Multi-model analyzes

of climate policy options
and their impact on
China and India
in terms of costs and energy system development

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Background

- Efforts to limit temperature increase to max 2°C above pre-industrial levels (Copenhagen Accord and Cancún Agreements).
- Need to cut global GHG emissions 35-55% by 2050 compared 1990 (to meet 2°C-target with probability of at least 50%).
- Emissions from developing countries alone will soon exceed global emission trajectory for reaching ambitious targets.
- Expected growth of Indian and Chinese economy implies important role in shaping the dynamics of the future global energy system and related CO_2-emissions.
- Mitigation efforts of India and China increasingly important.

Why this collaborative project?

- Traditionally, assessment of climate policy impacts in India or China has
  - either been carried out in national model or global models.
- Large differences in
  - assumptions on e.g. economic growth, energy prices and technology development
  - effort sharing approaches
- Global analyses often made in industrialized countries.
- National analyses often lack international perspective.
- Difficult to compare different studies.

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In this project:

A more consistent perspective by harmonizing and soft-linking different kinds of models.

- Global models - international linkages and feedbacks
- National models - national impacts of climate policy
- Energy system models - technological details
- CGE models - macro-economic feedbacks, changes in demand and trade.

Collaborating partners

- Chalmers University of Technology, Sweden
- Netherlands Environmental Assessment Agency, The Netherlands
- Kiel Institute for the World Economy, Germany
- Indian Institute of Management - Ahmedabad, India
- Institute of Economic Growth, India
- Tshinghua University, China
- Beijing Institute of Technology, China

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Aim

- Analyze global climate agreements, and their impact on China and India, focusing on
  - impact on energy systems; and
  - gains and costs
- Understand the
  - major driving forces in different models.
  - drivers behind the partly diverging model results.

Methodological approach

- A multi-model based approach
- Addressing model similarities/dissimilarities
- Harmonizing assumptions (partly)
- Application of climate regimes
  - common but differentiated convergence (CDC)
- Sensitivity analysis
  - Economic growth
  - Timing of emission reductions
  - Delayed effort-sharing

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Models

- Six models differing in
  - Geographic scale:
    - Global
    - China
    - India
  - Scope:
    - economy wide models (CGE models)
    - energy system models (Markal type)
- A seventh model
  - Determines global emission pathway's for the 2°C target
  - National emission allowances based on effort-sharing approach

The FAIR model

- Used to construct long-term greenhouse gas emission pathways consistent with the 2°C target
- Analyze emission reductions and abatement costs for different effort-sharing approaches.
- Uses a least-cost approach involving regional Marginal Abatement Cost (MAC) curves.
- Allow offsetting mechanisms such as emission trading and the Clean Development Mechanism (CDM).

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Energy-system models - details

- TIMER
  - Dynamic, **global**, 26 world regions, energy and industry related emissions of all Kyoto gases, substitution processes of various technologies based on long-term prices and fuel preferences.
- **China** MARKAL and MARKAL-**India**
  - Dynamic, linear, cost-minimizing models, energy related CO_2 emissions .

Computable general equilibrium (CGE) models - details

- DART
  - **Global**, 13 regions,
  - Divided into private households, government sector, capital, labor, land and natural resources.
- CEEPA
  - **China**, single country, based on input-output data of the National Bureau of Statistics PR China.
  - Consumers divided into households, enterprises and government.
- IEG-CGE
  - **India**, single country, based on a social accounting matrix.
  - Consumers divided into households, based on socioeconomic characteristics, enterprises and government.

