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Transactive Incentive-Signals to Manage Electricity Consumption (TIME) System

Integrated Energy Policy Report (IEPR) Commissioner Workshop on Demand Response

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Outline

1. Goals and Objectives
2. Analysis and Signal Design
3. Preliminary Findings
4. Discussions

Goals and Objectives

Design, implement, and operationally deploy transactive load management (TLM) signals to facilitate demand response (DR) by California utility customers et al.

DESIGN

- Perform literature review of dynamic TLM signal experience
- Survey experts and review related projects for unpublished experiences
- Determine initial definitions for TLM signaling framework and design

IMPLEMENT

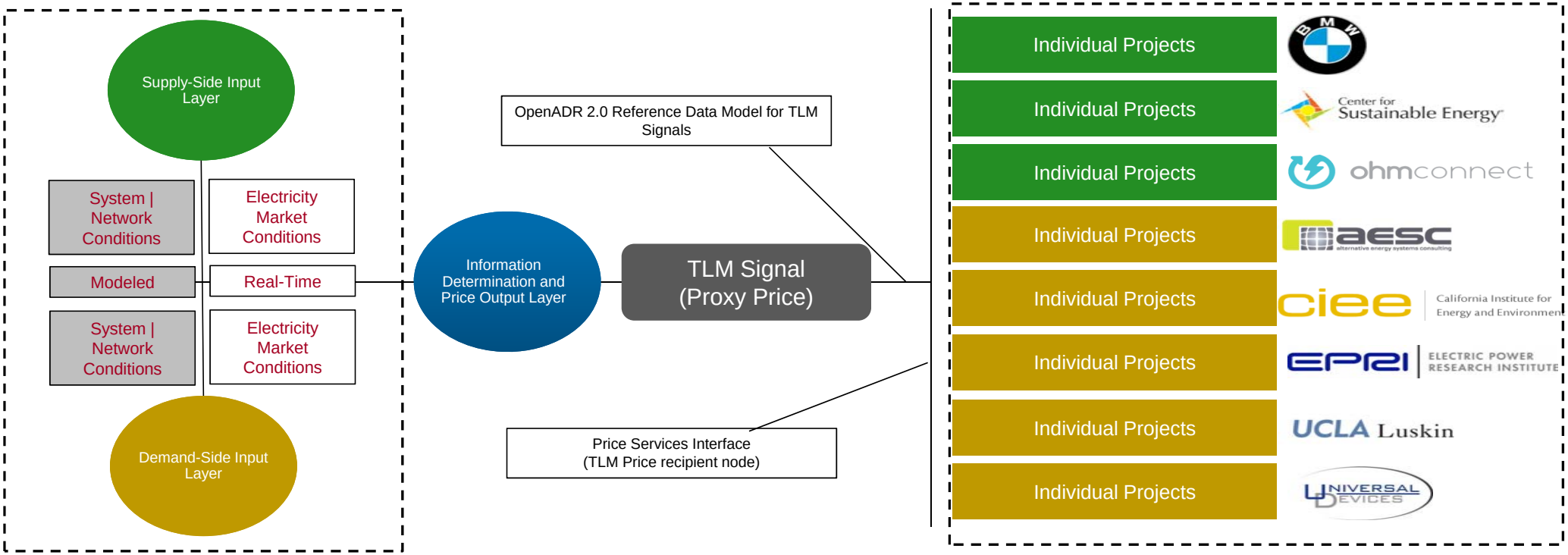
- Interface to required data sources and calculate TLM signals
- Send reference TLM signals via standard communication infrastructure
- Integrate and test TLM signals with Group 1 and 2 projects

OPERATE

- Provide operational TLM signals to Group 1 and 2 projects
- Use Group 1 and 2 feedback to refine and improve TLM signals

TIME Design Framework and Evaluation Structure

A total of 8 projects—participating, as supply-side or demand-side resources—will use the TIME framework



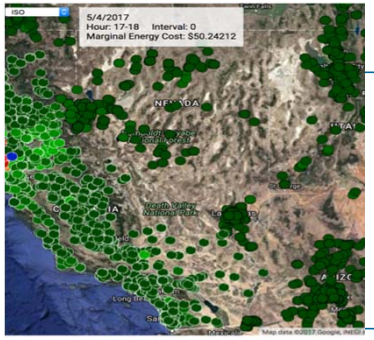
TLM Prices Analytics at a Point*

Outside TIME Project Scope

* This point can be a generic construct within the grid based on potential future advanced TLM designs that may account for spatial granularity.

