



POTSDAM INSTITUTE FOR  
CLIMATE IMPACT RESEARCH

## **Assessing long-term climate change stabilization using an Integrated Model of energy, economy, land-use and climate**

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# Content

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- Introduction
- The Integrated Assessment Model framework
- Scenarios
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- Conclusion

## Introduction – Why model integration is needed?

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- Achieving low stabilization targets is a strong challenge for economy, energy, and land use
- Land-use GHG emissions
- Bio-energy and co-emissions
- Net negative emissions and concentration peaking
- Implications on agricultural sector, (water use, poverty, ...)
- Interacting price formation mechanisms for energy, carbon, bio-energy, food, ...
- Afforestation and soil carbon
- Effects of fragmented climate policies

# The Integrated Model Framework

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**ReMIND**

**MAGPIE/LPJmL**



# The Integrated Model Framework – Shared Assumptions

## Scenario

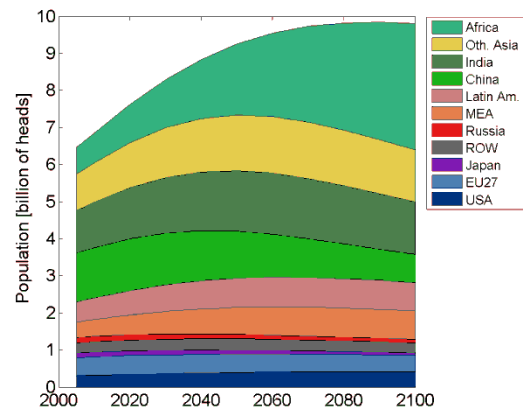
Specific assumptions derived from general narratives

## Common pathways

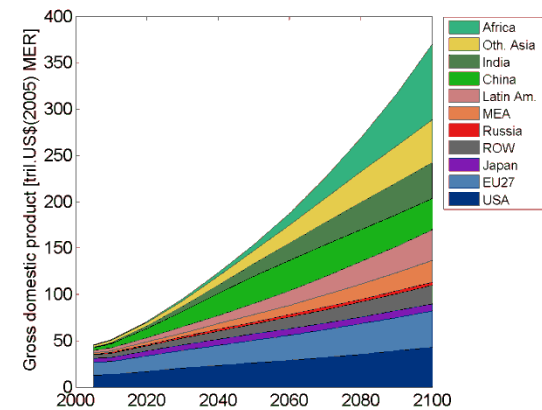
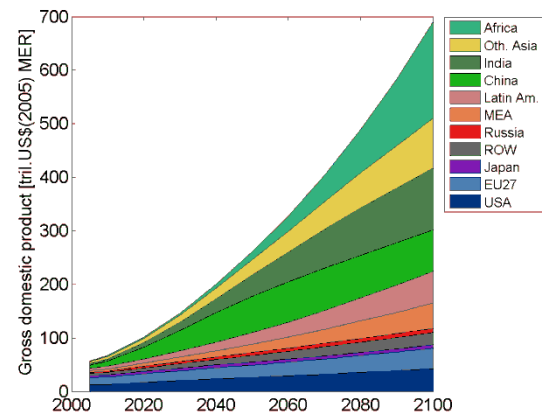
Demographic

Macro-economic growth

### ReMIND



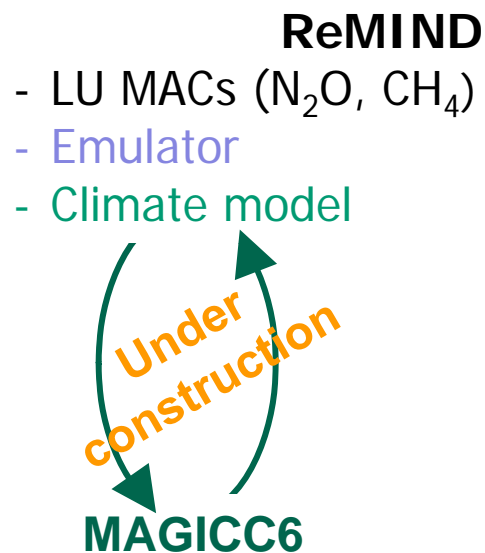
### MAGPIE/LPJmL



# The Integrated Model Framework – Coupling

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- biomass demand
- GHG prices ( $\text{CO}_2$ ,  $\text{N}_2\text{O}$ ,  $\text{CH}_4$ )



## MAGPIE/LPJmL

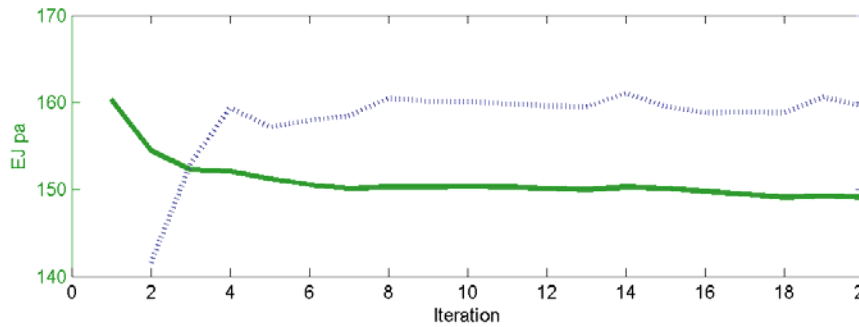
- Up-date emulator
- LULUCF emissions ( $\text{CO}_2$ ,  $\text{N}_2\text{O}$ ,  $\text{CH}_4$ )

