ICPIA Workshop
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Emission targets and their distributions: Modeling consistency and convergence by an extended Kaya approach

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My agenda

- **How to find targets**
  - **Limits of MAC approach**
- **How to distribute targets**
  - **Consistent**
  - **Fair**
  - **Operational**
- **How an extended Kaya approach works**
  - **Structural energy model**
  - **Convergence of key parameters**

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(1)

How to find targets

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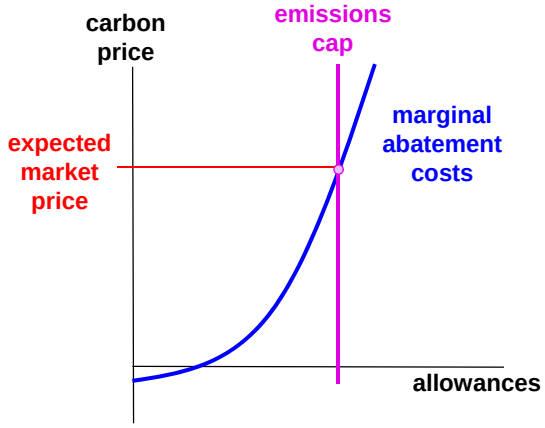
The simplistic view of the carbon market

- **Based on courageous assumptions**
  - Perfectly informed forward looking agents
  - Market knows until 2020 the aggregated marginal abatement costs for all installations



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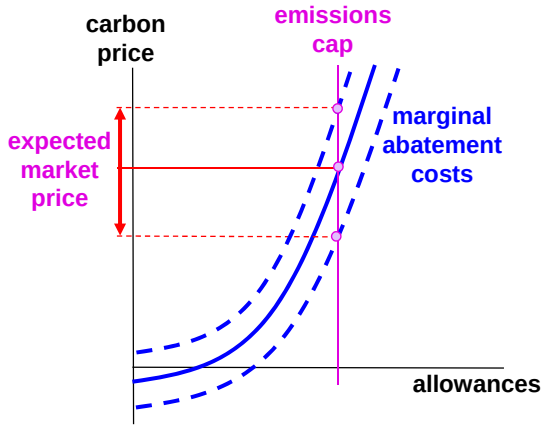
But: Perceived abatement costs may vary

- There is high uncertainty about abatement costs
- Abatement costs vary
  - Interest rates
  - Capital depreciation rates
  - Energy prices
  - Cyclical fluctuation
- Abatement costs may not be unique at all
  - e.g. joint production structures



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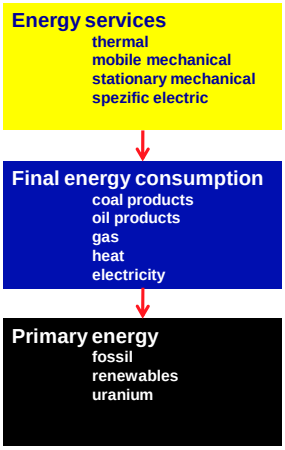
Opening the black box of an energy system

- Focusing on energy services
- Considering the cascade structure of energy systems
- This structural approach is radically different from conventional MAC analysis
  - No nested production functions with elasticities of substitution
  - Separation from structures and mechanisms



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(2)

How to distribute targets

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Structural energy model

Basic identities

$$F = E - L \,.$$

$$E = E_{res} + E_{foss} + E_{oth} \,.$$

F	final energy consumption
E	total energy supply and
L	losses
E_{res}	renewable energy
E_{fosss}	fossile energy
E_{oth}	other energy (nuclear and net electricity imports)

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Three 2020-targets may be inconsistent

Consistent final energy volume

$$F = (1 - e_{loss}) \cdot [1 / (1 - e_{res} - e_{oth})] \cdot [1 / a_{GHG}] \cdot A_{GHG}$$

Policy targets

A_{GHG} cap for GHG emissions

e_{res} share of renewables in energy supply

Technology parameters

a_{GHG} GHG intensity of fossil energy supply.

e_{loss} share of losses in total energy supply and

e_{oth} share of other energy in total energy supply.

