White Paper

Using Optimization to Drive Your DER Strategy and Build Value

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Shareables

- Today's mostly customer-driven DER adoption pattern misses opportunities for utilities to capture significant system value.
- Optimization pays off for utilities by driving strategies to reduce rate pressure, increase the net benefits of utility programs, and improve customer relationships.
- Our utility case study shows how a locationally optimal DER portfolio can save save tens of millions of dollars in traditional distribution grid upgrades, allowing capital redeployment, and facilitate smart program targeting to increase effectiveness and new approaches to rate design.

Executive Summary

DER valuation has been a complicated knot to unravel in recent years, as it must account for multiple DER options and a stack of potential value streams, while taking locational and temporal constraints into consideration. By leveraging and enhancing the analytical tools developed through work with clients across North America, ICF is now able to identify optimal configurations of DER that maximize the benefit to the distribution system. This framework is unique in that it allows ICF to perform optimizations at three distinct levels of granularity—premise/building level, feeder/substation level, and system level—which can be tailored to the needs of the utility. The approach uses granular electric grid data to estimate the output characteristics of DER in different sections of the grid, and can be combined with DER implementation cost and system benefits data to design an optimal and cost-effective mix on a locational basis.

3 Benefits of Optimal DER Portfolios

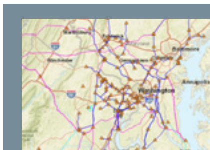
- Bending cost curve to reduce rate pressures
- Crafting more cost-effective programs with better returns for all
- Strengthening customer relationships as interest in DER grows

A case study of this analysis performed on one North American utility shows that this type of approach can reveal meaningful differences in value across many locations and combinations of DER; providing a compass for utilities and other DER market participants to discover and capture value for their customers.

Optimization of DER Creates Significant Utility and Customer Benefits

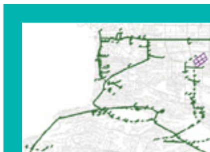
Today, DERs typically come onto the grid haphazardly based on individual customer decisions, in a way that may or may not enhance overall value on the system and could even impose costs. Any value delivered to the system is largely random, thus some DERs are overcompensated, while others undercompensated relative to actual value to the grid.[1] For example, DER deployment driven by net energy metering (NEM) or generic Value of Solar tariffs may create overall system value by decreasing central station generation and potentially reducing pressure on transmission and distribution infrastructure, but those pricing mechanisms do not consider location-specific factors or direct DERs to areas of the grid that can most benefit from them.

For DER to truly become resources that add value to the system, they must be brought onto the grid as part of an overall planning and acquisition strategy that leverages the locational benefits[2] of DER to support future grid planning and investments. A DER strategy can target location-specific or broader system issues to maximize benefit, address distribution system needs, and align compensation accordingly. An optimal DER portfolio can lead to several significant advantages that may be monetized to benefit both utilities and their customers. Additionally, this approach can help utilities deliver the best pricing, program and procurement signals to customers and third party developers. ICF performs this system optimization at three levels of analysis for utility clients.



Distribution System Portfolio

- Finds an optimal portfolio to maximize energy, capacity and cost savings, or other goals across utility programs.
- Example: ICF helped one utility find a demand side management portfolio that achieved 4% more energy savings at $70 million lower cost.



Locational – Feeder or Substation

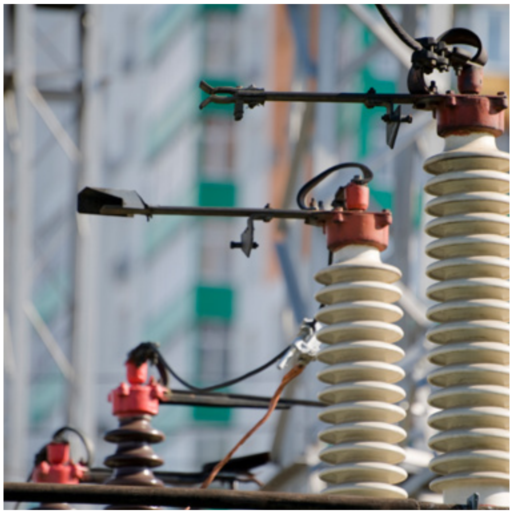
- Determines the best portfolio of DERs for a specific section of the distribution system.
- Example: ICF analysis for a utility identified $35 million in feeder and substation upgrades that could be saved through targeted DER deployment.

