


Past, Present and Future Directions with Open Demand Response Communications

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Presentation Outline

- History of OpenADR
- The Changing Electric Grid and DR
- Distributed Energy Resources
- The Need for a Common Energy Service Interface
- OpenADR Activities in China
- Model Predictive Control

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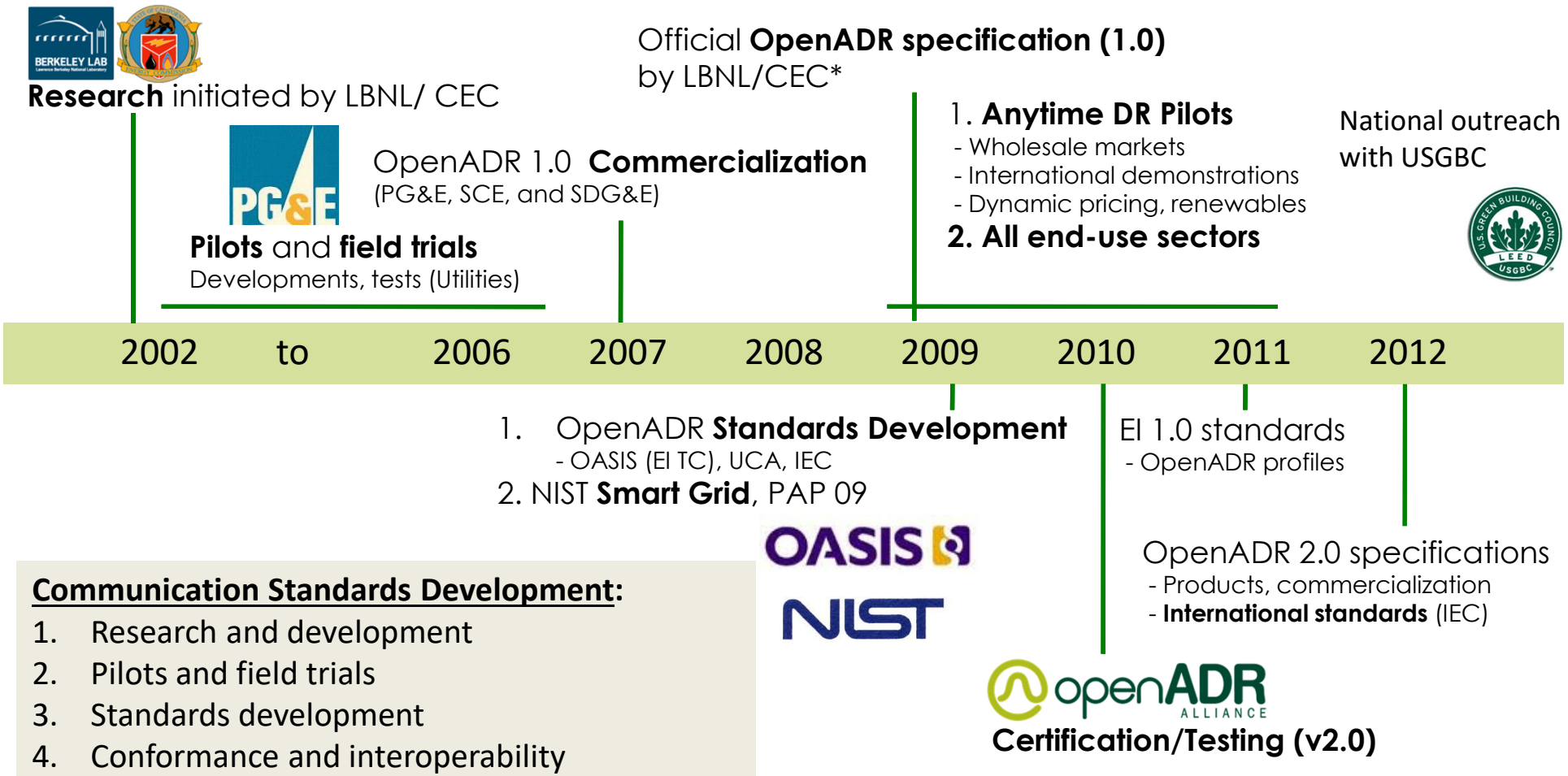
OpenADR Interoperability Progress

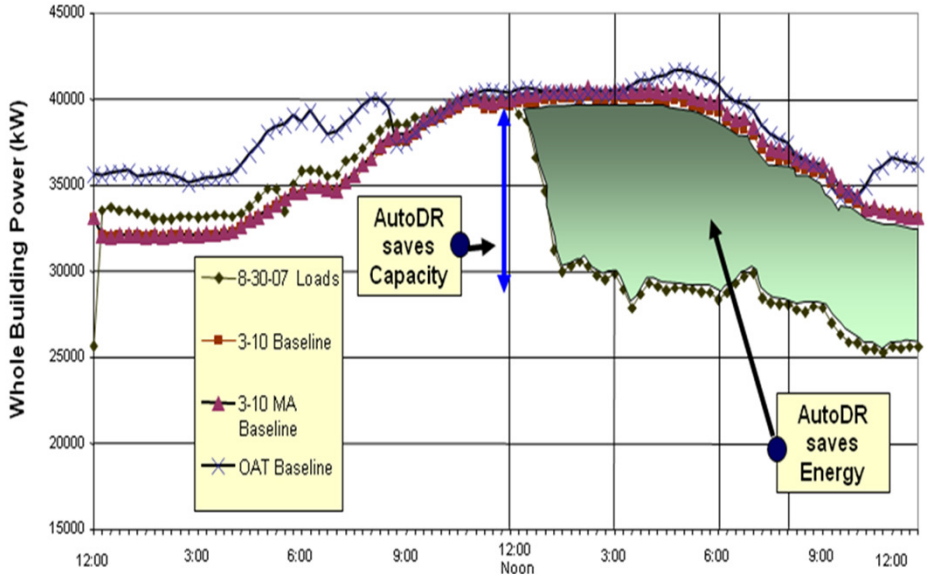


Communication Standards Development:

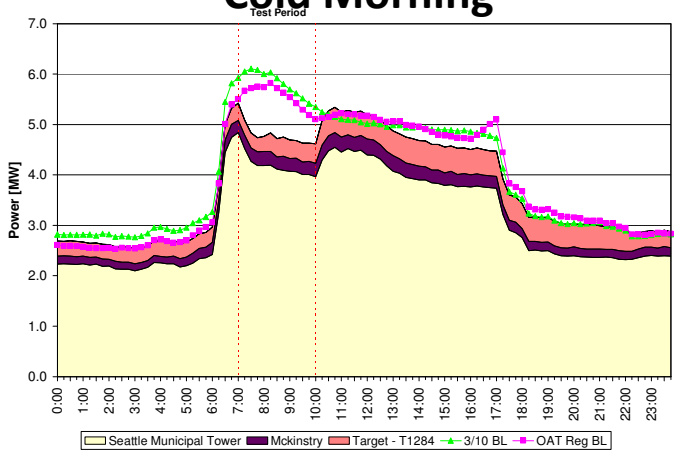
1. Research and development
2. Pilots and field trials
3. Standards development
4. Conformance and interoperability

