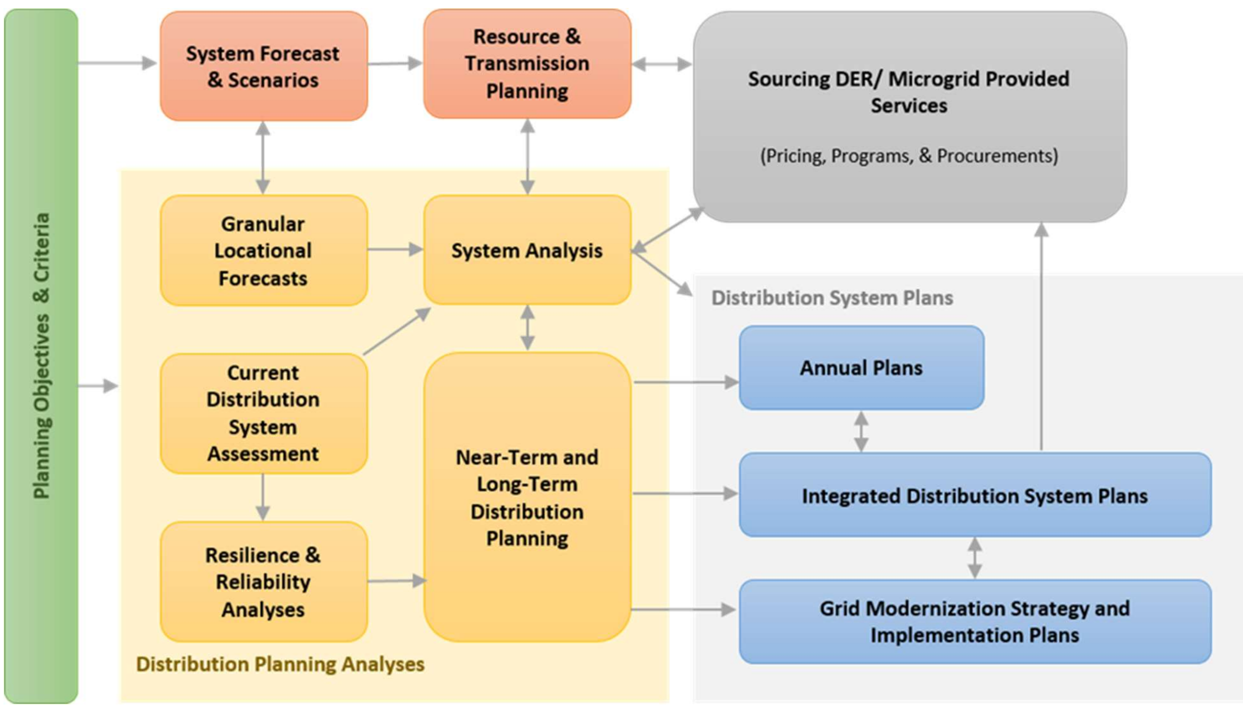
Planning Objectives and Metrics for Integrated Distribution Planning Processes

View of an Integrated Distribution Plan (IDP) Process

A detailed view of an integrated distribution planning process is provided in **Figure 1** which shows the various elements and their relationships. The process begins with a set of well-defined planning objectives and criteria which typically take into account policy goals, customer expectations and preferences, and foundational requirements related to ensuring the security, resilience, and reliability of the electric grid.

