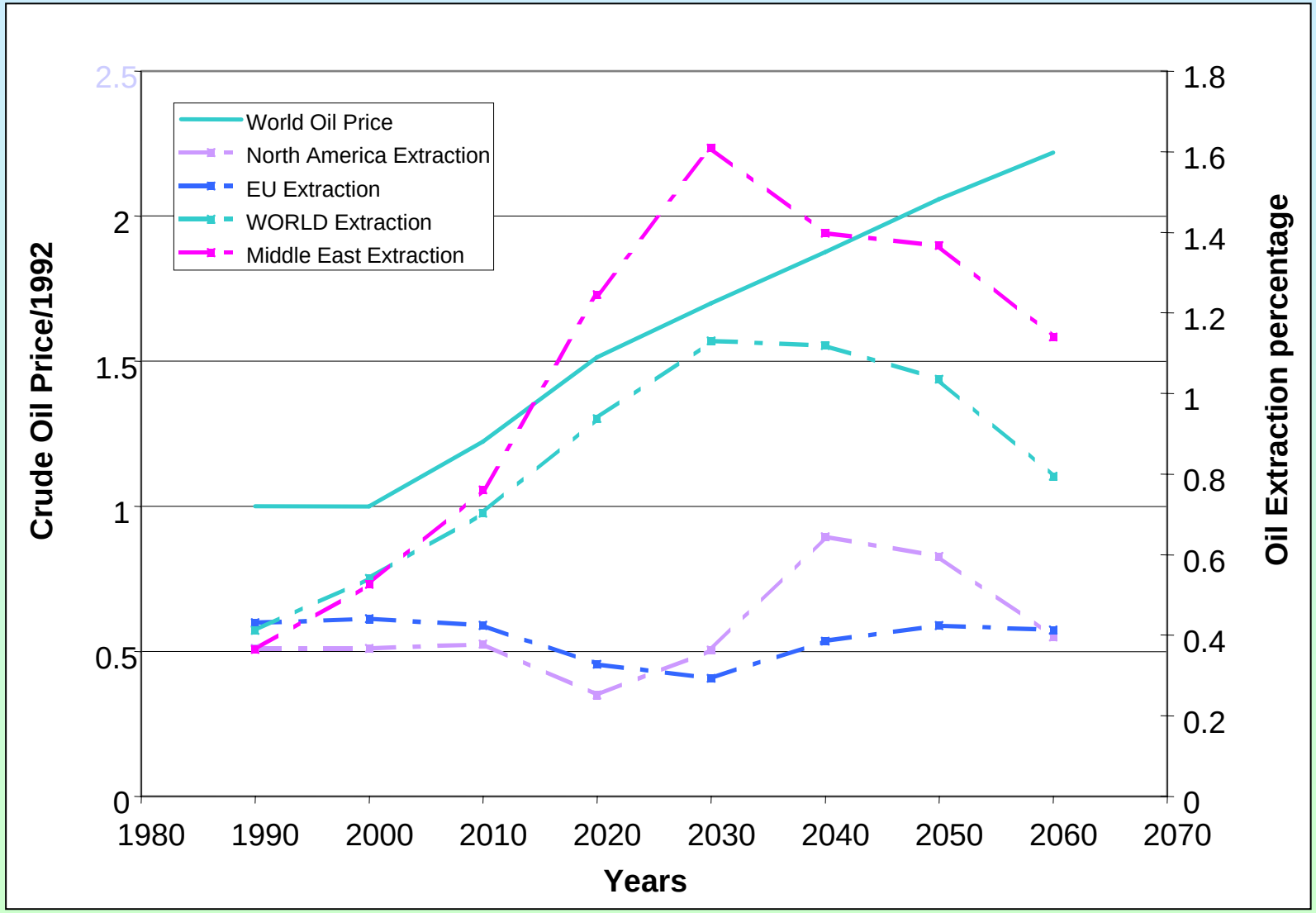
Energy resources used in four CONSAVE scenarios



