Panel-1 Decentralization:
Solutions and Challenges in the Making

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Decentralization
Solutions and Challenges In the Making

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Leveraging from proven best practice in daily operations …

Demand Side Management practice

1993, 2016+

- Utility DSM programs of 1993
- Time of day tariffs of 2016+

Energy Efficiency & Emission Mandates

2005+ Contd. in

- Annual tightening of appliances minimum EE standards
- LED's and dramatic 80% decrease in lighting loads
- Emission constraints in AGC and Market dispatch

Generation Dispatch

CC plants, Wind & PV generation growth 2012+

- Improved demand & renewable forecast
  - Interval forecast
  - Probabilistic
  - Net load forecast
- Look Ahead SCED
- Dynamic reserves & Limits
- Flexible capacity (ramp) managed by market dispatch

Storages Growth

High DER (roof tops & battery) growth 2018+

- Solutions in the making
  - Storage SoC mgmt.
  - Microgrids optimized
  - MDMS & DERMS
- FERC 2222 guided models and solutions for
  - Market/System Op's
  - Scheduling coordinators
  - T&D Operators
  - Aggregators

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Main Points of FERC 2222, FERC 2222A, FERC 2222B

Allows DERs aggregations to participate in RTO/ISO wholesale markets

Capacity, Energy, and Ancillary Services

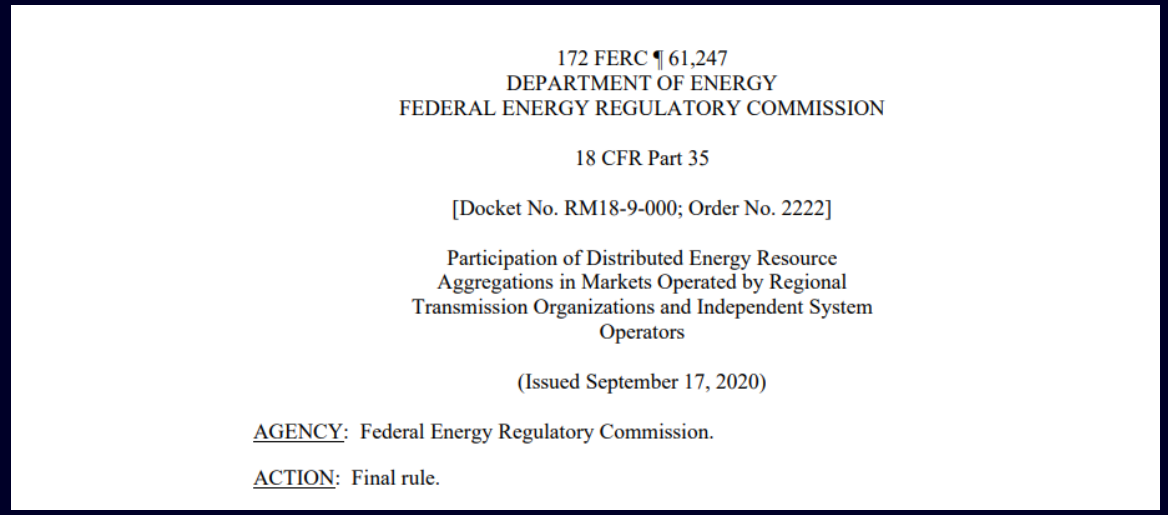
Requires RTO/ISO to remove existing barriers to participation of aggregations

Flexibility

Participation Models

Coordination with Transmission, Distribution utilities, Aggregators

Distribution utility can re-dispatch for reliability



172 FERC ¶ 61,247
DEPARTMENT OF ENERGY
FEDERAL ENERGY REGULATORY COMMISSION

18 CFR Part 35

[Docket No. RM18-9-000; Order No. 2222]

Participation of Distributed Energy Resource Aggregations in Markets Operated by Regional Transmission Organizations and Independent System Operators

(Issued September 17, 2020)

AGENCY: Federal Energy Regulatory Commission.

ACTION: Final rule.

Defined DERs as:

- BESS, Generation, Energy Efficiency, Demand Response, Thermal Storage, EVs and EVSE, located on the distribution system in front of or behind the meter
- Order 2222B, recognizes Order 719. allows homogeneous aggregation of DR opt-out of participation in wholesale markets. Order 719 opt-out would **not apply** to Heterogeneous aggregations including DR
- **But FERC is still now taking a new look at rules for Demand Response opt-out (thru Notice of Inquiry, RM 21-14-000)**

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Ecosystem impact from FERC 2222 Order

3rd Party Aggregator
- Microgrids
- Generation
- Demand Response
- Batteries
- Thermal Storage
- Forecasting

DER Owner
- Solar PV
- Batteries
- EV Charger
- Demand Response Assets

Utility Aggregator
- Microgrids
- Generation
- Demand Response
- Batteries
- Thermal Storage
- Forecasting

Distribution Utility
- Distribution Grid
- Distribution Planning
- Metering
- Billing and Settlement
- Emergency Re-dispatch
- Forecasting
- Outage Planning

Transmission Utility
- Interconnection Study
- Wholesale Metering
- Forecasting
- Outage Planning

RTO/ISO
- Market Clearing
- Wholesale Billing & Settlement
- Interconnection
- Registration
- Transmission Planning
- Forecasting

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Needs of Wholesale-Retail Market Integration

- Wholesale prices change every 5 minutes and there are reserves that can be released
- Demand elasticity as a reactional measure from price signals has not been effective

- Continuous range of load & generation dispatch and reserves are made possible by storages
- DER participation in ISO day ahead and hour ahead clearing commercializes the elasticity

Bi-directional flows:

- Congestion management must be considered in distribution networks

Value of lost load should not be a show-stopper:

- Local storages reduce the lost-load probability
- DER commercial offers are time based and are $-MW segments)

Essential needs in offers for energy and reserve balancing in Day Ahead & Hour Ahead clearing:

- Realizable capacities
- Cost basis for segments of MW range
- Forecasted limit and achievable rate of change