Historic focus on Seasonal Grid Stress

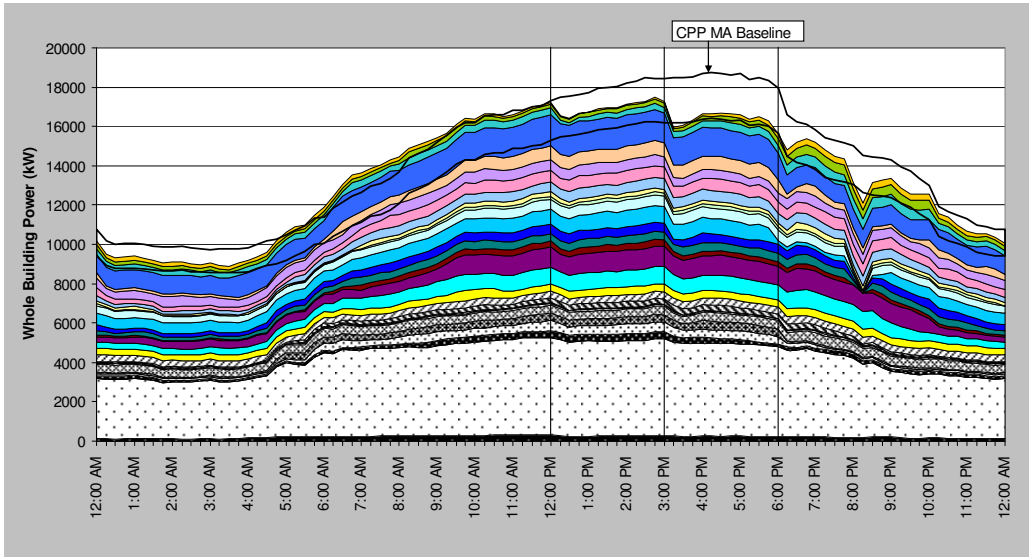
OpenADR PG&E Demand Bid Test Day



OpenADR Northwest Test on Cold Morning



OpenADR Cumulative Shed in July 2008



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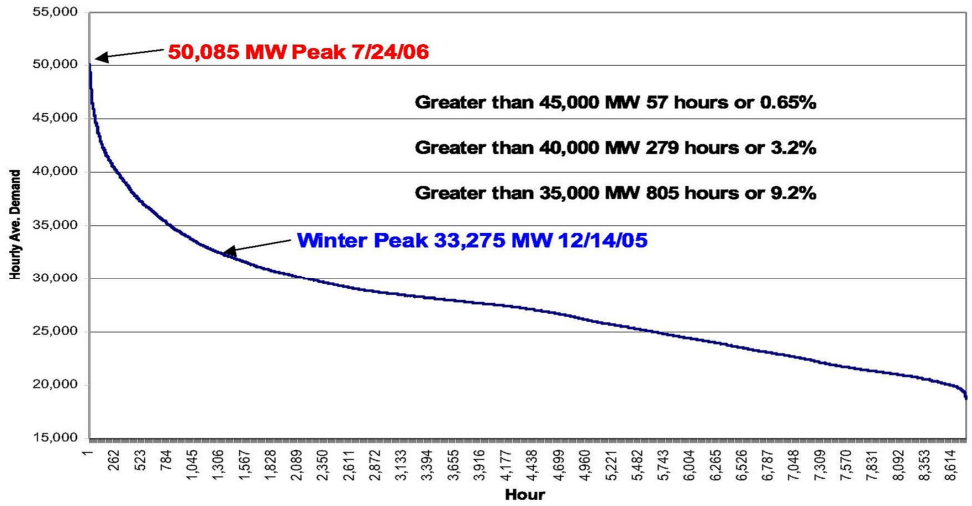
The Electric Grid is Changing

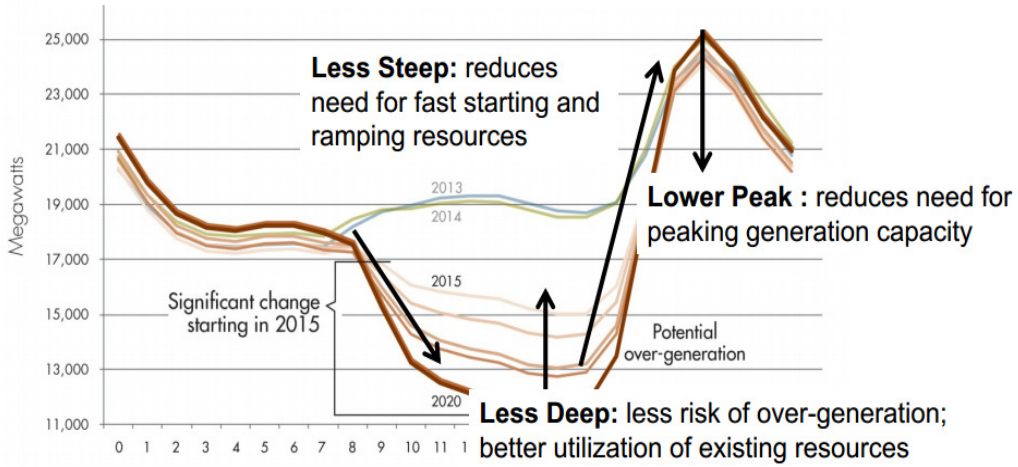
California ISO
Your Link to Power

California Independent
System Operator Corporation

CAISO Load Duration Curve

Sept '05 to Sept '06





Note, this curve is being updated, it is used here to represent how we should look at what we are trying to accomplish

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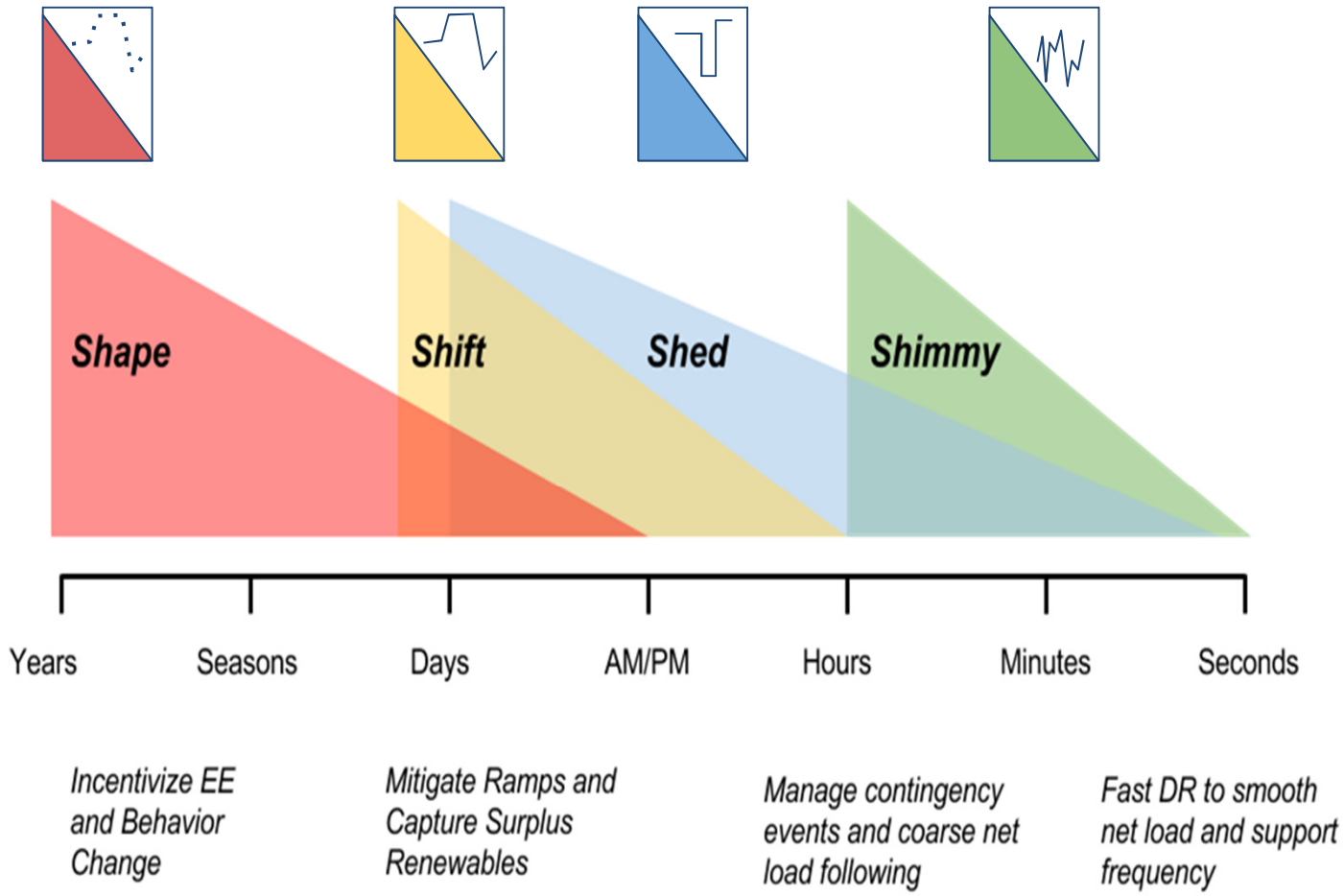
DR Service Across Timescales to Meet Future Grid Needs



