ENSURING NOT ONLY CLEAN ENERGY, BUT RELIABILITY

The Intersection of Resource Adequacy and Public Policy

COP26 Policy Brief by the Redefining Resource Adequacy Task Force

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ESIG
ENERGY SYSTEMS INTEGRATION GROUP

COP26 POLICY BRIEF

This brief was prepared by the Energy Systems Integration Group's Resource Adequacy Task Force, with substantial input from subject matter experts from several of the Global Power System Transformation Consortium's founding system operators. Resource adequacy is a topic of great importance at this moment in time, and represents a potential short-term pitfall for ambitious clean energy targets globally. This brief was prepared in anticipation of COP26 to support the policy community by offering guidance on managing resource adequacy as the power system transforms.

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Executive Summary

The transition to more variable and flexible clean resources brings new considerations for maintaining a reliable electricity system, which has traditionally relied upon the predictability and generally high availability of fossil fuel resources. Often, public policy focuses primarily on affordability and sustainability, with the assumption that reliability—specifically resource adequacy—is ensured regardless of policy decisions. However, policymakers have an important, ongoing role in ensuring resource adequacy as fossil fuel resources continue to be displaced by cleaner alternatives, while balancing tradeoffs with cost. Over the next five to 20 years, public policy for decarbonization goals has the potential to shape investment decisions for new resource additions as well as generator retirements, both of which will affect the resource adequacy of the system.

From Annual Energy Targets to a Reliable Resource Mix Across a Range of Weather Conditions

While clean energy policies often involve annual energy targets, such as 50 percent renewable by 2030, the successful implementation of these policies requires a mix of resources that can meet demand across a wide range of uncertain weather conditions throughout the year. In particular, resource adequacy for a high-renewables grid requires resources to be available when they are needed, not just when weather conditions are favorable. Planning a high-renewable and decarbonized grid requires consideration of an operable resource mix that balances fluctuating loads, variable renewable generation, anomalous weather events, and evolving climate trends and other uncertainties.

Tradeoffs Between Reliability and Cost

A grid with close to 100 percent reliability would be prohibitively expensive to build and operate and would require a substantial overbuild of generating capacity that would likely never run. This was true historically, and will be as well in future decarbonized grids. Assessments of how much we are willing to pay for reliability will need to be continually adjusted as the energy transition proceeds. While designing a grid to achieve a certain level of reliability is clearly in the purview of grid operators, determining the desired level of reliability is ultimately a policy decision.

The Roles of Policymakers for Ensuring Resource Adequacy

- Policymakers can establish the resource adequacy criteria, define minimum requirements, and solicit information on costs relative to reliability benefits.
- Policymakers can consider incentives for resources capable of improving resource adequacy.
- Policymakers can enable interregional coordination on reliability planning.

Overlapping Responsibilities

As decarbonization goals and environmental policy increasingly change the grid's resource mix, the responsibilities of grid operators and policymakers will increasingly overlap. Policymakers can take several actions to better integrate reliability planning with decarbonization policy.

Policymakers Can Take the Following Broad Actions:

- Provide increased transparency and justification of reliability criteria
- Provide increased funding for research and coordination
- Incentivize generation and load resources capable of improving resource adequacy

In Addition, Policymakers Can Take the Following Actions to Support Grid Planners:

- Develop training and outreach programs for and between policymakers and grid operators
- Enable or require improved interregional coordination
- Provide funding and develop programs for improved weather and climate data

The stakes are high. Poor resource adequacy can have real consequences for human health and safety and for the economy. If clean energy policies are implemented without regard to grid reliability and its evolving requirements, these policies will ultimately be unsuccessful, making the path toward deep decarbonization much more onerous. Policymakers and grid planners need to possess a clear understanding of the elements of resource adequacy today and into the future, and take steps to ensure that policy goals support not only decarbonization but reliability in a high-renewables grid.

While designing a grid to achieve a certain level of reliability is clearly in the purview of grid operators, determining the desired level of reliability is ultimately a policy decision.

How Do Resource Adequacy Needs Influence Public Policy?