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California Distributed Energy Resource Program (DERP) highlights

- DERP is the California ISO's predecessor of FERC 2222
- Proxy demand resource, Reliability Demand Response & Non-Generating (NGR) resource models paved the way
- Started in 2017 with four phases through 2021
- DERP already meets the FERC 2222 mandate for California ISO

California LV network – as of September 2022

- ❑ **12 GW of rooftops in service**
- ❑ **400 batteries/week are getting installed**

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CAISO DERP Initiative
Retail Participation

Distributed Energy Resource Provider Initiative

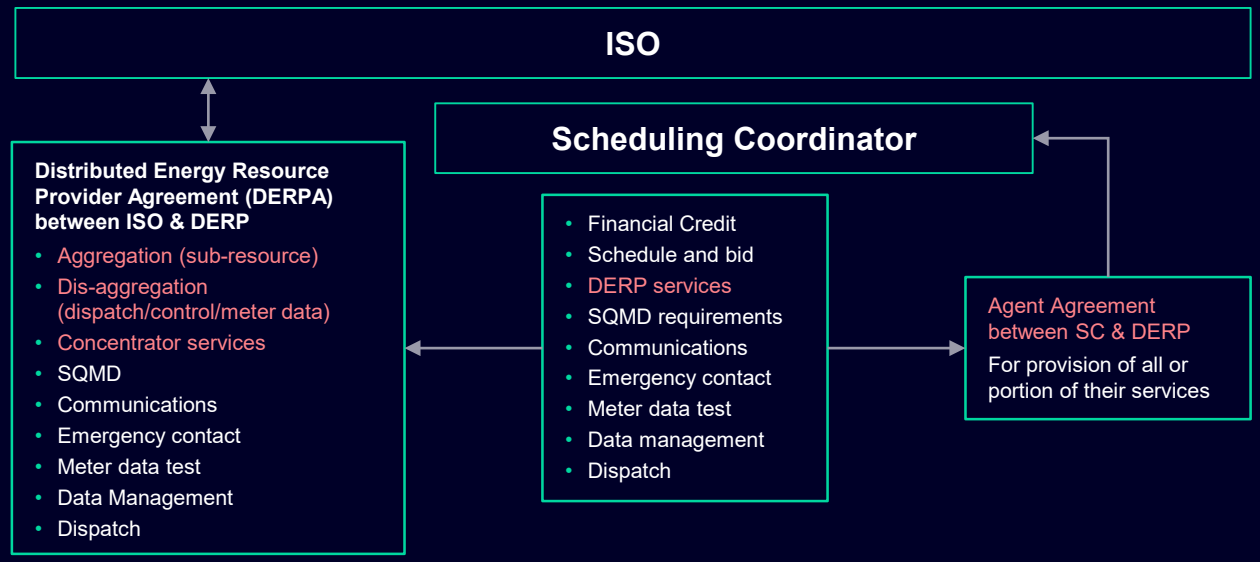
DER provider can be a scheduling coordinator (SC) to CAISO or provide services through an SC

DERP's bundle the roof-tops, storages, loads & gens. and offers them to the wholesale

Initiative impact the conventional generation dispatch

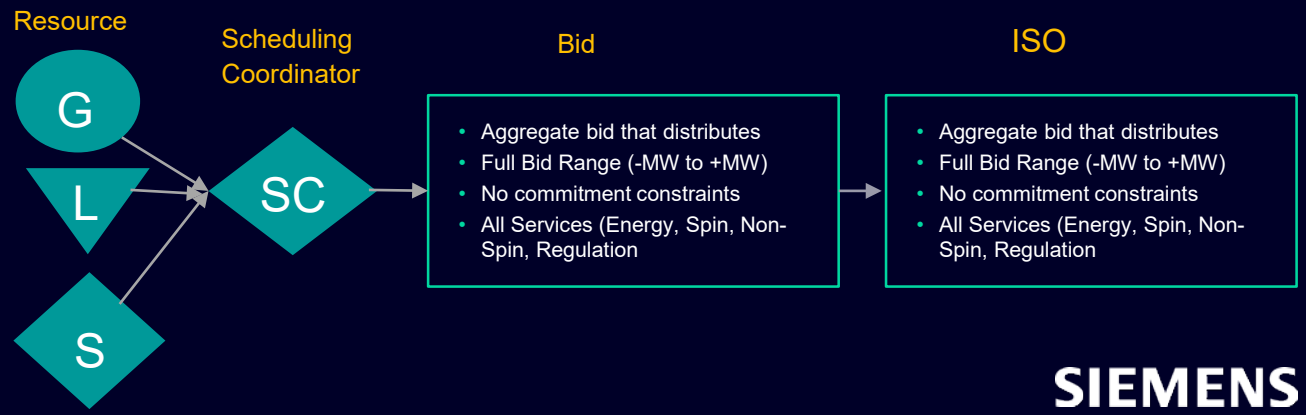
FERC 2222 is expected to stimulate more active participation of DER : Makes wholesale participation more attractive than net metering

Source: caiso.com



Distributed Energy Resource Provider – DERP

Distributed Energy Resource Aggregation



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ESDER
Energy Storages and DER in wholesale

A model that supports a standard, aggregated and hybrid configuration and facilitates accurate scheduling and reliability impact. Bidding is supported at individual or aggregate level

