The impact of policy decisions on the Indian electricity system in 2040 - a model-based analysis.

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Contents

- Introduction
- Research Question
- Input Data and Assumptions
- Results and Analysis
- Conclusion
**Status Quo**

- **CO₂ Emissions - Power System**

  1,065 Mt CO₂ (IEA, 2015)

![](image)

**Electricity Mix FY 2018-19**

- Thermal: 78%
- Nuclear: 10%
- Hydro: 9%
- Renewable: 3%
Electricity Requirement Projection

3 X increase in demand

source: Author based on (CEA, 2017a) and (MOSPI, 2018, p. 52)
Government Energy Policy

- 29-36% RE share in Generation Mix
- Growth to take place autonomously.

RE share in Generation Mix

<table>
<thead>
<tr>
<th>Year</th>
<th>RE Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>8%</td>
</tr>
<tr>
<td>2040</td>
<td>36%</td>
</tr>
</tbody>
</table>
Policy Decisions

• Targets
  • Certain share of electricity is sourced from renewables
  • RE share target of 36%
  • RE share target of 29%

• No Targets
  • Allowing market to decide the power sector growth

• Carbon Tax
  • Taxing the CO2 from power sector

• Emission Limit
  • Limiting the CO2 emissions to the long-term Paris goal
Modelling Tool

- Partial equilibrium model
- Economical capacity expansion
- Least-cost dispatch
- Perfect competition
- Non-market system- Perfect planning
Inputs and Assumptions
Regions

• 5 Grid Zones
  • Demand Profile
  • Electricity Demand
  • Existing Power Plant Capacity (MW)
  • Existing Transmission Capacity (MW)
  • Fuel Potential
  • Cost of Power Plant in Future
  • Fuel Price Projection

Source: (David et al., 2017, p. 8)
Electricity Demand Profile

- POSOCO: *Electricity Demand Pattern Analysis.*
Energy Technologies

NON-RENEWABLE TECHNOLOGIES

• Coal
• Gas
• Nuclear
• Hydro – Storage
• Hydro – Run Off

RENEWABLE TECHNOLOGIES

• Solar
• Wind Onshore + Offshore
• Bio
• Small Hydro (<25 MW)

STORAGE TECHNOLOGIES

• Pump hydro Storage
• Battery
Planned Capacity Additions

• 175 GW Renewables by 2022. (MNRE)
• 30 GW Offshore by 2030.
• 22 GW of nuclear plant capacity by the year 2031 (DAE, 2018).
• Planned hydro capacity additions
Investment Cost - Solar

- 1100 USD/KW
  IRENA (2018)
Solar Potential

700 GW

Source: NISE
Scenario & Results
Includes stated policies and projections until 2040:

- RE contributes 36% of total electricity generation mix
**Generation Mix**

**2017**
- **Coal**: 927 TWh (73%)
- **Hydro**: 11%
- **Nuclear**: 4%
- **Gas**: 4%
- **RE**: 8%

**1275 TWh**

**Stated Policy 2040**
- **Coal**: 1793 TWh (49%)
- **Hydro**: 11%
- **Nuclear**: 5%
- **Gas**: 9%
- **RE**: 36%

**3660 TWh**
### Installed Capacity

#### 2017

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Capacity (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>197</td>
</tr>
<tr>
<td>Biomass</td>
<td>8</td>
</tr>
<tr>
<td>Diesel</td>
<td>24</td>
</tr>
<tr>
<td>Gas</td>
<td>41</td>
</tr>
<tr>
<td>Hydro</td>
<td>34</td>
</tr>
<tr>
<td>Hydro Small</td>
<td>13</td>
</tr>
<tr>
<td>Nuclear</td>
<td>7</td>
</tr>
<tr>
<td>Pump Hydro</td>
<td>7</td>
</tr>
<tr>
<td>Solar</td>
<td>3</td>
</tr>
<tr>
<td>Wind Offshore</td>
<td>250</td>
</tr>
<tr>
<td>Wind Onshore</td>
<td>212</td>
</tr>
<tr>
<td>Total</td>
<td>793</td>
</tr>
</tbody>
</table>