Site Specific – House or Building

- Assembles the right EE and DER program mix to maximize results in new construction or existing structures

[1] ICF White Paper: The Value in Distributed Energy: It's All About Location, Location, Location.

[2] Locational value analysis is necessarily inclusive of both the location of a DER and its temporal characteristics; such that references to locational value may be understood to also refer to temporal considerations.

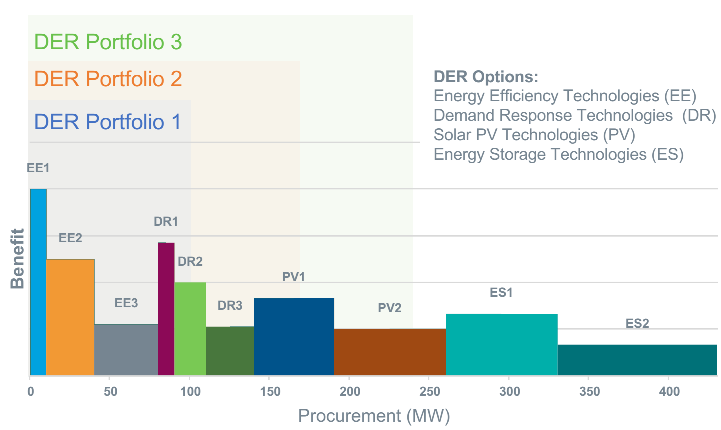


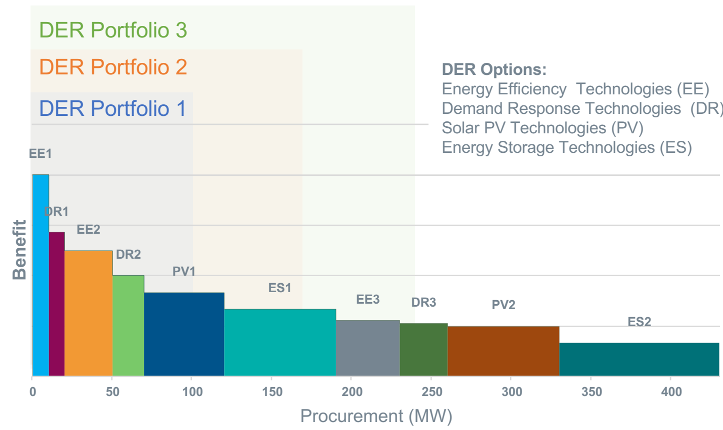
The type of optimization used should be driven by the specific problem a utility wants to solve and the data available. For example, a utility looking to get the most out of existing programs and with the ability to alter their program mix might optimize at the portfolio level. A utility looking for potential cost savings on the distribution system or to enhance program effectiveness by tying in locational avoided costs would want to assess locational value at the feeder level. Our case study below looks at optimization at the locational feeder level.

Applying ICF's Locational Optimization Approach

Developing optimal DER portfolios is difficult given the many possible DER combinations and variations in locational value. Existing DER portfolio designs are often based on "distribution loading order" or "preferred resources" that give higher preference to one particular DER technology over another. The resulting DER portfolios tend to be uncoordinated and suboptimal because they neglect a range of other equally, or more efficient, options. The true value of a DER portfolio that includes different technologies is much more complex than a simple loading order. For instance, integration of solar PV is dependent on the ability of the distribution feeder to absorb PV output at all times. The upper limit of PV that the system can accommodate is known as hosting capacity, and beyond this limit, the distribution grid needs an upgrade to accommodate more PV, thereby increasing cost. Given the variation in costs, an optimal portfolio of DER should include the most efficient resources from a range of technologies that maximize overall benefit at both the wholesale and distribution levels. This scenario is depicted conceptually in Exhibit 2, in which the top graphic shows sub-optimal DER portfolios that are based on non-optimized procurement or random growth of DER driven solely by customer preferences, while the bottom graphic shows a portfolio of DER that is optimized based on locational value and temporal characteristics against system hosting capacity constraints and achievable potential. As shown in the graphic on the right, under the optimized approach, the resources with the greatest benefit are chosen first.