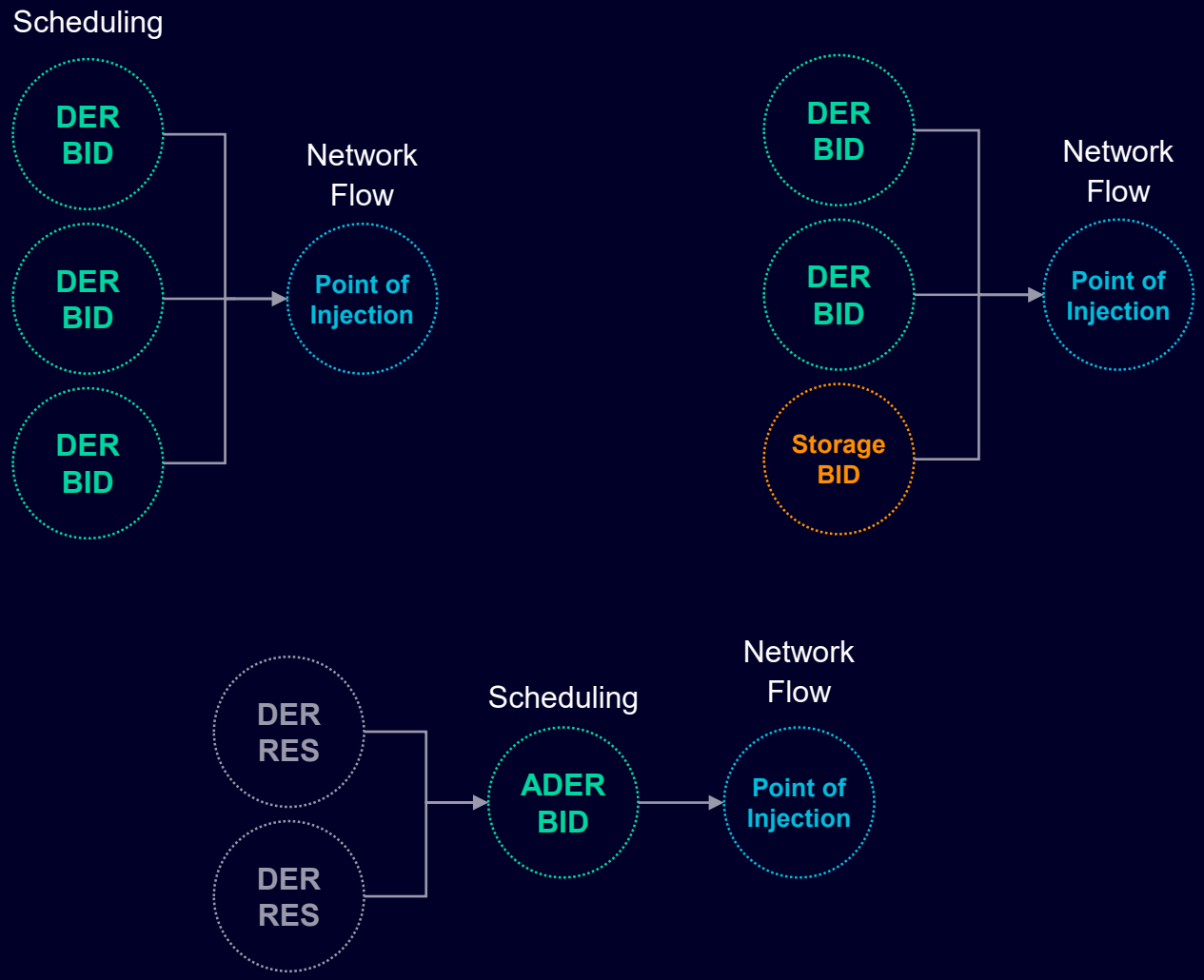
Simultaneous Co-optimization (using mixed Integer – Linear Programming solver) of DER, storage, and conventional resources

Commitment/dispatch for **Forward and Real Time Markets** in a look-ahead horizon (multi-interval form) subject to resource and network constraints

Model can be extended to DER , DR, and storage combinations

Legend:
DER: Distributed Energy Resource – Load or Generation)
ADER: Aggregated DER
Storage: Can be load (charging) or generation (discharging)

Illustrations of the DER and Storage Participation in Market



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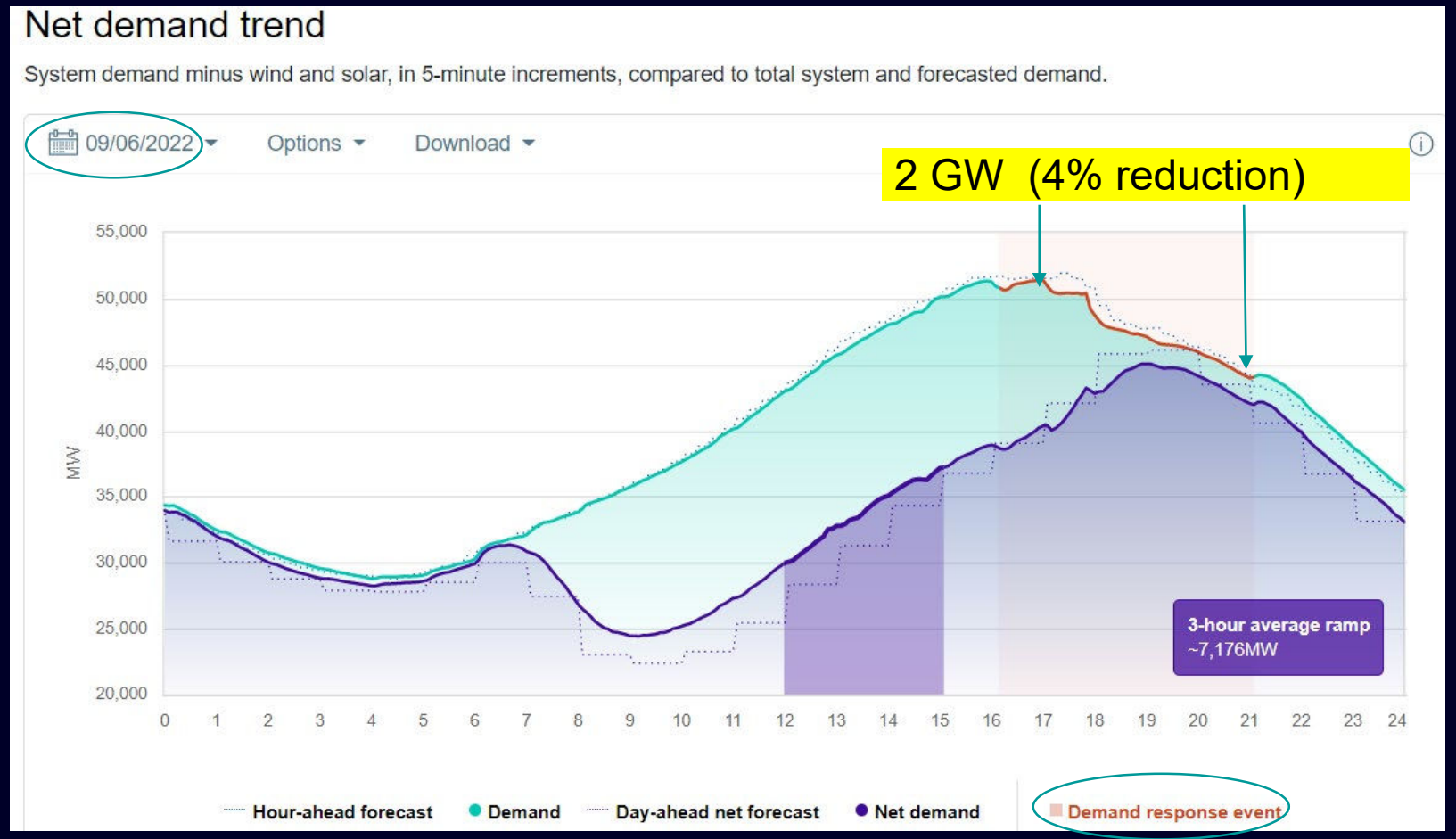
Demand Response : Actual event on 06-SEP-2022

