NARUC
National Association of
Regulatory Utility Commissioners

NARUC-NASEO TASK FORCE
ON COMPREHENSIVE
ELECTRICITY PLANNING

NASEO
National Association of
State Energy Officials

Opportunities to Improve Analytical Capabilities towards Comprehensive Electricity System Planning

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Background and Purpose

The National Association of Regulatory Utility Commissioners (NARUC) and the National Association of State Energy Officials (NASEO), in partnership with the United States Department of Energy (DOE), launched the Task Force on Comprehensive Electricity Planning in 2018. The Task Force, composed of NARUC and NASEO members from fifteen diverse states, was established to develop new approaches to better align electricity planning processes and create tools and roadmaps for all NARUC and NASEO members to adapt and refine for use in their states. This two-year initiative provided a forum for the development of state-led pathways toward planning a more resilient, efficient, and affordable grid that will best support evolving state policies. For more on the scope of the Task Force or the other supporting documents referenced below, see https://www.naruc.org/taskforce/.

As part of this initiative, Task Force members identified opportunities to improve analytical capabilities that could enable comprehensive electricity system planning. These include data, tools and methods for conducting integrated analyses across key points in electricity planning processes that would help achieve the visions of the Task Force. Through internal Task Force conversations and by engaging industry leaders and subject matter experts, the group identified capabilities that could make aligned planning an actionable objective. The material is intended to reflect the aspirations and insights expressed during Task Force meetings, workshops and interviews but are not intended to advocate for or prescribe a particular approach or method.

> ***Electric power system planning will need to address a broader range of needs related to evolving objectives, including those tied to resilience, cybersecurity, decarbonization and electrification***

This document provides a summary and synthesis of Task Force outputs related to tools and methods needed to support greater alignment between resource, transmission and distribution planning processes. These capabilities, methods, tools and approaches can form the basis of a future gap analysis and research agenda to identify the capabilities, methods, and tools that could have the greatest impact in advancing these objectives.

The discussion below draws a contrast with traditional planning efforts but does not attempt to catalog the capabilities of current planning tools nor describe where the planning capabilities described here represent a departure from what available methods and models can deliver. Rather, the focus is on data needs and modeling capabilities, not details about specific models, particular methodologies or comparisons between alternative analytical approaches.

The Task Force's five state team cohorts each developed a unique vision[1] for aligned planning to meet their respective objectives. The sections below provide examples of the implications stemming from the Task Force visions and the ways planning could evolve to reflect the changing landscape of resources connecting to the grid and emerging objectives of the system. While the elements of these five visions vary significantly across cohorts, several common themes related to the technical capabilities of planning tools emerged. These include (1) a recognition that the power system will need to address new objectives, (2) a common desire to ensure that planning considers a broad set of system resources to meet those objectives, and (3) that new data sources and new planning tools will be needed to enable evaluation of all resources on an equal basis.

1. New Objectives, Emerging Needs

Traditional planning efforts have focused on objectives such as meeting reserve margin requirements, mitigating transmission congestion, evaluating contingencies, and addressing distribution system voltage, thermal and protection requirements. However, Task Force members recognized that the electric system planning will need to address a broader range of needs related to evolving objectives, including those tied to resilience, cybersecurity, decarbonization and electrification. This will require setting and defining new planning objectives, incorporating those goals into planning criteria and establishing a means to measure progress against those objectives.

These capabilities, methods, tools and approaches can form the basis of a future gap analysis and research agenda to identify the capabilities, methods, and tools that could have the greatest impact in advancing these objectives.

In some cases, the "new planning requirements" in Figure 1 represent extensions ongoing efforts such as the integration of variable energy resources like wind and solar or valuation of energy storage serving long- and short-duration applications. While these are not new, continued advancements will enable planners to capture the impact of higher penetration rates of these resources commensurate with evolving policy requirements.

These new requirements in Figure 1 also refer to characteristics such as inertia and dynamic voltage support. More explicit representation of these might be needed as central station generators retire and as the penetration of inverter-based resources increases. Planning objectives that have been met implicitly in the past when all generation options were large,

[1] Task Force materials, including individual cohort roadmaps are available at https://www.naruc.org/taskforce/

rotating machines may now need to be addressed explicitly to address emerging trends in short circuit ratio and related metrics.

In addition, the Task Force identified the need to address the "emerging requirements" in Figure 1 that are not typically addressed in system planning. These could include the need to address adaptation to climate change, environmental justice and energy equity considerations. These represent objectives that have garnered significant attention in public policy contexts but for which planning approaches are still nascent.