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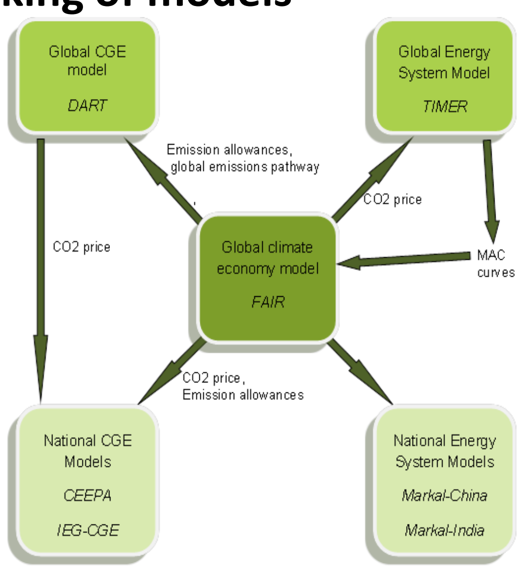
Soft-linking of models

- Common baseline scenario
- **FAIR** calculates the emissions pathway and regional emission allowances
- **DART** determines the carbon tax based on the global CO_2 pathway and the regional emission allowances from FAIR
- The **national CGE** models use the emission allowance from FAIR and the carbon tax from DART to determine changes to the energy system and total climate policy cost
- **TIMER** and the **national MARKAL** models use the emission allowances and carbon tax from FAIR to determine changes to energy system and total climate policy cost.



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Common-but-differentiated convergence (CDC) allocation (effort sharing) scheme

- **Similar to contraction and convergence (C&C) regime but developing countries start reduce CO_2 only after reaching a certain threshold of per capita emissions.**
- Important parameters
  - the threshold that requires countries to enter the regime
  - the long-term per capita emissions convergence level

- All countries that made a reduction pledge under Cancún Agreements are assumed to meet their targets in 2020.
- After 2020, developed countries follow the convergence trajectories.
- China and India start in 2025 and 2030, respectively.
- China and India take 30 years to converge.
- All countries converge to a level of 1.7 tCO_2/capita in their respective convergence year.

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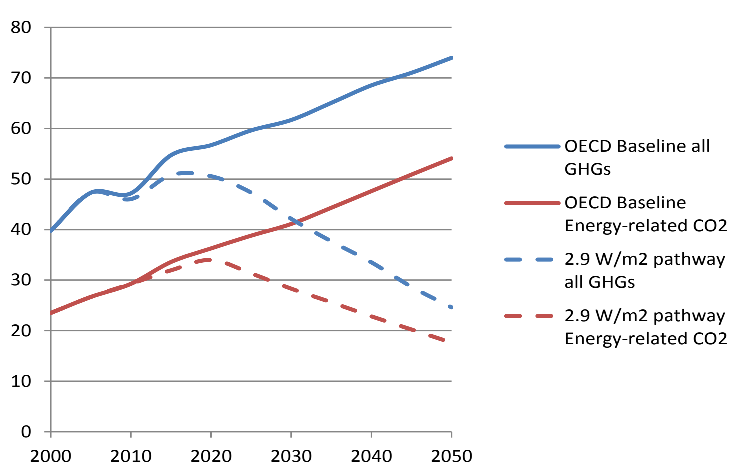
Global GHG emission pathways



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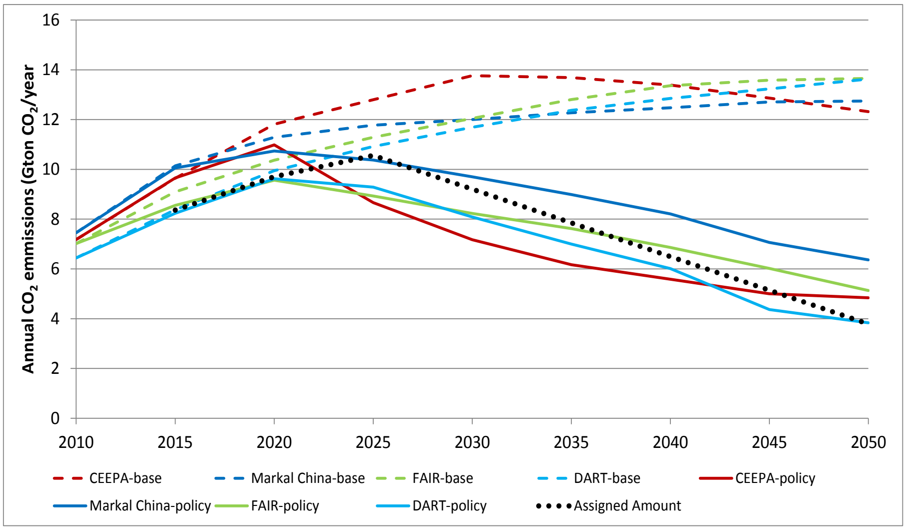
Results: Emissions China