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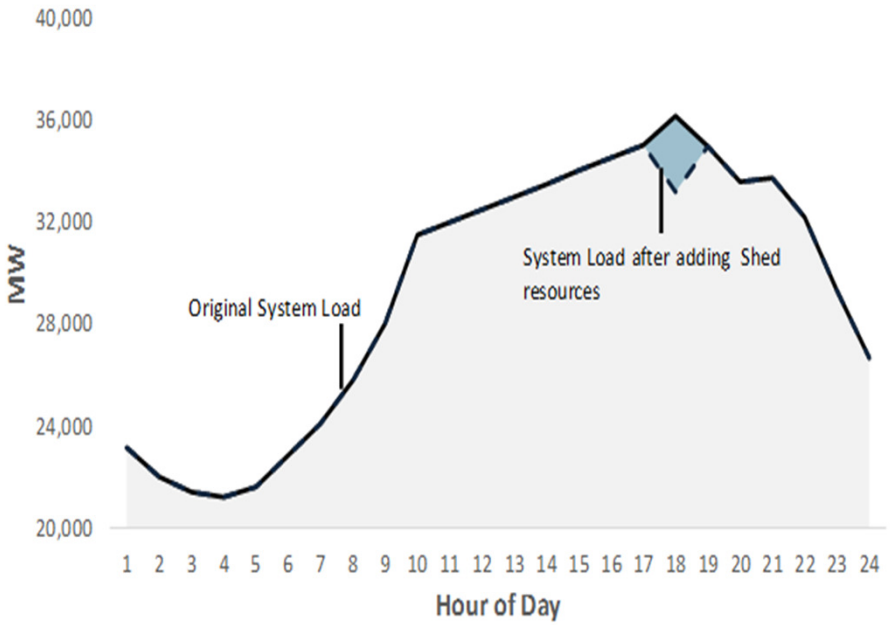
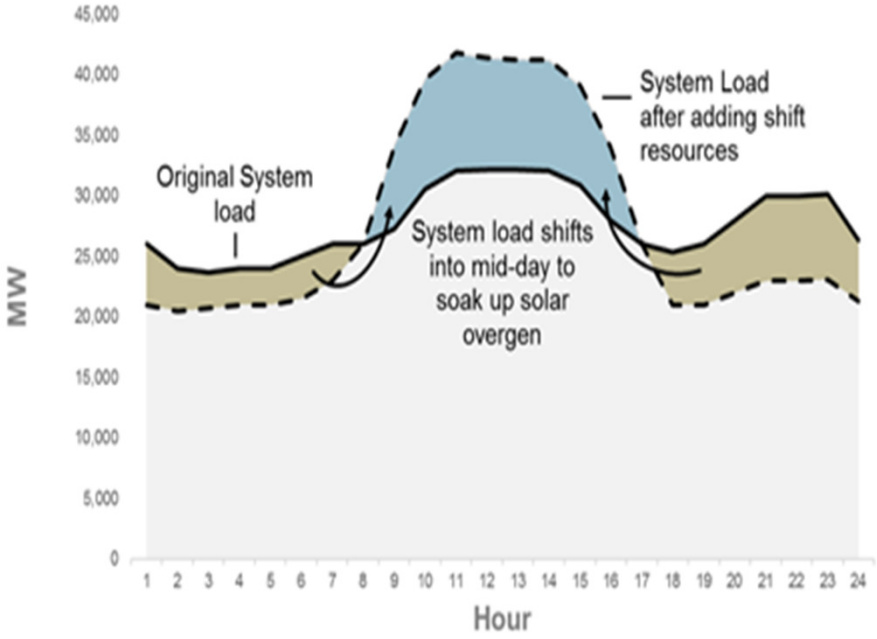
DR Potential Study - Shed and Shift

Shed Service Type: Peak Shed DR

Shift Service Type: Shifting load from hour to hour to alleviate curtailment/ overgeneration





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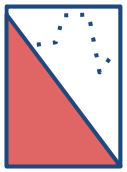
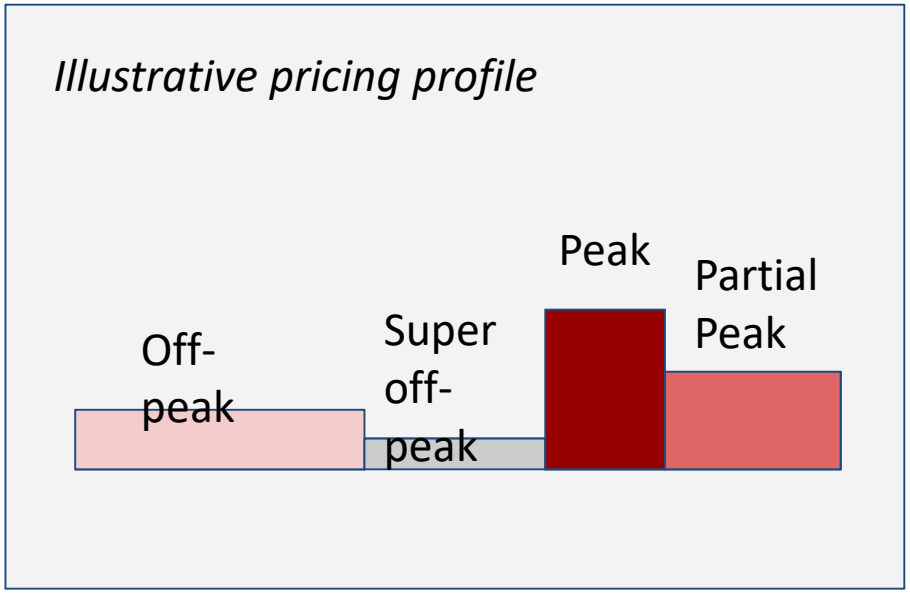
Energy+Environmental Economics

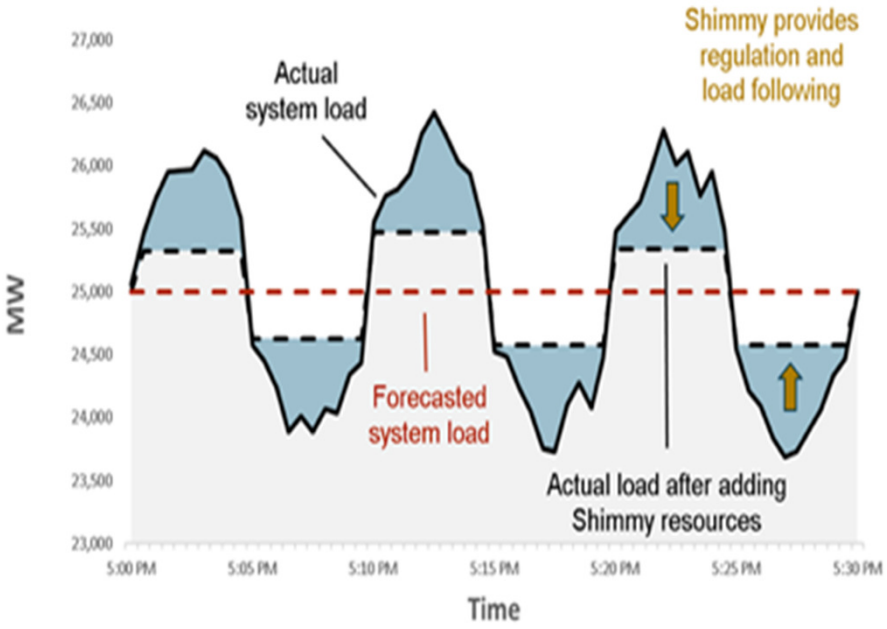
DR Potential Study - Shape and Shimmy



Shape Service Type as modeled: Accomplishes Shed & Shift with prices & behavioral DR.

Shimmy Service Type: Load Following & Regulation DR





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Energy+Environmental Economics

End Uses and Enabling Technologies

Sector	End Use	Enabling Technology Summary
All	Battery-electric and plug-in hybrid vehicles	Level 1 and Level 2 charging interruption
	Behind-the-meter batteries	Automated DR (Auto-DR)
Residential	Air conditioning	Direct load control (DLC) and Smart communicating thermostats (Smart T-Stats)
	Pool pumps	DLC
Commercial	HVAC	Depending on site size, energy management system Auto-DR, DLC, and/or Smart T-Stats
	Lighting	A range of luminaire-level, zonal and standard control options
	Refrigerated warehouses	Auto-DR
Industrial	Processes and large facilities	Automated and manual load shedding and process interruption
	Agricultural pumping	Manual, DLC, and Auto-DR
	Data centers	Manual DR
	Wastewater treatment and pumping	Automated and manual DR

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Enabling Technology Modeling Framework

Components:

Costs

- Initial
- Operating
- Etc.

