Energy Policy in India

A Research Agenda

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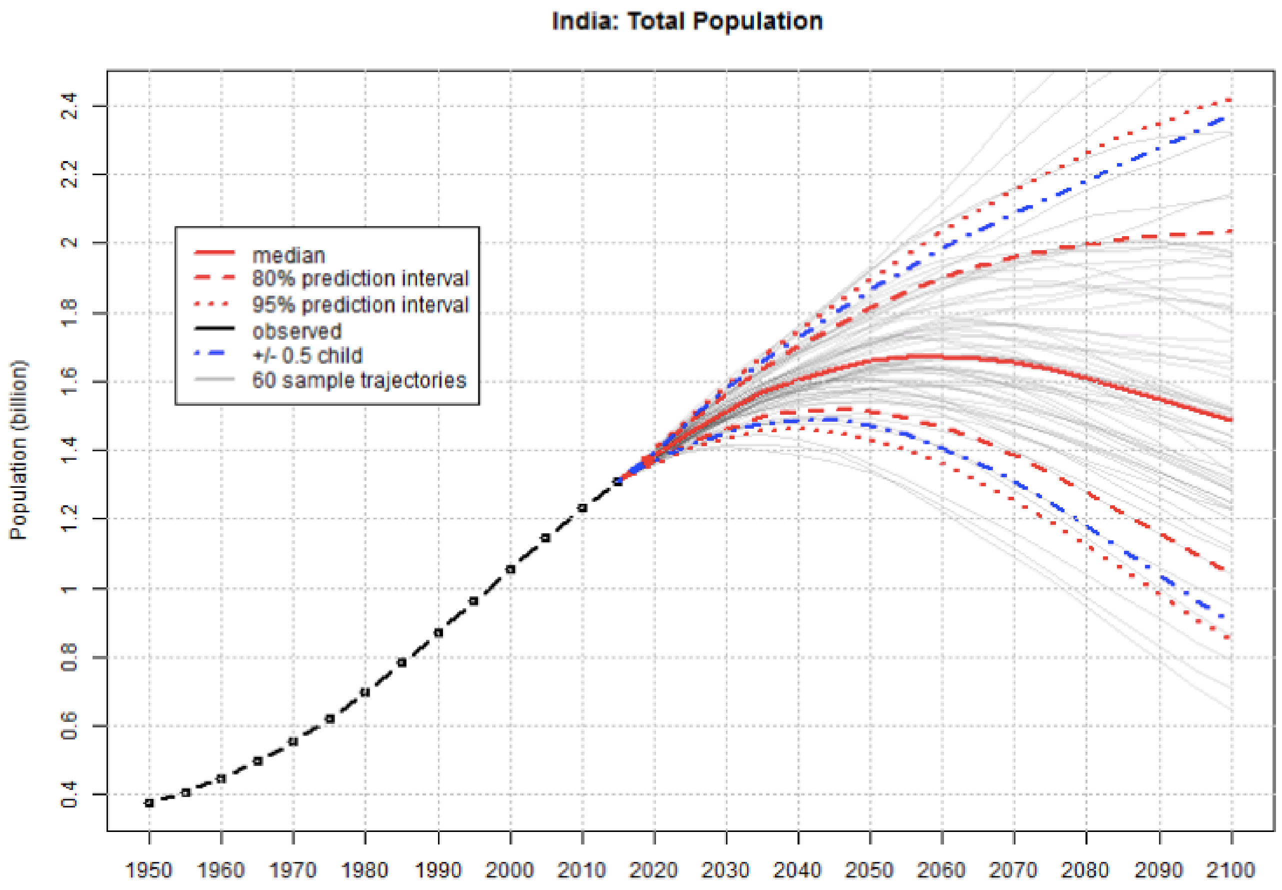
Contents

India’s Predicament – A Global Challenge

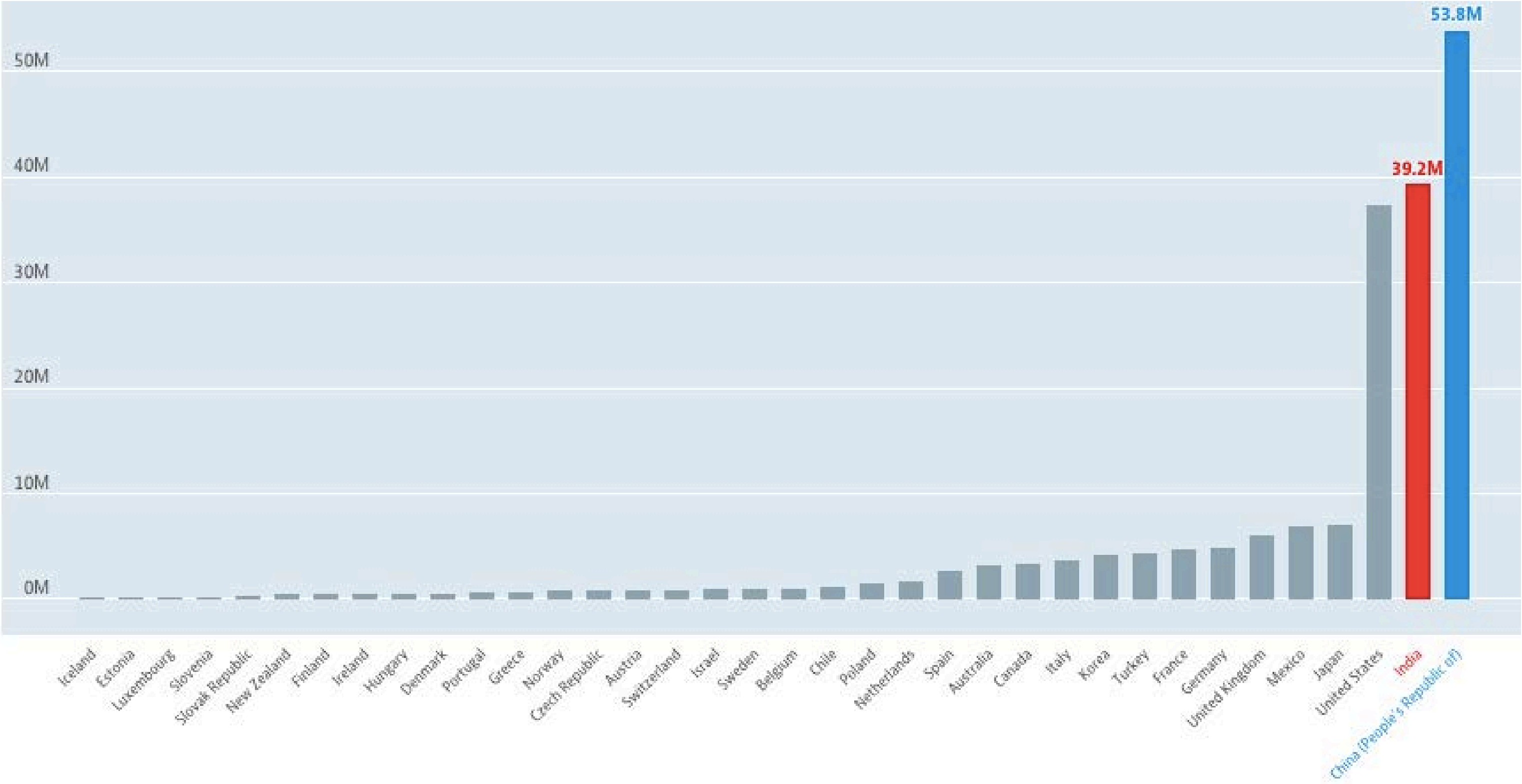
On Population in 2050

- ~1.7 Billion people
- By 2050, India will be the most populous nation in the world.
- India’s projected population of will be equal to the populations of the U.S. and China combined.