Excessive and sustained heat wave for weeks in California in August/September



CA Governor Newsom's alert message & appeal reached 26 Million CA residents at 5+ PM

Result: 2 GW (4%) load reduction & successful avoidance of rotating load shed.

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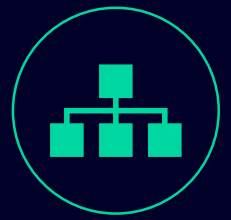
Modeling Examples needed in Decentralization

Storage optimization models

Continuous heterogeneous model (battery, load & generation)

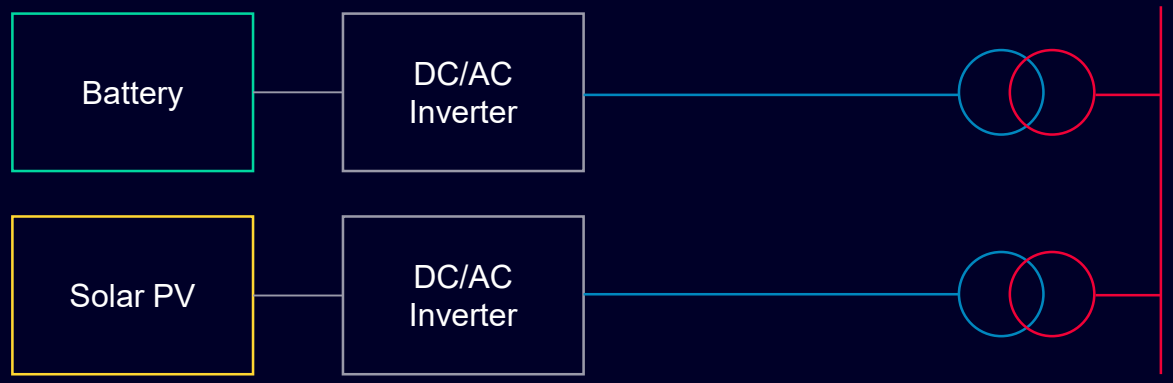
Structuring DER Forecast



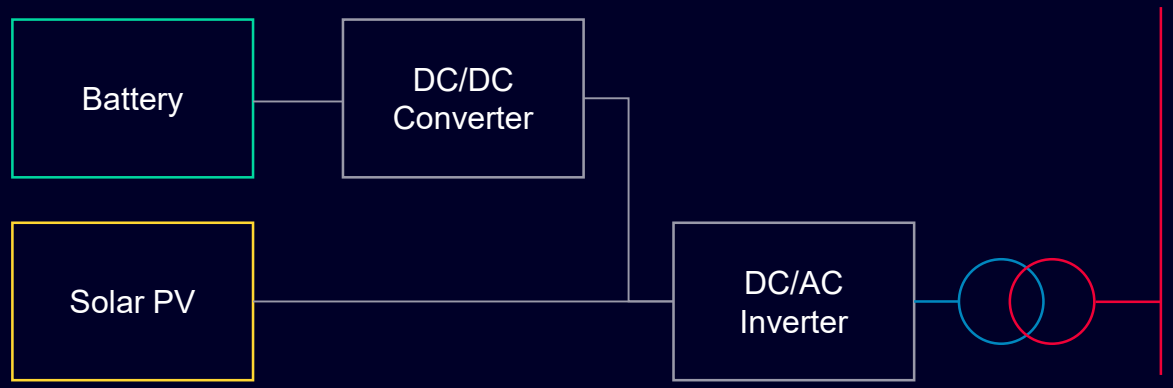
Nodal models for commercialization

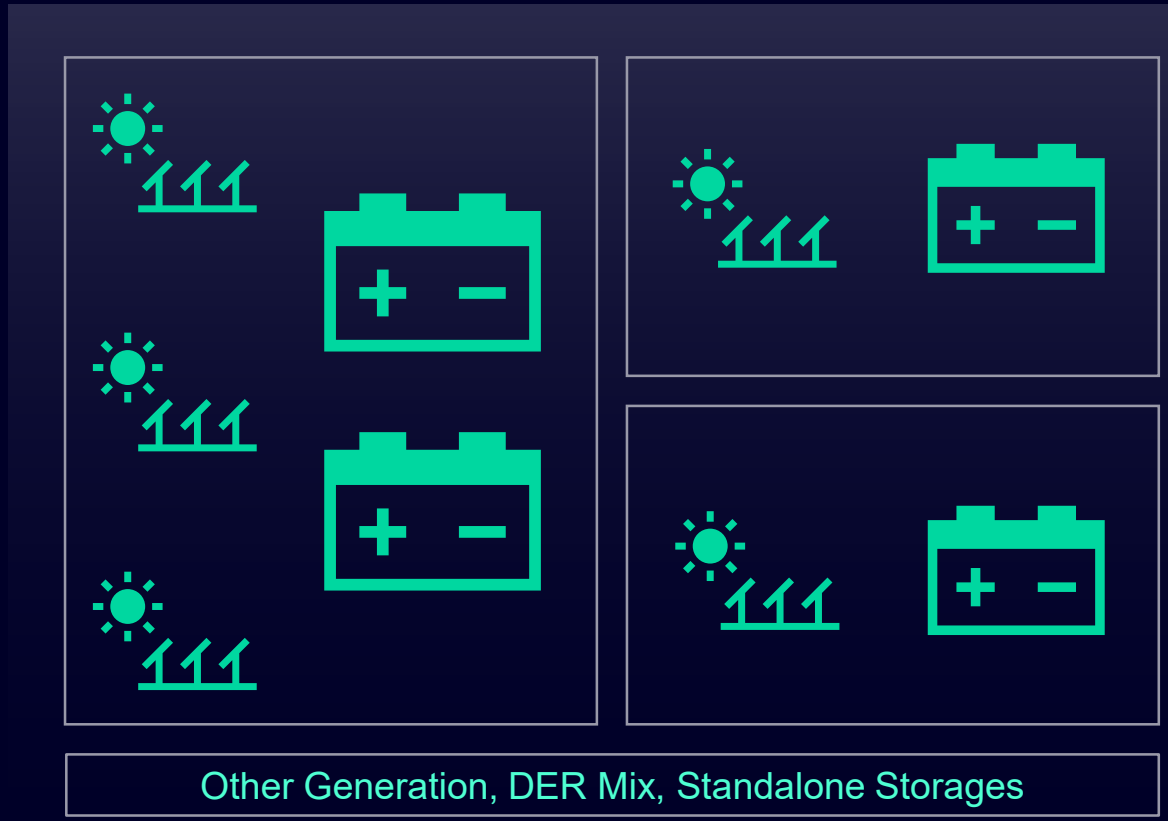
Storage – Individual and Group Configurations
Generalized Models and Optimization

A.C. Coupled Systems



D.C. Coupled Systems





Groups:

- Any combinations represented in generalized Formulation
- Hybrids under Local or ISO optimization

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Battery Models and Optimization (implemented solutions)

