India’s Energy Transition under a Net-Zero Future

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Energy Access

Renewables

Power Sector

Industrial Sustainability & Competitiveness

Low-Carbon Pathways

Risks & Adaptation

Technology, Finance, & Trade

Centre for Energy Finance
A vision for Brics India 2021

Arunabha Ghosh and Vaibhav Chaturvedi

The 26th Conference of Parties (COP 26) is being held in interesting times. Three big forces are shaping the larger backdrop of this COP. The first is the COVID-19 pandemic which has ravaged humanity not just taking lives but also pushing millions into
Various perspectives in the Indian civil society

• Why are long-term targets important?
  – The power of policy signals cannot be underestimated
  – Credibility and Certainty are two important principles
  – Short term targets should guide us towards the long-term objective

• Comparing short term actions and long term actions is a false binary

• Peaking and net-zero have to go together for a growing economy

• Understanding alternative scenarios is important

• Net-Zero is about an Economic Transformation
Understanding the net-zero future through scenario analysis

<table>
<thead>
<tr>
<th>Sc No.</th>
<th>Scenario Name</th>
<th>Peaking year</th>
<th>Net-Zero Year</th>
<th>Availability of breakthrough technologies</th>
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<tbody>
<tr>
<td>1</td>
<td>Reference sc</td>
<td>As determined endogenously by the model</td>
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<td>2030_2050_NoCCS_LowH2</td>
<td>2030</td>
<td>2050</td>
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<td>2050</td>
<td>2080</td>
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</table>
Transitions in the electricity sector are going to be massive

Source: Chaturvedi and Malyan (forthcoming)
Transport and industrial sector will also need to redefine their energy architectures.
12 Key Steps for 2040 peak -2070 net-zero sc, with hydrogen without CCS

**Power sector**
1. Coal-based power generation must peak by 2040 and reduce by 99 per cent between 2040 and 2060
2. Solar-based electricity generation capacity must increase to 1689 GW by 2050 and to 5,630 GW by 2070, while
3. Wind-based electricity generation capacity must increase to 557 GW by 2050 and 1792 GW by 2070
4. Nuclear-based electricity generation capacity must increase to 68 GW by 2050 and to 225 GW by 2070

**Transport sector**
5. The share of electric cars in car sales must reach 84 per cent by 2070
6. The share of electric trucks in freight trucks must total 79 per cent by 2070, the rest being run mainly on hydrogen
7. The share of biofuel blend in oil for cars, trucks, and airlines must touch 84 per cent by 2070

Source: Chaturvedi and Malyan (forthcoming)
12 Key Steps for 2040 peak -2070 net-zero sc, with hydrogen without CCS

**Industrial sector**
8. Coal use in the industrial sector must peak by 2040 and reduce by 97 per cent between 2040 and 2065
9. Hydrogen share in total industrial energy use (heat and feedstock) must increase to 15 per cent by 2050 and 19 per cent by 2070
10. The industrial energy intensity of total GDP must decline by 54 per cent between 2015 and 2050, and by a further 32 per cent between 2050 and 2070

**Building sector**
11. The intensity of electricity use in the building sector with respect to total GDP must decline by 45 per cent between 2015 and 2050, and by another 2.5 per cent between 2050 and 2070

**Refinery sector**
12. Crude oil production in the economy must peak by 2050 and decrease by 90 per cent between 2050 and 2070

Source: Chaturvedi and Malyan (forthcoming)
Economic trade offs, sooner or later

- Power pricing reforms
- New economic paradigm for coal dependent states
- Half a million coal workers: Compensation package?
- Coal India, ONGC, GAIL?
- Shifting geopolitics
- Stranded assets
Understanding policy costs for creating an economy of the future

Source: Ghosh and Chaturvedi (2021)
Land requirement could be a big impediment

**a) Water consumption**

Note: Water consumption here is a representation of consumption only in power sector

**b) Land requirement**

Note: Land requirement here is a representation of consumption only in power sector

**c) Fulltime equivalent employment**

Note: Include direct and indirect jobs associated with the power sector
Information for framing net-zero scenarios

<table>
<thead>
<tr>
<th>GDP CAGR</th>
<th>2015-50</th>
<th>2050-2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>3.7%</td>
<td>1.3%</td>
</tr>
<tr>
<td>EU</td>
<td>1.4%</td>
<td>1.4%</td>
</tr>
<tr>
<td>India</td>
<td>5.5%</td>
<td>2.5%</td>
</tr>
<tr>
<td>US</td>
<td>1.1%</td>
<td>0.6%</td>
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</tbody>
</table>

Source: CEEW Analysis
Net-Zero Future Would be Disruptive

**Institutional**
- Reduced government enterprise dominance
- Less powerful labour unions in the energy sector
- A new power sector market design
- Market based retail electricity pricing structure
- Reduced role of state governments in electricity distribution
- Diversified economic development strategies of fossil dependent states
- Environmentally aware and responsible citizens
- Modified curriculum of engineering schools
- A fully functional GHG emissions trading market
- An automated MRV system

**Infrastructural**
- Fast charging electric vehicle charging infra
- Electricity and hydrogen infra for industrial energy use
- An IT based demand side management architecture
- A grid connected distributed electricity generation infra

Source: Chaturvedi (2021)
Thank you

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Global Change Assessment Model

- Global model (32 regions) with India as a separate region
- GCAM-IIMA version, set up at IIM Ahmedabad during 2007-09, under Prof P R Shukla
- Model used extensively for national and international exercises
- Extensively published in high impact international journals
- An important part of IPCC assessments on modelling related literature
- One of CEEW’s in-house models
Key inputs and outputs

• **Inputs**
  - Economic growth and population trajectory
  - Urbanisation rate and rural urban inequity
  - Costs and efficiencies of technologies: solar electricity cost, EV cost, hydrogen cost, AC cost, etc
  - Resource potentials
  - Carbon constraints or tax, carbon market configurations

• **Outputs**
  - Final Energy consumption by sector and technology, primary energy consumption
  - Electricity generation mix
  - **Global** energy price trajectories (long term trajectories)
  - Emissions and Carbon price, global temperature, sea level rise

• **Other relevant information**
  - Not used for informing operational planning of the grid
  - Not an inter-temporal optimization model
  - Models investor and consumer behaviour