Figure 1 – Integrated Distribution Planning Process

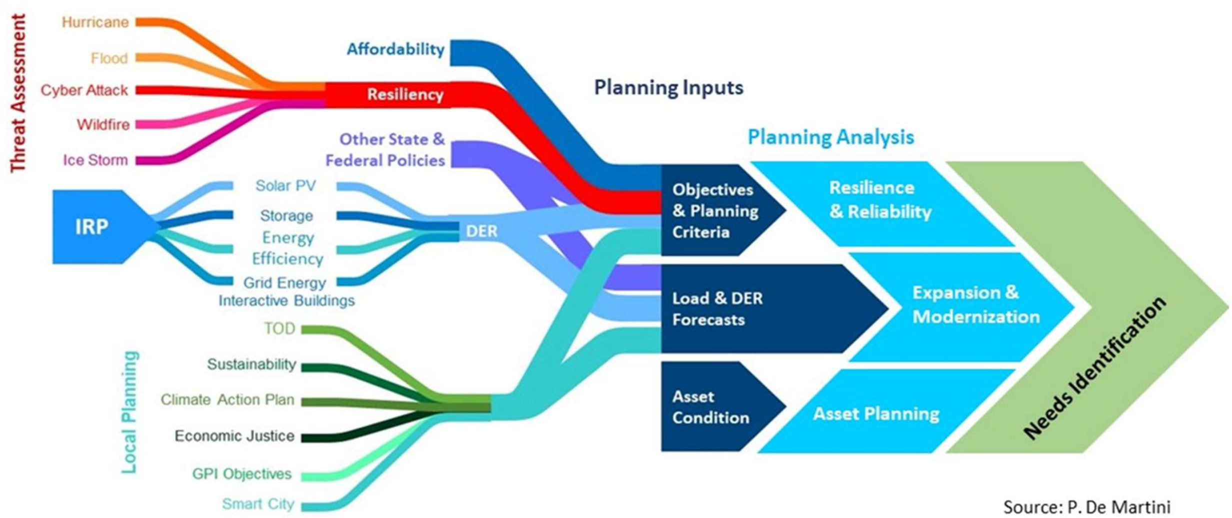


Distribution system planning has become more complex as we now need to develop strategies for integrating and utilizing increasing levels of distributed energy resources[1] (DERs), the interaction and contribution of resources across the transmission and distribution systems, and the translation of multiple objectives into investment strategies. Smart grid technologies (i.e., sensing, communication, control, and computing technologies) are required for enabling the advanced functionality envisioned for the electric grid. Regulators and utilities often apply the term *grid modernization* to represent the

[1] DERs are resources sited close to customers that can provide all or some of their electric power needs or can be used by the system to either reduce demand (such as improve energy efficiency) or provide supply to satisfy the energy, capacity, or ancillary service needs of the grid. The resources are small in scale, connected to the distribution system, and physically close to the load. Examples of DER types are solar photovoltaic (PV), wind, combined heat and power (CHP), energy storage, demand response (DR), electric vehicles (EVs), microgrids, and energy efficiency (EE).

deployment of advanced grid capabilities. In addition, considerations of resilience, equity, and sustainability as inputs into the planning process has shifted how we evaluate alternatives from an approach based mostly on economics basis to one that includes both economic and societal concerns. Inputs into the IDP process are shown in Figure 2.

Figure 2 – IDP Inputs



Planning Objectives and Criteria

The starting point for an IDP, especially if it will need to determine grid modernization investments, is to consider the existing **mission** and **guiding principles** developed for a community or jurisdiction. In some cases, a utility may have developed a set of guiding principles. In any case, these principles provide the foundational reference for the logical structure of a functional taxonomy.[2] Principles serve to inform the development of objectives and subsequent strategies and plans for grid investments.

An example of jurisdictional principles from the Missouri Public Service Commission:[i]

"*We will:*

- *ensure that Missourians receive safe and reliable utility services at just, reasonable and affordable rates;*
- *support economic development through either traditional rate of return regulation or competition, as required by law;*
- *establish standards so that competition will maintain or improve the quality of services provided to Missourians;*

[2] A functional taxonomy for mapping grid capabilities and functional requirements against planning objectives is provided in Volume 1 of the Next-Generation Distribution System Platform (DSPx) Modern Distribution Grid Report. See: https://gridarchitecture.pnnl.gov/modern-grid-distribution-project.aspx.

- *provide the public the information they need to make educated utility choices;*
- *provide an efficient regulatory process that is responsive to all parties, and perform our duties ethically and professionally."*

An integrated planning process, as described in an example from the Minnesota Public Utilities Commission,[ii] is necessary to achieve "comprehensive, coordinated, transparent, integrated distribution plans" to:

- *"Maintain and enhance the safety, security, reliability, and resilience of the electricity grid, at fair and reasonable costs, consistent with the state's energy policies.*
- *Enable greater customer engagement, empowerment, and options for energy services.*
- *Move toward the creation of efficient, cost-effective, accessible grid platforms for new products and services, with opportunities for adoption of new distributed technologies.*
- *Ensure optimized use of electricity grid assets and resources to minimize total system costs."*

The Minnesota Commission also notes that this planning process will provide information that it can use to understand near-term and longer-term distribution system plans, cost-benefit analyses for particular investments, and analyses of impacts to ratepayer cost and value.