Source: (UNDP, 2018)

India’s Predicament – A Global Challenge



(OECD, 2018)

- On Economic Growth in 2050:
- India expected to be among the world’s largest three economies, with China and the US.

Why should we care?

- Of the top five CO2 emitters, only India’s emissions are still rising.
- 18% rural households do not have access to electricity.

- Energy is essential for economic growth.
- The challenge: to provide that energy for about ~250 million people, and still keep emissions low.

- This is a challenge that concerns the world – it could mean the difference between climate catastrophe and mitigating emissions.

Climate change

How India’s battle with climate change could determine all of our fates

India’s population and emissions are rising fast, and its ability to tackle poverty without massive fossil fuel use will decide the fate of the planet

▲ Rajesh stands beside a solar light installed in his home by a student group - one of two functioning lights in the entire village of Rajghat. Photograph: Michael Safi for the Guardian

Damian Carrington *and* **Michael Safi** *in Rajghat*
Mon 6 Nov 2017 03.36 EST

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“It’s a lucky charm,” says Rajesh, pointing to the solar-powered battery in his window that he has smeared with turmeric as a blessing. “It has changed our life.”

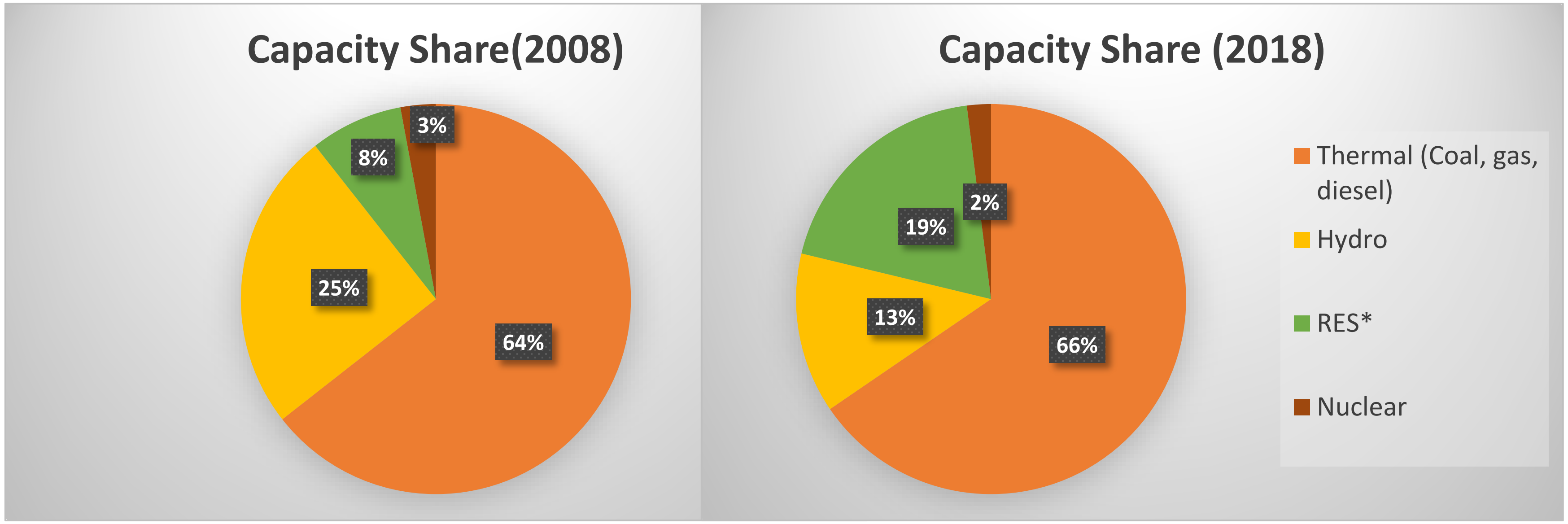
He lives in Rajghat, a village on the border of Rajasthan and Madhya Pradesh states, and until very recently was one of the 240 million Indians who live without electricity. In the poverty that results, Rajghat has become a village of bachelors, with just two weddings in 20 years.

What has India committed to?

- Commitments at the Paris Agreement:
  - 40 percent electric power capacity from non-fossil fuel sources by 2030.
  - to reduce the emissions intensity of its GDP by 33 to 35 percent by 2030 from 2005 level.
- 175 GW of wind and solar by 2022 (Current total capacity is ~ 340 GW)
- Last-mile connectivity to all households by December 2018 (Saubhagya)
- Policy U-turns on Electric Vehicles

