Use IMAGE/TIMER for integrated assessment of energy /climate change policies in China

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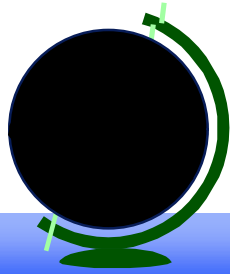

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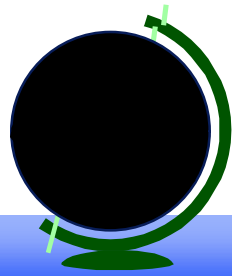
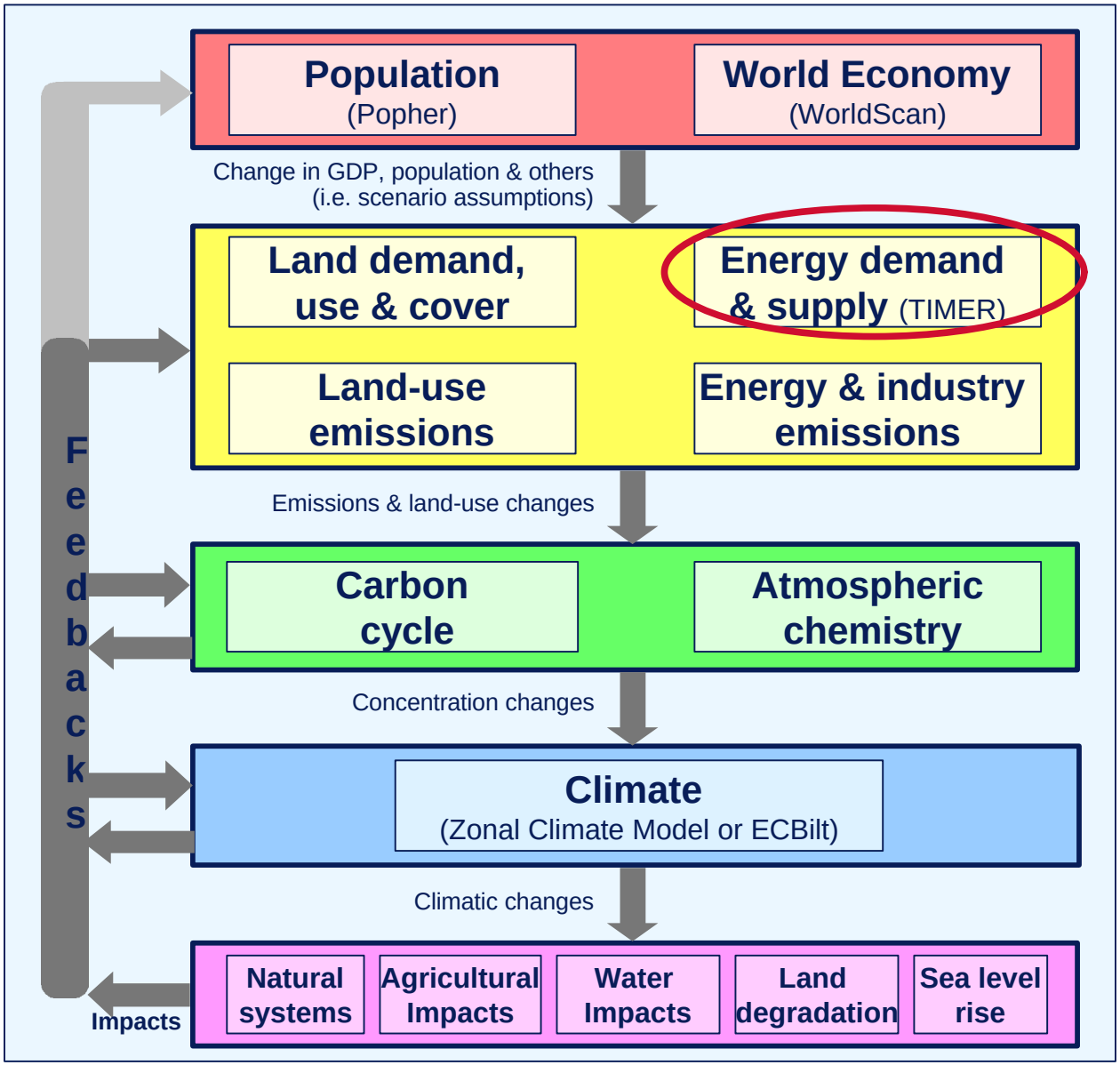
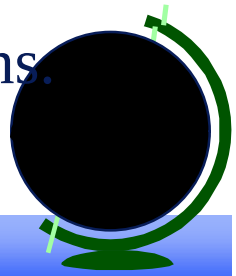


IMAGE 2.2: Framework of models and Linkages

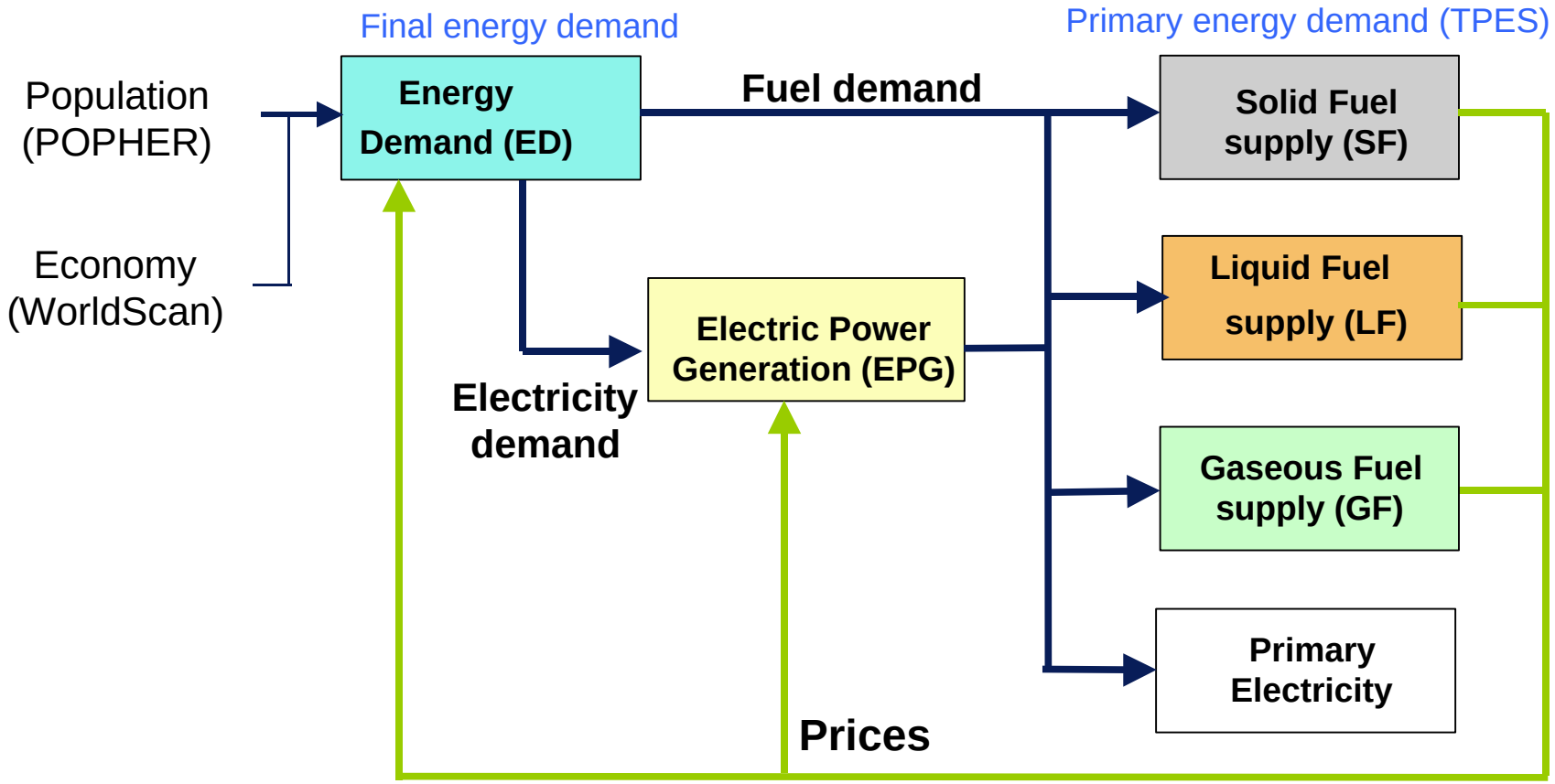


Main Features TIMER

- a 'system dynamics' simulation model, with endogenous trade and endogenous learning
- Demand based on structural change and autonomous and price-induced changes in energy intensity
- Exploitation dynamics of fossil fuels based on depletion and learning dynamics;
- Price-based substitution of biofuels which are assumed to be subject to learning as well as depletion dynamics;
- electric power generation based on thermal power plants and nucluar and solar/wind alternatives based on relative costs and learning;
- trade of fossil fuels and biofuels between the 17 world regions.

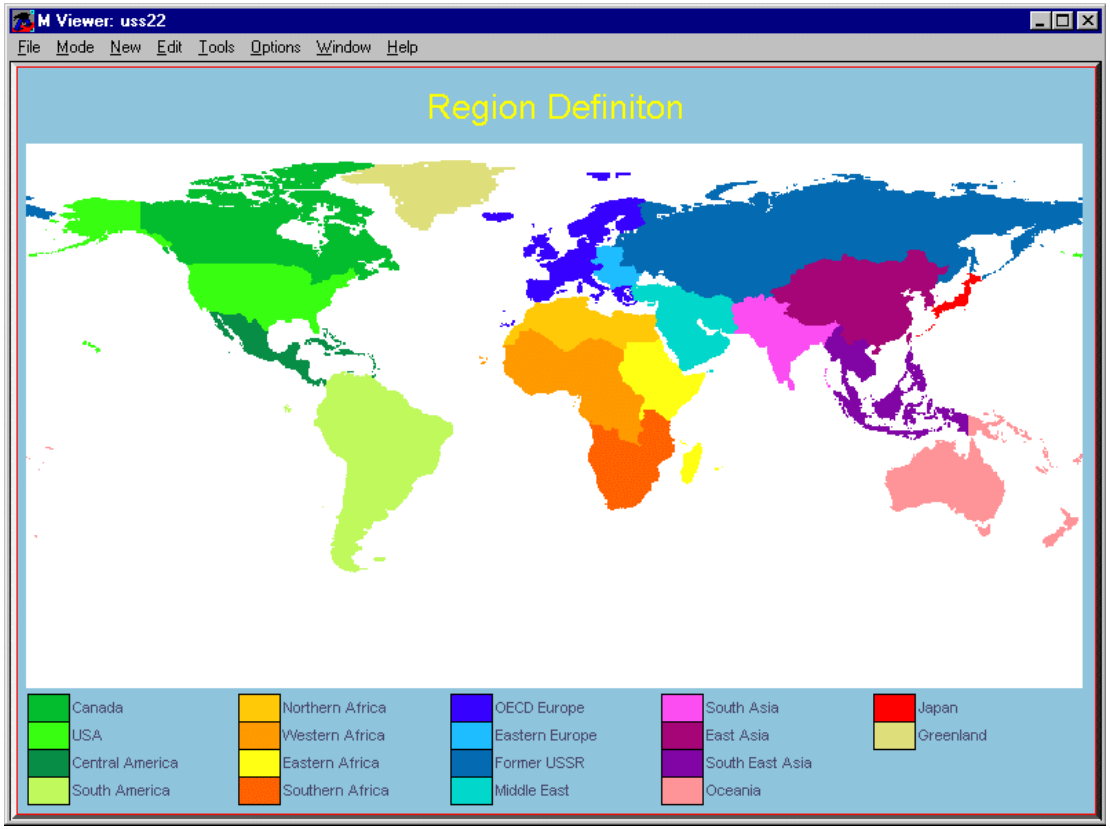


TIMER Model : five submodels



Model dimensions

17 World regions
/ countries



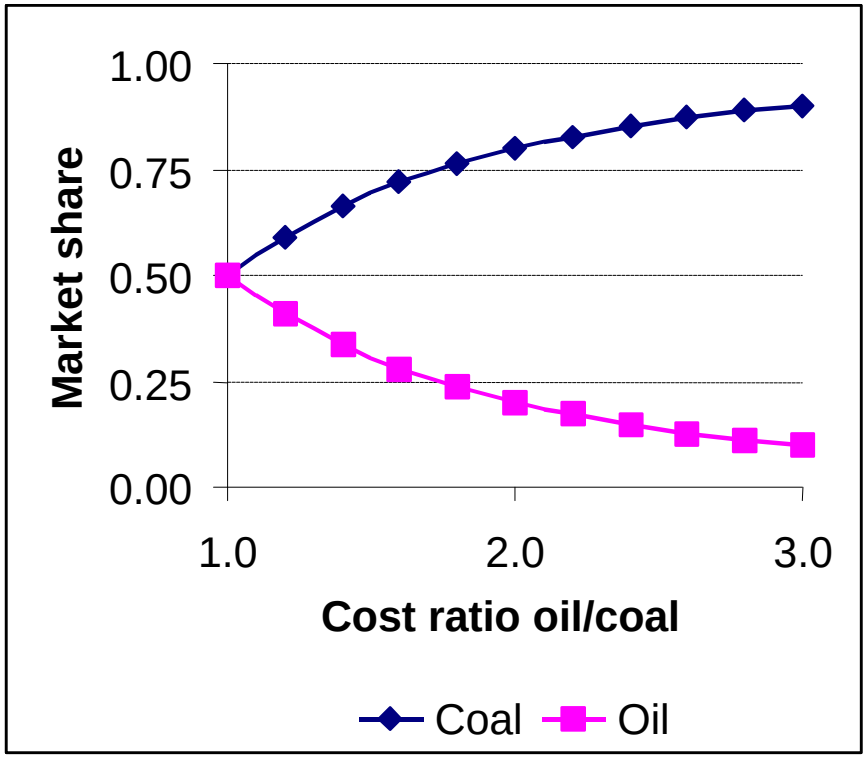
Energy carriers:

- Oil
- Natural gas
- Coal
- Traditional biomass
- Modern biomass
- Renewable electricity
- Nuclear
- Hydro

5 end-use sectors: industry, transport, residential, services, other

No feedback from energy system to economic system

Market shares of fuels

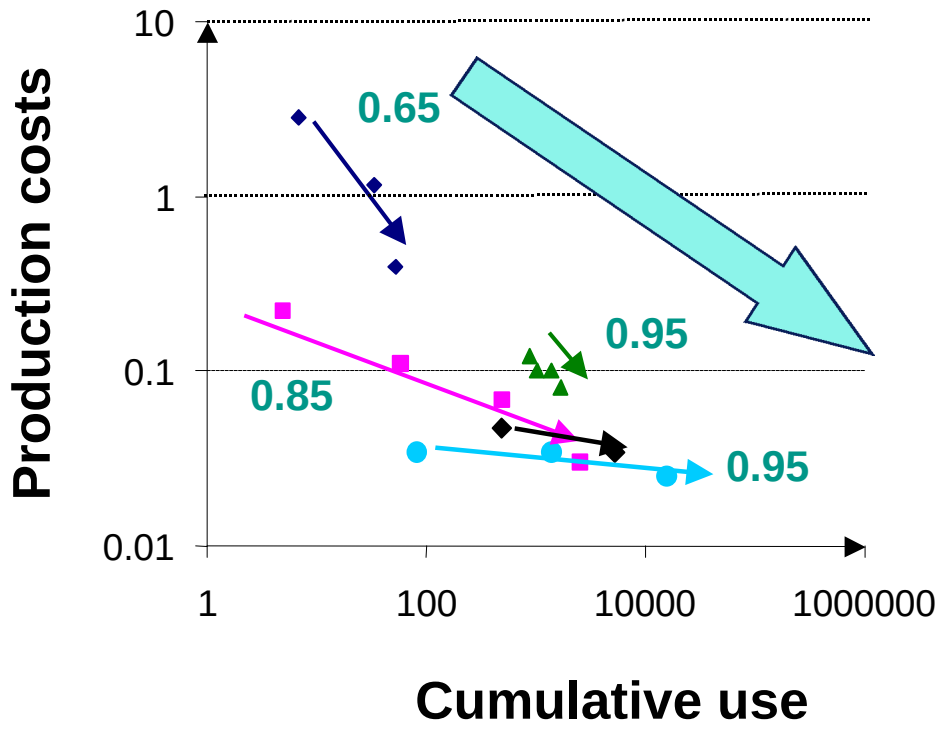


$$IMS_i = \frac{a * p_i^{-\lambda}}{\Sigma\, a * p^{-\lambda}}$$

Market allocation based on multi-nomial logit function and a combination of market prices/costs (p) + premium values/preferences (a).

The latter includes non-price factors determining market shares, in particula preferences.

Learning curves for technology development



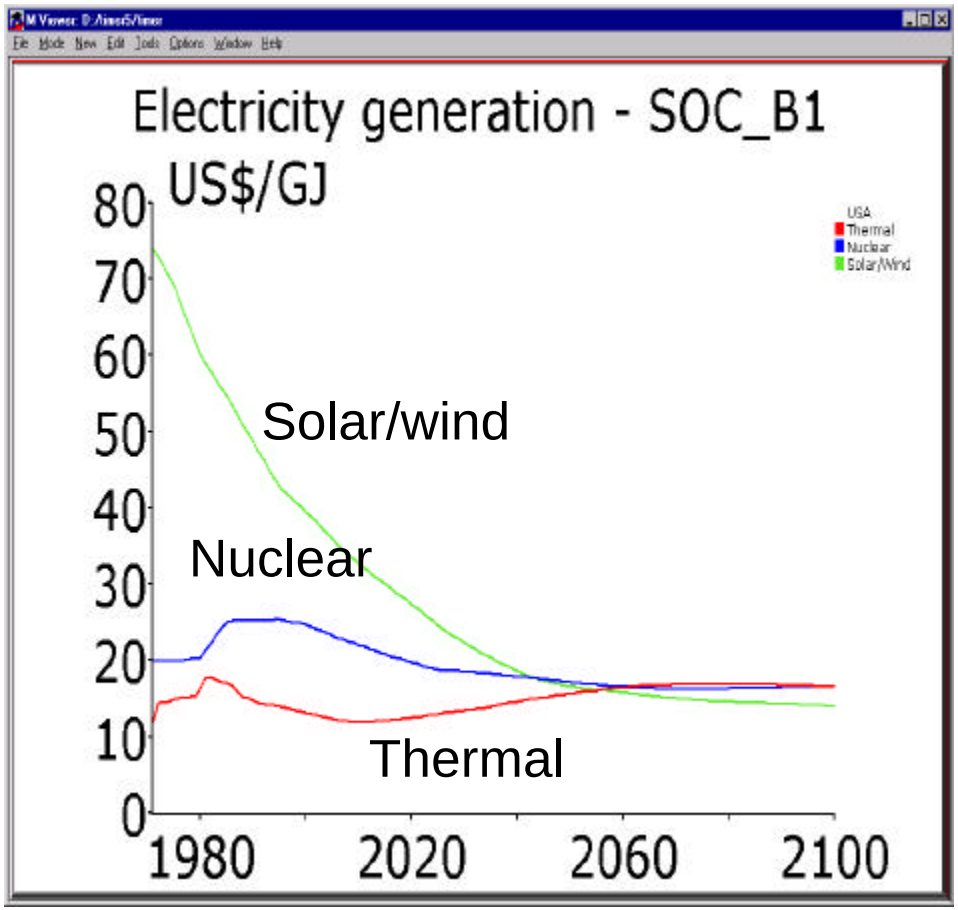
Graph shows historic data; concept used in model.

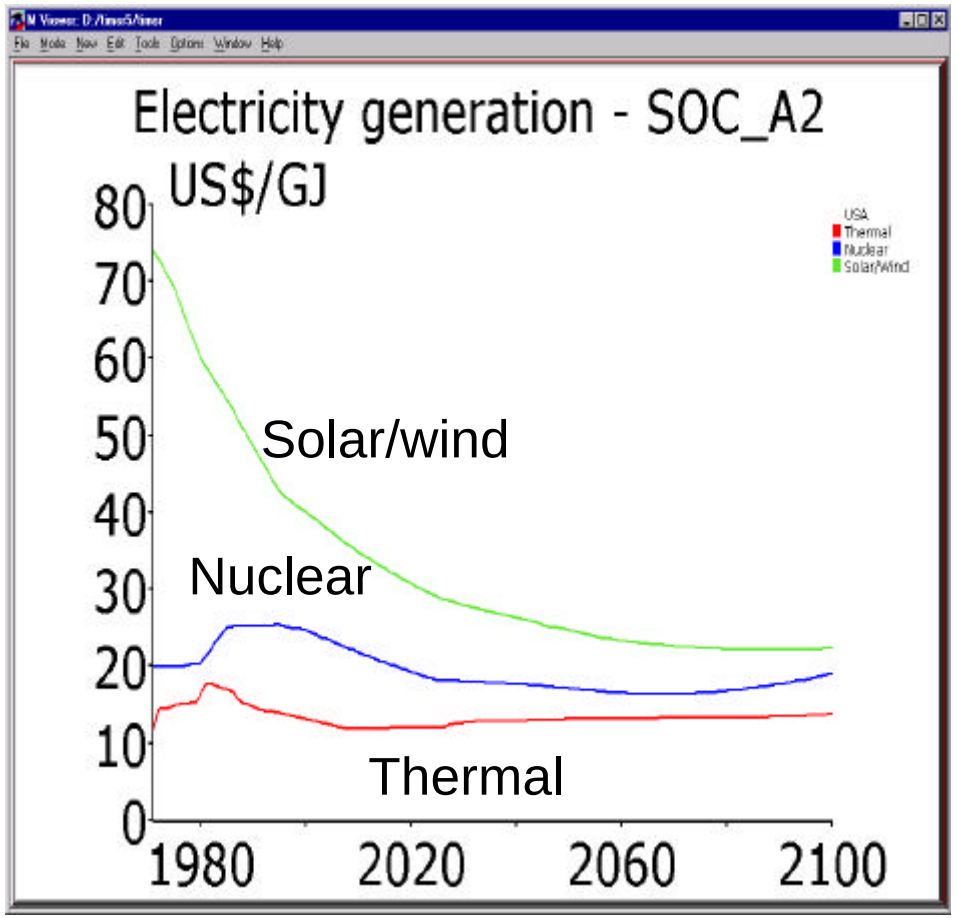
Electric technologies, EU 1980-1995

- Solar
- Wind
- Biomass
- Natural gas Combined Cycle
- Advanced Coal

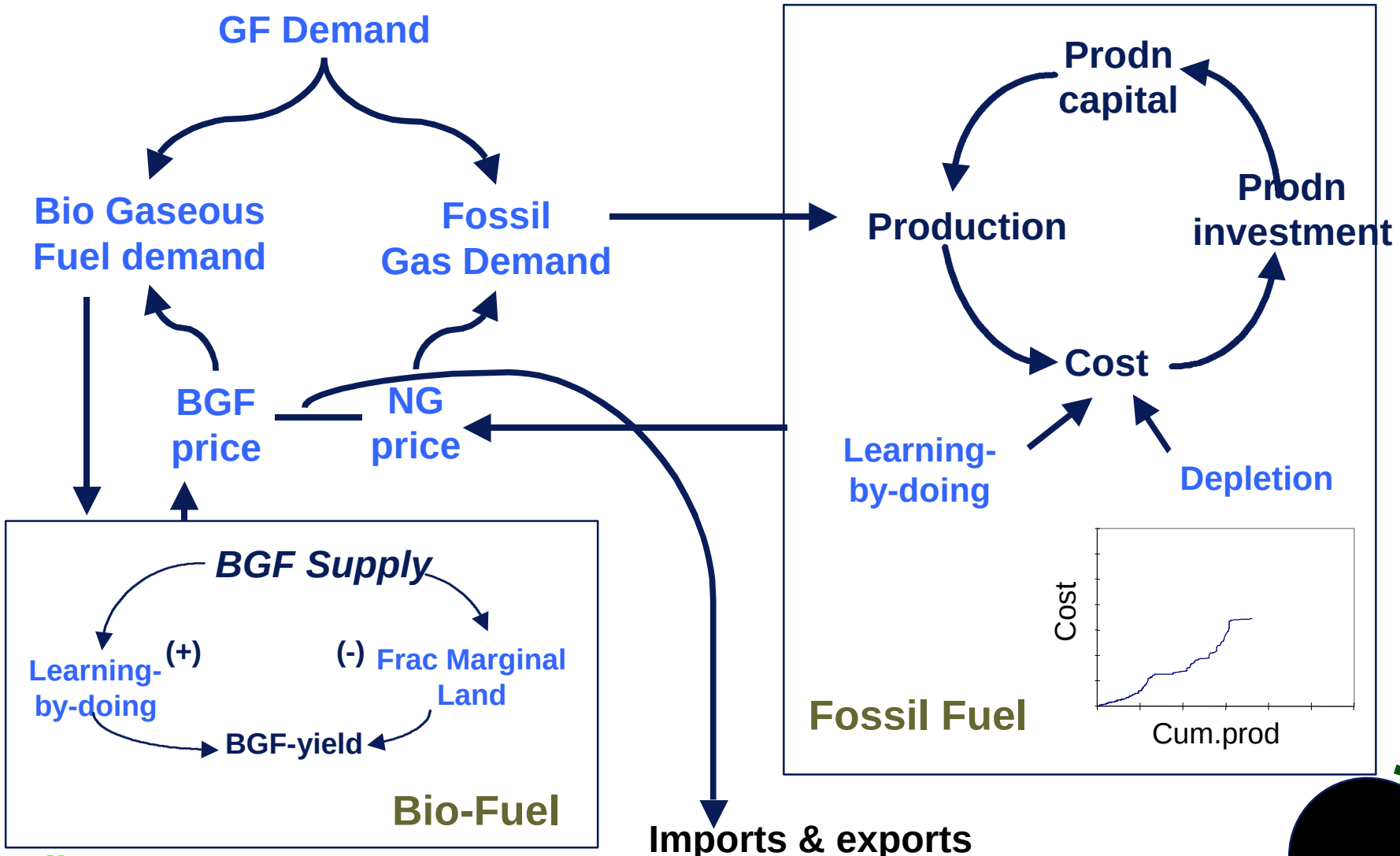
- Learning-by-doing (= decreasing production costs along with cumulative output) could reduce mitigation costs significantly.
- Learning coefficients obviously uncertain.

