Assessing the evolution of India's power sector to 2050 under different CO_2 emissions rights allocation schemes

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Introduction: India

- Electrification rate is 85%
- About 200 million people does not have access to electricity
- India's annual national electricity consumption per capita was less than 600 kWh compared to nearly 13,000 kWh in the U.S
- India is the third largest CO_2 emitter
- Three fourth of the electricity generation is from coal based power plants
- India overtakes China as the largest growth market for energy by the late 2020s

Burden sharing

- There are discussions on mitigation burden sharing due to:
- Differences in per capita emissions as well as CO_2 intensity (CO_2/GDP).
  - It is also fair to say that several factors affect the energy consumption of a country such as electrification rate, climate, spatial distribution of populations, sectoral compositions of the economy, Climate, etc.
- Historical responsibility
  - Decreasing marginal warming potential despite their long lifetimes.
- Development first objectives

Burden sharing

- **Equal per capita emissions**: near impossible to comply because of high current emission levels, such as USA, Canada and Australia; it does not take into account the fact that high-income countries are responsible for a majority of the historical emissions
- **Contraction & convergence** (C&C) and equal cumulative per capita emissions (commonly known as historical responsibility).
- **Common but Differentiated Convergence** (CDC) - actions of developing countries are delayed and conditional on developed countries taking action ('differentiated').
- **Based on intensity**: The use of emission intensity will likely place a greater burden on developing countries that do not have a services-based economy
- Based on country's **GDP/capita**
- The costs of emissions reductions (deployment of low carbon technologies and reducing resource consumption) must be shared equally

Objectives and scenarios

- Thus, this paper focuses on how does India's power sector evolve till 2050 under different emissions rights allocation scheme.
- This paper identifies important trends and future developments in the Indian power sector under the different allocations and evaluates role of key generation technologies and examine the appropriateness of current policies.
- The scenarios are built around INDC's and analysis also focusses on lock-in investment and stranded assets (coal generation technologies) under different scenarios.

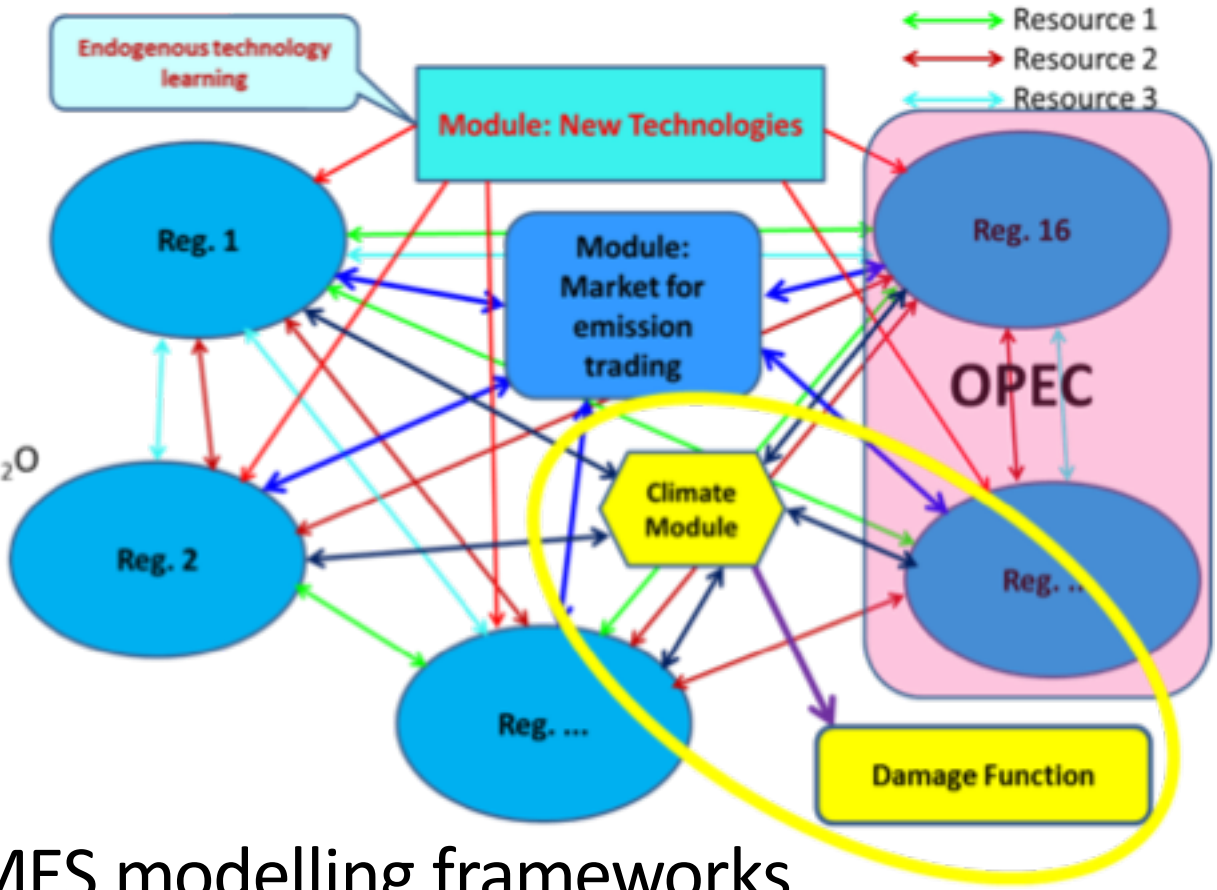
Target year	Emissions intensity of GDP	Non-fossil installed electricity capacity
2030	35% lower than 2005	40%
2040	50% lower than 2005	45%
2050	65% lower than 2005	50%