The Indian Power Sector – Generation Capacity

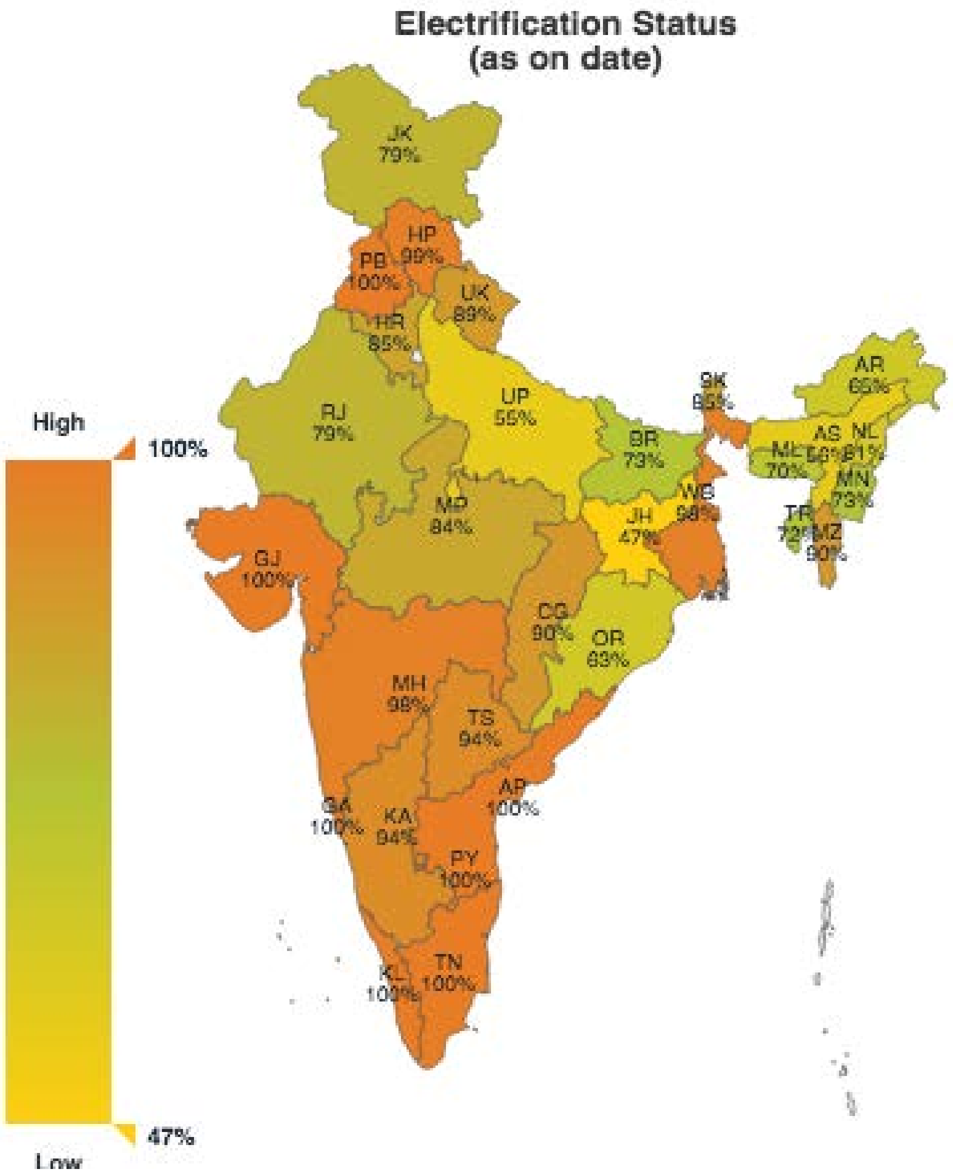
- Generation capacity more than doubled in ten years.
  - 141.0 GW in 2008 to 340.5 GW in 2018(March)



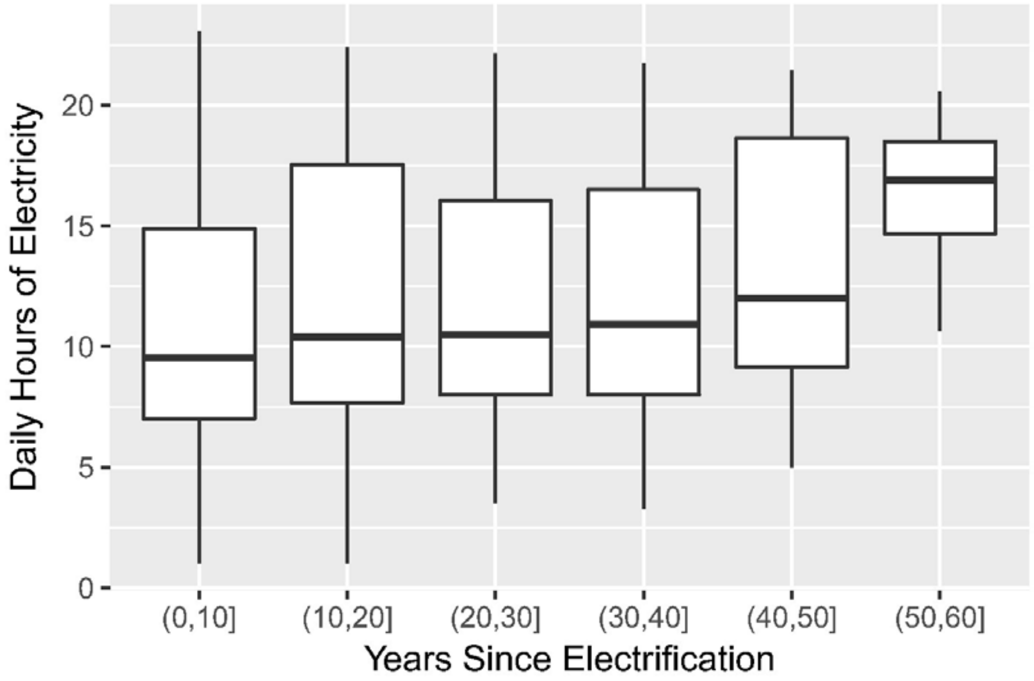
Access: Possessing a grid connection

- Possessing a grid connection
  - 83.2 of rural households
  - 97.5 urban households

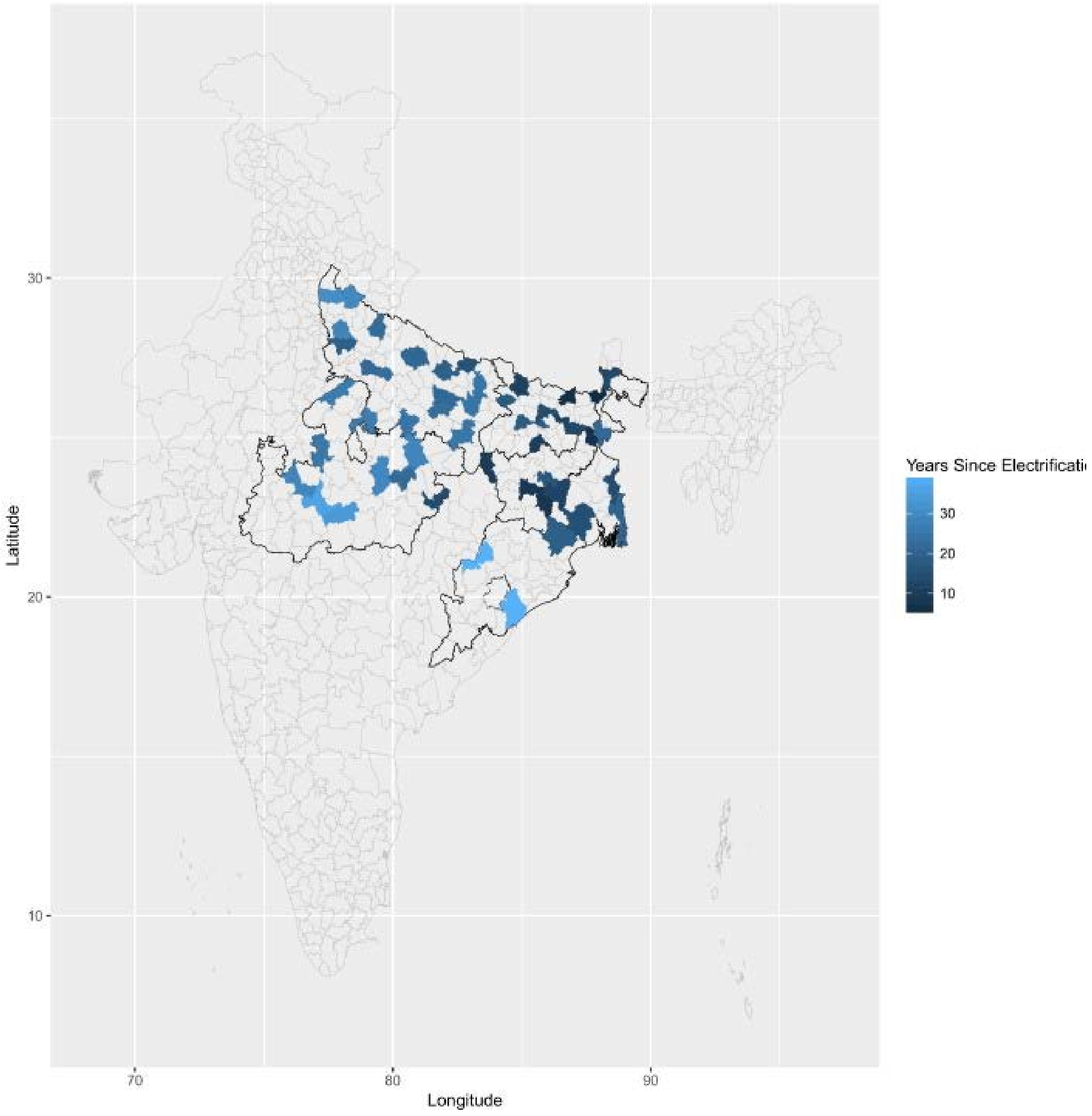
- North-eastern region worse-off than others
- Reliability of electricity supply