Overarching principles and mission statements may in turn be used to define a set of guiding principles for grid modernization strategy and planning development. As an example, the guiding principles below were adopted in Hawaii by the Hawaiian Electric Companies:[iii]

- *"Enable greater customer engagement, empowerment, and options for utilizing and providing energy services.*
- *Maintain and enhance the safety, security, reliability, and resiliency of the electric grid, at fair and reasonable costs, consistent with the state's energy policy goals.*
- *Facilitate comprehensive, coordinated, transparent, and integrated grid planning across distribution, transmission, and resource planning.*
- *Move toward the creation of efficient, cost-effective, accessible grid platforms for new products, new services, and opportunities for adoption of new distributed technologies.*
- *Ensure optimized utilization of resources and electricity grid assets to minimize total system costs for the benefit of all customers.*
- *Determine fair cost allocation and fair compensation for electric grid services and benefits provided to and by customers and other non-utility service providers."*

The Ohio Public Utilities Commission (PUCO) developed the following principles and objectives for their PowerForward Initiative:[iv]

"Principles – foundational tenets to guide PUCO grid modernization decisions:

- *Do No Harm – maintain the delivery of safe, reliable electric service at fair prices while the industry advances in grid modernization.*
- *Provide Net Value to Customers – insist that EDUs spend ratepayer dollars wisely and in a manner that delivers eventual net value to the customer.*
- *Create an Environment that Fosters Innovation – support and develop opportunities within the stakeholder community and at the PUCO that fosters innovation in technology and regulation.*

- *Enhance the Experience for All – ensure that investments and the environment fostered create societal benefit and allow for an enhanced customer electricity experience accessible to all customers.*

Objectives – desired outcomes from PUCO grid modernization decisions:

- *A Strong Grid – a distribution grid that is reliable and resilient, optimized and efficient and planned in a manner that recognizes the necessity of a changing architectural paradigm.*
- *The Grid as a Platform – a modern grid that serves as a secure open access platform— firm in concept and as uniform across our utilities as possible—that allows for varied and constantly evolving applications to seamlessly interface with the platform.*
- *A Robust Marketplace – a marketplace that allows for innovative products and services to arise organically and be delivered seamlessly to customers by the entities of their choosing.*
- *The Customer's Way – an enhanced experience of the customer's choosing on the application side, whether for reasons arising from financial, convenience, control, environmental or any other chosen consideration."*

Each jurisdiction or utility will have very specific principles, missions, or grid modernization guidelines in relation to their situation and needs. The examples above are provided only to illustrate the type of information that may exist or could be developed to shape the direction of distribution system planning.

Timing and Scope

Grid modernization planning, as part of an IDP process, is a rigorous engineering-economic activity that should be driven by clear objectives; otherwise, it becomes difficult to assess whether resulting plans are responsive, and key stakeholders may not accept them. It is important for each jurisdiction or utility to define the scope of grid modernization through a unique set of objectives based on their guiding principles and timing considerations with respect to DER adoption and resilience concerns. Objectives are associated with improving existing capabilities or adding new ones, often related to improving customer experience or system characteristics.

It is important to consider that **an objective is a goal or outcome with an associated timing and/or performance metric**. For example, objectives may include a) specific customer, policy, and/or business outcomes and b) associated timing and/or performance requirements. Objectives inform what is needed by when and guide the subsequent steps in the process. In practice, identifying objectives or goals without an understanding of the price tag is a significant challenge and has led to sticker shock.