Performance

- Speed of response
- Magnitude
- Persistence

Propensity to Adopt

- Based on customer factors

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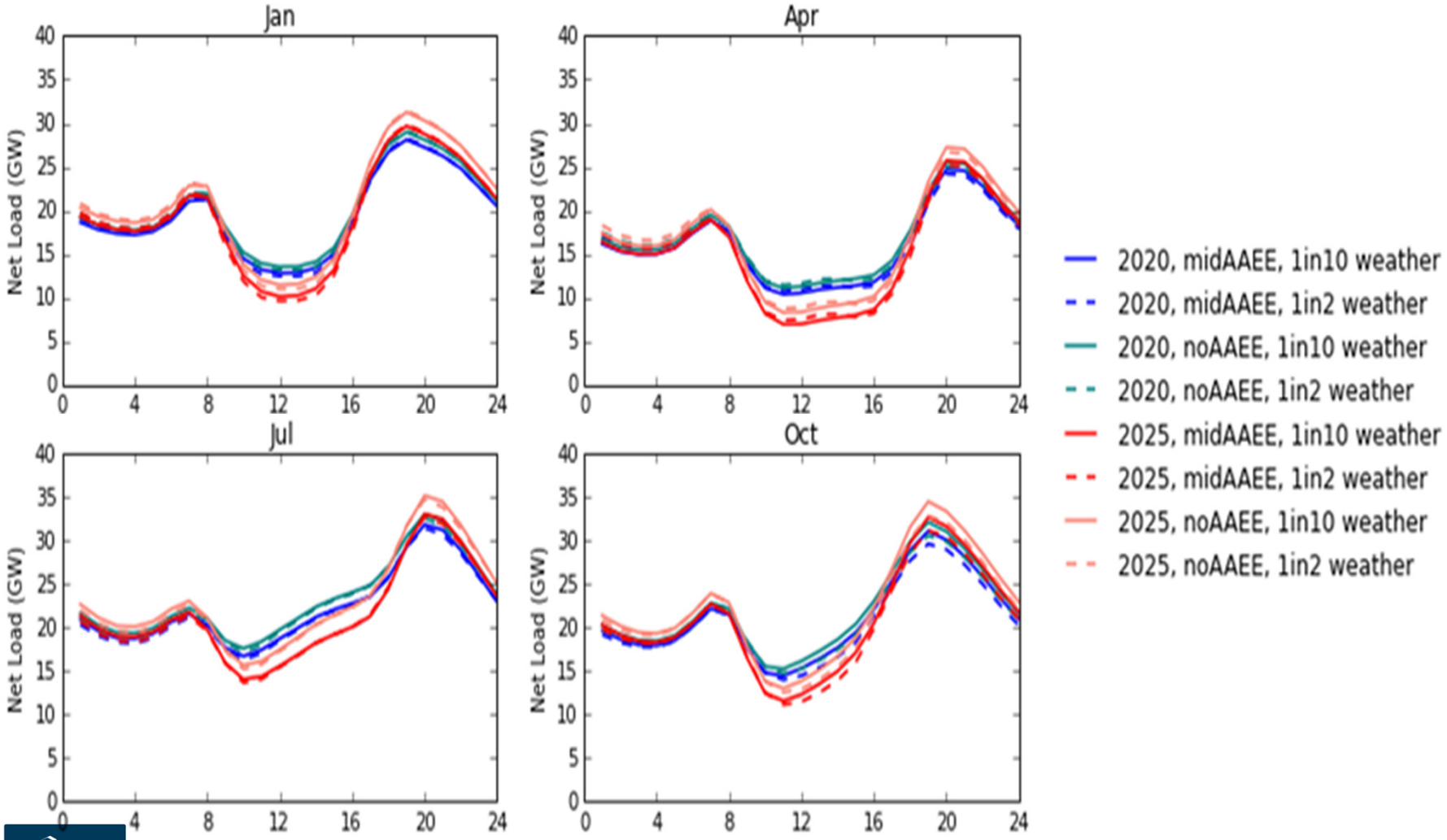
Forecast Results - System Net Load for 8 Scenarios

Gross Demand - Solar & Wind Generation

Scenarios will be more Ducky with more electrification



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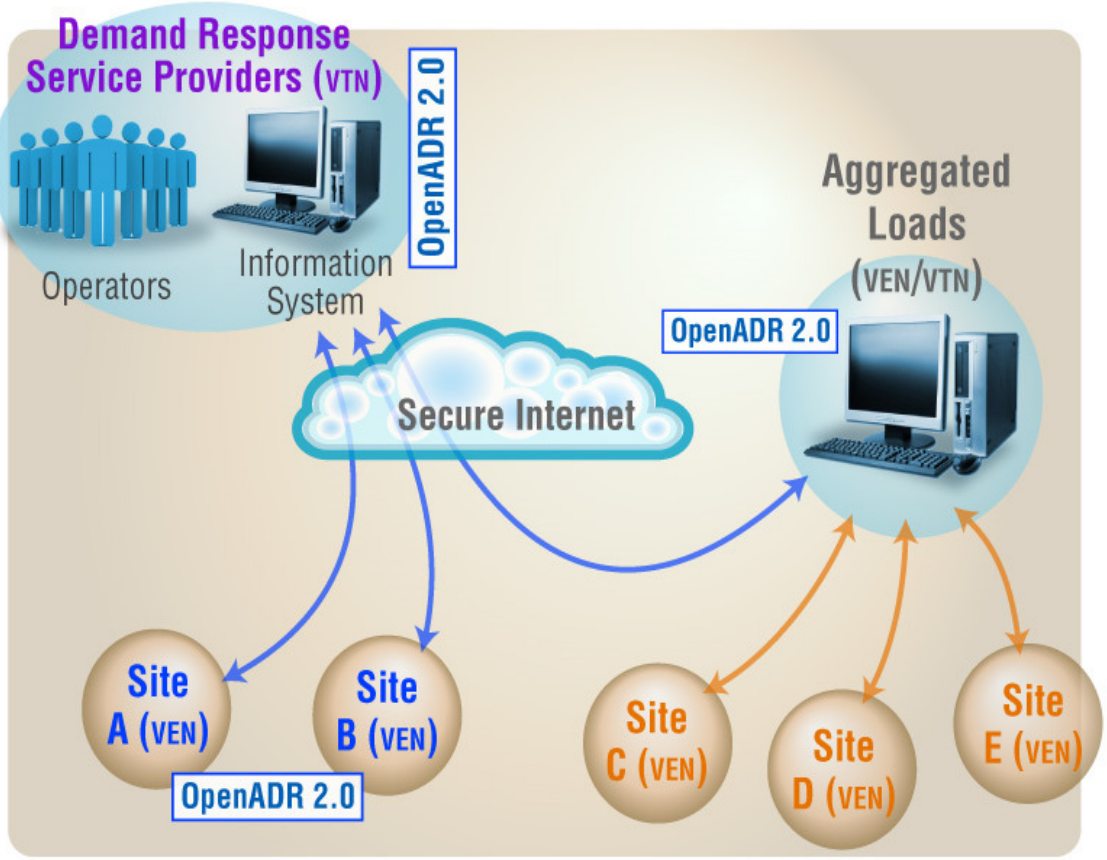
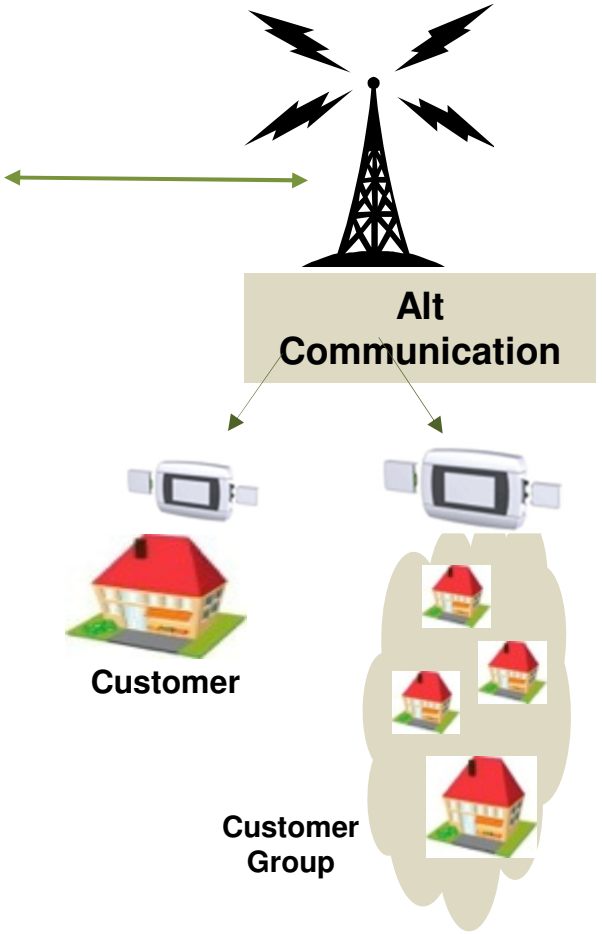
Consider New Architecture for Future Communications





