

Distribution-Level Integrated Resource Plans: A Necessity for the Future



How should utilities
evolve resource planning
to meet complex future
energy challenges?

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Integrated Resource Planning (IRP) and distribution planning are topics that are top of mind for utility executives. Utility leaders realize the importance of focusing on planning and operations for the future, but until recently, proper tools were not in place to optimally execute advanced planning procedures.

Proper planning for the future demands that utility leadership adopt new, more sophisticated approaches and leverage new technologies and tools such as grid analytics. Now is the time to take planning to the next level, by using real-time data for effective IRP and distribution planning.

Integrated Resource Planning traditionally has sought to meet system demand by looking at an optimal mix of central generation with some demand response. On the other hand, distribution planning has historically looked at loads on a local level and determined the most effective way to build stations and lines to meet the load. However, distribution systems now

have distributed resources in many cases as well as demand response and voltage control options. Consequently, distribution planning starts to look like an Integrated Resource Plan at a local level. In addition, the real time net energy needs at a local level become a primary input to the system-wide IRP.

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The Historical Approach to Integrated Resource Planning

In the United States, utilities have predicted long-term needs by using an IRP. The focus of an IRP is on meeting forecasted annual peak and energy demand. In addition, the plan takes into account the reserve margin of existing and planned resources. Resources in the IRP include:

- Supply-side resources provided by the utility, customers or a third party
- Demand-side resources such as demand response or energy efficiency programs
- Renewable energy to meet state or utility goals
- Transmission constraints

In the 1980s, Integrated Resource Planning began in response to nuclear plant overruns and the perceived oil supply risk due to the 1973 Arab Oil Embargo. When restructuring of the electric utility industry occurred in the mid-1990s, some states dropped or significantly changed the IRP process since the utility was no longer the supplier of all native loads in its service territory. Around 80 percent of states, however, still have a formal requirement for an IRP — or at least a long-term plan.

The length of time covered by an IRP varies by state, ranging from 10 to 30 years, with an average of around 20 years. The first few years include highly detailed plans with the later years primarily focused on understanding how future years might constrain the options for meeting power needs. Although the IRP process is continuous, completely updated plans are required every two to three years.

Risks considered in the traditional approach

One major component of an IRP is testing the various options against the risk of either not generating enough energy to meet demand (security of supply) or of acquiring more supply than needed (stranded costs). In general, risk is defined in an IRP context as the measure of bad outcomes that could arise from each planning option. Uncertainty is also a factor, but is somewhat different from risk. Uncertainty deals with the quality of information used to develop the IRP. The type of risks or uncertainties considered when testing options include:

- Fuel prices for coal, oil and natural gas
- Load growth/economic conditions
- Electricity spot prices
- Variability of hydro resources
- Environmental regulations
- Changes in the market structure
- Technology impacts

Utilities must develop various alternatives for meeting the projected needs and accounting for all potential resources. In addition to looking at the cost of alternatives, their value based on location needs to be considered as well. For example, a generation option may cost roughly the same if placed in two different locations. In one location, however, it may add to transmission congestion, while in another location it may relieve transmission congestion. Because of the technical and financial complexity of considering various options, utilities use sophisticated optimization modeling tools to evaluate various scenarios objectively. At the same time, utilities must also recognize there is no substitute for experience and judgment to supplement the analytical tools.

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The Historical Approach to Distribution Planning

Distribution planning has focused on maintaining adequate feeders and stations to serve existing and projected loads. The majority of the distribution systems in the United States have been radial or one-way in nature. One exception is secondary networks in urban areas that improve reliability by having an interconnected secondary system served by multiple feeders. In addition, capacity is often provided on adjacent circuits to enable “back-up” options through automated or manual switching after an outage. The studies tend to look at a five-year horizon in detail and a ten-year horizon to assess the longer-term value of near-term options. Distribution planning is continuous at utilities; individual stations and circuits are reviewed on a two- or three-year cycle.

Key Factors in Historical Distribution Planning

- Load forecasting based on local economy and weather patterns
- Maintaining adequate voltage
- Avoiding overloaded primary conductors for normal load
- Designing adequate capacity to pick up load after an outage from adjacent circuits
- Adequacy of protection plan to carry normal and emergency load
- Adequacy of protection plan to trip for all expected fault conditions
- Minimizing technical losses
- Balancing the feeder’s three-phase sections
- Power factor correction
- Avoiding overloaded station transformers, breakers and associated equipment
- Optimal utilization of existing transmission assets

More recently, distribution planners have also begun to consider how technology like distribution automation can help optimize feeder reliability.