Task Force members noted that grid capabilities will continue to evolve to meet societal needs and each cohort outlined interfaces for state policy to inform planning objectives. Implementation of these objectives could require the definition of metrics to reflect the resilience of the system and its ability to withstand and recover from long-duration outages. This could also include more rigorous approaches to quantifying system flexibility to mitigate net load variability over a range of characteristic timescales.

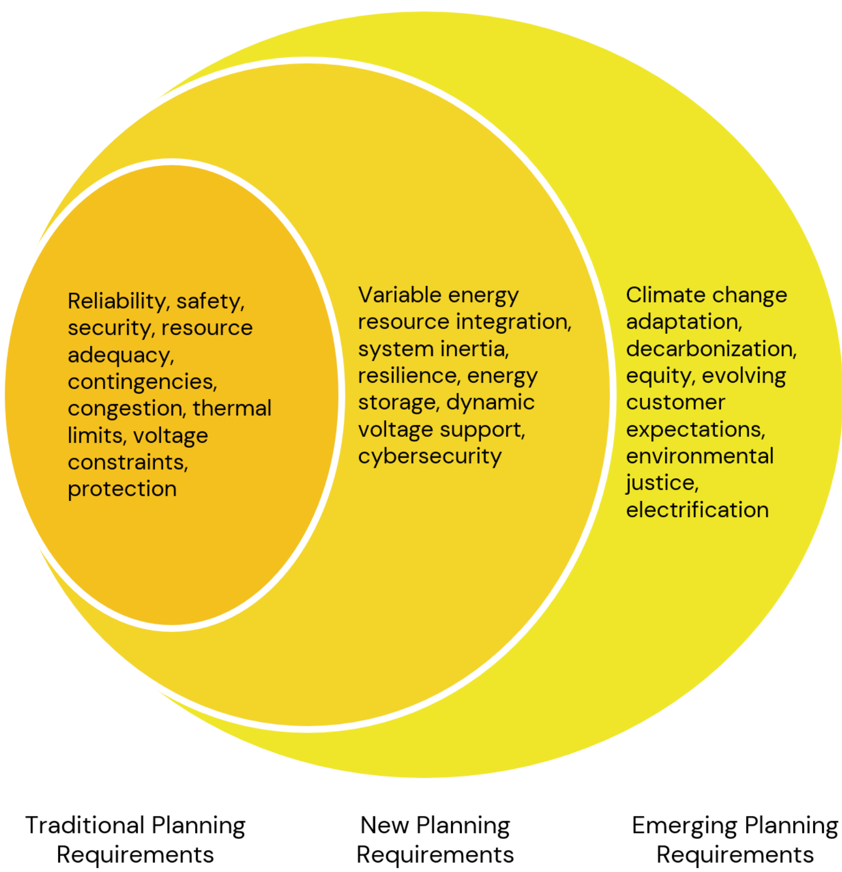

Figure 1 Evolving System Planning Objectives, Criteria

Members noted the importance of effective risk management approaches and incorporation of emerging requirements such as energy equity, resilience and system efficiency in realizing intended outcomes. Being able to plan for these objectives requires the quantification of new metrics and planning criteria that embody those goals if standard definitions are not available. The establishment of new objectives to drive planning in this way implies a strong policy and regulatory role to establish clear goals by which to measure plan outcomes. It also means that the impact of resources on system needs must be evaluated in a way that reflects the unique characteristics of each resource type. Defining objectives and establishing the means by which to measure them provides the first step toward realizing improved planning outcomes.

2. Expanded Solution Options

Each of the Task Force cohorts recognized the value in leveraging all available resources to meet these new and emerging needs. This includes reflecting the impacts that resources have on both the distribution system and the bulk power system (BPS) as well as quantifying their contributions toward meeting the evolving set of system needs described above. It also means incorporating the contributions of energy efficiency, demand response and flexible load as resources on an equal basis with traditional supply-side options.

The cohorts noted that to the extent that distributed energy resources (DER) can have an impact on transmission, distribution and resource needs across both traditional and emerging system objectives, it is essential that they be evaluated on an equal basis with traditional solutions.[2] One cohort described this need for holistic solution identification in terms of "a combined set of solution options to meet identified needs across all the distinct planning processes, to enable a whole-system review of options to determine the optimal set of solutions that collectively meet all the needs." Another cohort noted that "a comprehensive range of potential solutions" should include traditional "wires" solutions (i.e., traditional infrastructure investments such as substations, transformers, wires, etc.), non-wires solutions (e.g., targeted deployments of DERs that defer or avoid the need for a wires investment), utility operational changes or maintenance activities, third-party or customer-based solutions, and rate designs.