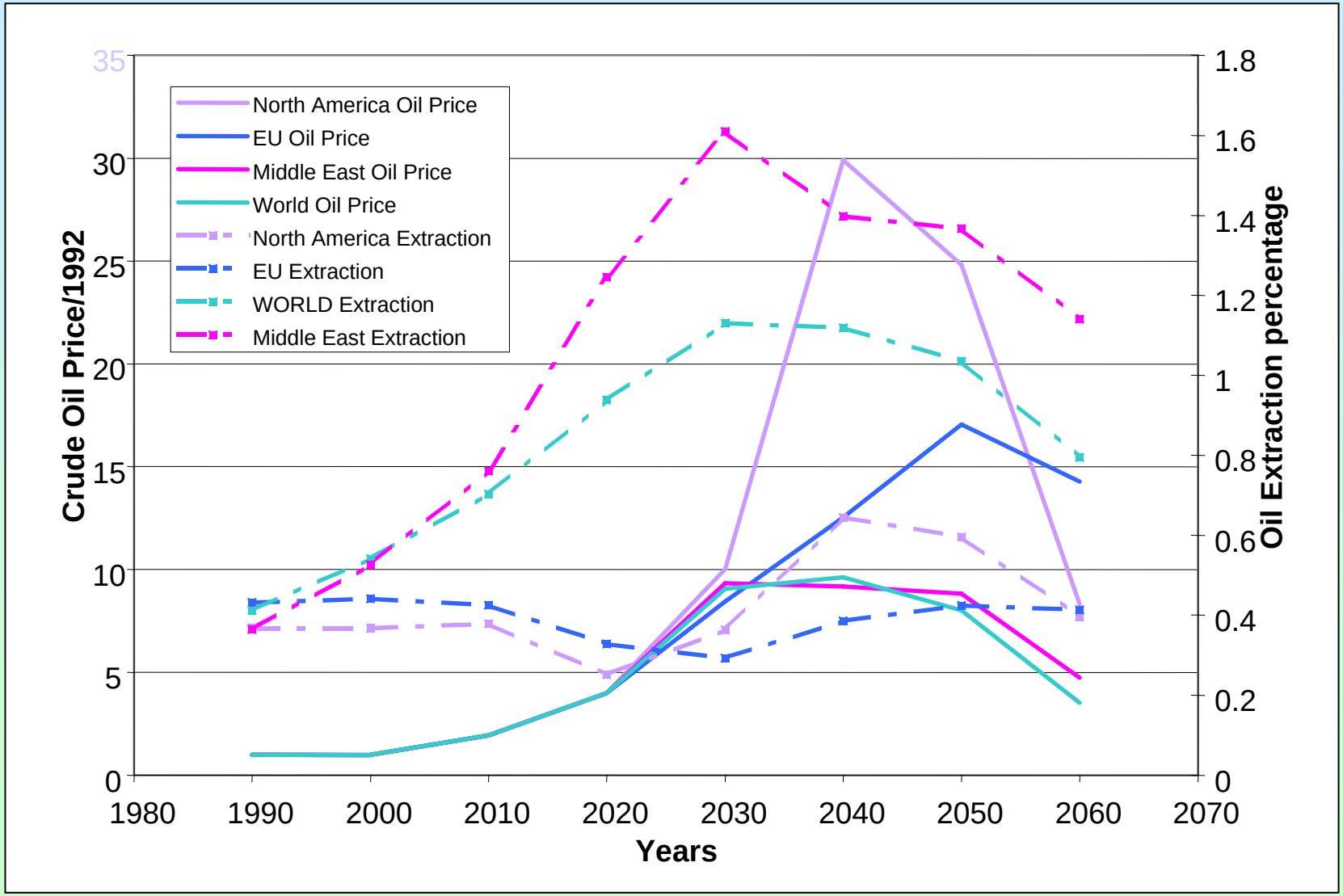
Energy resources used in four CONSAVE scenarios