Generation costs





TIMER : Production models



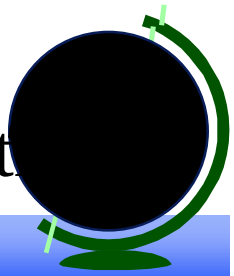
2. SRES-IMAGE baseline scenarios

Storyline-based scenario approach:

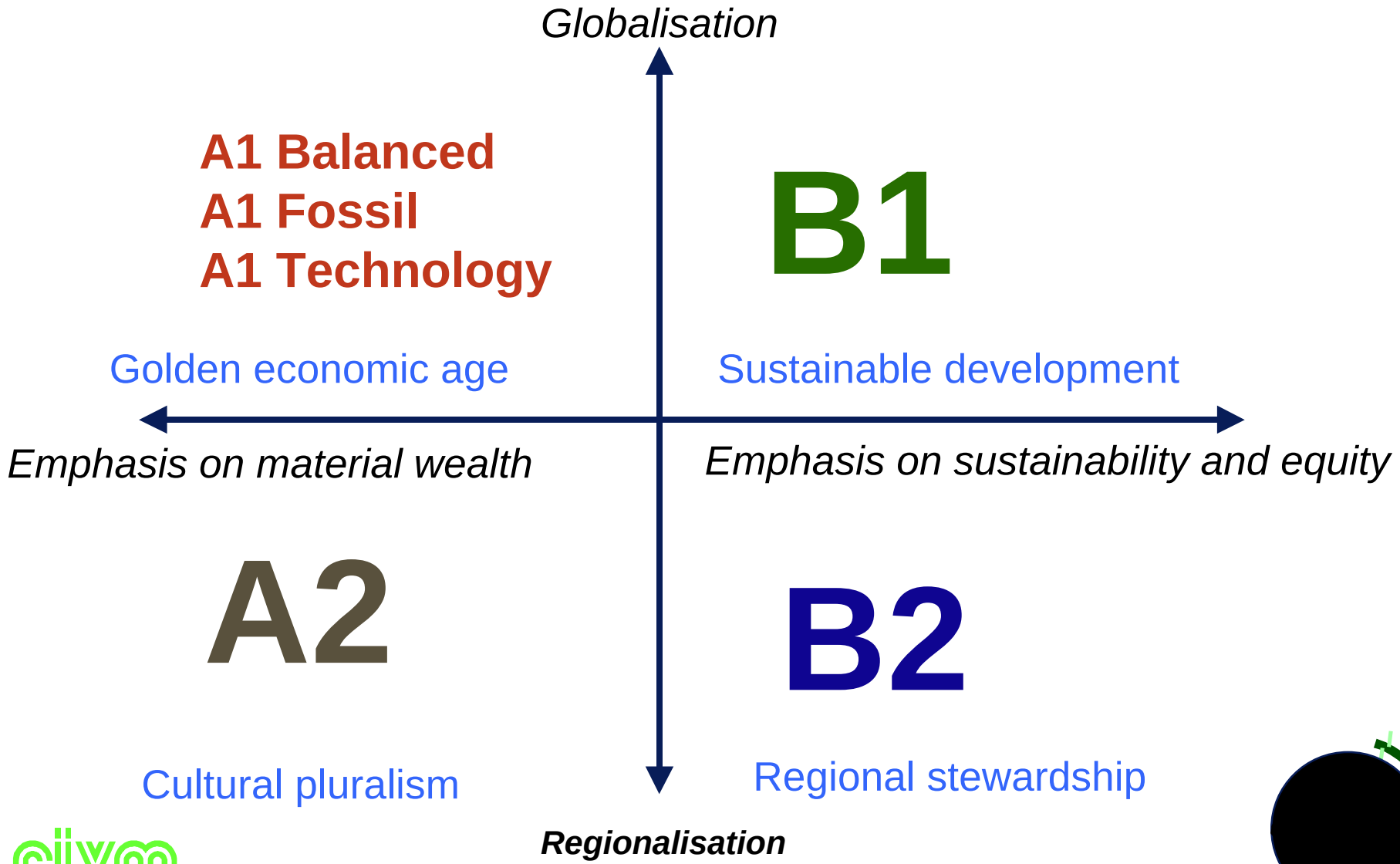
- Will the world be characterised by
  - Globalisation or regional emphasis ?
  - Interest in environmental/equity issues or materialism ?

SRES: IPCC project by 6 modelling teams.

Here: IMAGE 2.2 implementation
(IMAGE 2.2 CD-ROM available next mont



What are the IPCC SRES scenarios?



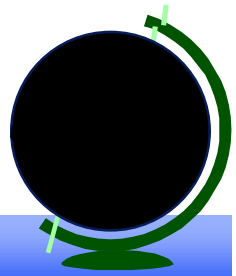
3. Baseline scenarios for China

Two storylines:

A1B (Catching-up): China continues its open-door policies. Spurred by globalisation it sees a future of high economic growth and strong technology development.

B2F (solutions for regional problems): The world emphasises local identity and stewardship of own natural resources. China chooses to focus on use of domestic coal supplies, based on clean coal technologies.

None of the storylines contains explicit climate change policy



Baseline scenarios construction for China

Scenarios for China

C1: mid population and economic increase

C2: mid population and rapid economic increase

SRES scenarios

A1B, B2

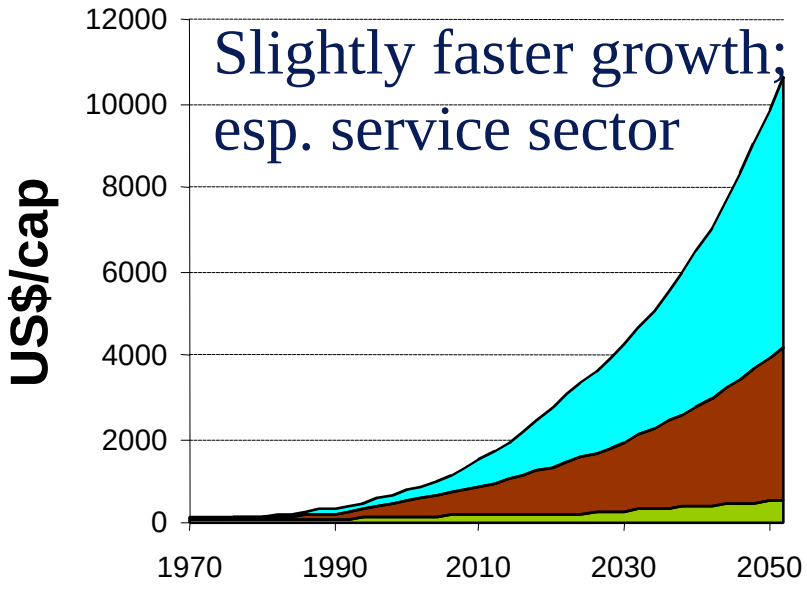
Scenarios for China under SRES framework

A1B-C2: an ‘open’ China in a globalized world

B2-C1: China oriented at solving regional environmental problems

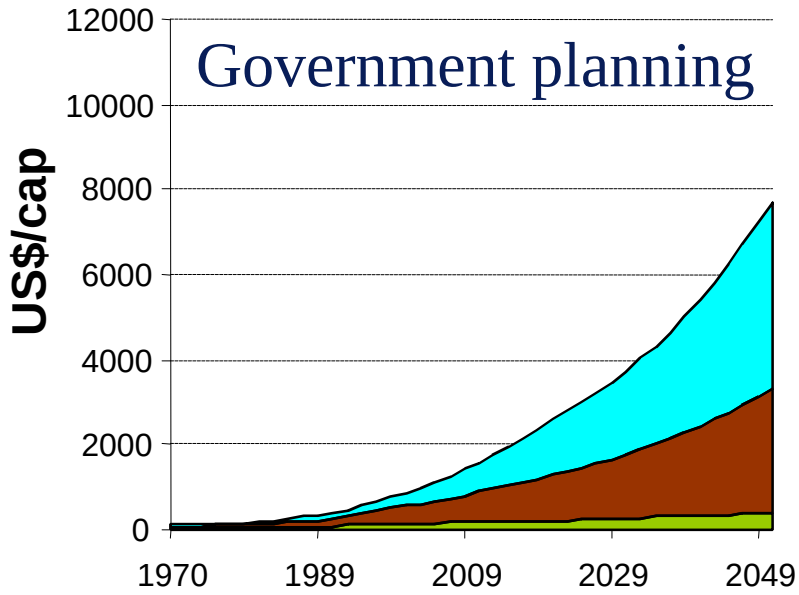
Economic growth and industrial structure

