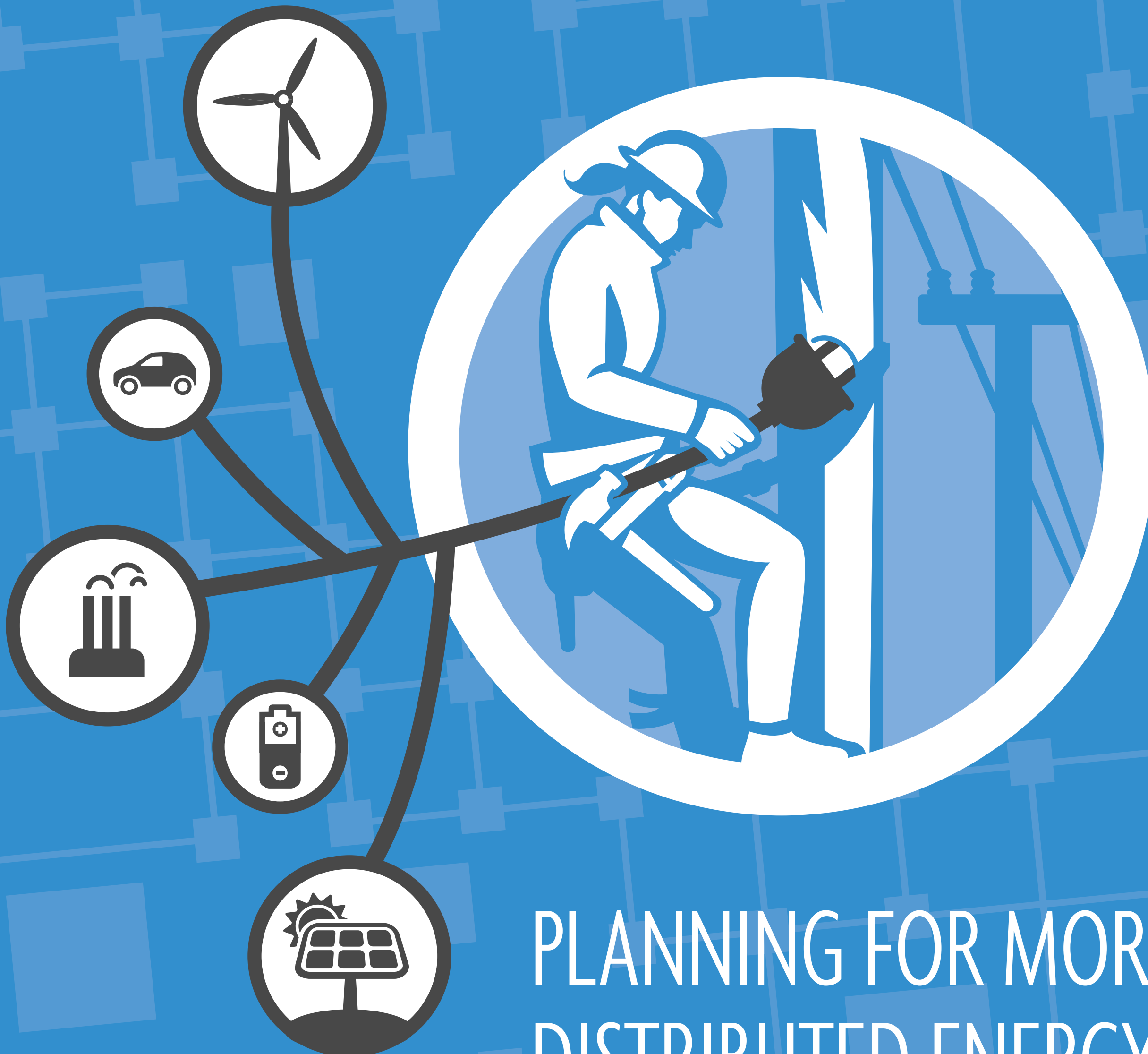


PLANNING FOR MORE DISTRIBUTED ENERGY RESOURCES ON THE GRID

A SUMMARY FOR POLICY-MAKERS ON THE WALK-JOG-RUN MODEL

GRIDWORKS

GRIDWORKS

PLANNING FOR MORE DISTRIBUTED ENERGY RESOURCES ON THE GRID: A SUMMARY FOR POLICY-MAKERS ON THE WALK-JOG-RUN MODEL

PAUL DE MARTINI, TONY BRUNELLO, AND ANNIE HOWLEY

EXECUTIVE SUMMARY

Distributed Energy Resources (DER) such as renewable energy, energy efficiency, battery storage and demand response are now increasingly competitive economically, and these technologies offer great opportunity to transform our electric power system. However, there is a larger concern shared by some that the grid could become unreliable if local DER provides too much peak power. With the electricity grid rapidly moving to a more distributed model, this paper defines what it takes to start planning for the future distribution grid today with the goal to accommodate increasing amounts of DER for the benefit of the distribution grid, transmission system, and wholesale markets. This type of planning can be done today and involves a wider and more complex range of engineering and economic valuation approaches considered in a cohesive and multi-disciplinary fashion, with stakeholder participation.

