

Structure and dynamics of energy systems

A comparative analysis

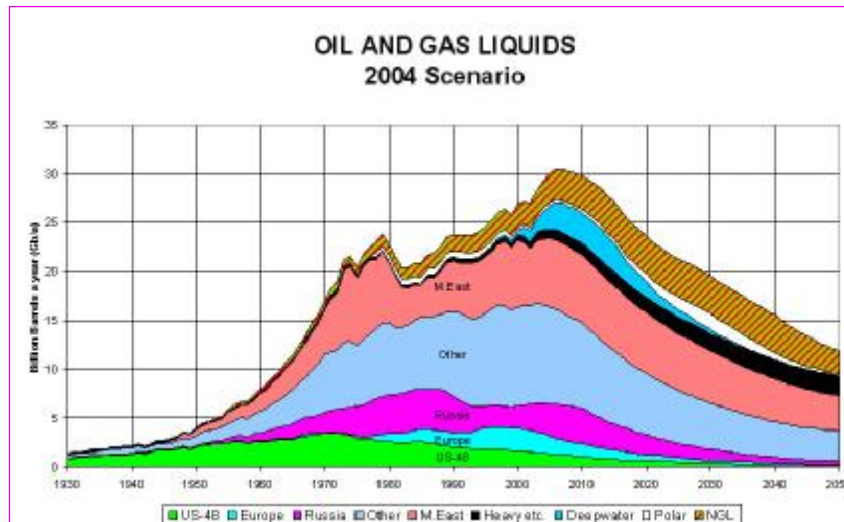


Jirina Jilkova
Stefan Schleicher



The challenge

Approaching global peak-oil production



The incentive Trying to understand our energy systems

n Comparative analysis of energy systems

- ä **Structure**
 - Composition of demand and supply
- ä **Drivers**
 - Relation to economic activity
- ä **Key parameters**
 - Elasticities and intensities

n Preparation for structural modeling analysis

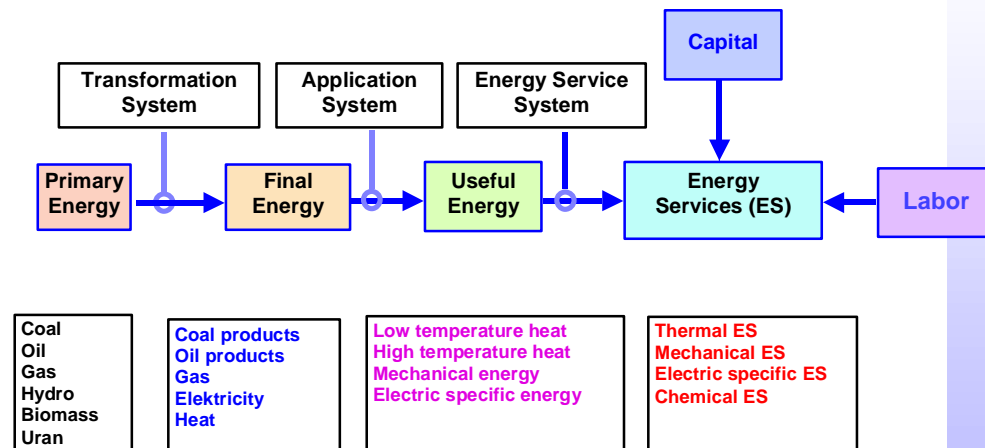
- ä **Energy services**
- ä **Final energy consumption**
- ä **Primary energy supply**

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Modeling the structure of energy systems



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Data base

- n **OECD data from 22 countries**
 - ä **Energy Balances**
 - ä **CO2 Emissions**
 - ä **Economic Outlook**
- n **Organized in XLS**
- n **Standardized fact sheets for each country**

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FEC Final Energy Consumption

