Community Oriented Grids

Architecting 21st Century Sustainable Communities

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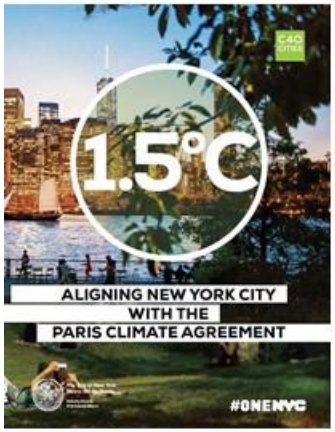
Cities are Taking Action



CHICAGO
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Community Choice Aggregation (CCA)

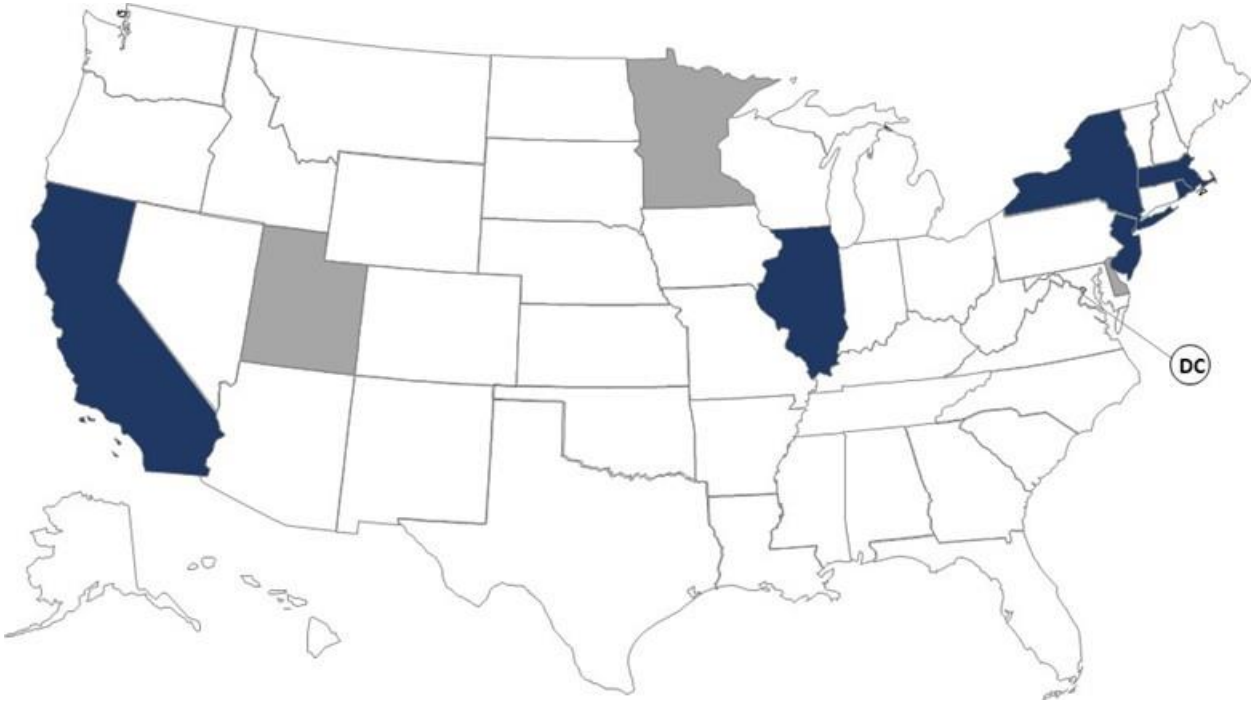
Legislation that empowers local governments to aggregate the electricity loads of residents, businesses, and/or municipal facilities.

Enacted in:

- California
- Illinois
- Massachusetts
- New Jersey
- New York
- Ohio
- Rhode Island

Under Consideration:

- Delaware
- Minnesota
- Utah



Source: LEAN Energy U.S.

