POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

"Endogenous Sector-specific R&D Investments into Energy Efficiency as Mitigation Option"

INTERNATIONAL ENERGY WORKSHOP
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Leibniz Gemeinschaft

Potsdam Institute for Climate Impact Research
Research Domain Sustainable Solutions

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- Calibration
- Reference Scenarios: Baseline and Policy
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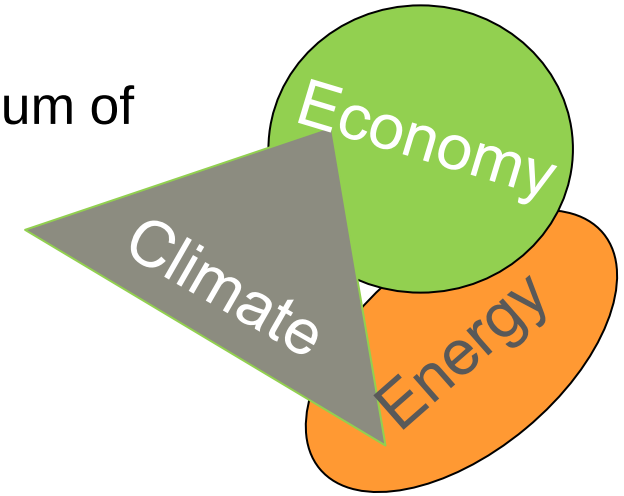
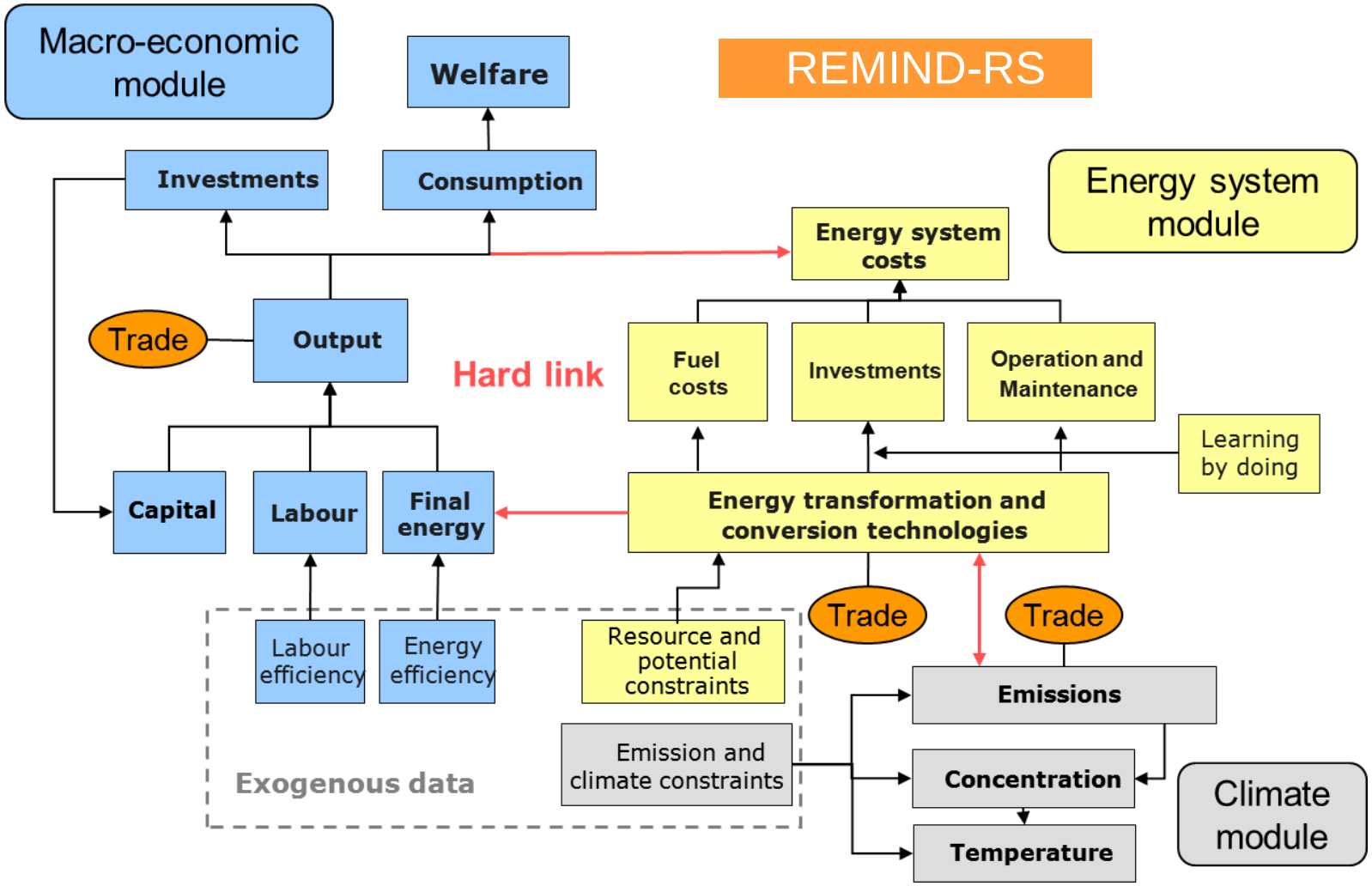
REMIND-RS

REMIND-RS:

- Hybrid Modell: hard link between detailed energy system, macro economy and climate module
- Endogenous growth model, intertemporal (2005-2150)
- 5 regions: USA, EU27, China, INA (developing regions, less resources), ROW (manly resource exporting regions)
- Negishi-Algorithm: maximizes the weighted sum of regional welfare functions