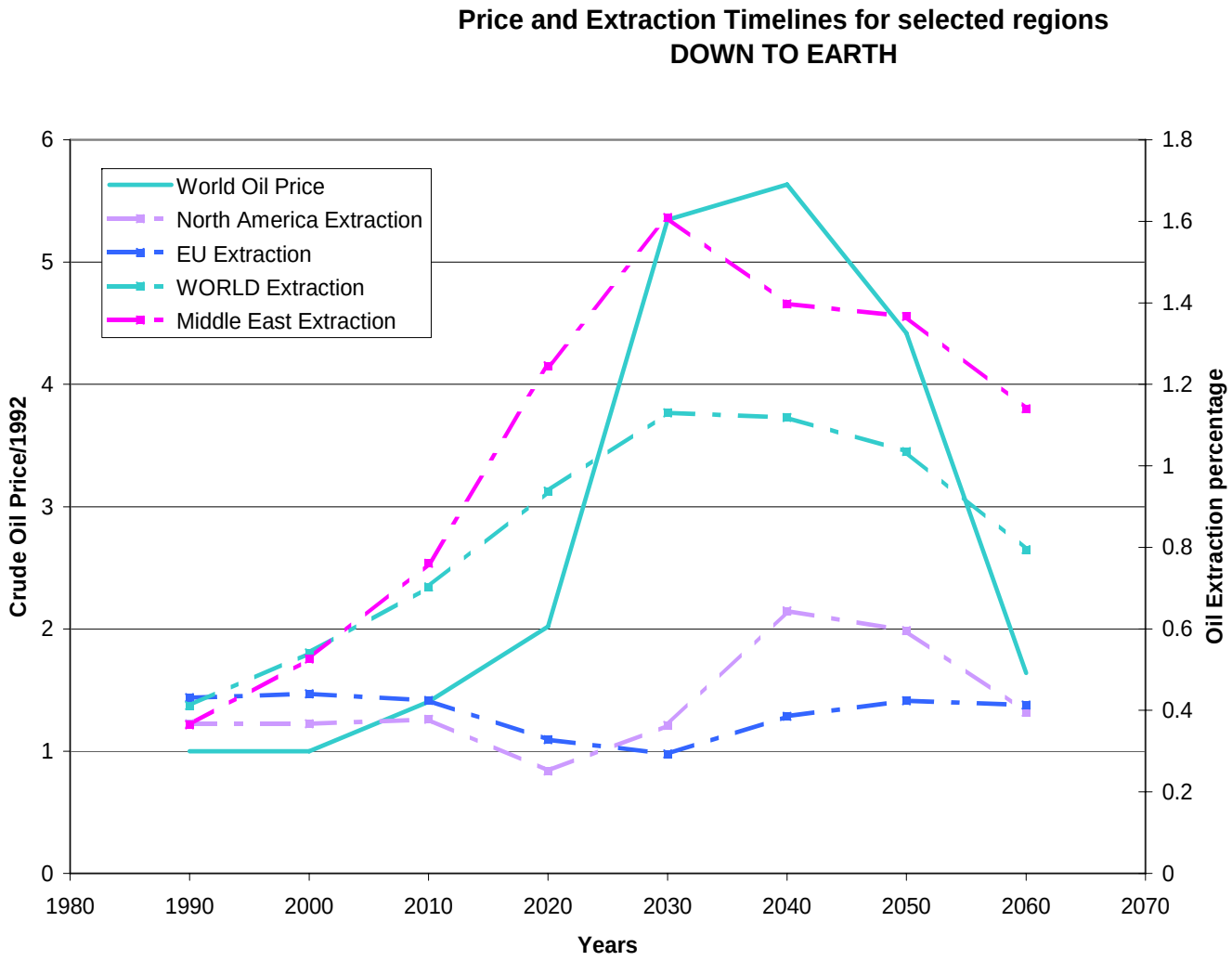
Oil price development - Unlimited Skies



