Incorporating Energy Efficiency and Demand Response into Electric Company Power System Resource Planning

Technical Brief — ***Resource Planning for Electric Power Systems (Program 178), Energy Systems and Climate Analysis Group (ESCA), PDU Integrated Grid and Energy Systems***

Abstract

Electric companies, industry stakeholders, and regulators are placing increasing emphasis on accurately representing distributed energy resources (DER) in electric company long-term resource planning efforts. While there is substantial literature on the *qualitative* advantages and disadvantages of distributed energy resource modeling methods, there has been little research that *quantitatively* assesses implications across methods. This study quantitatively demonstrated the impact of a variety of approaches to representing *energy efficiency (EE)* and *demand response (DR)* in electric company resource planning modeling and analysis. Overall, a comparison of resource planning modeling simulations showed there are conditions under which certain approaches may be more appropriate than others for integrated resource planning. Resource planners can use the results and insights developed to assist them in deciding upon EE and DR modeling approaches for their own resource planning. Results also can be used by other industry stakeholders to analyze resource plans in a more informed way.

Keywords

- Energy efficiency
- Demand response
- Behind-the-meter resources
- Distributed energy resources
- Integrated energy network planning
- Integrated resource planning
- Capacity expansion modeling

Introduction

Electric companies, electricity industry stakeholders, and regulators are placing increasing emphasis on accurately representing distributed energy resources (DERs) in electric company integrated resource planning (IRP) efforts. While there is substantial literature on the *qualitative* advantages and disadvantages of modeling DERs in IRPs, there has been little research that *quantitatively* assesses implications across methods. The purpose of this study was to quantify the implications of different approaches for incorporating DERs into resource planning, demonstrating each approach using the same resource planning model for an individual, illustrative electric company.

To illustrate the impact of various energy efficiency (EE) modeling approaches, we simulated the IRP of a hypothetical electric company that is representative of the U.S. national averages in terms of resource mix proportions and load characteristics. It does not represent any individual existing electric company.[1,2]

The results presented here focus on methods to incorporate EE and demand response (DR) into resource planning. This is part of a broader EPRI research project that is exploring methods to incorporate a variety of other DERs, such as rooftop solar photovoltaics and electric vehicles. Key research questions addressed in the study are summarized below.

Demand-Side versus Supply-Side Methods to Represent Distributed Resources

There are two established approaches for modeling EE and DR in IRPs. A **Static** (i.e., demand-side) approach screens each EE/DR measure for cost-effectiveness outside of the resource planning model, subtracts cost-effective EE/DR impacts from the model's input load forecast, and then models generation resource decisions to meet this "net" load forecast. Alternatively, a **Dynamic** (i.e., supply-side) approach represents each EE/DR measure as part of an EE/DR supply curve, which directly competes against other generation resources in the model's capacity expansion planning decision optimization algorithm.

This study first explored various implementations of the Static approach for a representative portfolio of EE measures. The study found that specific refinements to a simplistic implementation of the Static approach can greatly improve modeling outcomes. Those refinements included hourly representation of marginal (i.e., avoidable) energy costs, better alignment between the assumed marginal capacity costs and forecasted capacity costs from the IRP model, and more sophisticated representation of the coincident peak demand savings of the EE measures. Based on these refinements, simulated net system cost savings attributable to EE increased, while the total required investment in EE measures decreased.

[1] We completed the quantitative modeling and analysis described here using the GridSIM model developed by The Brattle Group.

[2] GridSIM is a capacity expansion model used to evaluate emerging technologies and associated issues in the electric power sector. The model determines cost-minimizing investment by resource type, given energy, generation capacity, and ancillary service requirements.