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(3)

How an extended Kaya approach works

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Modeling based on Kaya approach (1)

Basic identity

F + L = E = EF + ER + EO

F	final energy consumption
L	losses from transformation and distribution
E	total energy supply
EF	energy fossil
ER	energy renewable
EO	energy other

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Modeling based on Kaya approach (2)

Basic Kaya equation

A = (A/E)·(A/Q) ·(Q/P) ·P

A	emissions
(A/E)	carbon intensity of final energy
(Q/P)	gdp per capita
P	population

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Component analysis (3)

Extended Kaya equation

$$F + L = E = EF + ER + EO$$

$$A = (A/EF)\cdot[1 - (ER/E) - (EO/E)]\cdot(1 - (L/E))^{-1}\cdot(F/Q)\cdot(Q/P)\cdot P$$

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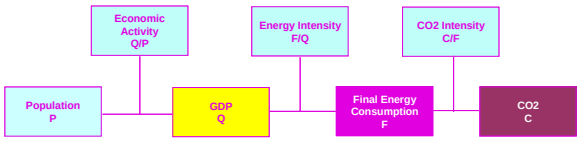
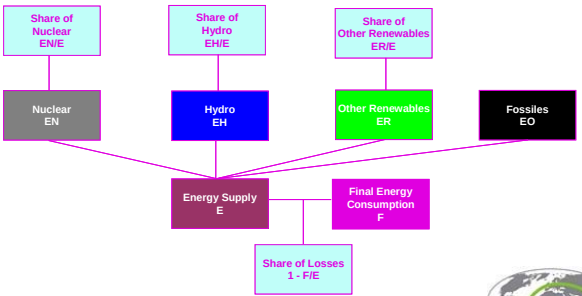
Structural model based on extended Kaya approach

Demand module



Supply module



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Some structural parameters for EU

GHG intensity

GHG / FEC	1990	1995	2000	2005	2008
EU-27 2005 = 100					
Austria	95.6	90.7	82.3	80.9	77.8
Belgium	107.9	95.3	84.4	82.2	75.9
Bulgaria	162.2	180.1	179.9	173.8	170.7
Cyprus					
Czech Republic	140.7	141.0	142.6	126.9	126.4
Denmark	127.8	128.3	117.9	105.3	105.0
Estonia	166.4	184.3	170.4	155.9	155.2
Finland	76.4	76.7	69.6	64.7	64.9
France	95.1	88.2	82.5	79.6	77.0
Germany	125.3	116.2	109.2	100.0	100.7
Greece	173.9	171.4	165.1	155.9	146.4
Hungary	113.9	110.6	108.5	96.9	95.4
Ireland	178.8	178.0	154.5	139.5	130.0
Italy	108.6	106.0	103.0	97.4	98.0
Latvia	101.1	79.5	75.0	67.8	69.1
Lithuania	118.7	107.6	108.9	107.5	99.4
Luxembourg	113.1	88.9	73.5	79.9	77.4
Malta					
Netherlands	104.2	101.2	91.3	85.0	81.8
Poland	177.0	164.6	161.8	153.6	146.3
Portugal	107.2	110.9	101.0	102.3	98.2
Romania	138.7	166.9	142.5	143.3	139.3
Slovakia	113.3	117.4	104.1	103.4	100.2
Slovenia	120.8	107.0	97.8	94.6	93.5
Spain	113.3	110.2	107.6	103.0	99.0
Sweden	54.4	50.1	47.1	47.3	45.8
United Kingdom	135.7	120.2	108.6	106.6	106.7
EU-27	120.1	112.8	105.1	100.0	98.4

Energy intensity

FEC / GDP	1990	1995	2000	2005	2008
EU-27 2005 = 100					
Austria	98.8	96.0	91.9	100.1	88.7
Belgium	128.3	140.0	132.9	123.3	117.6
Bulgaria	869.5	677.7	564.7	472.9	404.9
Cyprus					
Czech Republic	451.9	372.1	328.4	302.7	254.6
Denmark	79.4	77.9	66.1	65.1	62.7
Estonia	752.0	495.8	337.4	268.6	248.8
Finland	167.1	172.9	147.0	137.7	127.0
France	97.7	98.3	91.6	87.4	81.5
Germany	116.5	101.4	91.1	92.5	83.9
Greece	107.3	106.8	108.4	99.9	91.4
Hungary	351.6	329.0	271.1	255.6	225.4
Ireland	113.4	96.9	81.8	70.5	68.5
Italy	91.5	90.0	87.6	92.3	84.6
Latvia	459.7	481.4	313.5	260.6	227.5
Lithuania	483.5	408.3	285.4	234.7	222.1
Luxembourg	168.5	139.5	119.7	123.8	106.9
Malta					
Netherlands	130.0	126.6	109.9	109.5	101.4
Poland	390.4	366.0	253.6	229.3	205.9
Portugal	117.5	123.2	128.8	129.6	118.4
Romania	731.7	507.9	478.7	396.5	323.6
Slovakia	621.5	474.3	418.0	337.5	267.0
Slovenia	165.8	193.4	174.3	161.5	147.1
Spain	102.9	108.4	109.8	111.7	99.8
Sweden	118.9	128.2	107.3	92.5	84.8
United Kingdom	89.4	85.9	75.9	66.5	60.1
EU-27	123.2	114.0	102.8	100.0	91.8