Transitioning to a decarbonized grid requires the rapid expansion of clean energy resources while simultaneously reducing our reliance on fossil fuel generation such as coal and natural gas plants. This transition to more variable and flexible clean resources brings new considerations for maintaining a reliable grid, which has traditionally relied upon the predictability and generally high availability of fossil fuel resources. As the world's grids continue to decarbonize, grid planners, policymakers, and regulators need to balance affordability, sustainability, and reliability. Often, affordability and sustainability are the focus for public policy—with the assumption that reliability is ensured regardless of policy decisions.

However, the annual energy targets typically used in clean energy and renewable policy—such as 50 percent renewable by 2030—do not themselves lead to a reliable grid. Reliability challenges come in many forms, from downed power lines on a local distribution circuit, equipment failure on the transmission and distribution networks, potential cyber-attacks, and insufficient resource adequacy—conditions where there are not enough resources to serve the load. Grid planners and policymakers use resource adequacy analyses to make investment decisions—or provide market signals—for new resources and to determine the size and type of replacement capacity (if any) necessary to retire high-carbon generation. This policy brief discusses new elements of policymakers' continued role in ensuring resource adequacy as levels of renewable energy continue to climb.

Resource Adequacy's Wide Time Horizon

Resource adequacy needs—ensuring enough grid resources to serve the load—span a wide time horizon. They extend from day-ahead planning of the availability of generation and need for electricity imports the next day, to seasonal decisions around maintenance scheduling and putting short-term contracts in place, and, ultimately, long-term planning for new resource additions or generator retirements. Along this continuum the range of uncertainty and potential futures increases exponentially with longer horizons. Fortunately, so do available mitigations and solutions to reliability challenges. For the purposes of this policy brief, the resource adequacy horizon extends five to 20 years into the future, where public policy for decarbonization goals has the potential to shape investment decisions for new resource additions as well as generator retirements. The wide range of both risks and mitigations for policy and grid planning is shown in Figure 1 (p. 6).

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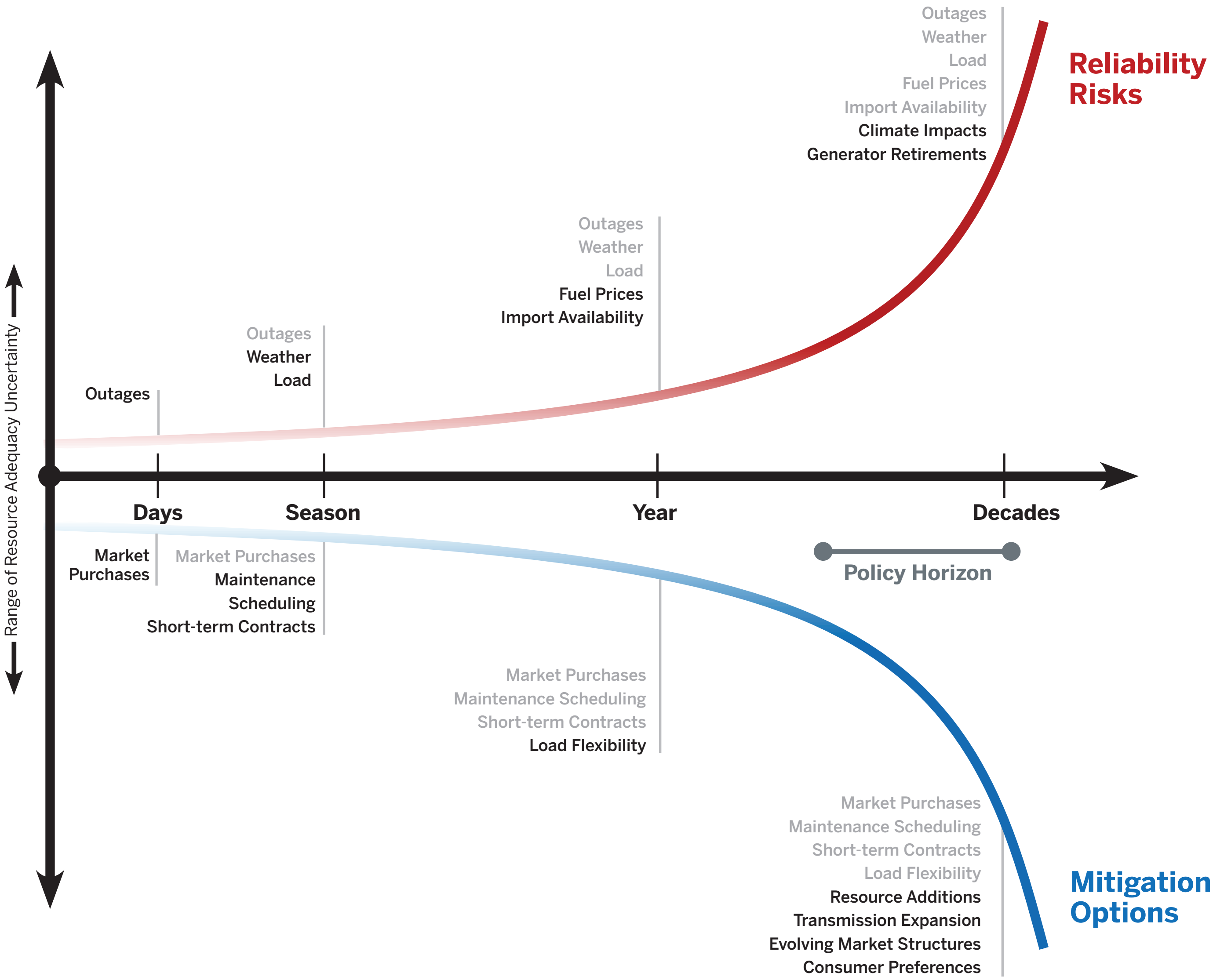
From Annual Targets to a Reliable Resource Mix

