Transactive Oriented Grid Architecture

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Transit Oriented Development (TOD)

Transit-oriented development (TOD) is a planning and design strategy that consists in promoting urban development that is compact, mixed-use, pedestrian- and bicycle-friendly, and closely integrated with mass transit by clustering jobs, housing, services, and amenities around public transport.

Economic growth, urban transport, and land use can be managed more efficiently if planned together.

TOD has been successfully applied at a city scale in cities around the world including Stockholm, Copenhagen, Hong Kong SAR, Tokyo, and Singapore.

Source: World Bank

Source: Energy Innovation Technology & Policy, LLC

Why is TOD relevant to electric industry?

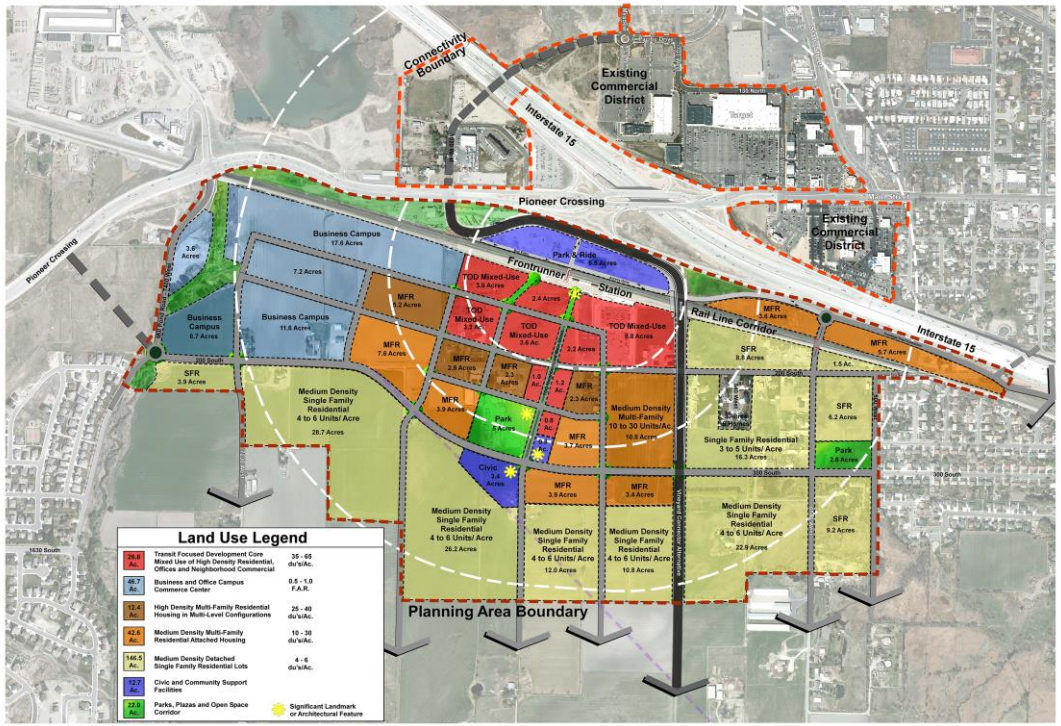
TOD is a design approach employed in connected communities that are improving societal value by:

- 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

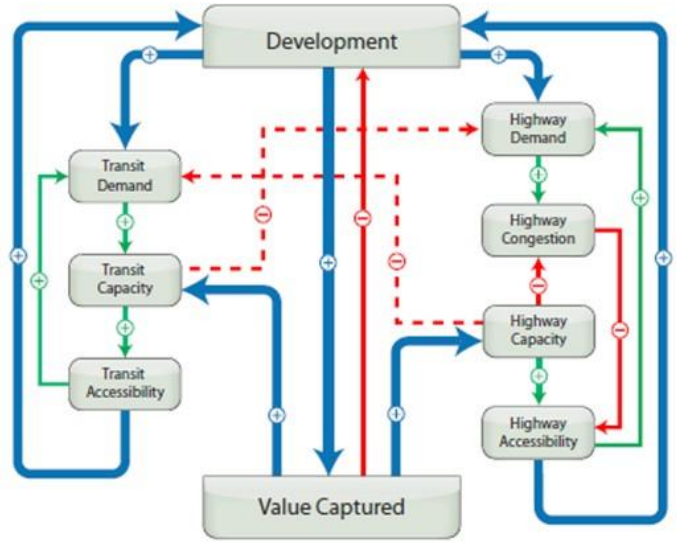


Source: PSOMAS

TOD Architectural Qualities

- **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.