Oil price development - Fractured World

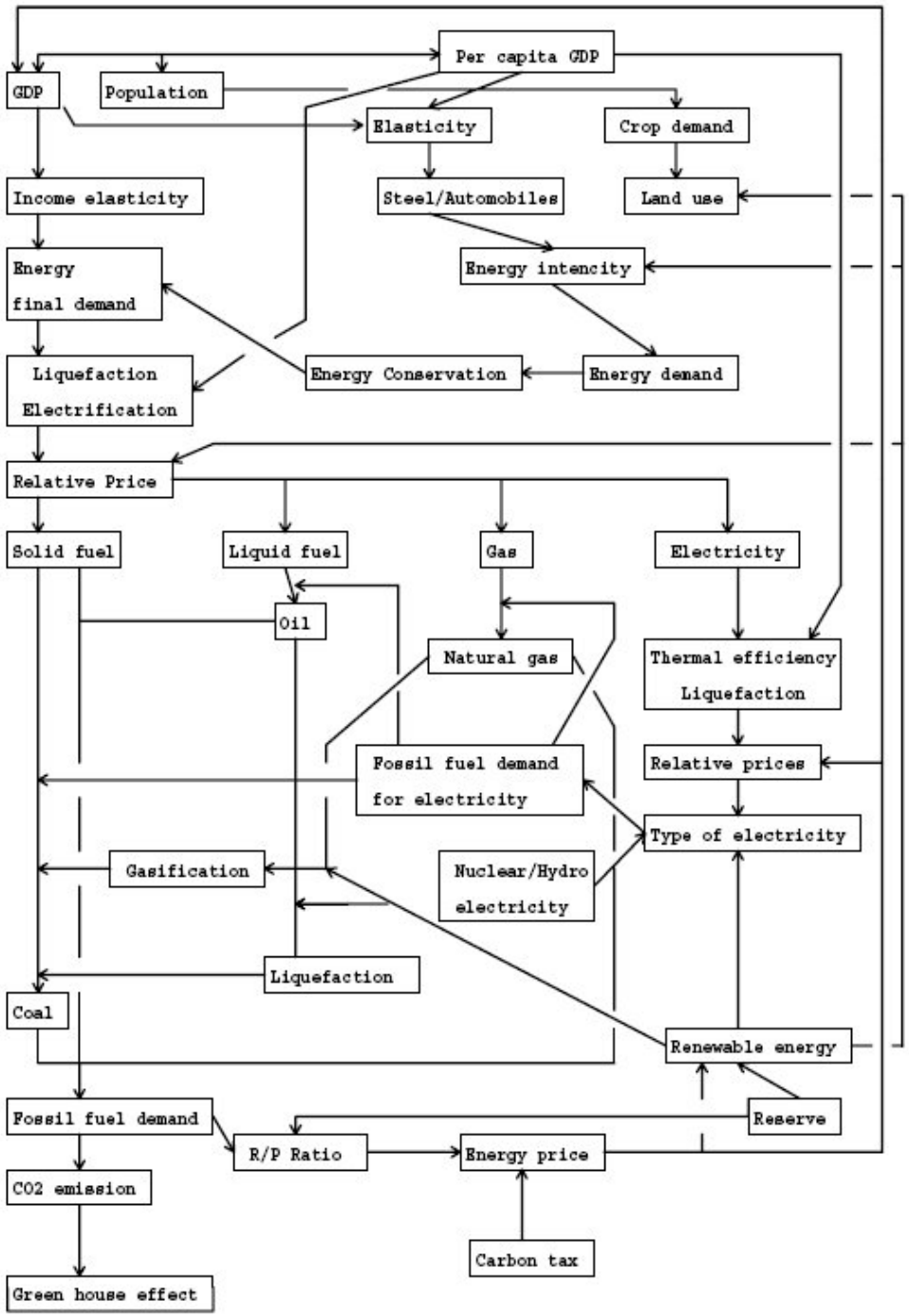