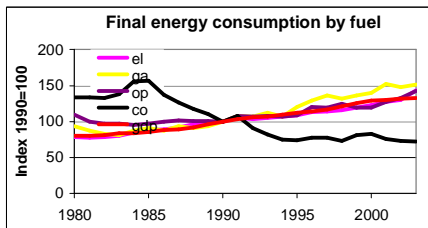
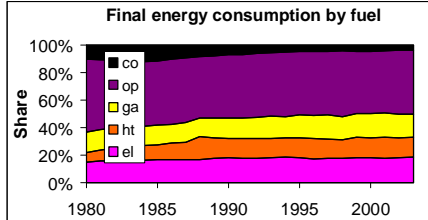
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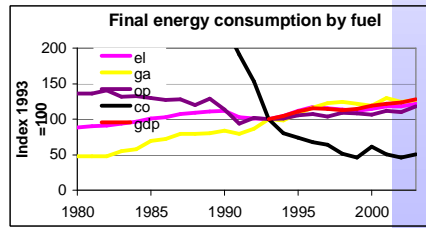
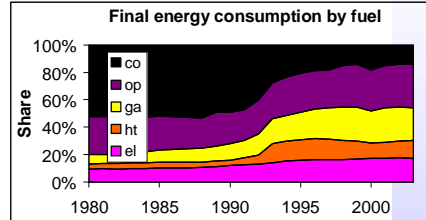
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FEC: by fuel

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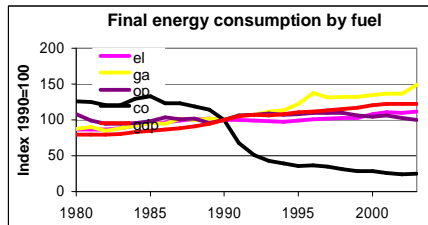
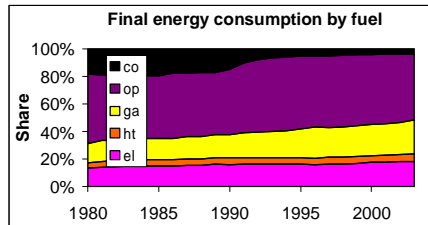
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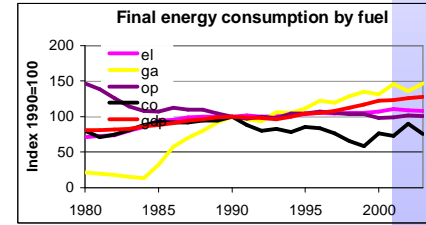
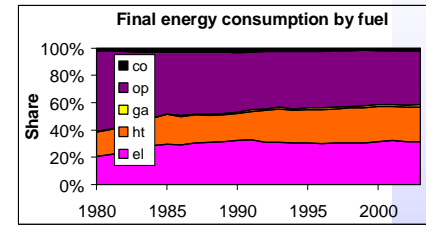
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FEC: by fuel

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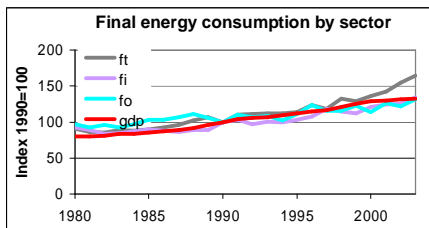
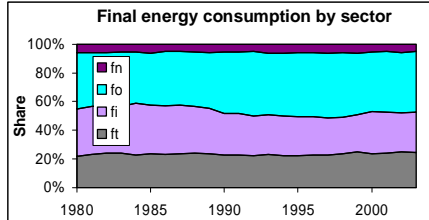
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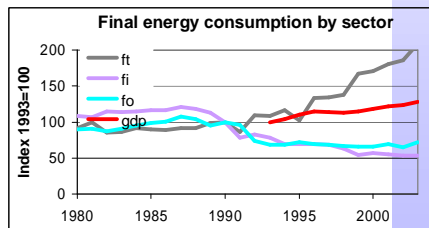
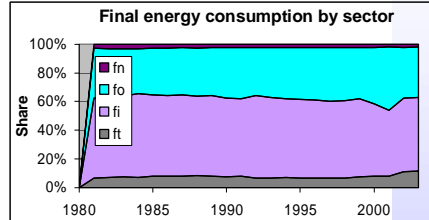
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FEC: by sector