> ***Evaluation of DER impacts across transmission, distribution, and resource to address emerging planning needs requires evaluation on equal basis with traditional solutions.***

Taking this broader, holistic approach to solution identification and solution evaluation implies new planning capabilities and analysis requirements. First, the **visibility of the planning process must directly or iteratively extend to all relevant subsystems of the system** in order to capture the impact those resources have in each process. Second, planning tools must also be able to **capture all the dimensions of resource value** relevant to the objectives described above. Finally, the model must accurately **capture the quantities and costs of resource supply at each location**.

Visibility

There are several approaches to mitigate limited model visibility that range from attempting to represent the full system to running ensembles of tools iteratively. The result is planning

[2] For more details on each cohort's approach to incorporating a broader ensembles of solutions in planning see the individual cohort roadmaps posted at https://www.naruc.org/taskforce/

analyses that better reflect the impact of resources across the system and which reflect the tradeoffs between bulk system resources and distributed resources for meeting planning objectives.

Traditional capacity expansion models and transmission models lack visibility down to the distribution system. Similarly, distribution power flow tools typically only represent a small portion of the system and don't attempt to capture all bulk system dynamics. As a result of this limited scope, planning tools often rely on approximations of the rest of the system to impose appropriate boundary conditions for the relevant calculations. While this kind of iterative modeling approach can be efficient and effective, the assumptions upon which those approximations are based must be continually updated and expanded based on detailed modeling of the rest of the system to ensure that the boundary conditions are accurate and appropriate. In other words, it's not always necessary to explicitly model the full system in each planning process, but the representation of the rest of the system through equivalent reduced-form representations must be benchmarked and calibrated against detailed modeling.

In other cases, the need for increased visibility in planning could imply the need for large-scale integrated models that span the full system. Explicit modeling of the full system might be possible depending on the temporal and geospatial granularity, the time horizon and physical extent of the model, and the nature of the quantities being modeled. The specific capability needed will depend on the requirements of the system, the planning objective being addressed, and the resource characteristics that need to be reflected in the relevant models.

Value

The second dimension the Task Force considered were improvements in resource valuation. This includes reflecting the value of resources to meet the new and emerging system needs described above. But it also implies the need to better reflect resource characteristics to account for new types of resources such as energy-limited resources like energy storage or resources with variable system location like electric vehicles and mobile generators.

Cost comparison tools must also meaningfully compare assets that have vastly different expected lifetimes, e.g., 50 years for transmission, 25 years for distribution, 10 years for battery storage. In a period of rapid technology developments and transition of the supply fleet, shorter-lived assets offer a type of option value that can allow for re-evaluation of needs and reduce the risk of stranded assets. By reflecting the full range of possible solutions and relevant system characteristics, planning tools can better identify the portfolio of resources to meet system objectives.