Existing distribution planning processes have evolved from seeing power as predominantly generated at the bulk power system level and transmitted to the distribution system for delivery to customers across a utility's territory. The growth of DER at or near the point of actual use will necessitate a shift in distribution planning to effectively forecast local changes in power used, power generated, and customer flexibility to modify use in conjunction with system needs. As policy makers start planning for this additional support for DER, it is important to utilize a framework and methodology such that any utility, utility commission, and community can achieve DER deployments in an optimized, cost-effective and scalable manner using tools readily available today. This paper outlines Gridworks' Walk-Jog-Run model used in a growing number of states like California, New York and Minnesota that can help enable increasing DER loads, combined with other DER solutions, while maintaining grid reliability and power quality. In sum, this methodology will accelerate a substantial, existing asset – the distribution grid – towards a more highly utilized, cost-effective, and sustainable electric system.

CONTENTS

ABOUT GRIDWORKS

Gridworks is a 501(c)(3) nonprofit organization that brings industry, advocacy and government experts together to develop solutions for integrating more distributed generation resources gradually into state electricity distribution grids. A key focus is in providing assistance to states to follow the Gridworks Walk-Jog-Run® Framework for modernizing distribution grids through an engineering-based framework that acknowledges the unique energy policies of each state. More information can be found at www.morethansmart.org.

We also wish to acknowledge the assistance from the Gridworks Working Group in developing the thinking and frameworks outlined in this report. The content of this report does not imply an endorsement by any individual or organization that participated in any Gridworks workshop or reflect the views, policies or otherwise of any specific state.

AUTHORS

Paul De Martini, Newport Consulting Group
Tony Brunello, Gridworks
Annie Howley, ICF International

DEFINING THE PLUG & PLAY GRID

This is both an exciting and challenging time to be working on electricity policy in the United States. Depending on which region of the country you reside, you could be witnessing the mothballing of coal plants; rapid increases in wind and solar energy generation; popular discussions defining the next "electric utility business model"; greenhouse gas reduction mandates; or a mix of all of the above. Disruptive changes to the electric utility industry are nothing new as seen over the last several decades. In their time, changes to allow non-utility power plants to provide third party power in the 1970's, deregulation in the 1990's, and renewable portfolio mandates in our generation have rocked the system – such that Thomas Edison would not recognize it today.

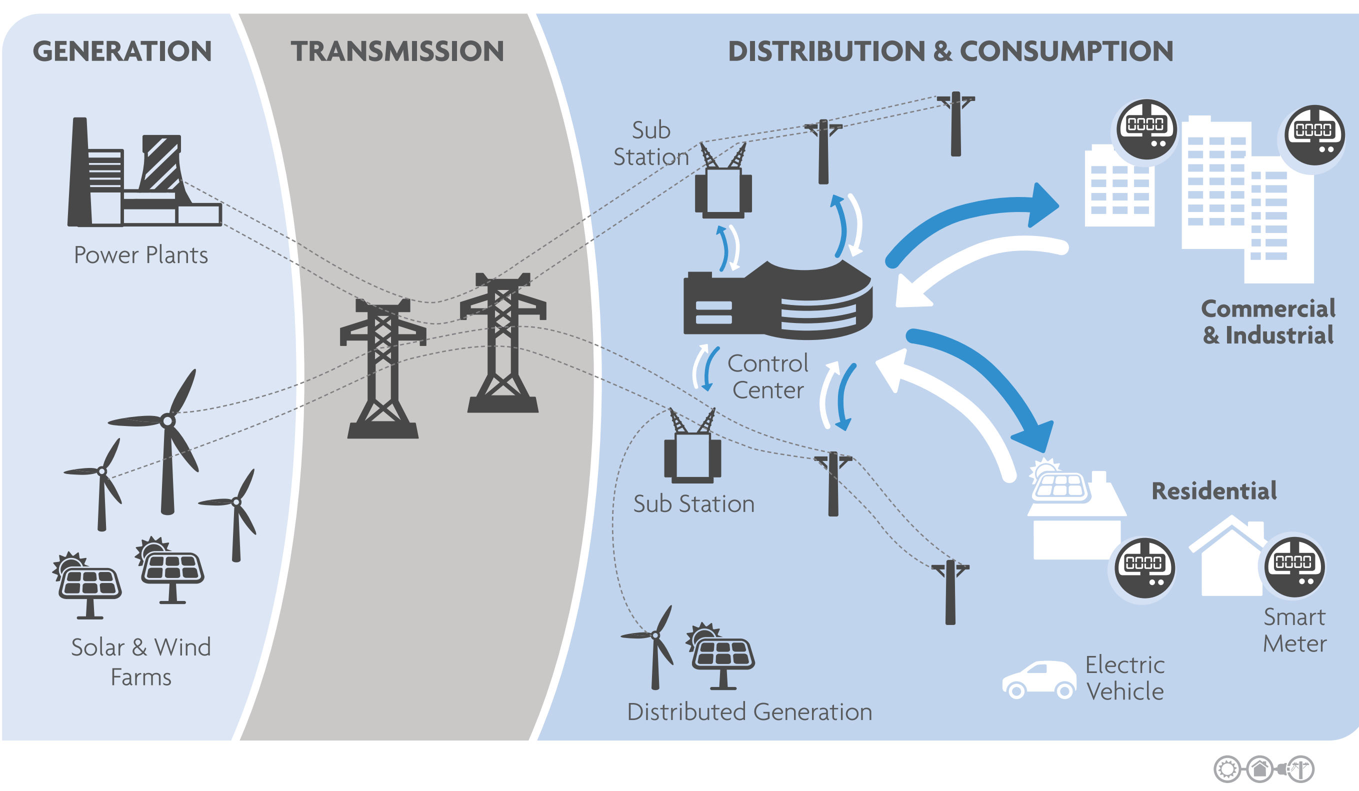
However, changes underway will have significantly greater and lasting impacts. Now, the electricity sector appears to be following the path of the Internet's development, where large centralized computers sending bits one way evolved into a dynamic integrated network of centralized regional data hubs linking computers in every home, enabling distributed content sharing, collaboration and communication. Over the next 10 years, it is not hard to imagine a similar evolution where centralized power plants sending power one way to customers will evolve into a hybrid network of a relatively few large renewable, nuclear and fossil power generators and a large number of small distributed energy resources (DER) that are optimally utilized to provide reliable, safe and cost effective power for all customers. It is also possible to see the emergence of distribution level market opportunities for DER to provide grid services to distribution utilities and possibly energy transactions across the distribution grid to other customers or service providers.