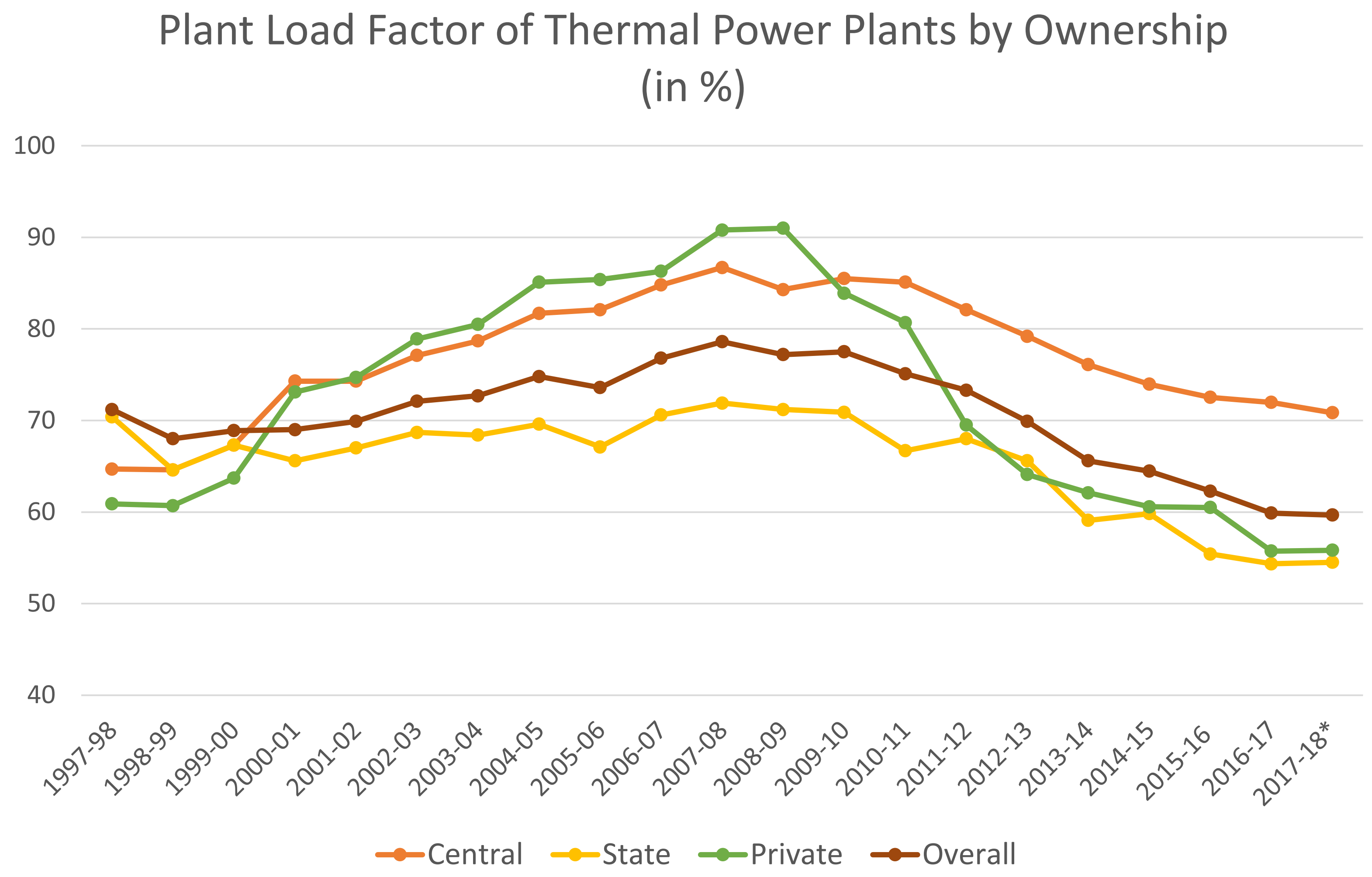
Access: Reliability of electricity supply



(Thomas and Urpelainen 2018)