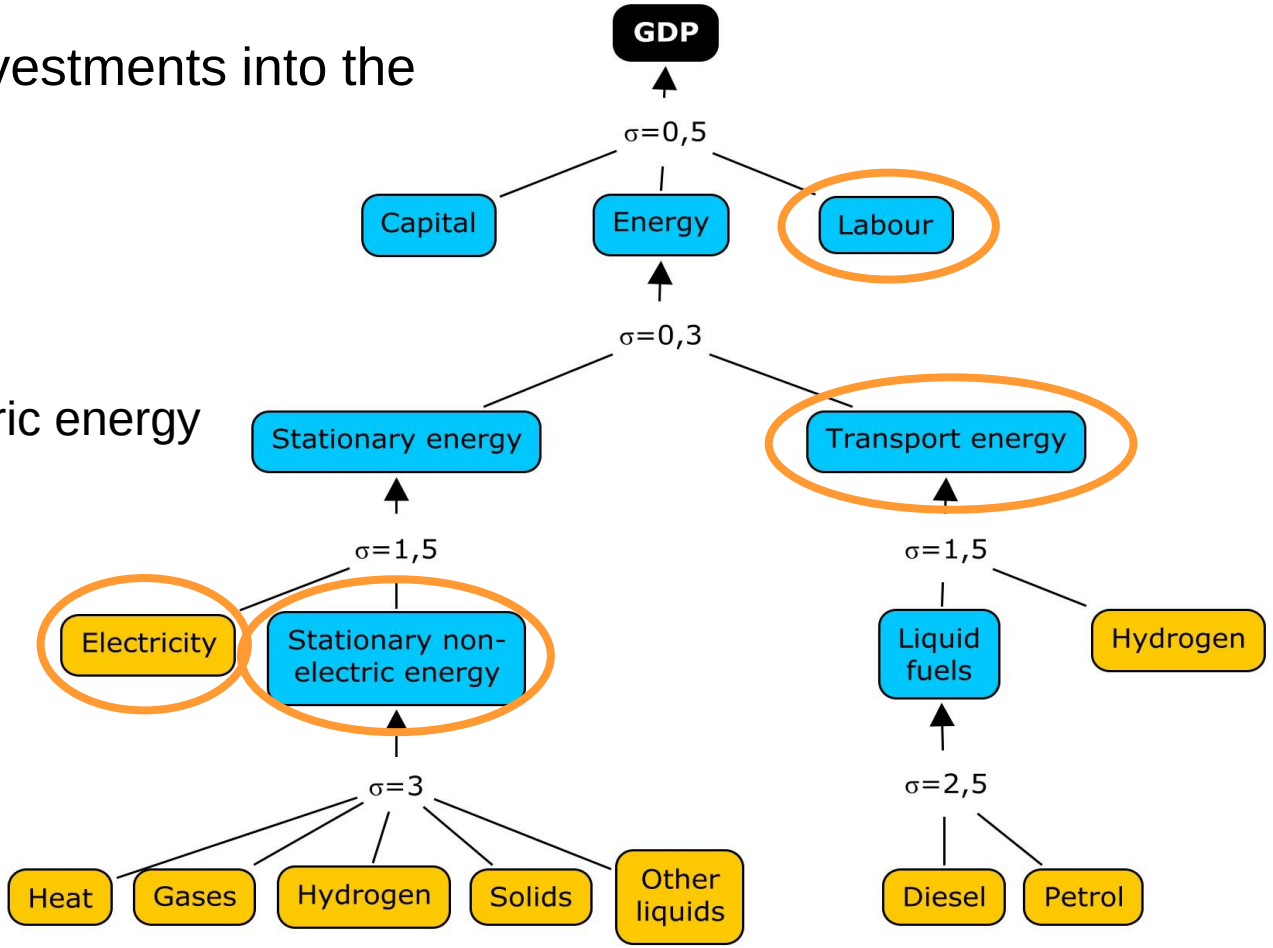
REMIND-RS


Macro-economic module
Welfare
REMIND-RS
Investments
Consumption
Energy system module
Energy system costs
Trade
Output
Hard link
Fuel costs
Investments
Operation and Maintenance
Learning by doing
Capital
Labour
Final energy
Energy transformation and conversion technologies
Trade
Trade
Labour efficiency
Energy efficiency
Resource and potential constraints
Emissions
Emission and climate constraints
Concentration
Climate module
Exogenous data
Temperature

REMIND-RS

Endogenous R&D investments into the efficiency of:

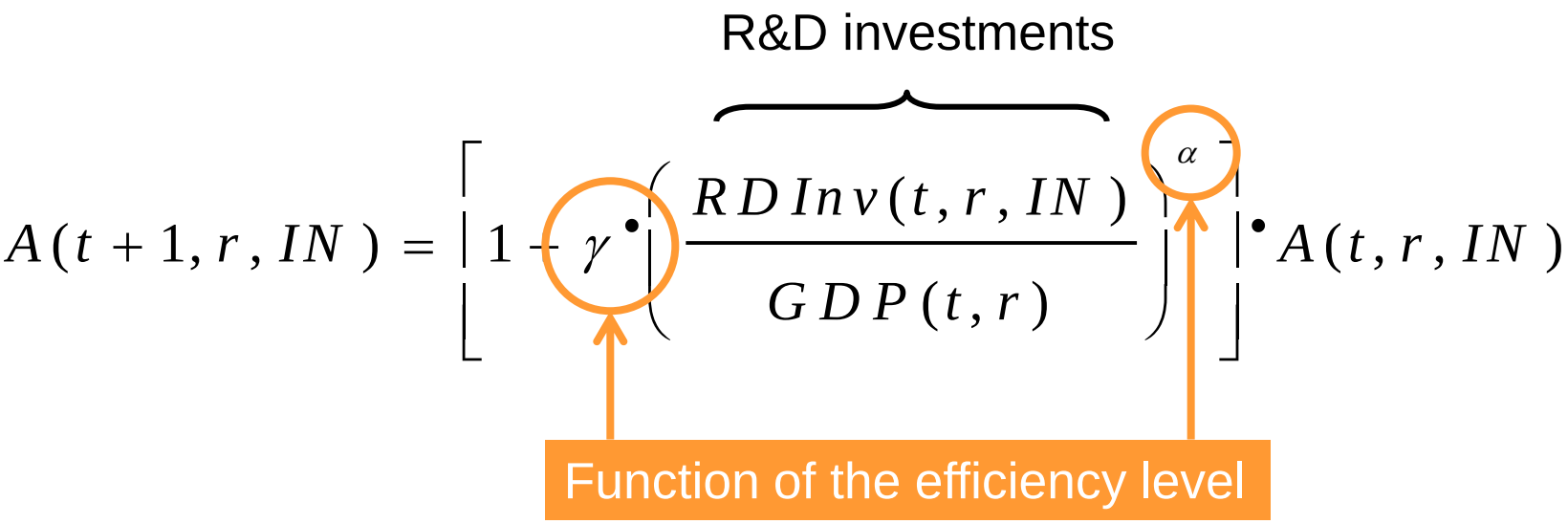
- labour
- electricity
- stationary non-electric energy
- transport energy



Nested CES-production function

Calibration

R&D function of REMIND-RS:

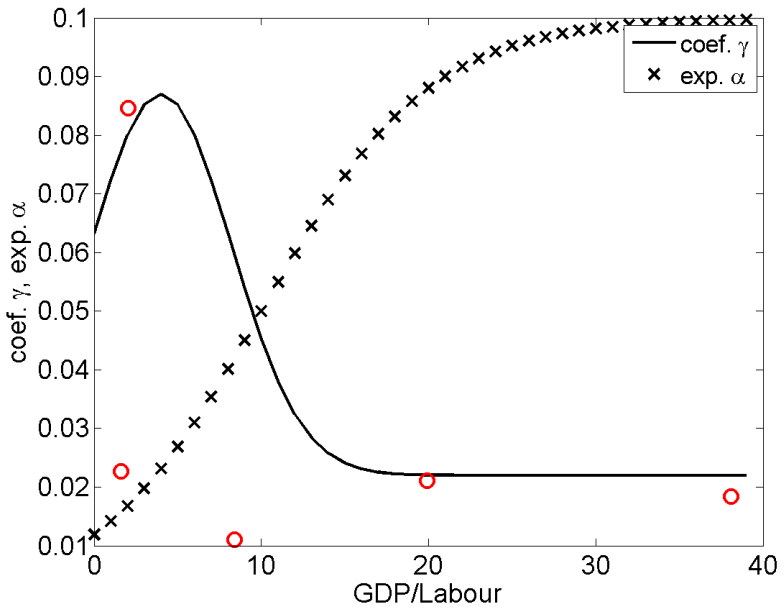


$A(t,r,IN)$ - efficiency of production factor IN in region r at time t

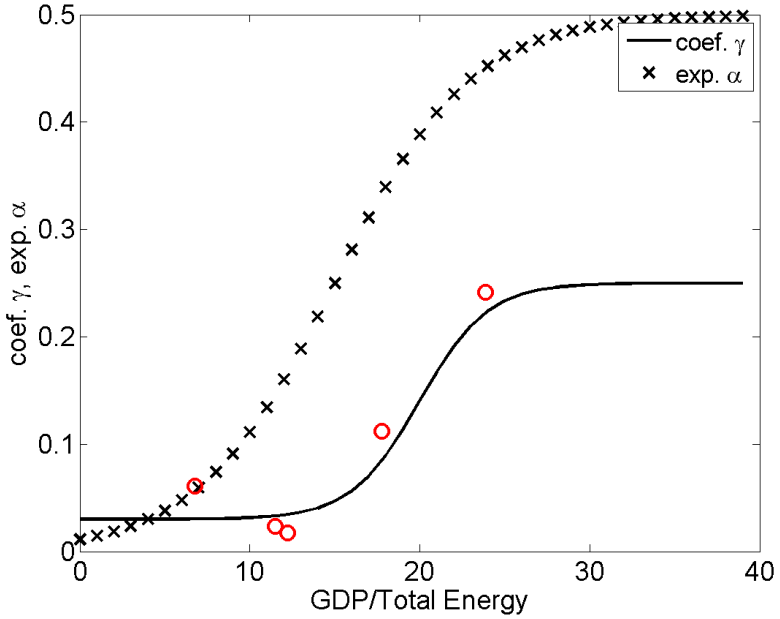
Jones, Williams (2000):
"Too Much of a Good Thing? The Economics of Investment in R&D"

Calibration

Labour



Energy

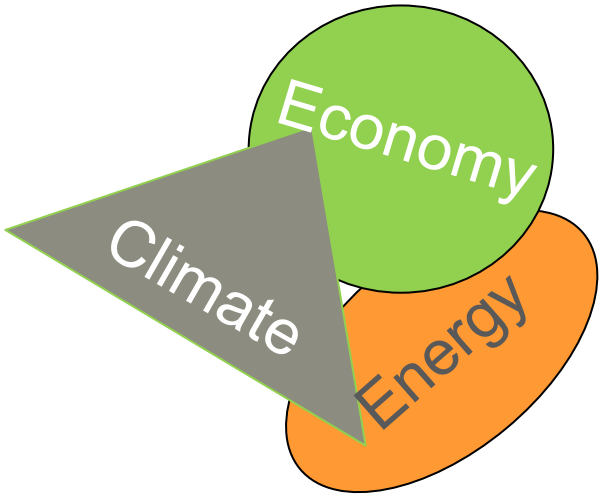


The higher the efficiency level,
the higher the elasticity of the R&D function (α)

Reference Scenarios

Baseline:

- Business-as-usual, no climate policy
- No climate change damages

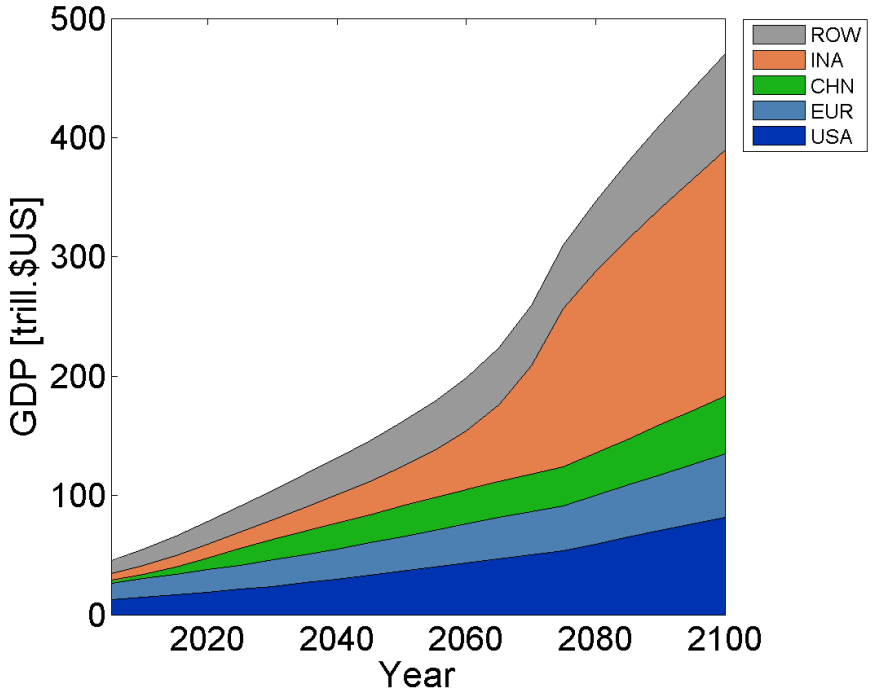


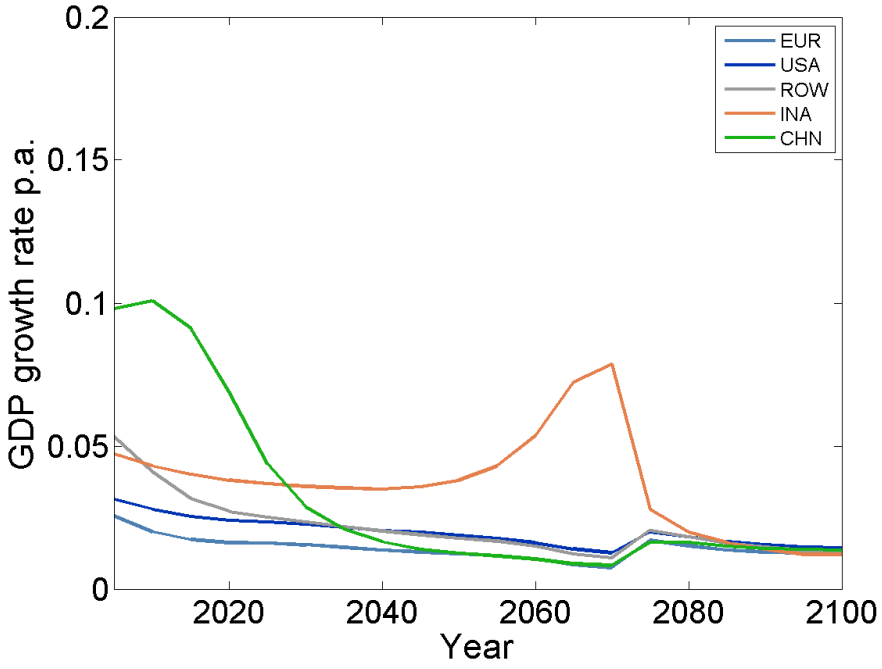
Policy:

- Cumulated emissions restricted to 300 GtC between 2005 and 2100
- Emission permits are allocated to the regions via Contraction&Convergency scheme
- Within a cost-efficiency mode the optimal use of regional energy production is calculated

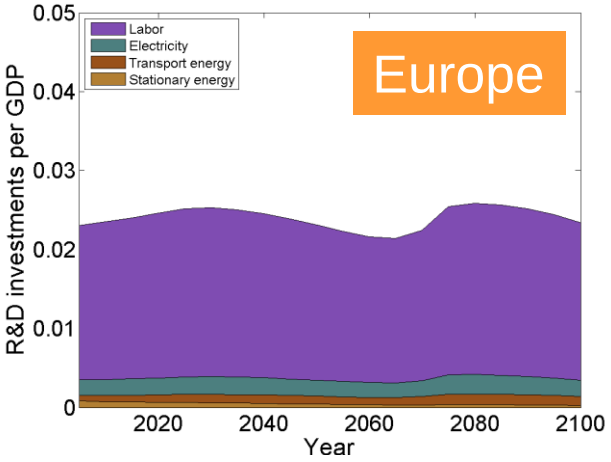
Reference Scenarios: Baseline

The discontinuous GDP growth path is induced by the labour efficiency growth path due to R&D investments.

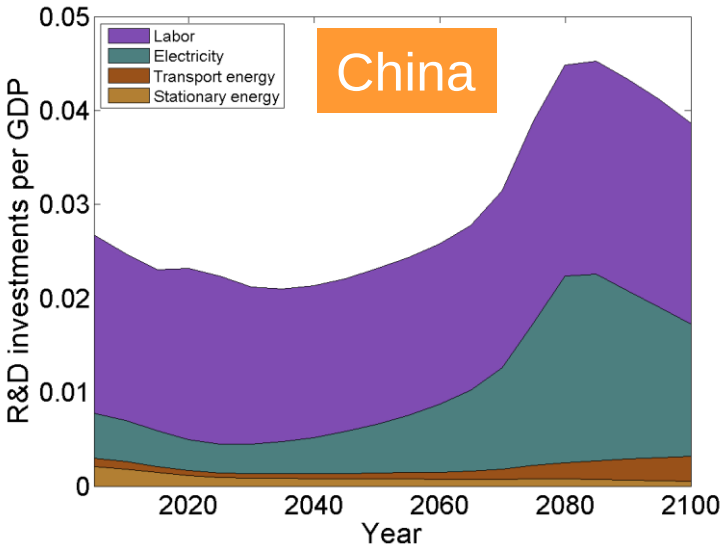


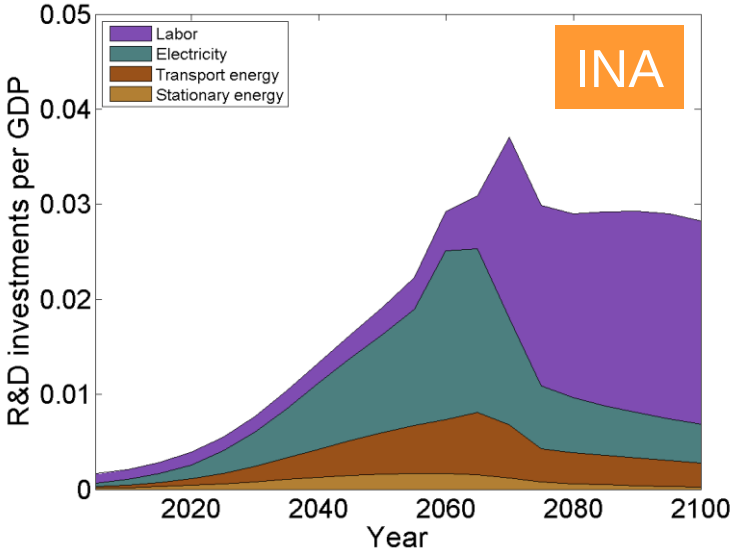


Reference Scenarios: Baseline



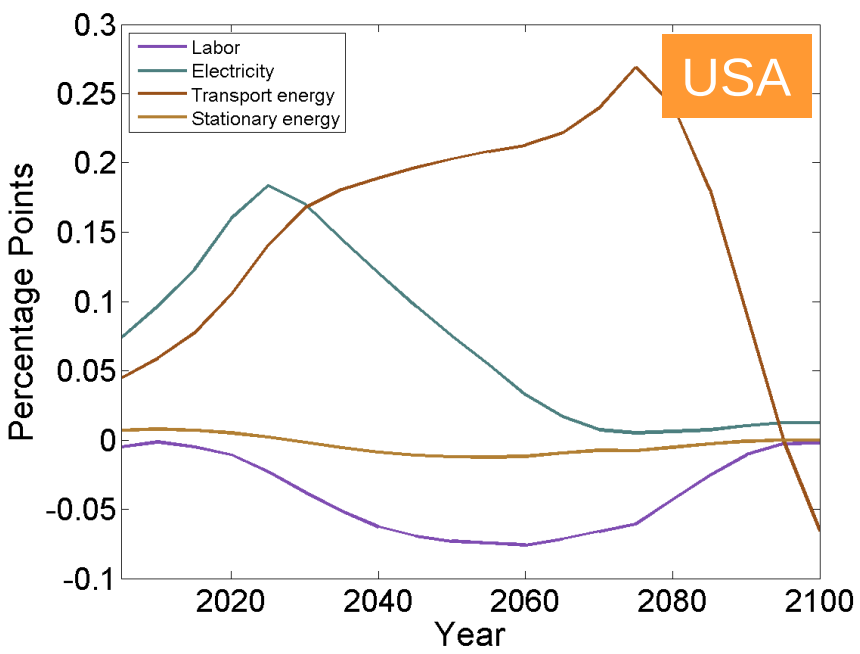
R&D investments into the energy related sectors are one-fifth of the investments into labour efficiency.

