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# India regulatory toolkit: Resource adequacy

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## Introduction

A discussion of resource adequacy fits within a broader context: that of reliability, the "ability of the system or its components to withstand instability, uncontrolled events, cascading failures or unanticipated loss of system components."[1] While system operators, generators, distribution companies (discoms), and even consumers come to the question of reliability from unique vantage points, in the end it comes down to the simple matter of keeping the lights on and determining how much one is willing to pay to do so. Experience in the United States and elsewhere shows that those who are directly charged with maintaining reliability – system operators and load-serving entities (LSEs) – have historically tended to overlook a wide range of non-traditional resources that serve that need at lower cost and at higher value for the system and, ultimately, consumers.

At the system level, there are two dimensions to reliability. There is the operational dimension (typically referred to as *system security*) in which a combination of available resources is deployed to match expected demand in real time at the lowest reasonable cost. The second is an investment dimension (typically referred to as *resource adequacy*), in which investment is required to maintain, refresh, expand and transform the portfolio of resources (generation, transmission, distribution, and demand-side) so that they will continue to be available as needed to meet future demand at the lowest reasonable cost. A growing reliance on variable (intermittent) renewable resources fundamentally transforms the system security dimension, placing greater emphasis on the ability of the other system resources to efficiently and reliably complement renewable production. This means, therefore, that notions of resource adequacy – the longer-term dimension that ensures that the system will have the capabilities it needs – are changing: resource adequacy in a system characterised by high penetrations of renewable resources is not simply a matter of meeting peak loads, but rather one of balancing variable supply with variable demand at all hours.

In this brief, we'll focus on the investment dimension – resource adequacy – by first looking at experience in the United States and then by drawing some general

[1] Campbell, R. (2018). 'Electric Reliability and Power System Resilience,' *Insight*, Congressional Research Service. https://crsreports.congress.gov/product/pdf/IN/IN10895.

observations that may have relevance in India as it develops its own resource adequacy requirements. In so doing we'll identify some of the important challenges that mark the exercise, particularly in the context of the transition to competitive markets and India's global climate commitments, and some new ways to resolve them.

# Origin of the resource adequacy concept

Resource adequacy is a concept that goes back to the early days of modern power system design. It was intended to be the point beyond which the incremental *cost* of additional resources would exceed their incremental reliability *value* to consumers in reducing the risk of involuntary service interruptions. Power systems have greatly evolved since the idea of resource adequacy emerged in the 1940s, but this underlying principle is still apt.

In the years following, a proxy rule of thumb for assessing adequacy emerged in North America. It's called the '1-in-10' rule and its origins are obscure. It's still widely accepted, even though its benefit-cost validity has never been rigorously tested, which seems odd in light of the dramatic changes in society and technology over the decades. The rule, as broadly applied, means that resources will be considered adequate if the expectation of interruptions caused by supply shortfalls is no greater than once every 10 years. How much load is interrupted and for how long are not specified. It is therefore impossible to definitively analyse its costs and benefits to consumers, though reasonable estimates have been made.[2] At the same time, there is no comparable recognised standard for the 'adequacy' of transmission and distribution network assets. Customer service

### Renewables in wholesale markets

Intermittent renewable sources such as wind and solar have very low operating costs, which, in energy markets, allows them to underbid nearly all other resources when they are able to generate. This is sometimes referred to as the 'merit order effect' by which lower-operating-cost resources drive down wholesale power prices. The claim is that renewables exacerbate the so-called 'missing money' problem, namely that energy markets by themselves cannot generate sufficient revenues to support new investment. This critique does not stand up to careful analysis. Well-designed energy markets will yield pricing that reflects the true marginal cost of energy, not simply short-run production costs. Power system resources have always been capital-intensive. The true marginal cost of energy always reflects more than just short-run production costs (e.g., opportunity and, when present, scarcity costs); in parts of the U.S., the failure to properly price energy has for a long time led to this 'missing money' problem. This is not new: it's simply become more apparent in markets with high shares of renewables and imperfect energy-price formation. The low operating cost of renewables doesn't threaten resource adequacy; flawed energy price formation (both wholesale and retail) does and has always done so.