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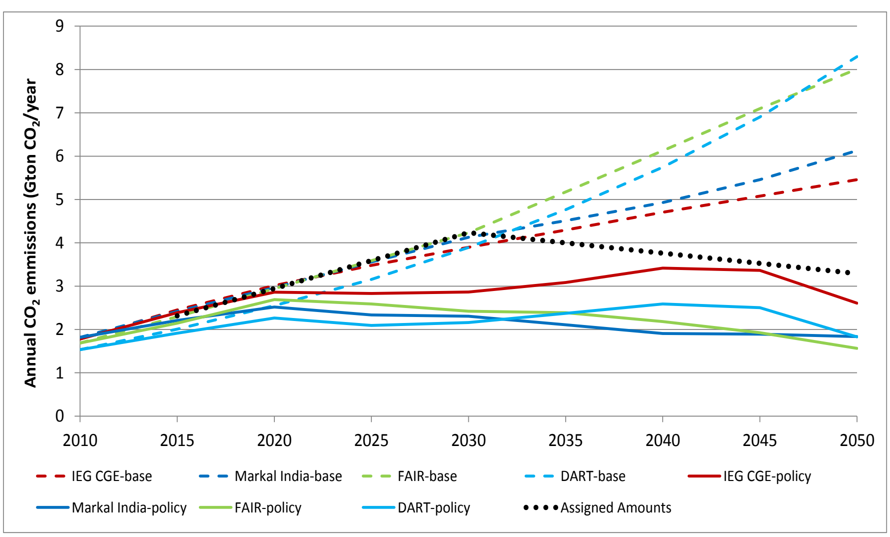
Results: Emissions India



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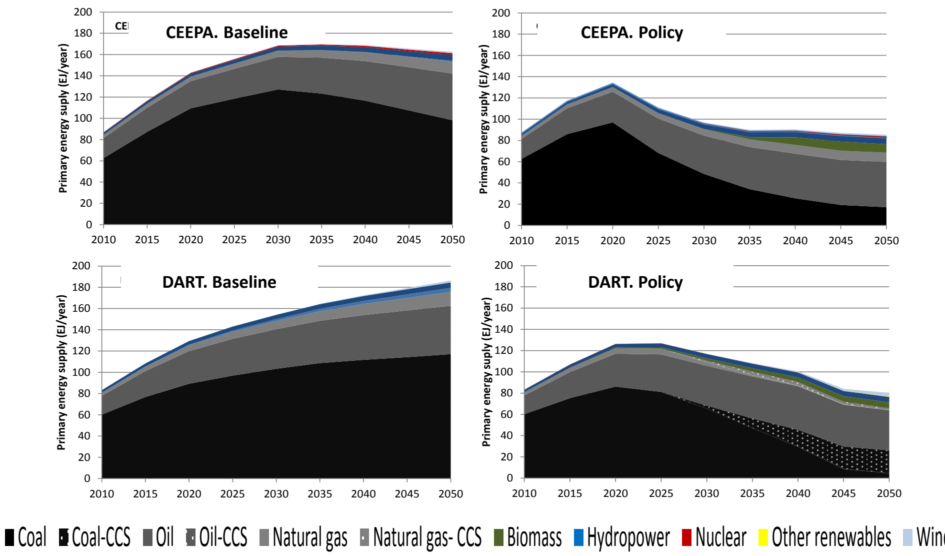
Results: Changes in fuel mix China I