## Emulator

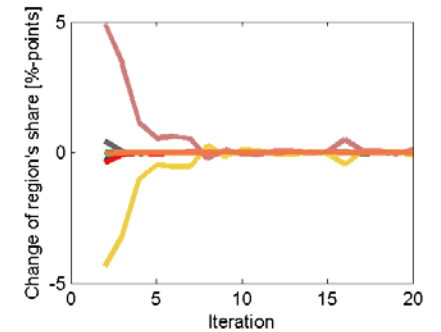
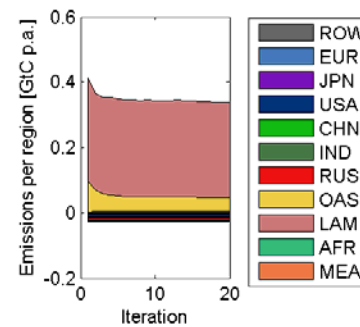
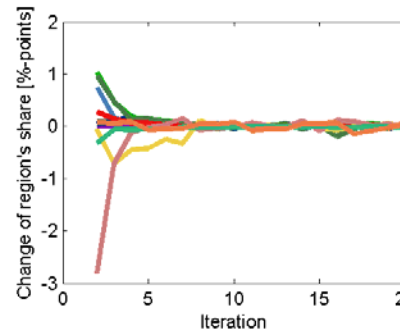
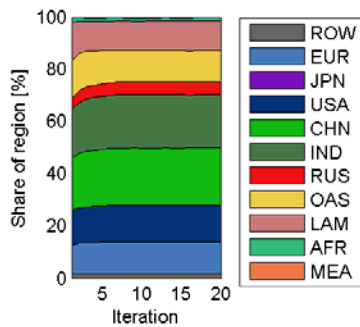
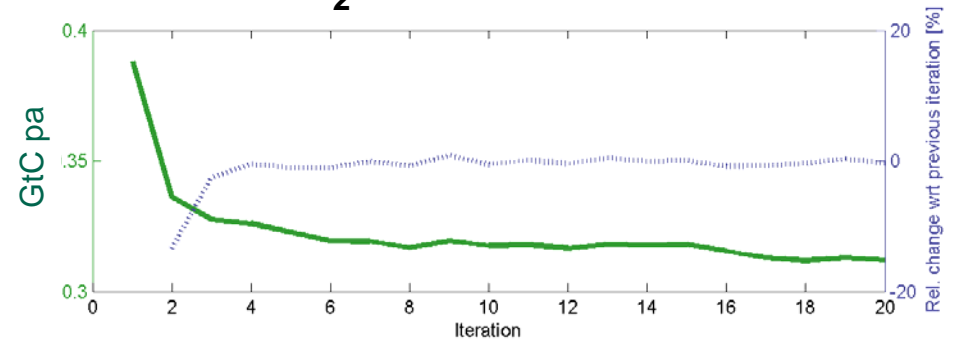
- Bio-energy supply with adjustment costs
- From various scenarios

# Convergence of the Iterative Soft-Link

## Bio-energy in 2100



## CO<sub>2</sub> emissions LUC



## Scenarios

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- BAU: No climate change mitigation policies
- Pricing of all CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O emissions
  - 550: stabilization of GHG at forcing level equivalent to 550ppm CO<sub>2</sub> only not to exceed
  - 450: achieve forcing level equivalent to 450 CO<sub>2</sub> only by 2100 with overshoot
  - 450C: bio-energy constrained to 300EJ
- No pricing of LULUC emissions
  - 550#
  - 450#

Note: Aerosol emissions are no mean to achieve the forcing level. The simple model achieves total forcing 2.6W/m<sup>2</sup>, but MAGICC6 2.85W/m<sup>2</sup>.