EXHIBIT 2 & 3. CONVENTIONAL DER PORTFOLIO (TOP) VS OPTIMIZED PORTFOLIO (BOTTOM)





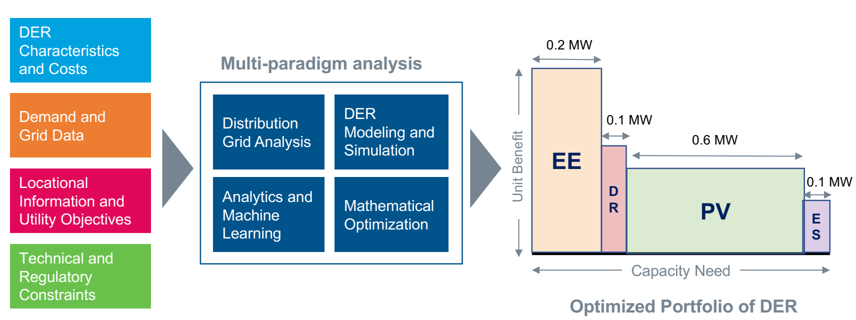
Source: ICF

Any optimization approach must take into account the locational and temporal variability in demand and DER output to ensure feasibility of the DER solutions. ICF's multi-dimensional analytical framework uses a combination of engineering modeling and mathematical optimization techniques to develop detailed demand and DER output scenarios and ultimately identify optimal configurations that maximize the locational benefits (Exhibit 4). Overall, this platform aims to give utilities a highly practical, streamlined tool grounded in rigorous methodology—one that can deliver actionable results with relative speed and cost-effectiveness. ICF's approach to locational value and optimization ties together many analytical capabilities across multiple DERs, including:

- Streamlined but highly functional hosting capacity analysis;
- DER technical, economic, and achievable potential estimation and growth projection;
- Wholesale and distribution avoided cost analysis; and
- Locational optimization modeling.

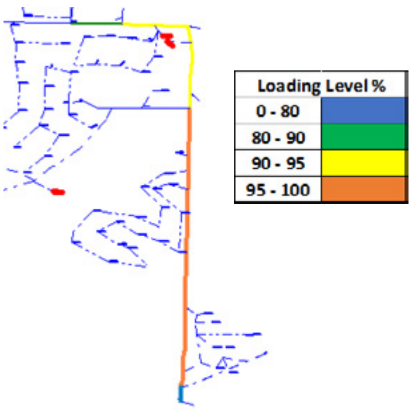
Perhaps the biggest strength of the multi-paradigm approach is the modularity and customizability of the framework, which can be tailored to optimize utility portfolios for a range of objectives, in particular to minimize risks associated with DER delivery and savings goals and estimate sensitivity of various measures and programs on the overall portfolio.