Hourly charging and discharging cost curve	Max & Min SOC	Charge & Discharge Ramp Rate	Max hourly/time charging & discharging amount
SOC schedule	Target SOC	Resting SOC	Reserve Model

Hybrid Resource Model (co-located & continuous heterogeneous models)	Commitment & Dispatch of the Battery

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Roof-Top Forecast Example in 2017 Datasets
DoE Project / Sunshot Initiative

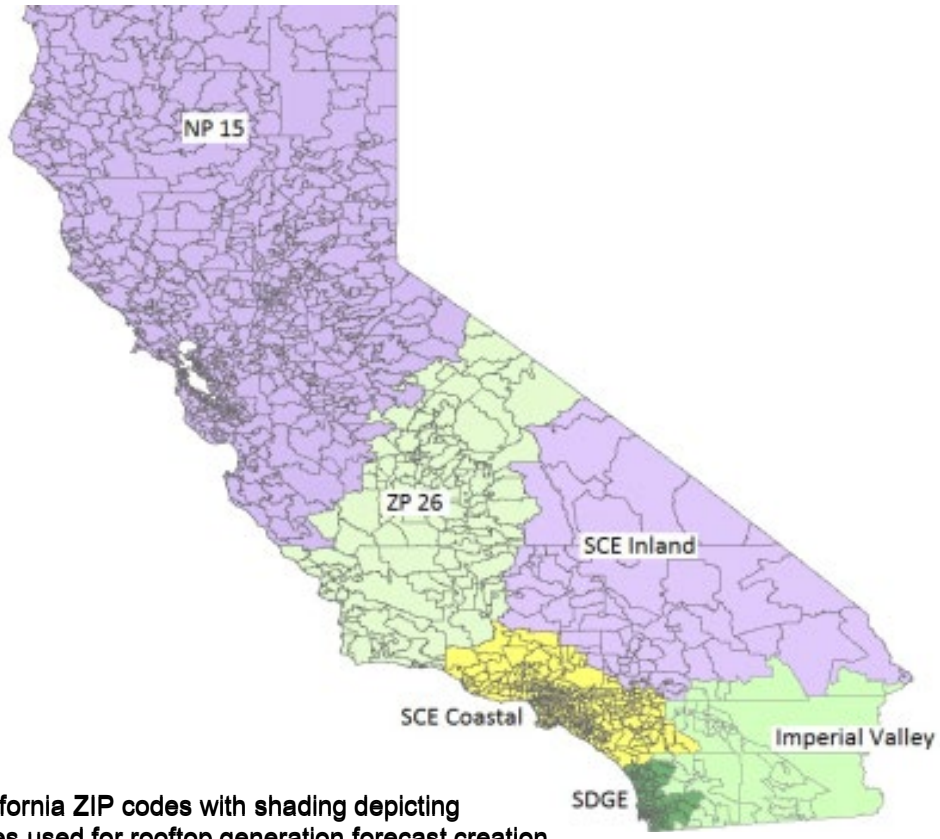
DER (roof top) solar forecast calculated in zip code granularity, for hourly intervals for a day, and 5-minute intervals for the next hour.

Bottom-up forecast for each one sq. km granularity is technology already available

DG Zones	Installed Capacity (MW)
Imperial Valley	64.0
SDGE	161.0
SCE Inland	59.4
SCE Coastal	523.3
ZP26	257.9
NP15	584.8

Source: DE-EE0006327 US DoE

Fast forward to 2022 in California LV network:
12 GW of rooftops
400 batteries/week are installed



Map of California ZIP codes with shading depicting the six zones used for rooftop generation forecast creation.