Linking Analysis to TLM Signal Constructs

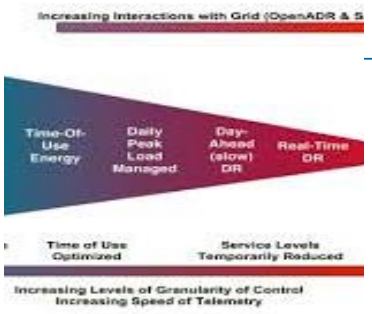
Group 1 and 2 project analysis and TAC feedback resulted in quantitative metrics to propose a generic design framework for TLM signals



Price and generation resource
(LMPs*)

Locational targeting
(LAP, Sub-LAP)

Source of generation or social costs
(Variability, GHG)

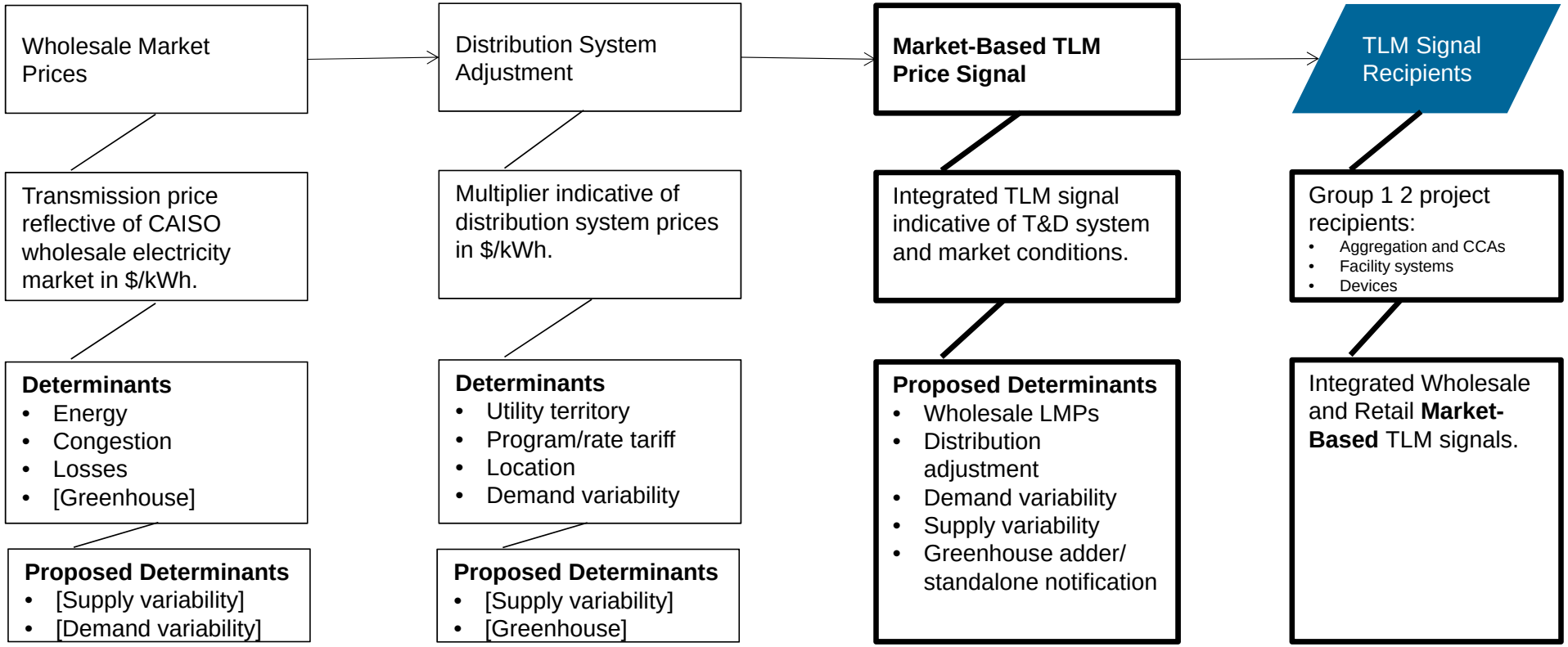


Notification period and intervals
(OpenADR)

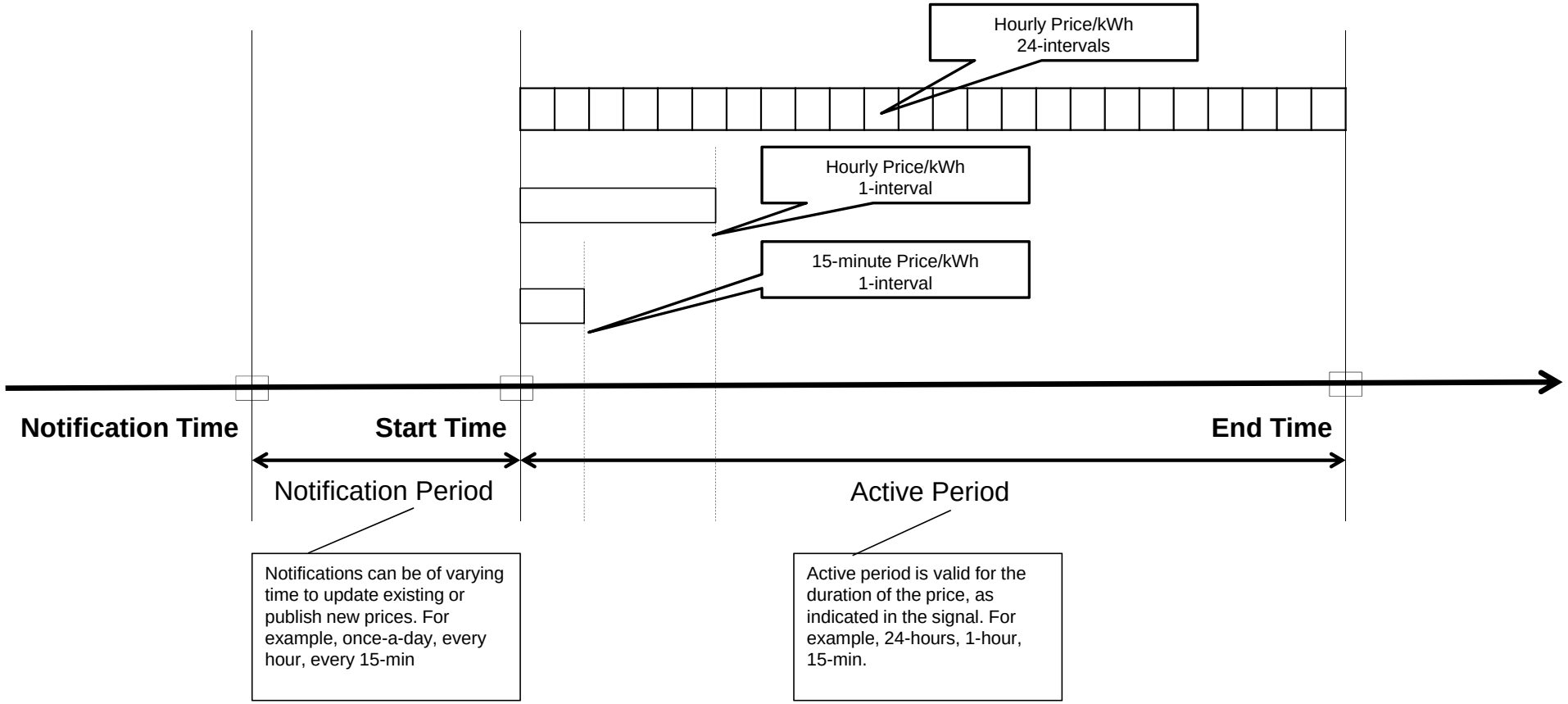
* LMP = *Supply-Side Components (**Energy + Congestion + Losses**)*