This potential future use of the grid will require new engineering methods, advanced grid technology and systems to enable seamless integration and operation of an integrated electric network. We call this new system the "Plug & Play Grid" and is outlined in Figure 1 below. This report outlines how this evolution is (and can) proceed using a rational step wise approach regulators, utilities and others can follow to best enable this change.

The electricity grid has been called the most complex machine ever built, but it is far from being the Plug & Play Grid envisioned in this paper. The important point for regulators is that this future system can be built from our existing electric distribution system, particularly given the modernization efforts already underway. An evolutionary approach will create a more reliable, safer, lower cost, cleaner and responsive solution for customers. This will require state, federal and local energy jurisdictions to engage customers, services providers, utilities and other stakeholders. This engagement begins with planning this

FIGURE 1.

THE PLUG & PLAY GRID



Plug & Play system, investing in the right new infrastructure to ensure the customer benefits from this future are not lost or delayed. With nearly $879 million projected to be spent on T&D infrastructure across the U.S. by 2030, this Plug & Play model for the grid is becoming a priority across many states.

A key driver pushing the evolution of the Plug & Play Grid is the rapid expansion of Distributed Energy Resources (DER) in the last decade. In this report, DER includes clean distributed generation, storage, electric vehicles, energy efficiency, and demand response that are connected to the distribution grid or located on customers' premises. Table 1 shows the level of DER in each state. Several states (e.g. California and Hawaii) already have relatively high DER in relation to peak demand. States that have a higher penetration of DER are seeing the rapid use and deployment of DER driven largely by customer adoption due to the ever declining capital and deployment costs of technology such as solar panels.

Given the relatively low adoption rates of DER in most states, regulators currently have the time to address the steps towards enabling a Plug & Play Grid that can evolve over time based on the pace and shape of DER adoption. These states with high DER penetration are seeing the rapid use and deployment of DER driven largely by customer adoption due to the ever declining capital and deployment costs of technology such as solar panels. Also, there are opportunities to "learn by doing" through a variety of pilot programs and developing state specific plans based on lessons from other states going through similar processes across the U.S. right now. This report outlines the basics for understanding where most of the dynamic change is happening – the low voltage distribution grid – and provides a step wise process regulators can use to take charge of the large projected DER growth in the next decade in a systematic way. This process is based on engineering and regulatory experience gained from numerous state and federal regulators, utility grid planners, DER companies and interested stakeholders. In this paper, we explain Gridworks' Walk-Jog-Run model to help as a starting point. In order to learn more in depth about the findings in this report, see the Gridworks website or join us in developing your own model.