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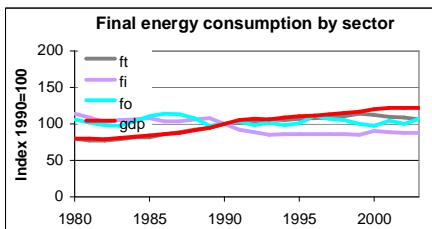
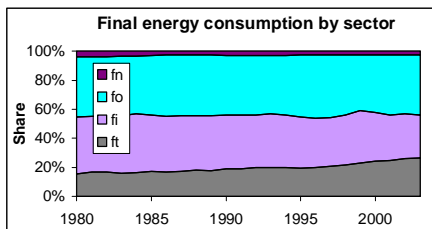
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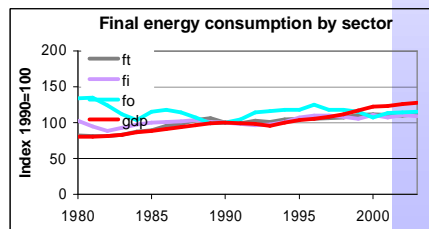
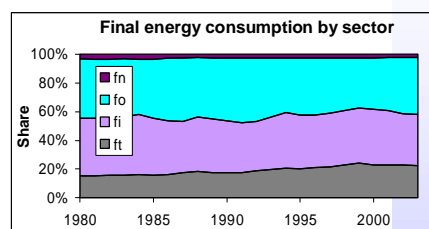
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FEC: by sector

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PES Primary Energy Supply

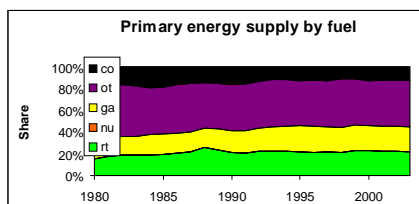
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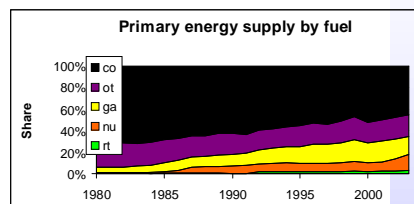
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PES: by fuel