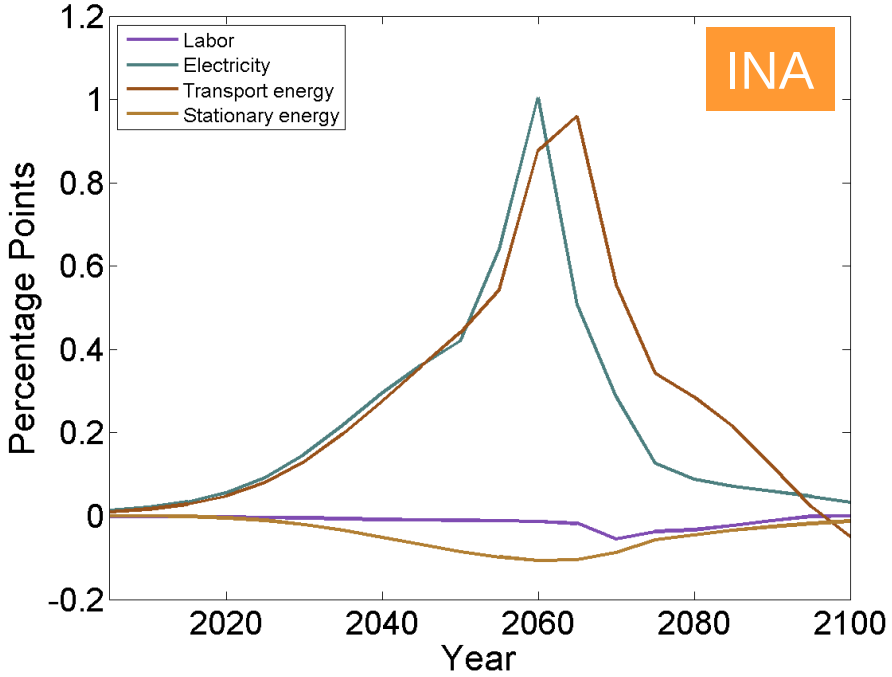




Reference Scenarios: Policy

Investments into the efficiency of electricity and transport energy use are increased.





Difference of R&D investment shares between baseline and policy.

Energy Sector and Technology Experiments

Energy Sector Experiments:

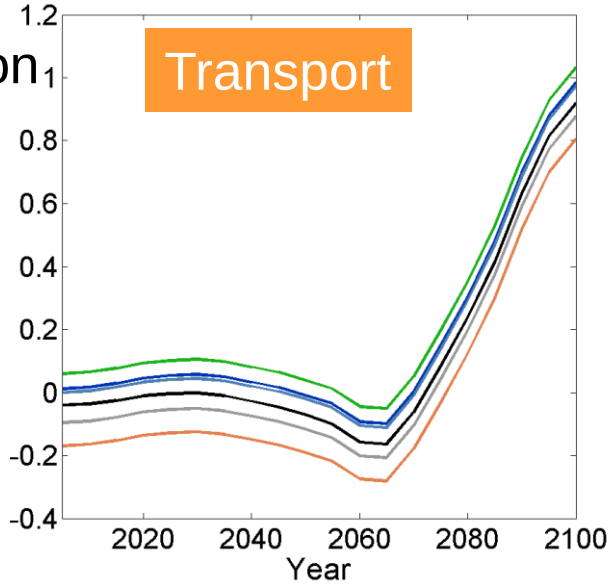
Within which sectors are R&D investments most important for climate change mitigation?

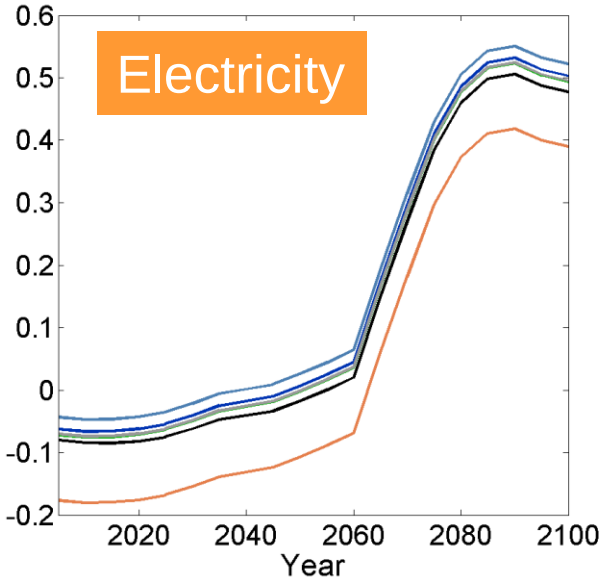
Technology Experiments:

Might R&D investments compensate increased mitigation costs if the use of some technologies is restricted?