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GDP per capita

GDP / POP	1990	1995	2000	2005	2008
EU-27 2005 = 100					
Austria	103.0	110.2	126.7	133.4	144.0
Belgium	99.3	105.7	120.3	127.4	133.2
Bulgaria	9.1	8.3	8.3	11.2	13.6
Cyprus	56.7	63.0	71.3	76.5	81.7
Czech Republic	28.3	27.1	29.3	35.4	40.3
Denmark	127.9	141.1	159.1	166.8	171.7
Estonia	19.9	15.1	22.0	32.8	37.4
Finland	105.6	100.0	124.7	140.1	153.6
France	99.6	103.3	116.1	121.6	125.4
Germany	103.2	111.8	122.7	126.0	135.4
Greece	51.8	53.6	61.8	74.2	81.7
Hungary	22.5	20.1	24.6	30.6	32.5
Ireland	73.6	90.0	134.9	161.2	163.2
Italy	87.7	93.3	102.3	103.9	104.2
Latvia	20.7	12.5	17.5	26.8	32.0
Lithuania	23.1	13.6	17.3	25.9	31.8
Luxembourg	173.2	194.8	244.5	273.1	294.5
Malta	35.3	43.8	53.0	53.2	57.0
Netherlands	100.1	108.4	128.4	133.7	145.0
Poland	16.5	18.2	23.8	27.7	33.1
Portugal	45.0	48.8	58.4	59.2	60.7
Romania	10.1	9.2	8.8	12.0	15.1
Slovakia	18.9	17.1	20.0	25.5	32.4
Slovenia	44.2	42.9	53.1	63.2	73.2
Spain	60.0	64.0	76.6	83.4	86.2
Sweden	125.0	125.3	146.9	163.8	170.3
United Kingdom	106.7	114.1	133.2	147.3	153.4
EU-27	76.4	81.4	93.2	100.0	105.5

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Population

GDP / POP	1990	1995	2000	2005	2008
EU-27 2005 = 100					
Austria	93.3	96.6	97.3	100.0	101.3
Belgium	95.2	96.8	97.9	100.0	102.3
Bulgaria	112.6	108.5	104.1	100.0	98.5
Cyprus	76.5	85.9	91.6	100.0	105.3
Czech Republic	101.3	101.0	100.4	100.0	102.0
Denmark	94.8	96.5	98.5	100.0	101.3
Estonia	117.8	107.4	101.8	100.0	99.5
Finland	95.0	97.3	98.7	100.0	101.1
France	92.4	94.4	96.5	100.0	101.8
Germany	96.2	99.0	99.7	100.0	99.6
Greece	93.2	95.8	98.4	100.0	101.3
Hungary	102.8	102.4	101.2	100.0	99.5
Ireland	84.6	86.7	91.6	100.0	107.0
Italy	96.8	97.0	97.2	100.0	102.2
Latvia	116.1	109.3	103.1	100.0	98.5
Lithuania	108.3	106.4	102.5	100.0	98.4
Luxembourg	80.9	87.2	93.6	100.0	104.3
Malta	89.1	93.6	96.5	100.0	101.7
Netherlands	91.6	94.7	97.5	100.0	100.7
Poland	99.7	100.3	100.3	100.0	99.9
Portugal	94.8	95.1	97.0	100.0	100.7
Romania	107.3	104.8	103.7	100.0	99.4
Slovakia	98.3	99.4	100.2	100.0	100.4
Slovenia	99.8	99.4	99.4	100.0	101.0
Spain	89.9	90.8	92.8	100.0	105.0
Sweden	94.8	97.8	98.2	100.0	102.5
United Kingdom	95.0	96.3	97.8	100.0	101.8
EU-27	96.1	97.3	98.1	100.0	101.3