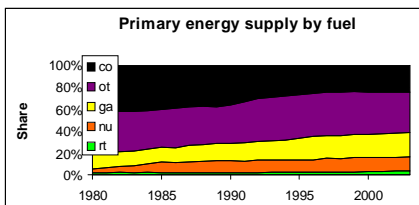
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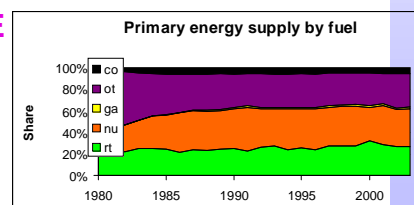
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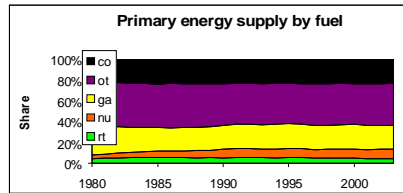
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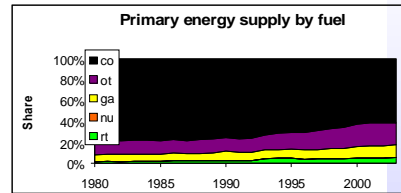
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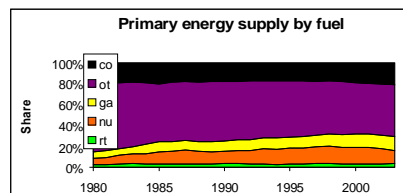
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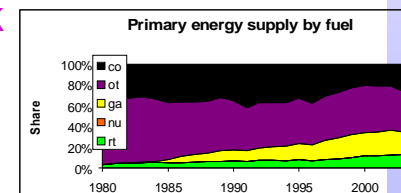
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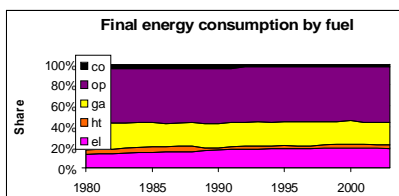
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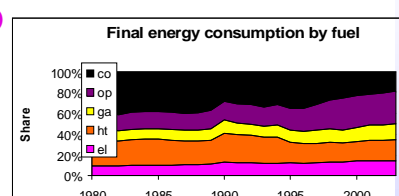
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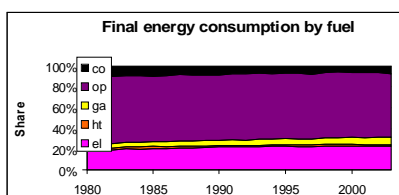
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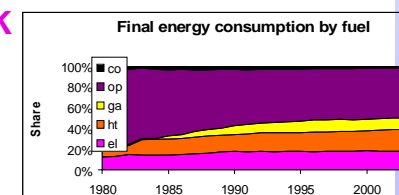
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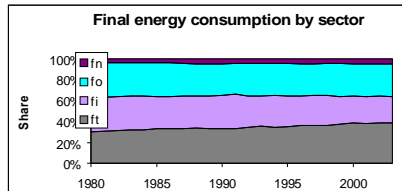
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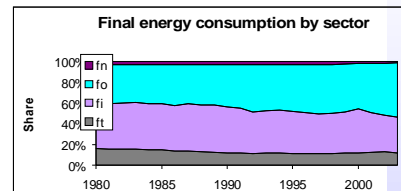
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FEC: by sector

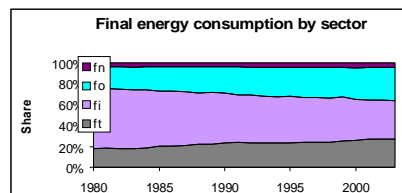
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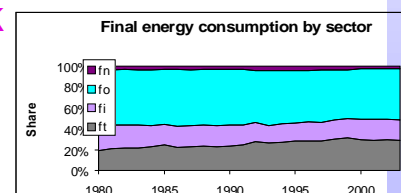
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FEC
Percentage change
GDP-Elasticities
GDP-Intensities

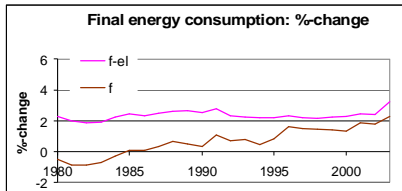
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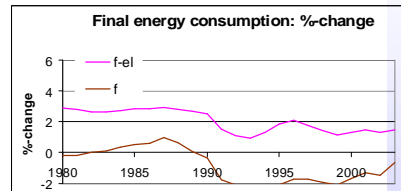
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FEC: Percentage change

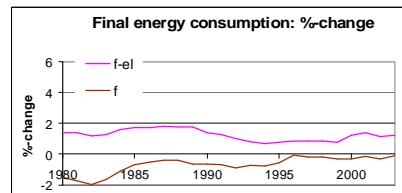
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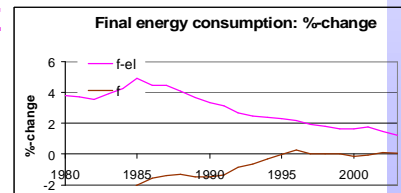
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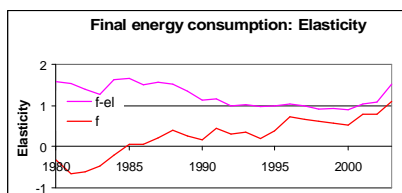
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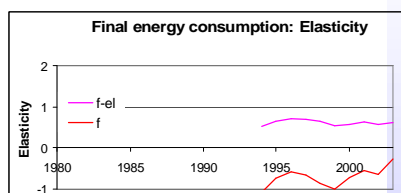
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FEC: GDP-Elasticities