Commercial & Industrial

Residential, Small Commercial

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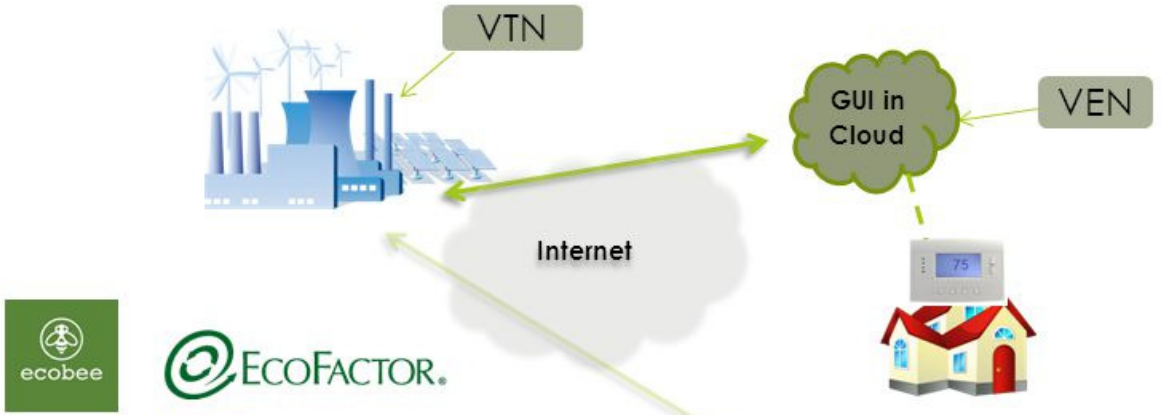
OpenADR with VEN Residing in Cloud is Challenge for DR Programs and Codes

Cloud Interface



ecobee

EcoFactor

EnergyHub

EMERSON

nest

Honeywell

thinkeco

- **OpenADR 2.0 a or b** enabled
- Retail or Operator provided or bring your own thermostat
- Cloud interface
- No resource constraints
- Feedback supported

openADR ALLIANCE

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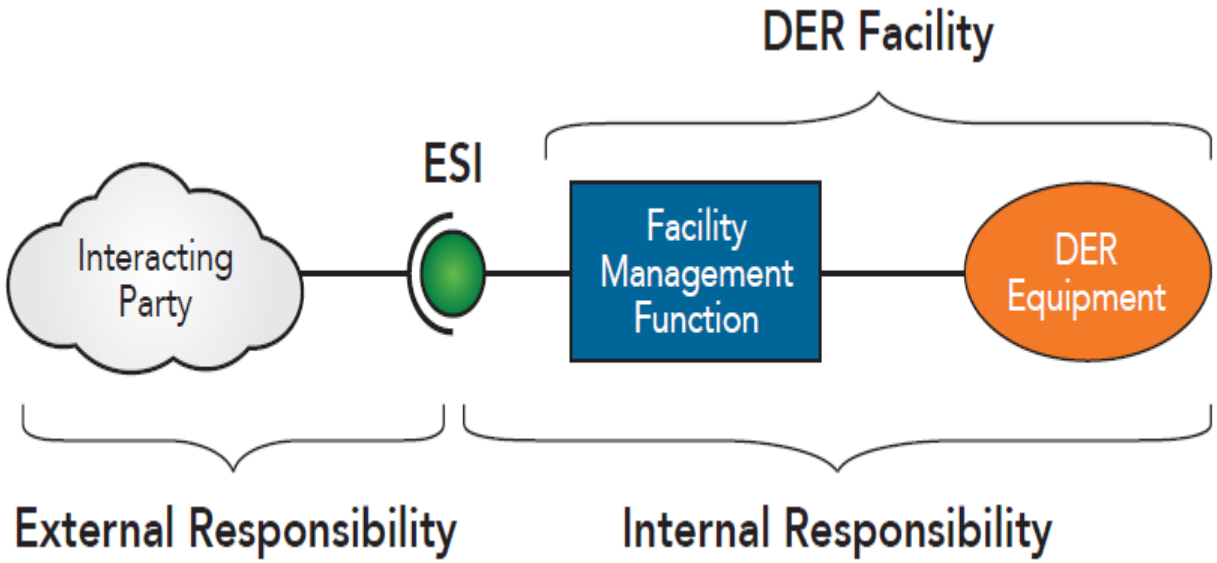
Energy Services Interface Vision for DER

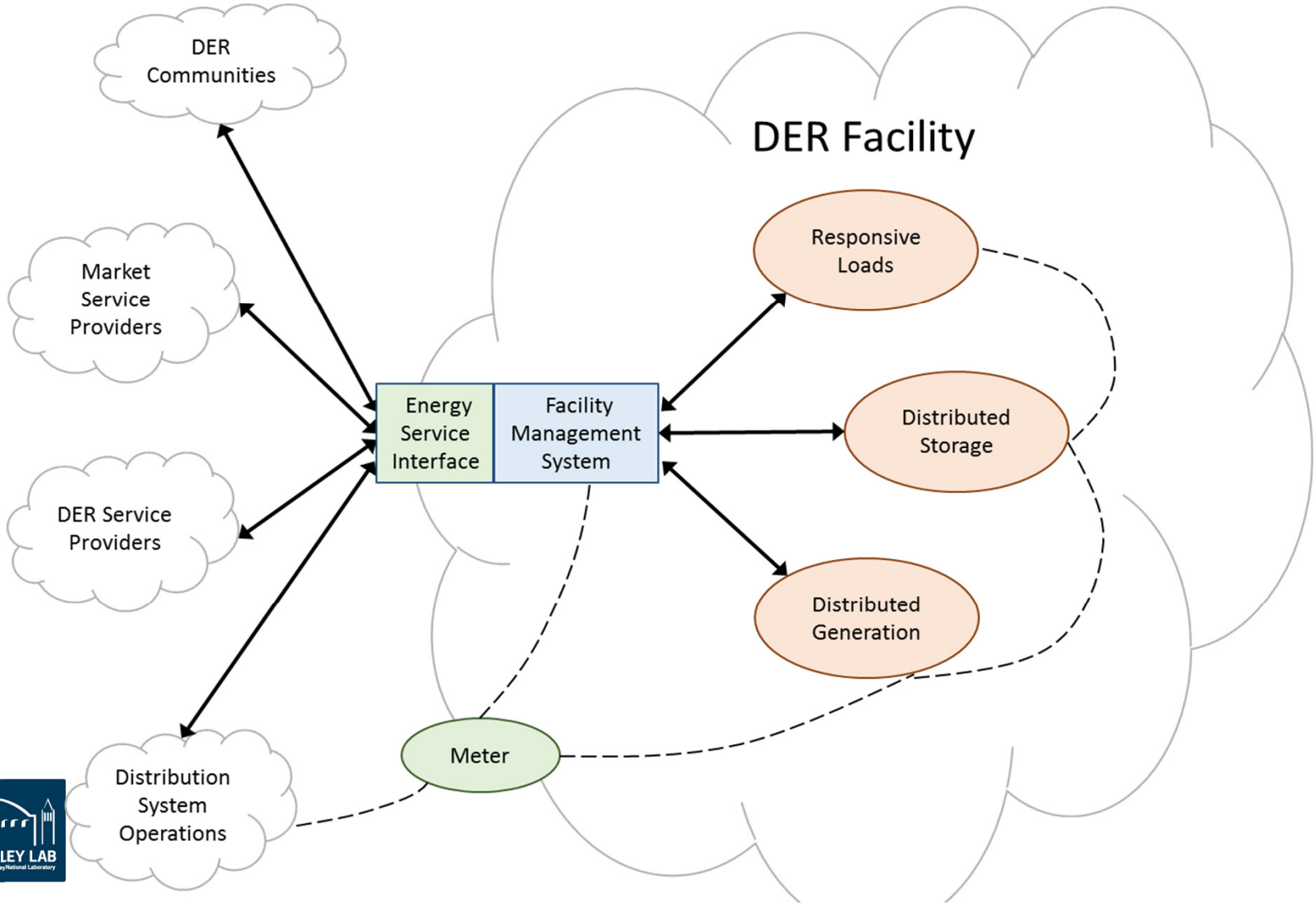
"ESI is a bi-directional, *service-oriented*, logical interface that supports the secure communication of information between entities inside and entities outside of a customer boundary to facilitate various energy interactions between electrical loads, storage, and generation within customer facilities and external entities."



