Foresight For Solar Energy Technologies and Electricity Storage Systems till the Year 2032

PhD Work in Progress Presentation
9th June, 2014

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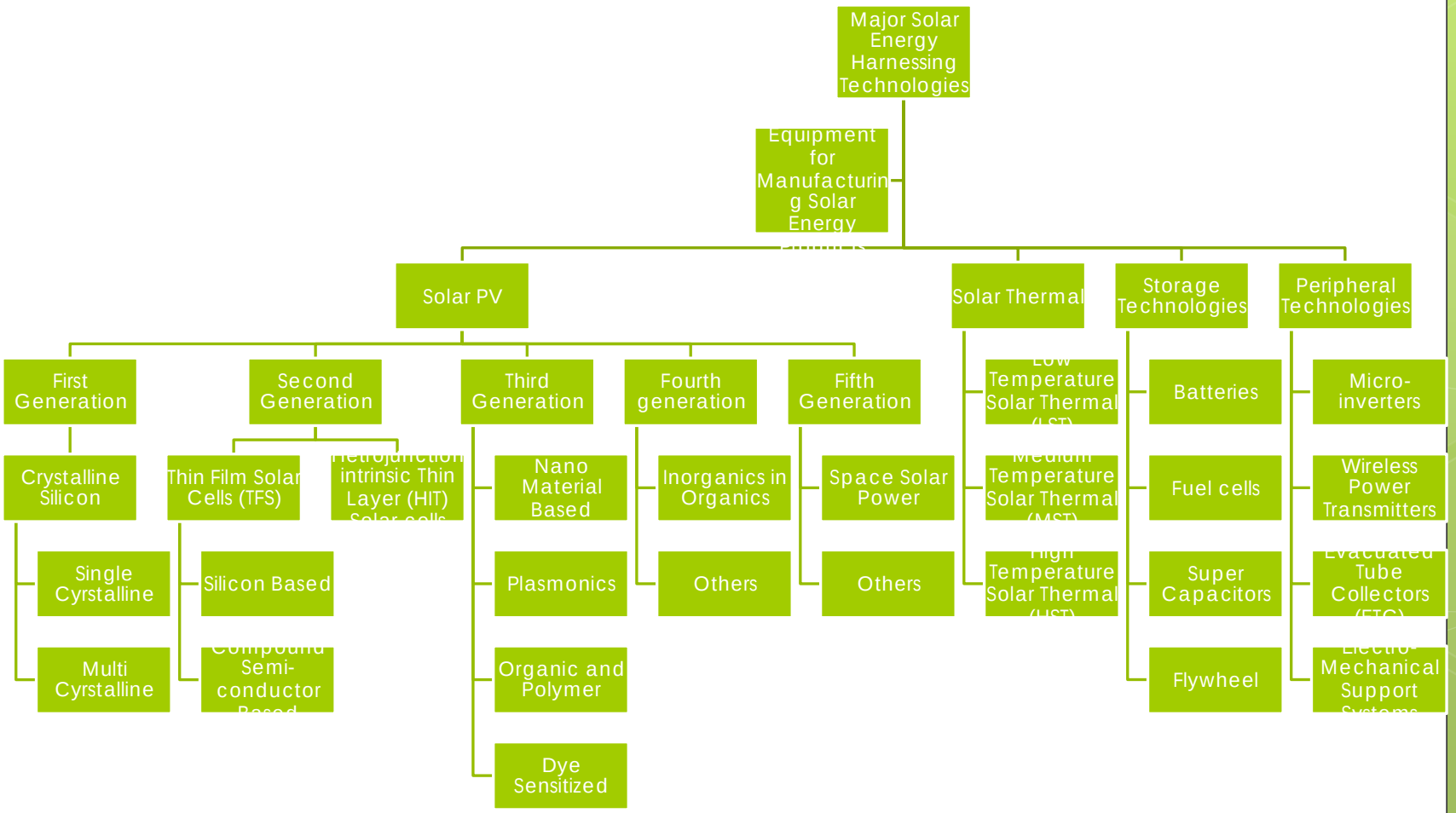
Context, Universe and Rationale of the Study