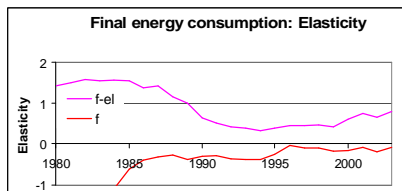
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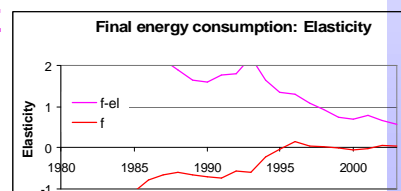
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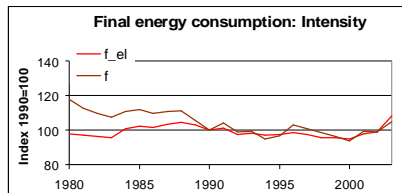
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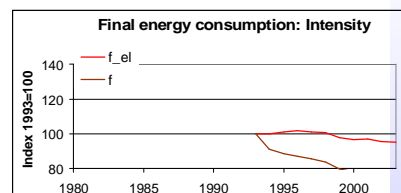
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FEC: GDP-Intensities

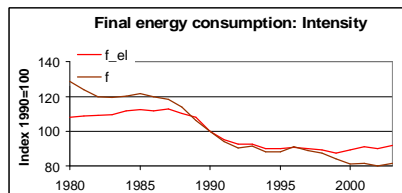
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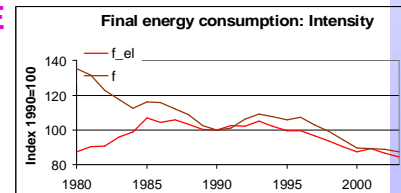
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Overview of current energy systems in industrialized countries

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Final energy consumption

	Shares in percent					Elec- tricity
	Coal products	Oil products	Gas	Heat		
Austria	3,7	46,7	16,4	14,5	18,6	
Belgium	4,2	52,9	24,6	2,3	16,1	
Denmark	1,4	48,5	11,2	20,8	18,2	
Finland	3,5	34,3	3,1	32,6	26,5	
France	2,1	51,2	20,3	6,1	20,3	
Germany	3,8	47,9	24,8	5,7	17,8	
Greece	2,8	70,7	2,4	4,8	19,4	
Italy	2,0	48,8	29,9	1,3	18,0	
Netherlands	1,1	43,1	37,6	4,3	13,9	
Portugal	0,7	62,7	5,8	13,0	17,8	
Spain	1,6	60,1	15,8	3,9	18,7	
Sweden	2,2	39,4	1,5	25,7	31,2	
United Kingdom	1,5	46,6	32,3	1,5	18,1	
Switzerland	0,6	59,8	11,1	6,4	22,0	
Czech Republic	14,3	31,6	23,8	13,3	17,0	
Hungary	3,5	30,1	40,7	11,5	14,2	
Poland	18,4	31,5	15,1	20,8	14,2	
Slovak Republic	10,8	25,4	34,6	11,6	17,5	
Japan	6,9	61,5	7,0	1,8	22,7	
United States	2,0	54,0	21,9	3,0	19,0	