Transactive Energy Market Evolution

Transaction types are cumulative so will ultimately involve a wide range of parties and transactions

Stage 2: Operational Markets

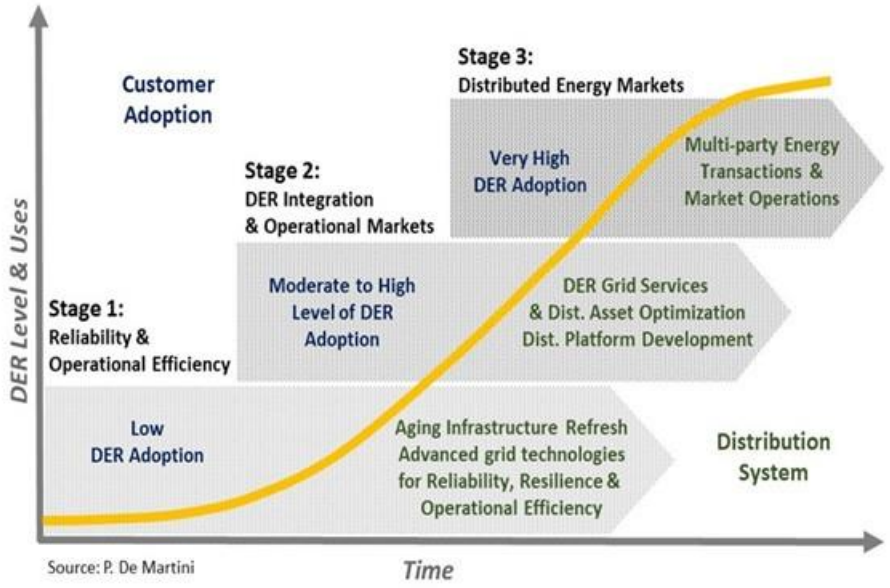
A. Use of DER as load modifying resource for both Distribution non-wires services (NWS) and Bulk Power capacity and ancillary services

B. Participation of DER export energy (discrete/aggregated ahead of the meter and aggregated behind the meter) in bulk power markets