The Indian Power Sector – Capacity Utilization

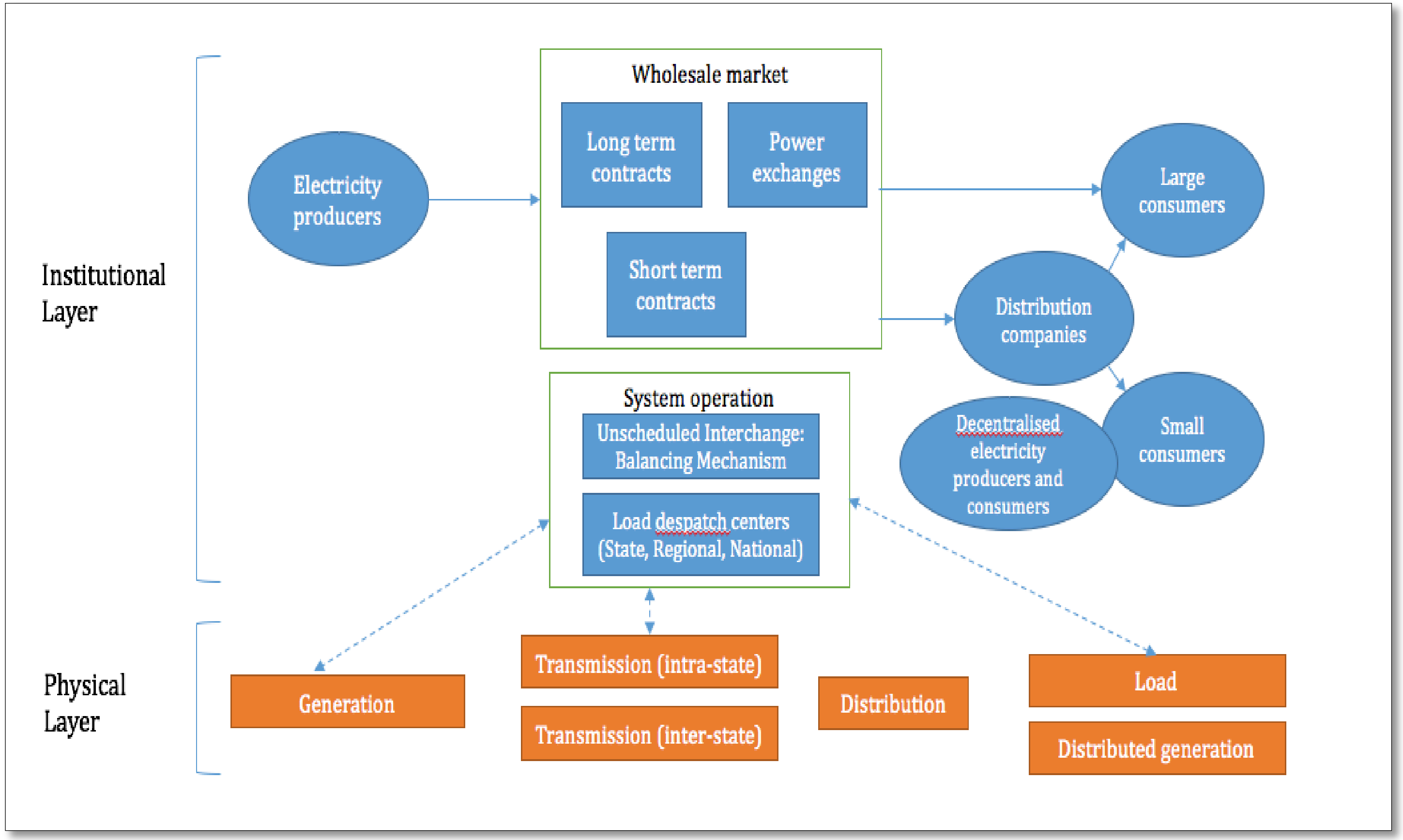


The Paradox that is India's Power Sector

- Surplus capacity in generation, low power deficits
- ~20 percent of households unconnected, and others receive unreliable supply
- Yet, capacity utilization of thermal plants continue to fall
- And continued investments into further capacity additions are taking place, both renewables and conventional power plants

Institutional Structure and Market Design
An Overview

- Electricity Act 2003 mandated liberalization
- Distribution: No separation between carriage and content, no retail competition.
- Dispatch occurs in the following order: state, regional, national
- Extent of unbundling varies by state, and takes on slightly different forms



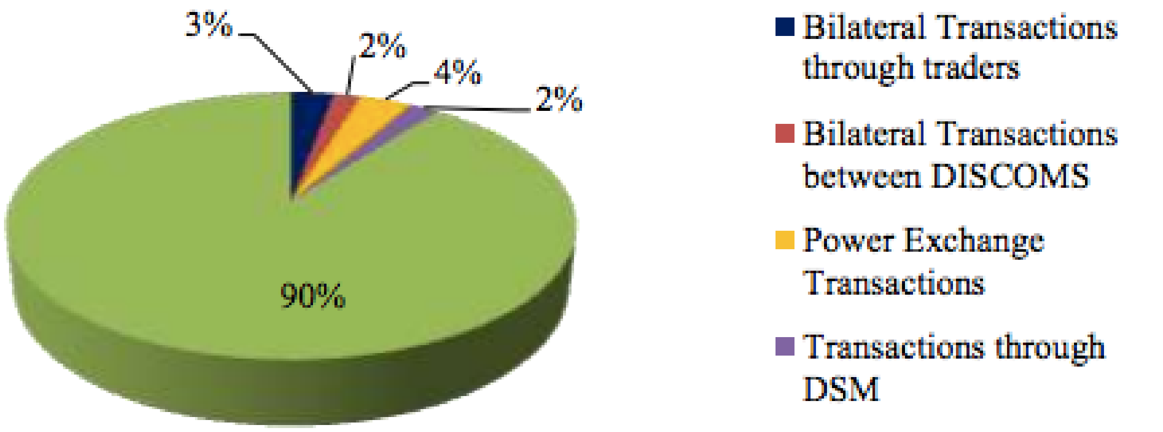
Institutional Structure and Market Design
The Dominance of Long-Term Contracts

- 90% of all electricity traded over long-term contracts (>25years?)
  - Implemented as a two-part tariff (fixed and variable components)

- During dispatch, at the regional level, contracts take precedence over merit order

- Inter-state and Intra-state generators subject to different dispatch centres, rules