TLM Price Signal Design and Process

Design Framework for TLM Signal Construction at each Point of Price Proxy

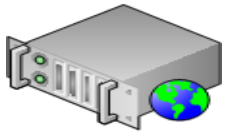


Signal Science*: Generic TLM Price Signal Construct

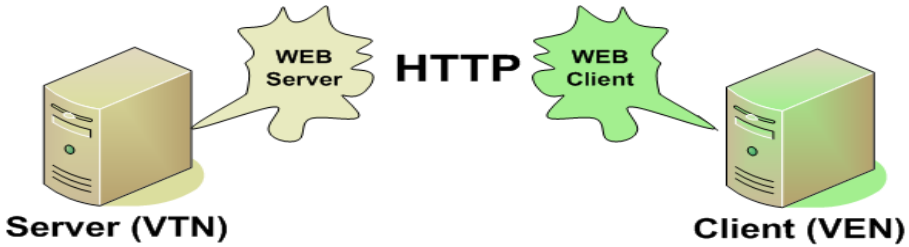


* Illustration not to Scale

Implementation using OpenADR 2.0 Standard



	EPRI VTN
Role	Virtual Top Node
Designed Use	DRMS
License	BSD 3-Clause
Profiles	2.0a and 2.0b
Data Models	Push/Pull (Poll)
Transports	HTTP, XMPP
Programming Language	JRuby, Java
Tested Operating Systems	Linux, Mac OS
Available on GitHub.com	Yes



- Complete OpenADR 2.0b-compliant server
- Available as open source since February 2014; updated most recently in January 2017
- Received Alliance certification in October 2014
- Profile 2.0b
  - EiEvent (full)
    - ELECTRICITY_PRICE
    - marketContext
    - eiTarget
      - serviceArea; serviceDeliveryPoint; serviceLocation

TLM signals are intended to be standards-agnostic.

Preliminary Findings

1. The 24-hourly day-ahead LMPs constitute the consensus temporal base basis for TLM signals (though we recognize there are outliers).
2. The Pnode LMPs are be the lowest desired spatial disaggregation for wholesale electricity market prices.
3. The distribution system variability (demand/supply) adjustment and electricity service providers and operations can be considered for integrated systems and markets.
4. An integrated and inclusive approach to the CAISO (transmission and generation) domains and electric utilities (distribution) domain is critical for “fair market” TLM signals.