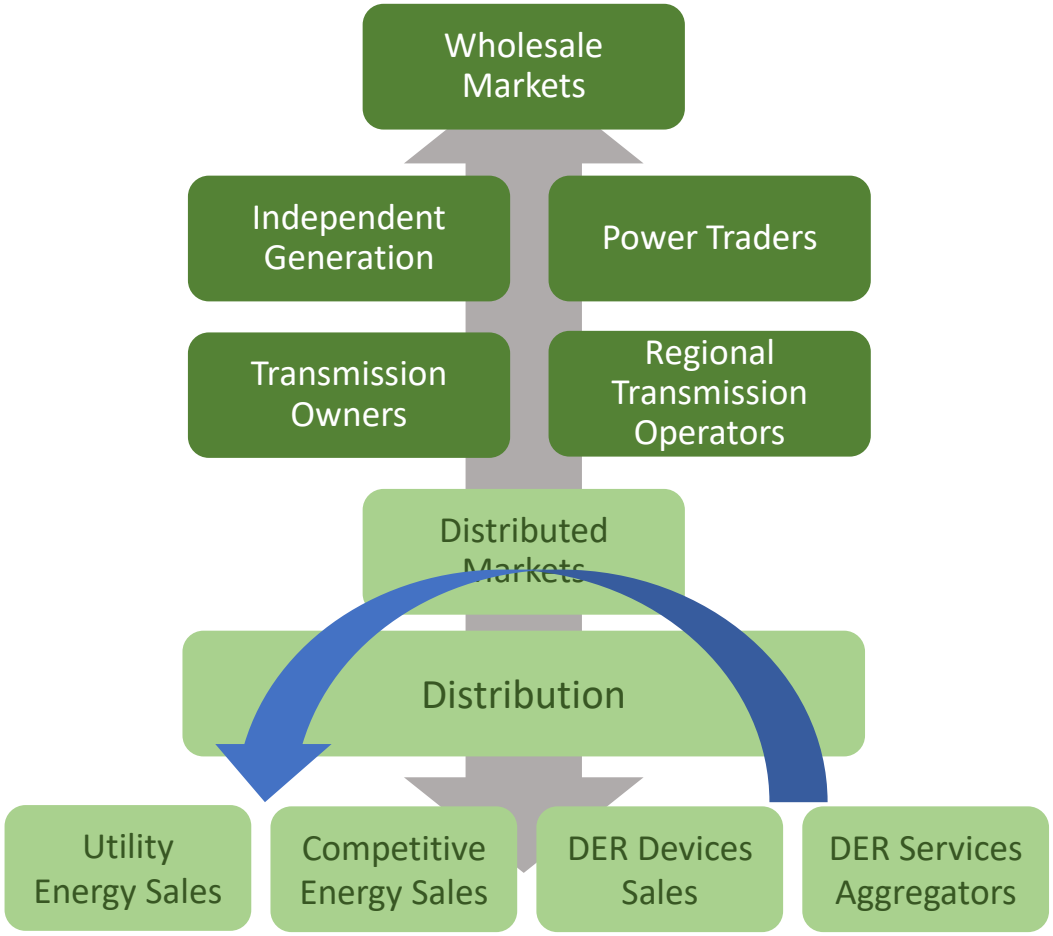
Stage 3: Distributed Energy Markets

A. Sale of DER export energy to LSEs at distribution delivery point (distribution substation bus) for resale to meet local distribution area retail customers without accessing transmission (incl. multi-use microgrids)

B. Peer-to-peer energy transactions across distribution system without accessing transmission (e.g., customer DER export energy sold to another customer on same circuit/substation bus)



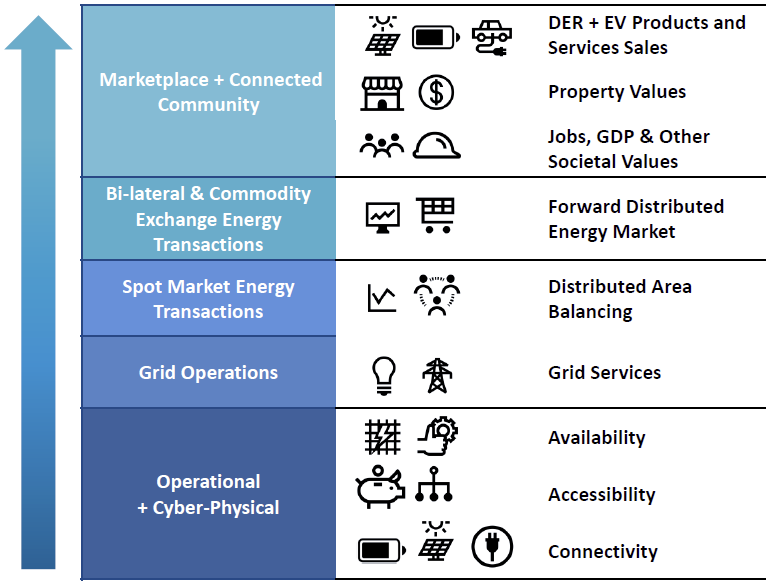
Electric Transactions c. 2030 (Post-NEM)



Distribution Network Value Potential

Realizing the value potential requires a different mental model

- The cyber-physical grid infrastructure can provide the foundation for network value creation
- Total value increases through the interdependent capabilities of each value layer
- Higher electrification and DER adoption drives value
- Capturing benefits requires a broader view of the solution set and deliberate alternative grid designs & investment to support value realization