Scenarios

- **REF**: Reference Scenario with nor climate policy
- **NDC**: Implementing India's two key pledges: Emission intensity (GDP) and non-fossil installed capacity
- **2C**: Limiting temperature rise to 2°C
- **PCC**: Per Capita Convergence. CO_2 emissions of all regions converge to 1.3 tonne/person in 2050
- **EIC**: Emissions Intensity Convergence. CO_2 emission per unit of GDP off all regions converges to 80 tonne/million US$ in 2050.
- **ATP**: Ability to Pay. Regions are allocated CO_2 emission allowances in the inverse of GDP/capita, i.e. poorer regions are allowed to emit more CO_2.

TIAM-UCL

- Global energy system
- Cost optimisation model
- 16 regions
- Flexible time horizon
- Climate module
  - ✓ GHGs emissions:CO_2 CH_4 and N_2O
  - ✓ Radiative forcing
  - ✓ Global ΔT
- Damage function



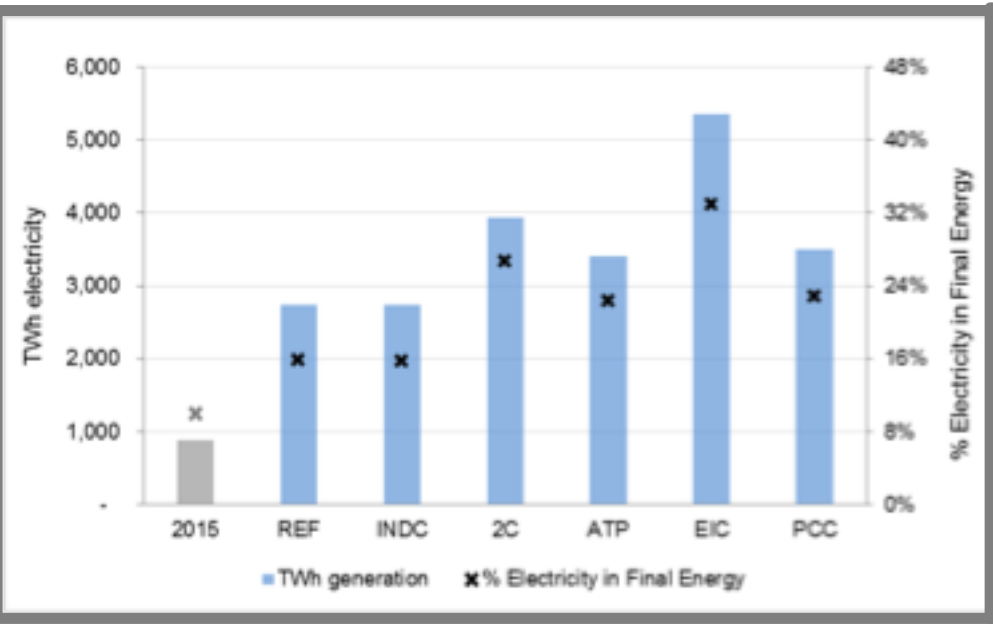
TIAM is based on TIMES modelling frameworks