PLANNING FOR THE PLUG & PLAY GRID

THE WALK-JOG-RUN MODEL

As described in the previous section, the existing power grid was designed primarily to deliver electricity in a one-way fashion: from large, centralized generating facilities across many miles to the cities and towns where it is used. Due to decreasing costs and improved operations, DERs are now increasingly competitive economically, and these technologies offer great opportunity to transform our power system. However, there is a larger concern shared by some that the grid could become unreliable if local renewable generation provides too much peak power.

Given the description and requirements of the Plug & Play grid of the future, what does it take to start planning for the future distribution grid today? The goal should be to accommodate increasing amounts of DER for the benefit of the distribution grid, transmission system, and wholesale markets. This type of planning can be done today and involves a wider and more complex range of engineering and economic valuation approaches considered in a

FIGURE 2.

THE FOLLOWING STATES LEAD THE COUNTRY IN DISTRIBUTED ENERGY RESOURCES (MW).

CALIFORNIA
- *Total DER*
- *DG*
- *Storage*
- *EE*
- *DR*
- *CHP*
- *EVs*

GEORGIA
- *DG*

INDIANA
- *EE*

MICHIGAN
- *Storage*

MINNESOTA
- *Demand response*

NORTH CAROLINA
- *Total DER*
- *EE*

NEW JERSEY
- *DG*

NEW YORK
- *CHP*
- *EVs*

SOUTH CAROLINA
- *DR*

TEXAS
- *Total DER*
- *CHP*

WASHINGTON
- *EVs*

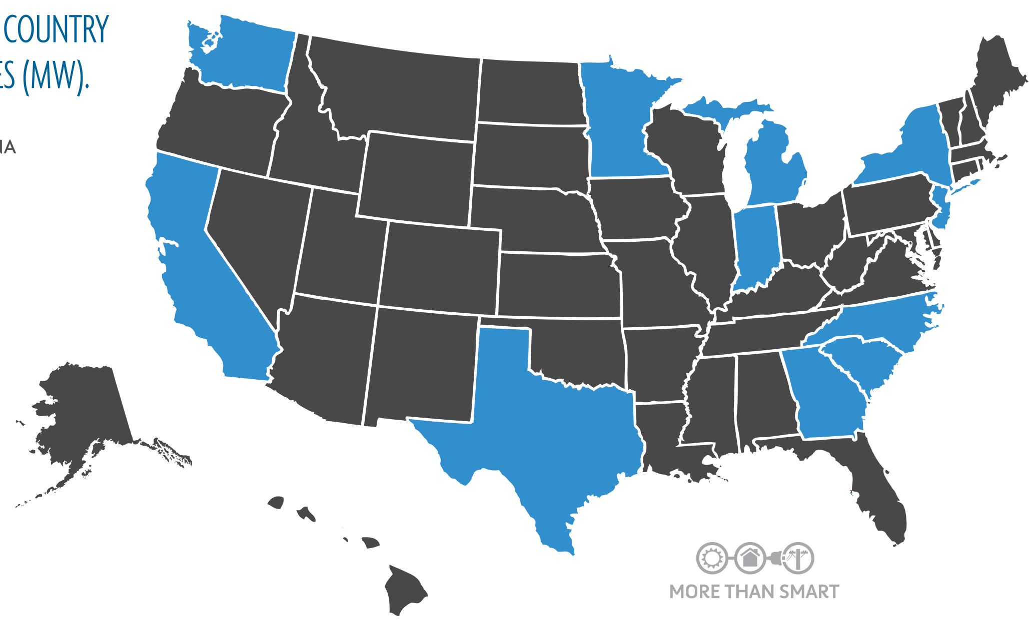


TABLE 1.