A1B-c



2000-2025: 6.9%
2025-2050: 4.5%

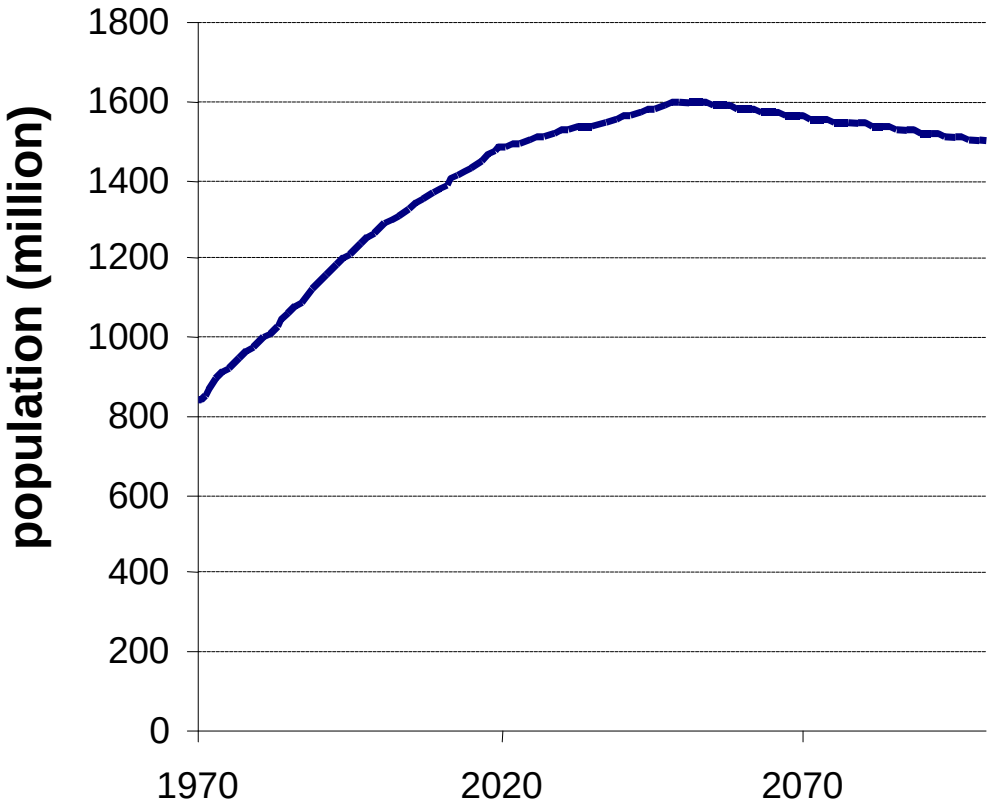
B2-c



2000-2025: 6.1%
2025-2050: 4.0%

Agriculture Services Industry

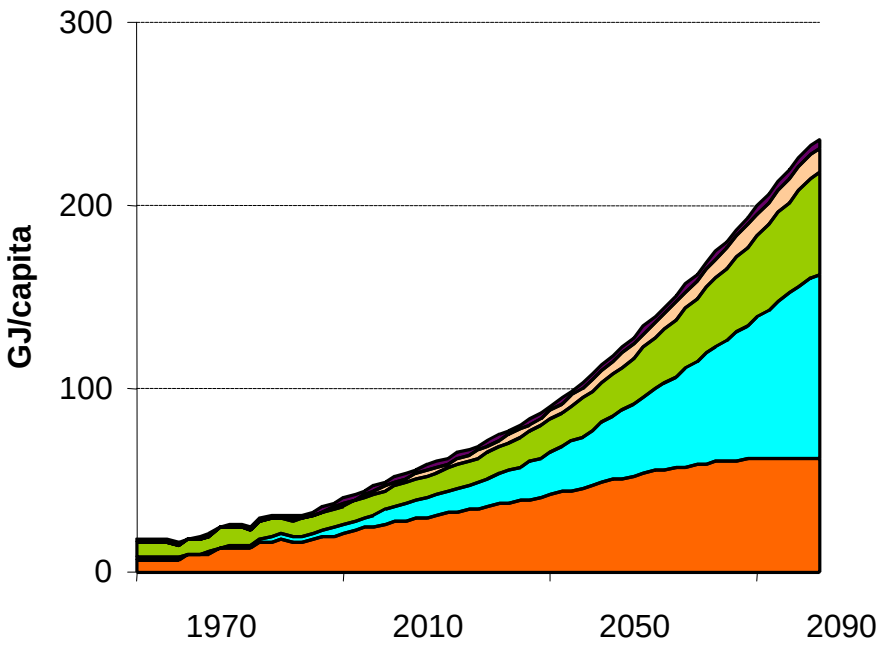
Population growth



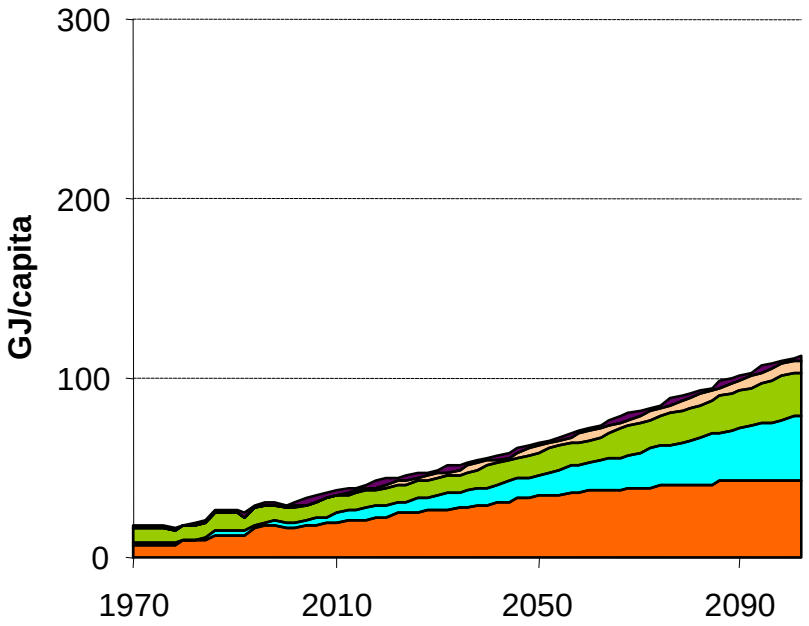
- Population grows to 1.6 billion in 2050 and slowly declines thereafter (ERI based on CASS and others).

Final energy demand by sector

A1b-C2



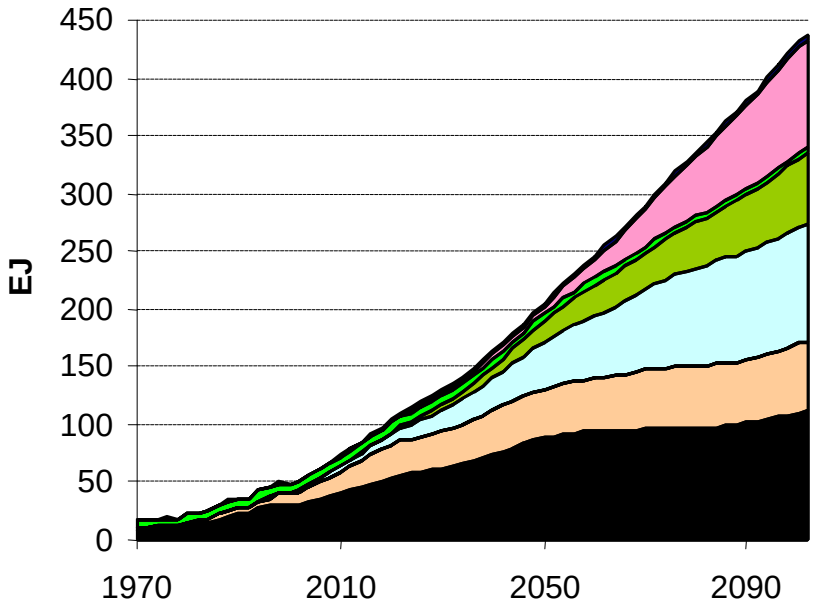
B2-C1 scenario



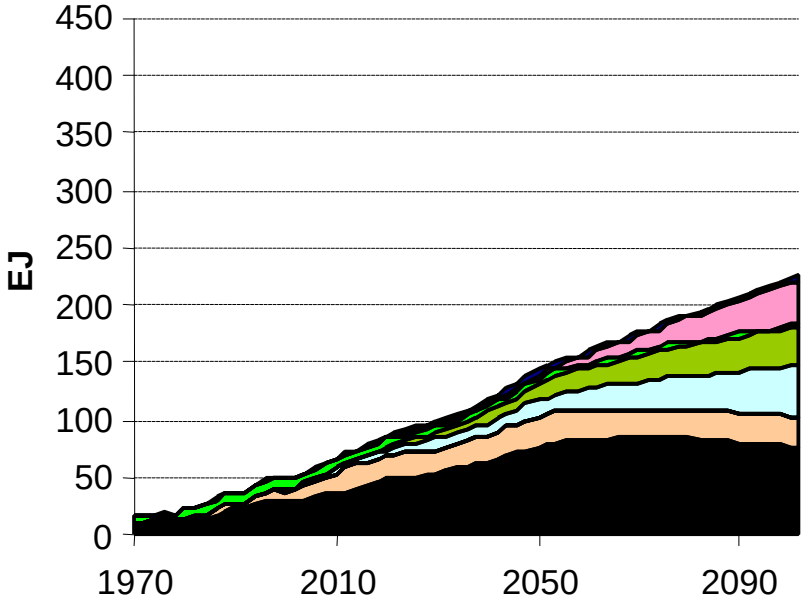
- Strong differences between the two scenarios in terms of energy demand
- Transport grows strongly

Primary energy demand of China

A1b-C



B2-C

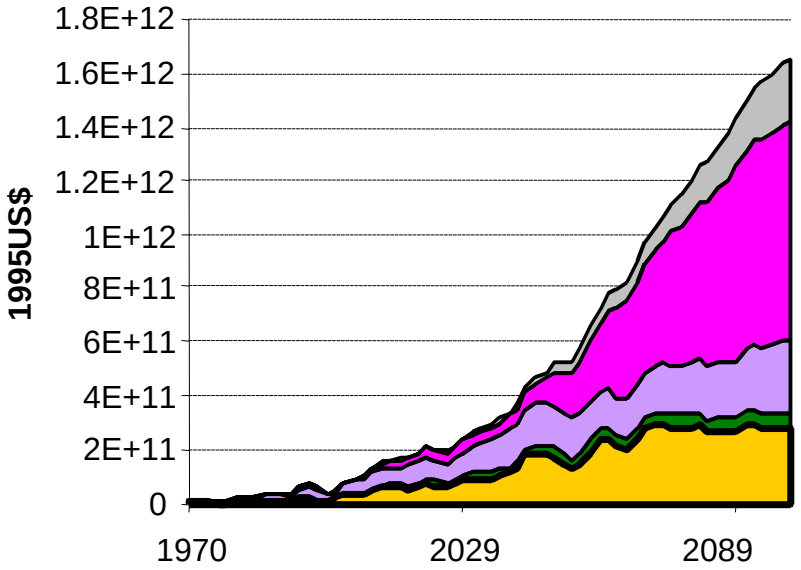


- Coal
- Oil
- NG
- Trad.biofuel
- Mod.biofuel
- Non-therm. Elec.
- Hydro

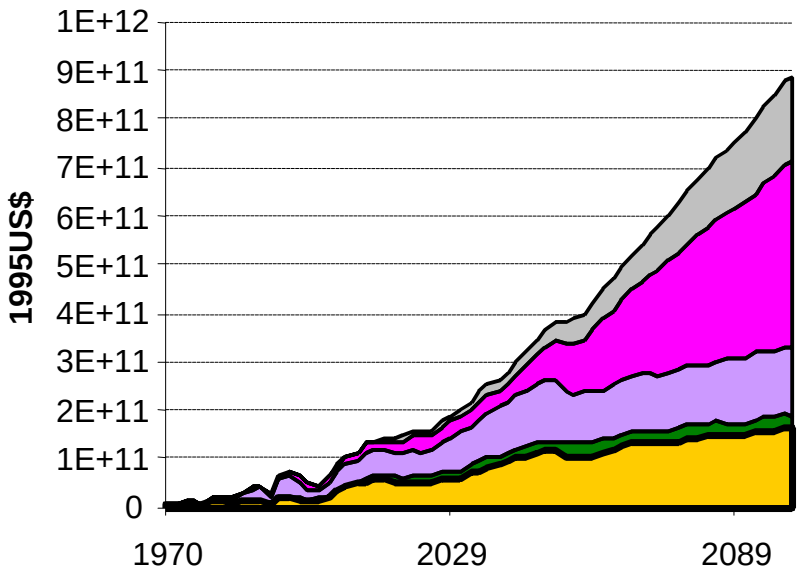
- Energy demand grows by factor 3-4 between 1995 and 2050
- Coal slowly uses market share to oil (1995-2020), natural gas (2020-205 and biomass/nuclear/renewables (2100)