Together…Shaping the Future of Electricity

Back-Up Slides

California's Electricity Flow and Markets 1.0

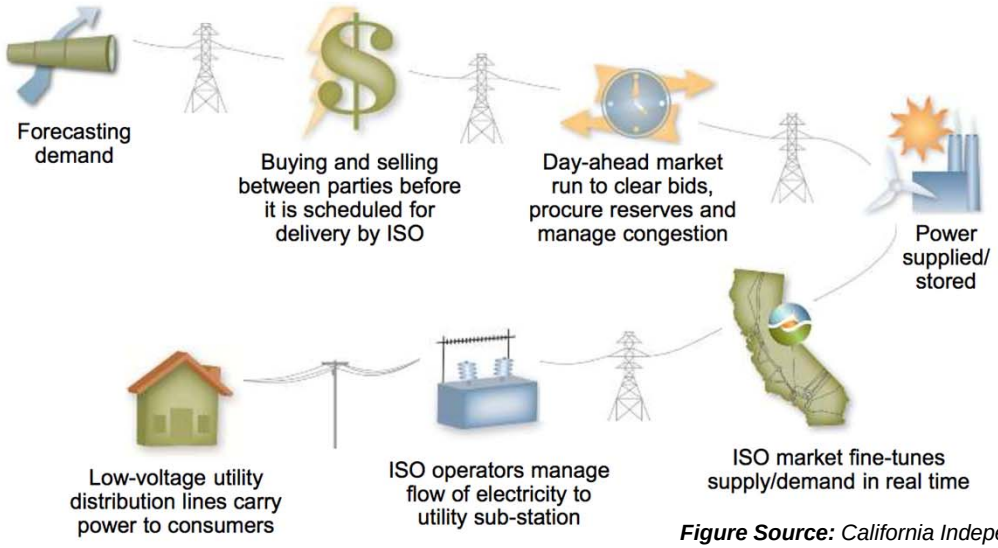


Figure Source: *California Independent Systems Operator (CAISO)*

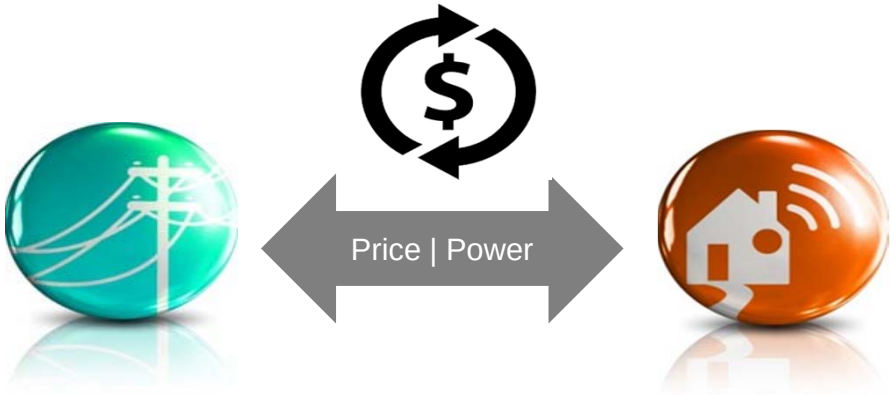
A customer-centric electricity market pricing system (Markets 2.0) for transactive load management (TLM) must account for:

1. Demand response, as a supply-side resource
2. Behind-the-meter generation and demand variability
3. Transmission- and distribution-level generation variability (to an extent demand from EVs)
4. Real-time wholesale prices and retail market electricity rate tariffs
5. Social costs (e.g., Greenhouse gas emissions)

What is Transactive *.*?

In the electricity context, transactive refers to:

i. Enable buying/selling of electricity (inherently 2-way)
ii. Actions based on economic principles
iii. Information exchange: operators, providers, and prosumers (systems)



Example: Price-based automated demand response (DR)

. Represents any or all combinations of : Energy; Systems; Networks; Controls; Signals; Standards, etc.

Transactive Load Management (TLM) Design Conundrum

How existing capabilities can be used to design and operationalize TLM signals?

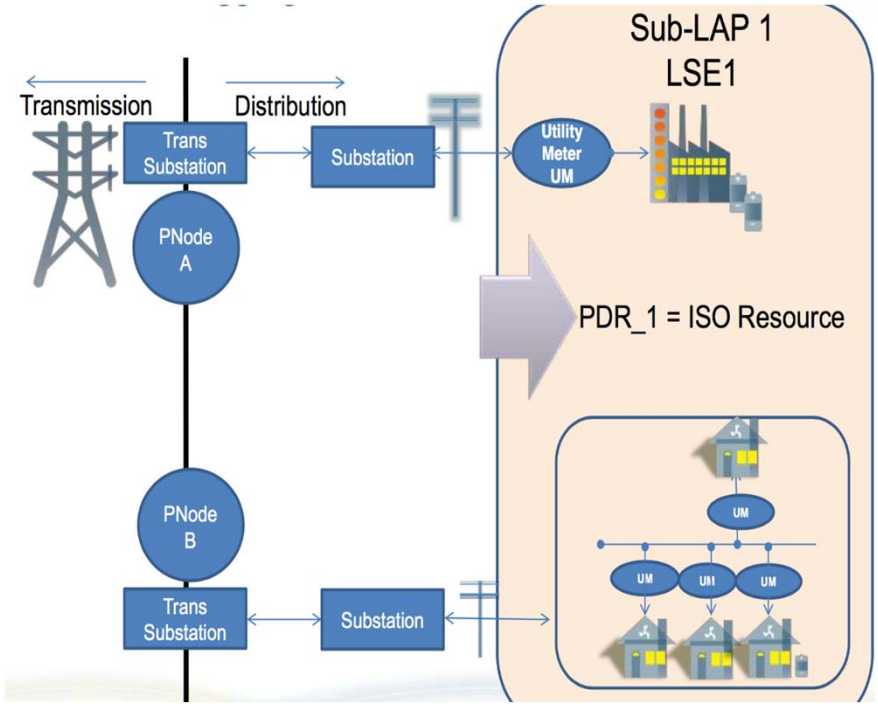
Transactive Energy (TE)
Domain: Entire Smart Grid*
Status: Theory and concept