DISTRIBUTED ENERGY RESOURCES BY STATE

STATE	TOTAL DER[ii] (MW)	DISTRIBUTED[iii] GENERATION (MW)	STORAGE[iv] (MW)	ENERGY[v] EFFICIENCY T(MW)	DEMAND[vi] RESPONSE (MW)	CHP[vii] INSTALLATIONS (MW)	# ELECTRIC[viii] VEHICLES
AK	391	9	0	0	22	360	155
AL	1,263	522	0	22	610	109	773
AR	715	299	0	88	230	99	374
AZ	1,136	646	0	228	226	35	4,361
CA	8,387	3,149	5	584	2,998	1,651	126,283
CO	436	277	0	99	29	32	4,001
CT	520	119	0	47	88	267	2,476
DC	62	20	0	8	20	14	493
DE	190	54	0	0	129	7	383
FL	1,052	428	0	105	347	173	10,383
GA	1,212	775	0	102	197	139	15,551
HI	636	527	0	28	3	78	3,050
IA	463	38	0	143	127	155	928
ID	860	70	0	252	472	66	409
IL	533	33	0	12	54	434	6,694
IN	1,110	33	0	548	401	127	1,697
KS	141	10	0	2	45	85	750
KY	565	64	0	96	358	47	701
LA	825	520	0	80	0	226	527
MA	1,088	570	0	184	16	319	4,612
MD	597	183	0	124	191	99	5,028
ME	604	504	0	19	0	81	695
MI	659	181	1	160	28	290	8,844
MN	1,604	226	0	460	730	188	2,775
MO	302	100	0	65	29	107	1,859
MS	999	274	0	23	655	47	201
MT	63	15	0	37	0	11	362
NC	1,886	384	0	701	625	175	3,384
ND	373	11	0	4	311	46	91
NE	496	6	0	46	409	35	579
NH	97	41	0	9	0	47	761
NJ	1,635	1,146	0	86	74	329	6,021
NM	213	70	0	70	43	30	637
NV	301	83	0	36	158	24	1,509
NY	1,256	441	0	214	37	564	11,278
OH	874	155	0	371	198	150	3,814
OK	336	76	0	73	123	65	806
OR	557	301	0	11	35	211	5,681
PA	936	343	0	120	101	371	4,540
RI	115	18	0	39	n/a[ix]	58	417
SC	1,546	353	0	268	753	172	1,056
SD	271	1	0	162	100	8	160
TN	1,054	228	0	50	703	73	2,730
TX	1,457	287	0	243	543	384	9,925
UT	273	35	0	53	120	64	1,565
VA	701	398	0	17	142	145	3,628
VT	69	33	0	12	1	24	840
WA	772	304	0	302	15	151	12,291
WI	677	224	0	106	99	248	2,429
WV	215	106	0	4	84	22	271
WY	44	2	0	7	4	31	73
TOTAL	42,569	14,691	6	6,517	12,683	8,672	278,851

cohesive and multi-disciplinary fashion, with stakeholder participation. Existing distribution planning processes have evolved from seeing power as predominantly generated at the bulk power system level and transmitted to the distribution system for delivery to customers across a utility's territory. The growth of DER at or near the point of actual use will necessitate a shift in distribution planning to effectively forecast local changes in power used, power generated, and customer flexibility to modify use in conjunction with system needs.

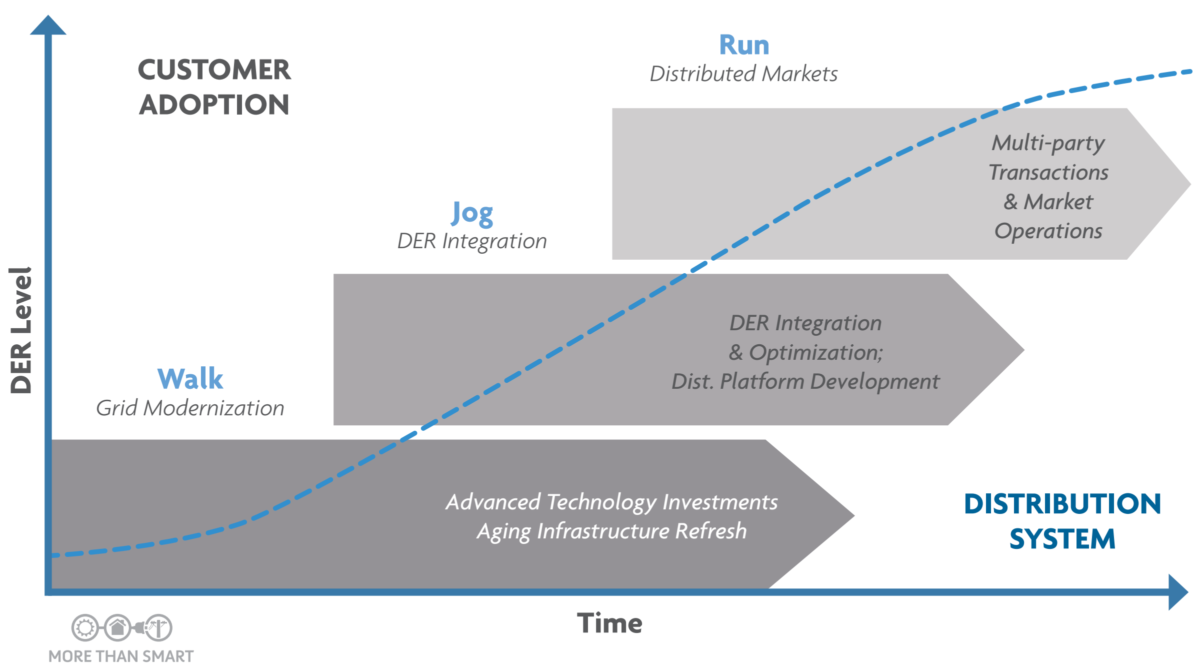
As we start planning for this additional support for DER, it is important to utilize a framework and methodology such that any utility, utility commission, and community can achieve DER deployments in an optimized, cost-effective and scalable manner using tools readily available today. One approach described here is Gridworks' Walk-Jog-Run model that can help enable increasing DER loads, combined with other DER solutions, while maintaining grid reliability and power quality. In sum, this methodology will accelerate a substantial, existing asset – the distribution grid – towards a more highly utilized, cost-effective, and sustainable electric system.