EXHIBIT 4. THE DER OPTIMIZATION FRAMEWORK USES THE LOCATIONAL VALUE OF DER

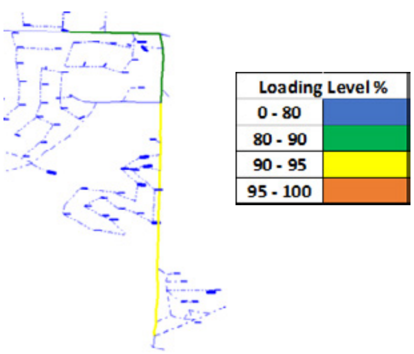


Source: ICF

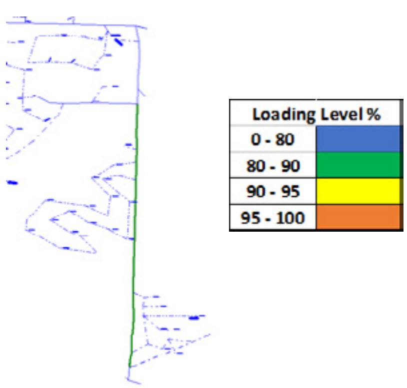
EXHIBIT 5. BENEFITS TO THE GRID



Overloading in a section of the distribution grid



A conventional DER portfolio does not eliminate the issue completely



An optimal DER portfolio can provide a more effective solution

Source: ICF

Case Study: Non-Wire Alternative (NWA) Analysis

For one North American utility, we compared the impacts of a DER portfolio developed with conventional planning methods to an optimized portfolio derived through the process depicted in Exhibit 5. First, we modeled the impact of future load growth on the distribution grid using standard distribution system analysis software to identify feeders that experience voltage violations and overloading during peak and off-peak periods. The peak demand was expected to exceed the feeder capacity in the future on these overloaded feeders (Exhibit 5a). Next, we analyzed the impact of a DER portfolio based on the utility's existing planning methodologies. The conventional DER portfolio lowered overall demand during localized peak periods, diminishing overload on the system and alleviating the need for some grid upgrades (Exhibit 5b). However, the effectiveness of the DER solutions based on conventional portfolios varied under different DER growth scenarios. Therefore, we developed optimized DER portfolios that were designed for the particular need of the system, which proved to be more robust under different growth scenarios (Exhibit 5c), and thereby identified multiple locations with opportunities for utilizing DER portfolios as the solution for local grid needs.

Based on data from the utility, we estimated that the grid investments required in the traditional scenario due to load growth—including upgrading multiple feeders and substation transformers across the entire distribution system—would cost approximately $35 million over the next five years. The analysis showed that programs, prices, and procurements targeted to achieve optimized DER portfolios could instead provide the needed load relief and result in tens of millions of dollars in savings (Exhibit 5).

Summary and Key Takeaways

As DERs become deployed more widely on the distribution grid, it is increasingly important that utilities understand the cost and operational implications on their systems. By understanding what the deployment of an optimized portfolio looks like, utilities have a better chance of directing either their own or third party investment in a way that benefits the entire system.

About the Authors

Hameed Safiullah, Ph.D., has over 5 years of experience in energy system modeling, renewable resource integration and electricity markets research. At ICF, Dr. Safiullah's work is focused on evaluating the impacts of distributed generation resources on the power grid. He specializes in power system economics, energy system modeling, optimization, and data analytics. He is currently working on locational value analysis of distributed energy resources.

Dr. Samir Succar is a Senior Manager analyzes and models power market supply-demand fundamentals, develops forward price curve assessments, and performs generation asset valuations. His transactional experience includes acquisition support for potential bidders, largely private equity and independent power producers (IPPs), and sellers of generation assets and portfolios. Dr. Succar has a Ph.D. in Electrical Engineering from Princeton University and a B.A. in Physics from Oberlin College.

Matt Robison is a Senior Manager with ICF. He leads client projects focusing on distributed energy grid integration and associated regulatory proceedings on the evolution of distribution system planning, operations, and markets. He has helped develop ICF views and perspectives for utility clients on a diverse array of power sector issues including wholesale market design and transmission, but focuses primarily on the implications of distributed energy. Mr. Robison holds a Masters in Public Policy from the Harvard Kennedy School of Government and a Bachelors in Economics from Swarthmore College.

Carolyn Brouillard is a Manager of Distributed Energy Resources at ICF. Carolyn has over 10 years of experience supporting transformation in the energy sector. She spent nine years in policy, strategy and regulatory roles at a major U.S. electric and natural gas utility, where she advised on a broad range of industry issues and represented the company in stakeholder processes, including Minnesota's e21 Initiative.

Steve Fine is a Vice President with ICF and leads the Distributed Energy Resources Team. Steve has particular expertise in evaluating the economics of conventional and renewable energy resources—both central station and distributed generation—within the context of developing technologies, market design and environmental regulations. He works with many of the major U.S. power companies and developers in evaluating the impact of distributed energy resources (DER) on their system and the implications for their business models and their distribution system planning and operations.

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