Chapter Overviews and Volume Summary

RAHUL TONGIA

CHAPTERS OF THIS VOLUME

RAHUL TONGIA discusses *renewables integration* in the context of the larger electricity system, especially the interconnected grid. More than just the global challenges of location-specifics (concentration in often remote locations), variability, and economics, the Indian power system is different from that of the west. Most importantly, the Indian grid peak demand is mostly in the evening, driven by lighting and household plus commercial use, and many renewables have limited if not zero output at this hour. While storage technologies might help, this is some ways away from commercial viability. Thus, for every kilowatt of solar capacity added, almost one kilowatt of something that can be despatched (called on demand) must be added. There is also the challenge of a weaker grid, with no spinning reserves. To address these, some of the recommendations span proper accounting, improved pricing (that doesn't treat every kilowatt hour the same, rather adding factors for time of day, location, congestion, etc.), and the creation of ancillary services for the grid. These are systems if not markets for non-traditional non-kilowatt-hour services such as frequency regulation and voltage support, which make the grid more stable, especially in light of fluctuations in both supply and demand.

ANISH DE explores the *institutional and financial aspects of renewables,* especially in large scale. While cheaper is better is a starting point, a few of the questions that frame recommendations are how much should support mechanisms play a role, and in what form are they most effective. Operational improvements are an easy starting point, and that includes coordination with the grid so that renewable energy is never wasted (curtailed because the system couldn't handle it), in addition to better forecasting. Given the capital intensive nature of renewables (with nearly but not quite zero operating costs), cheap financing is a vital need – this links to risk management for renewables projects. There also need to be improvements in Renewable Portfolio Obligations and other support mechanisms such as RECs (Renewable Energy Certificates) that balance generator needs with buyer (utility) constraints. At a big picture level, coordinated planning and even an integrated National Mission for Sustainability (instead of silos of National Solar, Wind, Efficiency, etc. Missions) can improve broader electricity sustainability in India.

RAHUL TONGIA shares a focused chapter on the *economics of renewables,* pointing out that more than just typical power plant variables like construction cost, interest rates, plant load factors (aka capacity utilization factors), etc., economic comparisons must factor in network level costs due to the variability of most renewables. With one set of assumptions, solar power could already be cheaper than imported coal power. With another set of assumptions, it is 2 to 3 times as expensive over the lifetime from a utility procurement perspective.

SUMANT SINHA talks about *making grid scale renewables work,* drawing especially from his experience with the wind sector. First and foremost, he suggests consistent, realistic policy support, which can give industry a combination of a lofty target as well as a realistic pathway to get there. As prices for the Clean Development Mechanism (CDM) have slumped, a domestic push through improved RECs and RPOs (tradable Renewable Energy Certificates and state-level Renewable Portfolio Obligations) are recommended. In addition, coordination and grid integration are key needs, especially as the scale of renewables becomes larger and larger. In another dimension, cheaper financing as well as means to reduce risks and costs become important, including land acquisition and financial hedging options.

HARISH HANDE and colleagues discuss *making small scale renewables work,* drawing especially from their experience with solar power (which is pretty much the only renewable energy option that works down to the household scale – almost everything else is village scale if not larger). Small scale power shouldn't be viewed merely in a Rs./kWh lens, instead being valued for its social impact as well as availability, reliability, and more. To that end, the end beneficiaries (or target groups) aren't just citizens but also programs on education, health, etc. Making small scale systems work will ultimately depend on a favorable ecosystem, which emphasizes the multitude of factors and stakeholders that must align, ranging from financing, supply-chain (including quality and quality assurance), training, maintenance, etc. Such networks can span to not only the so-termed market, but also government, NGOs, donor groups, academia, etc.

ASHISH KHANNA and colleagues talk about *energy efficiency,* which is a complement to renewables and another tool in the portfolio needed for making the broader electricity ecosystem in India sustainable. A specific link to renewables is the expected (and some say inexorable) transformation the grid will need to manage the variability of renewables, and that will come from more effort on the consumption side. At the ultimate level, dynamic management of demand becomes a Smart Grid. Even before a Smart Grid, efficiency in power consumption is a low-hanging fruit where the first need is aggressive and innovative targets. While targets are one step, they become realized when incentives align, which is where the institutional framework for energy efficiency needs enhancement, also extending far beyond the Center down to the states. In fact, they suggest a network, based on a hub-and-spoke model (with layered institutions in the middle), to cover the dimensions of stakeholders for finance, training, markets, behavioural change, R&D, and policies.