THE WALK-JOG-RUN DISTRIBUTION GRID PLANNING FRAMEWORK

The Walk-Jog-Run model is used for characterizing the current and anticipated future state of DER growth in a given jurisdiction, with incremental steps growing the volume and diversity of DER penetration while shaping the regulatory, market and contractual framework in which DERs can provide products and services to the distribution utility, end-use customers, and potentially to each other. (Please refer to Gridworks' original report for an in depth description of Walk-Jog-Run steps (De Martini, 2014) as well the Lawrence Berkeley National Labs report on Future Electric Utility Regulation (De Martini and Kristov, 2015). Figure 3 below outlines how states should evolve their distribution grid planning efforts based on Walk-Jog-Run. It is assumed any distribution system will evolve in response to both top-down (public policy) and bottom-up (customer choice) drivers. Each Walk-Jog-Run stage represents additional functionalities to support more DER adoption and the level of system integration desired. Each level builds on the prior stage resulting in an increasingly hierarchical, yet
rational, system.

- WALK
  The Walk stage represents the state of distribution utility grid modernization and reliability investments currently underway. In this stage, the level of customer DER adoption is low and can be accommodated within the existing distribution system without material changes to planning, infrastructure or operations. Here the distribution system has very little automation beyond a substation and is a largely analog system. At this stage, states first need to identify the existing capacity for DER supported by the distribution grid infrastructure already in place and operational, and lay out a plan for expansion of DER in the future. More information on the Walk phase is explained below.

FIGURE 3.
THE WALK-JOG-RUN FRAMEWORK



- JOG

  The Jog stage is where DER adoption reaches a threshold level of roughly 5-10% of peak load and may require changes to grid capabilities and operations as well as to the potential to realize material system benefits. Bi-directional power flows will begin on high-penetration DER circuits. In response, more advanced control technologies and operations capabilities will be required to manage these parts of a distribution grid in a safe and reliable manner. Distribution utilities can source services from flexible DER to support reliable operation or as qualified alternatives to traditional infrastructure investments. Here regulators need to consider DER procurement mechanisms to source DER at specific, targeted locations that optimize the DER characteristics, such as load profile and/or load management. Markets would have a single buyer – the distribution operator – and would not involve energy transactions that could raise federal/state jurisdictional issues. But in order for DER services to be transacted, a set of complex issues regarding telemetry data and data exchange standards need to be addressed. With DERs frequently not being owned or controlled by utilities, but with having the legal obligation to serve all customers and meet reliability targets, important bi-directional exchanges of real-time operating data need to be exchanged between utilities and DER providers.

- RUN

  The Run stage enables a combination of high DER adoption and advanced policies supporting distribution system markets with multi-sided transactions ("many-to-many" or "peer-to-peer"). Here, DER providers and "prosumers" go beyond providing services to the wholesale market or distribution utility and engage in transactions with each other. This, of course, requires regulatory changes to allow retail energy transactions across the distribution system, including transactions that are still within a local distribution area (LDA) defined by a single substation, thus not relying on transmission service. Enabling such a multi-sided market will require a formal distribution-level market structure to facilitate peer-to-peer energy transactions. In this environment, the distribution system operator role may evolve from the "one-to-many" coordination predominant in the Jog stage to an enabler of "many-to-many" physical coordination, with financial clearing and settlement.

The scope of the Walk-Jog-Run framework is on basic distribution utility functions limited to those of a distribution wires company. The focus at the beginning is not to define "new business model" frameworks determining who provides competitive DER services to customers beyond standard distribution wires company functions. This does not start in earnest until a state evolves into the Jog phase. Finally, it is helpful to focus planning on the services technologies provide to the grid and not on the specific technologies themselves.

TAKING A WALK – THE FIRST STEPS

WALKING STEP 1
Develop a standardized planning and analysis framework.

Such a planning framework could involve several changes and additions to traditional distribution planning including the following:

1 | Use DER adoption scenarios linked with a shift from deterministic to probabilistic engineering methods

The uncertainty of the types, amount and pace of DER expansion make singular forecasts ineffective for long-term distribution investment planning that often spans up to a 10-year horizon. A better approach is to use at least three DER growth scenarios to assess current system capabilities, identify incremental infrastructure requirements, and enable analysis of the locational value of DER (described below). Effective power engineering analysis and scenario development are fundamental to a shift in distribution planning. As such, standardized methodologies across the state are required to facilitate market development and participation. For distribution engineering, it is important to identify the need and timing considerations for a shift toward more probabilistic distribution engineering methods, as well as an assessment of the current state of the art regarding methods and commercial analysis tools. This assessment should include specific recommendations for needed research and development.