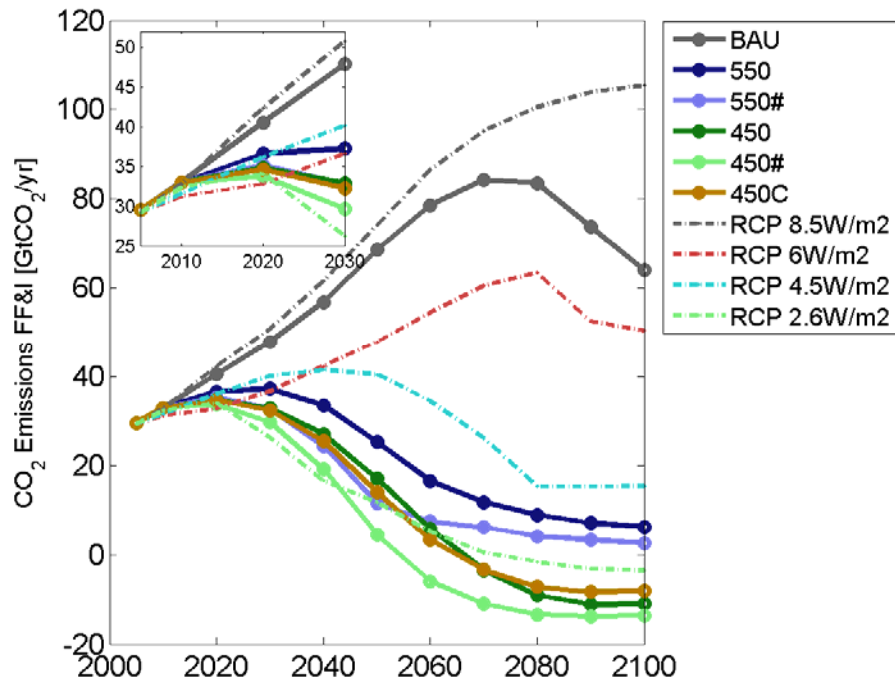
# Results

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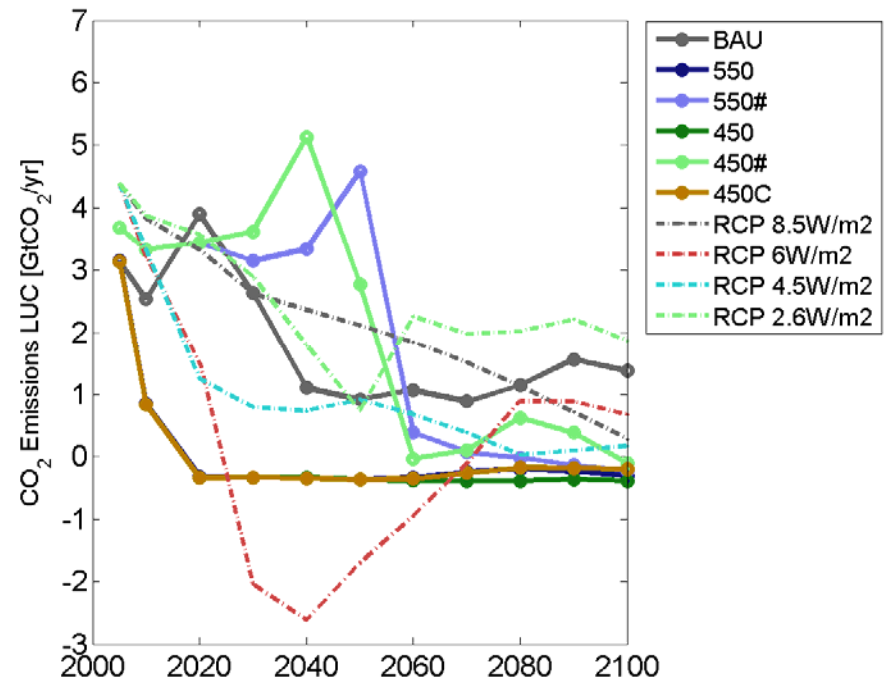
- GHG-Emissions
  - Over time
  - Cumulative
  - Carbon prices and abatement
- Energy sector
- Bio-energy
  - Global use
  - Regional use and trade
  - Prices
- Land-use change
- Agriculture prices