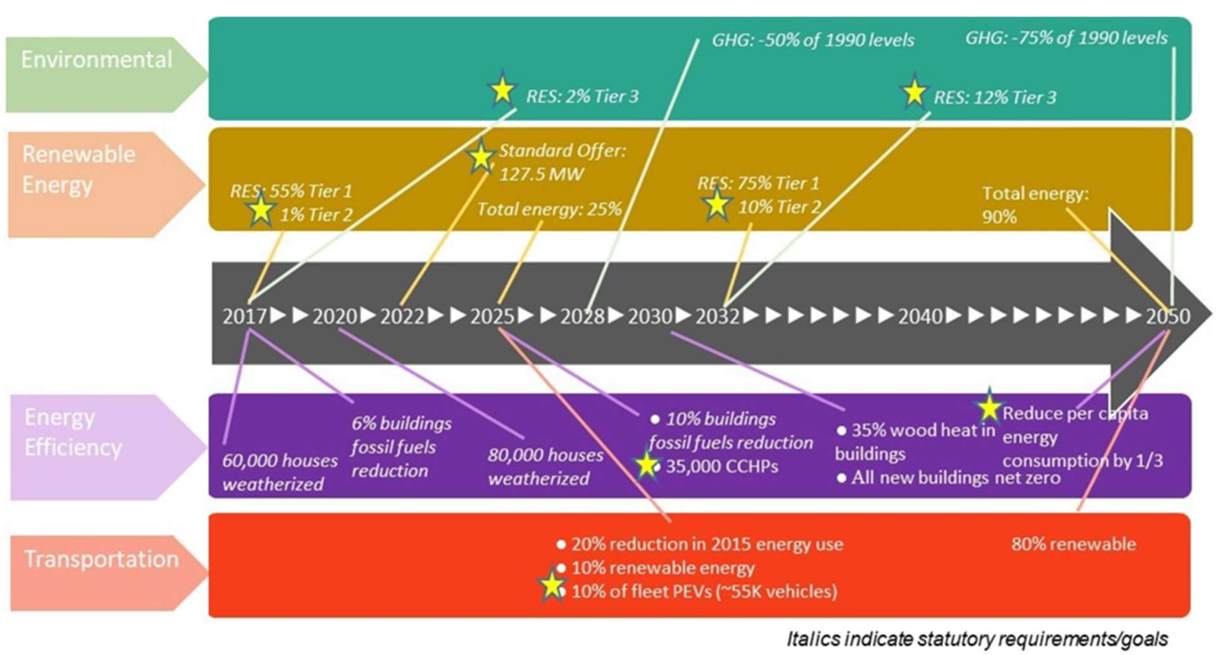
Figure 3 provides a list of objective categories. This is offered as a reference to use in developing jurisdiction/utility-specific objectives that may align to these or to other categories, owing to each jurisdiction's and utility's unique set of circumstances.

Figure 3 – Objective Categories

Any strategy or planning effort requires clear direction on *"what"* the desired outcomes are. Planning also needs a sense of *"when"* the outcomes are expected. These timing expectations set an important constraint that informs the later steps in the overall process, which will involve a realistic evaluation of what is achievable within a given timeframe as well as assessing technology maturity in relation to when it is needed. Strategic investment planning of this type, given the relatively long life of grid modernization investments and certain deployments, may benefit from a time horizon of at least 5 years and perhaps up to 15 years.

Objectives can often be derived from legislative and/or executive orders. For example, Vermont's overall policy drivers include clear objectives and timelines with grid modernization implications, shown in Error! Reference source not found.**4**.[v]

Figure 4 – Vermont Policies with Grid Modernization Implications



Planning Criteria

Planning criteria are system design and operating parameters established to ensure safe and reliable grid operation under normal, transient, and contingency conditions, and they must be considered in planning processes. Such criteria often define requirements for the management of current thermal limits, voltage, and frequency, as well as service quality to customers.[3] They are often expressed in national, state, and regulatory standards for service quality and reliability that are also codified in regulation. Regulatory standards also cover many other areas including clean energy, interconnection of distributed energy, resilience, and customer service.

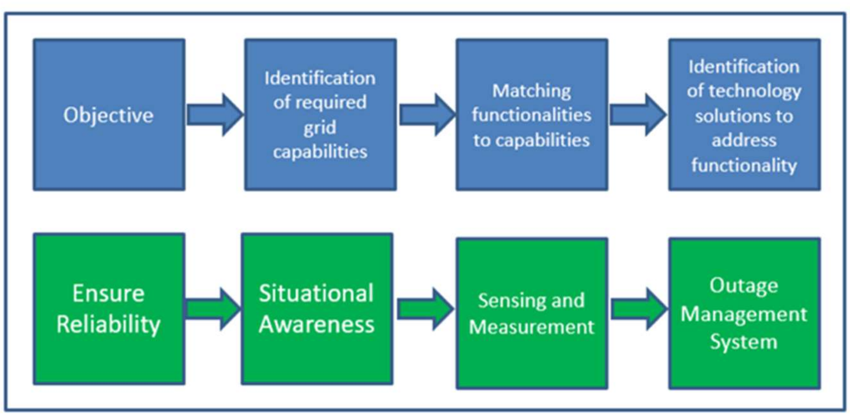
These standards define acceptable and unacceptable levels of distribution system performance, utility reporting requirements, and applicable incentives and/or penalties for utility performance.[4] They also establish the minimum performance requirements that any additional requirements, such as DER and microgrid integration and utilization, must not negatively impact.