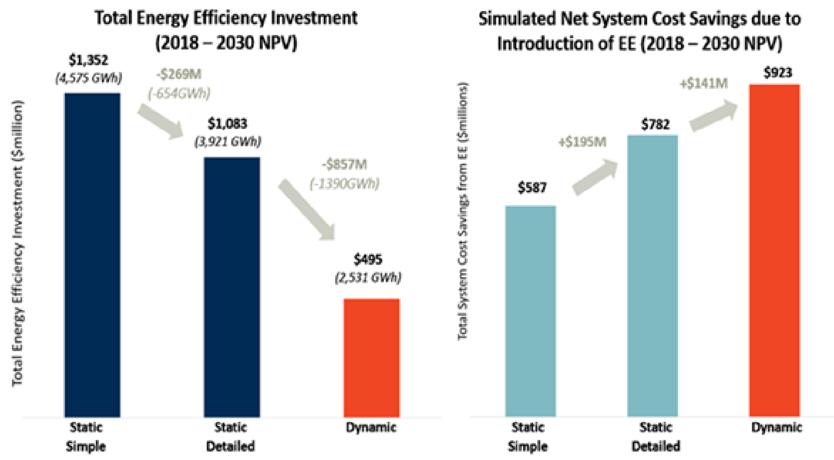

Figure 1. Impacts of Various Approaches to Modeling EE

Note: The figure illustrates three options for representing EE in an IRP model: Simplistic representation on the demand side ("Static Simple"); refined demand side representation ("Static Detailed"); and, including EE endogenously as an option on the supply side ("Dynamic").

The study then explored the impact of the Dynamic approach to EE modeling. EE investment decreased even further when implementing the Dynamic approach. However, despite this lower EE investment, the Dynamic approach leads to a modeled total system cost that is *lower* than either of the Static approaches. Results are summarized in Figure 1.

EE investment decreases with the Dynamic approach, primarily because the Dynamic approach accounts for the declining marginal benefit of EE. For instance, whereas the first EE measure to be added might displace expensive, inefficient peaking capacity that is on the margin during peak hours, the next EE measure may displace output from a more efficient natural gas combined cycle plant during those hours.

Modeling EE dynamically on the supply side accounts for this important phenomenon of declining incremental value, while the Static approach does not.

The finding that EE investment decreases with the Dynamic approach is noteworthy, because there is a commonly held perception among some IRP stakeholders that including EE on the supply side using a Dynamic approach will increase the total amount of EE investment.

The Effects of Measure Bundling

In many cases, model constraints force resource planners to "bundle" EE measures by grouping individual measures into a smaller number of aggregated resources. Here we explored two different EE bundling methods: one in which EE measures are grouped based on their *cost*, and a second in which they are grouped based on an estimate of their *net system value*. *If extensive bundling of EE measures is required, this study found the Dynamic approach may not identify a portfolio of EE measures that is any more optimal than the portfolio identified using the Static approach.*

For the hypothetical electric company analyzed in this study, cost-based measure bundling led to significant over-investment in EE, producing estimates of total system costs similar to those of the Static cases. However, refinements to bundling methodologies, such as the value-based approach explored through this study, can significantly improve results.

The Relationship between Incentives and DR Participation

To incorporate DR into IRP models, it is necessary first to establish the costs and capabilities of each DR measure being evaluated. The "Standard approach" used by most resource planners is to represent each DR program as a unique combination of a single cost and a single associated estimate of peak load reduction capability. Implicit in this type of cost estimate is an assumption about the level of incentive payment that would be offered to participants to achieve the modeled level of participation and anticipated DR deployment.

In practice, however, the incentive payments offered in DR programs can be tailored specifically to the electric company's costs and system conditions. Under the "Detailed approach," this relationship between enrollment and incentives is accounted for in the IRP model. Rather than modeling each DR program as a single point-estimate of cost and impact, each DR program is modeled as having a plausible range of potential incentive costs and associated impacts. The impacts vary based on estimates of how enrollment would change at different incentive levels.

In this study, accounting for the relationship between incentives and enrollment resulted in twice as much DR being added by the IRP model, and a 4x reduction in system costs. Greater cost savings under this approach are attributable to reduced investment in new generation capacity, though those savings are partially offset by higher variable costs associated with running less efficient generating units to serve load.

Figure 2 illustrates the larger amount of DR that is selected by the resource planning model when accounting for the relationship between incentives and enrollment ("Detailed Approach"). As shown, when using the "Standard" approach, the resource planning model would have assumed that only 367 MW of DR capacity is available at a cost of $80/kW-yr, while using the Detailed approach the model would have assumed a much larger 694 MW of capacity would be available at the same $80/kW-year cost.

DR "Investment Flexibility" Value

Typically, developing new DR programs does not require the same kind of long-term investment commitment as developing new conventional generation assets. DR program enrollment and costs can be scaled down if peak demand forecasts unexpectedly fall. Conventional generation sources do not have this same type of flexibility. Conversely, DR "capacity" also can be scaled up relatively quickly if load expectations increase, whereas conventional assets may have longer development lead-times. As such, DR has "investment flexibility value."