2 | Establish baseline capacity of the distribution grid to host DER ("hosting capacity")

The maximum DER penetration for which a distribution grid (from substation through feeder) can operate safely and reliably is the hosting capacity. Hosting capacity methods quantify the engineering factors that increasing DER introduces on the grid within three principal constraints: thermal, voltage/power quality and protection limits. These methods should be standardized for use by a utility. This will require adaptation of industry methods, especially the network systems, as the current industry methods have been based on radial systems. Also, these methods will need to be normalized across the utilities for consistent application. This should focus on matching local generation and local loads as much as possible, targeting optimal locations to add the local generation. As mentioned above, an example of optimal locations are Commercial and Industrial areas within substations. These areas typically are served by robust feeders and distribution grid infrastructure, incur large daytime loads, and have expensive electricity bills as a result of both large uses of electricity and demand charges.

3 | Evolve interconnection studies for DER based on revised planning methods and to accommodate scale of requests

Many existing state interconnection agreements can be enhanced by requiring the use of online portals to request interconnections to utility grids. Such portals can be used to facilitate market knowledge of the hosting capacity of the grid as such methodologies are deployed. The Methodologies and processes for interconnection studies will need to evolve to address growth in DER adoption and microgrid development. Specifically, the need to revise engineering methods and criteria consistent with above. Also, address processes to accommodate scale of requests seeking to connect to the utility-side of the distribution system.

4 | Identify the locational net value of DER to the grid, which may be positive or negative

The value of DER on the distribution system is locational in nature – that is, the value may be associated with a distribution substation, an individual feeder, a section of a feeder, or a combination of these components. Based on an analysis of near-term and long-term uses of the distribution system, incremental infrastructure or operational requirements may be met by sourcing services from DER, as well as optimizing the location of DER on the distribution system. The objective is to achieve net positive value for all utility customers. These net values may include avoided or deferred utility capital spent on distribution assets and avoided operational expenses. There may also be environmental and customer benefits based on a specific location. Locational value of DER is not always net positive, as it depends on any incremental distribution system costs (not including the DER developer/owner's costs) to integrate the DER. Figure 3 below shows a list of value components on the societal, wholesale and distribution level.

The evolution of the scope of benefits that may be included in the locational benefits analysis may be dependent on changes to electrical standards, the acceptance of standardized net benefits methods, commercial analytic tools, data availability, and integration with wholesale and transmission planning. As such, an implementation roadmap should be developed that identifies which of the value components may be evaluated in the near-term (0-2 years) to start, in the intermediate term (3-5 years) and in the longer term (>5 years). This roadmap should identify specific gaps regarding the necessary prerequisites, including those above, to value a component within the five-year horizon of Stage 1.

5 | Integrate energy procurement, resource adequacy, and transmission and distribution planning to consider the valuation of DER across the power system while adhering to quality and reliability standards.

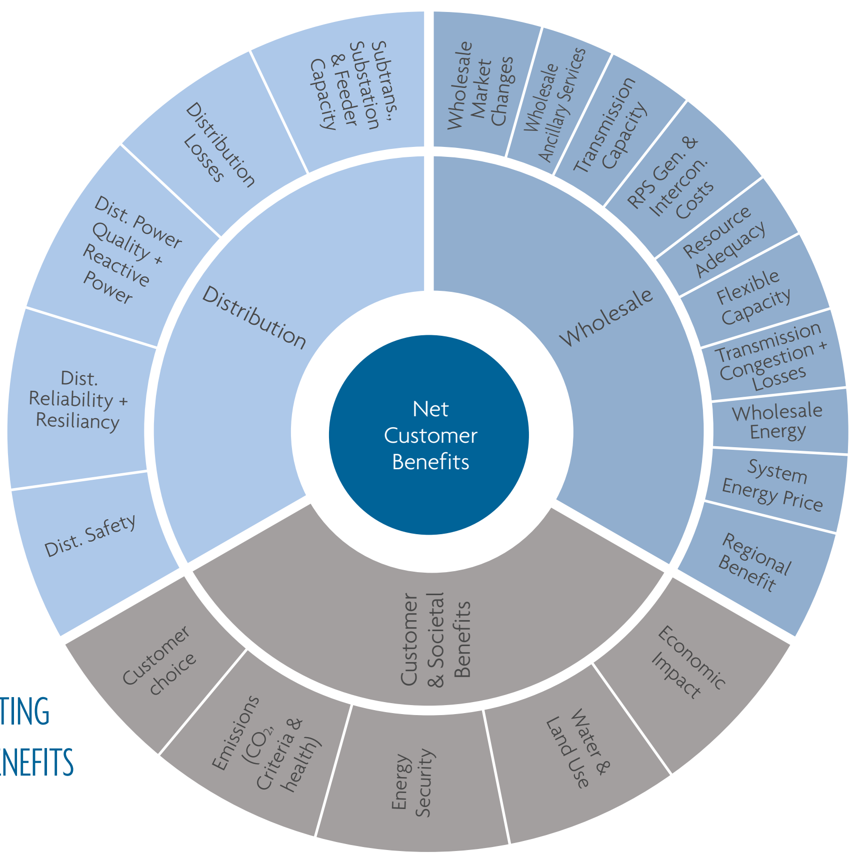


FIGURE 4.