Investment in energy of China

A1b-c



B2-C

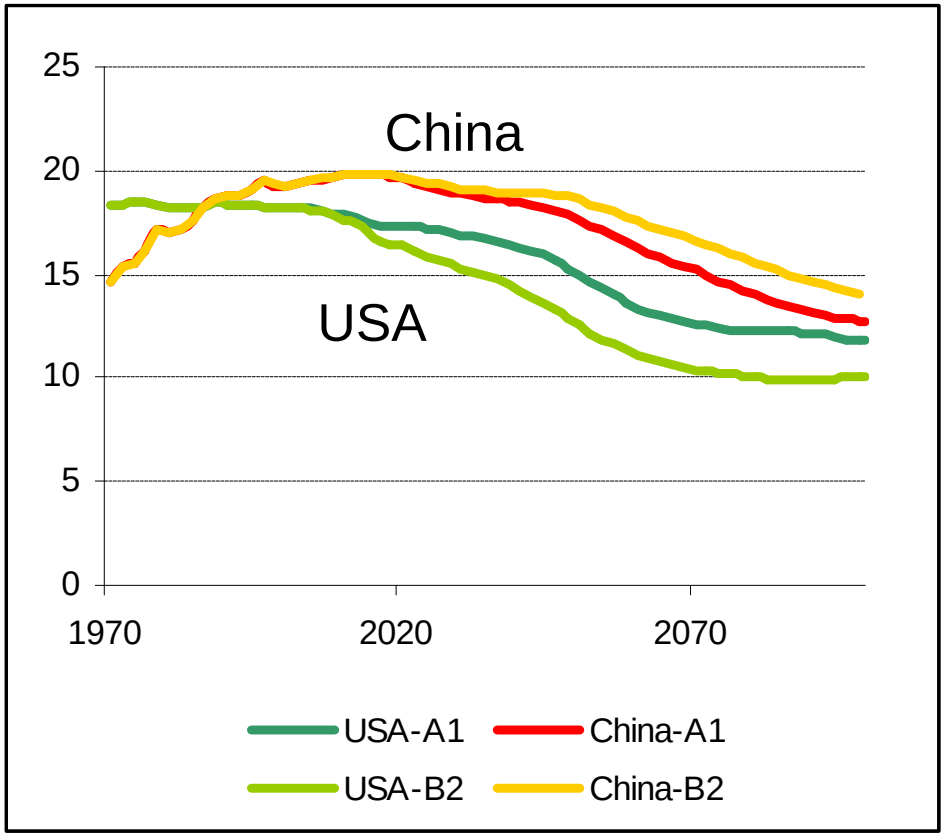


Fossil Mod. Biofuels TE&infrastructure
NTE Savings

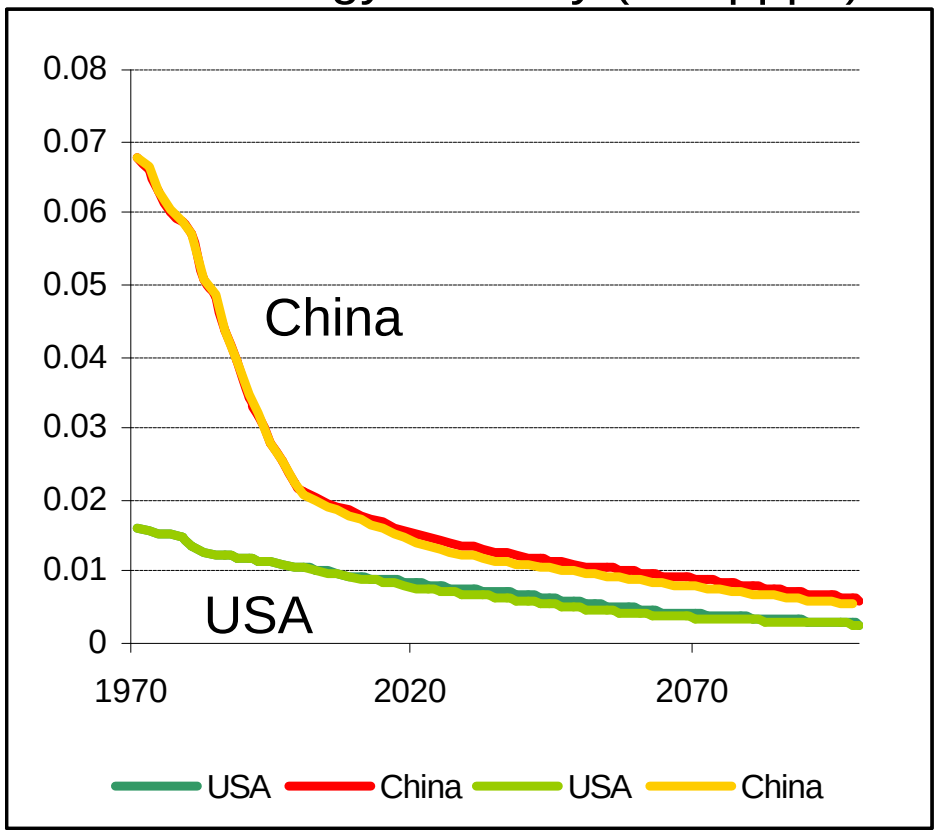
- Strong increase in investments mainly into electricity;
- Until 2020 even increase in share of GDP. After 2030 slow decline

Kaya indicators

Carbon factor (kg C/GJ)



Prim. Energy intensity (GJ/ ppp$)

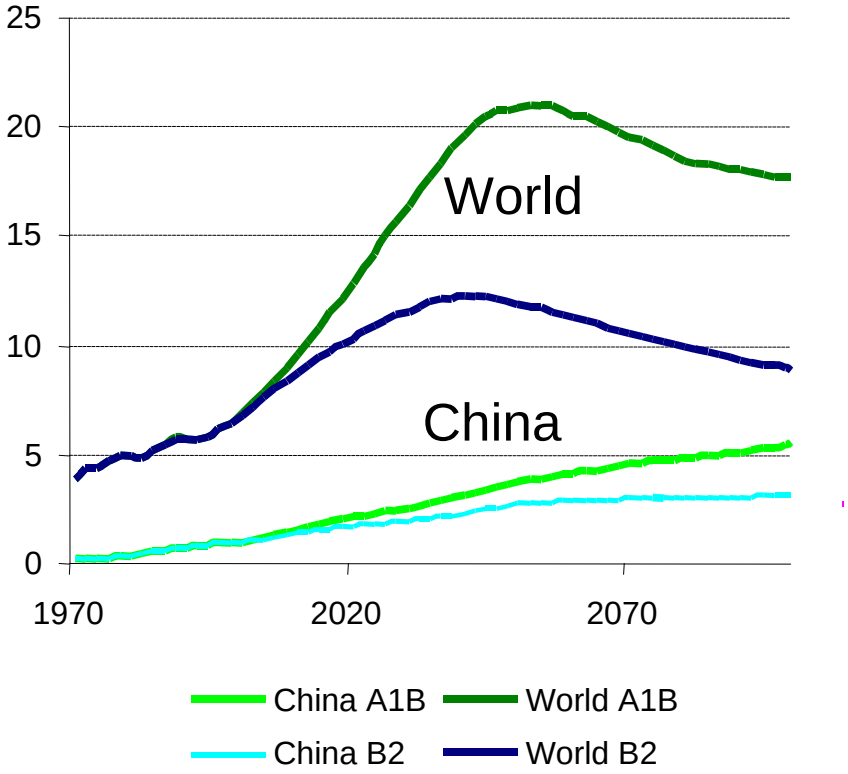


Note: includes non-commercial energy at 0 kg C/GJ

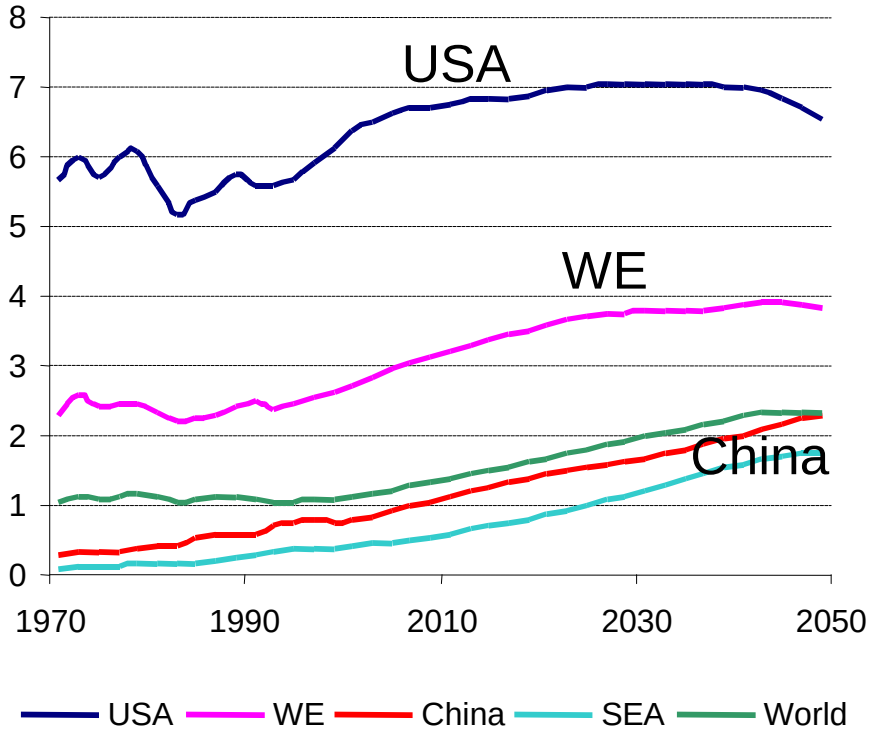
Note: alternative figures can be based on market exchange rat

Carbon emissions

Total emissions

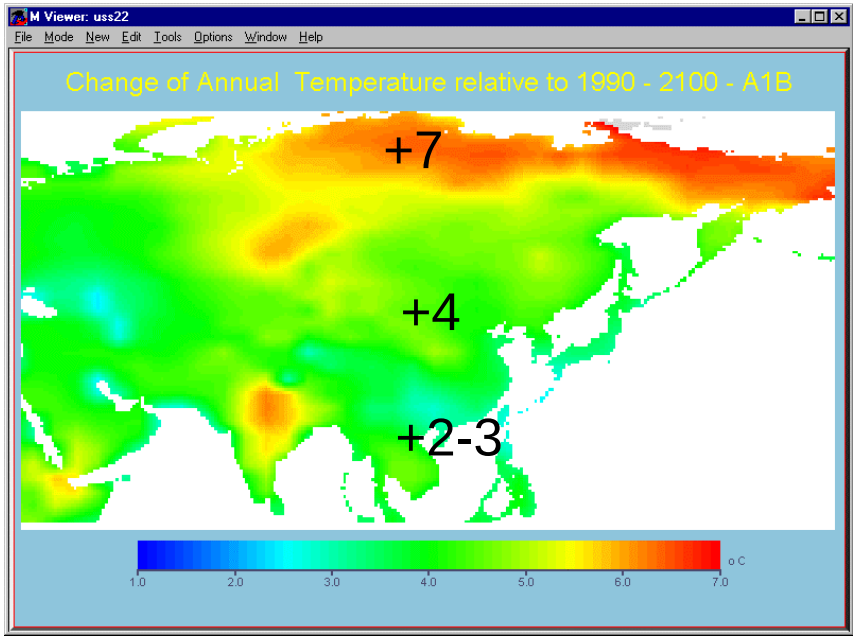


Emissions per capita



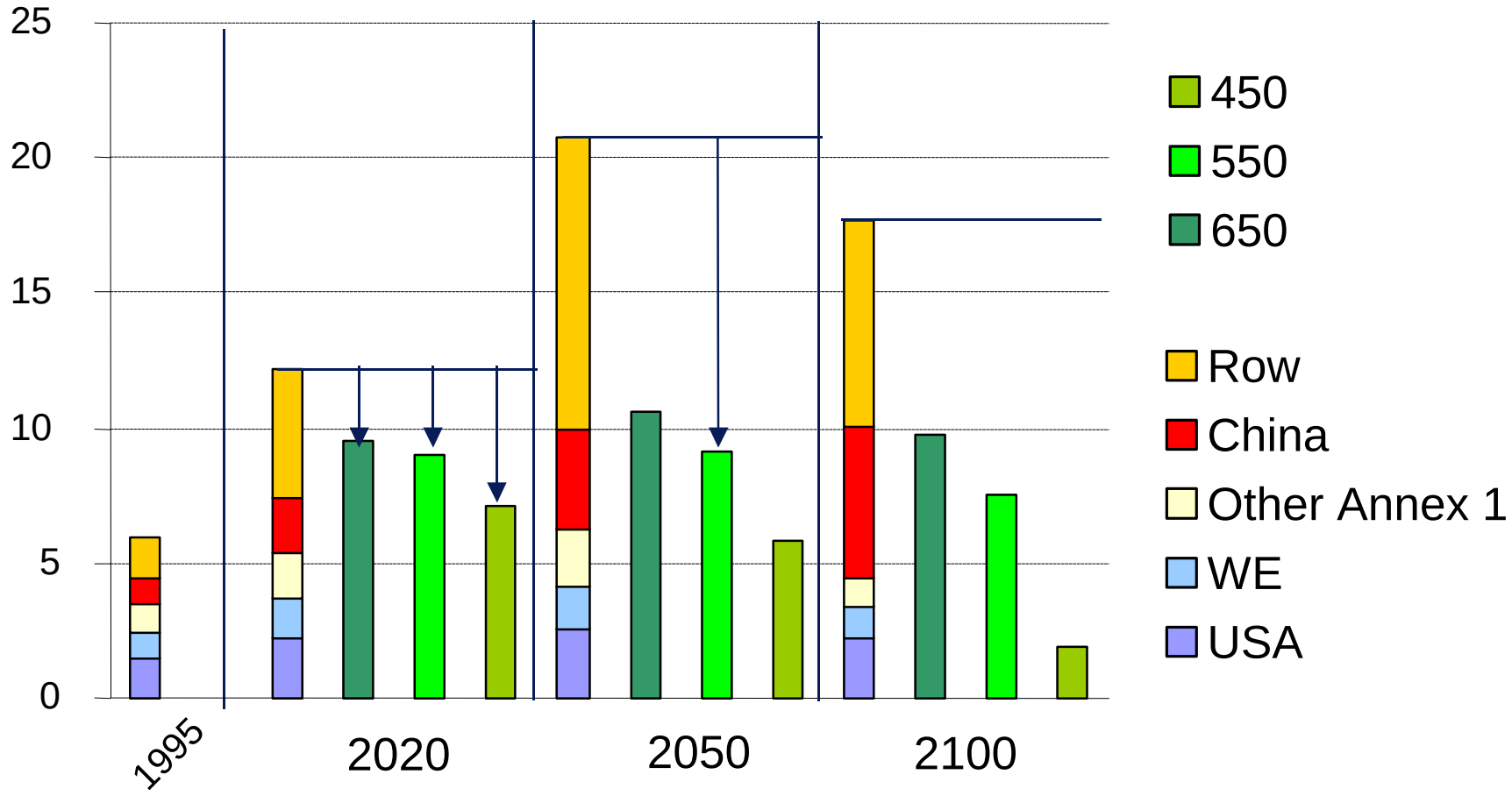
Indication of climate change impact

	carbon dioxide concentration (ppmv)			*Global average atmospheric temperature increase (^{o} C)*		
	1995	*2050*	*2100*	*1995*	*2050*	*2100*
b1	364	500	525	0.5	1.8	2.5
b2	**364**	**515**	**605**	**0.5**	**2.0**	**2.9**
a1b	**364**	**680**	**780**	**0.5**	**2.6**	**3.5**
a1f	364	700	930	0.5	2.6	3.9