All major energy and economic sectors have been modelled

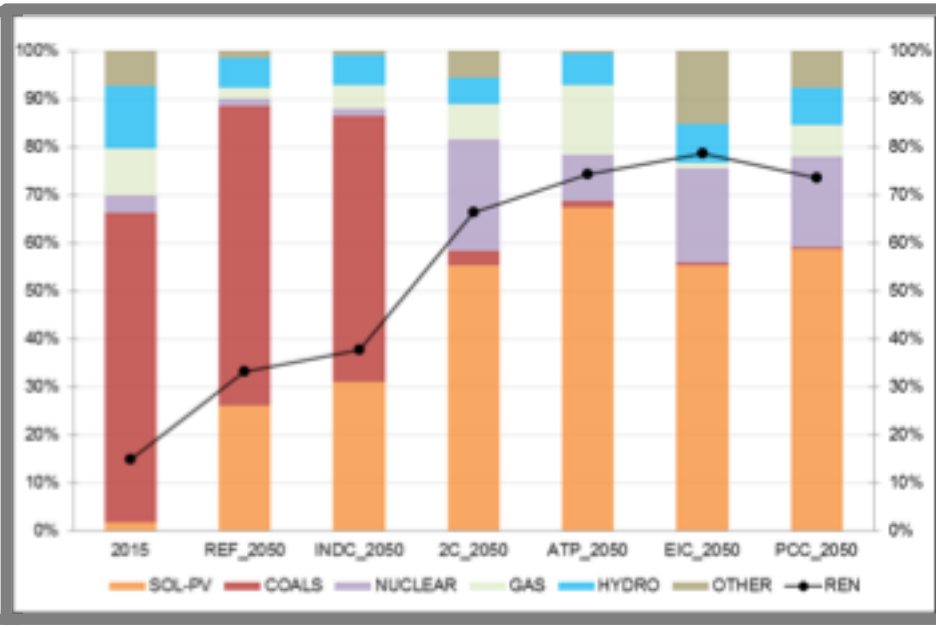
India has been modelled as an explicit region