Primary energy supply

	Shares in percent					Rene- wables
	Coal & products	Oil & products	Gas	Nuclear		
Austria	11,8	42,3	22,4	0,0	20,6	
Belgium	9,9	41,5	24,1	20,7	2,0	
Denmark	28,3	41,8	23,3	0,0	13,9	
Finland	21,7	28,3	10,8	15,6	21,5	
France	5,4	34,3	14,8	43,3	6,5	
Germany	24,5	36,5	22,8	12,4	3,8	
Greece	29,6	57,2	6,7	0,0	5,3	
Italy	8,0	47,1	34,2	0,0	5,9	
Netherlands	10,6	38,3	43,7	1,3	2,5	
Portugal	12,6	58,7	10,1	0,0	16,7	
Spain	14,8	50,7	15,7	11,8	6,9	
Sweden	5,1	29,7	1,7	33,6	25,7	
United Kingdom	16,5	35,1	37,0	10,0	1,4	
Switzerland	0,5	46,9	9,8	26,8	18,0	
Czech Republic	48,8	20,5	18,4	15,8	3,0	
Hungary	13,9	23,4	44,1	10,7	3,4	
Poland	62,1	21,8	12,1	0,0	5,8	
Slovak Republic	24,9	17,1	30,9	25,7	3,6	
Japan	20,8	49,7	13,7	12,1	3,7	
United States	23,3	40,4	22,8	9,0	4,5	

Energy and economic activity

	GDP	Index 1990 = 100		Elasticities	
		Final energy consumption		Total	Electricity
		Total	Electricity		
Austria	132,8	139,4	143,7	1,1	1,5
Belgium	127,5	128,5	137,5	0,5	1,2
Denmark	129,0	110,4	114,4	-0,1	0,7
Finland	127,3	115,5	137,2	0,5	1,1
France	125,2	117,7	135,3	0,4	1,3
Germany	121,8	99,3	111,9	-0,1	0,8
Greece	142,7	139,6	170,7	1,1	1,6
Italy	120,1	118,3	135,8	0,8	1,6
Netherlands	134,7	121,7	136,7	0,5	1,0
Portugal	132,7	149,0	183,3	1,5	2,2
Spain	140,4	160,3	173,2	1,2	1,6
Sweden	127,8	111,4	107,8	0,0	0,6
United Kingdom	135,2	110,5	123,0	0,2	0,6
Switzerland	112,1	109,8	117,4	0,6	1,4
Czech Republic*	128,2	98,0	121,8	-0,3	0,6
Hungary*	140,9	110,9	115,4	0,1	0,4
Poland*	153,7	91,1	114,0	-0,2	0,2
Slovak Republic*	152,8	109,8	113,5	-0,1	0,2
Japan	116,6	121,2	124,6	0,8	1,1
United States	146,0	120,2	131,9	0,3	0,7

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The challenges for energy policy

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The fundamental controversies

n The wrong questions

- ä How can we substitute the current requirements for energy flows?

n The right directions

- ä Check your energy services
 - What will be the future requirements
 - How many are redundant?
- ä Check the potentials for raising efficiencies
 - Application technologies
 - Transformation technologies
- ä Develop policy guidelines
 - Low carbon
 - Low energy
 - Low distance

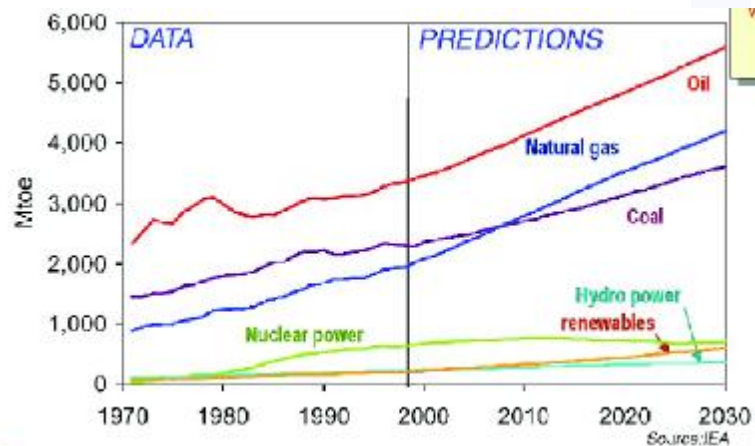
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IEA: The main stream Business as Usual

n +2% CO₂
pro Jahr



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The anti-thesis: The Pacala-Socolow proposal

“Humanity already possesses the fundamental scientific, technical, and industrial know-how to solve the carbon and climate problem for the next half-century and climate problem over the next half-century.”