Figure-9: Share of Market Segments in Total Electricity Generation, 2016-17

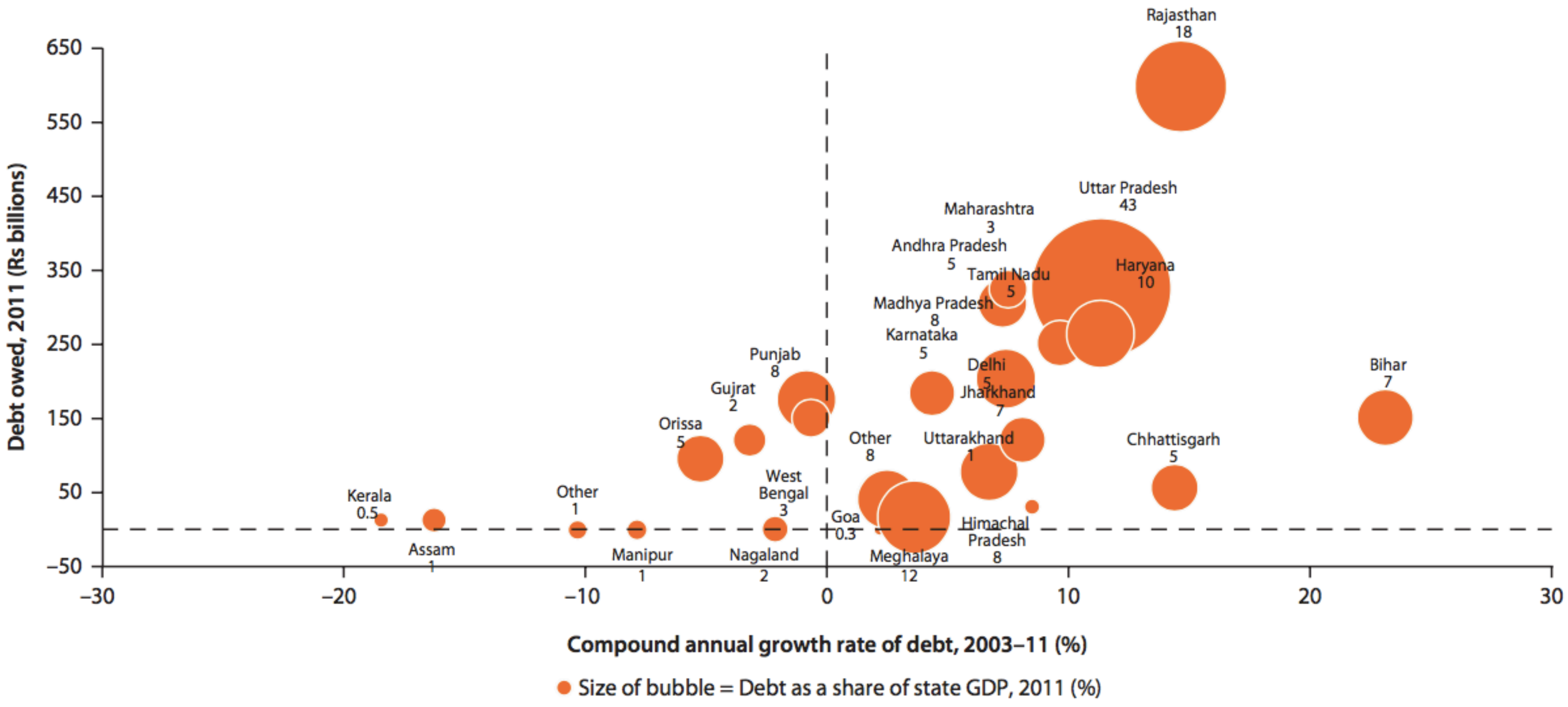


Institutional Structure and Market Design: Adversities of Distribution Companies

- Distribution utilities make huge losses due to cost-revenue gaps.
- Cost-revenue gaps largely due to non-recovery of cost from subsidized rural and agricultural consumers.
- The state government annually allocates subsidies from its budget to distribution utilities, approved state electricity regulatory commission (SERC).
- Subsidies booked by utilities are not entirely paid by state governments (varies across states)
- Utilities are unable to cover their costs or make the investments required to serve customers— or both, sometimes

Institutional Structure and Market Design: Adversities of Distribution Companies

- Debt forms significant shares of GDP
- Financial contagion has spread to banks
- Banks reduced lending to the sector in 2011
- Discoms unable to pay for power even when it is available
- UDAY Scheme launched in 2011
- Moral hazard still exists



Source: Khurana and Banerjee 2013.

Institutional Structure and Market Design: Variation by State

Karnataka

- Karnataka Electricity Reform Act passed in 1999
- Karnataka Electricity Regulatory Commission was established in 1999
- Successful unbundling of generation and transmission in 1999
- Transmission and distribution were further unbundled in 2002 – to form 4 electricity supply companies

Jharkhand

- Jharkhand State Electricity Regulatory Commission established in 2002
- "Jharkhand State Electricity Board" was unbundled in late 2014 into a holding company, a genco, a transco, and a discom
- Practically, companies located in the same building, share board members, and personnel regularly transferred across companies.
- JSEB has little financial agency, cannot recover costs.

(Centre for Policy Research, 2017)

Causes for the Paradox

- Distribution companies' ill-financial health – discoms
- Transactions dominated by legacy contracts between generators and discoms
  - Contracts prioritized over least cost generation, especially at the regional, national levels
  - Inter-state generators and intra-state generators dispatched by different system operators.
- True demand not reflected due to un-connected households.

Technology-Policy Challenges for an Energy Transition

- Flexible resources are essential for integrating renewables
  - Technically – by balancing out intermittency
  - Economically – by increasing their market value

- Options for flexibility in the Indian power system are
  - Coal (76% of generation), heavily polluting
  - Gas (4% of generation), severely constrained for supply
  - Transmission capacity
  - Hydro (10% generation)
  - Nuclear (3% generation)

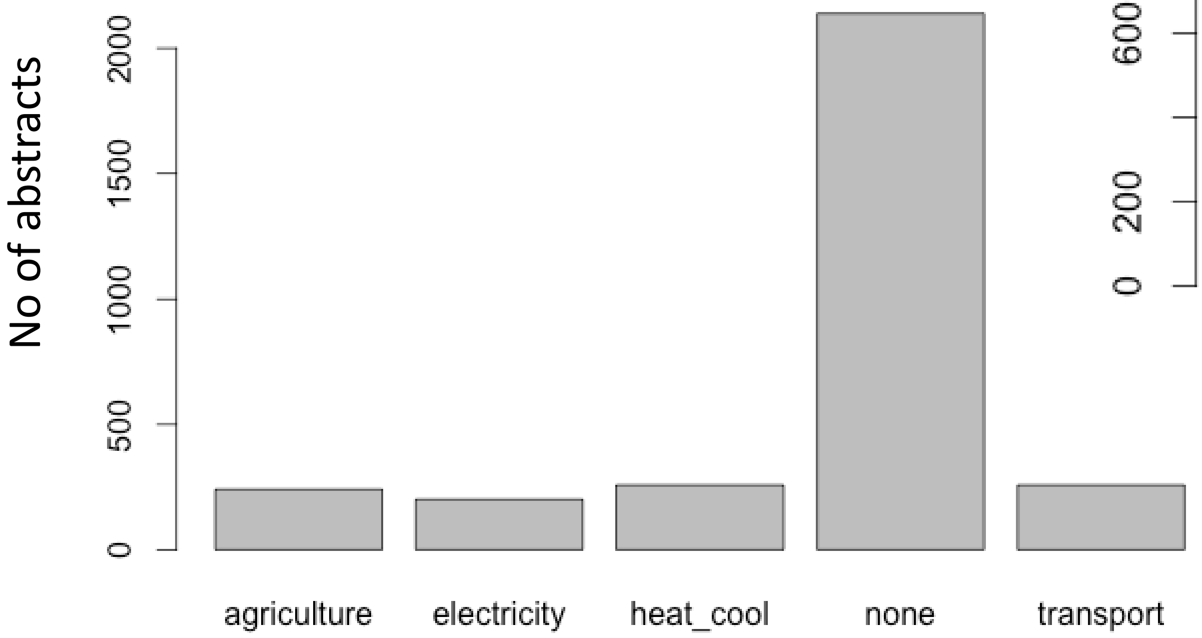
Proposing a Research Agenda

- A Survey of Literature
- Major Lacunae
- An India Project at the Science Technology and Public Policy (STPP)
  - Evaluating Market Design
  - Evaluating Flexible Technology Options
  - Reliability Studies