Oil price development – Down-to-Earth

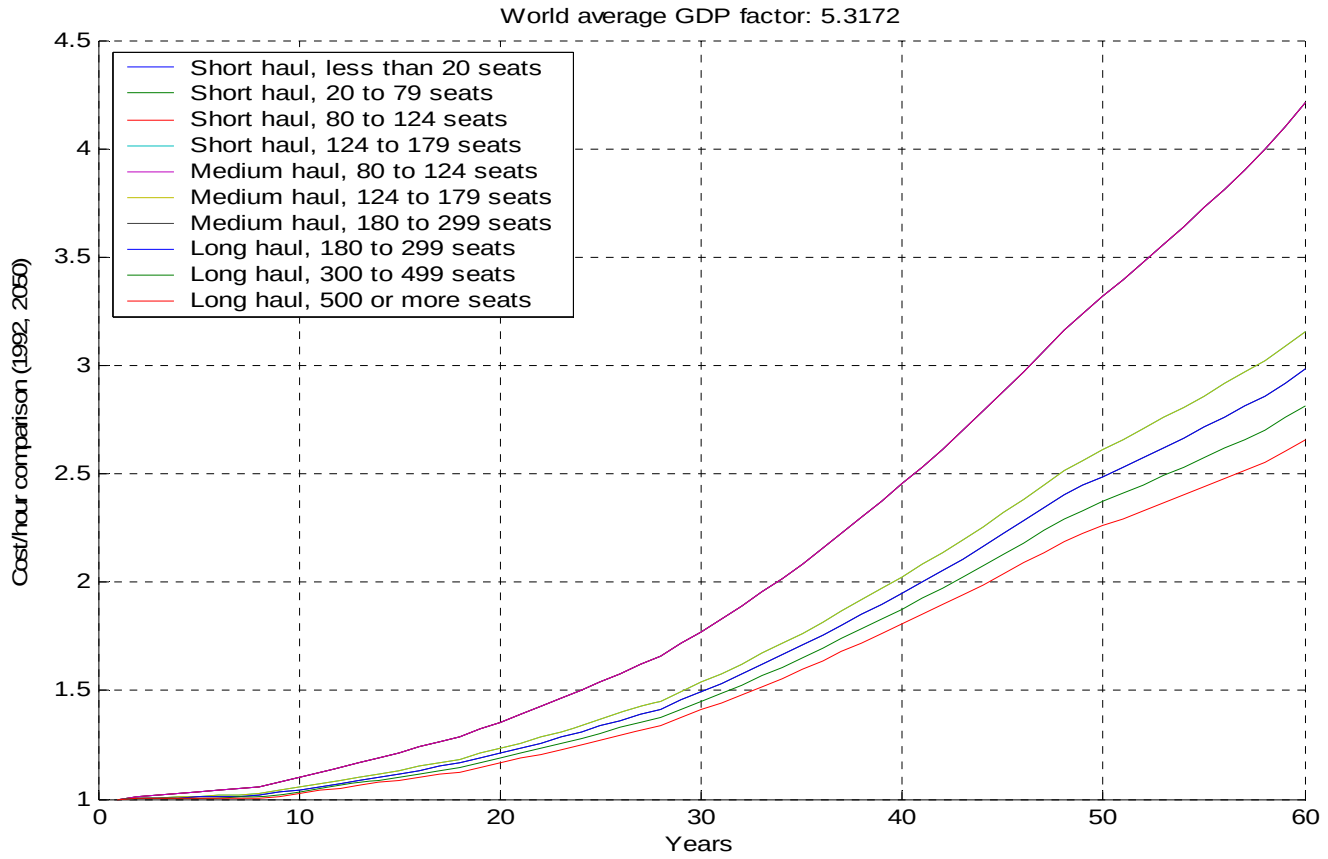


CONSAVE approach:

Crude Oil prices, resources and production



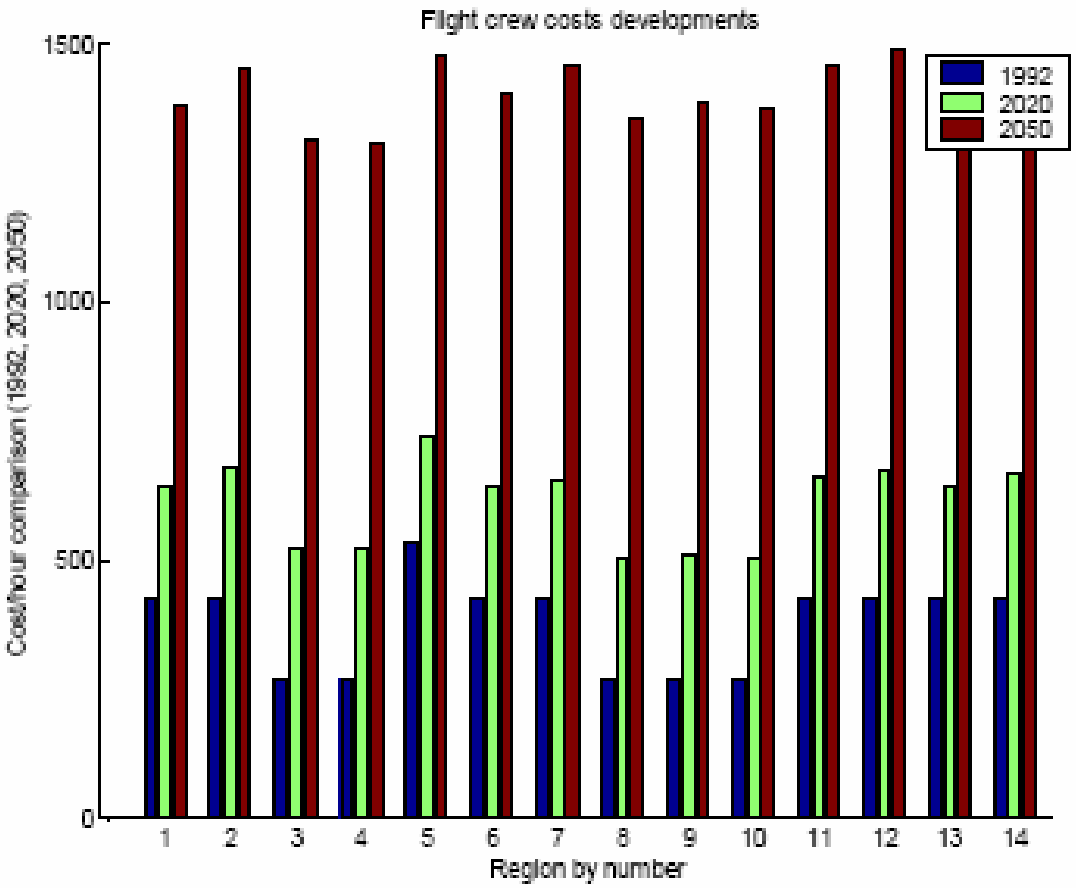
Assumptions about aircraft new price increase



Aircraft new price increase as a function of years beyond 1992 for the Unlimited Skies scenario. Impact of technology (beyond a reference rate) is not included.

