Integrated Resource Planning

Generation Transitions: *Practical Realities*

Key Insights

- Rapid change is increasing the complexity of electric sector planning and exacerbating uncertainties and risks that challenge development of long-term investment strategies.
- Integrated resource planning is a continuous process for ensuring the adequacy and security of electricity supply while meeting company goals and objectives.
- IRPs are used to inform project execution development strategies, including near-term solicitations and procurements for new capacity, research and development needs, and preliminary engineering studies.
- IRPs do not address all of the actions, uncertainties, and risks involved in making investments and developing, operating, and maintaining new generation, storage, and other resources.
- Evolving modeling methods and tools, combined with enhanced project execution frameworks, can help advance understanding of risks and uncertainties and identify best practices for navigating challenges in moving from the resource planning phase through the implementation phase.

Overview

Data centers are driving rapid load growth, and innovation is occurring across the energy sector. Resilience is of rising concern, and significant increases in electricity consumption will be required in order to meet future targets for net-zero carbon emissions. These ongoing and anticipated developments imply both a substantial expansion in power generating capacity and an unprecedented transformation in energy networks across the remainder of this decade.

While the energy transition will vary greatly across companies and regions of the world, today's investment decisions will impact the timing and trajectory of progress toward mid-century targets, as well as the services received and rates paid by customers.

Integrated resource planning is a process commonly used by energy companies in the United States and globally to develop investment strategies over 20- to 30-year periods. Alternative scenarios are applied to evaluate existing assets and new generation, storage, and demand-side options and to identify flexible and robust portfolios for meeting long-term electricity needs and other objectives, including reliability and resilience standards, net-zero commitments, and environmental compliance obligations. The portfolios and strategies described in integrated resource plans (IRPs) are intended to define plausible pathways for meeting specific objectives across a range of future scenarios.

What Do Today's IRPs Tells Us About the Energy Future?

More than 90% of U.S. companies that file IRPs have carbon reduction objectives, including 55% with net-zero goals for future power supply. Reviewing recent IRPs collectively can provide insights on the direction of the future generation mix. As shown in Figures 1 and 2, IRPs filed between 2019-23 by companies across the U.S. generally show rapid near-term capacity expansion driven by demand growth due to electrification and data centers. (EPRI, 3002026243)

Collectively, an increase in installed capacity of more than 35% is projected through 2035 compared to 2020. Solar is by far the leading choice, followed by

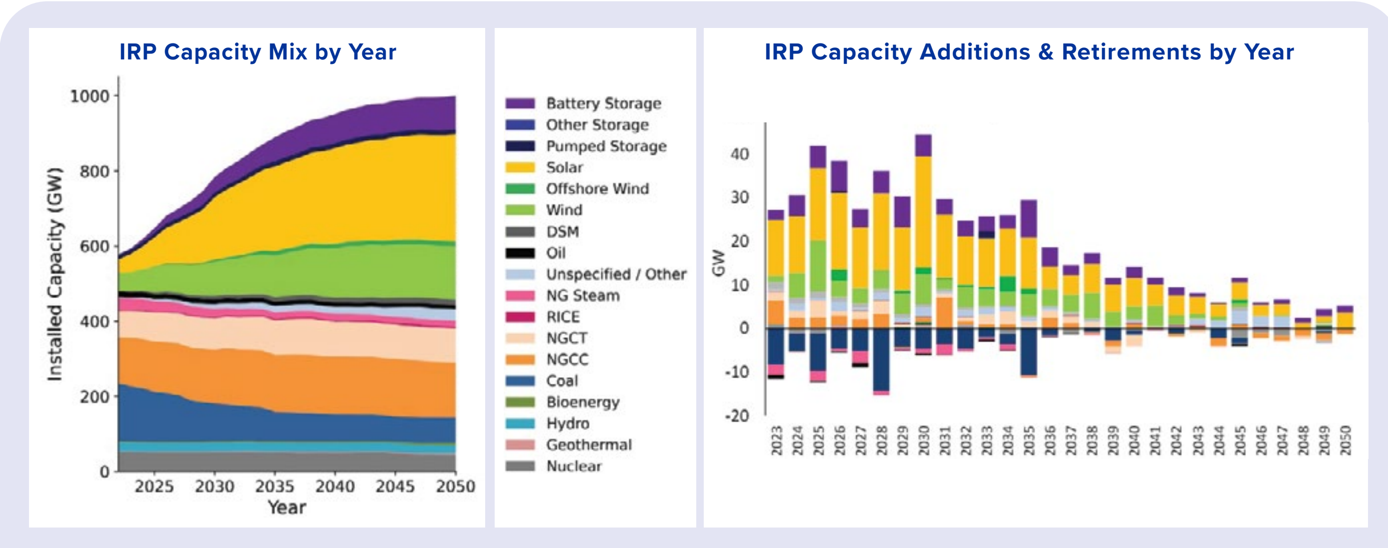

__Figure 1 and 2.__ Across recent IRPs, regulated providers plan unprecedented capacity additions and substantial retirements. Extending the trends shown to all generation capacity owners, the nationwide system expansion would include an average annual addition of more than 27 GW of variable resources and 21 GW of flexible resources, plus an annual reduction in dispatchable resources of 2.5 GW. Because many IRPs include projections only through 2035, the flattening of the capacity expansion curve reflects a reduction in the number of IRPs estimating capacity additions, rather than a slowing in anticipated load growth after 2035. (EPRI, 3002026243)

wind and battery storage. An increase in combined-cycle natural gas is also planned, partially offset by retirements of legacy gas-fired units. Coal accounts for the majority of retirements. Generally, recent IRPs account for U.S. regulations that tighten standards for air toxic emissions and phase in control of carbon emissions from fossil plants.

