Unpacking India’s Energy and Carbon Future

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CASI-KCEP Seminar
November 2017
Outline

• Landscape of energy and climate change debates in India
• India’s carbon emissions projections
• India’s energy projections
  — Supply; Electricity; Demand
• Energy demand: Bottom-up
  — Residential electricity use and the case of the National Capital Region
• Conclusions
## India as an emerging economy

<table>
<thead>
<tr>
<th></th>
<th>GDP-PPP (current International $) 2014 $ billion</th>
<th>Total GHG Emissions (Mt CO₂) – 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>17,419</td>
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<tr>
<td>EU (28)</td>
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<td>Russia</td>
<td>3,745</td>
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<td>Germany</td>
<td>3,704</td>
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<td>Brazil</td>
<td>3,263</td>
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<tr>
<td>Bangladesh</td>
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</tbody>
</table>

Source: World Bank; Global carbon atlas
## India as a premature power

<table>
<thead>
<tr>
<th>Country</th>
<th>GDP-PPP per capita, (current international $) 2014</th>
<th>GHG Emissions per capita (including LUCF) in 2012 - tCO$_2$e</th>
<th>Multidimensional Poverty Index rank</th>
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<tbody>
<tr>
<td>US</td>
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<td>EU (28)</td>
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<td>Brazil</td>
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<td>South Africa</td>
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<td>Bangladesh</td>
<td>3,123</td>
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</table>

India’s energy and climate context

• Inter-related challenges:
  — Significant emitter of GHG emissions
  — Starting from a low base of development with high vulnerability to climate change impacts

• Indian actions central to shaping global climate future
  — But do they make India a ‘villain’ or ‘hero’?
  — Shifting global perceptions: From a focus on jeopardizing the climate to a forerunner of low-carbon actions

• Are these perceptions rooted in facts and analysis? What can we credibly say about India’s energy and climate future?
India’s impending transitions

• Uncertainties posed by the pace, scale and scope of transitions
  — Urbanisation: Urban population to double between 2014 and 2050
  — Infrastructure: Two-thirds of building stock in 2030 yet to be built
  — Jobs: 10 m people to enter the job market annually in next two decades
  — Access: 800 m lack clean cooking fuel, 300 m lack access to electricity

• Methodological and conceptual challenge of estimating trajectories

• Subsequent method: Synthesize results across (15) recent model scenarios of India’s short and medium term energy future
Daily CO₂ emissions from energy (2030 projections)

Annual CO₂ emissions from energy (2030 projections)

- Wide range of 2030 projections
  - Range of projected emissions of same order of magnitude as current emissions
- Compare pre 2015—post 2015 reference to extract useful information
  - Recent policies impact on emissions reduction (175 GW of RE; EE)
  - Tight clustering of post 2015 projections: Doubling of CO₂, consistent with pledge of 33-35% reduction in emissions intensity from 2005 levels
- Per capita
  - India’s 2030 per capita projections (2.5-3.6 T/cap), after two decades of steep rise in absolute emissions, below the 2014 global average of 4.7 T/cap
Doubling of CO2 emissions (2030) as upper bound

- Post-2015 scenarios best capture current policy environment
- Studies assume partial (realistic) not full policy implementation, latter would lower emissions
- Assume average GDP rates 7-7.5% until 2030 (higher than historical rates of 6-7%) – likely lower rates would lower emissions
- Doubling of 2012 CO2 emissions from energy by 2030 == 43% of China’s 2015 emissions
Underlying future energy trends: Supply-side

- Coal remains dominant through 2030
  - Doubling or more in reference/policy scenarios
  - Swamps oil and gas rise

- Future supply requires untangling the inter-connected projections of coal use and renewable energy growth
Underlying future electricity sector trends

- Electricity = 49.6% of CO₂ emissions from energy (2012)
  - Pace of decarbonisation key to extent of FF displacement
- High rates of non-fossil fuel electricity growth, from RE
- Total electricity demand rises faster than RE growth, with overall FF growth
  - But at what rate?
**Diminishing interest in coal?**