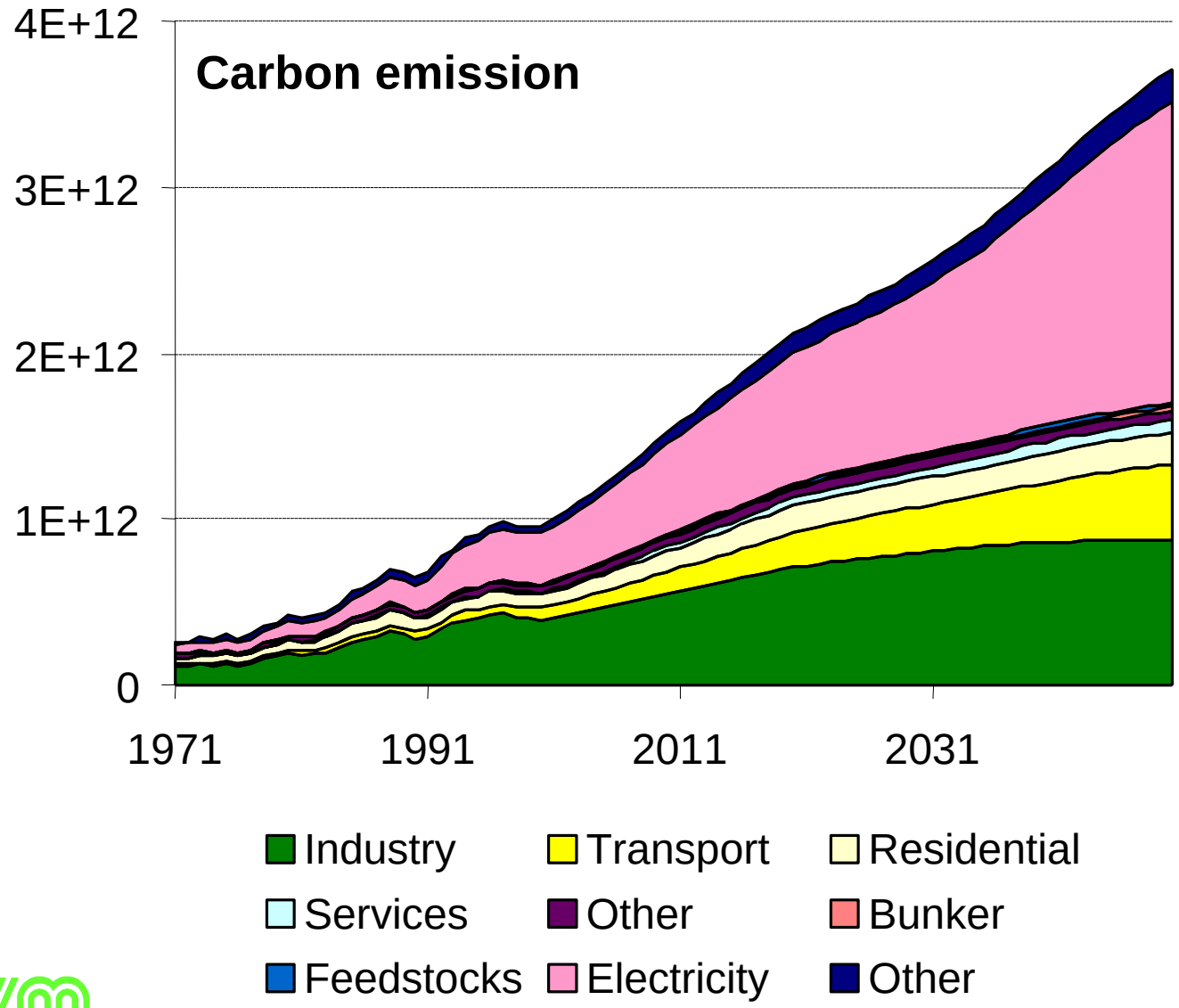
A1b in 2100; IMAGE 2.2 based on Hadley GCM

Desired emission reductions

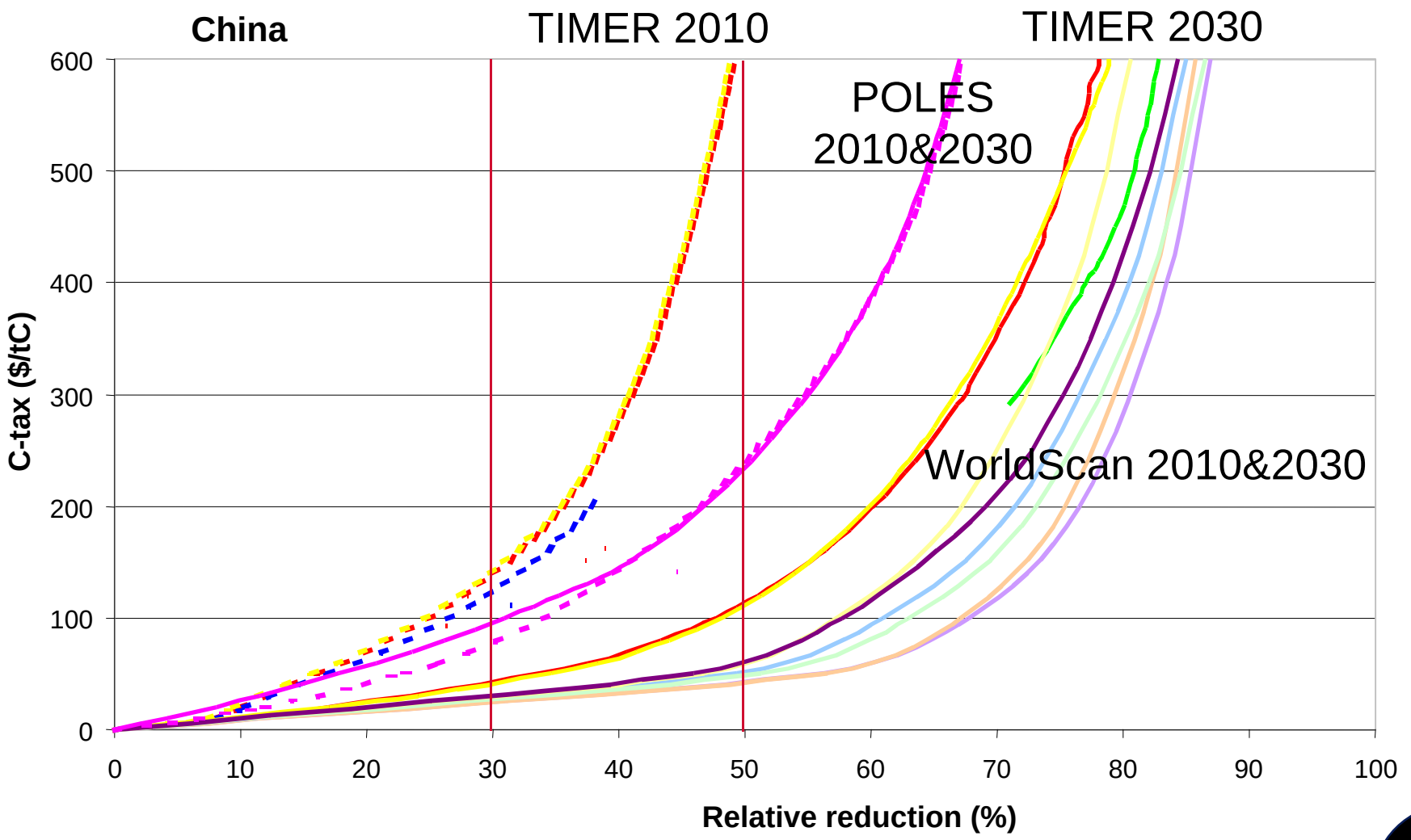


- Explore possibilities for 30-50% reduction of Chinese emissions by 2050

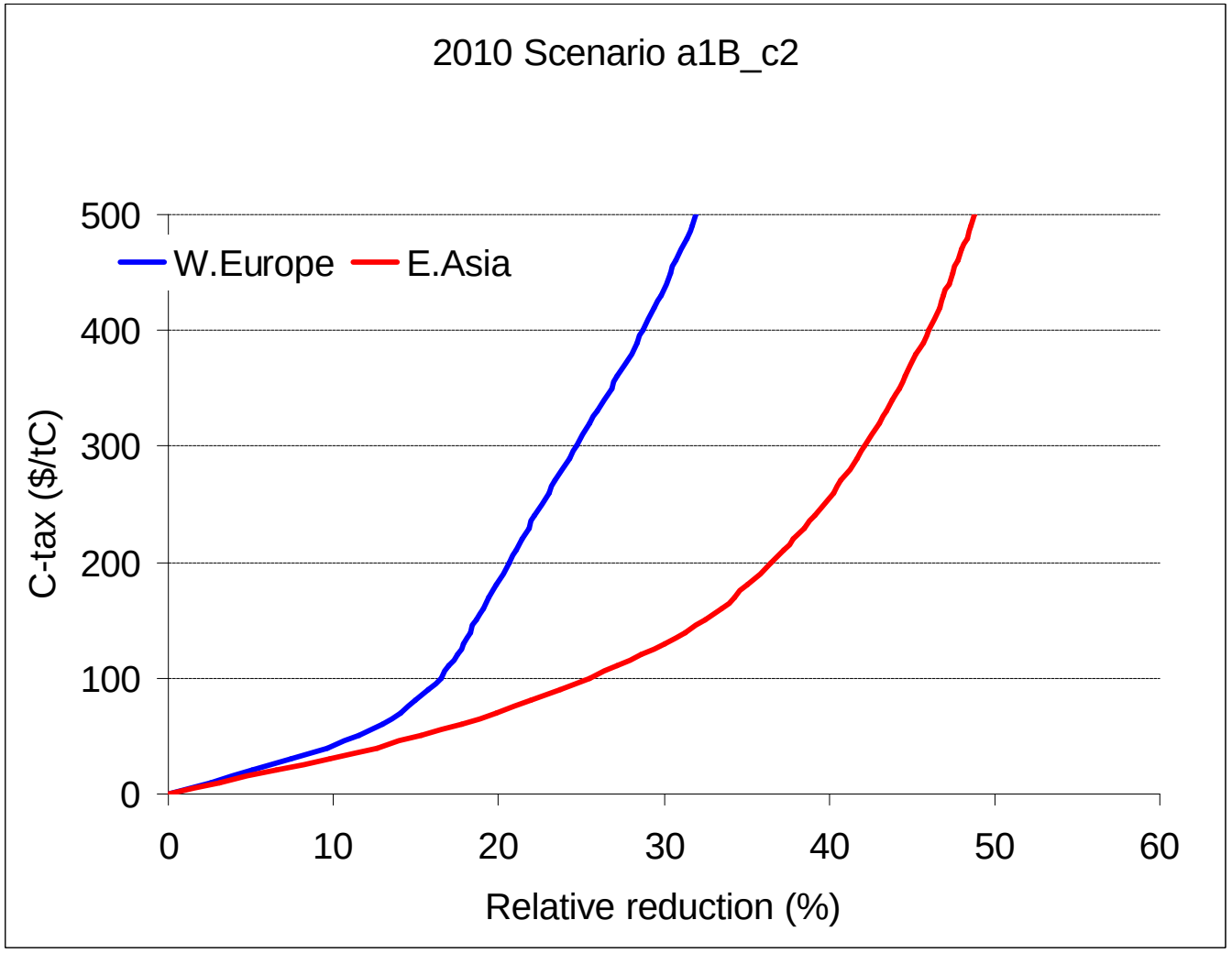
Where do the Chinese emissions come from ?



