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WHY THE CLEAN ENERGY INDUSTRY SHOULD BE INTERESTED IN RESOURCE ADEQUACY

BY ERIC GIMON ● JULY 2020

Climate mitigation depends on building a much larger and cleaner electricity grid, without sacrificing reliability – in fact electric reliability is probably more important in a low carbon economy. Clean power displaces emissions from fossil fuel generation, and a larger power system enables clean electricity to substitute for dirtier fuels in buildings, industry, and transportation.

The power sector's clean transformation will have to accelerate capacity additions from 1 percent of system mix per year to 3 percent per year to reach even the most modest climate goal of 80% clean energy by 2050, but planning concerns about resource adequacy -- making sure that grid operators always have the resources at hand to balance supply and demand -- could slow this transformation in two ways if not addressed in a constructive manner.

First, the most economical and realistic prospects for generation in a clean power sector depend on significant variable renewable energy generation deployment – namely wind and solar. These upend the historical power sector paradigm once they reach larger fractions of the overall energy mix. This is a real challenge because we will have to operate the grid in an unprecedented manner, but in many ways the challenge is likely more solvable than many experts believe: Clean technology keeps improving and dropping in cost while engineering, and business practices are adapting to economically and reliably integrate high levels of renewable energy. Meanwhile, we have only started to scratch at the potential for connections to other sectors like heat and transportation along with dynamic demand.

Second, incumbent fossil generators are aggressively protecting their investments. Having failed to make the argument that clean power is too expensive – outflanked by the rapid cost declines in clean technology, which are now cheaper than fossil fuels in many parts of the world – they are now falling back on resource adequacy as a last bastion to defend their market share and slow the power grid's decarbonization.

This brief looks at one piece of the clean energy transformation puzzle: resource adequacy as a planning problem and how the clean power transformation challenges the current grid planning paradigm for managing it, how incumbent interests are taking advantage of real – or perceived –

challenges to electric grid reliability and resiliency, and why changing policy-makers' perception of and instincts for resource adequacy must be a top priority for climate mitigation.

THE RESOURCE ADEQUACY PARADIGM FOR OUR POWER SECTOR YESTERDAY, TODAY, AND TOMORROW

Grid operators, including vertically integrated utilities and those in organized wholesale markets, match electricity supply with demand (plus reserves) on a moment-by-moment basis by managing the generation resources they can dispatch. But they can only call on resources that are available to them when it comes to their real time needs and grid resources like generators, transmission, and batteries take many years to build and commission. So, some long-term planning must happen for grid operators to feel confident they will have adequate resources at hand; this is usually referred to as resource adequacy planning.

In vertically integrated utilities, this planning is managed through a regulatory process, while in organized markets -- where more risk is assumed by resource owners -- it also functions through price anticipation and forward markets. Combined approaches, like California's involving state mandated standards also exist.

In all cases, planning has rested on two ideas: One, that conceptually all these plants can be called on "at will" meaning they are dispatchable within some operating range, provided they are turned on in advance to provide electricity to the grid. And two, that real-time fuel costs dominate calculations of which resources are most cost effective to run at any given time and which new resources to plan for.

The functional separation into traditional categories with names like baseload, mid-merit, and peaker is not a technical requirement of serving load but purely a result of how the economics of dispatchable fossil plants balance out. In this historically adequate paradigm, demand is an independent input into the moment-by-moment challenge of running the grid securely and economically, but demand flexibility is seldom used as a tool for system balancing other than in emergency situations.

The significant addition of fuel-free solar and wind resources and distributed energy resources to today's generation mix presents new challenges to the historical resource adequacy planning paradigm. Grid operators have adjusted to current realities by allowing adjustments to demand forecasts from distributed energy resources (DERs), and furthermore by replacing demand as the variable to be met with "net demand," demand (including DER adjustments) minus the production of utility-scale variable renewables.

This reasonable adjustment has worked better than expected at today's clean energy penetration levels, but it also presents new challenges, creating economic dislocation for incumbent resources and potentially putting resource adequacy under stress – especially when viewed in the traditional way.