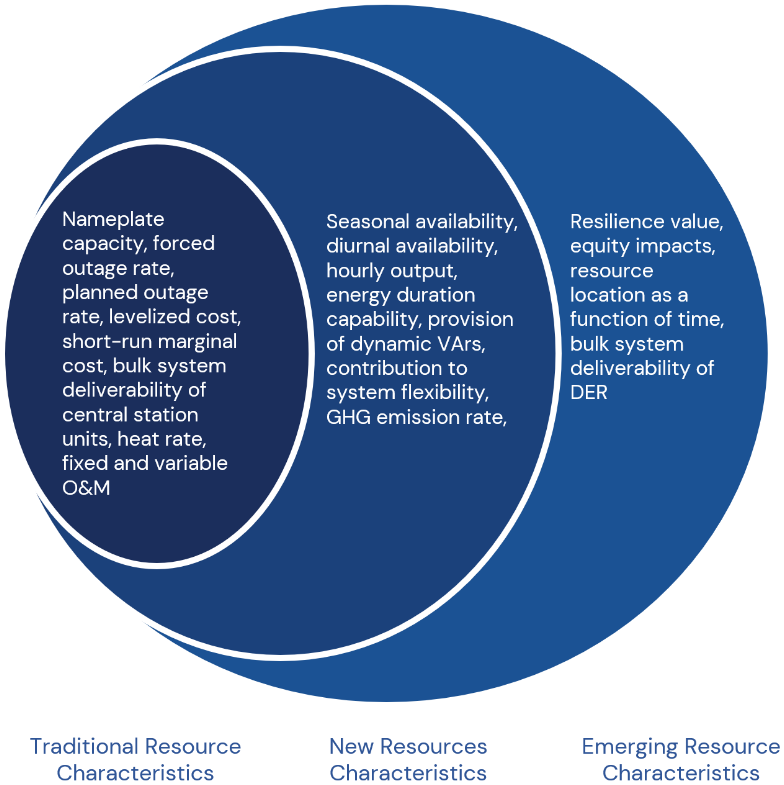

Figure 2 Evolving system resource characteristics for aligned planning

Supply

While increased visibility and improved reflection of resource value enables planning tools to identify the best mix of resources to meet system requirements, these are subject to locational supply considerations as well. Some Task Force cohorts discussed the need for a composite supply curve that would reflect the quantity of each type of resource that could meet both local requirements and bulk system needs. This requires detailed location-based information about the characteristics of resources at each relevant location and the characteristics of congestion and deliverability that informs the ability of resources to meet those needs. This, coupled with accurate cost information, could form the basis of a supply curve measured against each of the various objectives defined for the relevant planning process. This might be accomplished through the development of supply curves that capture not only capacity value, but also the other dimensions of system need, and the full range of planning objectives described above.

Taken together, these elements allow for consideration of all resources on an equal basis. The increased visibility puts all resources together in a composite view of system supply. The comprehensive view of resource value allows for comparison of resource across all salient characteristics relevant to that planning process. The added dimension of supply identifies the quantities available at varying prices at each location to meet system needs to form a composite view of available resources to meet an evolving set of system requirements.

3. Planning Inputs and Methods

Realizing better planning outcomes through more expansive treatment of all resources requires detailed data inputs and innovative planning methods that can accurately quantify relevant system attributes in a way that reflects the unique characteristics of each resource. Being able to accurately reflect the characteristics of DER on the system means capturing output characteristics, locational dimensions, growth rates and customer behavior. This includes not only individual customer supply and demand, but also aggregator dispatch decisions. Both customer and aggregator supply and demand characteristics could themselves be a function of factors such as retail tariff design and wholesale market dynamics.

Capturing these dynamics depends on high quality data to characterize resources and enable accurate solution evaluation. For example, planning inputs and approaches could include more granular data inputs, better use of system monitoring data, new methods for forecasting and scenario development, improved device models that capture behavior over a broader set of characteristic timescales and tools with enhanced visibility across distribution and the bulk power system.

The Task Force cohorts reflected elements of data needs in their roadmaps. One cohort noted that "early in the process developers of DER will need information on distribution circuit-level hosting capacity in order to target DER development to locations with available capacity." Another group found that forecasts should have "adequate data standardization and incorporates scenario analysis to capture policy uncertainties." These underscore the view that planners should source high quality information to plan against a range of possible future scenarios and to ensure that benefit-cost assessments evaluate all solutions equivalently.

Task force members discussed several aspects of these data and modeling challenges and several possible approaches for addressing them. One central theme emerged around the need for improved distribution modeling capabilities and tools to **reflect emerging capabilities of DER and accurately reflecting their limitations**. This included the recognized need for new device models (e.g. inverter models) to reflect DER impact on bulk system response and system dynamics. For example, planning should not only reflect the cost of system upgrades stemming from bulk system deliverability requirements for DER to provide bulk system services, but also the value of grid-support functions that DER can provide via autonomous and advanced smart inverter settings.

Another dimension of the discussion centered around the need to better characterize expectations and system performance requirements for non-wires alternatives in a way that leverages the unique characteristics of distributed resources rather than requiring DER aggregations to mimic traditional solutions. This points not only to the need for more flexible system planning criteria, but also more detailed data inputs that characterize aggregation output in a way that can give grid operators confidence in their performance capabilities and reliability contribution.