- Growing energy demands
- Changing profile of energy use
- Climate change
- Addressing Intermittence in Renewable Energy.
- *Barriers*
  - *External Barriers* (eg. non-availability of technological knowhow, balance of equipment crisis (BoE)) and
  - *Internal Barriers* (eg. lower R&D, gap between expansion plan of manufacturing base and the growing demands for more power plants and no specific plans to control the growing demand)
- Various types of Renewable Energy Technologies considered in this study
  - We limited our universe of our study to solar power and electricity storage technologies

Various types of Renewable Energy Technologies considered in this study

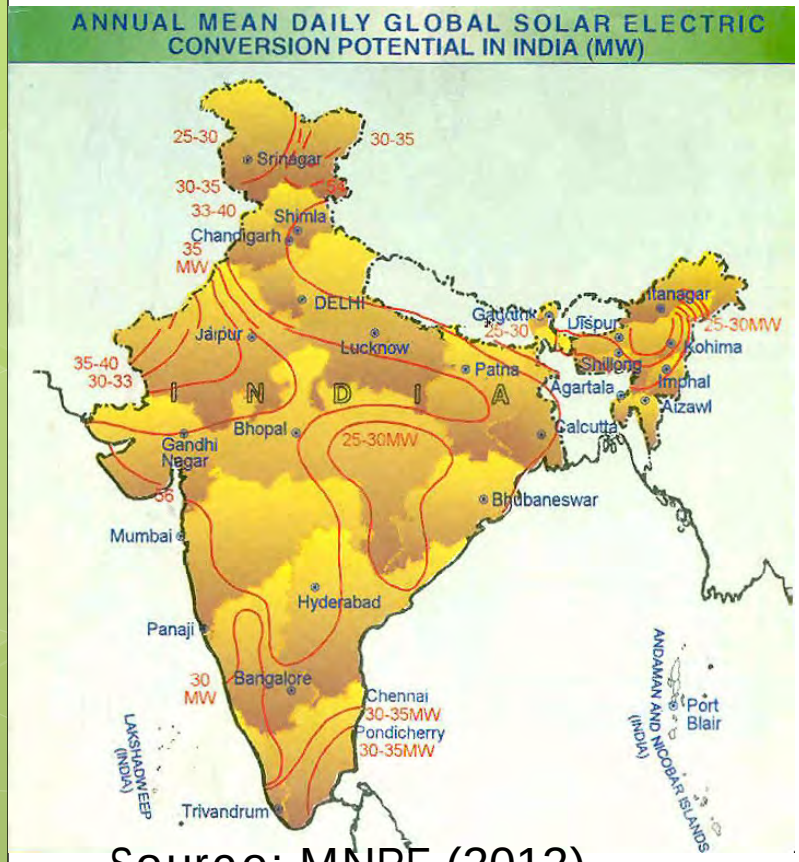


Source: Prepared by Author.