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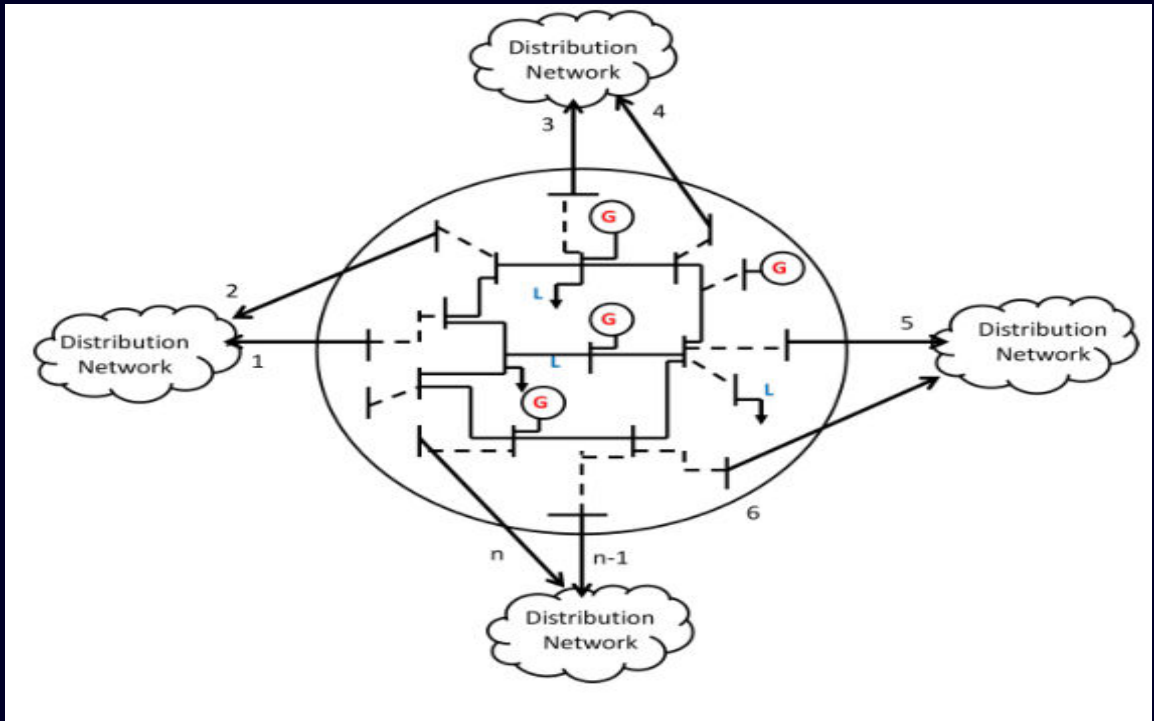
Identifying DER quantity & cost basis subject to grid physical constraints for Distribution Operators in forward time intervals – Leveraging Technology

DLMP Calculation

(using proven Standard Market Design (SMD)
for ISO optimization and MILP based on Cplex or Gurobi solver)



Calculate

Multi-Interval Dispatch Targets
for Wholesale, DER and Storage

By Minimizing sum of Costs

- Wholesale Power Cost
- DER and Storages

Subject to

- Power Balance Constraints
- DER Forecast (Capacities)
- Storage Constraints
- Network Constraints

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Ecosystem use cases needed in shaping Decentralization

Microgrid optimization – while connected to grid

MDMS and analytics use for DERMS

FERC 2222 use case for Aggregators (Day ahead, Intra day, and real time markets for normal and emergency)

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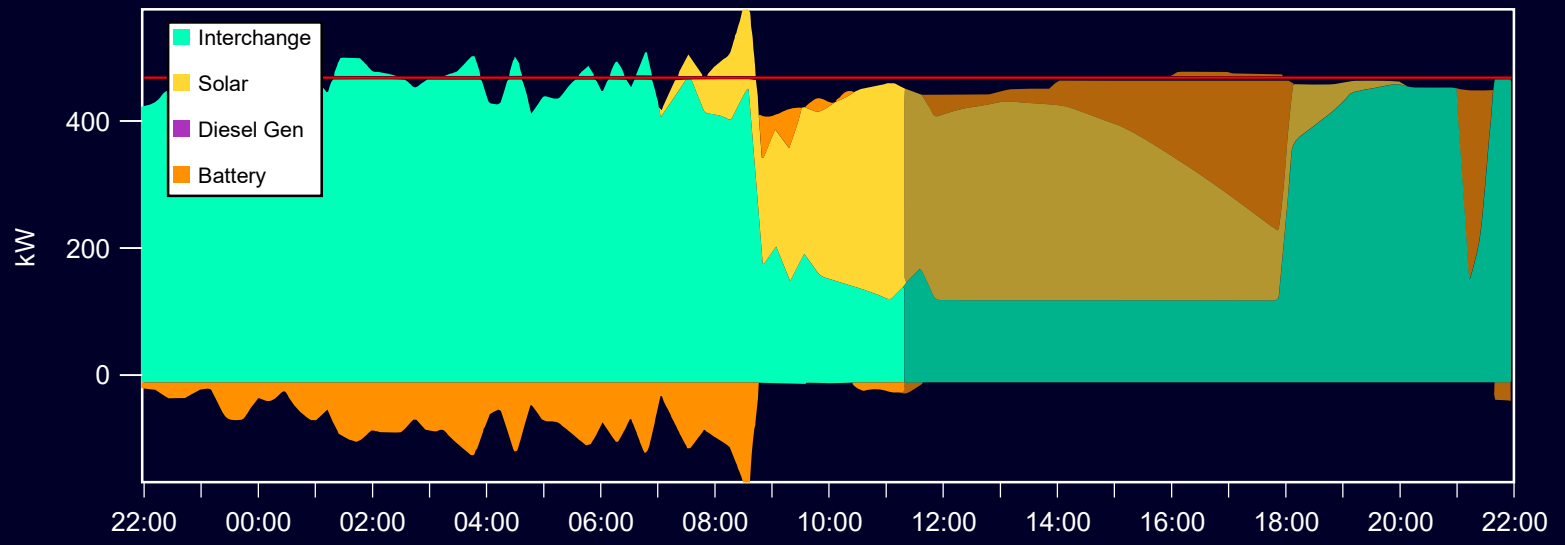
Complex Campus Microgrid
Blue Lake Rancheria, CA