- **Mixed signals on coal**
  - 2014: 1500 MT coal consumption target for 2022 (Ministry of Coal)
  - 2016: Only 25% increase in existing coal fleet (44 GW) until 2027 (National Electricity Plan)

- **Declining private sector attractiveness, increasing coal investment risk**
  - Falling RE costs (Solar: 17.91 INR/kWh in 2011 to 2.44 INR/kWh in 2017)
  - Cancellation of plants because of surplus requirements
  - Air and water pollution impacts

- **A lower carbon future than currently projected.**
  - Contingent on demand
Future energy demand trends

- Demand increases as India transitions
  - 2015 policies reduce demand
- Recent trends suggest lower demand
  - Electric Power Survey dropped projections for 2027 by 25% between 2012-2017
- Magnitude of demand growth is contingent
  - Electric vehicles in 2030
  - Extent of EE

Unpacking energy demand: Bottom-up

- Model and policy predictions demonstrate variability in demand and role of immediate interventions
- Salient elements of energy planning oriented towards supply
- But transitions pose a real risk of accidental ‘lock-in’ to consumption patterns, since the bulk of development is yet to occur
  - Buildings, transport, industry can form up to 23-25% of reduction in emissions intensity from 2005 levels by 2020 (Planning Commission)
- Necessary for sensible supply-side planning
  - 40% non-FF electricity by 2030: But based on 650 or 1000 GW grid?
- Focus on residential electricity demand
Scale of residential electricity use

- 85% of floor space in 2050 to be residential
- Residential electricity consumption increased 50 times since 1971
- Residential uses ~25% of total current electricity
  - With quarter of households with no electricity
- Projected to increase 5-6 times btw 2014-2030 with rapid electrification, increasing incomes, and tech development

Source: Ministry of Statistics and Programme Implementation & Central Electricity Authority data; Prayas (2016)
But limited understanding of household consumption

- Large variation in projections from varying methods, assumptions, base years
- Lack of knowledge significant barrier to estimating demand, planning appropriate supply, and managing climate mitigation

Source: Prayas (2016)
Case study: Energy services in the National Capital Region

- National Capital Region (NCR): Delhi, Haryana, Uttar Pradesh, Rajasthan
  - Approx. 30 million (approx. 130 cities/towns)
  - 22,500 sq miles
  - Population growth 20% per decade
  - ~5500 households surveyed
## Per-capita consumption perspective

<table>
<thead>
<tr>
<th>Country</th>
<th>Annual per capita residential elec. use (KWh)</th>
<th>Year</th>
<th>Source</th>
</tr>
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<tbody>
<tr>
<td>USA</td>
<td>4413</td>
<td>2014</td>
<td>Prayias, 2016</td>
</tr>
<tr>
<td></td>
<td>4376</td>
<td>2015</td>
<td>EIA, 2017; US Census Bureau, 2017</td>
</tr>
<tr>
<td>China</td>
<td>512</td>
<td>2014</td>
<td>Prayias, 2016</td>
</tr>
<tr>
<td></td>
<td>550</td>
<td>2015</td>
<td>NBSC, 2017</td>
</tr>
<tr>
<td>India</td>
<td>153</td>
<td>2014</td>
<td>CEA (Prayias, 2016)</td>
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<td></td>
<td>174</td>
<td>2015</td>
<td>Niti Aayog, 2017</td>
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<tr>
<td>Delhi</td>
<td>550</td>
<td>2012</td>
<td>CEA (Prayias, 2016)</td>
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<tr>
<td></td>
<td>606</td>
<td>2015</td>
<td>Niti Aayog, 2017</td>
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<tr>
<td>NCR</td>
<td>611</td>
<td>2016</td>
<td>CASI Survey, 2016-17</td>
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</table>
Which electricity services drive NCR consumption?