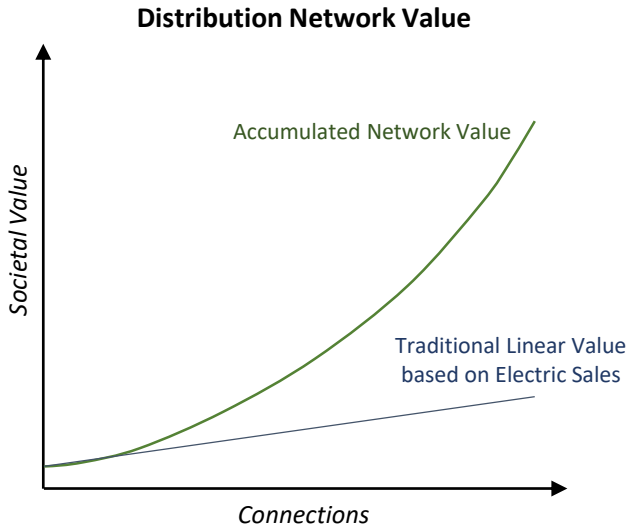


Source: De Martini & ICF

Distribution Grid as a Network Platform

Electric Distribution Network Value Can Be Super Linear

- **Metcalfe's Law:** Value of a network grows at the square of the number of connections – *not applicable to electric grids*
- **Geoffrey West:** With each increase in size, cities get a super-linear value-add of 15% in increased efficiency and productivity.
- **De Martini-ICF:** Increases in DER, electrified buildings and EVs (number of grid connections) create super-linear societal value - findings consistent with West's "Scale" research



Distribution Grid as a Platform for Connected Communities

Building & Transportation Electrification + DER + Grid Platform Enable Connected Communities

- Societal value from the creation of Connected Communities accrues in significant part based on the efficient use of clean, resilient electricity to create sustainable communities
  - Connected communities in California will be supplied increasingly in large part by distributed resources (perhaps 40% or more by 2040)
  - Connected communities will need to be resilient – this will depend in part on microgrids and other customer resources that need to be linked
- Connected communities cannot be developed without *a node-friendly distribution network that is open, visible, flexible, reliable, resilient and safe**

Source: Energy Innovation Technology & Policy, LLC

**More Than Smart* principle adopted by CPUC

Why is TOD relevant to electric industry?

TOD is a design approach employed in connected communities that are improving societal value by:

- Improving Quality of Life
- Economic Competitiveness
- Improving Resilience
- Addressing Climate change

These community development efforts typically incorporate energy related elements including:

- Transportation Electrification
- Critical Infrastructure Resiliency
- Local Distributed Resource Development

American Fork, Utah

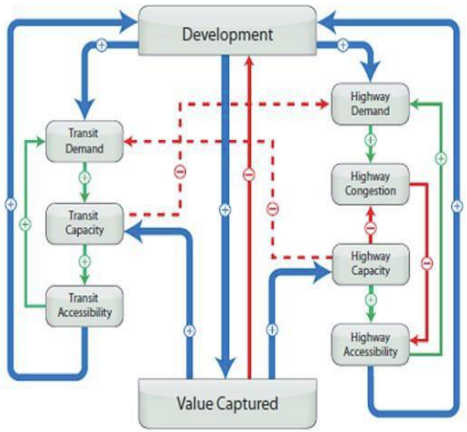
Source: PSOMAS

Transportation Network Characteristics

Adapting Transportation Concepts for Electrified Connected Communities

- **Connectivity:** Connectivity refers to the density of connections in path or road networks, capacity and directness of links.
- **Accessibility:** Accessibility refers to market access measured through statistical indicators of effective market size or effective market density and ease of access.
- **Availability:** Availability refers to a transportation system's performance to deliver services when demanded.

Figure 2. The Virtuous Circle of Development, Accessibility, Value Capture, and Infrastructure



Source: Michael Iacono and others, "Value Capture for Transportation Finance: Report to the Minnesota Legislature." Report No CTS 09-18S (University of Minnesota Center for Transportation Studies, 2009).

Distribution Network Criteria

California's highly distributed electric system will need to address these criteria

Connectivity

Connectivity in the power system has several dimensions.

- Bulk power system deliverability of a transmission connected resource to a designated node.
- Also, a wholesale DER resource's deliverability across distribution to a bulk power system node.
- Distribution connected resource connectivity is related to:
  - Interconnection point on a distribution network
  - Related distribution hosting capacity to support transaction deliverability

Accessibility

Accessibility in the power system relates to access to & size of markets.