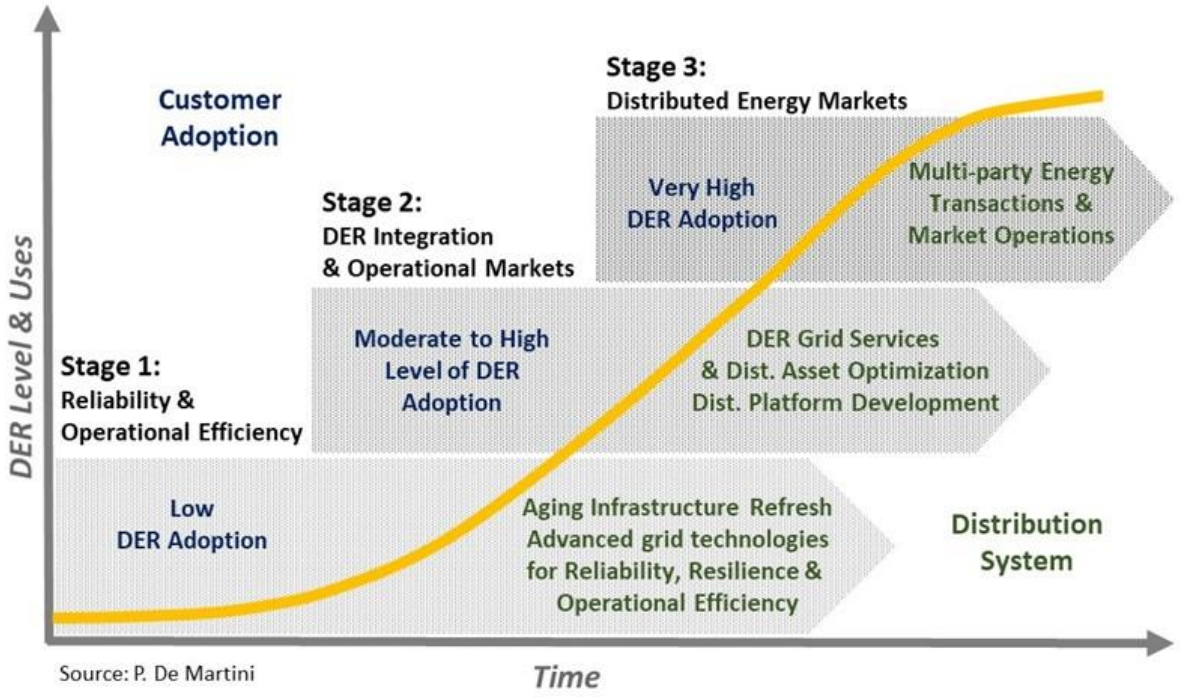
Figure 2. The Virtuous Circle of Development, Accessibility, Value Capture, and Infrastructure



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).

Transactive Energy Market Evolution

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



Source: P. De Martini

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)

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Transactive Oriented Grid Architecture Qualities

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

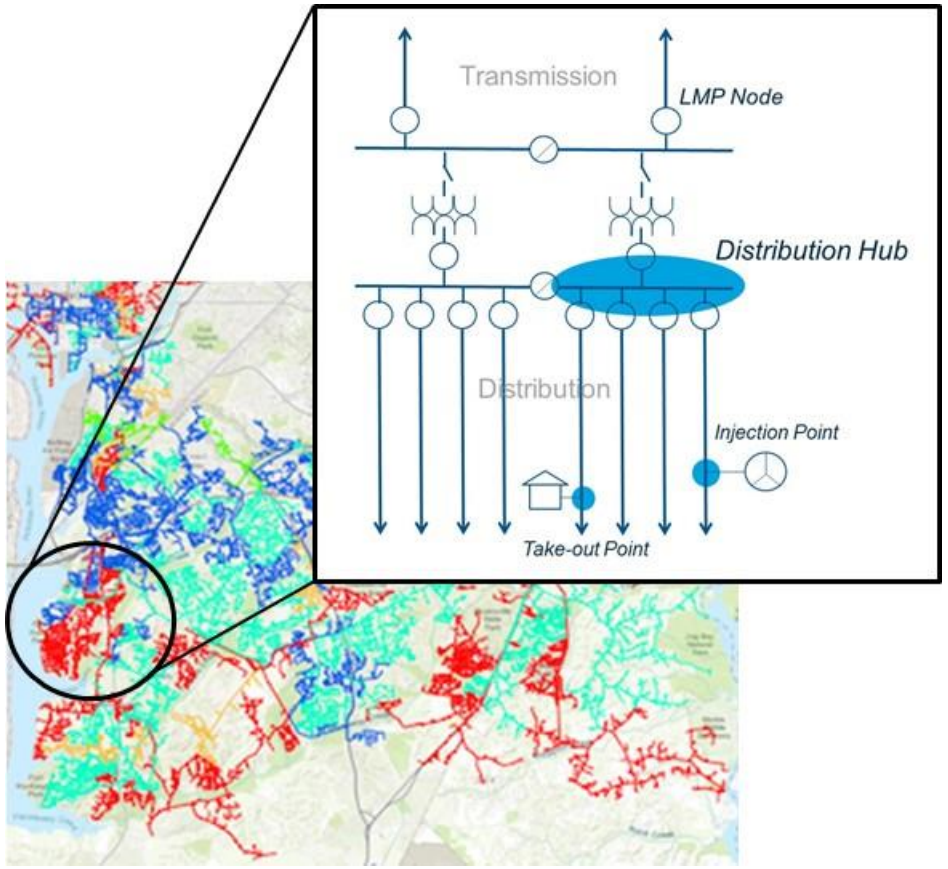
Distribution transactions are scheduled for delivery to and from this “hub” via corresponding injection and take-out points on interconnected circuits

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.