RAHUL TONGIA explores the future of the grid as a *Smart Grid*, in particular how it can synergize with renewable power. This includes new (dynamic) pricing schemes, storage technologies, and dynamic demand management. Each of these aspects, rather, the entire spectrum of a Smart Grid needs policy support, independent of the links to increased renewable power. These include new tariff and pricing schemas, support for new technologies, and even a new framework for Smart Grid rollouts across the nation. One additional area where Smart Grids and renewables intersect is for distributed generation, including microgrids, where now power can flow upwards from the edge, instead of top-down (aka centralized delivery). This requires legal, regulatory, and safety-engineering standards and policies to materialize and scale.

RAMAPRASAD SENGUPTA examines the link between *energy and the environment*, presenting depth to the obvious environmental benefits of renewable energy, in addition to other externalities such as energy security. While always fraught with assumptions, using literature and his own calculations, he gives ranges for the externality costs of coal-based power, which then allows a more sustainable view of the price of renewable power. For coal based power, the mainstay of power in India today, these costs can be in the same order as the nominal costs of today. This is not to say there are no externalities to renewables, not only land use but also even carbon (especially during construction of solar panels), but these need to be in perspective. One of the takeaways to try and internalize the externalities (e.g., through pollution taxes) is the need for better numbers on the lifecycle costs, which start with fuel extraction (mining), and extend to power plant chimney stack emissions, as well as water usage.

SABINA DEWAN makes the case for *employment by growing renewables,* something even the US focused on during Presidential elections. More than just the actual number of jobs created (which must be examined in comparison to jobs in with other energy forms, and these are not all the same, e.g., diesel is imported), the quality, safety, and wages can be higher in clean energy than many traditional fuel systems. One of the flip sides of clean energy jobs is the need for skills upgradation and training, which can be a bottleneck without focused effort and even policy support. Given the relatively smaller scale of renewable deployments and large role of the private sector, one of the first needs is a consistent database of jobs in the renewable energy space, something which hasn't been compiled yet.

GOPICHAND KATRAGADDA focuses on some contours of *R&D and innovation for renewable power,* which will take us further along the price-performance curve. Almost unsaid because of its primacy is the need for Indian innovation or at least innovation accessible to India at low-cost. Some of the recommendations focus on specific technologies, such as adopting newer solar cell technology to leap frog in the current environment of abundant (and some would say over-abundant) cheap cells from foreign suppliers, or the immediate prospects for low-wind-speed wind turbines (since India's wind speeds are lower than Western Europe or parts of the US). Also highlighted in the discussion are game-changing issues such as hydrogen availability to make fuel cells viable. Other recommendations ask for new models of collaboration, especially the need to bring together industry, academia, and government.

KIRIT PARIKH examines *policies for making renewables sustainable,* spanning a high-level view all the way to the details. Starting by putting renewables in the broader context of the current (fossil-fuel dominated) power system, the chapter focuses on renewables, offering suggestions on existing schemes such as RECs and RPOs (which need to be enforced) all the way to increasing domestic capabilities in manufacturing and innovation. Some of the recommendations draw from the Expert Group on Low Carbon Strategies for Inclusive Growth, aka Parikh Committee Report (Planning Commission), but there are also new calculations, such as the premium renewable energy entails, and the fiscal impact of this, which is high enough to be visible on the GDP scale!

SUMMARY: MAKING RENEWABLE POWER SUSTAINABLE

The key areas that need policy effort or solutions, whatever these may be, focus on:

1) ***Finance.*** The high cost of capital is just one reason for the relatively high cost of renewable power. In addition to absolute costs (which are falling), risks of

all power projects remain, making the required returns on investment higher than optimal. Utilities are cash strapped, and broader reforms and improvements in utility operations and finances will go a long way to making the case for renewable power (rather, all power). By some measures, traditional fossil-fuel power projects have higher risks, since they require fuel linkages, water supply, etc., and are often very large sized. On the other hand RE projects might sometimes be given a short-shrift by states, with delayed payments and other operational headaches.

2) ***Grid integration for renewables, with dynamics***. While we now have a unified national grid, it wasn't designed for taking Tamil Nadu wind power to Delhi air conditioners. (It's a separate issue that the 5 Regions of India's grid have limited interconnectivity—which must be strengthened—and dedicated transmission "green corridors" don't entirely solve the problem).

- *Coordinated and dynamic planning (and trans mission pricing).* For all bulk RE projects, not only must transmission be firmed up in advance, such calculations must be for a dynamic grid, instead of a static/average calculation. The transmission system today needs upgraded calculations to handle dynamics, and congestion, ideally through a pricing mechanism such as Locational Marginal Pricing (LMP).

- *ToD and dynamic power pricing (bulk procure ment, and eventually consumers).* The broad er power system needs to move towards Time of Day (ToD) pricing. While retail (consumer) ToD will take time and requires new meters, the first step should be bulk power procurement ToD by Distribution Utilities, instead of today's generation contracts which focus on a single dimension of kilowatt-hours through PLF targets.