Using tools for distribution planning, utilities can look at all the important factors under a given set of loading conditions. The results are an approximation of the actual conditions because the overall feeder load is simply spread in a manner proportional to connected transformers. Normally, peak-load and light-load conditions are considered part of the study. With only a snapshot of circuit conditions, the feeder dynamics are not considered part of the historical distribution planning process.



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Forces Demanding a New Approach

Technology is advancing in both functionality and affordability, which creates new opportunities for optimizing utility capital deployment. But the new technologies require the following changes in distribution planning and operations:

- Accommodate two-way flows from distributed energy resources (DERs) of all types
- Optimize the charging and discharging cycles of battery storage devices
- Integrate demand reduction schemes

Five important technologies are driving this change

1 DISTRIBUTED RENEWABLES

Solar prices
have come down
33%
over the past 6 years

The falling price of solar cells, along with purchase incentives, is making home and business use of solar panels more attractive. Installed solar prices, excluding incentives, have come down from \$6/watt to \$3/watt from 2010 to 2016—which is on par or better with most U.S. utilities, assuming a 20 year life.¹ In addition, the increased sensitivity of the public to environmental issues is motivating utility customers to invest in distributed solar. Third parties as well as utilities also have incentives to invest in distributed solar. Moreover, states like Hawaii and California have specific renewable targets that are driving further investment. For example, Hawaii has a target of 30% renewable energy by 2020 and California has a target of 50% by 2030.^{2,3} Other states are expected to follow, but at varying rates of deployment.

With high concentrations of renewable energy on distribution feeders, utilities must develop ways to:

- Include the output of distributed renewable energy, along with the dynamic need for other supply resources, in the IRP process
- Maintain adequate voltage on each feeder given the variability of the renewable resources
- Take into account the positive and negative aspects of renewable resources on distribution lines and equipment
- Protect distribution feeders built for one-way feeds that will now have two-way feeds
- Optimize capital investments in feeders to solve traditional feeder problems while enabling as much use of renewable energy as possible

¹ <http://solar-power-now.com/cost-of-solar/>

² Glick, Mark. "What the mainland can learn from Hawaii's road to 100% renewables." GreenBiz. June 7, 2016. <https://www.greenbiz.com/article/what-mainland-can-learn-hawaiis-road-100-renewables>

³ Pyper, Julia. "California passes a bill targeting 50% renewables by 2030." Greentech Media. September 12, 2015. <http://www.greentechmedia.com/articles/read/california-bill-50-percent-renewables>

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2 BATTERY ENERGY STORAGE

Battery energy storage has come down in price over the past few years. For example, lithium-ion batteries in a large scale have seen a cost reduction of 30% in three years (2013 to 2016) and are expected to further reduce 20% by 2020.⁴ Today's cost for an installed lithium-ion battery and power electronics is around \$1,000/kWh. Another technology, sodium-sulfur batteries, is pricing out around \$500/kWh.⁵ The typical electric utility in the U.S. builds the system capacity for a peak that occurs one or two percent of the year. If the peaks and valleys of load could be leveled all year long, the generation, transmission and distribution systems could carry more than twice their existing load with no additional investment.

Consequently, utilities are looking at energy storage as an alternative to distribution, transmission and generation capacity investments. For example, a two-hour lithium-ion battery would cost around \$2,000/kW and could offset the need for a generation-peaking plant costing

\$1500/kWh and distribution capacity improvements costing \$700/kW for a total benefit of \$2200/kW if installed on the distribution system.⁶ Other potential benefits include:

- Smoothing the variability of distributed renewable energy on distribution feeders
- Improving the power factor
- Controlling voltage with rapid response
- Improving power quality on distribution feeders
- Improving reliability on distribution feeders as the typical outage in the U.S. lasts two hours
- Providing ancillary services (short-term transmission and generation stability)

Battery energy storage offers the possibility of solving multiple problems at the same time. The highest value is created when the batteries are installed on the distribution system. This in turn requires the distribution feeders to accommodate two-way power flows for charging and discharging.

3 VOLTAGE AND VAR CONTROL

Voltage and Volt-ampere Reactive (VAR) control have been integral to utility operations since the beginning of the industry. In recent years, it has been recognized that voltage and VAR control can be managed to reduce energy use, reduce peak demand or decrease system technical losses. For example, a utility

could reduce voltage on a distribution feeder and thereby reduce demand on the feeder at peak, reducing both the demand on the transmission system and the need for generation. Consequently, voltage and VAR control have become an option for distribution planning and an IRP.