Practical Realities

IRPs are used to inform project execution development strategies, including near-term solicitations and procurements for new capacity, research and development needs, and preliminary engineering studies. However, realities encountered in putting a given plan into action can require changes in strategy and approach to meet the myriad of political, regulatory, stakeholder, and corporate objectives. As companies react to anticipated trends in electricity demand and work toward energy and emissions goals, careful consideration of practical realities can help in identifying risks, concerns, and solutions to support IRP implementation over time.

IRPs reflect a snapshot in time in a complex and uncertain world. A number of factors will influence demand growth and the future attributes of energy resources and emerging technologies. Policies and regulations can change, assumptions and generalized cost estimates can prove inaccurate, and future scenarios can become more or less likely. Detailed IRP scenarios explore a range of possible futures to understand key drivers and sensitivities and identify the best pathways forward, but given changing conditions and evolving uncertainties, their conclusions ultimately provide strategic direction and guidance at a snapshot in time. For this reason, IRPs are typically developed on a cycle of every few years.

Barriers and bottlenecks to chosen resource pathways can emerge in many forms. Integrated resource planning and IRP implementation are akin to theory and practice, with the real world introducing myriad complications. For example, the confluence of deployment and retirement schedules across recent U.S. IRPs could create supply chain challenges for solar, wind, and storage projects, adding costs and extending timelines. Common bottlenecks include interconnection queues, land and labor availability, transmission constraints, siting and permitting processes, and public acceptance. Proposed assets can also face evolving financial constraints, market dynamics, regulatory hurdles, technology challenges, and other barriers.

Long-term technology assumptions underpin—and thus can change—IRP development and deployment plans. New low-carbon technologies, including small modular reactors, novel batteries and long-duration storage technologies, hydrogen-fueled power generation, and virtual power plants, are expected to emerge over the periods addressed by IRPs. Uncertainty exists in timelines for achieving commercial availability and cost and performance targets, and significant deviations from the assumptions used in an IRP can lead to uneconomic choices or lost opportunities. For example, during wind and solar market entry, annual cost reductions surpassed planning assumptions, leading many to underestimate when the technologies would be economic and how much capacity would be added. On the other hand, the cost of offshore wind in the U.S. has approximately doubled in recent years. Uncertainty is an issue even for established technologies. Gas prices can be extremely volatile, and recent IRPs show a wide range of assumed operations and maintenance costs for wind and solar assets.

Changing dynamics introduce new operational complexities. Planned capacity additions have shifted from dispatchable thermal power plants to variable resources, including inverter-based renewables and battery storage. Higher solar and wind capacities increase the difficulty in balancing output with load and require additional flexible dispatchable resources, plus greater coordination in operations to ensure system reliability. In addition, the increased frequency and severity of extreme weather and wildfires and the growing interdependencies among electricity, fuel, communications, transportation, and other networks create compounding uncertainties and risks.

Industry & EPRI Responses

Integrated resource planning processes are continuing to evolve as energy company planners seek to bridge the gap between IRP development and implementation. Changing system dynamics are pushing the need for new planning methods and metrics, infrastructure upgrades, and advanced operating strategies and management tools.

EPRI's Integrated Energy Systems Planning team continues to refine modeling inputs and understanding of uncertainties and to identify new modeling methods for representing emerging resources in planning tools. Likewise, the Integrated Strategic System Planning (ISSP) Initiative is developing frameworks and tools for conducting holistic planning across generation, transmission, distribution, and end-use systems. Stochastic modeling explores how and what uncertainty is reflected in the modeling tools used for resource planning, while realistic constraints research explores processes, barriers, and limits experienced by planners and developers in practice but not currently directly represented in modeling tools. Load forecasting research addressing data centers, decarbonization, and U.S. reindustrialization characterizes key drivers and uncertainties in demand, while Climate READi research is developing methods to address resilience considerations in the context of extreme weather and climate change.

Complementing research to advance modeling, EPRI is developing project execution frameworks to apply best practices for navigating challenges in moving from the resource planning phase through the implementation phase. The multitude of regulatory, technology, and market risks that a project might face between initial technology selection and final construction and plant operation is being characterized, and approaches for managing uncertainty and integrating flexibility into project planning and execution are being identified.

EPRI's work to incorporate the relevant data, models, and tools in comprehensive decision-support frameworks will take some time. Meanwhile, ongoing efforts to characterize risks and uncertainties, improve methodologies, understand emerging approaches, and transfer state-of-the-art practices will help energy companies and other stakeholders in developing projects and deploying technologies for meeting long-term electricity needs and additional IRP objectives.

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