Planning criteria will also be informed by resilience and reliability objectives. These objectives should be translated into engineering and operating criteria. For example, an objective to reduce customer outage exposure may involve designing the system to enable an adjacent circuit to pick up the load of a portion of another circuit. This N-1 contingency operating criteria will be translated into a limit on the normal loading of circuits to allow the emergency transfer of an adjacent circuit segment.

Translation of Planning Objectives into Technology Investments

Planning objectives and criteria set the direction for grid investments; likewise, it is important to trace all investment decisions back to objectives. Figure 5 depicts the logical structure of objectives driving new capabilities for outage management.

Figure 5 – Mapping of Grid Capabilities to Objectives (by the NH PSC)



[3] An example of a high-level planning criterion that would then guide more detailed engineering requirements may be articulated as follows: "neither end-use customer load nor interconnected customer generation shall cause any power quality-related issues to the utility grid or any utility end-use customer."

[4] An example of such a standard may be found in: Michigan Department of Public Labor and Economic Growth, Public Service Commission, *Service Quality and Reliability Standards for Electric Distribution Systems*, https://www.michigan.gov/documents/mpsc/Service_Quality_Standards_672262_7.pdf.

This "line of sight" reasoning facilitates a robust discussion of the interdependency of technology investments to support objectives. Conversely, if technologies are proposed without regard to objectives, capabilities, and functions, it would be nearly impossible to understand the reasonableness and logic of a grid modernization proposal. **Figure 6** provides examples of how the DSPx taxonomy[5] is used for mapping objectives capabilities, functions, and technologies.

Figure 6 – Examples of Technology Choices Mapped Back to Objectives

Objective	Capability	Function	Technology
Customer Choice through information access for small business & residential customers to support decision making by 2020	Provide online customer access to relevant & timely information	Remote meter data collection & verification Customer data management Energy management & DER purchase analysis	Customer Portal Customer Analytic Tools Greenbutton Smart Meter Telecommunications Meter Data Management System Customer Info System Data Warehouse
Reliability improvement by reducing customer unplanned outage durations Achieve 1st Quartile CAIDI Performance by 2020	Improve outage identification and customer service restoration	Fault Identification Fault Location Fault Isolation Service restoration	Fault Current Indicators Outage Notification from Meters Outage Management System Geospatial Information System Distribution Management System and/or SCADA Automated Switches Work Management System

[5] The taxonomy developed through the Next-Generation Distribution System Platform (DSPx) initiative is presented in *Modern Distribution Grid, Volume 1 – Objective Driven Functionality*, Version 2.0, November 2019 which is located at: https://gridarchitecture.pnnl.gov/modern-grid-distribution-project.aspx.

Metrics

Metrics provide a means of measuring operational performance with regard to expectations set by planning objectives. Below are examples of metrics associated with reliability, resilience and energy justice (equity).

Reliability Metrics:

The IEEE 1366 Standard[6] defines 12 reliability indices and provides guidance for calculating them. The most frequently monitored and reported indices include:

- The System Average Interruption Frequency Index (SAIFI) which equals how often the average customer experiences an interruption, where:
    - SAIFI = total number of customers interrupted/total number of customers served
- The System Average Interruption Duration Index (SAIDI) which equals the total number of minutes (or hours) the average customer experiences, where:
    - SAIDI = sum of customer interruption durations/total number of customers served
- The Customer Average Interruption Duration Index (CAIDI) which equals the average time required to restore service, where:
    - CAIDI = sum of customer interruption durations/total number of customers interrupted

These reliability indices may be applied across a utility's service area or portions of it and may cover specified periods of time, e.g., a year. In addition, SAIFI, SAIDI, and CAIDI are typically applied for *sustained interruptions* (i.e., those greater than 5 minutes) which may be caused by routine occurrences or major events, e.g., storms.