Transactive Load Management (TLM):
Price-based signals to manage customer loads
Domain: All but, centralized/bulk generation*
Status: Practice and concept

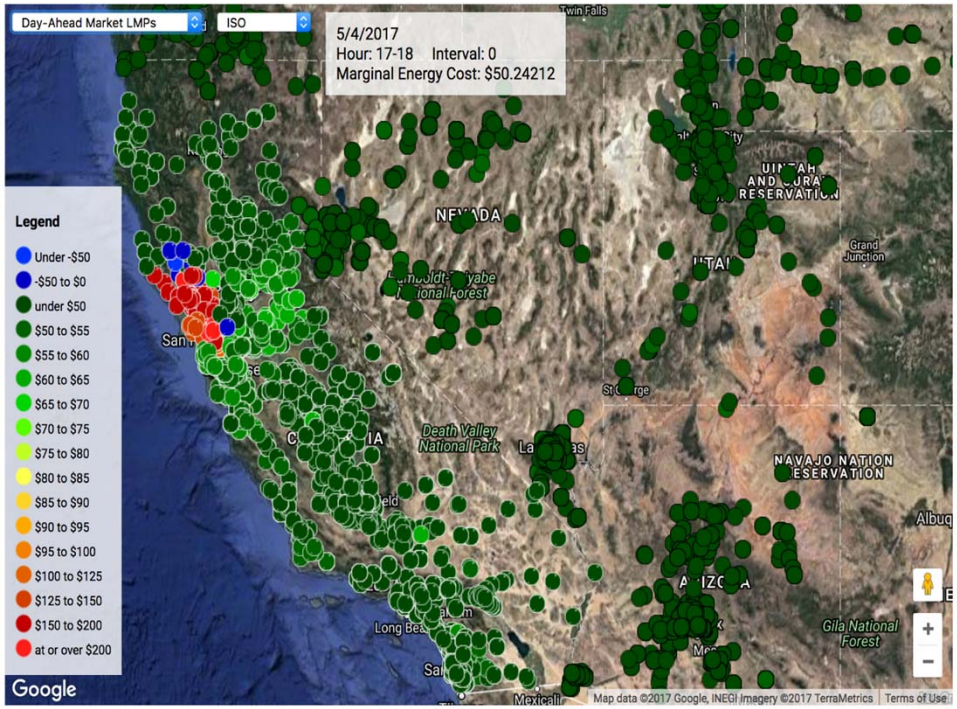
Price-based Demand Response (DR)
Retail and/or wholesale DR markets.
Domain: All but, generation & transmission*
Status: Practice

* Reference to National Institute of Standards and Technology (NIST) Smart Grid framework with seven domains – *Generation, Transmission, Distribution, Service Provider, Markets, Operations, and Customer*

Illustration: Loads Participating in PDR/RDRR Supply-side Market Products



The components of LMP are:
Energy + Congestion + Losses



CAISO's Locational Marginal Price Nodes (>3000)

Figure Source: California Independent Systems Operator (CAISO)
PDR: Proxy Demand Response (100 kW min), **RDRR**: Reliability Demand Response Resource (500 kW min)