[2] This brief draws heavily from Hogan, M., and Littell, D. (2020). *Reclaiming Consumer-Centric Resource Adequacy*. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/get-what-you-need-reclaiming-consumer-centric-resource-adequacy/. At page 3, the authors note that studies in the United States and Europe have shown that, as a general matter, the *maximum* value that average residential and small commercial consumers place on lost load (the value of lost load or VoLL) is in the neighborhood of US$25,000/MWh. A loss of load of one *day* in 10 years – the interpretation used by some system operators – equates to a loss of load of 2.4 hours per year. Using a reasonably conservative assumption about the quantity of a typical supply shortfall, the cost of meeting the '1-in-10' rule comes to roughly US$50,000/MWh. If, however, the '1-in-10' rule is interpreted to mean one *event* in 10 years – a common interpretation – then (using reasonably conservative assumptions for the parameters of an average 'event') the cost to meet the standard rises to US$350,000/MWh or higher. It appears that consumers in the United States are vastly overpaying for supply margins under the existing standard.

interruptions are tracked in most markets using metrics such as System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI). Performance over many years as tracked by these metrics reveals an average rate of consumer service interruption dozens of times greater than any reasonable interpretation of the 'one-in-10' rule applied strictly to supply adequacy; interruptions are driven overwhelmingly by failures in the transmission and distribution networks. This points to an incomplete and misleading framework in current practice for assessing the factors determining overall service reliability.

# Resource adequacy given significant penetration of intermittent resources

As solar and wind generation underbids coal, oil, nuclear, and even gas generators, the grid will see a smaller share of generation that is fully controllable. The old paradigm of dispatching supply to follow inelastic demand is becoming unsustainable. At the same time, demand-side technologies such as smart meters, flexible end-uses, batteries, and real-time load controls can quickly adjust demand to make the most economic use of varying supply. Where we once forecasted load and scheduled generation, increasingly we will forecast generation and schedule load. Fortunately, wind and solar forecasting is becoming much more accurate, giving system operators a better opportunity to anticipate and plan for shifts in variable production. Improved operating practices have shortened dispatch intervals from hourly to as frequently as every five minutes, enabling a more accurate dispatch of system resources to match forecasts of production that become exponentially more accurate as real time approaches. The contribution of variable resources to resource adequacy can be significantly increased by taking full advantage of both sides of the customer's meter – that is, of the flexibility of both supply and demand. Unfortunately, traditional approaches to resource adequacy have failed to capture the vast majority of these valuable options.

While load is becoming more flexible, in most regions of the United States it is also growing slowly. That will change as demand rises with the electrification of transportation and space heating. These new demands are changing the shape of load, as load shapes are also being altered by increasing investment in behind-the-meter resources such as rooftop solar. Batteries are already providing cost-effective frequency regulation in the area covered by PJM under market rules that allow them to compete on an equal footing with traditional generators.[3] These shifting and less predictable *net load* characteristics are giving rise to a need for an expanding suite of flexibility services that will continue to evolve as the transition progresses. The traditional thinking behind resource adequacy, which leans heavily on large, central station generating capacity, should give way to a broader approach, one that relies on resource *capabilities* available from many different sources. Non-traditional resources can often be more valuable than traditional generation by being faster, more accurate (i.e., more precise in scale and timing), more localised and more resilient. A resource adequacy process should give them fair market access and fair compensation, reflecting the value they provide to the grid and all its customers.

[3] The PJM Interconnection is the regional transmission organisation (RTO) that manages the wholesale operations of the electric grid in 13 mid-Atlantic and midwestern states and the District of Columbia. The RTOs in California, New York and New England call themselves 'independent system operators' or ISOs. Like PJM, they were created before the term RTO was adopted. However, they are all designated RTOs by FERC, and so we apply the term to them here as well.

# Who should bear the resource adequacy obligation?

This is a question whose answer will vary from country to country, depending on history and institutional framework. A brief look at the U.S. experience, though, will illuminate particular challenges that can arise from ambiguities about jurisdictional boundaries and which emerge in debates among decision-makers, industry actors, and other stakeholders about how to allocate and minimise the risks of system failures.

Regional grids such as the regional transmission organisations (RTOs) in the United States extract maximum efficiency from the wholesale power system by operating it (1) with regard only to physical constraints, rather than to artificial boundaries drawn around local utility service areas, and (2) by dispatching their resources (both supply and demand) according to economic principles ('merit order').[4] The development during the last decade of the Western Energy Imbalance Market (WEIM) is the latest demonstration of the benefits of the geographical expansion of system operations. The WEIM is a voluntary real-time energy market facilitating trading among some 22 balancing authorities (the California ISO, individual utilities, and smaller regional operating systems) in the western United States. As the WEIM has grown from November 2014 to January 2023, it has yielded gross benefits (savings in the form of reduced operational costs for its members) of US$3.4 billion, over US$1.2 billion of that in 2022 alone.[5]

Individual utilities (or 'load-serving entities', LSEs) in the United States are obligated, under the laws of the states in which they operate, to provide what is typically described as 'safe, adequate, and reliable' service to end-users. They are responsible for their own resource adequacy. However, with the development of regional operating systems – first power pools that dispatched the shared resources of their members so as to minimise total operating costs, share the savings and reduce the costs of reserves; and then RTOs with competitive wholesale markets – the *de facto* responsibility for resource adequacy passed to the regional system operators.