Annual energy targets developed by policymakers need to be translated into a resource mix that is reliable across a wide range of uncertain weather conditions that could occur throughout the year. A reliable grid requires a diverse resource mix that balances fluctuating loads, variable renewable generation, anomalous weather events, and evolving climate trends. In particular, resource

FIGURE 1

Resource Adequacy Uncertainty as a Function of Reliability Risks and Mitigation Options



Source: Energy Systems Integration Group.

adequacy for a high-renewables grid requires resources to be available when they are needed, not just when weather conditions are favorable. Today, in most regions, this balancing service is provided by thermal generation, including natural gas–, coal-, and nuclear-fueled generation. In a highly decarbonized grid, the balancing will need to be provided by a different combination of resources which may include variable renewables, short- and long-duration storage, load flexibility, biomass, geothermal, and hydrogen generation.

The need for sufficient amounts of low-carbon, non-variable resources highlights the tight coupling between resource adequacy and decarbonization goals. Grids across the world are in the midst of this resource adequacy transition in which resource adequacy assessment methods—and capacity procurement decisions—need to be adjusted. This has broad implications not just for grid planners conducting the analyses, but also in the way that public policy designs clean energy goals and regulators ensure reliability.

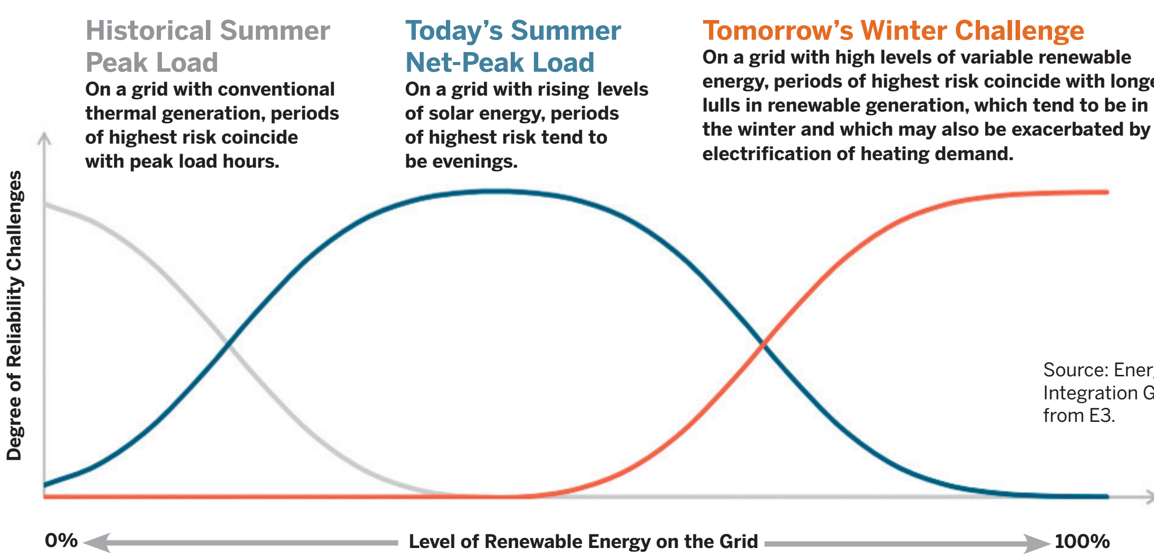
Resource Adequacy Analysis, Then and Now