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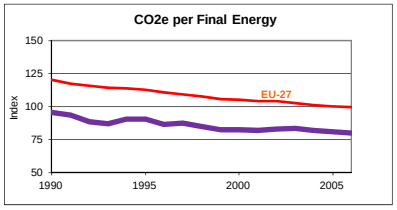
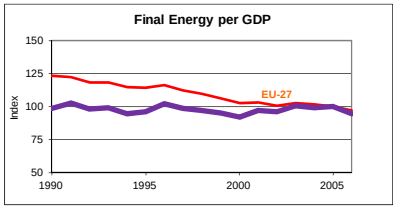
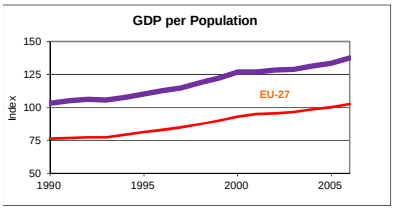
Austria

Austria







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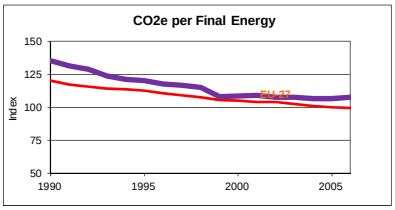
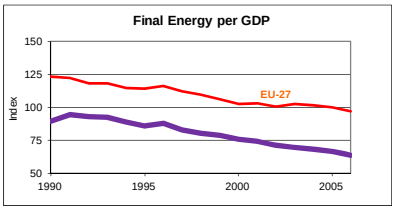
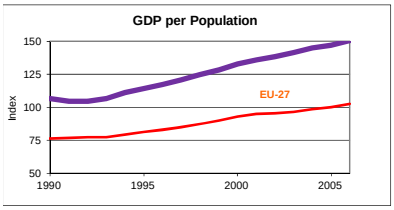
United Kingdom