# Results – GHG Emissions

## CO<sub>2</sub> emissions FF&I

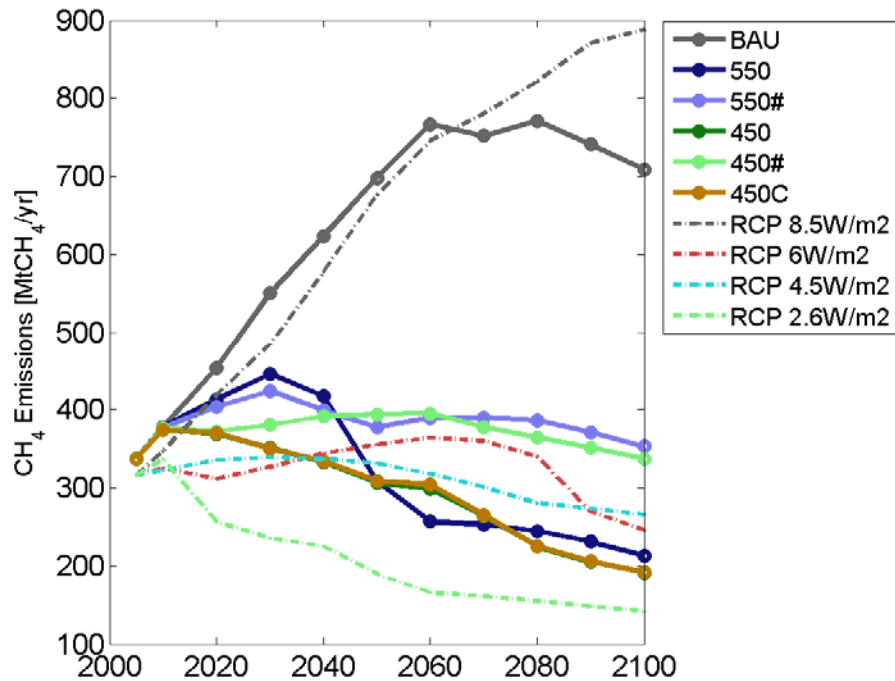


## CO<sub>2</sub> emissions LUC

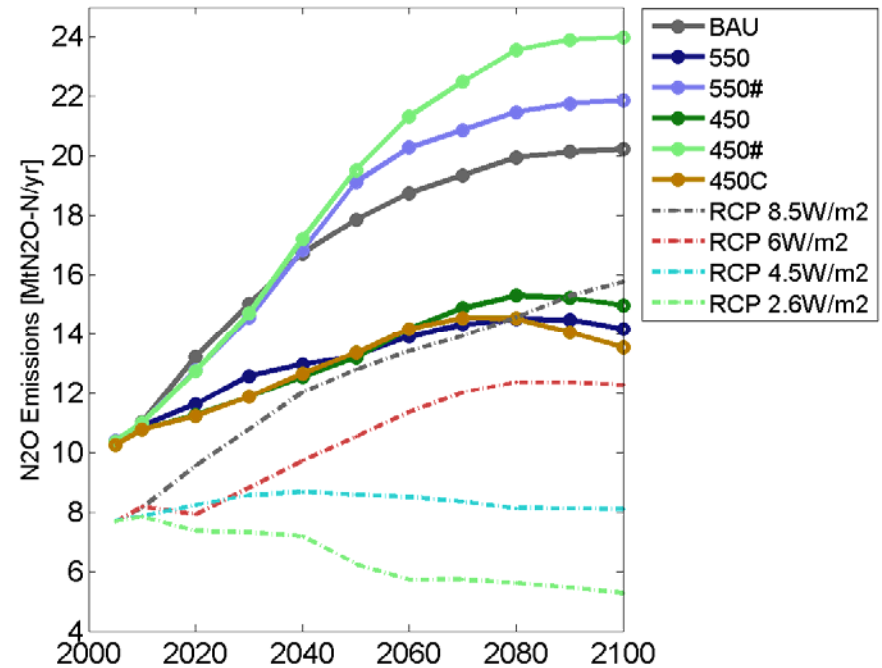


# Results – GHG Emissions

## CH<sub>4</sub> emissions

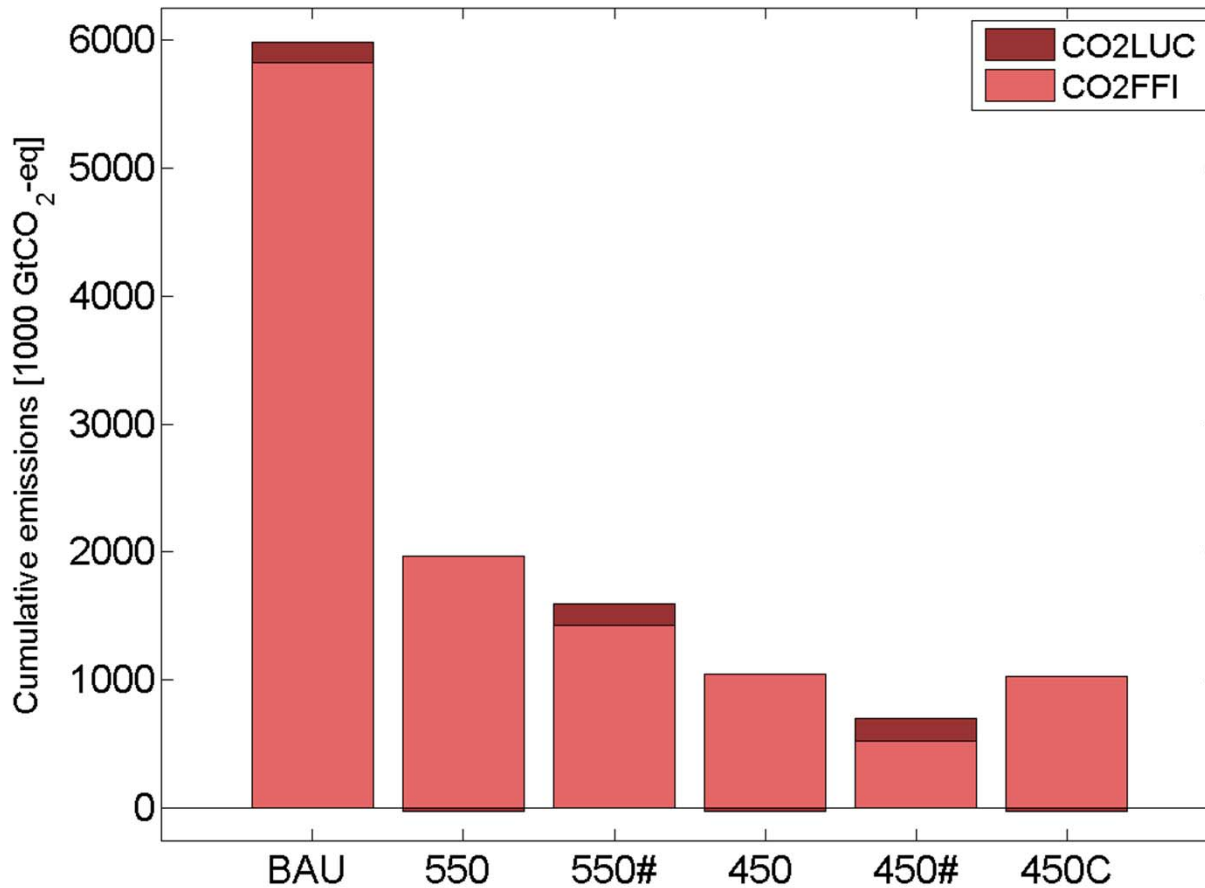


## N<sub>2</sub>O emissions



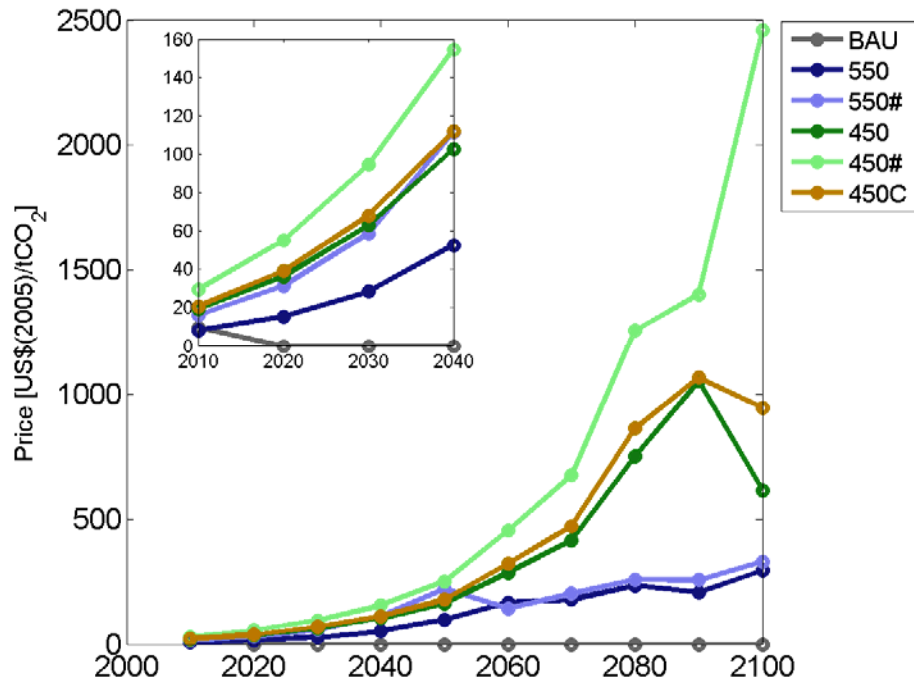
# Results – GHG Emissions

## Cumulative CO<sub>2</sub> emissions 2010-2100

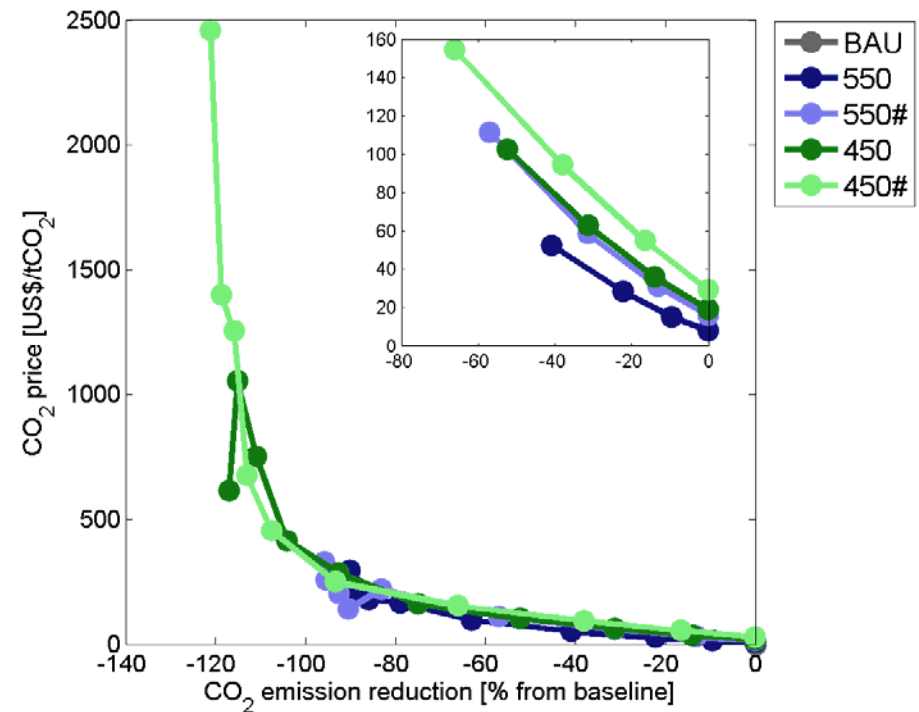