Historically, most grid planners had to plan only for peak load conditions. Because most generation resources were not significantly constrained by weather variability or the limitations of energy storage, if the bulk power system had enough resources to cover the highest load hour of the year, the assumption was that it also had sufficient resources the rest of the year. Grid planners used a planning reserve margin to determine the amount of capacity above peak load that was required to cover uncertainty in the load forecast and unexpected generator outages. In this context, all capacity was treated as equal; the relevant characteristics of a generator were its installed rating, or the megawatts of power it could provide, and its own inherent reliability.

The addition of wind and solar inherently *improves* resource adequacy by adding more resources to the system; therefore, the resource adequacy challenge is caused not by these renewable additions themselves, but by the simultaneous retirement of fossil fuel–fired capacity and the speed at which enabling technologies and other complementary sources of capacity can be installed. These simultaneous shifts mean that, going forward, the periods of highest risk of shortfall will no longer be limited to the peak load hour. Reliability risk in the typical peak load period may go down, due to solar and wind generation offsetting the system's load, and the highest-risk hours may first shift to the peak net load (load minus renewables), often occurring later in the evening for regions with high amounts of solar energy and/or periods with low wind availability.

Under these circumstances, all capacity cannot be treated as equal. Rather, the value of a resource is a function of when it is (or is not) available and how long its availability can be sustained. Other high-risk intervals may occur during multi-day periods of low wind and solar when there are not enough renewable resources or storage to serve load. These periods often occur during the winter, and risk of a shortfall can be exacerbated by increased electrification of heating demand. While historically, resource adequacy shortfalls lasted only a few hours during the system's peak load, future events may be less frequent, but could be longer, more disruptive, and less predictable if planning does not adapt. This transition from smaller, intraday needs toward multi-day low wind and solar risk is illustrated in Figure 2.

FIGURE 2
Changing Reliability Challenges over Time



Source: Energy Systems Integration Group, adapted from E3.

Balancing the Tradeoffs Between Reliability and Cost

While our modern societies have come to expect—and demand—grid reliability, it is important to remember that while the grid is more than 99.9 percent reliable, it can never be 100 percent reliable. As a grid approaches 100 percent reliability, it gets prohibitively expensive to build and operate and would require a substantial overbuild of generating capacity that would likely never run. Improvements in reliability exhibit a diminishing return on investment, which becomes severe as we approach 100 percent. As a result, society implicitly decides how much grid reliability it is willing to pay for, knowing it must accept a number lower than 100 percent. Regardless of decarbonization trends, assessments of how much we are willing to pay for reliability will need to be continually adjusted as the energy transition proceeds.

Grid reliability is, therefore, both a technical issue and policy issue. While designing a grid to achieve a certain level of reliability is clearly in the purview of grid operators and engineers, determining the desired level of reliability is ultimately a policy decision. Decisions in response to questions like "how much are we willing to pay for reliability?" and "what is an acceptable level of risk?" are not for grid operators, but rather local, regional, and national policymakers.