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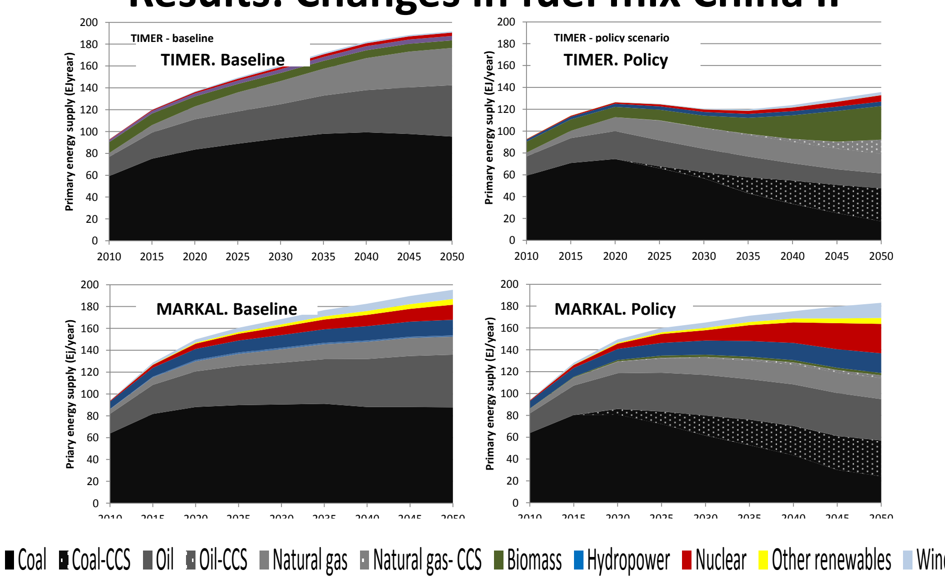
Results: Changes in fuel mix China II



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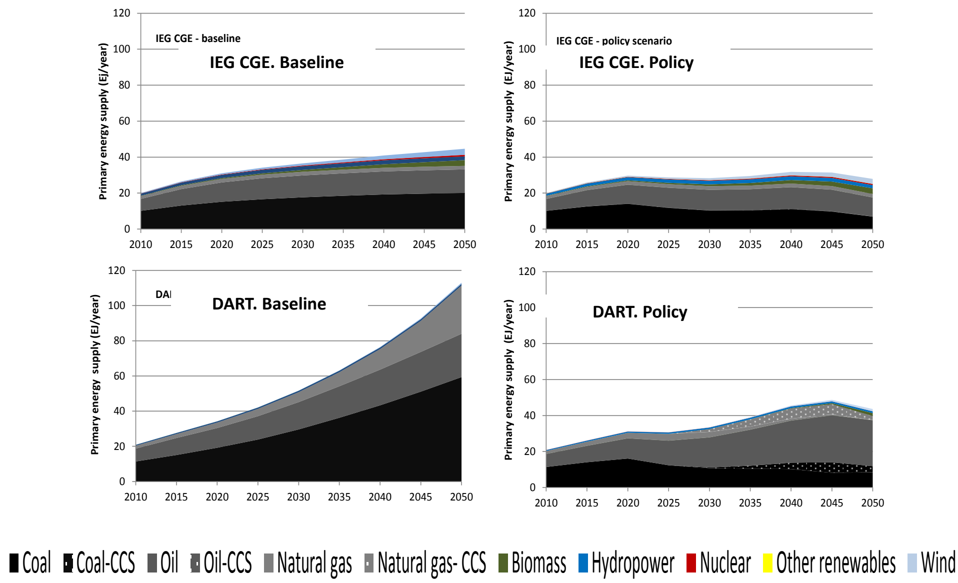
Results: Changes in fuel mix India I