The first resource adequacy challenge stems from renewables' increasing ability to offer lower energy prices than the marginal cost of "baseload" resources like coal and nuclear. As a result, they steadily push these resources, already being squeezed by cheap new gas generation, out of the system along with whatever traditional resource adequacy value they were providing. From the climate point of view, displacing coal is a good thing, but it is important to understand that these are not interchangeable resources. Baseload resources were historically a mostly reliable presence during periods of peak system stress, while variable renewable resources varied based on local weather factors. Variable renewable resources provide plentiful low-cost energy (and many other reliability services) but require a system-wide perspective to address variability, such as coordinated use of resources across the transmission system that may include mid-merit and peaker generators, demand flexibility, batteries, and other sources to economically maintain a reliable grid.

This challenges conventional assumptions because many "baseload" resources were designed with the anticipation they would run most of the time, but they may have limited flexibility to move their output into higher value periods. Conversely, they mostly compete on megawatt-hour (MWh) economics, so they are most vulnerable to new clean entrants into the market.

Distributed resources, including distributed solar photovoltaics (PV) and various forms of energy efficiency, exacerbate the situation by reducing demand relative to load forecasts. This throws off the system planner load forecasts used to justify excess capacity and forces a zero-sum game transition in a rapid but disorderly and stuttering fashion. During periods of load growth, transitioning generation technology is easier as new technology mostly serves new load growth and any system overcapacity is quickly used up. But today DERs drive flat load growth – again, a good thing for emissions but a challenge to incumbent resources that must compete economically with renewables and natural gas. As a result, some of these traditional generators shut down, often because they cannot economically operate under these new conditions.

The second emerging resource adequacy challenge stems from the inflexibility of many fossil fuel resources – the need to commit well ahead of the real-time window, minimum run rates and limited ramp rates -- matched against the increased penetration of cheap variable resources. Because variable resources are often the most economic source of real time energy, maximizing their use for economic reasons can drive more variation in net load even down to sub-hourly scales. If conventional resources meet net load, they may be called upon to ramp their output more often and more quickly or become available with less advance notice.

The poster child today is California's infamous "duck curve" from solar reducing net demand in the middle of the day, but solar output dropping in the early evenings right when demand peaks. Non-baseload traditional resources like combined-cycle gas plants, called upon to ramp quickly from a low minimum in the afternoon to maximum output in a couple hours will see more wear-and-tear as result. Baseload coal can also ramp, but is less flexible than required, and more vulnerable to wear-and-tear. New storage resources and "hybrid resources" coupling storage with other resources will increasingly be used, but the near-term impacts on traditional resources is significant in any case.

Meanwhile, existing California resource adequacy rules create a situation where traditional resources are paid to address the ramp, but sometimes aren't there to meet ramp needs because they were never turned on – they were deemed too expensive to commit in the day ahead dispatch when ramp needs looked lower and then their long lead times for turning on make it too late to use them when conditions change closer to real-time. In such cases, neighboring systems provide additional supply, or more expensive resources or reserves are used. Inflexible system stalwarts need to make way for new sources of flexibility, like more fast-ramping low-minimum run rate generators, storage, managed curtailment, or demand side flexibility.

The danger of traditional planning mindsets is that planners may over-prioritize flexibility from new generation in integrated resource planning processes or through resource adequacy payments without looking holistically at a least-cost solution using a broader portfolio of resources.

It seems inevitable (and desirable from the climate perspective) that continued cost declines will drive variable renewable resources and DERs to dominate future capacity additions to the grid. That means grid planners will have to shift the resource adequacy framework from ensuring that baseload is complemented with enough flexible resources to maintain reliability**, toward metrics that ensure reliability with variable renewable resources as the foundation.** Tomorrow's resource stack could increasingly exhibit **three features**:

- Abundance of essentially free energy during many hours of the year
- Predictable fluctuations of larger magnitude requiring greater flexibility
- Episodic shortages when solar and wind resources are low (magnified in smaller balancing areas with less effective connection through transmission)

The presence of the first feature means the second and third features can be met with injections of abundant free energy if it can be stored, or they can be dealt with using more opportunistic demand. Whether affordable energy storage will become available through continued cost declines, and how much dynamic load response comes to the table, will determine the resource mix necessary to preserve reliability. With such significant change underway, it's easy to understand why grid planners are scratching their heads as to the future of resource adequacy paradigms.