But RTOs are not larger versions of the vertically integrated utilities whose operational responsibilities they supplanted. They are not subject to state law that regulates retail service. As originally chartered, RTOs were responsible only for short-term (that is, operational) reliability. Since operation of the synchronous electric grid is not limited by state boundaries (except in Hawai'i, Alaska, and most of Texas), RTOs are overseen by the Federal Energy Regulatory Commission (FERC) as a regulator of interstate commerce. Responsibility for identifying and securing adequate long-term supply commitments remained with those with a need to manage the risks inherent in serving retail consumers, and who could – and under any market model would – provide the business case for the necessary investments. Indeed, the Federal Power Act affirmed this obligation of the load-serving entities: it was up to them, licensed and regulated by the states, to assess their needs, evaluate the market risks inherent in meeting those needs, and ensure they had access – via self-supply, bilateral contracting, or (more

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[4] This is security-constrained economic dispatch (SCED) of precisely the kind that Indian policymakers are developing today. Whether dispatch is based on administratively-determined operating costs or prices formed in competitive markets, it will nevertheless be bound by the physical properties of the system.

[5] Western Energy Imbalance Market, https://www.westerneim.com/Pages/About/QuarterlyBenefits.aspx, as shown on 2 May 2023.

recently) exchange-based transactions – to resources adequate to manage those risks cost-effectively. The entities' ability to recover the associated costs was to be subject either to traditional regulation or, alternatively, to the demands of active retail competition.

RTO capacity mechanisms were developed as backstop mechanisms relatively early in the transition to competitive wholesale markets, mainly to compensate for flaws in the energy markets – i.e., low price caps that did not reflect the true value of lost load; market rules that dulled LSEs' incentives to enter into medium- and long-term contracts to maintain adequacy; the absence of demand-side bidding (for both purchases and load reductions) or dynamic retail pricing; and poorly designed protections against market power abuses.

But the backstop capacity mechanisms intended to address these problems in the early years of competitive markets soon evolved into the primary means by which resource adequacy was secured, displacing LSEs. Unfortunately, RTOs have all the same incentives to rely on the most familiar resources (primarily dispatchable fossil-fired supply) and to acquire more than is needed, given the true value of lost load. Moreover, the region-wide auctions for 'adequate' capacity (characterised as only that which is needed to meet system peaks) have failed to account for local (i.e., state) preferences for particular resource mixes, such as those consisting of high penetrations of non-emitting, variable resources. Without some means of revealing the value of such resources (e.g., a carbon price or emissions constraint), the capacity mechanisms have had the effect of favouring resources with the lowest capital costs (and highest operating and environmental costs) – not the ones with the lowest total costs, which are needed to meet both a region's energy needs *and* its public policy goals.

The U.S. RTOs are struggling with this challenge. Some of the proposed reforms of recent years would have exacerbated the problem by excluding state resource mandates (e.g., renewables and other clean energy obligations) from serving resource adequacy needs, thus in effect doubling their cost by requiring consumers to pay for both the renewables and the added resources needed for resource adequacy. A well-designed resource adequacy construct should preserve states' authority over their long-term resource portfolios, as constrained by the Federal Power Act.[6] Where competitive (energy-only or energy-and-capacity) markets are used, they should be structured to incorporate those resource choices to the extent that they meet the resource adequacy eligibility requirements. Lastly and most importantly, the definition of resource adequacy itself should be reappraised and given a broader ambit. A wider range of capabilities will be needed in power systems marked by high penetrations of variable resources and low carbon emissions requirements. The old construct, and the market mechanisms used to serve it, only provide a costly entitlement for existing generation, much of it unneeded, while falling short in providing efficient incentives for new resource investment.

[6] In Europe, Member States approach the question of the resource adequacy value of renewables differently. Where capacity mechanisms (CMs) have been adopted, renewables are still supported in most Member States by various policy instruments, and the CMs both exclude such resources from participating *and* deduct their resource adequacy capacity value from the demand for capacity procured through the CM. While this is an improvement on the proposed reforms under consideration in the US, it is not a long-term solution.