Analysis: Group 1 and 2 Project Findings

Project/Signals	Objectives	Notification	Temporal	Spatial	End-point
BMW[1]	EV smart charge management and optimization based on cost and carbon savings.	Day-ahead (DA) Optionally, real-time (RT).[*]	Hourly price intervals. Optionally, DA and RT 15-min and 5-min price intervals.	Across 10 counties of PG&E and CCA	Aggregation cloud, as the single-point managing entity.
Center for Sustainable Energy[1]	Demonstrate the resource model for CAISO Proxy DR (PDR).	DA (stage 1) May consider RT energy or spinning/ non-spinning reserve.	Hourly price intervals. Optionally, minutes.	System-wide and/or LMP.	Aggregation cloud, as the single-point managing entity.
OhmConnect[1]	Generate load changes from large numbers of residential customers at specific times and in specific geographic areas.	Two hours for many aggregated loads. Seconds for a small number of loads.	Five minutes	Can utilize precise spatial targeting to dispatch loads in targeted areas	Aggregation cloud, as the single-point managing entity.
Alternative Energy Systems Consulting[2]	Demonstrate optimization of residential energy consumption based on day-ahead hourly pricing posted to the HEMS or aggregation.	DA Intra-hour	Hourly price intervals for DA 15-min intervals for intra-hour	Within distribution circuit, CAISO Pnode.	HEMS behind the SDG&E meter. Aggregation cloud manager.

Legend: DA: Day Ahead, RT: Real-Time; SMB: Small and Medium Business, LSE: Load Serving Entity, BtM: Behind-the-Meter

[1] Group 1 project that focuses on the role of demand response to meet the supply-side conditions—i.e., wholesale market products offered by the systems operator(s).
[*] Real-time is broadly defined, as a signal with intra-hour notification period.
[2] Group 2 project that focuses on the role of demand response to meet the demand-side conditions—i.e., retail market products offered by the distribution utilities.

Analysis: Group 2 Project Findings

Project/Signals	Objectives	Notification	Temporal	Spatial	End-point
California Institute of Energy and Environment[2]	Use real or projected prices to initiate control sequences in small to large commercial building HVAC, lighting and plug loads.	DA Can handle hour ahead as well.	Hourly intervals for 24-hour Can handle 15-minute intervals.	Sites in southern and northern CA	Signal received at each of 20 buildings. Can set up an aggregation point.
Electric Power Research Institute[2]	Demonstrate aggregation of a wide variety of load types and products for residential and SMB customers.	DA minimum. 5-15 minutes are workable and possibly ideal.	N/A - Hourly?	N/A	End devices, aggregators or Facility EMS depending on the test scenarios.
UCLA Luskin Center[2]	Study how consumer response to incentives varies to weather, day of week, and time-of-day.	Optimally, DA price signals.	Events take place over 3 hour intervals	Disaggregation within PG&E and SCE territory.	Aggregation cloud, as the single-point managing entity.
Universal Devices[2]	Demonstrate residential and commercial automated and self-managed energy use and storage.	3-minutes	Next 24 hourly intervals Next 5 minutes. Next 15-minutes.	Single location at Moorpark SCE Substation Pnode	Cloud-based TEMIX platform for Distribution Operators and LSEs

Legend: DA: Day Ahead, RT: Real-Time; SMB: Small and Medium Business, LSE: Load Serving Entity, BtM: Behind-the-Meter