# Results – Carbon permit prices

## Over time

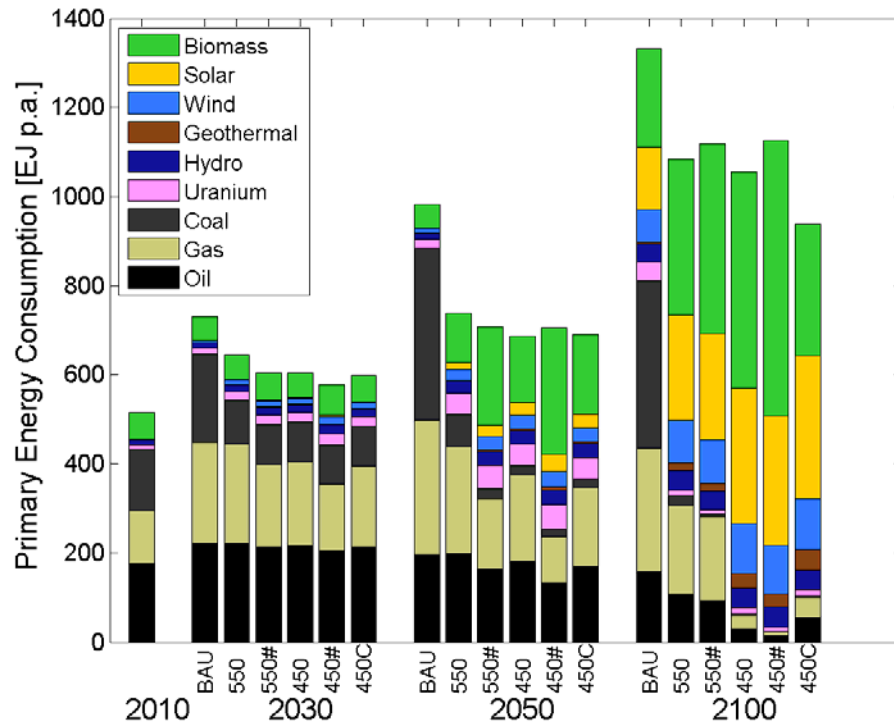


## Over abatement level (FF&I)

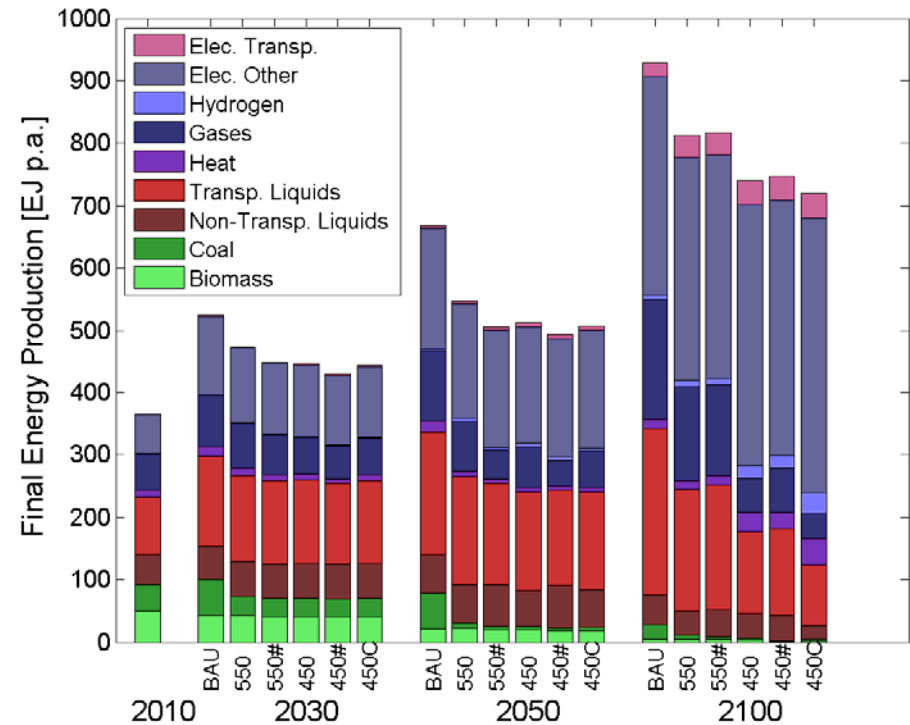


# Results – Energy Sector Implications

## Primary energy mix

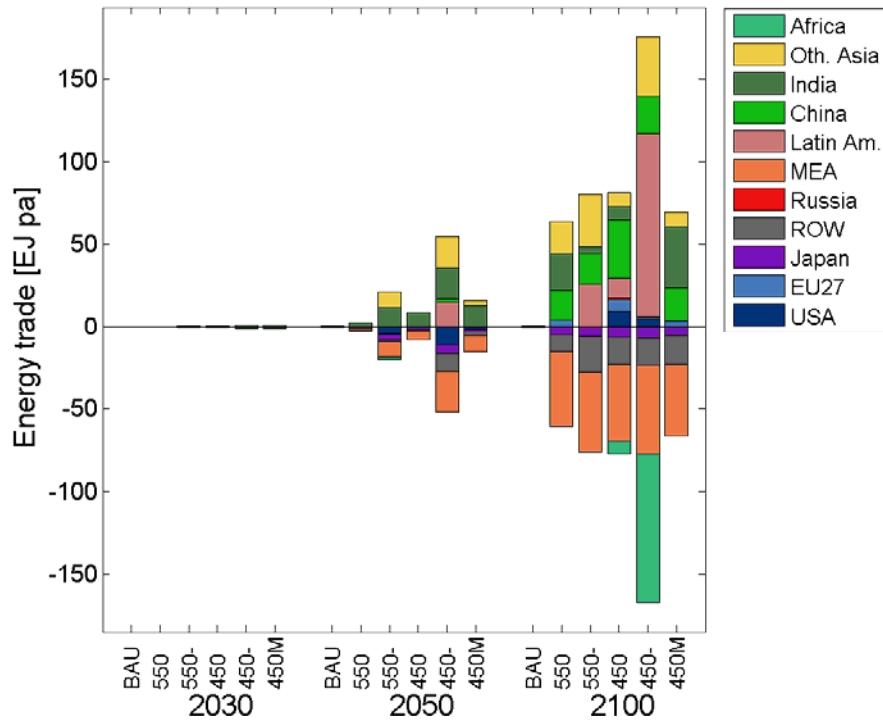


## Final energy mix

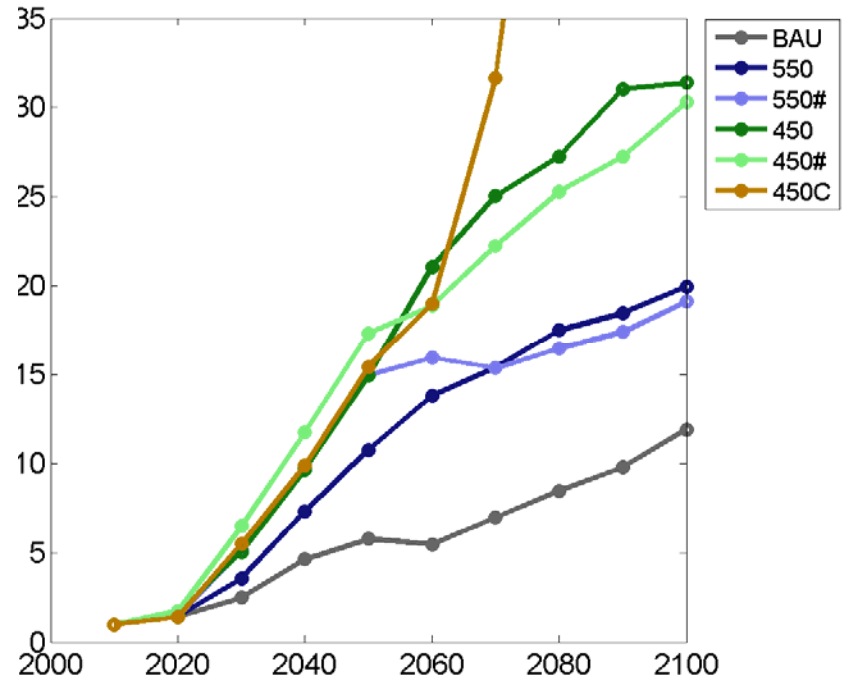


# Results – Bio-Energy Market

## Bio-energy

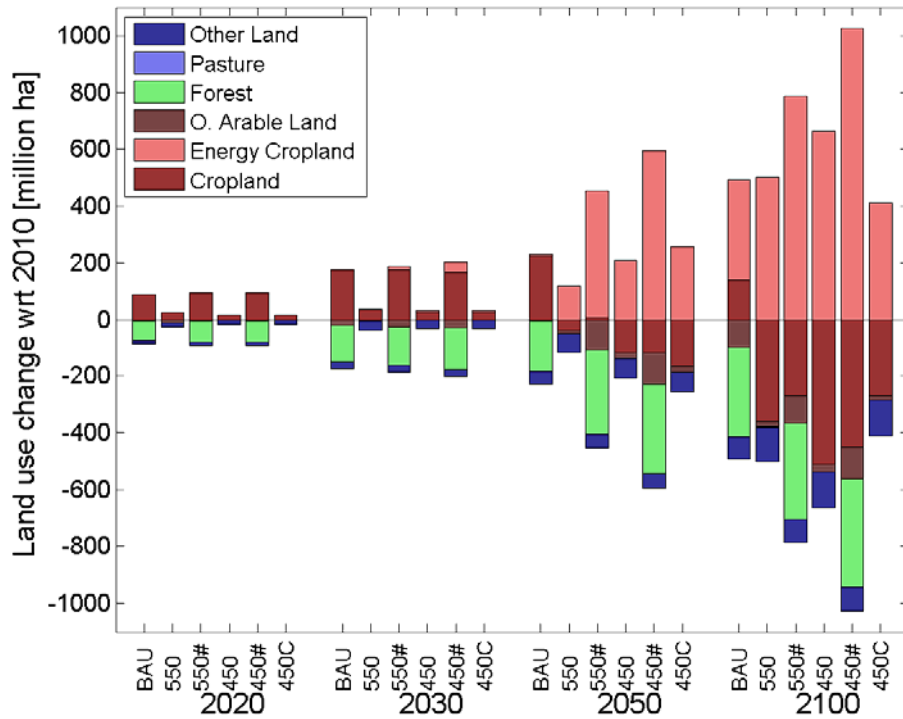