A common reliability target used in many regions of the world is loss of load expectation often measured in either days per year (common in North America) or hours per year (common in Europe). However, this criterion is poorly justified, poorly documented, and frequently misunderstood. It fails to distinguish between shortfalls of different durations, and it does not specify how much of the load would be affected by such "acceptable" outages, whether a small fraction or the majority of the grid.

But to determine an acceptable level of reliability is challenging. For one, it is difficult to describe and quantify impacts (including both economic and health impacts) and to make decisions around low-probability events that might only occur once every several years, if at all. However, there are metrics available that better characterize the size, frequency, duration, and timing of shortfall events to address reliability risk more rigorously with specific mitigations.[1] In addition, economic metrics can also be incorporated to better address the implicit tradeoff between reliability and costs.

Society implicitly decides how much grid reliability it is willing to pay for, knowing it must accept a number lower than 100 percent.

In order for policymakers to determine the level of reliability the grid must achieve, grid planners will need to provide them with information on the causes and characteristics of the reliability failures stemming from resource adequacy analysis—including the size, frequency, duration, and timing of capacity shortfalls. This will give policymakers a better understanding of the impacts and societal costs of the shortfalls, help them develop programs to respond to potential shortfalls, and indicate how they might incentivize resources and technologies that can specifically meet the reliability needs.

1 Redefining Resource Adequacy Task Force, *Redefining Resource Adequacy for Modern Power Systems* (Reston, VA: Energy Systems Integration Group, 2021), https://www.esig.energy/reports-briefs.

The Roles of Policymakers for Ensuring Resource Adequacy

The need to balance reliability risk and costs raises important considerations about who is ultimately responsible for grid reliability. In much of North America, this responsibility falls under state jurisdiction, regardless of market construct and even in large interconnected systems. In Europe, this responsibility is often held at the national government level, despite interconnected grids and markets. The grid operators are then ultimately responsible for implementing the reliability criteria. This gap in oversight and responsibility clearly indicates a need for both grid planners and policymakers to be involved in reliability planning. While systems across the world may privatize the generation, transmission, and distribution of the grid, reliability often stays in the purview of government. This is similar to the approach for renewable standards and emissions constraints.

Public policy therefore has a unique capability to influence grid reliability in three ways: by determining the reliability criteria based on social acceptance, incentivizing reliability resources, and supporting coordination with neighboring grids for mutual support.

Policymakers Can Establish the Resource Adequacy Criteria, Define Minimum Requirements, and Solicit Information on Costs

Policymakers can better link decarbonization goals and resource adequacy by being more engaged in establishing the minimum level of expected reliability, which currently uses loss-of-load-expectation metrics. Determining what level of reliability society is willing to accept is a judgment call based on the costs incurred to increase reliability through additional resource adequacy investments and the decision to live with some amount of risk. Today, most regions have a pre-specified loss of load expectation (measured in either days or hours) to determine whether a grid is reliable or not. However, there is often little or no explanation for or justification of how the minimum reliability criteria were established or what an acceptable level of disruption is. Instead, the industry has simply grown accustomed to a 1-day-in-10-year LOLE criterion across much of North America or equivalent LOLH criteria in Europe, and many are hesitant to change.

There needs to be a clear linkage between reliability and system costs so that policymakers who set the reliability criteria have sufficient information to make these important societal decisions.

Importantly, to establish a reliability criterion for resource adequacy analyses requires knowing how much different levels and types of reliability would cost. For example, improving grid reliability from 2-days-in-10-years to 1-day-in-10-years may be extremely expensive in some cases and not be justifiable given only a modest increase in expected reliability. But currently there is little transparency in the costs to achieve that level of reliability or the benefits to consumers. There needs to be a clear linkage between reliability and system costs so that policymakers who set the reliability criteria have sufficient information to make these important societal decisions.

Policymakers Can Consider Programs that Incentivize Resources Capable of Improving Resource Adequacy

Resource adequacy analysis has a long-term horizon, which gives policymakers the opportunity to develop decarbonization goals anticipating—and incentivizing—the development of new technologies that are not yet commercially available, with an eye on the eventual needs of an evolving power system. This can, and should, be done for both supply-side and demand-side resources.