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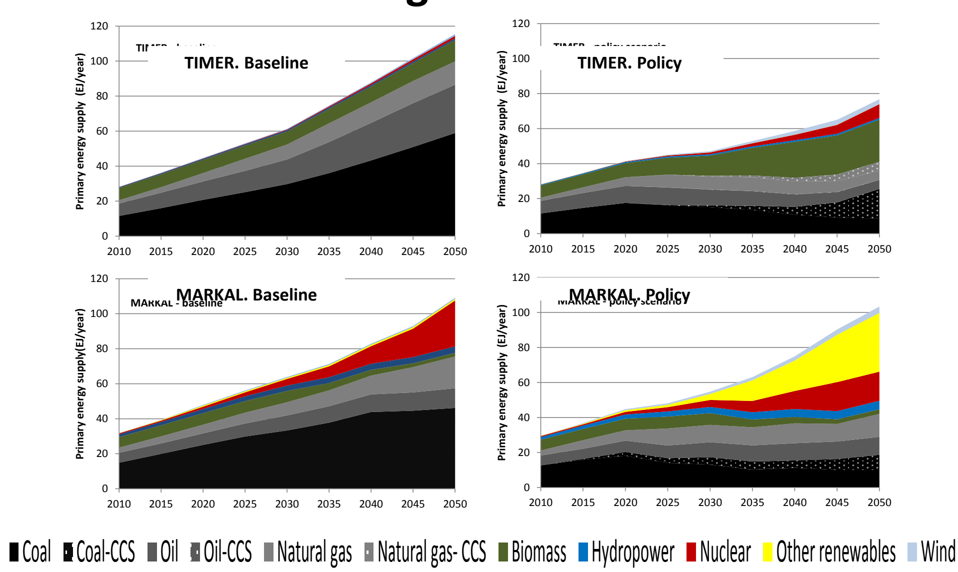
Results: Changes in fuel mix India II



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Decomposition of abatement

Decomposition analysis can help to better visualize the differences in how abatement is taking place in the models

Here, results are analyzed using the Kaya identity:
E_{CO2}=GDP*EI*CI

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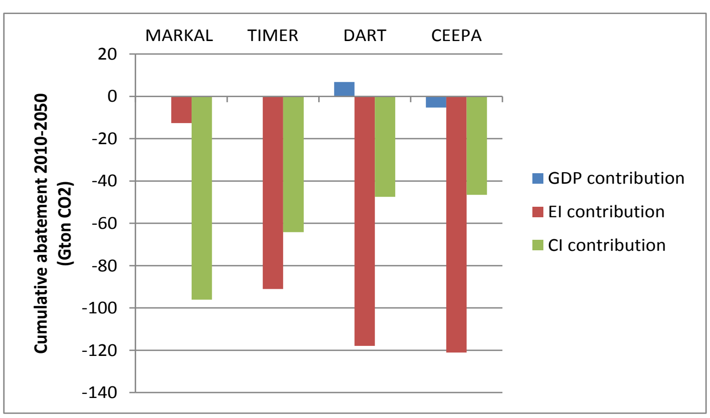
Abatement in models: China



EI = annual average energy intensity (i.e., unit primary energy per unit GDP)
CI = annual average CO_2 intensity (i.e., unit CO_2 emissions per unit primary energy).

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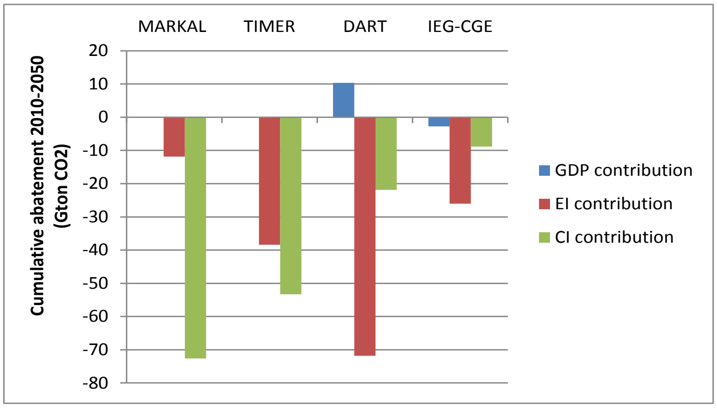
Abatement in models: India



EI = annual average energy intensity (i.e., unit primary energy per unit GDP)

CI = annual average CO_2 intensity (i.e., unit CO_2 emissions per unit primary energy).