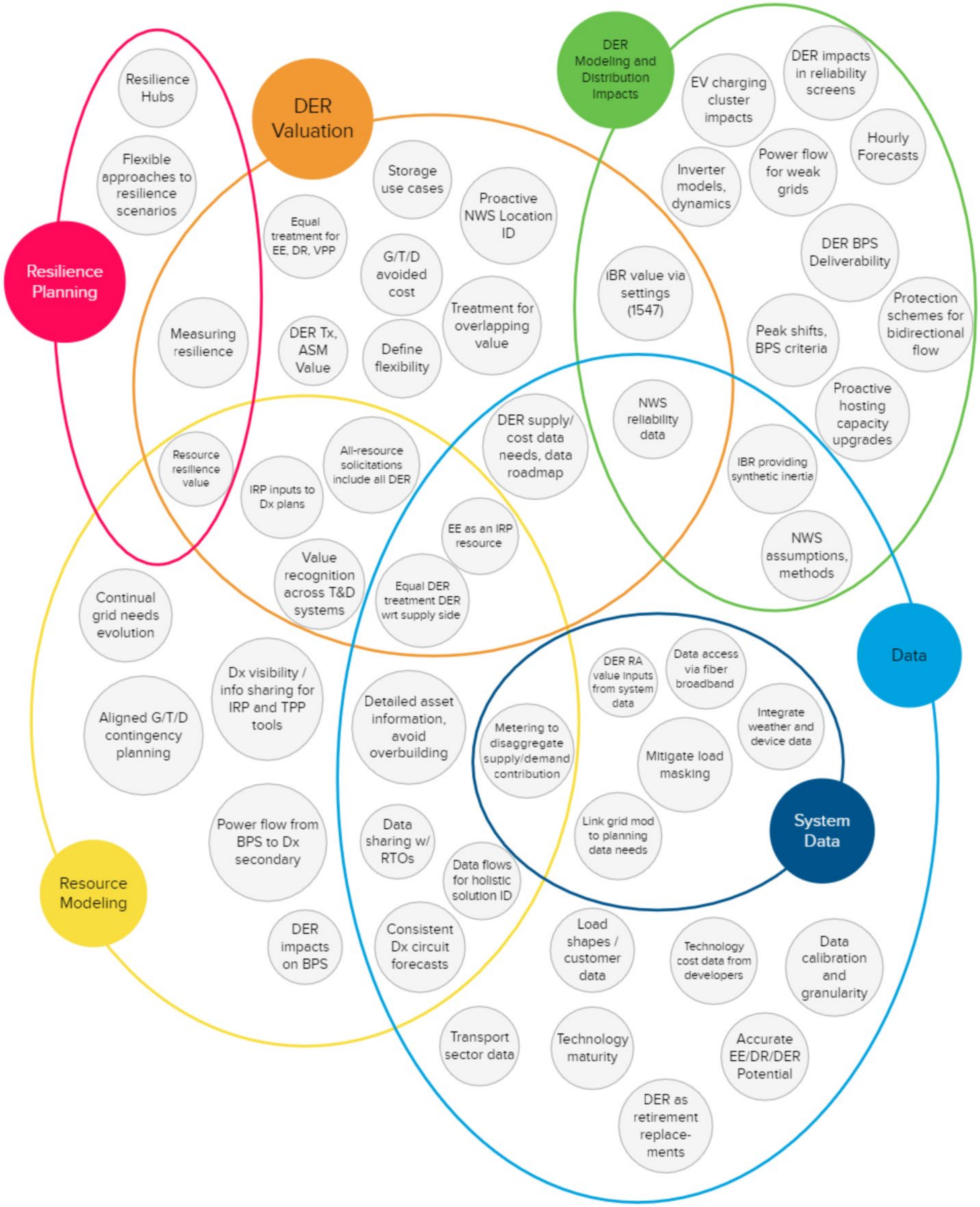

Figure 3 Task Force interviews with planning SMEs identified a set of considerations and planning requirements needed to realize the cohorts' visions for aligned planning

The use of **system monitoring information** emerged as still one more theme in this context. Figure 3 (see previous page) summarizes some of the themes that emerged, including topics related to data needs, data roadmaps and the use of system data to advance planning analyses. While systems for sensing, measurement, analysis and control are typically not primarily deployed to inform system planning, these can improve the fidelity of planning inputs and forecasts and significantly improve the quality of planning results. Leveraging data from advanced metering infrastructure, supervisory control and data acquisition systems, line sensors, as well as third party device data can enable planners to better manage risk by improving the precision and accuracy of inputs and models. This can inform load allocations, power flow modeling, circuit level forecasts, system level forecasts and a host of other planning functions.

As shown in Figure 3, data themes intersect with aspects of distribution modeling, DER valuation, and resource planning. This figure illustrates breadth of issues and the relationships across the themes that emerged in the context of the Task Force initiative.

Conclusions and Next Steps

The road toward better planning starts with a clear statement of policy objectives the electricity system must support, which informs the development of planning criteria and the identification of resource characteristics needed to achieve those outcomes. Improved data, inputs, models and methods can enable planners to leverage the broadest possible set of solutions and ensure that all resources are evaluated on an equivalent basis and reflects the unique characteristics of each. These capabilities help define a path toward achieving better outcomes and realizing the promise of aligned planning that the Task Force cohorts have envisioned.

Next steps could include a detailed gap analysis to determine which of these analytic capabilities are available already. Many tools are already available to address many of these challenges and the landscape of these tools is advancing rapidly. A gap analysis could take stock of current progress toward these analyses and identify high impact advances that could accelerate progress toward the kind of aligned planning that the cohorts have defined. This could help inform prospective research and development activities or other supportive activities aimed at supporting the continued advancement of electric system planning.

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