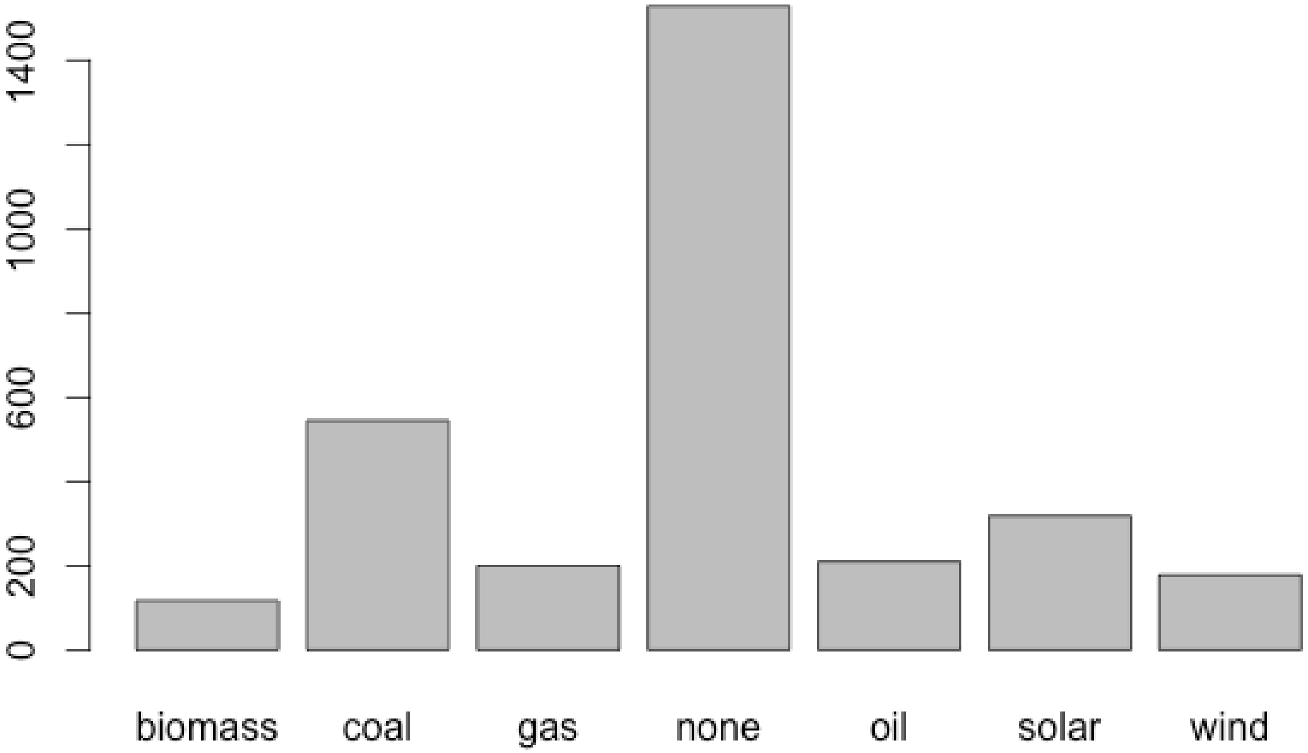
A Survey of Literature

- 3097 abstracts for full length articles downloaded from Scopus
  - Source title consisting of the term “Energy”
  - Abstract-title-keyword consisting of the term ”India”
- Content analysis – depending on terms found, abstracts were categorized by
  - Demand sectors
  - Supply sources
  - Theoretical foundations
  - Policy Objectives (to be done)

Literature Analysis

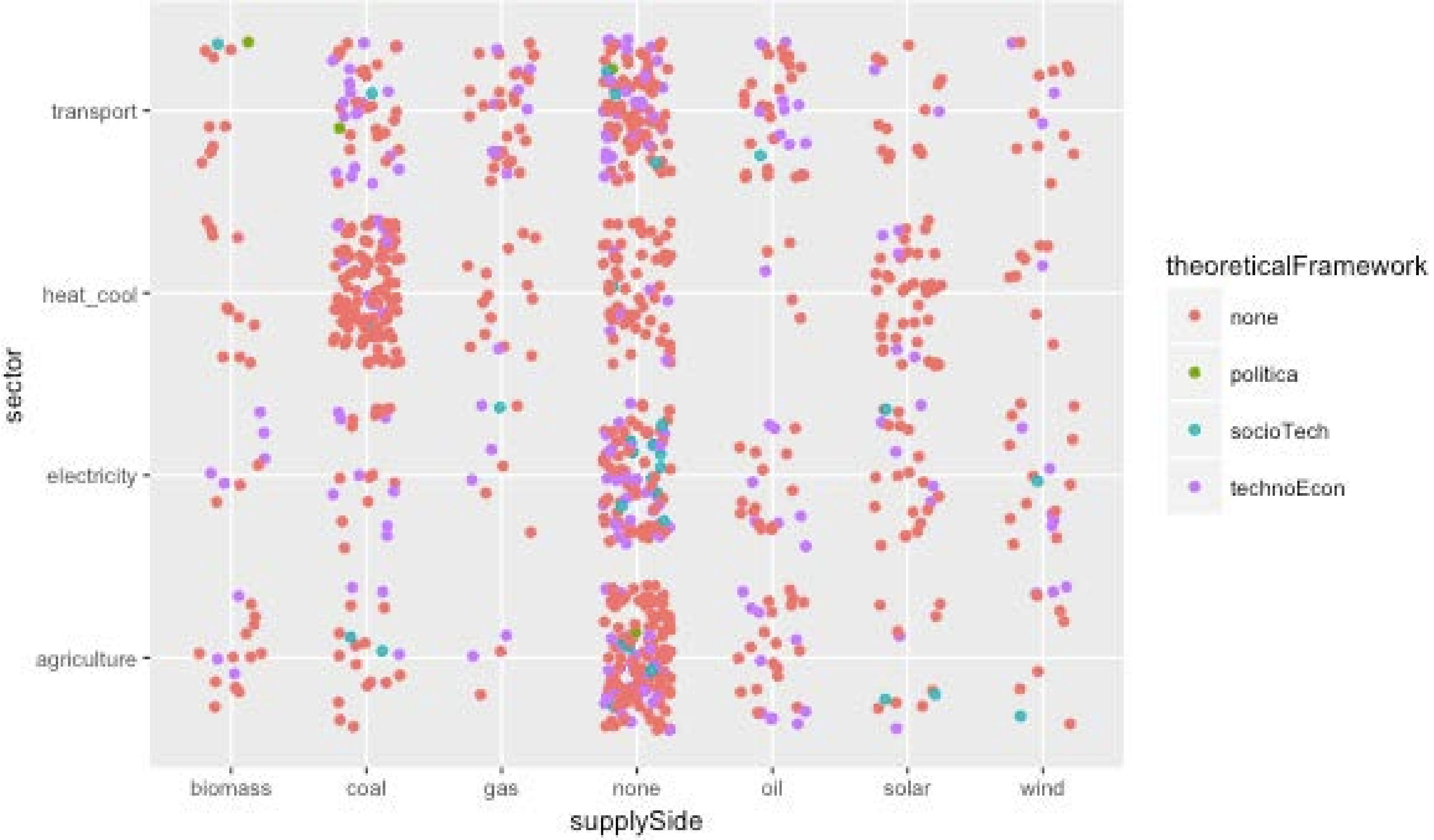


Demand Side



Supply Side

Literature Analysis



STPP Research Objectives

- *Towards the decarbonization of India's energy sector, we propose to evaluate the effects of India's wholesale market design on renewable energy integration outcomes*
- *To evaluate technological alternatives for flexible resources to balance out the intermittency brought in by variable renewable sources, in terms of cost effectiveness and potential to reduce emissions.*
- *Towards ensuring reliable and greater electricity access, we propose to evaluate options to improve reliability*