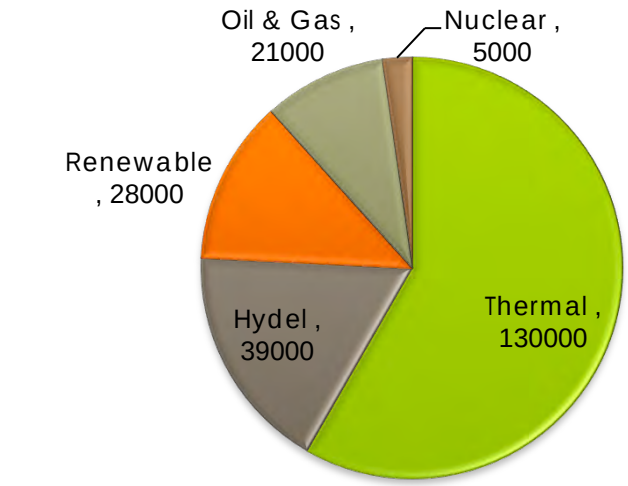
Introduction: The Challenge

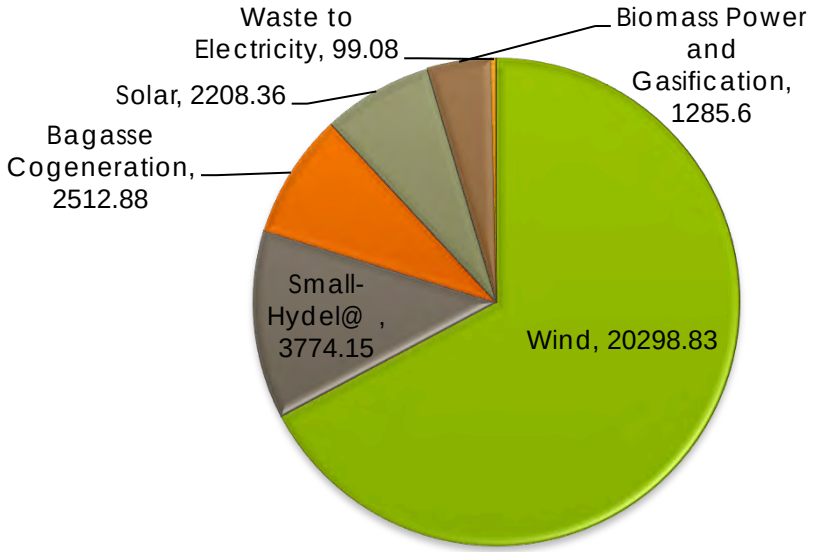
Why the Electricity is a Cause of worry and what options India has to tackle it?

- India's current per capita electricity consumption stands at 626 kWh units (IEA, 2012).
- India's per capita electricity consumption standards are even lower among the BRIC group of nations (6,431 kWh Russian Federation, 2,944 kWh China and 2,381 kWh Brazil).
- EIA's projection says that by the year 2020 India will be the major importer of coal across the world.



Source: MNRE (2012)





Analytical Framework

- Technology foresight approach within theoretical framework of systems of innovation in energy sector with due consideration to responsible innovations.
- We made an attempt to fathom the approach and methods of different foresight programs and two foresight thesis at CSSP that were related to develop energy and technology futures.
- The critical technology identification programs of USA in 70's and 80's.
- Nordic Energy Foresight
  - Market indicator
  - Industry indicator
  - Role of Actors and Agencies
  - Papers and Citations
  - Patents
  - Governmental R&D expenditure

Research Methodology Adopted

Applying a combination of Futures analysis methodologies within the system of innovations perspective, which is the combination of both quantitative and qualitative tools i.e.