Assumptions about Flight crew costs

per flying hour for Unlimited Skies 1992, 2020, and 2050

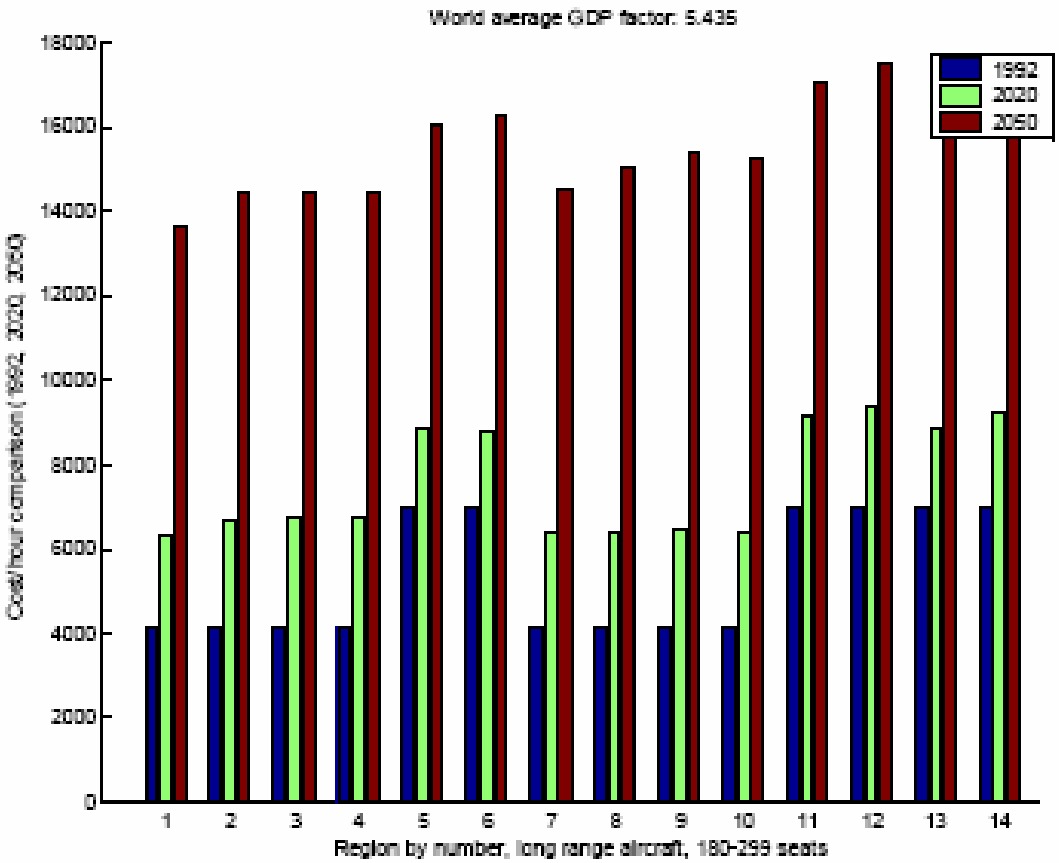


Region number and name

1 North America
2 Central America
3 South America (Northern Part)
4 South America (Southern Part)
5 EU
6 Non-Aligned Europe
7 Middle East
8 Eastern Africa
9 Western Africa
10 Southern Africa
11 Far East (North)
12 Far East (South)
13 Southwest Pacific
14 Former Eastern Bloc

Assumptions about maintenance costs

1992, 2020, 2050 for long haul aircraft with 180-299 seats for Unlimited Skies



Region number and name

1 North America
2 Central America
3 South America (Northern Part)
4 South America (Southern Part)
5 EU
6 Non-Aligned Europe
7 Middle East
8 Eastern Africa
9 Western Africa
10 Southern Africa
11 Far East (North)
12 Far East (South)
13 Southwest Pacific
14 Former Eastern Bloc

Ranges of assumptions for the scenario year 2020 made in different studies

Scenario Drivers	Maximum	Source	CONSAVE Scenarios				Minimum	Source
			High Growth		Fractured World	Down to Earth		
			Unlimited Skies	Regulatory Push&Pull				
Population [billion]	8.0	UN 2002	7.5		8.2	7.5	7.1	UN 2002
Economic growth rates (p.a.)	3.9%	IPCC SRES A1	3.9%	3.8%	2.3%	3.3%	2.0%	International Energy Outlook - Scenario C (EIA 2001)
World GDP-mer (trillion $)	58	International Energy Outlook 2003	57	56.4	40	53	40	Global Energy Perspectives - B
Energy use [EJ]	730	International Energy Outlook - Scenario B (EIA 2001)	700	610	600	580	430	Faktor 4-Szenario
Ratio of global oil production (1990=1)	1.7	US DoE 1999	1.3		2.2	1.5	0.9	Global Energy Perspectives - C
Crude oil price (1990=1)	no value found		1.5	2	4	2	1	U.S. Department of Energy 2001
Zero-carbon energy rate	27%	Global Energy Perspectives - C	15%	20%	regional differences	20%	20%	Global Energy Perspectives - A
Air Transport Demand Index (1990=1)	3.3	CAEP/4 - FESG Report 4, 1998 - Fe	3.2	2.6	2.0	1.9	2.2	CAEP/4 - FESG Report 4, 1998 - Fc
Fuel Efficiency Change	-20%	Scientific Advisory Board of the German Ministry of Transport	-10 to -20% below 2000 level (0.75% reduction p.a.)		2020: -10 to -20% below 2000 level (-0.75% p.a.); N.America: -2% p.a. after 2020; Eurasia & Far East: -1% p.a.	+10% c.f. 2000 levels (+0.5% increase p.a.)	12% below 1999 levels	IPCC 1999
LTO NOx Levels	50% below CAEP/2 levels	IPCC 1999	45% of 2000		N.America - gradual increase to 2x 2000 levels (+11.5% p.a.); Eurasia & Far East - maintain 2020 tech levels; Middle East - 2010 to 2020 aircraft mean levels; Subcontinent, Unaligned Regions - post-2000 aircraft mean levels	30% of 2000	4% below CAEP/2 levels	IPCC 1999
Noise Reduction	- 10 dB	Scientific Advisory Board of the German Ministry of Transport	10 dB reduction by 2020				-4dB'	Based on 2.2x traffic increase to keep current noise levels
Fleet Lifespan (in years)	35	IPCC 1999	<30	<25	NAmerica, Eurasia, Far East <20; All other regions >30	<20	25	IPCC 1999
Aircraft Size Growth	1% per year	Airbus 2003	large		large	large	0,2% per year (until 2015)	ICAO 2004
CO2 Emissions [billion kg pa]	300	IPCC 1999 - Scenario Ecb	906.5	748.9	622.6	624.9	850	IPCC 1999 - Scenario Eeh