- *Storage technologies.* In addition to the technology innovations needed to reduce costs, storage technologies need an appropriate regulatory frame to provide value. In addition to ToD pricing to encourage energy arbitrage (supply: off-peak to peak, demand: peak to off-peak), storage especially helps for short-term fluctuations in supply and demand, through ancillary services.

- *Ancillary Services.* These are systems, which could operate through a market mechanism, but don't have to, for keeping the grid stable, instead of just valuing kilowatt-hours. A few of the ancillary services include the ability to ramp-up/ramp-down quickly, frequency regulation, and black-start capability.

3) ***Forward-looking yet realistic targets, incentives, and perhaps penalties (for RPO or other non-compliance).*** Realistic targets that factor in transmission, grid management, variability, finance, etc. would be much more sustainable than the (almost) cycles of boom-bust that accompany support-driven growth of renewables, which collapse when the rules change. If there are Renewable Portfolio Obligations, these must be enforced, which would then send stronger pricing signals, either directly or through tradable Renewable Energy Certificates. If a Regulator wishes to set the price for renewable power, they might not get it right. Too low and there would be few suppliers. Too high and not only would many cry foul, the buyers (utilities) would struggle to pay. This highlights the challenge of bids and so-called market solutions as being done today. They may be efficient from a supplier perspective, but this does little towards discovering utility equilibrium willingness-to-pay. In such cases, an encouraged (if not mandated) target may be required.

Any future policy plans need to also reflect structural issues of ownership and incentives. Unlike solar farms, most wind farms have many small individual owners (e.g., one turbine each), but are operated by a wind promoter. Thus, policies need clarity between owner and operator, individual turbine or farm. This also impacts any attempts at "re-powering" wind farms, a key need since older turbines are less powerful and less efficient. Here, the ability to collate and consider farms as cooperatives may be important since we have can different owners of individual turbines within a wind farm, each with different vintage, efficiency, tariff, etc.

For solar power, the incentives issues is further complicated for small-scale distributed generators (e.g., rooftop solar), where now end-user's rational economic comparison becomes between solar generation (which can be cheaper if opportunistic, i.e., without any output back-up or predictability) and retail grid-power, which has cross-subsidy based pricing, and thus higher tariffs for some classes of users, precisely the ones most likely to jump into personal renewable generation. These aren't comparable, since the grid is inherently designed for multiple supply options, redundancy, maintenance, etc.

4) ***Better accounting and numbers.*** The above-mentioned dynamic aspects of operations and payments are just a subset of the improved data required for making renewables more sustainable.

- *Predictions.* While computational improvements (especially so-called "big data", "Smart Analytics," etc.) can help, real-time monitoring stations with instantaneous sharing of data will go a long way towards at least knowing about upcoming variability. This needs coordination, perhaps through the proposed Renewable Energy Monitoring Center(s) (REMCs). Dynamic and granular (localized) information will help grid operations – an average number isn't good enough.

- *Environmental impacts, especially on a lifecycle basis*. While externalities are a tough challenge to handle, worldwide, even before we consider how to alleviate them (taxes, subsidies for helpful things, regulatory fiat, etc.), we first need to properly measure the externalities and other environmental impacts of energy, both renewable and conventional. A transparent framework combined with a database would be the direction to move towards.

- *Jobs and employment, both during implementation and ongoing operations.* Given the mix of public and private, large and small, owned and outsourced, etc., there are no good numbers on the manpower implications of green energy. Such information isn't just to help choose technologies but also to improve deployments, especially given skilled labour (for not only deployment but operations and maintenance) is a bottleneck for many projects, especially in remote locations.

5) ***Innovation.*** Renewable energy is inherently about innovation, and R&D can help with not just the efficiency of a solution (the science), but also its costs (the engineering). India has been riding the wave of global reduction in solar panel costs, but all of its cells are based on imported silicon. One worry some folks have is to what extent are recent (low) prices the result of a global glut or push for market share? Even if that is not the case, India should not only start and expand in-country production capabilities, it should innovate for technologies needed for its own conditions, such as low-wind-speed wind turbines, hybrid (grid + home) grid-interactive inverters for solar panels that don't switch off when the power fails but instead isolate the house and continue supplying power to the home, etc.

Some innovation is missing due to lack of policy clarity or support. Solar thermal power would benefit from Time of Day (ToD) pricing due to its ability to easily store energy for a few hours. Even more strikingly, solar thermal plants could be synergized with other fuel inputs for producing predictable if not continuous power (which also lowers the costs). However, policies in India disallowed innovation for multi-fuel options since the incentives were only for solar power, and there were worries about misuse. While measurements and cost allocations might not be 100% accurate (and based on assumptions), one could come up with transparent and fair norms for hybrid solar thermal power plants.