Hardin et al: http://www.gridwiseac.org/pdfs/forum_papers11/hardin_paper_gi11.pdf .
Note, the words "service-oriented" are added to the definition here.

Interoperability Energy Systems Interface

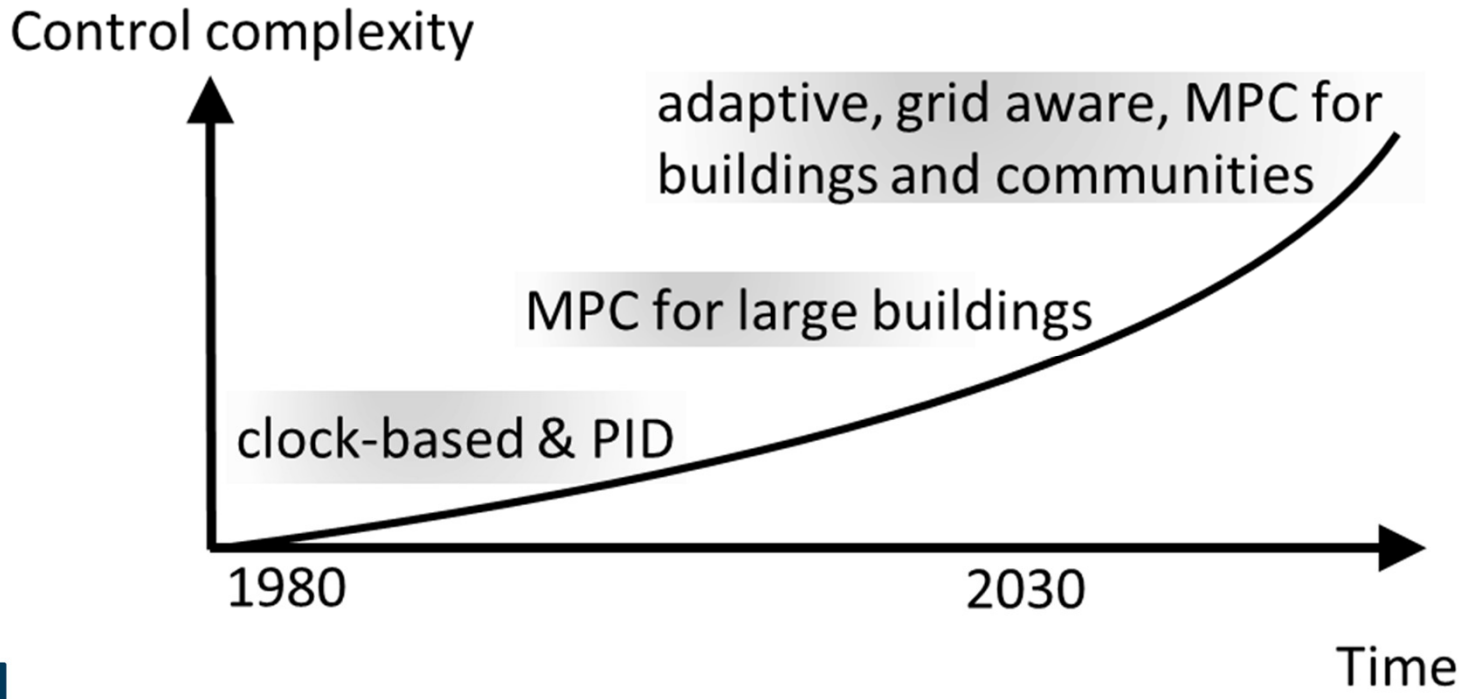
- US DOE starting Grid Interactive Efficient Buildings Program
- Grid Modernization Lab Consortium Evaluating ESIs and role of OpenADR



Evolution of Building Controls

Conventional control systems unable to meet future system requirements:

- Energy cost reduction
- Electric grid integration
- Fault detection and diagnosis
- Occupant-responsiveness