Resilience Metrics:

Significant work has been undertaken for developing metrics for measuring resilience performance and many of these apply the reliability indices described above. Resilience performance areas may include:[7]

- avoiding or reducing consequences to key electric infrastructure,
- avoiding or reducing consequences to priority customers, and /or
- avoiding or reducing consequences in key geographic areas.

Threat-based risk assessments can inform the development of resilience metrics by identifying key threats and assessing their impact on critical infrastructure and populations. The components of a stakeholder-driven, resilience planning process developed by the Hawaii Resilience Working Group are provided in Figure 7.[8]

[6] The IEEE 1366-2012 Standard is available at: https://ieeexplore.ieee.org/document/6209381.

[7] Approaches for developing resilience metrics are discussed within Performance Metrics to Evaluate Utility Resilience Investments, Sandia Report, SAND2021-5919, May 2021, which may be found at: Improving Electric Utility and Community Grid Resilience Planning | Synapse Energy (synapse-energy.com).

[8] Hawaii set up a Resilience Working Group. See June 1, 2021 report: https://www.hawaiianelectric.com/clean-energy-hawaii/integrated-grid-planning/stakeholder-engagement/working-groups/resilience-documents.

Figure 7 – Resilience Planning Components

Determine planning objectives and metrics	Sample Objectives (from Hawaii RWG): • Reduce outage risk during severe events • Increase ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially catastrophic event • Reduce restoration and recovery time following a severe event • Optimize cost (including capital and operating costs) • Return critical and priority customers' power within specified time • Return power to other customers within specified time Resilience Metric (from Hawaii RWG): Resilience Index that tracks restoration times with stated targets for critical, priority, and other customers
Identify and prioritize threats	Perform a threat assessment with key federal, state, and local stakeholders, as appropriate, to identify the potential threats and assess the risk of their probable impacts. See: FEMA Comprehensive Preparedness Guide (CPG) 201, Table 1, for a comprehensive list of threats (https://www.fema.gov/sites/default/files/2020-04/CPG201Final20180525.pdf)
Develop threat scenario reference cases	Develop reference cases for each threat scenario (e.g., low, moderate, severe) that characterize the threat and its impact on the grid, customers, and other critical infrastructures (e.g., hospitals, water/wastewater treatment, vulnerable individuals/populations, telecommunications, energy, and emergency services). Apply forecasts of future weather/climate threats.
Tiering and prioritization of key customers and infrastructure	Identify and prioritize key customers and infrastructure sectors with focus on system recovery and public safety and well-being: • Develop and apply criteria for identifying/prioritizing key customers and infrastructure based on priority and urgency. Categorize by tiers, e.g., Tier 1 represents critical customers/infrastructures, Tier 2 represents priority customers/infrastructures, and Tier 3 represents all others. (Hawaii criteria are on page 40.) Criteria development is a shared responsibility of the critical infrastructure sectors. • Alignment of tiering and prioritization needed with sectors/customers under existing emergency management, homeland security, and hazard mitigation/resiliency frameworks.
Determine capability gaps and solutions	Determine gaps in capabilities, including utility capabilities and self/back-up supply capabilities and requirements, and develop solutions. Apply cost-effectiveness framework (BCA vs least-cost/best-fit). Key customers and critical infrastructure owners/operators partner with utilities, other energy companies, and the government in developing local resilience solutions that can provide resilient power for essential service providers and enhance the overall resilience of the grid for all customers in mutually beneficial projects. Considerations include: • Implementing asset hardening practices, where needed • Developing and implementing load management/load curtailment capabilities • Maintaining ample onsite fuel supplies • Deployment of temporary emergency power generators • Partnering with utilities and the government to develop local microgrids • Utilizing grid-forming inverters so that renewables and DERS can provide a black-start capability • Ensuring availability of adequate road clearing equipment to speed recovery of key roads, etc.