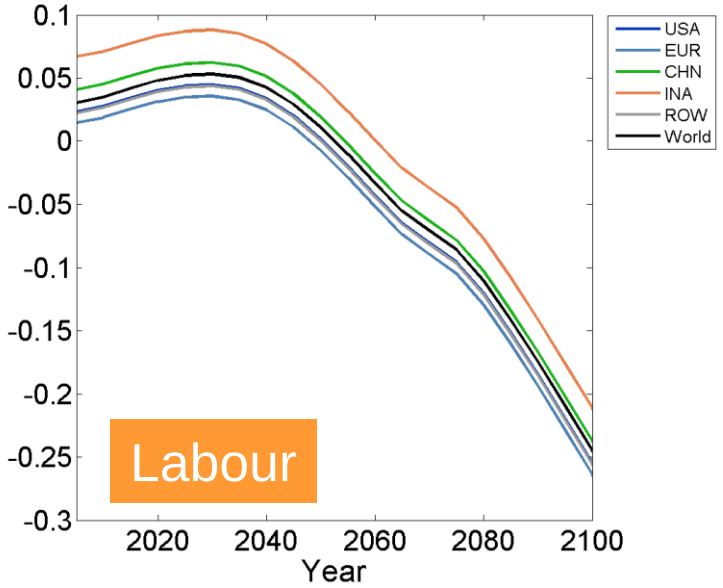
Energy Sector and Technology Experiments

Percentage consumption difference between Reference-Policy and scenarios with fixed R&D Investments





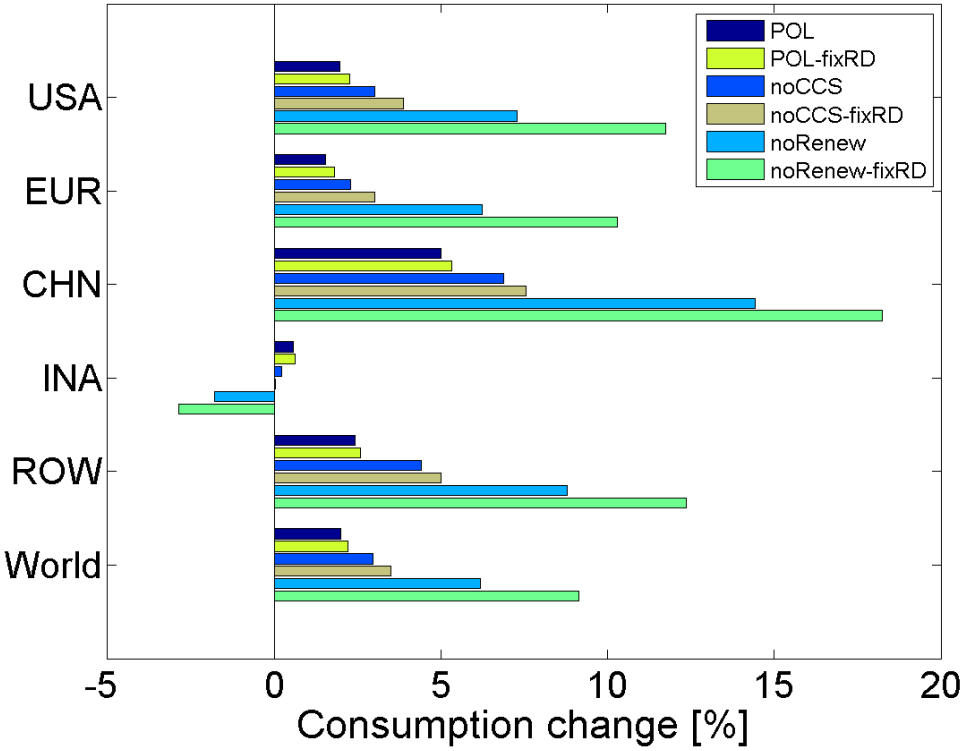
Positive values – more consumption in the policy scenario without restrictions of R&D investments



PIK

Energy Sector and Technology Experiments

Technology Experiments

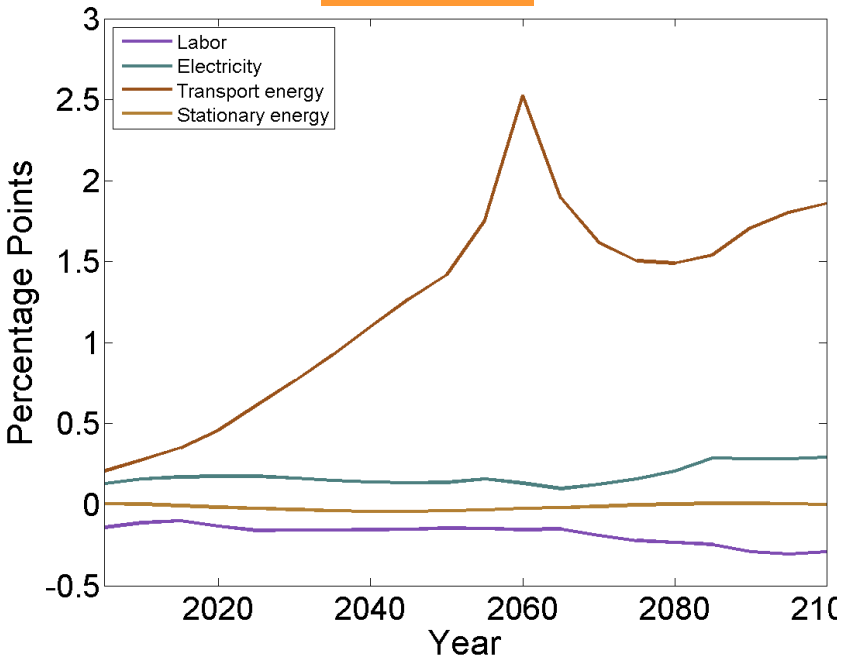


The meaning of R&D investments increases, the more technologies are restricted.

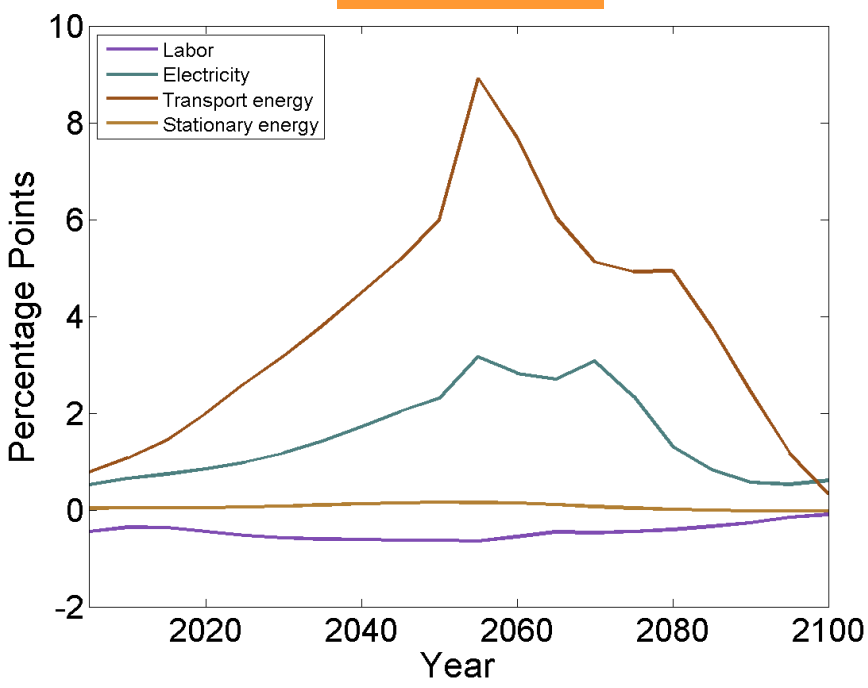
Mitigation costs – average percentage consumption difference

Energy Sector and Technology Experiments

noCCS



noRenew



Mainly the investments into the efficiency of the transport sector are increased if technological options are restricted.