#### Stated Policy Scenario

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Capacity (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>9</td>
</tr>
<tr>
<td>Biomass</td>
<td>7</td>
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<tr>
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<td>Gas</td>
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<td>Hydro</td>
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</tr>
<tr>
<td>Hydro Small</td>
<td>212</td>
</tr>
<tr>
<td>Nuclear</td>
<td>55</td>
</tr>
<tr>
<td>Pump Hydro</td>
<td>30</td>
</tr>
<tr>
<td>Solar</td>
<td>234</td>
</tr>
<tr>
<td>Total</td>
<td>1000</td>
</tr>
</tbody>
</table>
Power System Flexibility

Hourly Dispatch

- NUCLEAR
- COAL
- HYDRO SMALL
- BIOMASS
- HYDRO RVR
- HYDRO RES
- GAS
- WIND OFFSHORE
- WIND ONSHORE
- SOLAR
- PUMP HYDRO
- Grand Total
Power Sector CO2 Emissions

- Year: 2017, 2020, 2025, 2030, 2035, 2040
- CO2 Emissions (Mt CO2): 1034, 1200, 1348, 1496, 1644, 1848

- Stated Policy Scenario
Power Sector CO2 Emissions

- **Stated Policy Scenario**: ~3 X increase in emissions

<table>
<thead>
<tr>
<th>Year</th>
<th>CO2 Emissions (Mt CO2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>1034</td>
</tr>
<tr>
<td>2020</td>
<td>1200</td>
</tr>
<tr>
<td>2025</td>
<td>1400</td>
</tr>
<tr>
<td>2030</td>
<td>1600</td>
</tr>
<tr>
<td>2035</td>
<td>1848</td>
</tr>
<tr>
<td>2040</td>
<td>2000</td>
</tr>
</tbody>
</table>

- **Stated Policy**
- **2 C scenario**
Sensitivity Analyses: RE Share Target

RE share in Generation Mix

- 36% RE Share Target
- 29% RE Share Target
- 21% No RE Share Target
- Only Market Decide

Stated Policy Scenario (Reference Case)
- 36% RE Share Target
- 29% RE Share Target
- No RE Share Target

- 1.810 Mt CO2
- 2.036 Mt CO2
- 2.287 Mt CO2

2017
- 8% RE

2040
Stated Policy Scenario (Reference Case)

- RE share 36% in generation mix
- Exogenous capacity added
  - Planned Plant capacity
  - Planned Transmission capacity

Carbon Price Introduced

- 2025 - $17/ton $CO_2$
- 2040 - $35/ton $CO_2$

Scenario #2 Carbon Price
Power Sector CO₂ Emissions

CO₂ Emissions (Mt CO₂)

Year

Reference
Carbon Price

Year 2017 2020 2025 2030 2035 2040
Carbon Price Scenario

Carbon Price

750 1848

Stated Policy Scenario (Reference Case)

- RE share 36% in generation mix
- Exogenous capacity added
  - Planned Plant capacity
  - Planned Transmission capacity

Carbon Emission Limit

562 Mt CO₂ in 2040

Scenario #2
2°C
### Generation Mix

**Stated Policy**
- Coal: 49%
- Hydro: 9%
- Gas: 5%
- RE: 36%

**Carbon Price**
- Coal: 19%
- Hydro: 16%
- Nuclear: 15%
- Gas: 2%
- RE: 48%

**2°C Scenario**
- Coal: 14%
- Hydro: 16%
- Nuclear: 21%
- Gas: 3%
- RE: 46%
Conclusion

- 36% RE share target
  Emissions are still high

- Without government intervention - RE share 21%

- Carbon Tax 35$/tCO₂
  48% RE share

- 2 C scenario
  39 $/tCO₂
Thank You

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