Supply-side policy can be focused on legislation or incentives targeting resources capable of improving resource adequacy. These may include, but are not limited to, long-duration storage, hydro, hydrogen, geothermal, biomass, and other clean, non-variable resources. To date, policymakers have designed incentives and programs to spur research and technological advancement in renewable generation technologies, but may have done less to support enabling technologies and resources that are primarily needed for reliability. As incentives for wind and solar technologies expire (e.g., production tax credits and investment tax credits in the United States), research and development funding and incentives can be redirected to help commercialize low-carbon resources that can replace the capacity of the fossil fleet instead of the current, sole focus on annual energy contributions.

Equally important as supply-side incentives are policies and programs that target demand-side changes. Reducing demand through efficiency standards, building codes, and smart appliance standards improves reliability and reduces the need for capacity overbuild. Load flexibility is also critical, to shift demand outside of at-risk periods and into periods better aligned with renewable generation. This flexibility can be accomplished through dynamic pricing or demand response programs that allow consumers to respond to needs on the grid via a price or other type of signal. When constrained by other social equity and policy considerations, dynamic pricing and demand response programs can allow demand—and not just supply—to contribute to resource adequacy.

Policymakers Can Enable Interregional Coordination on Reliability Planning

Lastly, policymakers and regulators can enable—or require—interregional coordination on reliability planning and resource procurement by expanding the planning area. Broader planning areas typically increase the geographic diversity of wind and solar resources, smooth out peak load conditions, minimize the relative impact of extreme weather events, and increase the pool of resources available. Interregional coordination therefore tends to reduce the amount of capacity (and the cost) required to maintain reliability.

Given that electricity regularly flows across regional and national boundaries, so too should our grid planning and markets. There is a clear role for policymakers in taking the lead in enabling, supporting, and negotiating resource-sharing. This can be done through coordination between different grid operators or by subsidizing transmission linkages that improve reliability but may be difficult to monetize or allocate costs across many jurisdictions. This coordination is also important across sectors, including electric-gas coordination and coordination with communications and cyber-security.

How Can Policymakers and Grid Operators Support One Another?

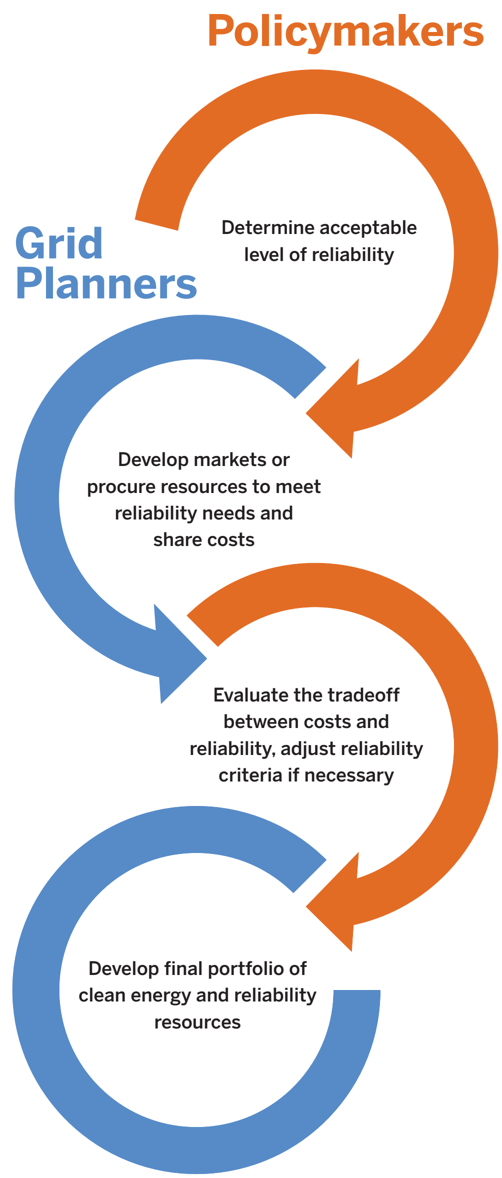
Resource adequacy is relevant not only for grid operators but also for policymakers. As decarbonization goals and environmental policy increasingly change the grid's resource mix, the responsibilities of grid operators and policymakers will increasingly overlap (Figure 3). Policymakers can take several actions to better integrate reliability planning with decarbonization policy.