MEASURING RESOURCE ADEQUACY

An informal but determinative planning metric that has emerged over the years for resource adequacy is to plan and procure resources to meet a "one-in-ten" threshold. It is not always clear what this means, one hour or one "event" of projected possible unserved load every ten years are two common interpretations, but it should be obvious that this is a hard metric to measure. It could take twenty or thirty years under constant conditions to understand how close a given grid configuration is to meeting this criterion. Because multiple failures within a decade could indicate resource adequacy is too low, planners effectively aim to overshoot the threshold. Since waiting around several decades to see if the grid meets the one-in-ten standard is impractical at best, grid planners and regulators use other means to evaluate if this standard is being met.

Two such means are modeling (running multiple simulations to see how likely shortages are) and heuristics (alternative measurements that tend to track the desired outcome and simplify modeling). Historically, planners have mostly used a heuristic called the planning reserve margin (PRM) to decide if a current or prospective generation fleet will be adequate to meet the one-in-ten standard. The PRM entails looking at total available capacity likely to be available to meet anticipated peak demand, with the PRM the anticipated percentage extra capacity over load. This heuristic mostly uses historical data about generator performance and load behavior as a function of weather, along with some prospective estimates of future load growth and capacity additions, to arrive at a fixed number.

Planners typically target at least a 15 percent PRM in order to meet the one-in-ten resource adequacy standard. However, actual major grid failures in the United States have tended to involve cascading failures of the transmission infrastructure more than any shortage in generation (see Rhodium Group[1]) and in any case, local distribution outages generate more service interruptions for customers than grid-wide events.

Still, to the extent the PRM heuristic has worked well in the past, it had the advantage of being not just a mostly objective metric, but also a catch-all metric. That is, a given generation mix meeting the PRM meant likely having enough capacity on hand to meet any number of other potential grid challenges, like a large generator outage, apart from just having “enough” to meet peak demand. This probably included some over-procurement (i.e., customers paid too much) and some resources getting paid more than their relative contribution to overall reliability, but overall this heuristic worked well enough and any excess capacity was likely to be needed in a future of growing peak demand.

RESOURCE ADEQUACY INADEQUACIES WHEN PLANNING FOR PEAK

The emergence of new variable renewable low-cost resources and of DERs not only challenges the economics of resources we depend on for reliability, but it also reveals the PRM heuristic as increasingly inadequate for measuring resource adequacy. It starts with the question of just how much any single power plant contributes to PRM accounting – all resources fail or are sometimes not fully available to serve when most needed because of weather, fuel shortages, transmission failure, or planned and un-planned outages. Because of this, planners discount resources and

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[1] https://rhg.com/research/the-real-electricity-reliability-crisis-doe-nopr/

assign each a capacity value – a percentage of peak megawatts (MWs) based on historical patterns – in the PRM count.

This reduces the whole probabilistic distribution of possible production outcomes for a resource class into a single number and tends to blind planners to challenges for traditional resources operating in a new world with much more variability in demand and supply. First, because it ignores some amount of agency (many clunky old peakers in ERCOT performed much better during peak relative to historical year-round patterns because they had strong incentives to tune maintenance to generate during highest price intervals). Second, it is harder to plan outages and hedge against unplanned outages, against a more uncertain net-demand forecast. Capacity value is especially reductive for solar and wind which have broader distributions of outcomes.

Even if the true capacity value contributions for wind, solar, and conventional resources are properly measured, large excursions either below or above expectations can add significant changes in the net demand peak from day to day on top of weather variability. In addition, increased DER contributions and embedded duration-limited flexibility from hybrid storage projects can markedly change the shape of the peak. It's also hard to factor useful correlations between various resources for a diverse fleet's improved performance if you want to just sum capacity values.

Renewables and DERs undermine the value of the PRM heuristic because they further expose the over-simplification of squeezing a whole distribution of possible outcomes into a single number. For significant penetrations of these resources the PRM is no longer a good catchall metric: With the wrong mix of resources you can have more than enough on hand for anticipated peaks and still face reliability challenges at other times. This has always been an issue with scheduled outages of conventional units and transmission lines, but it will evolve in new directions with the changing resource mix.