DER VALUE COMPONENTS RESULTING IN CUSTOMER NET BENEFITS

MORE THAN SMART

WALKING STEP 2

Develop a distribution planning process that defines the above planning analyses above with specific time-cycles incorporating stakeholder input and review, and regulatory approvals.

This step requires identification of planning data necessary to be made available between the various parties including grid operational data and DER market development information. Such a distribution planning process should also link clearly with service operator requirements and resource planning. This requires a collaborative effort between state agencies and interested stakeholders to utilize a core working group, albeit with participation of appropriate subject matter experts, to develop a new distribution process and necessary alignments to create a unified statewide power system integrated planning process. This new process should also consider linkages to other state processes and timing cycles for utility rate cases, rate designs and demand side management or other DER program design and funding.

WALKING STEP 3

State-wide implementation of the new distribution planning methods and process.

This involves several sub-steps. First, is demonstration of proposed planning methods (new distribution engineering, scenarios, hosting capacity and locational benefits) to validate, refine and normalize for system-wide use. This should involve conducting a full planning analysis for at least one distribution planning area that minimally addresses hosting capacity to the circuit level and locational benefits aggregated to the distribution substation level. Second, these demonstration planning analyses should be linked to one or more physical demonstrations of the net value of DER integration. The purpose is to validate and refine the planning methods and scenarios based on the lessons learned from these demonstrations as a precursor to system-wide implementation of the planning analysis. Third, the planning methods roadmap developed above should be overlaid with the development timeline for the new distribution planning process including integration with the other state-wide system planning and regulatory funding processes as discussed.

STATE EXAMPLES

As states progress through the Walk phase of planning for, and investing in, their distribution system, the next step is to move to the Jog phase. The full version of this report will include a description of the steps to take for the Jog phase, a list of state examples working through the Walk and Jog phase as well as a simple check list for getting started. Please go to www.morethansmart.org for more information.

California
http://morethansmart.org/state-action/gridwork-in-ca/

New York
http://morethansmart.org/state-action/new-york/

Hawaii
http://morethansmart.org/state-action/hawaii/

Minnesota
http://morethansmart.org/state-action/minnesota/

REFERENCES

[i] Data analyzed from the following:
- Energy Information Administration Form 826 http://www.eia.gov/electricity/data/eia826/
- Energy Information Administration Form 860 http://www.eia.gov/electricity/data/eia860/index.html
- Energy Information Administration Form 861 http://www.eia.gov/electricity/data/eia861/index.html
- Office of Energy Efficiency and Renewable Energy. Energy.gov. Plug-in Electric Vehicle Penetration by State in 2014 http://energy.gov/eere/vehicles/fact-876-june-8-2015-plug-electric-vehicle-penetration-state-2014
- US DOE Combined Heat and Power Installation Database https://doe.icfwebservices.com/chpdb/

[ii] 2014 Total DER (MW); Distributed Generation, Storage, Energy Efficiency, Demand Response and CHP installations

[iii] 2014 Distributed Generation (MW); Includes Photovoltaic, Solar Thermal, Wind, Wood and Wood Derived Fuels, and Other Biomass. Sectors include Commercial CHP, Commercial Non-CHP, Industrial CHP, Industrial Non-CHP, <1 MW and Net Metering. Energy Information Administration (EIA) Form 826, Form 860, Form 861

[iv] 2014 Distributed Storage (MW); inclusive of all technologies reported by EIA in Form 826, Form 860, Form 861

[v] 2014 Energy Efficiency demand reductions (MW) EIA Form 861

[vi] 2014 Demand Response demand reductions (MW) EIA Form 861

[vii] 2014 CHP (MW) reflects CHP installations below 25 MW to reflect likely distribution level resources based on data from US DOE Combined Heat and Power Installation Database https://doe.icfwebservices.com/chpdb/

[viii] 2014 Plug-in Electric Vehicle Penetration by State. Office of Energy Efficiency and Renewable Energy. Energy.gov. http://energy.gov/eere/vehicles/fact-876-june-8-2015-plug-electric-vehicle-penetration-state-2014

[ix] Data unavailable

MORE THAN SMART

www.morethansmart.org | info@morethansmart.org
426 17th Street, Suite 700, Oakland, CA, 94612