- Potential number of buyers and sellers of energy and energy services.
- Potential total volume of transactions and the value of those transactions.
- Relative ease of access to markets.

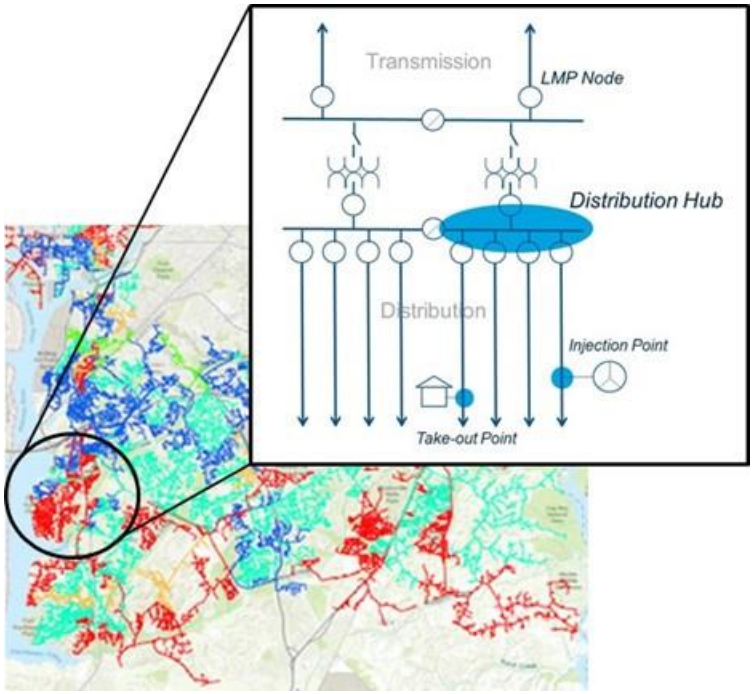
Availability

Availability is the performance of the system to enable transactions.

- A highly available system dependably facilitates transactional power flows under system normal as well atypical operating conditions (including avoiding resource curtailments).
- Hence, a highly available system can be thought to be extremely resilient.

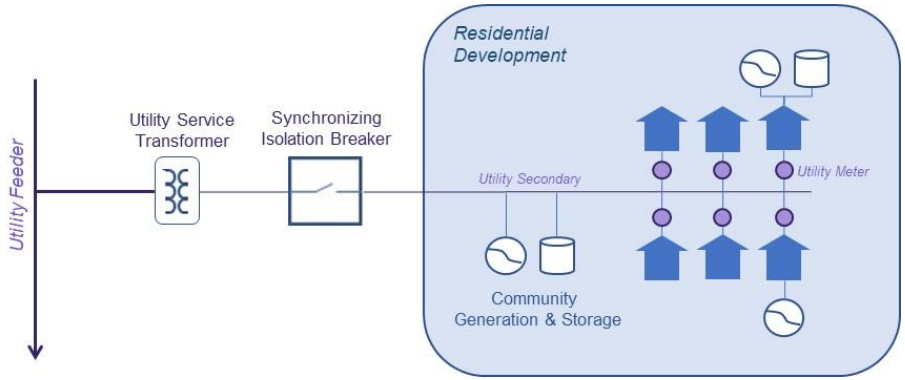
Transactive Hub Topology

- Transactive Hub
  - T-D Substation transformer bank, associated distribution bus section and feeders
- Distribution transactions
  - Distribution transactions are scheduled for delivery to and from this “hub” via corresponding injection and take-out points on interconnected circuits
  - Injection Point – Physical location at which scheduled power is injected into distribution system
  - Take Out Point – Physical location of the recipient of energy from the scheduled power.
- Distribution to transmission transactions
  - Interchange scheduling point is the associated LMP node on high side of substation transformer bank.