Planning for peak demand is becoming increasingly inadequate for ensuring resource adequacy at other times in several ways:

- **Shortages can happen any time –** Many fossil generators take their units offline for maintenance in the spring and fall shoulder seasons. But a combination of big demand draws and a drop in resource (like wind in a cold snap) can create off-peak scarcity, i.e. a sudden surge in net demand right when these generators are offline. In Texas, market monitor reports show that as much as 40 percent of the fleet that helps meet summer peaks may be unavailable during these times, potentially leaving the system short off-peak.
- **Harder to count on fossil resources being there –** The evening drop-off in solar or a big change in wind resource might require dispatchable generators to quickly ramp their output before or after the net demand peak. Wear-and-tear from frequent changes in output, or from having to run at full tilt for a long period in a way that was unanticipated in plant design, can increase unplanned outages for some older fossil units during peak (i.e., the capacity value of these resource may decrease).

- **Nobody’s perfect: physical limits of dispatchable generators –** To be available to ramp, generators generally must already be on, requiring some level of minimum generation, sort of like an idling car running at 1,000 RPM. The most flexible dispatchable generators might not be available because insufficient forecast demand exists for them to run at their minimum set-point prior to peak, especially if baseload resources are already meeting much of that demand.
- **Flexibility needs disconnect from peak needs** – All kinds of resources can complement low-cost energy resources to help meet peak, but they may have very different production profiles. Gas peakers can sustain long periods of output but require advanced notice to start up; not only have minimum set points but cannot absorb energy; are potentially subject to high fuel costs when conditions are tight; and may only be available seasonally. By contrast, battery storage systems have limited duration at peak output (requiring a portfolio of resources with different duration abilities for meeting peak demand) but can nimbly come on and offline in quick bursts and go from absorbing to producing power in no time. Procuring enough traditional peak resources doesn’t guarantee the presence of the most useful forms of flexibility at other times, especially with a new mix of low-cost clean energy resources.
- **Capacity metrics do a bad job of capturing benefits of sharing with neighbors** – More variability from place to place means that imports and exports across neighboring balancing areas is becoming more valuable for reliability. But this capability is often not sufficiently credited in planning metrics. For example, plants are paid to provide flexible capacity but stand idle in times of need because their use was not anticipated in the day-ahead timeframe, and so they were not committed and aren’t available. The balancing area manages instead by sharing more resources with its neighbors.
- **Demand-side resources** – Planning for peak has pushed engagement with demand-side resources into capacity auctions, but leave significant value on the table. Time-of-use rate design can be very helpful in shaping load to better match average production profiles, but an optimal future mix will also need to include more dynamic load response regulated by price or direct controls that doesn’t easily fit into the plan-for-peak paradigm.

These factors are just some of the ways a heuristic like PRM is starting to fail as a catchall and as a proxy for resource adequacy. Yet these impacts have yet to be reflected in what and how resources are valued from a resource adequacy point of view, in whatever form it takes (the relevant venues and markets are utility resource plans, state mandated resource adequacy schemes, or forward capacity markets). The impulse has been to double down on PRM by over-procuring peak capacity instead of looking at more diverse and granular signals for system planning.

Meanwhile, today’s resource adequacy planning is in turmoil, so what should replace the PRM? System modeling with today’s meaningfully more powerful computers is an obvious answer, but depends for accuracy on key assumptions that are often invisible or hard to assess. Multiple utility resource plan models have recently been challenged for egregiously ignoring cleaner, cheaper, better options than yet another gas peaker.

THE FOSSIL INDUSTRY PLAYBOOK

Incumbent owners and suppliers of fossil fuel generators are taking advantage of the confusion in resource adequacy planning to sustain their grip on the market as best they can and delay progress towards a cleaner, cheaper, and more efficient grid that no longer needs them. Their strategy appears to be (at least) three-fold: foster fear and uncertainty, re-write rules to their advantage, and keep competitors out. Some of these are likely explicit strategies developed behind closed doors in boardrooms, but many capitalize on resistance to change in the conservative culture of electricity, biases in the field, just as much in so-called neutral arbiters as in those entities that benefit from delaying change.