United Kingdom

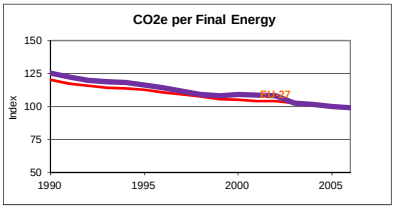


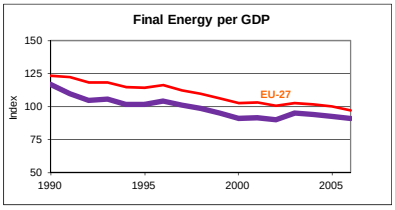


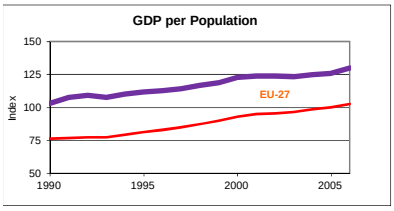


Germany

Germany





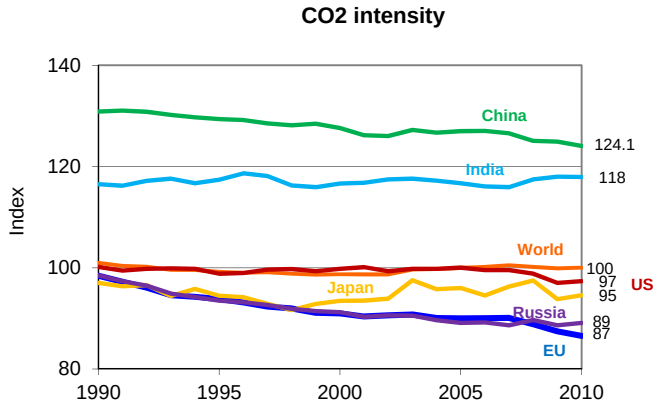


A global structural Kaya analysis

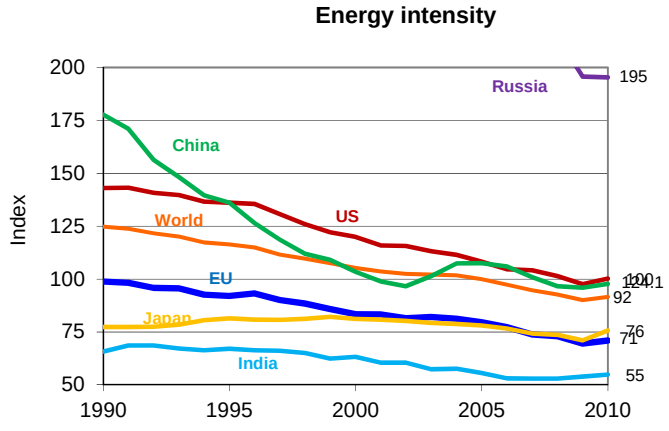
7 region global analysis

2010	Coal	Oil	Gas	Nuclear	Renewables	Total supply
European Union	2.2	5.5	3.7	1.7	1.2	14.4
United States	4.4	7.1	5.2	1.6	0.8	19.0
Japan	1.0	1.7	0.7	0.6	0.2	4.2
Russian Federation	0.8	1.2	3.1	0.3	0.3	5.8
China	14.3	3.6	0.8	0.1	1.5	20.3
India	2.3	1.3	0.5	0.0	0.3	4.4
Rest of the world	4.6	13.2	9.8	0.8	3.5	32.0
World	29.6	33.6	23.8	5.2	7.8	100.0

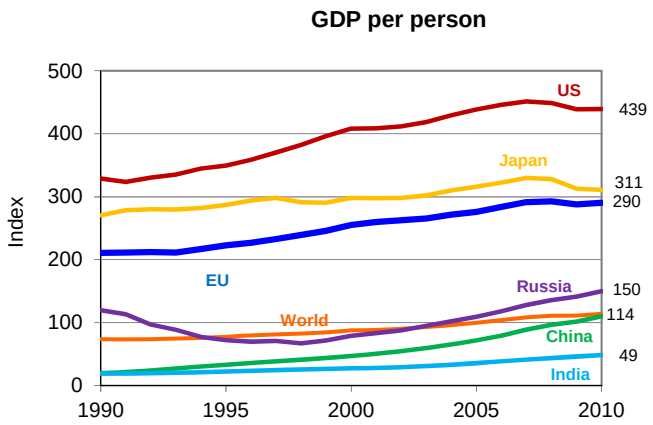
CO2 intensity



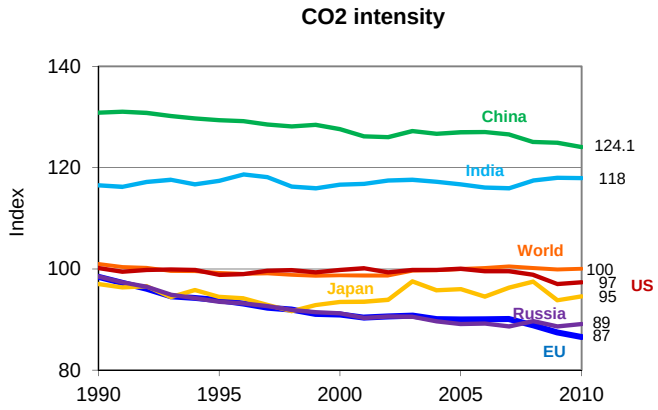
Energy intensity



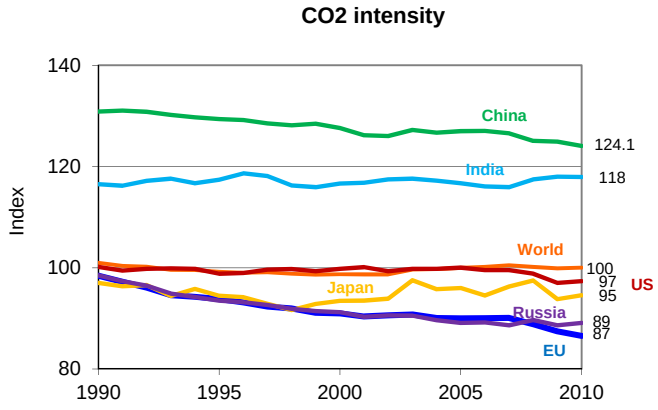
GDP per person



CO2 intensity



CO2 intensity



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Some conclusions

- **The obvious advantages**
  - A manageable database
  - Transparent
- **The shift of policy decisions**
  - The choice of technologies
  - Equityl
- **The extension by prices and mechanisms**
  - Distinction between investment and user costs
  - A new perspective for abatement costs

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