## Bio-energy avg. costs & prices

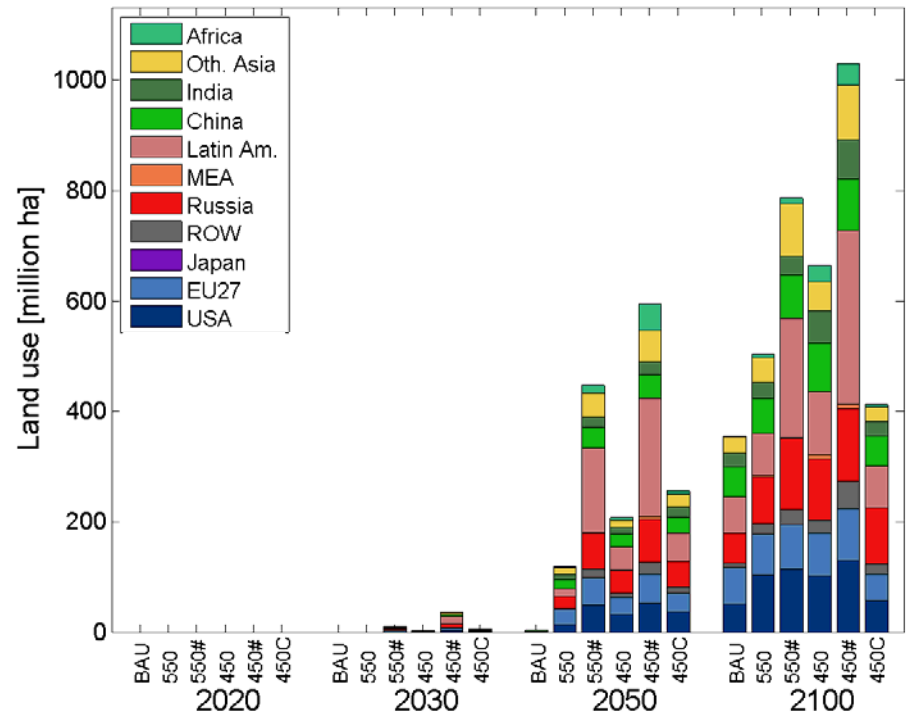


# Results – Land Use Change

## Global LUC change wrt 2010



## Energy crop area by regions

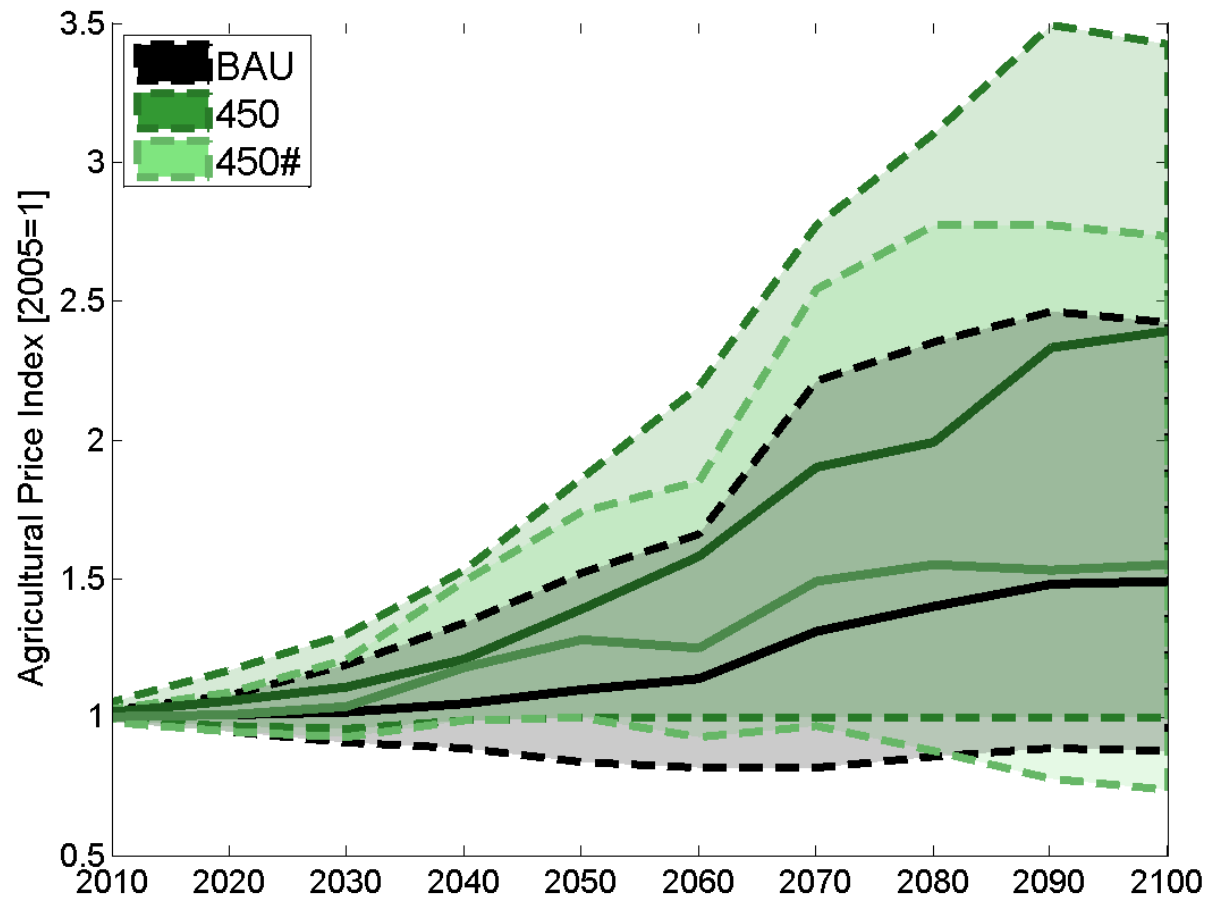


**Note:** total land cover 12,900Mio. ha





# Results – Agricultural Price Index



## Conclusions

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- Low stabilization targets climate change leads to a closer inter-action between economy, energy and land-use sector