⁴ Jacques, Carole. "Li-ion battery costs fall to \$397/kWh in 2020; not enough for mass adoption of electric vehicles." luxresearch. March 27, 2012. <http://www.luxresearchinc.com/news-and-events/press-releases/read/li-ion-battery-costs-fall-397kwh-2020-not-enough-mass-adoption>

⁵ Parkinson, Giles. "How battery storage costs could plunge below \$100/kWh." Renew economy. October 7, 2014. <http://reneweconomy.com.au/2014/battery-storage-costs-plunge-below100kwh-19365> 2015. <http://www.greentechmedia.com/articles/read/california-bill-50-percent-renewables>

⁶ Lithium-ion costs to fall by up to 50% within five years." Energy Storage Update. July 30, 2015 <http://analysis.energystorageupdate.com/lithium-ion-costs-fall-50-within-five-years>

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4 DISTRIBUTED FUEL CELLS AND FOSSIL FUEL GENERATION

The technology for efficiently utilizing fossil fuels at a local level is advancing rapidly. For example, solid oxide fuel cells could achieve efficiencies of up to 70% in MW scale and also effectively use bio fuels.⁷ Also, internal combustion technology continues to improve in both efficiency and durability. Coupled with low prices for natural gas and petroleum products, distributed fuel cells and fossil

fuel generation may become an attractive option to larger central generation. In addition to meeting overall supply (generation) needs in an IRP, other benefits include:

- Deferral of distribution and transmission capacity needs
- Improved resiliency for critical customers in major outage events

5 DEMAND RESPONSE

Demand response has been used for years to reduce peak demand of utilities. Demand response seeks to reduce the demand on the utility infrastructure by having customers reduce or shift their electric usage during peak periods. The customers respond to time-based rates or other forms of financial incentives.

Utility planners use demand response programs as a resource option to balance supply and demand. Consequently, demand response programs are often

part of a utility's IRP. Historical methods utilities use to engage customers include time-based rates in various forms, critical peak pricing and direct load control of major equipment in exchange for financial incentives. When integrated with feeder peak capacity needs, demand response can defer capital across distribution and generation. This makes demand response an attractive option for both distribution and IRPs.



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⁷ <http://ieeexplore.ieee.org/document/553868/>

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A New Approach Using Advanced Grid Analytics

Distribution systems of the past were built to deal with one-way power flows. Customer-owned, back-up power was generally not allowed to operate in parallel with the utility system.

On the other hand, distributed resources (for example, distributed solar and battery energy storage) are now designed to operate safely in parallel with utility distribution systems.

The systems were also designed to meet a fairly predictable peak load. The distribution system of the future will have both utility, third-party and customer-owned resources impacting the net demand on feeders, transmission lines and central supply (generation). Distribution systems will have both loads and energy sources. This dynamic interplay will require a new type of distribution planning to meet all requirements for adequate capacity, voltage and protection. The net result is the need for an IRP at a local level for each feeder. It should provide dynamic (24/7, 365 days-a-year) projections of net energy need, that can inform the full system IRP.

The analysis needed at a feeder level will take near real-time information from AMI, SCADA and distribution automation and perform time-series analysis of dynamic feeder conditions. Essentially, previous years' near real-time information will be uploaded and modified to reflect future growth or changing conditions, creating a dynamic projection on the planning horizon. In addition, dynamic information about sources like distributed solar, battery energy storage and voltage control can also be fed into the model to understand net system conditions throughout the planning period. The results will be used to inform both distribution and IRP.



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Many utilities have expressed an interest in a distribution level IRP process in recent months. The utilities need both a well-defined process and a time series feeder analysis tool. A more sophisticated IRP tool would help utilities:

- Understand the impact of future scenarios on financial outcomes and operational stability.
- Develop strategies for managing the complex future that inform the impacts on customers, distribution, transmission and generation both individually and as an integrated system.

- Develop tariffs, demand response programs and the true avoided/added costs from customer-owned DERs based on defensible near real-time analysis.
- Identify opportunities to simultaneously solve multiple problems across distribution, transmission and generation with a single capital project.

The future of energy is complex and proper planning is essential. As distribution systems of the future evolve to absorb new technology, planning processes will also change by leveraging the advanced analytics solutions available today.

Built on a powerful advanced grid analytics platform, Landis+Gyr's comprehensive suite of applications can help utilities with the type of sophisticated, data-driven IRP required to future proof their business operations.

The net result of IRP at a local level of each feeder are dynamic (24/7, 365 days a year) projections of net energy needs that can inform the full system.