Normal Operation

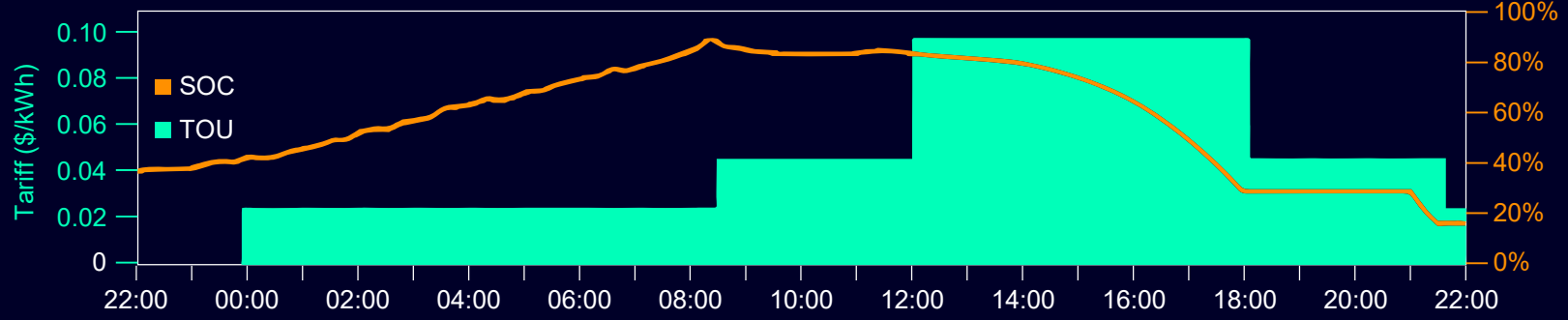
- MGMS installed to integrate and automate: 700kW Casino, hotel and office load, 1MW diesel gen, 175kW fuel cell + biomass and 500kW PV + 1MWh battery
- Site is not allowed to export to grid.
- Generation mix reflects what would be expected of site designed to meet majority of load via solar.
- Pull grid power at night to charge battery and meet load.
- Escalating tariff creates incentive for site to consume battery storage during 12-18h period.

Normal Operation

Generation (kW)



Grid Energy Tariff and State of Charge



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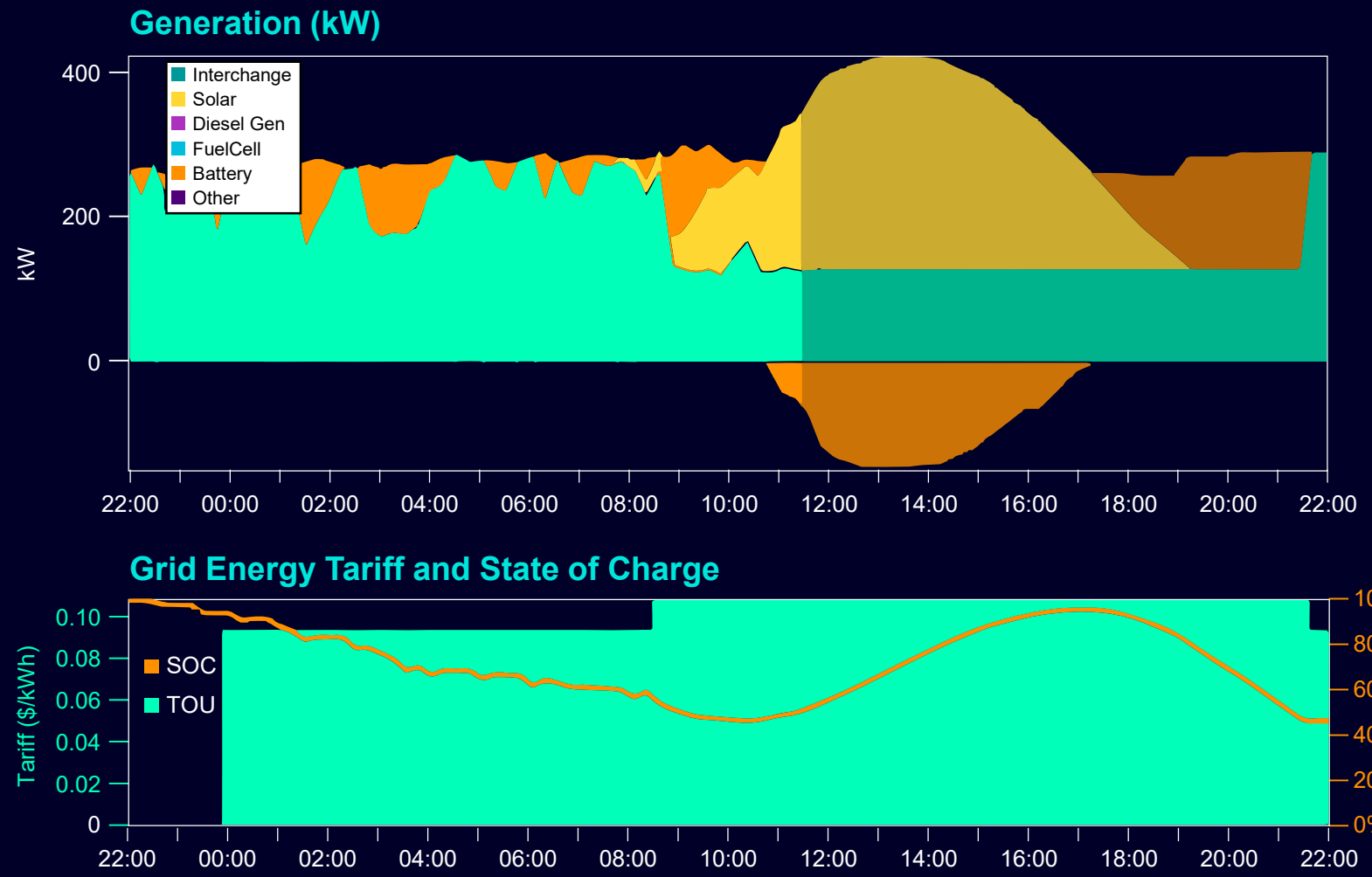
Complex Campus Microgrid
Blue Lake Rancheria, CA