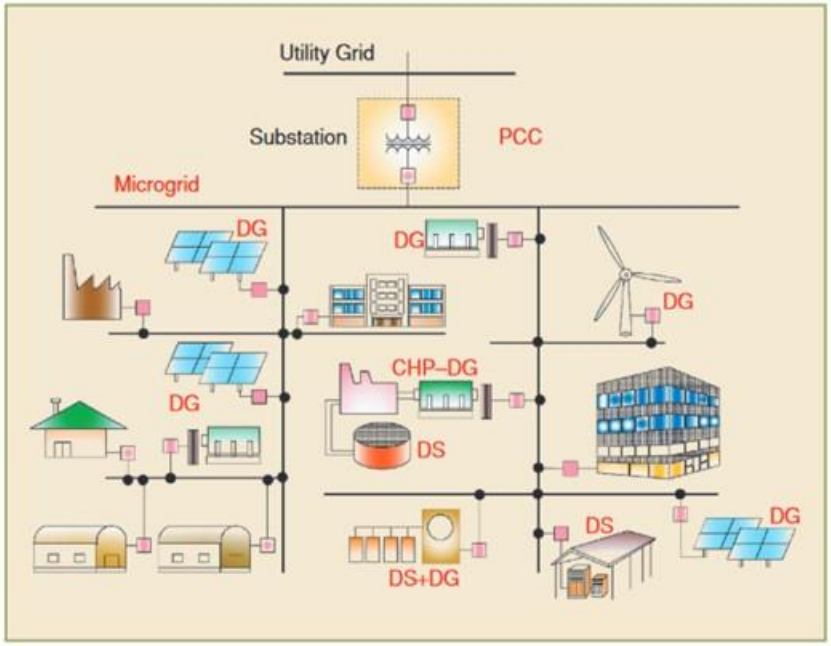
Hybrid Microgrid Example: Simple Hybrid MG

- **Simple Hybrid Microgrid** involves a smaller geographic area with a simpler electrical boundary, such as a defined residential community/industrial park/commercial retail center.
- A single entity representing all customers involved with microgrid, such as a home owners association, property manager, etc.
- Contiguous loads and resources within a section of a distribution feeder (primary and or secondary) that allows a single point of common coupling and relatively simpler operational coordination to ensure safety and operational effectiveness.



Hybrid Microgrid Example: Mini-grid

- **Mini-grid Hybrid Microgrid** involving a 3rd party microgrid operator operating a multi-user microgrid on behalf of itself and/or one or more microgrid participants to meet operational, environmental, reliability, resiliency and redundancy goals of the participants, managing both purchases from and sales of services to the grid. It will manage the microgrid in island mode.
- This mini-grid configuration involves linking various customer and 3rd party resources across utility distribution grid to supply energy to all customers within the electrical boundary.
- In the graphic, the electrical boundary (point of common coupling – PCC) is the distribution feeder breaker at the substation. All loads on the feeder illustrated are within the microgrid.
- This is a relatively complex engineering solution involving significant operational coordination, customer issues and other considerations to operate safely and effectively.



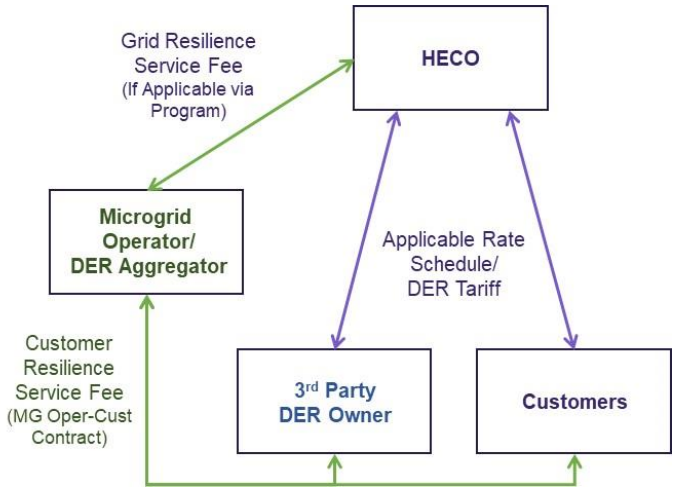
Source: "Microgrids Management" by Katiraei, Iravani, Hatziargyriou and Dimeas, IEEE, 2008