One could paint the following narrative: Renewables and DERs arrive and now we can't depend on the grid, things will only get worse. This ignores the health, climate, and economic advantages of a clean power sector transition, but plays well to those who fear change. To quote Machiavelli: *"There is nothing harder than to try and make a new idea become popular, as you will have strong opponents in those that are benefiting from the old idea, but only weak allies in those that might benefit from the new idea in the future."* If you can exaggerate and portray a technical issue as an "insurmountable barrier" and point to immediate job losses or reliability considerations, regulators and legislators often sit up and pay attention to your favorite "solution."

Meanwhile fossil incumbents can use the rules to protect themselves. For example, they push for "reform" to capacity markets that "protect the market" from state policy "distortion." They also define needs for "fuel assurance" when most blackouts result not from insufficient fuel but from generator breakdowns and transmission failures, or ask for payments to support the grid with very little accountability. Each case contains the nub of a real system issue to be dealt with, but incumbents use their position on decision-making bodies or at public utility commissions to push for resolution through rules that will advantage them.

Keeping competitors out can take various active and passive forms. Some utilities make life very difficult for third-party demand response providers that might compete with utility resources. Others might intervene in a commission proceeding to prevent DERs from counting towards local reserve capacity in dense urban pockets served via transmission lines from distant generation. PJM, the largest independent system operator, is dominated by fossil-affiliated generation and transmission owners. It's rules for qualifying as capacity require energy storage to be able to sustain maximum output for up to ten hours. But almost any objective analysis of energy storage in a large grid shows that it can deliver significant resource adequacy value with much shorter durations.

Climate advocates must realize that almost no amount of further cost declines in wind, solar, and other clean technologies will guarantee a fast or smooth transition to a clean power sector. Periods of time will always exist when dispatchable fossil resources will have a key economic advantage because of their capacity value unless significant carbon pricing or policy mandates drive new clean solutions, such as sufficient deployment of storage and other sources of capacity and flexibility. And that is on a neutral playing field that ignores health and climate externalities; incumbents have any number of ways to further skew the field to their advantage or for extra rents.

Advocates can push back by leveraging work from organizations like Rocky Mountain Institute and GridLab[2] demonstrating how clean portfolios can compete with fossil resources in established planning processes. National labs and technical groups like the Energy Systems Integration Group and Electric Power Research Institute can shed light into the nature of reliability challenges, new technological approaches to solving these (like hybrid renewable-storage systems,) and provide improved models and market concepts for energy transition. Ultimately, thoughtful thinkers about clean power sector transformation anticipate a major paradigm shift in how we manage and plan out the grid. Advocates who want to influence that shift must become more aware of what the reliability challenges and opportunities are, educate themselves on real (and fake) solutions, and coordinate to promote productive policy steps.

CONCLUSION

The transition to a clean power sector creates or enhances challenges to resource adequacy if not properly managed. Conversely, meeting resource adequacy expectations could be portrayed as a major obstacle to the clean energy transition. So far, the dynamic has centered around low-cost renewables along with cheap gas displacing baseload conventional resources in an environment of flat or declining loads. Undermining such baseload resources has had relatively low ill effects because their peak capacity value has been replaced or proven unnecessary, and they didn't provide much flexibility in the first place. However, opportunities for interference from fossil fuel-aligned incumbents will be rife. They will be actively pushing misleading or sub-optimal resource adequacy solutions while slowing down energy transition by disputing possible ways forward. As the nature of resource adequacy continue to evolve, the status quo planning for peak is unlikely to be enough to meet them. Advocates need to reverse the fossil incumbents' playbook: Shed light on the inadequacies of current schemes and the inevitability and necessity of change while actively promoting better solutions to resource adequacy.

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[2] e.g. RMI's "*The Economics of Clean Energy Portfolios*" (https://rmi.org/insight/the-economics-of-clean-energy-portfolios/) or GridLab's work on Integrated Resource Plans like Duke's recent IRP (https://gridlab.org/duke-irp/).