Research Objective 1 – Wholesale Market Design

- Comparing a contract based dispatch regime to a purely merit-order based dispatch
- Method:
  - Simulation of electricity market clearing, using a representation of the power system in two states in India, with limited representative load segments in a year, using an in-house model based on Python or Java.
  - The simulation will be informed by interviews to determine current-day rules of dispatch
- Performance Indicators:
  - Renewable electricity integration outcomes – curtailment, spillage
  - Capacity utilization of conventional power plants – Plant Load Factors

Research Objective 2 – Options for flexibility

- To evaluate technological alternatives to coal that can provide flexible resources to balance out the intermittency brought in by variable renewable sources
- Method:
  - Long-term simulation of the electricity market and investments.
  - Data required: cost projections and potentials for gas, transmission, nuclear, storage options
- Key Performance Indicators
  - Cost-effectiveness
  - Share of renewables in generation, without spillage
  - Impact on electricity prices, market value of renewables.

Thank you!

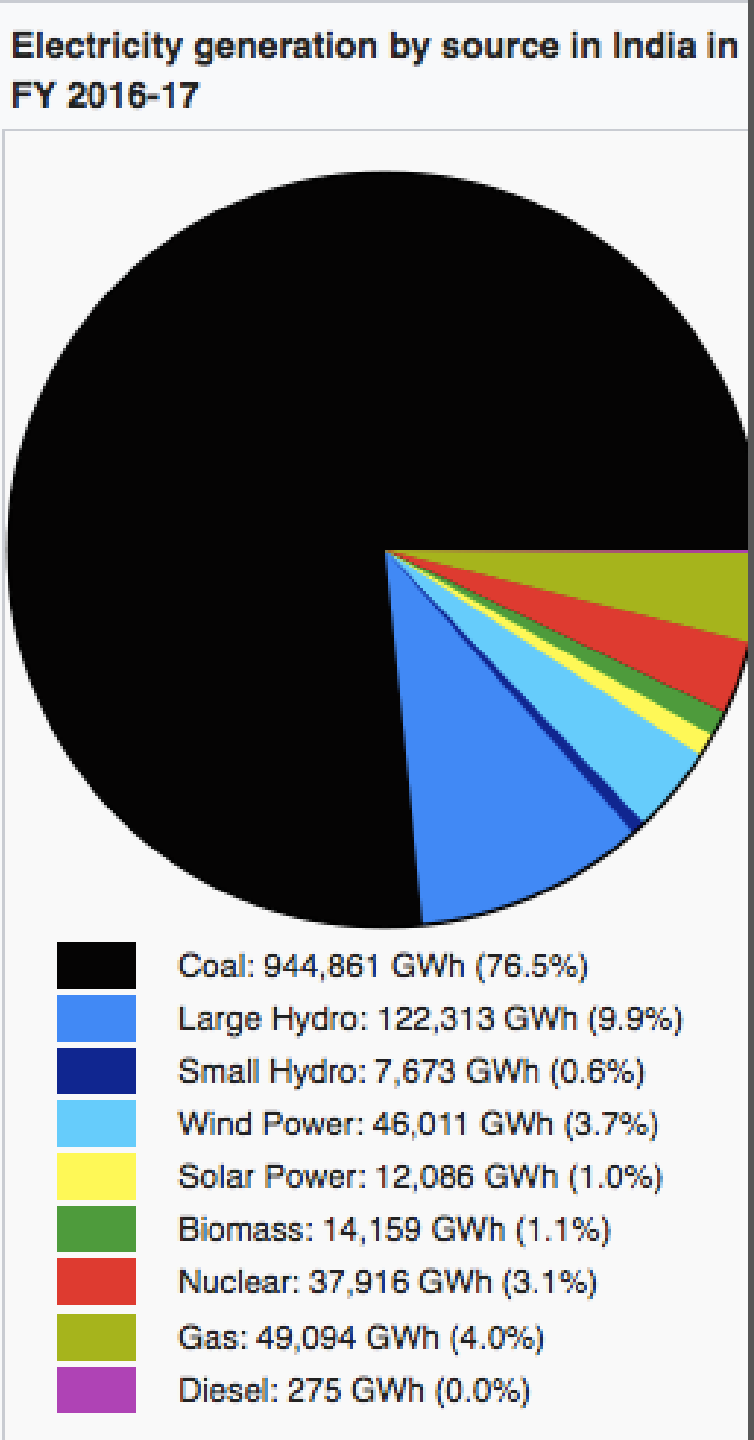
Questions?

Appendix

- Installed Capacities in 2008 and 2018 (in GW) by technology

Generation type	Capacity in GW (2008)	Share in % (2008)	Capacity in GW (2018)	Share in % (2018)			RES Capacity (2018)
Thermal (Coal, gas, diesel)	90.90	64.43	222.91	65.46		Small Hydro	4.48
Hydro	35.21	24.96	45.29	13.30		Wind	32.96
RES*	10.86	7.69	65.55	19.25		Bio-power	8.53
Nuclear	4.12	2.92	6.78	1.99		Solar	19.58
Total	141.08	100.00	340.53	100.00			65.54

Electricity Generation by Source 2016-17



Appendix

Table 2 : Day Ahead Scheduling Process

Day	Time	Intra-State Network	Inter-State Network
N	8 am	State generators and beneficiaries including the distribution utilities send their block wise generation and demand respectively to SLDC.	ISGS send their block wise generation capabilities to RLDC.
N	9 am	SLDC receives generation capabilities of ISGS for their shares from RLDC.	RLDC distributes and sends the ISGS capabilities to respective beneficiaries including states.
N	3 pm	SLDC prepares their drawl schedule considering generation and demand data from above received data including long-term access, medium-term and short–term open access, and sends to RLDC.	RLDC matches the drawl received from the states and other beneficiaries with capabilities received from ISGS. It checks for possible technical constraints and prepares net dispatch schedule for ISGS and net drawl schedule for states.
N	6 pm	SLDC receives net drawl schedule for states from RLDC.	RLDC sends net dispatch schedule for ISGS.
N	10 pm	SLDC makes corrections if necessary based on various constraints and sends revised drawl schedule to RLDC.	ISGS make corrections if necessary based on various constraints and sends revised dispatch schedule to RLDC.
N	11 pm	SLDC receives final schedule from RLDC.	RLDC sends final schedule to beneficiaries including states and ISGS.
N+1	12 am	Actual dispatch by the generators and drawl by beneficiaries starts in the state by merit order principle, in which the least cost generation is allowed to dispatch first.	Actual dispatch by ISGS and drawl by beneficiaries starts by merit order principle in which the least cost generation is allowed to be dispatched first.
N+1	12 am onwards	SLDC starts accepting revision of schedules from state generators and beneficiaries which become effective after 4th block (1 hour).	RLDC starts accepting revision of schedules from ISGS and beneficiaries which become effective after 4th block (1 hour).