General Actions Policymakers Can Take

- **Provide increased transparency and justification of reliability criteria.** It is ultimately a societal (policy) decision to determine the appropriate level of reliability and to balance the tradeoff between reliability and costs. Regulators and policymakers should evaluate the costs of meeting certain resource adequacy criteria, increase transparency into these costs, and establish and justify the selected criteria.
- **Provide increased funding for research and coordination.** Decarbonization goals and renewable policy are dramatically shifting the way the grid is planned and operated, at a pace the power industry is not accustomed to. Increased funding for research on resource adequacy topics and interregional coordination to share best practices can help ensure reliability in the energy transition.
- **Incentivize resources capable of improving resource adequacy.** Currently, most renewable energy targets are set at an annual level (e.g., 50 percent by 2030), but do not necessarily include enabling low-carbon technologies such as long-duration storage, hydro, hydrogen, geothermal, biomass, and load flexibility. Funding and incentives for research and development can be directed to help further develop and commercialize resources that can replace the capacity and provision of grid reliability services offered by fossil fuel–fired generators.

As decarbonization goals and environmental policy increasingly change the resource mix, the responsibilities of grid operators and policymakers will increasingly overlap.

FIGURE 3
Coordination Needed Between Policymakers and Grid Planners



Source: Energy Systems Integration Group.

Actions Policymakers Can Take to Support Grid Planners

- **Develop training and outreach programs for and between policymakers and grid operators.** Electricity policy and markets have become tightly connected with the rapid increase in new renewable resources required to meet local and national targets. However, resource adequacy has largely been left in the technical engineering realm. Increasingly, resource adequacy will be affected by environmental policy and vice versa, requiring a shared understanding between grid operators and policymakers. Efforts to deepen this shared understanding could include funding and participation in cross-disciplinary collaborations between policymakers, grid operators, researchers, and industry.
- **Enable or require increased interregional coordination.** Our grids are highly interconnected, and energy regularly flows across regional and national boundaries. However, resource planning and reliability are often left to individual regional or national interests. We can improve reliability and save money by increasing coordination and developing regional resource adequacy constructs across jurisdictions and wide geographies. This is especially true in high-renewables systems. Enabling or requiring the coordination of grid planning across grid operators enables improved reliability at a lower cost.
- **Provide funding and develop programs for weather and climate data.** Grid planners need robust data to perform resource adequacy analysis and make procurement decisions. This includes weather data across large continental geographies (typically in the purview of government research) that are better tailored to power system needs. Policymakers can therefore fund research and development designed to provide consistent year-round data on wind generation, solar generation, temperature, and load, as well as research to introduce climate trends for future years into resource adequacy analysis.

Renewable energy policy and decarbonization goals are tightly coupled with grid reliability. There does not have to be an inherent tradeoff between the two. However, the stakes are high. Poor reliability can have real consequences for human health and safety and for the economy. If clean energy policies are implemented without regard to grid reliability and its evolving requirements, these policies will ultimately be unsuccessful, making the path toward deep decarbonization much more onerous. Policymakers need to possess a clear understanding of the elements of resource adequacy today and into the future, and take steps to ensure their policy goals support not only decarbonization but reliability in a high-renewables grid.

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About the Energy Systems Integration Group

ESIG is a nonprofit organization that marshals the expertise of the electricity industry's technical community to support grid transformation and energy systems integration and operation. More information is available at https://www.esig.energy.

About the Global Power System Transformation Consortium

G-PST works to rapidly accelerate transitions to advanced, low-emission power systems in collaboration with power system operators in all regions. Its efforts focus on research, peer learning, and technical support for system operators; workforce development; and localized support for technology adoption. More information is available at https://globalpst.org.

Publications Available Online

This policy brief is available at https://www.esig.energy/reports-briefs and https://globalpst.org/resources/#_publications.

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You may also request more information by sending an email to the Energy Systems Integration Group at (info@esig.energy) or the Global Power System Transformation Consortium (globalpst@nrel.gov).

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