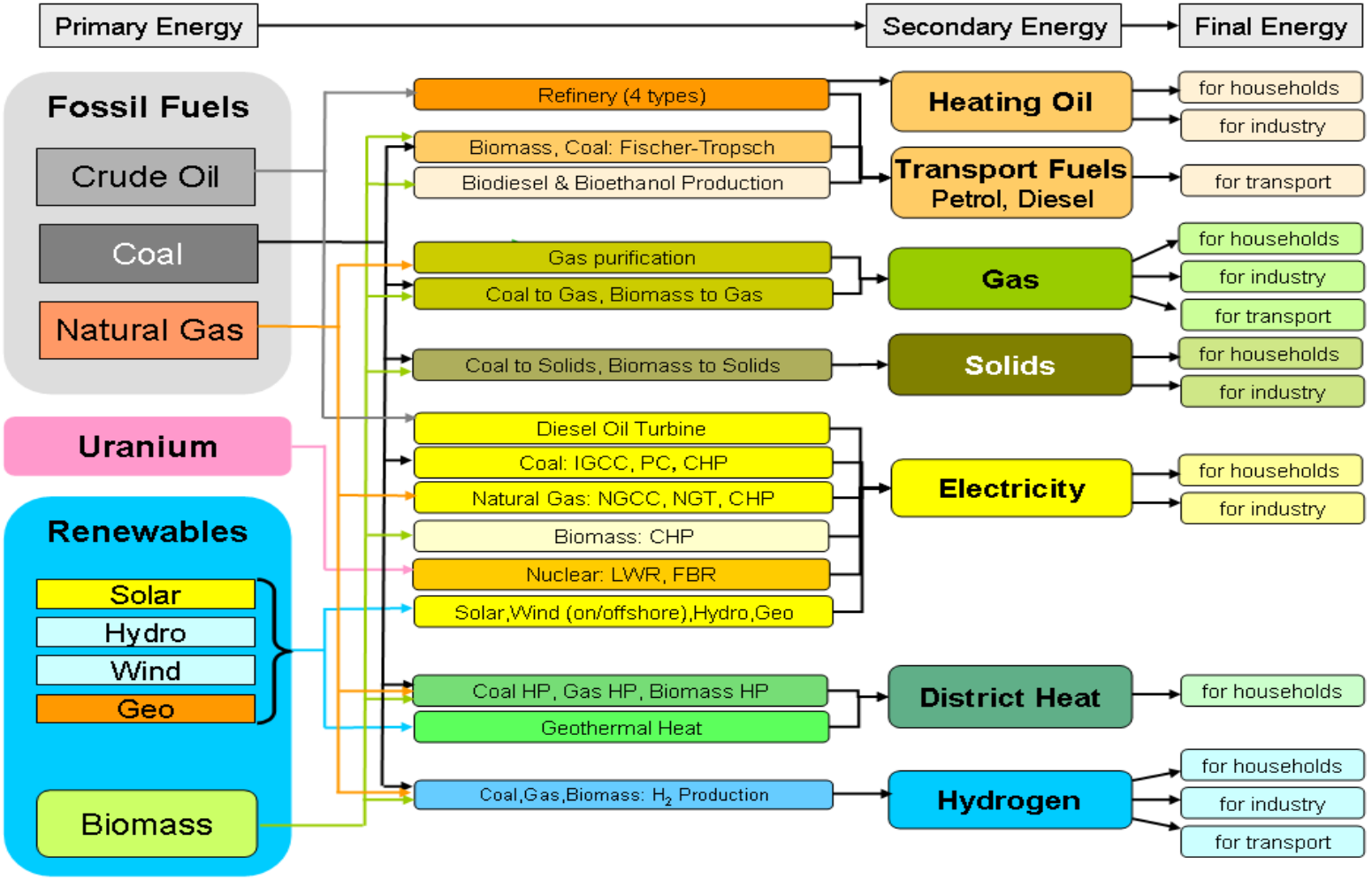
Conclusion

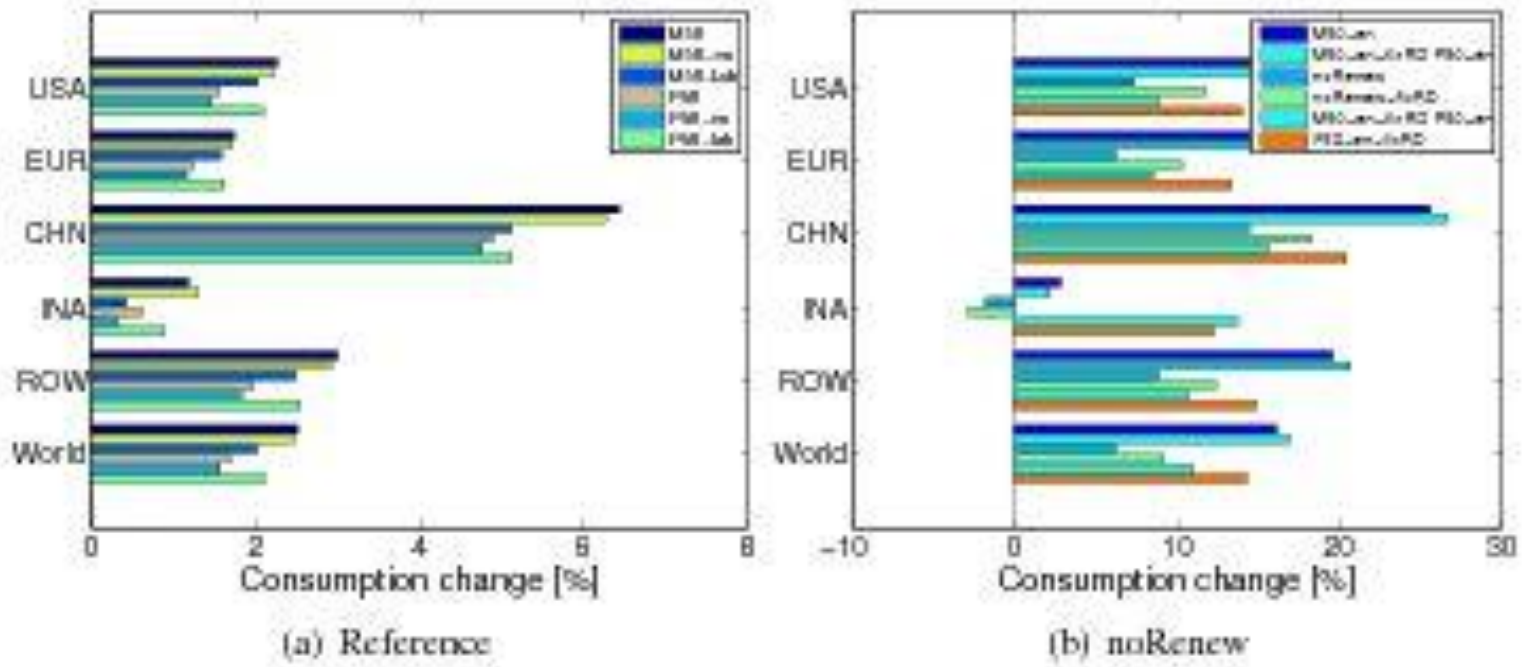
- The model of endogenous technological change based on R&D investments in labour efficiency simulates a plausible scenario of economic growth.
- Under climate policy, R&D investments are re-allocated to further improve the efficiencies of the energy related production factors.
- Energy sector experiments: mainly investments into the efficiency of the transport and electricity sector play a crucial role for lowering mitigation costs.
- Technology experiments: cost increase is partly compensated by investments into end-use energy efficiency improvements.