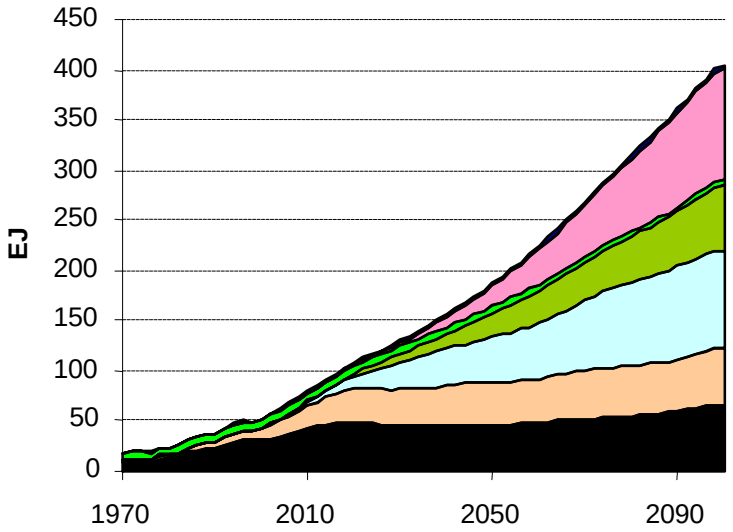
Marginal abatement curves

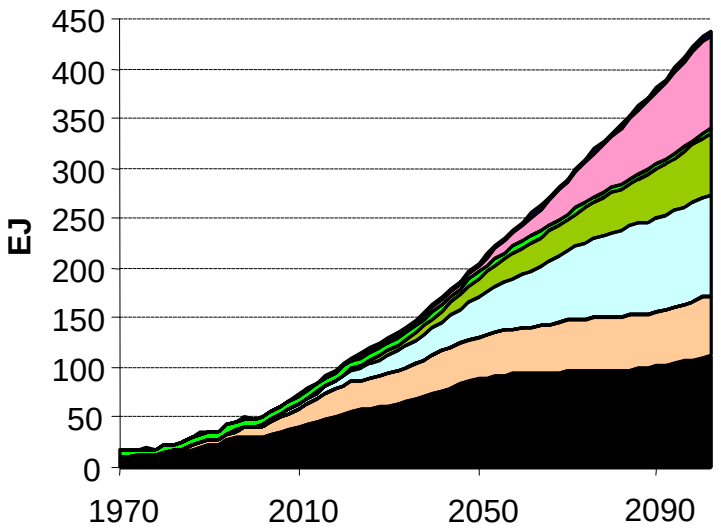


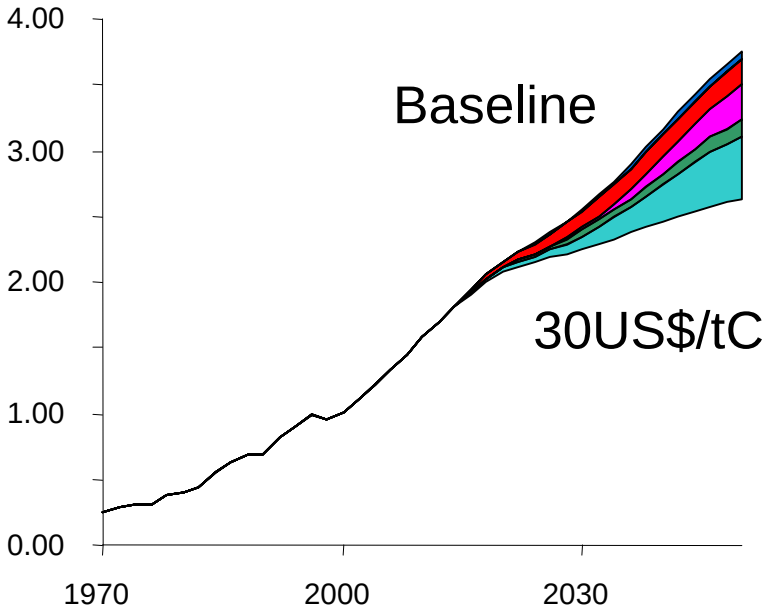
Marginal abatement curves

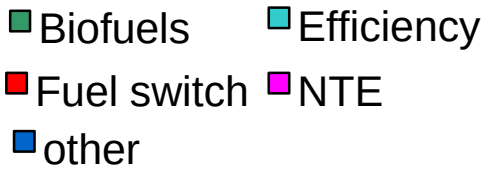


Response to 30 US$/tC









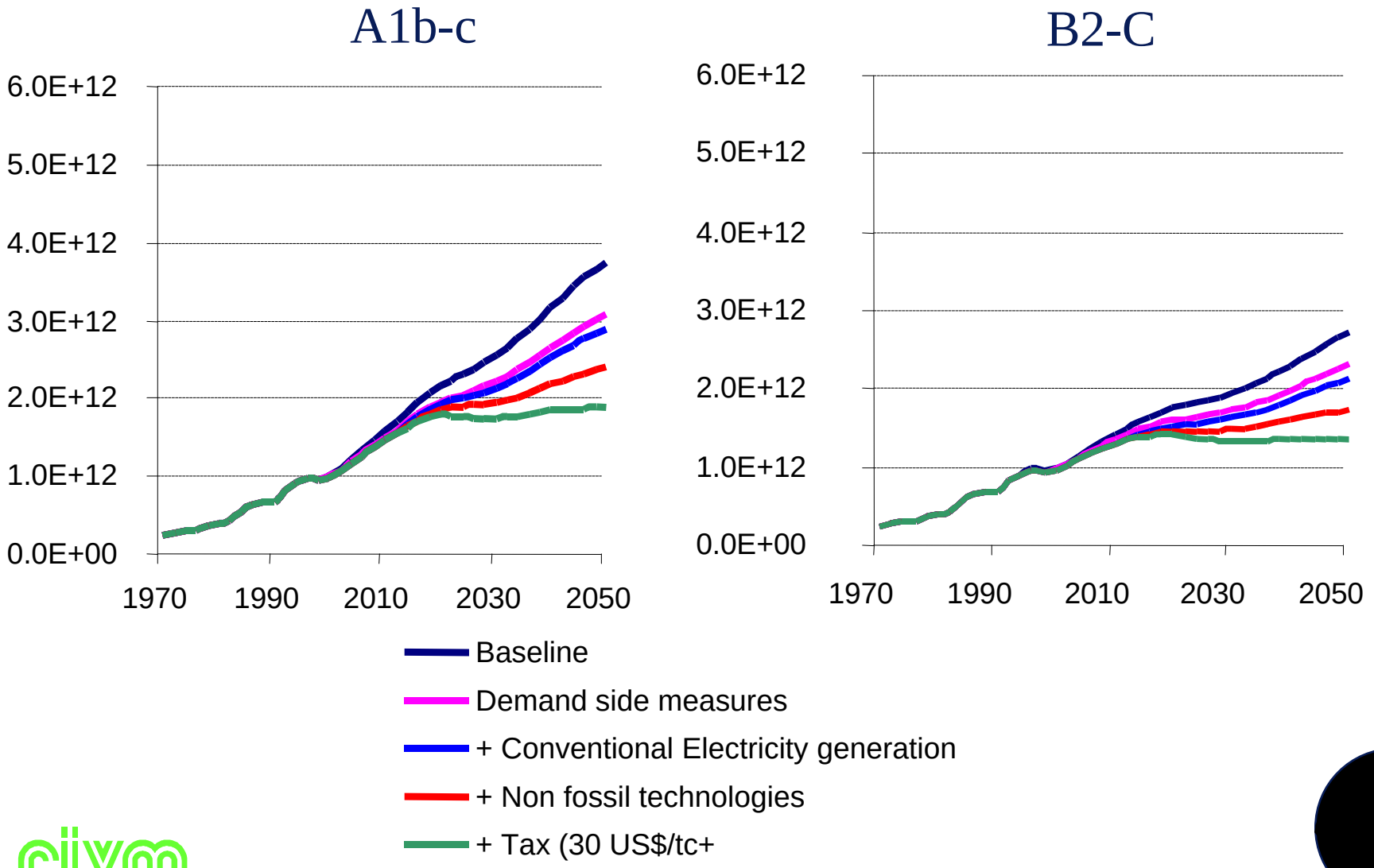
Exploration of different possible measures

Compared to baseline (A1B)

		Emission reductions		Impact on fuel import costs	
		2025	2050	2025	2050
1.Efficiency programmes	(closing gap with WE 50% 2050)	**-7.6%**	**-14.4%**	**-17%**	**-25%**
2.impr. energy taxation	(taxing on OECD level)	-2.0%	-3.6%	4%	0%
3. no coal in buildings		-0.9%	-0.5%	5%	1%
4. comb. Cycle	(15% in 2050)	-0.5%	-3.1%	1%	3%
5. IGCC	(all coal plants)	-3.1%	-1.8%	-2%	-5%
6.Elec. Grid	(OECD levels)	-1.0%	-1.0%	0%	-1%
7.Nuclear	(10% more in 2050)	-0.4%	-7.1%	0%	-5%
8.Solar /wind	(20% in 2050)	-2.2%	-3.0%	0%	-3%
9.hydro	(90% of max. potential)	-2.4%	-1.9%	-1%	-2%
10.biofuels	(20% in 2050 of oil use)	-0.3%	-2.0%	3%	9%
11. 30 US$/tC		-6.7%	-29.8%	**26%**	**18%**

- These technologies together offer large opportunities for reduction…. but if taken together the results will be less than their sum.

Exploration of different possible measures

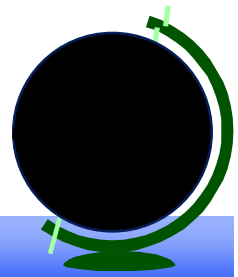


Conclusions

- Useful to considering more ‘baseline scenarios’ of the future for formulating climate policies
- Avoidance of high carbon emission profile for China is a global concern -> coal policies crucial
- Important co-benefits for climate to be expected from orientation on environmental sustainability (e.g. urban air pollution)
- In the different worlds there are different needs and opportunities for mitigation
- Options to reach significant emission reductions in China can be identified

Xiè-Xiè

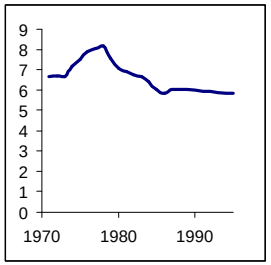
Thank you for your attention



TIMER Energy Demand (ED) Model

Sectors: Industry
Transport
Residential
Services
Other

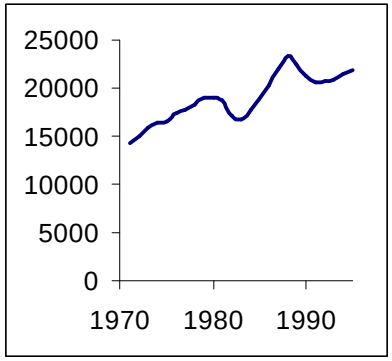
Prices



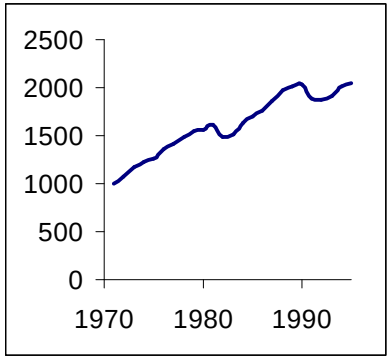
4. Price-induced efficiency improvement

5. End-use conversion efficiency

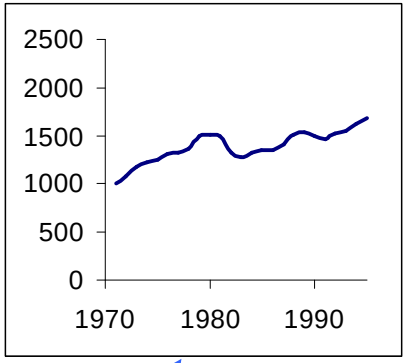
1. Activity per sector (macro-economic structure)



Demand for energy services



Final energy demand



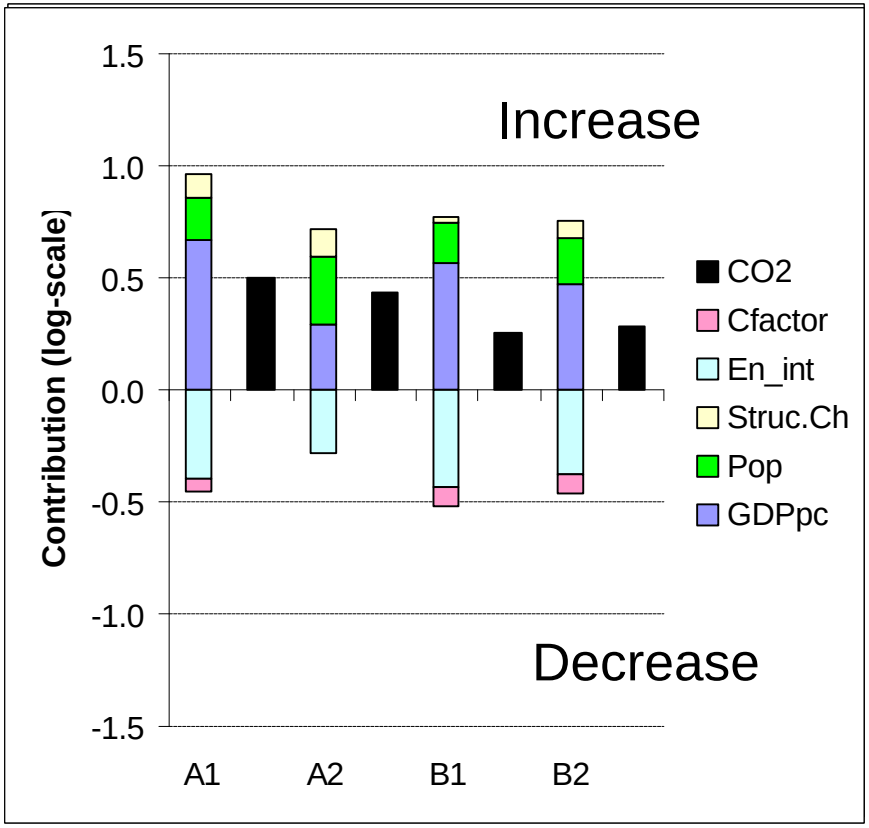
Energy carriers:
Solid
Liquid
Gaseous
Traditional
Electricity