When load growth expectations are asymmetrically skewed toward lower-than-planned growth, planners may explicitly account for DR's investment flexibility value by adjusting DR resource cost assumptions. In other words, if there is a disproportionate risk that the load forecast will, in reality, be lower than the forecast in the resource plan, then an adjustment that reduces the cost of DR measures would lead to a more optimal planning outcome. This "least-regret planning outcome" would increase the total system costs relative to the perfect foresight planning outcome, however the cost would still be lower than the cost that would result from "getting the load forecast wrong."

In this study's analysis, such an adjustment would reduce the expected net costs of load forecast error. However, this finding — that accounting for investment flexibility value will reduce expected costs — depends on the nature of the load forecasting error(s). When load growth expectations are asymmetrically skewed toward *higher*-than-planned growth, this study found that "overbuilding" DR would not reduce expected costs. In other words, the value of modeling adjustments to account for the investment flexibility value of DR depend on if an electric company has a view as to whether load is more likely to be higher or lower than the forecast in the resource plan.

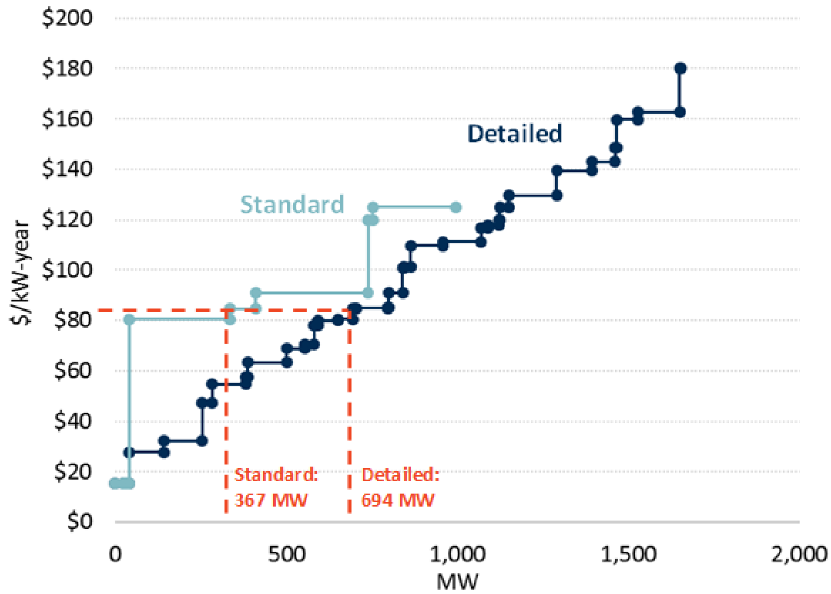

Figure 2. Standard and Detailed DR Supply Curves with Modeled DR Amounts

Note: The figure illustrates two DR supply curves. The "Standard" approach (shown as the light blue line) represents each DR measure as a single point-estimate reflecting a single assumed participation rate and incentive payment. The "Detailed" approach (shown as the dark blue line) models each DR measure as a plausible range of potential incentive costs and associated enrolment and impacts.

Conclusions

In an environment of increasing DER adoption, robust accounting for the impacts of EE and DR deployment has become an important consideration for resource planners. This study has shown there are opportunities to increase the sophistication with which DR and EE resources are represented in standard IRP and other resource planning modeling processes, especially given the increasing penetration of these resources. Benefits of these refined approaches could lead to more optimal resource investment and reduced system costs. The value of these approaches, however, hinges on the feasibility of their implementation. Additional effort will be required, at least initially, to develop this capability, and some existing IRP modeling platforms may be better suited to implement the methodologies explored in this study than others.

EPRI Resources

Incorporating Distributed Energy Resources into Resource Planning: Energy Efficiency. EPRI, Palo Alto, CA: 2019. 3002016493.

Incorporating Distributed Energy Resources into Resource Planning: Demand Response. EPRI, Palo Alto, CA: 2019. 3002016568.

Acknowledgements

The following organization, under contract to the Electric Power Research Institute (EPRI), prepared this Technical Brief:

The Brattle Group		
R. Hledik	S. Sergici	R. Lueken
T. Lee	J. Moraski	

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3002019626 August 2020

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