Covid Operation

COVID-19 Operation

- Note: site is not allowed to export to grid.
- Casino and hotel at reduced operation and load drops significantly (~450 -> 250 kW).
- PV still produces as much as before so must be curtailed (increase cost) or consumed.
- MGMS re-optimizes, **without human interaction**, to discharge battery at night to ensure solar is still used as much as possible to minimize cost.



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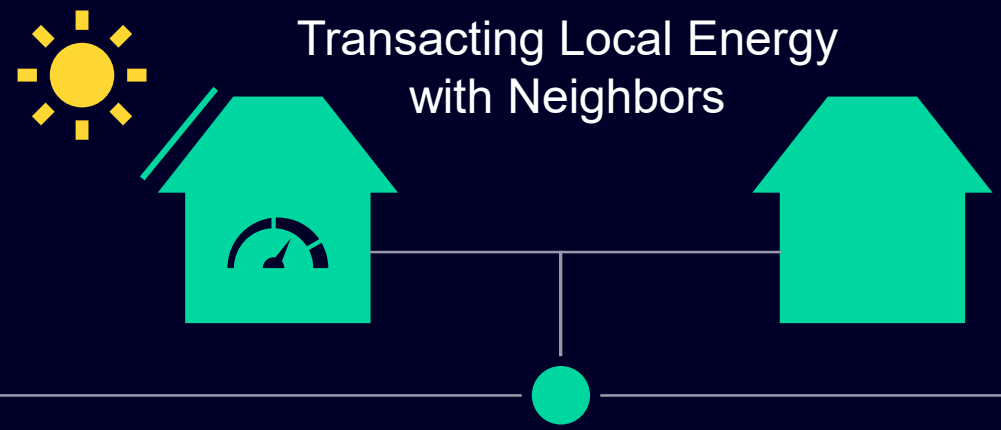
Transactive Energy is in nascent stage, but can be an Enabler -
Microgrids in Community Solar projects

Success story of Blockchain in the energy sector
by Siemens Grid Software, LO3, and the startup financier : Siemens Next47

The Brooklyn "Microgrid" Project



Consumers can choose where to buy renewables from:

Monthly bill:
10% from Regional
10% from Local Microgrid

Local
Transactive Microgrid

Regional
Renewable Provider

To enable the silent-majority we will ideally need:

- Consent & signed agreement from the consumer / prosumer
- Intelligent & automatic scheme to perform P2P selections, transactions & payments

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conEdison, inc.

Consolidated Edison

Smart metering at its best.

Solution

EnergyIP Meter Data Management to handle 5 million+ smart electricity and gas meters in Manhattan

Benefit

Reduce power consumption by up to 15% as stated by NY REV goals

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EnergyIP Meter Data Management and Analytics for Konstant Net A/S, Denmark

125,000 virtual meters

EnergyIP MDM provides unprecedented LV network transparency

3 weeks

Case analysis effort saved each data review period due to Analytics Foundation

20% DER

Analytics provides visibility into transformers and electricity flow from customers to the electricity grid

"It's a new world. The way electricity is produced differs from the past. Clients are buying rooftop solar panels and producing energy. You may not have the right cable for energy to go the opposite way. Being able to facilitate flexible electricity consumption requires you to know your load on the grid in great detail."

Poul Berthelsen - Innovation Manager, KONSTANT

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Concluding thoughts & discussions:
A zero-carbon system will have to evolve to accepting renewable generation and managing storage & loads

Technology and analytical solution kits are more-or-less available from proven practice

- Standardization & adaptation by the ecosystem is a bigger hurdle
- MDMS, MGMS & Analytics are paving the way for DERMS
- IEC CIM framework – increasing level of data exchange is essential (61970 Network Models, 61968 Asset Models, 62325 Market Communication are associated standards)

New Challenges

- Increased variability of generation, low inertia, frequency response, adapting flexible loads and managing BESS, lack of long-term storages

Regulatory measures to guide the ecosystem

- Consensus building – many parties are involved
- Silent majority buy-in is complex
- State mandates & incentives to assist the regulators

Overall ecosystem's wide adaptation takes time and efforts

- Pilots followed by standardization is ideal to ease and accelerate adaptation
- Behavioral economists' techniques can accelerate participation of a large population (e.g., Thaler's *Nudge Theory - a proven success)

*Nudge: Improving Decisions About Health, Wealth & Happiness, 2009, by Thaler & Sunstein

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Bio of Sankaran Rajagopal.
Siemens Grid Software

Sankaran Rajagopal is currently a Senior Director responsible for Energy Markets-Business Solutions at Siemens **Smart Infrastructure – Grid Software** out of Minneapolis, Minnesota, USA. He is an Iowa State Ph.D. in E.E. He's been with Siemens for over two decades.

His salient and active engagements at Siemens over the years have been:

- Power System Applications Development, Operator Training Simulators, Regional Black-start Drills & System Restoration
- Development and Product Release management
- Program Management for Siemens delivered market system at California ISO
- Engaged in Siemens Market system solutions thru' the rapid progression of game changers: shale gas, renewable penetration, energy imbalance market, storage penetration and now FERC 2222
- Global engagement in the topics of market design and the needed IT/OT Systems
- New business solutions dealing With Energy Markets and Market Participants

He is a regular volunteer as a teacher for children in the Sunday school and for non-profits fundraising. His fun activities are: running, road bike, puzzles, Bridge, classical music and face-time with his grand daughter.

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