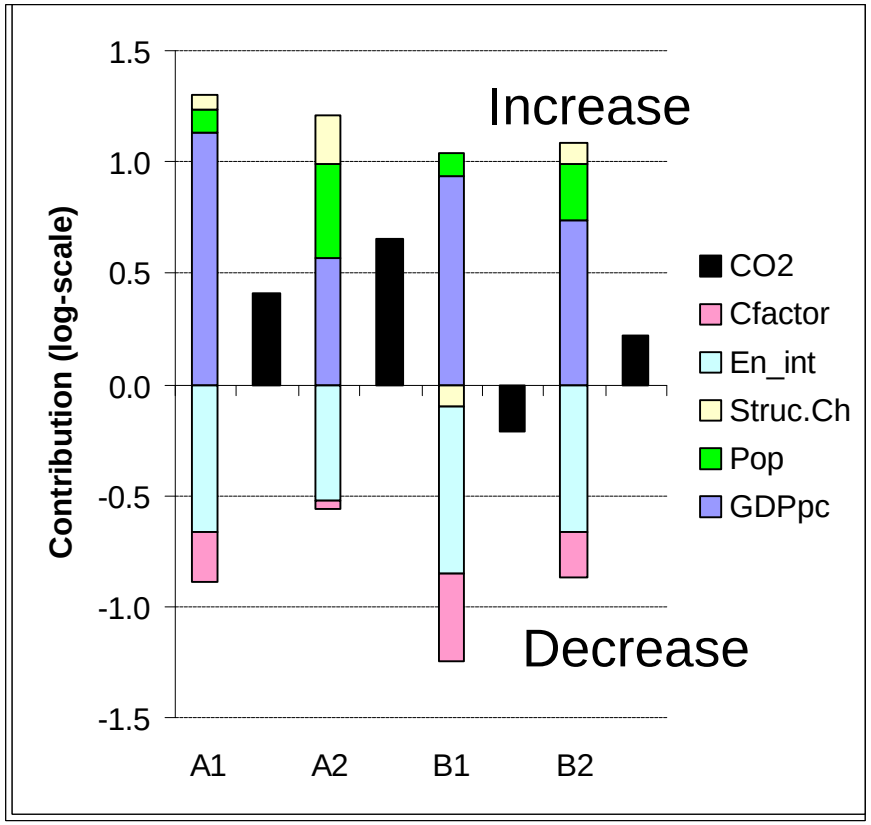
2. Structural change

3. Autonomous efficiency improvement

Contribution of various factors

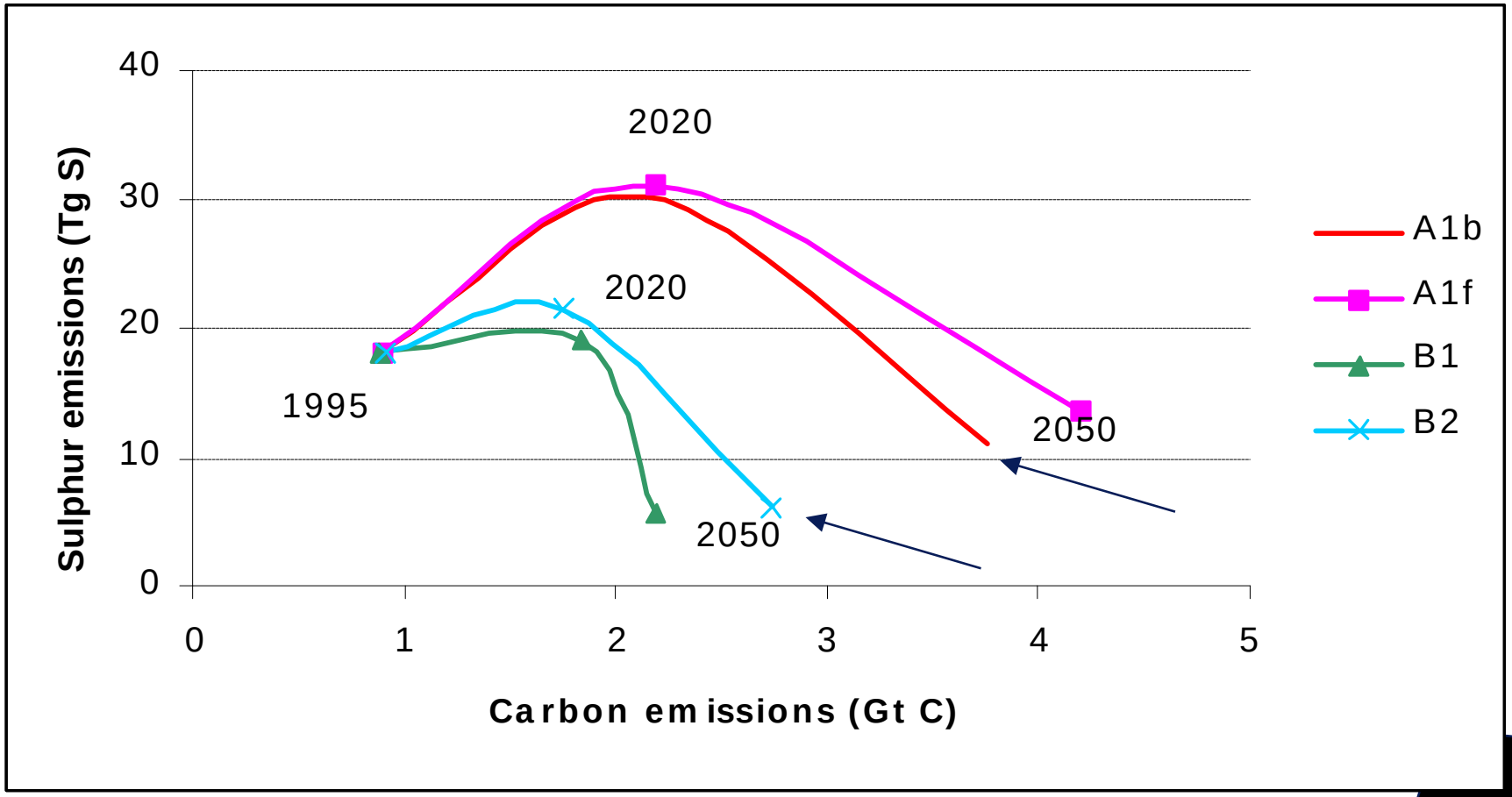
2050 Reference = 1995 2100





CO2 = GDPpc * POP * [StCh * EnInt] * Cfactor

Emissions of carbon and sulfur

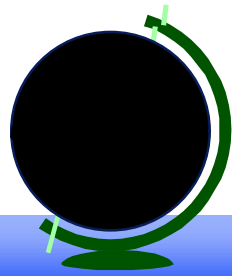


Kaya indicators for China and some selected regions under A1BC2 and B2C1

		Historic		A1BC2			B2C1		
		1990	1995	2010	2030	2050	2010	2030	2050
Pop	China	1,158	1,211	1,389	1,525	1,598	1,389	1,525	1,598
Million	USA	257	267	305	352	386	305	352	386
	Western Europe	379	384	407	425	426	407	425	426
	World	5,281	5,601	6,897	8,235	8,905	6,897	8,235	8,905
GDP/cap	China	909	1,403	3,193	6,630	12,437	2,991	5,528	9,390
Ppp$1995	USA	25,423	27,319	41,023	55,529	76,467	39,561	49,294	61,116
	Western Europe	18,608	19,500	28,014	40,252	56,036	26,796	34,581	42,582
	World	5,394	5,609	8,234	14,096	25,118	7,795	11,391	16,551
Energy	China	34.4	27.8	18.0	13.4	10.7	17.2	12.1	9.8
Intensity	USA	11.9	11.4	9.2	7.5	5.6	9.1	6.8	4.8
MJ/$	Western Europe	7.7	7.4	6.9	6.0	4.9	6.6	5.2	3.9
	World	12.2	11.6	10.1	8.4	6.3	9.8	7.7	5.8
Carbon	China	18.8	19.1	19.8	18.9	17.6	19.8	19.2	18.6
Intensity	USA	18.4	18.3	17.9	16.9	15.0	17.7	15.3	12.5
Kg-C/GJ	Western Europe	17.4	17.0	16.6	15.6	13.9	16.4	14.6	11.2
	World	16.4	16.2	16.8	16.8	14.9	16.6	16.0	14.1
CO2	China	0.7	0.9	1.6	2.6	3.8	1.4	2.0	2.7
Billion tons	USA	1.4	1.5	2.1	2.5	2.5	1.9	1.8	1.4
	Western Europe	1.0	0.9	1.3	1.6	1.6	1.2	1.1	0.8
	World	5.7	5.9	9.6	16.4	20.9	8.8	11.6	11.9
CO2/cap	China	0.6	0.7	1.1	1.7	2.4	1.0	1.[illegible]	[illegible]
Ton	USA	5.6	5.7	6.8	7.1	6.4	6.3	5.[illegible]	[illegible]
	Western Europe	2.5	2.5	3.2	3.8	3.8	2.9	2.6	1.9
	World	1.1	1.1	1.4	2.0	2.4	1.3	1.4	1.3

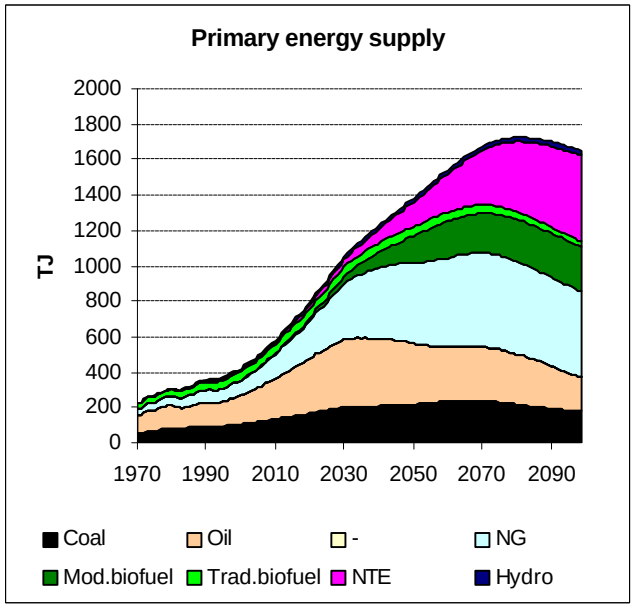
Important questions for China

- Use of domestic supplies or using oil / natural gas supplies in Russia and the Middle East ?
- Use of coal ?
- Further rapid decline of energy intensity ?
- Development of driving forces ? Economy ? Population
- Potential for renewable resources

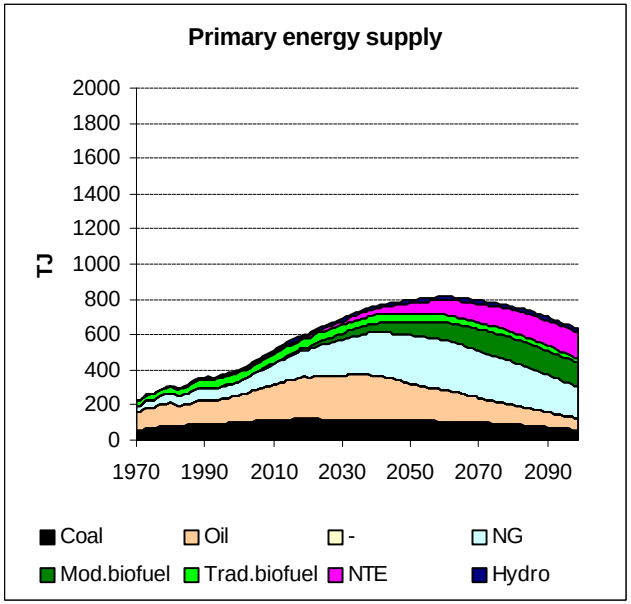


Primary energy use (World)

A1



B1



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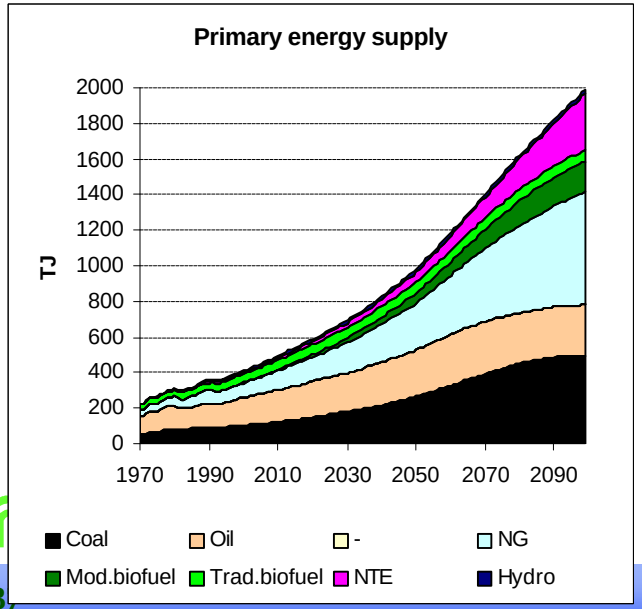

B2