- BE(CCS) competitive at high C-prices; starts 2040
- Net negative emissions at very high C-prices to limit FFI
- At very high C-prices WTP for bio-energy is high
- Bio-energy demand increases competition for land-use
- Pricing of LU emissions is crucial
  - If yes: reduced potential for intensification and extensification; bio-energy and food prices increase
  - If not: higher pressure on energy sector with higher carbon prices and bio-energy demand
  - Impact on re-allocation of CO<sub>2</sub> emission budget is significant

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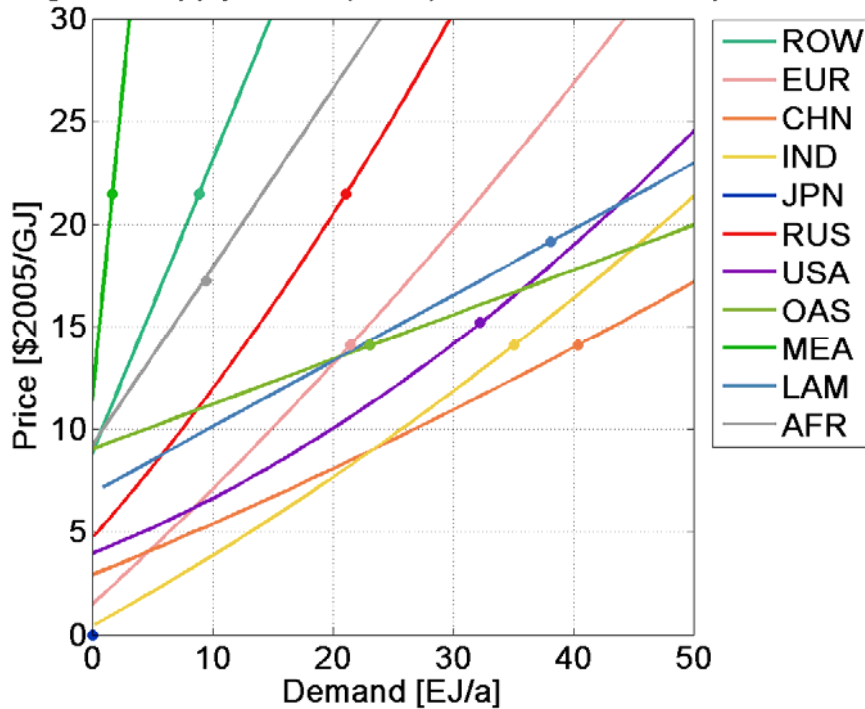
# Supporting slides



# Coupling approach – Bio-energy supply functions

## With irrigation

Regional supplycurves (2100) r4817-SSP2-CO2price



## Without irrigation

Regional supplycurves (2100) r4817-SSP2-CO2price-nolrrig