Equity Metrics:

A review of energy equity metrics was undertaken by the Pacific Northwest National Laboratory (PNNL) for the U.S. Department of Energy's Office of Electricity.[9] DOE and PNNL continue to pursue how to incorporate energy equity into electric grid planning processes. PNNL has developed a set of sample metrics associated with the following four dimensions of energy justice:

- Distributive Justice:
  - Addressing the unequal allocation of benefits and burdens and unequal distribution of the consequences
  - Increasing affordability and availability
- Procedural Justice:
  - The fairness of the decision-making process
  - Allowing for due process, transparency, and accountability
- Recognition Justice:
  - Addressing the practice of cultural domination, disregard of people and their concerns, and misrecognition
- Restorative Justice:
  - The response to those impacted by the burdens of energy projects
  - Addressing intra- and inter-generational inequities

[9] See *Review of Energy Equity Metrics*, by Tarekegne, Pennell, Preziuso, and O'Neil, PNNL-32179, October 2021 at: https://www.pnnl.gov/publications/review-energy-equity-metrics.

  - Creating sustainability
  - Establishing responsibility

Sample metrics include:

- For Distributive Justice:
  - Report on likelihood of achieving zero disconnections of customers (from the electric grid), specifically disadvantaged communities (DACs). Benchmark and track trends in disconnections over the last twenty years, causes, and human conditions that drive disconnections, and a plan (including partnerships) to get to zero.
  - Measuring above-median reliability performance (analyze reliability on the circuit level, identify median performance) and rate/rank circuits with communities that are below-median economic conditions and how to move them to above median (above others) performance.
  - Eliminating acute energy burden – examine sets of customers (not necessarily spatial) for whom energy affordability is acute, esp. seasonally, or energy burden is acutely dependent due to vulnerability such as medical devices, and resolve the acuteness of those burdens.
- For Recognition Justice:
  - Population identification and recognition, specifically DACs where targeted planning, programs, and analysis (benefit and consequence) is being looked at.
  - Land sovereignty violations
  - Disconnection policies protecting vulnerable populations
- For Procedural Justice:
  - Analyzing demographics of participants in planning processes, including within public hearing/response/testimony efforts, and identifying communities and individuals, specifically from Disadvantaged Communities (DACs) who are not participating in such processes.
  - Determining whether the responsiveness of planning processes to public participation are fair and decisions are fair and equitable. Tracking responsiveness to community in relation to community type.
    - Example: Does an affluent community member get a response in 48 hours versus a DAC family whose English is not a first language, so is placed toward the end of the response list?
- For Restorative Justice:
  - Access to community choice aggregation or virtual utilities
  - Treaty violations for construction of energy infrastructure
  - Partnerships of land/resources with indigenous/tribes and clean energy development

References

[i] Missouri Public Service Commission, "Mission Statement," accessed June 2020, https://psc.mo.gov/General/About_The_PSC.

[ii] Minnesota Public Utilities Commission, *Minnesota Integrated Distribution Planning Requirements For Xcel Energy*, August 30, 2018, Docket E002/CI-18-251, accessed June 2020, https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId=%7BF05A8C65-0000-CA19-880C-C130791904B2%7D&documentTitle=20188-146119-01.

[iii] Hawaiian Electric Companies, Hawaii PUC Decision and Order 35268, Grid Modernization Strategy Approval, Docket No. 2017-0226, accessed June 2020, https://www.hawaiianelectric.com/Documents/about_us/investing_in_the_future/dkt_2017_0226_2018_02_07_PUC_decision_and_order_35268.pdf.

[iv] PowerForward consisted of three phases: 1) the business case for pursuing grid modernization, 2) a deep dive into the engineering of the grid, and 3) a discussion of the elements that would create the modern grid along with the ratemaking/rate design that would best accompany this evolution. See: https://puco.ohio.gov/wps/wcm/connect/gov/38550a6d-78f5-4a9d-96e4-d2693f0920de/PUCO+Roadmap.pdf?MOD=AJPERES&CONVERT_TO=url&CACHEID=ROOTWORKSPACE.Z18_M1HGGIK0N0JO00QO9DDDDM3000-38550a6d-78f5-4a9d-96e4-d2693f0920de-nLBoZhy.

[v] Office of Electricity Delivery and Energy Reliability, "Strategic Planning for Grid Modernization: DSPx Phase 2" PowerPoint presentation provided at New England Conference of Public Utility Commissioners (NECPUC) Vermont Sessions, October 9, 2018, accessed June 2020, http://necpuc.org/.