Results

Generation in 2050

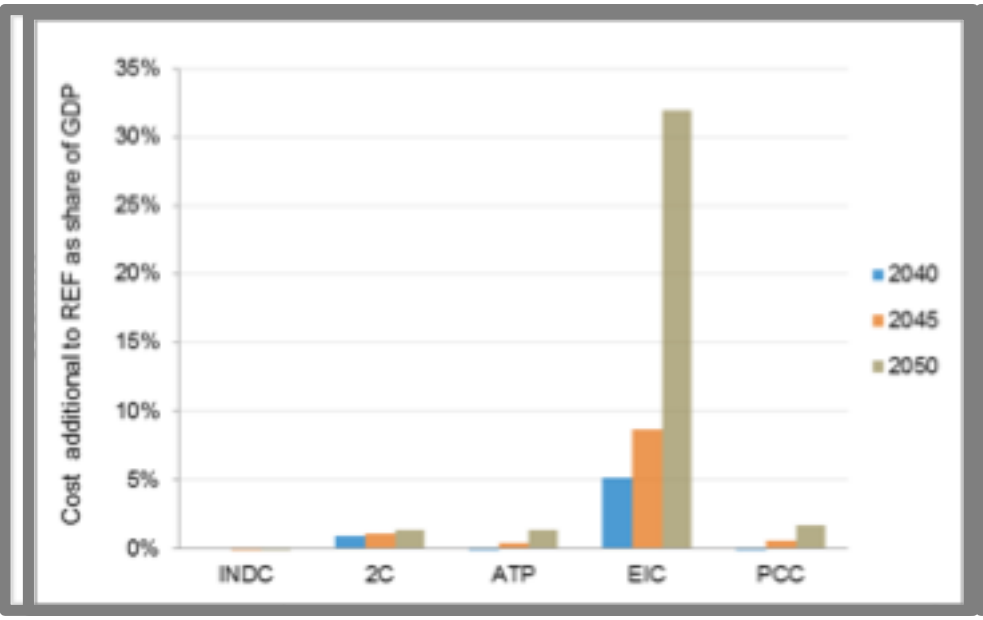


Generation mix in 2050

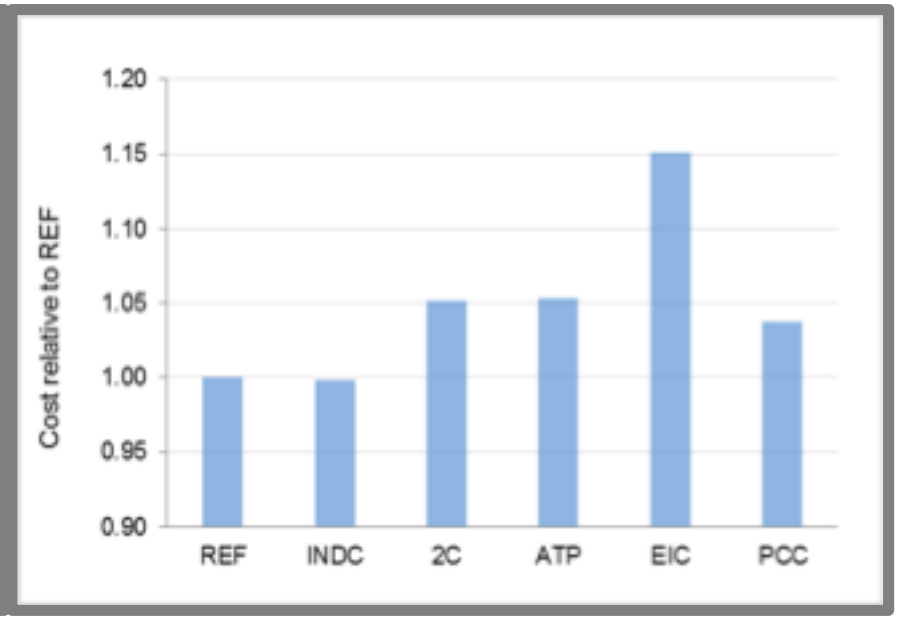


- Higher the burden, share of electricity in final energy increases – endues sector decarbonises by means of electrification.
- REF and INDC
  - The emissions intensity target in INDC does not place a significant constraint on emissions because of the strong growth in GDP.
  - India's 2030 INDC target is for 40% installed capacity to be non-fossil fuel based that can presumably include wind, solar, hydro and nuclear