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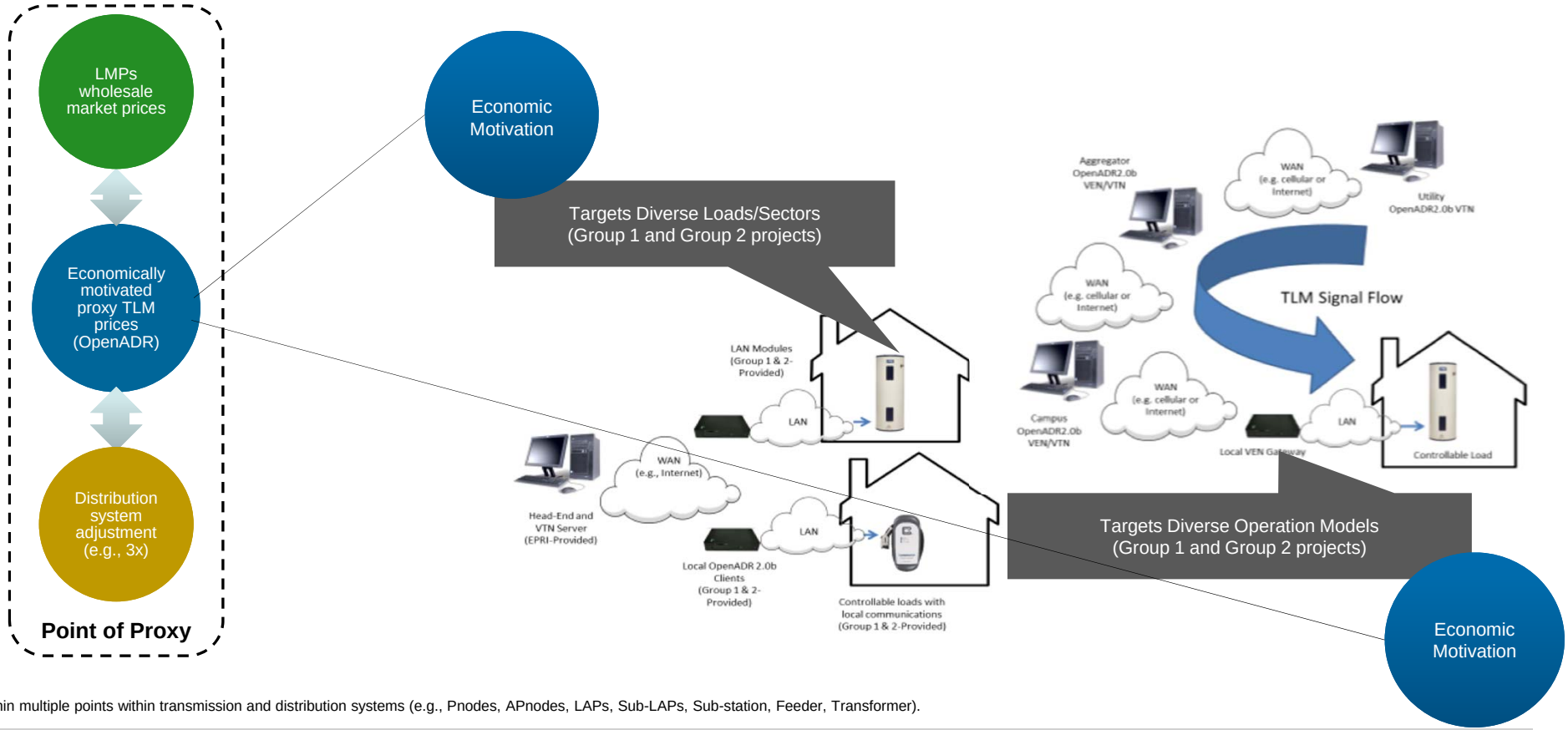
Integrated and Inclusive Fair-Market TLM Reference Framework

TLM signals can affect the demand for electricity and market efficiency.



* Determined within multiple points within transmission and distribution systems (e.g., Pnodes, APnodes, LAPs, Sub-LAPs, Sub-station, Feeder, Transformer).

Future Recommendations

- Develop a roadmap and evaluate the impacts on utility business models of extending CAISO LMPs within distribution system, based on real system and market conditions
- Develop a price-proxy open-source prototype software system and signaling tool using LMPs (wholesale) and substation (distribution)-level models
- Evaluate the technology and cost effectiveness of the TIME system for various scenarios for moving California toward a more transactive-enabled grid
- Leverage the state- and federal-level efforts to design and develop models to estimate distribution system price adjustments at different points within the distribution grid