% Penetration of Appliances NCR

- Fan: 99.4%
- TV: 96.95%
- Fridge: 87.24%
- AC Appliances: 18.84%
- Cooler: 81.96%
- Washing Machine: 50.21%
- Water Purifier: 38%

Source: CASI NCR Study, 2017
Appliances ladder: Ownership of a cooling device

Source: CASI NCR Study, 2017
Unpacking the residential demand transition

• Fans, TV and Fridges most prevalent elec. consuming appliances
  — None with scaled energy efficiency programs

• Cusp of exponential growth in AC market
  — Fan load: 60-100 W; Cooler load: 60-200 W
  — AC load: 1500-2000 W

• Impending increased load projections (LBL, AEEE)
  — ACs to add 150 GW to peak demand by 2030 (= 300 500-MW power plants)
  — Appliances to add 300 GW or 60-70% of the projected total peak load by 2030
  — Potential to reduce peak load demand 20-50%

• Once transition made, reversing investment decisions and consumption pathways prohibitive
Conclusions

• India is poised on the edge of an energy transformation
  — Enormous unmet energy needs; early stage of infrastructure development
  — Rapid global energy and information technological change
  — Global and national pressures re: energy sources and climate obligations

• Doubling of CO$_2$ emissions (from 2012) likely upper bound
  — Consistent with Paris pledge
  — Per capita emissions remain low

• Faster than expected transition from coal to renewables

• Scope for reduced rate of emissions growth by focusing on end-use demand

• Challenge for India is to decarbonise, increase energy access and use, address development, simultaneously under fluid demographic and urban transitions.
Thank you

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CASI-KCEP Seminar, November 2017
Institutional Framework: Climate Change
<table>
<thead>
<tr>
<th>Ministry of Environment and Forests (Climate change)</th>
<th>Special/Additional/Joint Secretary/Scientist (G)</th>
<th>Director/Deputy Secretary/Scientist (D,E,F)</th>
<th>Under Secretary/Scientist C</th>
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<tr>
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<tr>
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<td>Ministry of New and Renewable Energy</td>
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<td>Bureau of Energy Efficiency (BEE), Ministry of Power</td>
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## Figure 1: Multiple objectives framework for Rajkot’s climate actions

<table>
<thead>
<tr>
<th>Schemes and Projects</th>
<th>Environmental</th>
<th>Social</th>
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<tr>
<td><strong>Address climate change</strong></td>
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<tr>
<td><strong>Reduce energy demand</strong></td>
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<td>○</td>
<td>●</td>
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<tr>
<td><strong>Provide energy access</strong></td>
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<td>●</td>
<td>●</td>
<td>●</td>
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<tr>
<td><strong>Build affordable housing</strong></td>
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<td>●</td>
<td>●</td>
<td>●</td>
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<tr>
<td><strong>Enhance safety</strong></td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>●</td>
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<tr>
<td><strong>Improve transport access</strong></td>
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<td>●</td>
<td>●</td>
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<tr>
<td><strong>Provide water access</strong></td>
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<tr>
<td><strong>Increase financial savings</strong></td>
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<td>●</td>
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<tr>
<td><strong>Increase revenue</strong></td>
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<td>○</td>
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<tr>
<td><strong>Enhance implement-ability</strong></td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
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</table>

- **Primary objectives of the scheme or project**
- **Additional objective addressed by the Municipal Corporation**
- **Potential opportunities for further action in the city**

**Sources:**
- Smart City Proposal: National Guidelines (MoUD, 2015) and Rajkot’s Proposal (RMC, 2017)
- Affordable Housing Scheme: National (MoHUPA, 2016) and State (UDUH, 2013) Guidelines
- LED Street Lights Scheme: Sources from the Municipal Corporation
- JNURM & Low Carbon Mobility Plan: Reporting for JNURM by RMC (2010) and Low Carbon Mobility Plan (Munshi et al., 2014)
- Urban LEDS: Report by ICLEI SA (2016)
- Solar City Scheme: National level guidelines (MNRE, 2008) and Rajkot’s Solar City Masterplan (RMC & ICLEI SA, 2009)
Demonstrate synergies and trade-offs

Figure 2: Illustrative MCDA results for the buildings sector study