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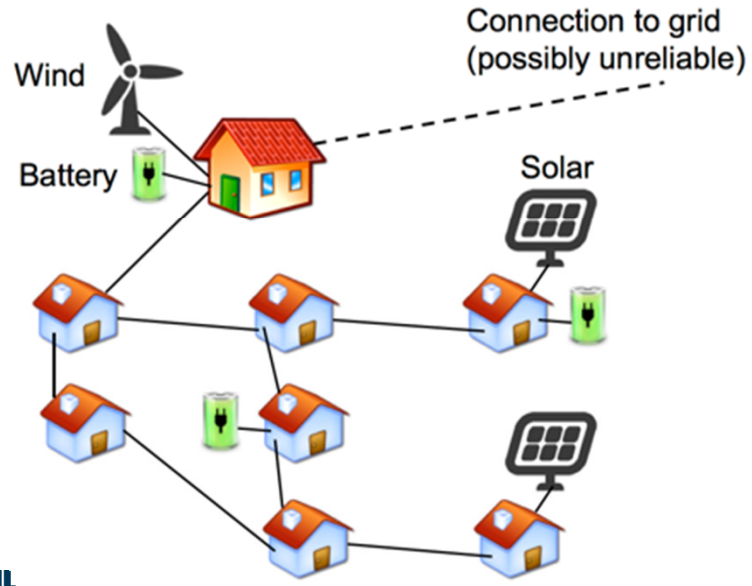
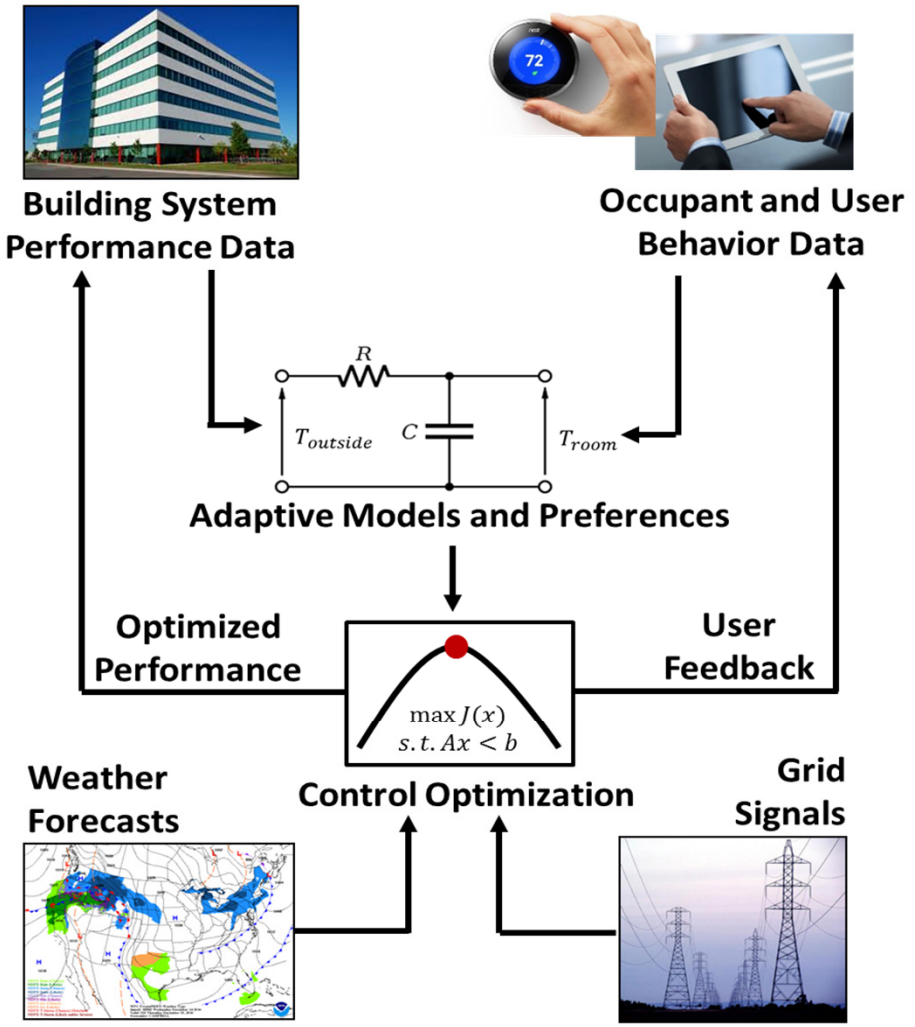
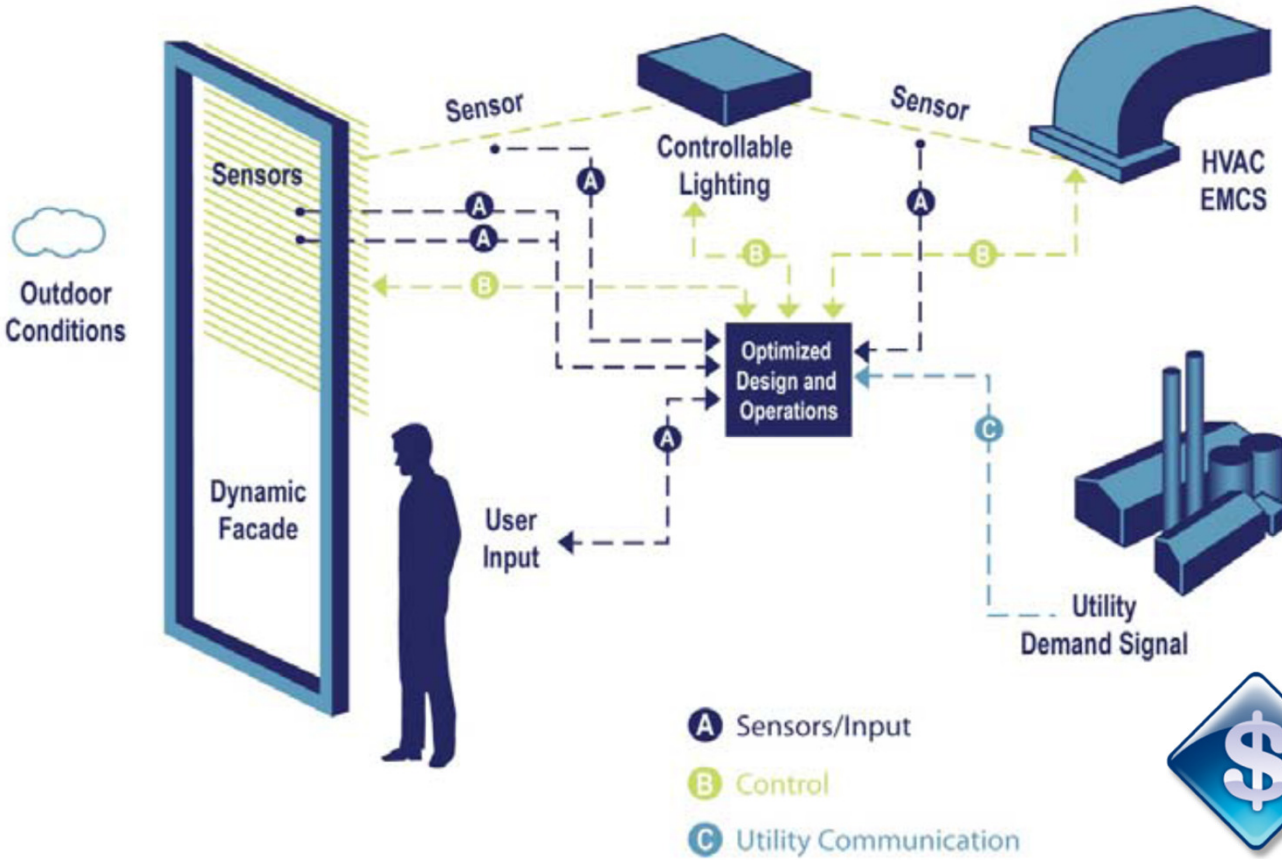
Strategies to Enable DR

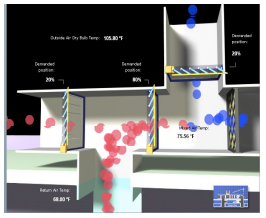
- Codes and Standards, DR-Ready Technology and Whole Buildings
- Community Scale Systems
- Market Transparency
- Model Predictive Control
- Improved Interoperability

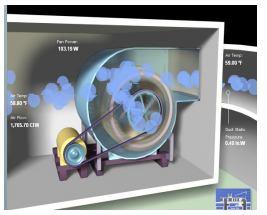




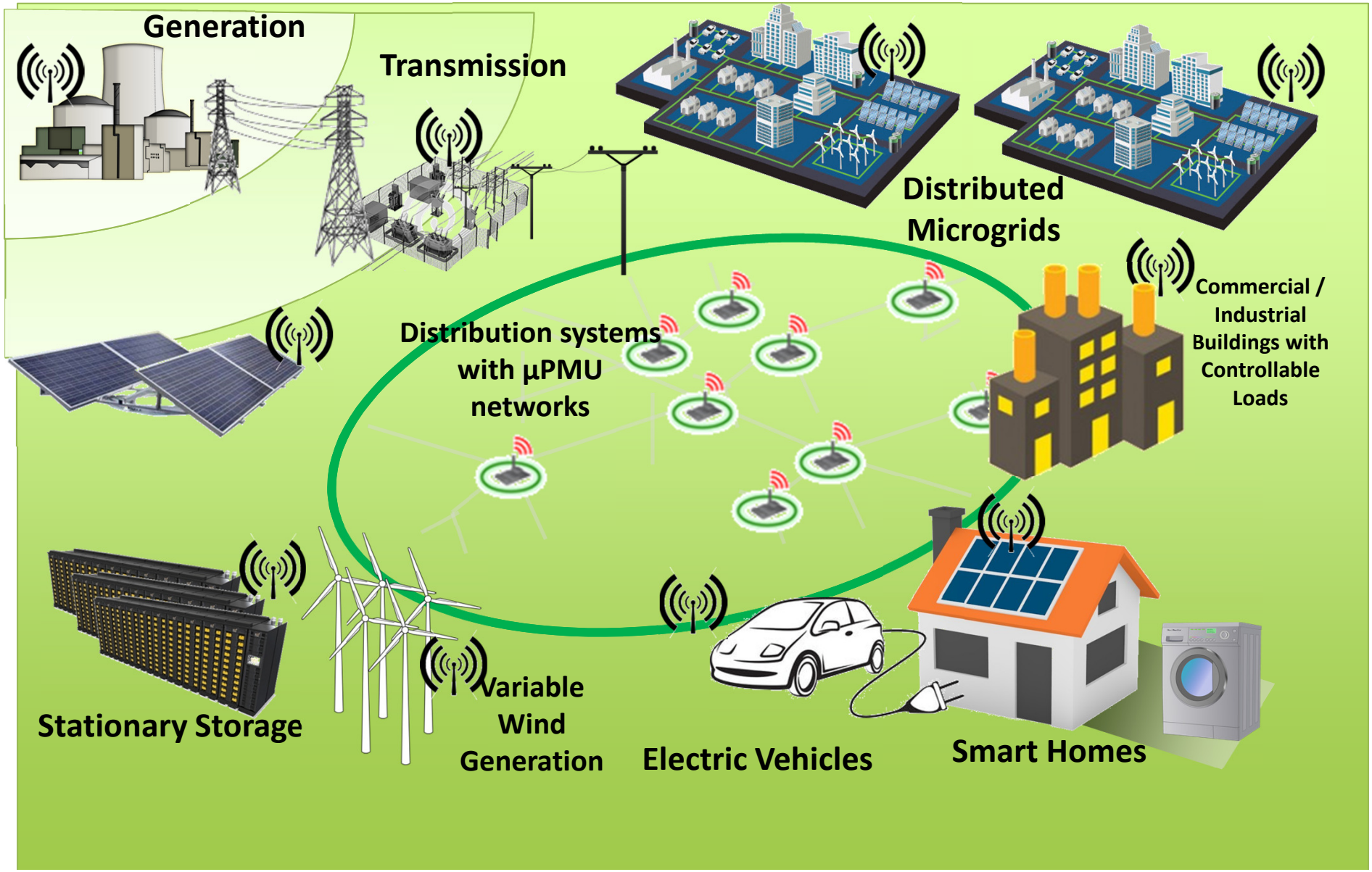
Integrated, Interoperable, Grid Responsive, Continuous Efficiency Analysis