# Procuring resources at least cost

Is this U.S. experience relevant to India and other nations and, if so, what conclusions might they draw from it? At first glance, the answer to the first part of the question appears to be 'no', or perhaps a very attenuated 'yes' given the distance between market development in the United States and India. But on closer examination several observations can be made that might help policymakers as they settle on resource adequacy rules in India, especially in light of the nation's stated desire to expand its competitive wholesale markets for power.

It goes without saying that a central objective is to ensure that adequate resource investment is most economically procured. To do so, those who are responsible for resource adequacy – in India, the discoms – should have access to a sufficient range of tools to hedge market risks, including a variety of financial instruments and contracts of varying lengths.[7] Their ability to build a least-cost portfolio of resources, including self-supply, in a competitive environment depends in significant measure on two things: (1) that energy is correctly priced so as to give all parties (discoms, retailers/aggregators, large wholesale buyers, and wholesale producers) incentives to enter into long-term contracts when and where needed to manage their business risks and deliver reliable customer service and value; and (2) that retail providers, whether monopoly or competitive, have the financial wherewithal to enter into contracts to manage the risks involved in serving their customers and to mitigate the risk of default.

## Good energy price formation

Good energy market price formation is the foundation for well-functioning markets, including markets that have adopted some form of capacity mechanism. Efficient long-term contracting relies on transparent and robust short-term market prices as the reference, and it is the expected response by market stakeholders to the need to manage the associated risks. Good energy market price formation is characterised by four conditions:[8]

- Prices are allowed to vary as needed, from a cap as close as practicable to the system-wide value of lost load to as low as necessary to clear the market.
- The marginal cost curve extends to all actions required to balance the system, including actions taken by the system operator outside of economic dispatch.
- The demand curve includes all demand on system resources, including demand for ancillary services that compete directly with demand to produce more energy.
- Prices reflect not only marginal production costs such as fuel but also, when applicable, non-production costs including the opportunity cost of reserve shortfalls.

The first of these conditions – a high price cap – creates risks of market power abuse and must be accompanied with a means of mitigating that market power. A number of organised markets, with and without forward capacity mechanisms, have developed

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[7] Contracts can reduce the cost of capital for individual investments, but this lower cost is the result of a transfer of long-term risk from investors to, ultimately, consumers. Not all such reductions are a good deal for consumers.

[8] Good best-practice examples and resources on this topic include Pope, S.L. (2014). *Price formation in ISOs and RTOs: Principles and improvements*. FTI Consulting. http://lmpmarketdesign.com/papers/Pope.EPSA_Price_Formation_Oct_29_2014_FINAL.pdf

*ex ante* and *ex post* tools that have proven increasingly effective in practice. The last measure listed – ensuring true marginal cost prices – may rely on administratively-set scarcity pricing mechanisms that have been developed in a number of markets (e.g., the Electric Reliability Council of Texas) and that also provide an additional defence against market power.

## Financial strength of entities with the resource adequacy obligation

While every country or region will have its own approach to this issue, it is essential that any entity granted a licence to serve retail consumers should also be charged with the responsibility of maintaining sufficient financial capacity to prudently manage the associated risks. This is one aspect of traditional utility regulation that remains crucially important to well-functioning competitive retail markets. While this in itself is in the public interest, it is also essential as a matter of resource adequacy that a population of financially sound counterparties for long-term contracts with load-serving entities be maintained. This will become especially important if competitive provision of retail services is permitted. Financial security mitigates risk both for LSEs and for retail customers (e.g., it enables retailers to continue serving consumers in the event of volatile market conditions). The specific standards adopted will need to strike a reasonable balance between sufficiently robust financial capacity and the need to facilitate market entry and workable competition.[9]

# Rethink resource adequacy metrics and benchmarks

A resource adequacy framework cannot best serve the public interest if it consistently obligates consumers to pay for more resources – particularly generation resources – than are needed to deliver a cost-effective level of reliability. Cost and value must be balanced. The question of what metrics and benchmarks to use to assess resource adequacy is a large and complex one. Metrics like 'hours per year' loss of load expectation (LOLE) or benchmarks like 'reference planning reserve margins' or '1-in-10' rules of thumb have come under growing criticism in the United States in recent years as more attention has been focused on oversupply in regions with capacity markets, coupled with incidents of supply shortfall in regions nominally oversupplied with 'firm' capacity. The fact that these traditional metrics and benchmarks result in the acquisition of significant quantities of large, grid-connected generating capacity years in advance, with little or no regard to what capabilities various forms of capacity do or do not offer, is becoming increasingly problematic.