Scientometric Analysis

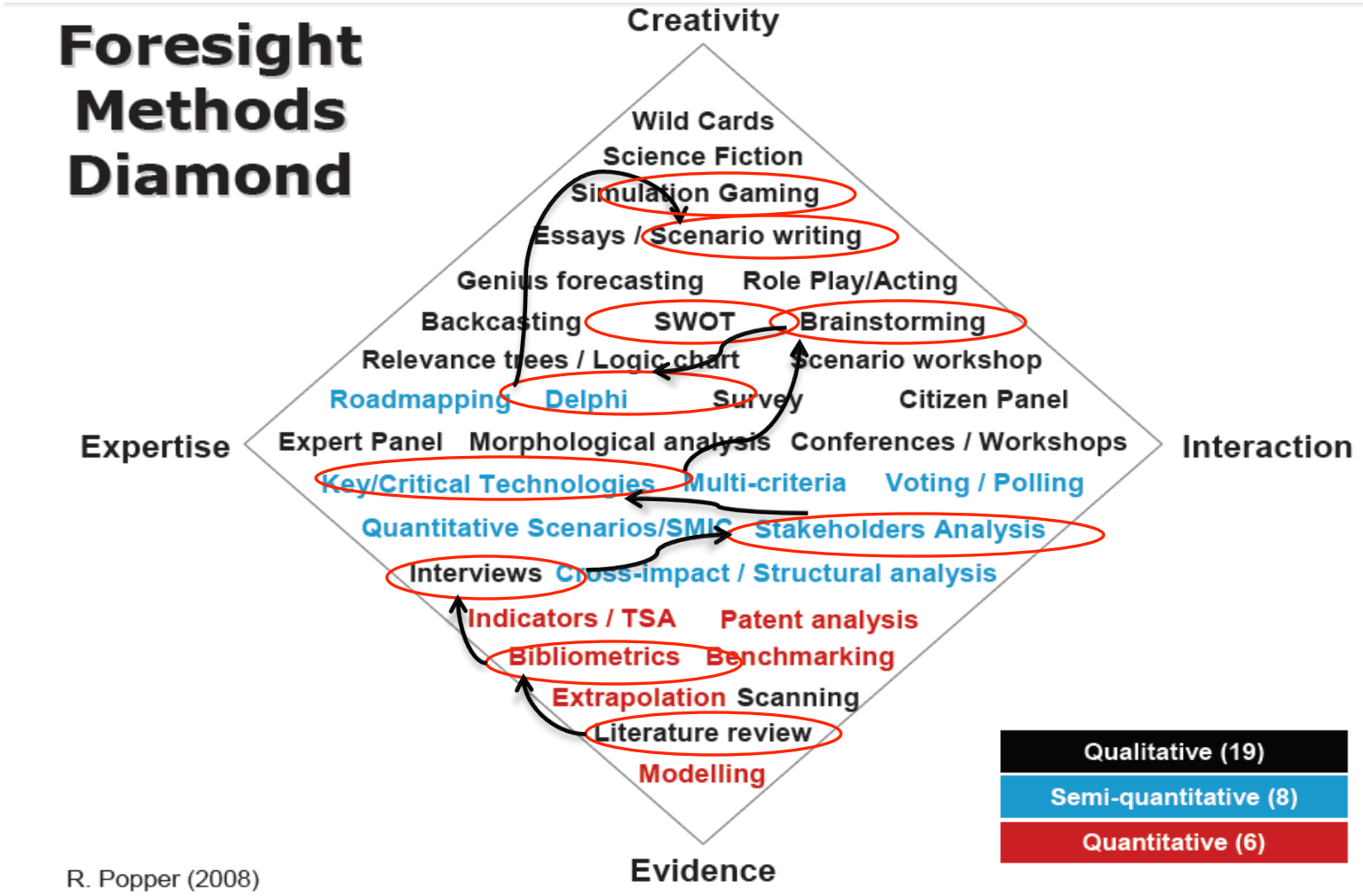
Scenario Planning:

- MICMAC: For studying the key Variable and their relationships and influence.
- MACTOR: For studying the key Actors and their relationships and influence.
- MORPHOL: For identifying and defining a group of feasible scenarios in medium and long term futures.
- Delphi