Ranges of assumptions for the scenario year 2050 made in different studies

Scenario Drivers	Maximum	Source	CONSAVE Scenarios				Minimum	Source
			High Growth		Fractured World	Down to Earth		
			Unlimited Skies	Regulatory Push&Pull				
Population [billion]	12.8	UN 2002	8.7		11.3	8.7	7.4	UN 2002
Economic growth rates (p.a.)	3.9%	IPCC SRES A1	3.9%	3.8%	2.3%	3.3%	1.2%	IPCC IS92c
World GDP-mer (trillion $)	196	Shell 2001	180	174.6	82	136	72.8	Global Energy Perspectives - B
Energy use [EJ]	1121	Shell - Spirit of the Coming Age	1350	1100	970	810	434	Faktor 4-Szenario
Ratio of global oil production (1990=1)	2.6	Global Energy Perspectives - A 1	2.2		1.7	1.5 - 1.8	0.8	Global Energy Perspectives - C 2
Crude oil price (1990=1)	no value found		2	4	8	4	no value found	
Zero-carbon energy rate	43%	Global Energy Perspectives - C1	33%	40%	regional differences	30%	27%	Global Energy Perspectives - A 2
Air Transport Demand Index (1990=1)	21.0	EDF Scenario IS92e High (Eeh)	10.4	7.2	3.4	2.0	3.9	CAEP/4 - FESG Report 4, 1998 - Fc
Fuel Efficiency Change	50% below 1999 levels	IPCC 1999	2020: -10 to -20% below 2000 level (-0.75% p.a.), -1.5% p.a. after 2020		2020: -10 to -20% below 2000 level (-0.75% p.a.); N.America: -2% p.a. after 2020; Eurasia & Far East: -1% p.a.	2020: +10% c.f. 2000 levels (+0.5% p.a.), -1% p.a. after 2020	30% below 1999 levels	IPCC 1999
LTO NOx Levels	70% below CAEP/2 levels	IPCC 1999	35% of 2000		N.America - gradual increase to 2x 2000 levels (+11.5% p.a.); Eurasia & Far East - maintain 2020 tech levels; Middle East - 2010 to 2020 aircraft mean levels; Subcontinent, Unaligned Regions - post-2000 aircraft mean levels	80% below CAEP/2 levels	10% below CAEP/2 levels	IPCC 1999
Noise Reduction	Possibly close to background levels outside airport	Silent Aircraft Project	10 dB reduction by 2020, further 8dB by 2050		10 dB reduction by 2020, further 3 to 8 dB by 2050 according to region	10 dB reduction by 2020, further 10dB by 2050	6dB	Based on 3.9x traffic increase to keep current noise levels
Fleet Lifespan (in years)	35	IPCC 1999	<30	<25	NAmerica, Eurasia, Far East <20; All other regions 30+	<20	25	IPCC 1999
Aircraft Size Growth	no value found		large		regional: NAmerica, Eurasia - large growth; Middle East, Subcontinent, Far east, Unaligned Regions - no change	large	no value found	
CO2 Emissions [billion kg pa]	230.6	ICAO CAEP/4 FESG 1998 Scenario Fc1	2441.6	1653.8	955	719.4	1975	IPCC 1999 - Scenario Eeh

For CONSAVE we are confident

- to be in line with respective main assumptions and results made in other recent scenario and forecast (especially demand and emissions) work
- that our set of aviation scenarios can serve as a European reference and as a future input for frame setting activities like ACARE and IPCC