Graphic referenced in BU-NECEC, "Multi-User Microgrids: Obstacles to Development and Recommendations for Advancement", Nov 2018

Hybrid Microgrid Tariff Structure & Roles

(adaptation of WG suggestion in Nov 21st Mtg)

- **Hybrid Microgrid Operator**
  - Provides microgrid operations and control of MG associated resources and provides single point of operational interface to HECO
  - Provides resilience service to MG associated customers during emergency/outage
  - May provide grid resilience service to HECO during emergency/outage
  - MG Operator may also acts as a DER Aggregator during normal mode
  -
- **Customer/3rd Party DER Owner**
  - HECO customer under applicable rate schedule/DER tariff/program during normal and emergency/outage conditions
  - Customer/DER provider export energy sold to HECO under applicable DER tariff/program continues in islanded mode during emergency/outage – no change in transactional relationship
  - Customer/DER Owner has contract with MG Operator for resilience services including operation and control of resources as well as resilience service & fee.
- **HECO**
  - Customer/DER Owner service relationship during normal mode under applicable rate schedule/DER tariff/program
  - HECO maintains operational responsibility for distribution infrastructure during emergency/outage in coordination with MG Operator
  - HECO continues to buy export energy from customer/DER owner resources during islanded MG mode during an emergency/outage.
  - HECO pays MG Operator a grid resilience fee only if broad public resilience benefits are provided. Grid resilience service and value would be identified in IGP resilience planning and conducted through a programmatic approach.



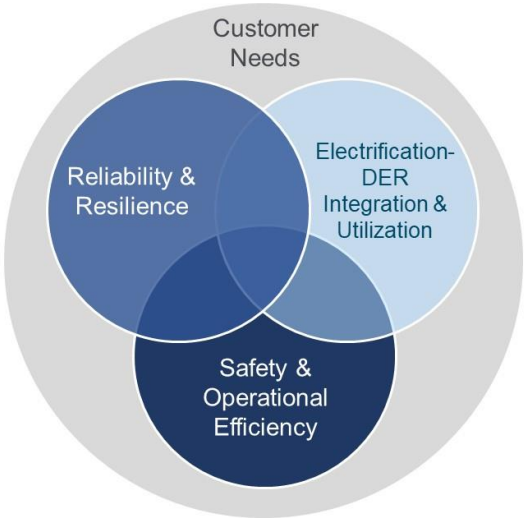
Community Oriented Grids

- Future architecture of community dominant transactive distributed power systems will be influenced by connected, resilient community development employing transit-oriented development (TOD) designs.
- The confluence of housing and commerce form economic hubs within metro centers. These developments create opportunities to develop transactive energy hubs based on related DER.
- However, to enable the development of these transactive energy hubs, it is necessary to consider structural changes in the architecture of urban distribution systems and the "customer to distribution" operational coordination necessary to align with TOD communities.
- A community oriented grid (COG) architecture would involve a proactive architectural approach to engage TOD efforts to align the structure of a distributed energy ecosystem to the urban plan.
- A COG architecture would inform electricity market designs, grid investments, operational coordination (including interoperability) and public policy shaping DER adoption.

Distribution Grid Planning Needs to Converge

- **Process Changes**: Discrete distribution planning activities need to be converged into an integrated plan:
  - Resilience Planning
  - Asset Management (aging infrastructure replacement)
  - DER based Planning (DRP)
  - Grid Modernization
- **Structural changes** in distribution grid designs are required – *grid we have is not the grid we need**
  - Resilient, 2-way networks are essential – CA's distribution grids need to become generation ties & transactive networks to meet our goals
  - Standard engineering design practices need to evolve
  - Requires optimized infrastructure investment
    - NWAs help optimize capital investment, but do not replace the need for distribution infrastructure investment to create the platform needed

Multi-faceted Distribution Planning Criteria



* Source: Hawaiian Electric

Thank you