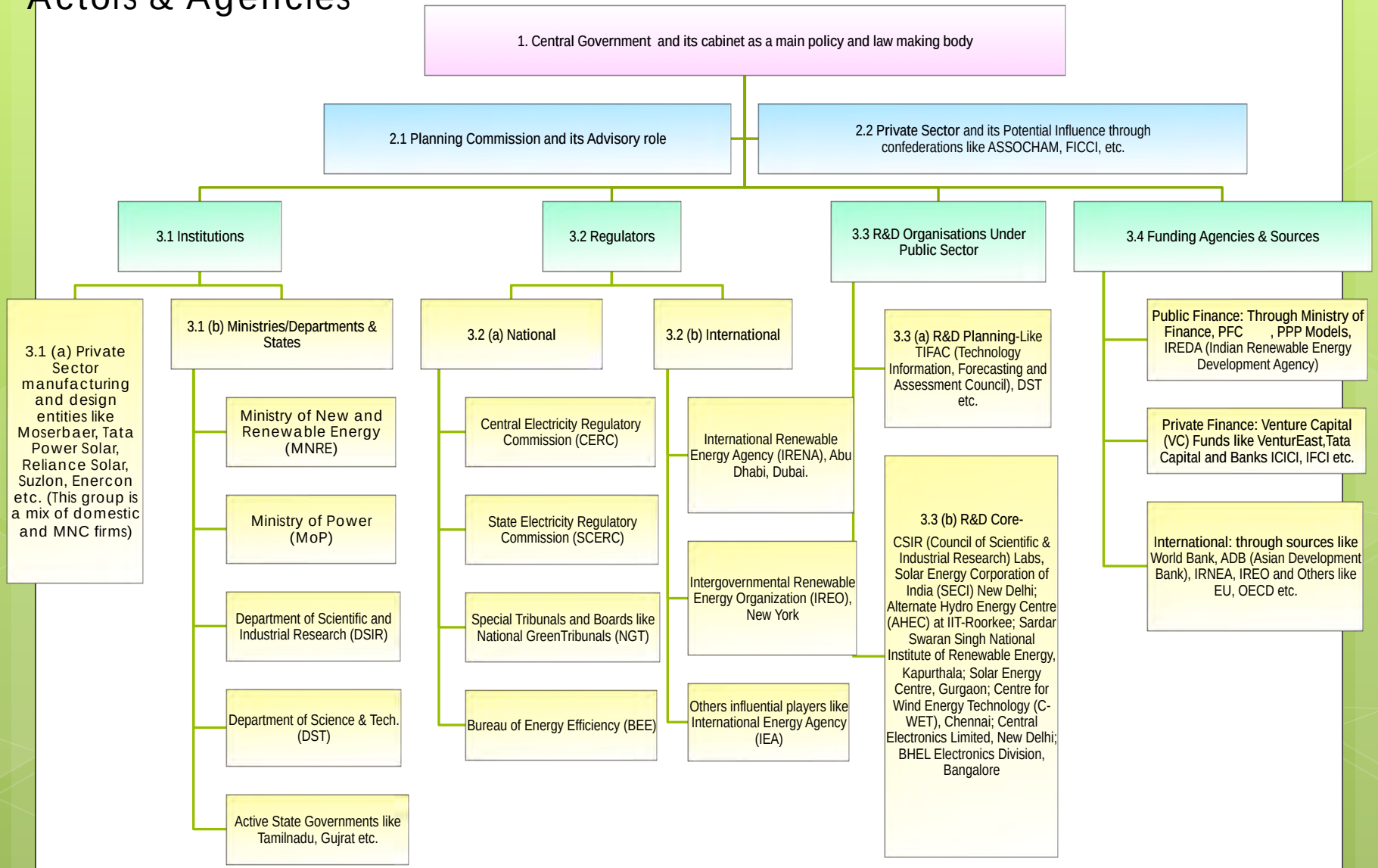
Simulation and Trend Analysis:

- ANN (Artificial Neural Network) Method with the help of MATLAB Software

Foresight Methodology



Actors & Agencies



Source: Compiled by the Author

Literature of Important Foresight Studies and lessons from Abroad

- Innovations Systems Perspective
  - Lundvall 1992; Freeman, 1995; Malerba, 2002; Hall et al, 2002; World Bank, 2007.
- Technology Foresight and the Innovation System
  - Martin (1995); Godet (2005); Johnston (2002); Keenan and Cagnin (2008); Miles et al. (2008); Georghiou's (2001)
- Technology Foresight in Regional Context
  - Kuwahara et al. (2008); Johnston and Sripaipan (2008); Jiayu and Yongchun (2001); Thai Science and Technology Vision 2020; TIFAC-Vision 2020; Energy Foresight in Pakistan; Popper and Medina (2008) ; UNIDO (2005)
- Technology Foresight for Energy Sector Involving Simulation Tools
  - Iniyan and Sumathy (2003) Suganthi and Williams (2000); Mallah and Bansal (2010)
- Application of Technology Foresight in Energy Sector or developing other technologies
  - Saritas et al. (2007); Chen, et al. (2012); Czaplicka-Kolarz, K. et al. (2009); Goel M, Maurya V, Desai PN (2014); Setiawan, Andri D. and Rajbeer Singh (2012)
- "Nordic H2 Energy Foresight"
  - development of low carbon energy futures
  - involvement of policy-makers closer to the other active actors
  - facilitating dialogue, communication and consensus on new technologies
- Japanese adherence to the Delphi methodology and assessing critical technologies through bibliometric analysis (Kuwahara et al. (2008)).
- China's "Selection of National Critical technologies".
- Thailand's Science and Technology Vision 2020 (Cooperation with Japan).
- Technology Vision 2020 reports (1996)
- "Energy Foresight in Pakistan" (Mainly STEEPV and Brainstorming)
- Application of Foresight in Energy Sector