Thank you

Back up

Energy System Module

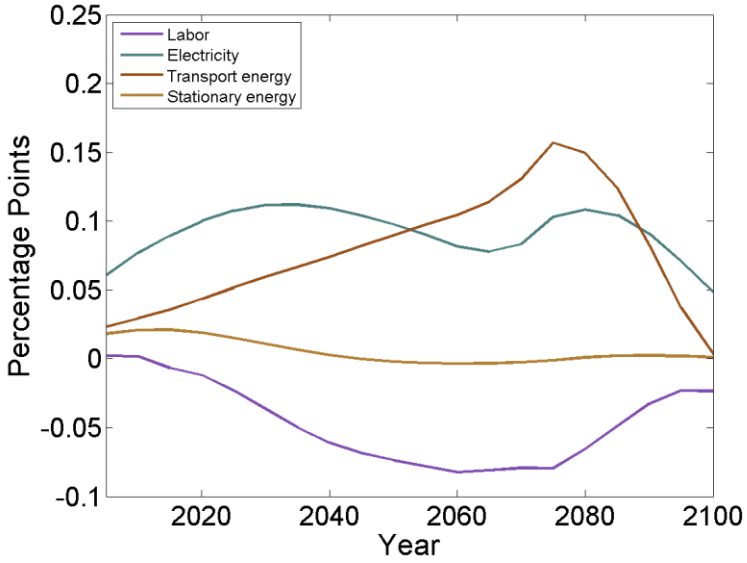



USA
EUR
CHN
INA
ROW
World
0
2
4
6
8
Consumption change [%]
(a) Reference
−10
0
10
20
30
Consumption change [%]
(b) noRenew

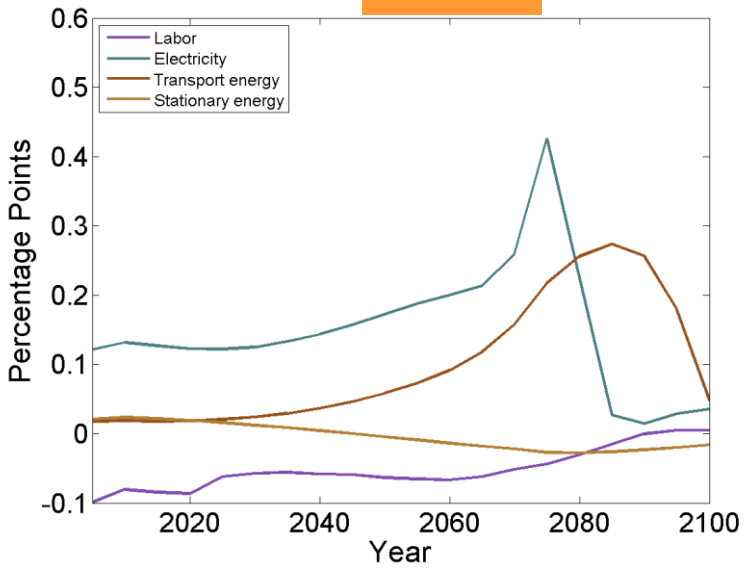
Production function is a nested CES-function of the general structure:

$$\underbrace{OUT(t,r)}_{\text{factor output}} = \left(\sum_{M_{CES}} \underbrace{(A(t,r,IN)}_{\text{endogenous efficiency parameter}} \cdot \underbrace{IN(t,r)^{\rho(r,OUT)}}_{\text{factor input}} \right)^{1/\rho(r,OUT)}$$

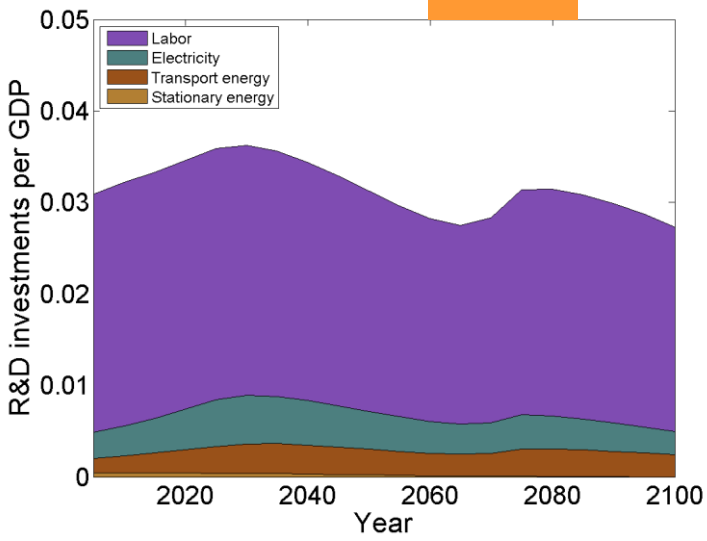
Europe



China



USA


Labor
Electricity
Transport energy
Stationary energy
R&D investments per GDP
0.05
0.04
0.03
0.02
0.01
0
2020
2040
2060
2080
2100
Year