Electricity CO_2 intensity in 2050

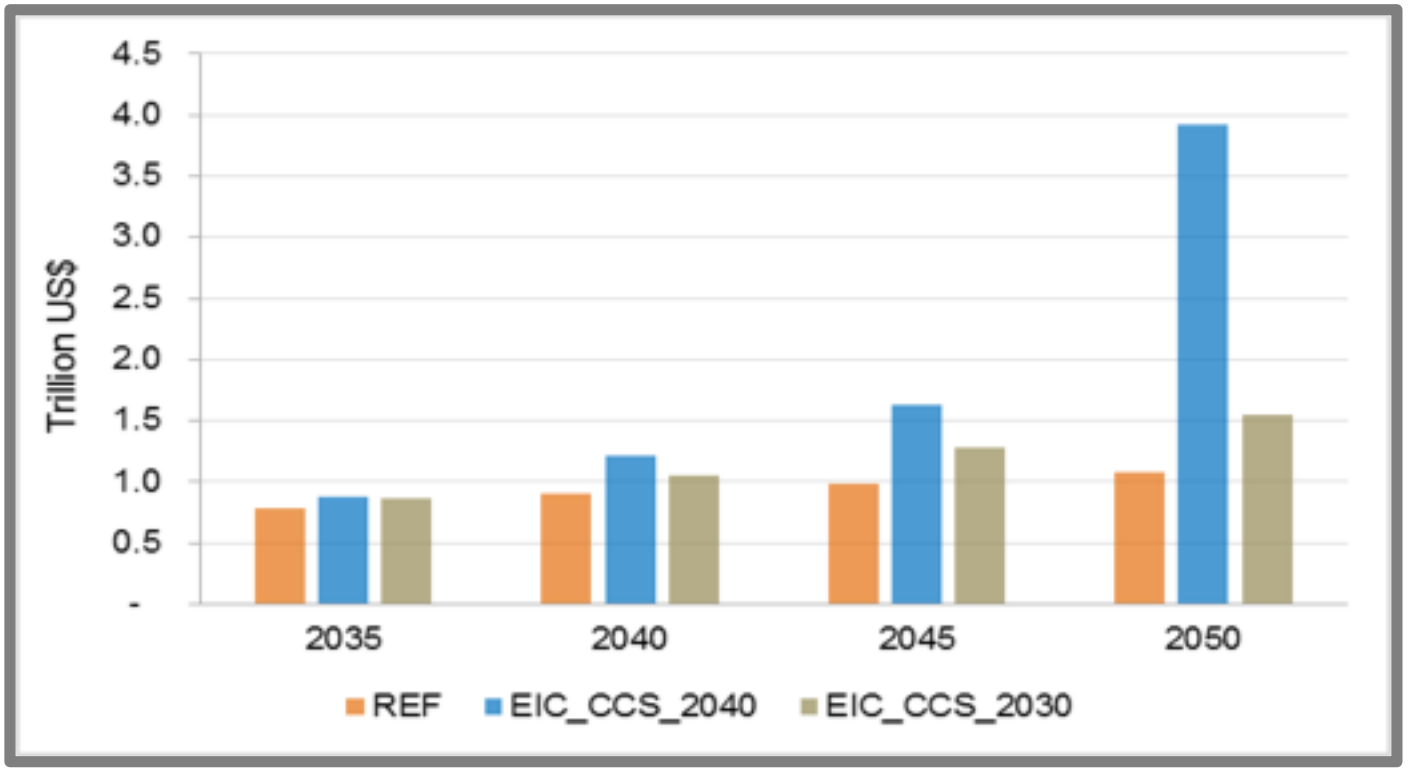


Additional discounted system costs



- Electricity CO_2 intensity goes to below 100 tCO_2/kWh in 2050 under 2C scenarios from 600 tCO_2/kWh in 2015
- Electricity CO_2 intensity goes to net-zero under EIC scenario – leading to increased the energy system costs in 2050 compared to the REF or NDC.

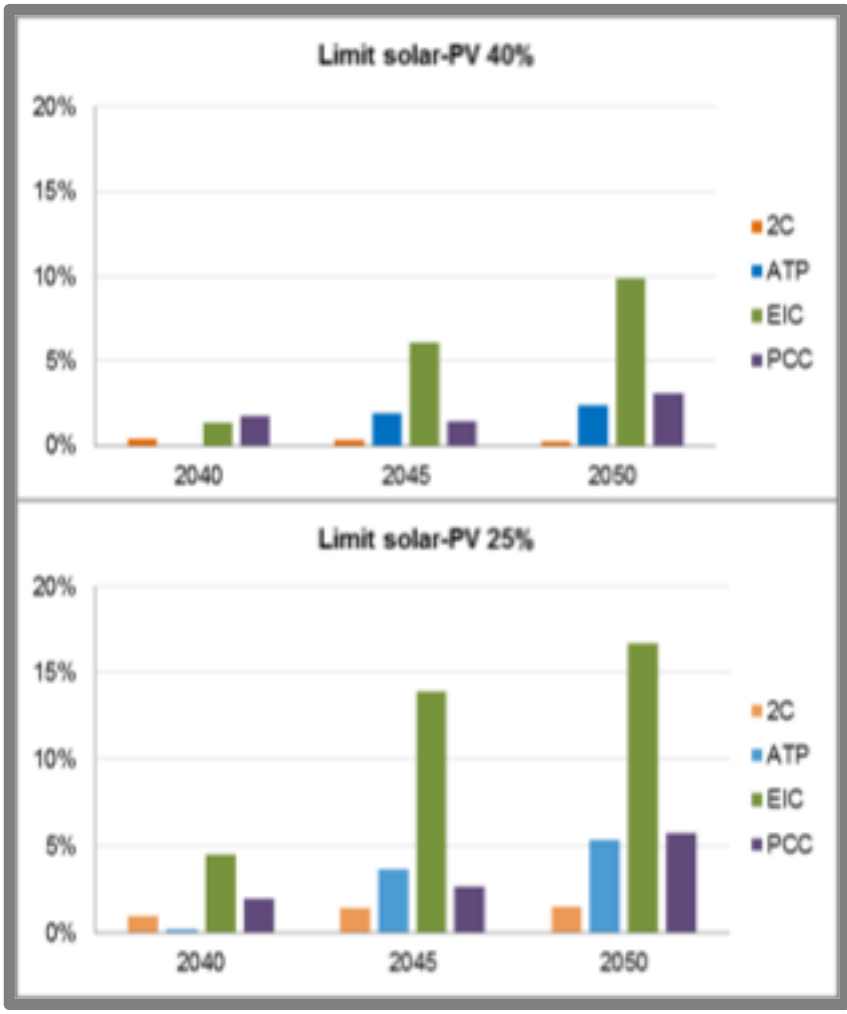
CCS sensitivity



- If the CCS was made available in 2030 instead of 2040, it can substantially bring down the cost of EIC scenario

Sensitivity: Limiting the share of Solar PV

- The 40% limit (share of generation) scenarios
  - EIC becomes 5% and 10% more expensive in 2045 and 2050 respectively.
  - The other three scenarios only show a marginal increase in annualized system cost.
- However, this effect becomes more pronounced when a stricter limit of 25% is placed.



Conclusions

- Per capita convergence (PCC) and Ability to Pay(ATP) based on GDP/Capita allocation schemes results in lower additional system costs to India compared to REF
- Under EIC (Emission Intensity Convergence) based allocation scheme, India may experience severe burden to decarbonise the economy
- Early availability of CCS can significantly reduce the system costs in EIC scenario
- Solar-PV is the most important renewable technology for decarbonisation of electricity generation (500-1200 GW in 2050) - presenting a significant challenge in scaling up from the 20 GW of installed capacity at present

Thank you