Complexity of Distributed Energy Resources



US China DR Collaboration

Test Case Name	Start Time	End Time	Result	Log
N1_0010_TH_VTN_1	Mon Sep 04 14:08:16 CST 2017	Mon Sep 04 14:08:49 CST 2017	PASS	View Log TraceLog_090417_140816_423.txt
N1_0015_TH_VTN_1	Mon Sep 04 14:15:34 CST 2017	Mon Sep 04 14:16:15 CST 2017	PASS	View Log TraceLog_090417_141534_856.txt
N1_0020_TH_VTN_1	Mon Sep 04 14:12:25 CST 2017	Mon Sep 04 14:13:22 CST 2017	PASS	View Log TraceLog_090417_141225_753.txt
N1_0025_TH_VTN_1	Mon Sep 04 14:17:55 CST 2017	Mon Sep 04 14:18:48 CST 2017	PASS	View Log TraceLog_090417_141755_862.txt
N1_0020_TH_VTN_1	Mon Sep 04 14:20:48 CST 2017	Mon Sep 04 14:21:40 CST 2017	PASS	View Log TraceLog_090417_142048_302.txt
N1_0030_TH_VTN_1	Mon Sep 04 14:21:53 CST 2017	Mon Sep 04 14:22:29 CST 2017	PASS	View Log TraceLog_090417_142153_403.txt
N1_0040_TH_VTN_1	Mon Sep 04 14:24:15 CST 2017	Mon Sep 04 14:25:06 CST 2017	PASS	View Log TraceLog_090417_142415_358.txt
N1_0050_TH_VTN_1	Mon Sep 04 14:34:40 CST 2017	Mon Sep 04 14:35:21 CST 2017	PASS	View Log TraceLog_090417_143440_322.txt
N1_0065_TH_VTN_1	Mon Sep 04 14:38:28 CST 2017	Mon Sep 04 14:39:17 CST 2017	PASS	View Log TraceLog_090417_143828_542.txt
N1_0060_TH_VTN_1	Mon Sep 04 15:26:20 CST 2017	Mon Sep 04 15:27:12 CST 2017	PASS	View Log TraceLog_090417_152620_016.txt
N1_0070_TH_VTN_1	Mon Sep 04 14:47:19 CST 2017	Mon Sep 04 14:48:12 CST 2017	PASS	View Log TraceLog_090417_144719_266.txt
P1_2010_TH_VTN_1	Mon Sep 04 15:37:22 CST 2017	Mon Sep 04 15:39:14 CST 2017	PASS	View Log TraceLog_090417_153722_258.txt

测试案例 Testing Case Study

- **被测样品**： “能量管理系统” （杭州赫智公司）
  - ✓ 支持OpenADR2.0b通信协议，能够在保证电力用户室内环境舒适度的前提下，基于内置需求响应策略针对不同用电设备实施精准控制。
- Test Sample: “Energy Management System” (Hangzhou Telehems)
  - ✓ Support OpenADR2.0b. Control different electronics using built-in DR strategy while maintain comfort indoor environment.
- **测试时间 / 单位**：2017.8.22-9.8 / 中国电科院电力需求侧管理技术实验室
- Testing Time / Unit: 2017.8.22-9.8 / CEPRI
- **测试结果**： 全部通过
- Test Result: All pass

国家电网公司
STATE GRID
CORPORATION OF CHINA

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中国行标《电力需求响应信息交换规范》介绍

Introduction of China Industrial Standard – Guides of Information Exchange for Demand Response

大数据中方工作组

2nd CCWG Big Data Workshop

2017年11月 南京

Nov, 2017 Nanjing, China

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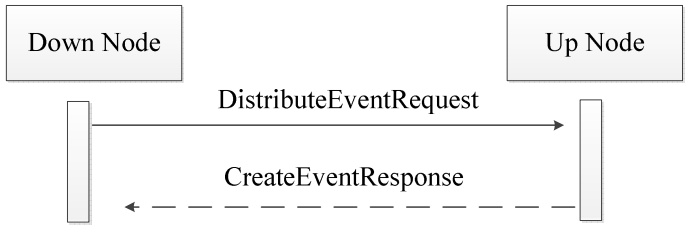
5.信息交换服务/Information Exchange Service

3.事件服务/Event



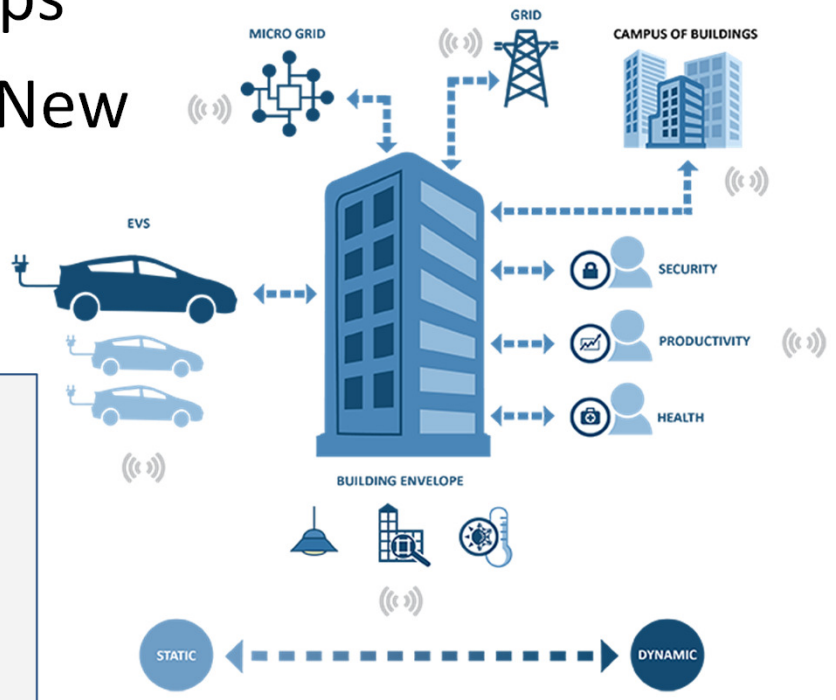
事件包内服务的调用时序图

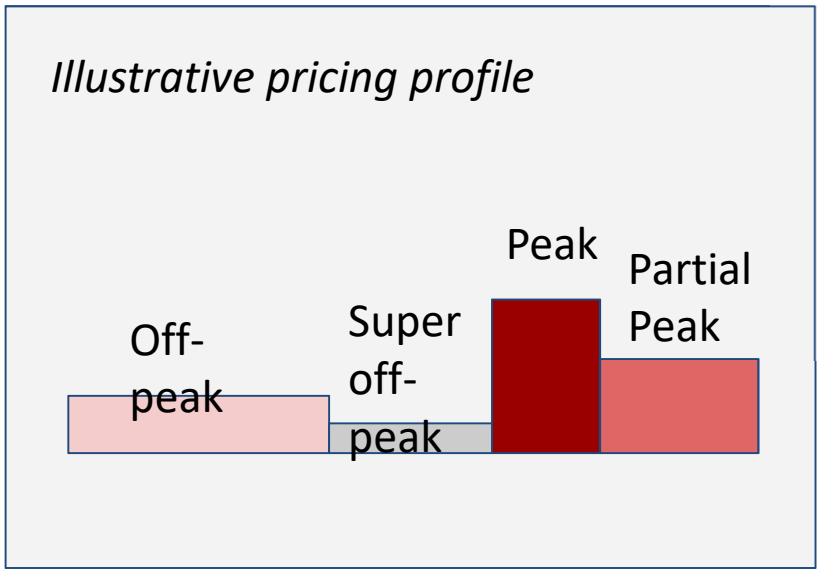
事件服务介绍/Introducation of Event

名称	描述
发布事件请求 （DistributeEventRequest）	UN向DN主动推送已经产生的事件。 UN actively pushes generated event to DN
创建事件响应 （CreateEventResponse）	DN对UN发布的每一个事件做确认响应，明确是否参与。 DN responds to each event released by UN and confirms whether or not to participate.

Summary

- Need more demonstration to integrate DR signals with Distributed Energy Resources
- Need International Partnerships
- Time-of-Use Pricing Suggests New Automation Needs
- Controls are Evolving





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