Lessons from Abroad

- Germany: Two issues: Create employment and an alternative to nuclear in post-chernobyl environment; Discoms are loosing revenue
- USA: Post-oil shock: a search for energy security ; Discovery off Shale gas a threat to RE!
- China: Business opportunity to fuel the German and demand by other nations; But currently 15-17 Assembly lines between Beijing and Shanghai are shut down,

Gap in the Literature

- Many models have been developed for energy sector as a whole and as well as for the renewable energy sector. However, such models are rarely able to focus on key variable of renewable energy sector, i.e. how can the manufacturing industry in key RE products can be boosted, what can be the paths of funding R&D and other policies are to be adopted etc.?
- Models and scenarios often end up with potential figures and projections for best and worst case scenarios.
- Models generally fail to throw a specific perspective plan that how to develop certain technologies to reach the projected figures in time with a definite strategy for instance JNNSM tells for 20 GW but how ?.
- This study is an attempt to bridge this gap by modeling the energy requirement vis-à-vis potential at one side and presenting a technology development strategy on the other side.

Research Objective(s) and Question(s)

1. What are the policy initiatives by the government with respect to solar power and electricity storage technologies in India and where they are lacking to boost a robout energy innovations systems in solar energy?
   - What are the various schemes and policies made for this segment and how the results of these policies were reflected in System of Innovations for RE? REVIEW OF POLICY DOUMENTS, SCHEMES etc.
   - How various actors and agencies interact within the renewable energy innovations system? MACTOR SIMULATION
   - What is the status of manufacturing, imports-export and investments scenario within the sub-segments of the solar power technologies? ANALYSIS of PROWESS and UNCOMTRADE DATA SETS.
2. To understand the dynamics of setting the R&D priorities for the sub-segments of solar power technologies and trace their technology development process in India.
   - What is the Research output of major actors vis-à-vis solar power technologies? SCIENTOMETRICS ANALYSIS
   - To identify various variables and see how they interact among themselves influencing the technology development process of solar power and electricity storage technologies. MICMAC SIMULATION
3. What will be the role of solar power and electricity storage technologies in futures Energy Spectrum of India?
   - How far can India reach with existing pace of RD&D in these technologies? ANN (Artificial Neural Network) Simulation.
   - What are the major strength, weaknesses, opportunities and threats (SWOT) areas of the India's renewable energy sector and converging them for priority setting for future research with respect to the Sociological, Technical, Ecological, Economic and Political (STEEP) drivers? SWOT and STEEP Analysis through identifying the major research frontiers DELPHI STUDY.
   - What technologies are required to be built by India to cater both its internal and global demands respectively both making India a leader in Solar Energy and a major exporter of solar energy products.

Net Resultant of the Indian Approach towards Solar Energy Policy till now

Policies

- The Electricity Act, 2003: Sec. 61 (a) & (h); Sec. 86(1) (e)
- National Electricity Policy (12.02.2005)
- Tariff Policy (6.1.2006)
- National Action Plan on Climate Change
- Integrated Energy Policy
- National Solar Mission

Net Resultant

- Tariff Increase
- incentives to the solar power generators in the state for encouraging solar power generation:
- 100% banking facility
- No wheeling & transmission charges
- No cross subsidy surcharge
- Electricity Duty exemption
- VAT refund for all the inputs required
- Refund of Stamp Duty & Registration charges
  - Result
    - But Still Solar Energy has not seen very high popularity in sales terms both at the consumers and the manufacturers/distributors end.
    - What Changes in policy and regulations are required this foresight study will address.