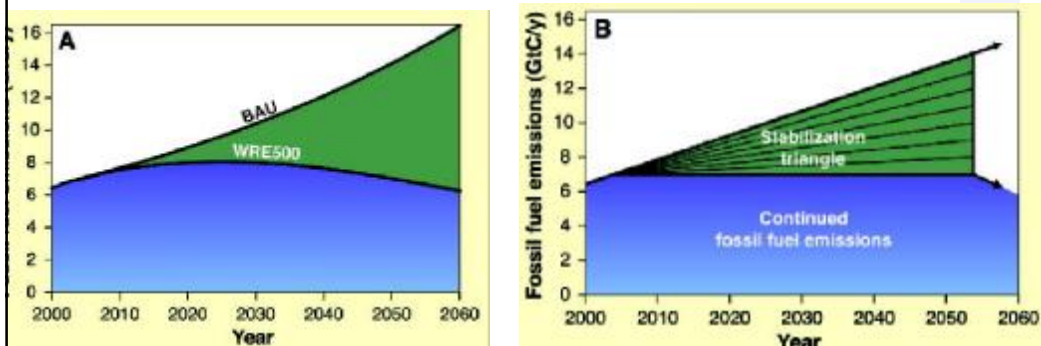
S. Pacala and R. Socolow
Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies
Science, Vol. 305, August 13, 2004.

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Current technologies for GHG stabilization in 50 years



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Current technologies for GHG stabilization in 50 years

n Efficiency and conservation

- ā Cars (4x -> 2 billion cars)
60 instead 30 miles/gallon
5000 instead 10000 miles per year
- ā Buildings
-25% energy
- ā Power plants
from 40 to 60% efficiency



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Current technologies for GHG stabilization in 50 years

n Decarbonization

- ā Electric power plants
gas substitutes coal
- ā New renewables
wind, thermal and photovoltaic solar

n Carbon capture and hydrogen storage

- ā Post-combustion carbon capture and storage in electricity generation
- ā Pre-combustion carbon separation and hydrogen storage as substitute for fossil fuels

n Carbon sinks



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The transformation of electricity

The electricity internet

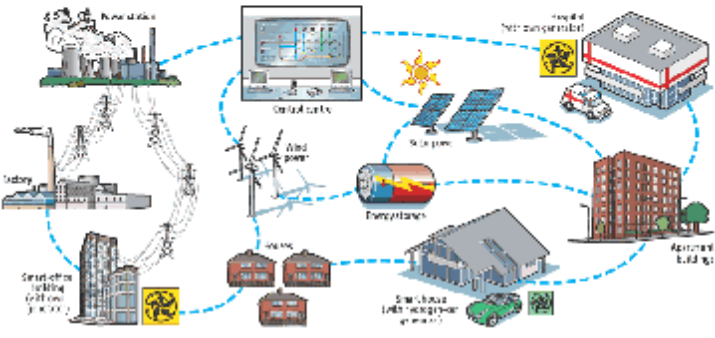
The shape of grids to come?

Conventional electrical grid
Central power stations generate electricity and distribute it to houses, factories and offices.



Energy internet
Regional generating stations and distributed renewable energy sources are connected to a distributed energy control system.

Classical electrical grids are controlled centrally by a central authority. In the future, the control system will be distributed and decentralized. This will lead to a more resilient and secure system. Distributed generation in the neighborhood will be used to supply power to the grid and to provide local services.



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Source: WIFO, June 2011

The 3 x 50 strategy

Transition to a 2.000 Watts energy system

	2005	20??	
Energy Services	100,0	150,0	+50 %
Energy Flows	100,0	50,0	-50 %
Of which Renewables	25,0	37,5	+50 %

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Thank you.



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Tasks

n Countries

ä AT CZ DE SE
ä US JP PO DK

n Final energy consumption

ä Structural differences

- By fuel
- By sector

n Primary energy consumption

ä Structural differences

- By fuel

n Energy and economic activity

ä Key indicators

- Percentage change
- GDP elasticities
- GDP intensities

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