The problem is further complicated by growing reliance on variable wind and solar resources, which challenges our more traditional notions of resource adequacy. The good news is that it's becoming clear that there's a broader and much richer variety of resources (among them demand flexibility, storage, seasonal peak shaving, and expanding the geographic scope balancing areas) that can serve the needs of

[9] Before competitive provision of retail services is permitted, policymakers will want to consider carefully how it might affect the maintenance of resource adequacy – for instance, how wholesale buyers will weigh the market risks of not contracting forward to meet their obligations against the risks of contracting for customers who then defect to the competition. This is further complicated by the introduction of 'suppliers of last resort' (or 'default providers') who serve consumers that, for whatever reason, are not served by competitive providers. This is not the circumstance in which India currently finds itself – it simply illustrates that establishing resource adequacy requirements and ensuring that they are met as efficiently as possible is an ever-evolving exercise.

tomorrow's grid at lower total system and environmental cost.[10] Some design objectives for a resource adequacy framework that enables them to participate might include the following:

- It should have risk-adjusted guidelines that reflect consumers' value of lost load (VoLL) for incremental generation investment.
- It should internalise the contribution that can be made by non-traditional and non-supply-side options.
- It should take account of changing and potentially price-responsive load curves.
- It should serve the interests of consumers first and foremost.

# Empower consumers through a role for the demand side in price formation

Giving non-wires alternatives a fair opportunity to provide energy services and meet resource adequacy needs means that consumers will play a central role in determining what resource investments provide the most value for their money. Retail product and service offerings are beyond the scope of this brief, but translating wholesale market information to end-use consumers in convenient and equitable ways, and enabling and incentivising them to act on that information, will offer increasing benefits to all consumers, not just those who choose to get involved. Not only can all consumers benefit when some consumers reduce demand during periods of tight supply (a traditional if historically limited role), but they can create even greater value for all stakeholders as the share of variable resources grows. By shifting loads from tight periods to periods when intermittent resources might otherwise be curtailed, they can dramatically reduce the amount of investment needed to achieve given levels of both reliability and clean energy market share. Once considered impractical, technology advances in recent years have made this load shifting easy, convenient and inexpensive. This will be especially true for new large flexible loads like electric vehicles and thermal storage. Price formation (together with network tariff design) can enable low-cost and advanced demand-side flexibilities like these to be accurately priced so customers have the option of being compensated for the value of changing when and how they consume electricity.[11]

# Conclusion

In the autumn of 2022, the Central Electricity Authority issued *Draft Guidelines for Resource Adequacy Planning*.[12] These are the outcome of a collaborative process that has been going on for several years and has involved key stakeholders and institutions in the Indian power sector. Putting in place sensible, enforceable resource adequacy requirements is, as the CEA notes, a necessary element of a power system in which "demand is reliably met in future, in all time horizons."[13]

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[10] In the United States, many of these resources are referred to as 'non-wires alternatives,' or NWAs.

[11] The demand for flexibility is going to grow and evolve, with more and different kinds of services (e.g., inertia replacement service) needed to maintain reliability. This will call for, among other things, an ongoing process of examining and, when appropriate, expanding or redefining the menu of ancillary services.

[12] CEA. (2022). *Draft Guidelines for Resource Adequacy Planning*. https://cea.nic.in/wp-content/uploads/irp/2022/09/Draft_RA_Guidelines__23_09_2022_final.pdf

[13] CEA, 2022.

The guidelines state that resource adequacy "is generally defined as a mechanism to ensure that there is an adequate supply of generation or demand responsive resources to serve expected peak demand reliably"[14] but then go on to observe that "an increasingly higher share of variable renewable energy sources being integrated into the grid ... demands a fresh look at the manner in which distribution licensees contract for power."[15] This is an important insight. While resource adequacy has never been only a matter of the quantity of resources, now more than ever the answer to the question 'How much?' depends on the answer to the question 'What type?' Resource adequacy is not merely a question of meeting annual system peak loads, but also of ensuring reliability, as the guidelines say, "at all points in time."[16]

India's vision is sensible. The distribution licensees – the discoms – are responsible for managing the long-term risks incumbent in meeting their obligations to their customers for economic and reliable electricity supply. Regulation governs the prudence and efficiency with which they carry out that responsibility. The system operators ensure system security, and as variable supply grows can rely on a wider range of capabilities – among them, flexible demand and interregional trading – to keep the system balanced.

Ensuring resource adequacy involves virtually all elements of power sector investment and operations, from planning to market design to finance to retail pricing and everything in between. Some useful insights can be drawn from international experience. In this brief, we've offered several that we think might have particular applicability in India.

[14] CEA, 2022.

[15] CEA, 2022.

[16] CEA, 2022.

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