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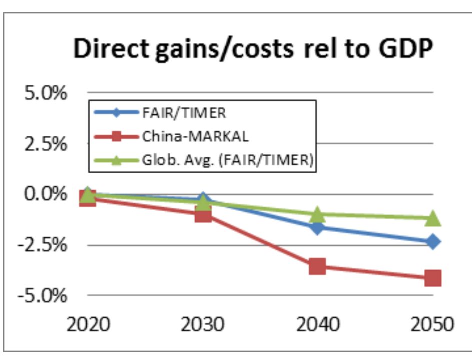
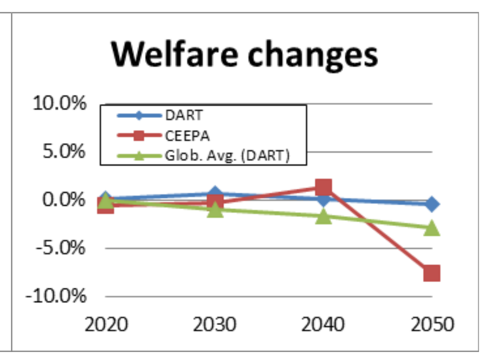
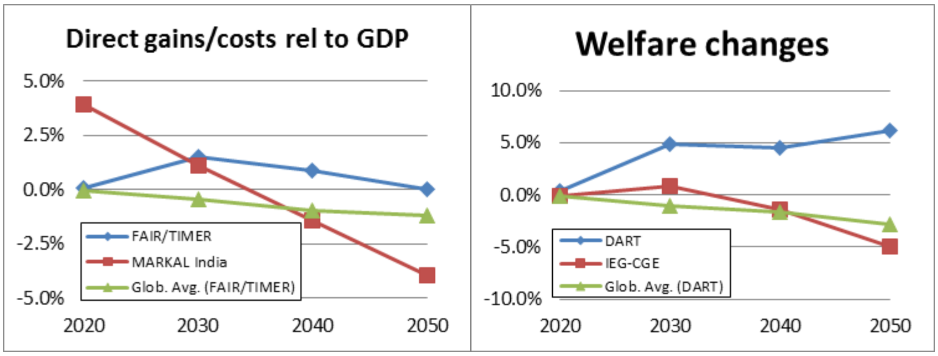
Gains/Costs of climate policy: China





In the policy scenario, international fossil fuel price declines. China import fossil fuels and thus profit from this. This effect is only captured in DART

Gains/Costs of climate policy: India



- Indian per capita emissions are low. India can sell more credits on the carbon market than China.
- Indian economy is smaller than the Chinese and net export of credits has a larger impact on India.
- The world (as a whole) consumes less fossil fuels in the policy scenario. International fossil fuel price declines. India import fossil fuels and profit from this. This effect is only captured in DART.

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Main insights I

- Economic and energy implications of climate policies for China and India vary per model.
  - Models with similar structure (CGE vs. Energy system) lead to comparable results.
  - Models with national focus tend to show more negative economic implications of climate policies than global models.
- Decreased energy intensity is most important in the CGE models
- Decreased carbon intensity is most important in the energy models.
- Thus, different models are required to address the different important aspects

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Main insights II

- To reach the 2 degrees target significant reductions are required - also in China and India – implying huge changes in their energy systems
- CCS is a central abatement technology, as is renewable energy.
- Climate policy costs (direct costs or as welfare change) vary per model.
  - In general, India benefits from allowance trading the entire period until 2050 while China becomes a buyer during the period.
  - Both India and China benefits from declining international fossil fuel prices.