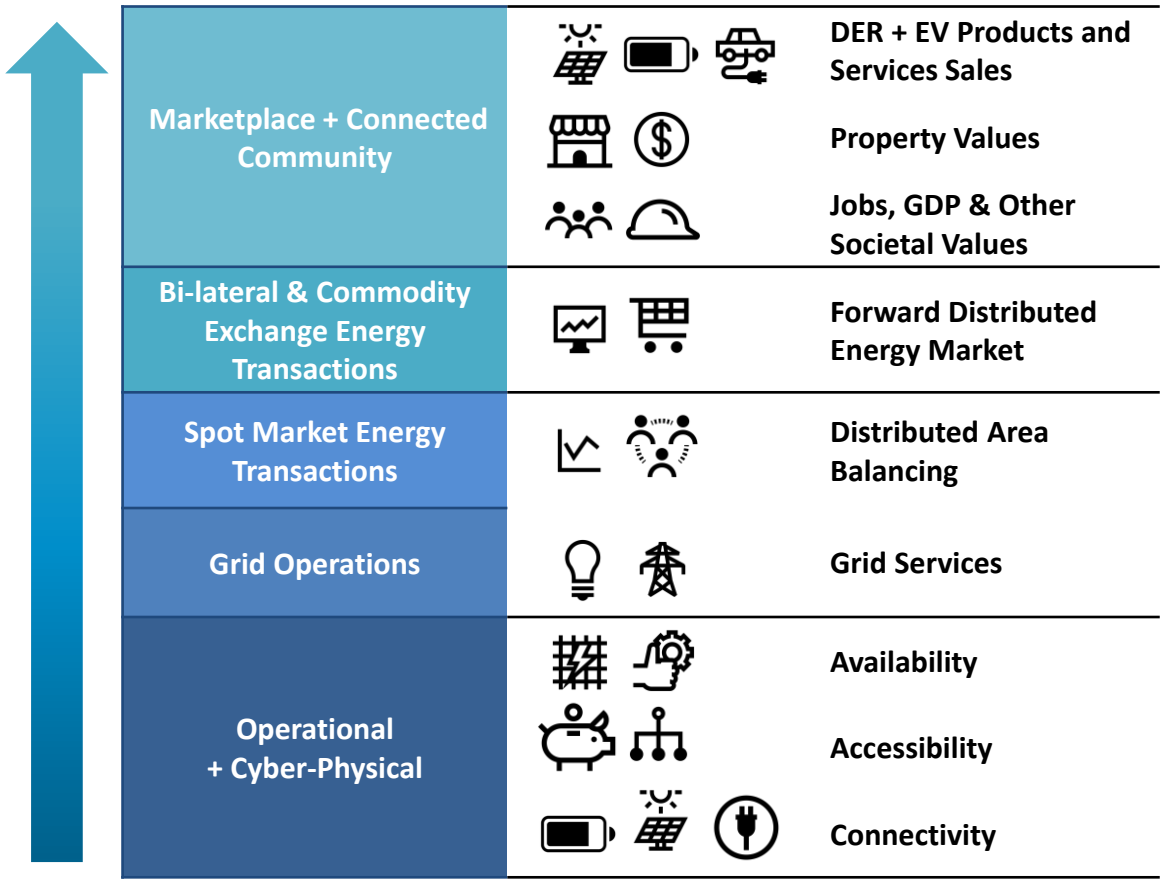
Distribution to transmission transactions

Interchange scheduling point is the associated LMP node on high side of substation transformer bank.



Grid as a Platform to Enable Value Creation

- The cyber-physical layer provides the foundation for network value creation
- Total value increases through the interdependent capabilities of each layer
- If higher density of DER adoption drives value, capturing benefits requires a broader view of the solution set and deliberate grid design to support value transactions



Source: De Martini & ICF

Transactive Oriented Grid Architecture

- Future architecture of 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 architectural of urban distribution systems and the “customer to distribution” operational coordination necessary to align with TOD communities.
- A transactive oriented grid architecture (TOGA) would involve a proactive architectural approach to engage TOD efforts to align the structure of a distributed energy ecosystem to the urban plan.
- A TOGA would inform electricity market designs, grid investments, operational coordination (including interoperability) and public policy shaping DER adoption.