Emerging Technologies Summit

MAKING THE CONNECTION:

From Energy Efficiency Innovation to Delivery

April 19 – 21, 2017

A Look into the Crystal Ball: Demand Response Tech Trends to Watch the Next 5 Years

CHRISTINE BAGINSK, DAVID WYLIE, MICHEL KAMEL, ANTONIO CORRADINI, SAMANTHA PIELL

A Look into the Crystal Ball: Demand Response Tech Trends to Watch the Next 5 Years

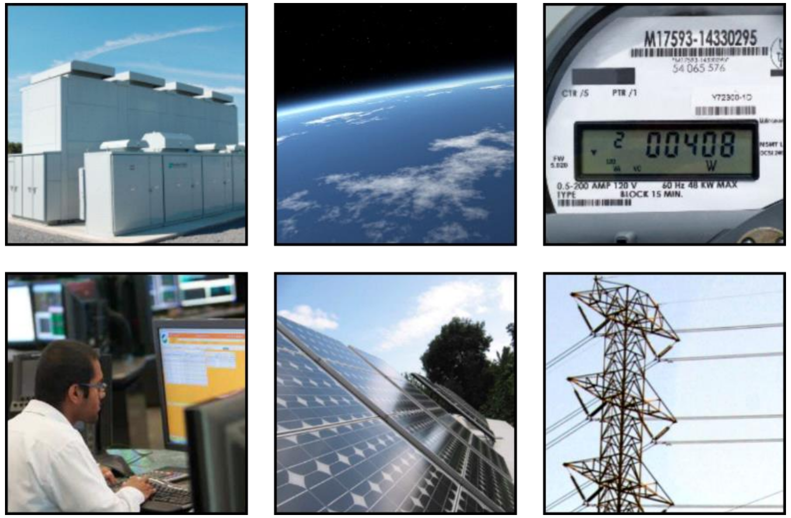
- Past DR used to reduce summer peak power (emergency or reliability)
- Future DR is evolving as Supply-side resource fast & flexible

A Look into the Crystal Ball: Demand Response Tech Trends to Watch the Next 5 Years

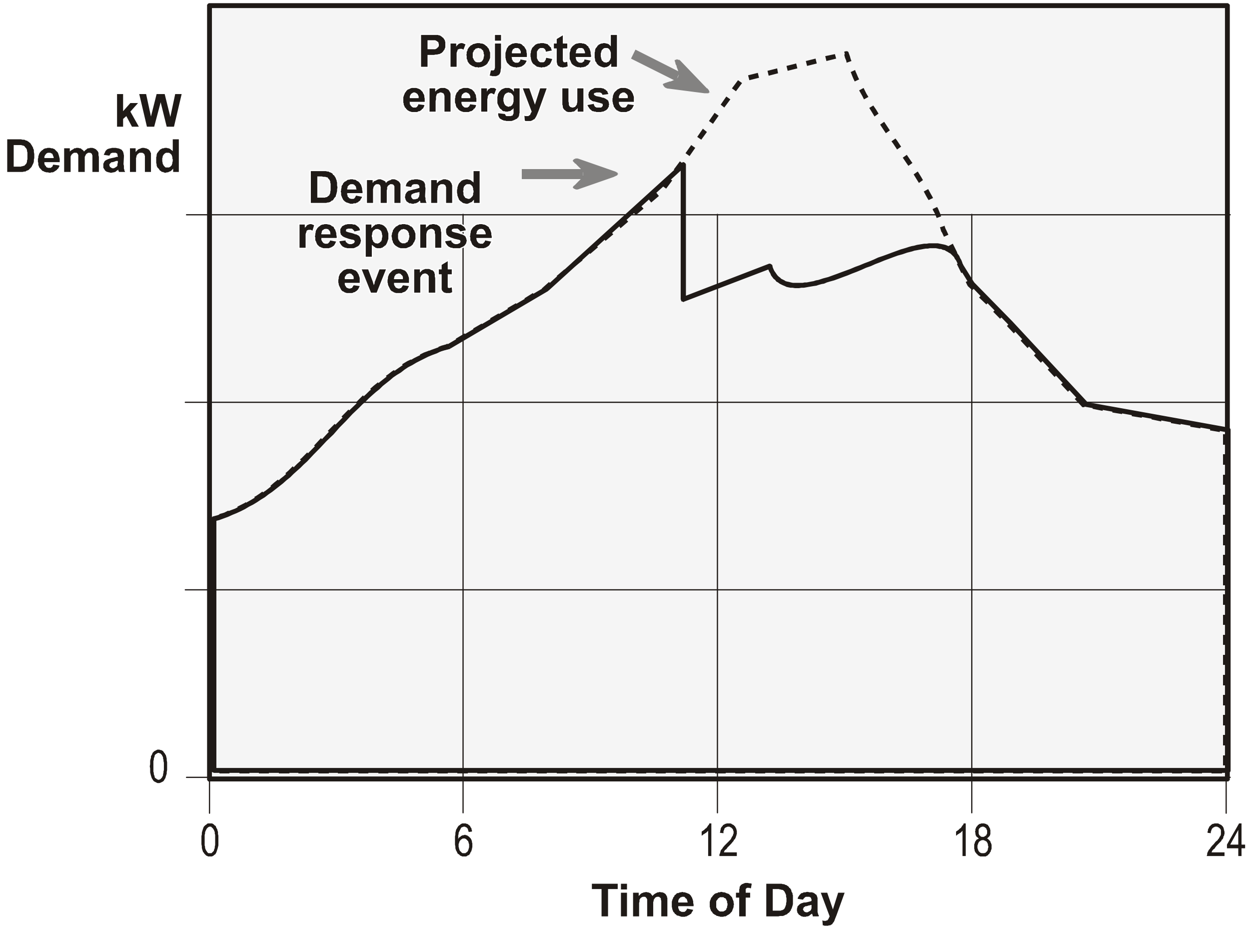
- Introduction of Panelists (CB)
- Question
  - What has been the most amazing Tech Trend (in DR) over the last 5-10 years?

The Changing Role of Demand Response 2017 and Beyond

Presenter: David Wylie, P.E.
ASWB Engineering



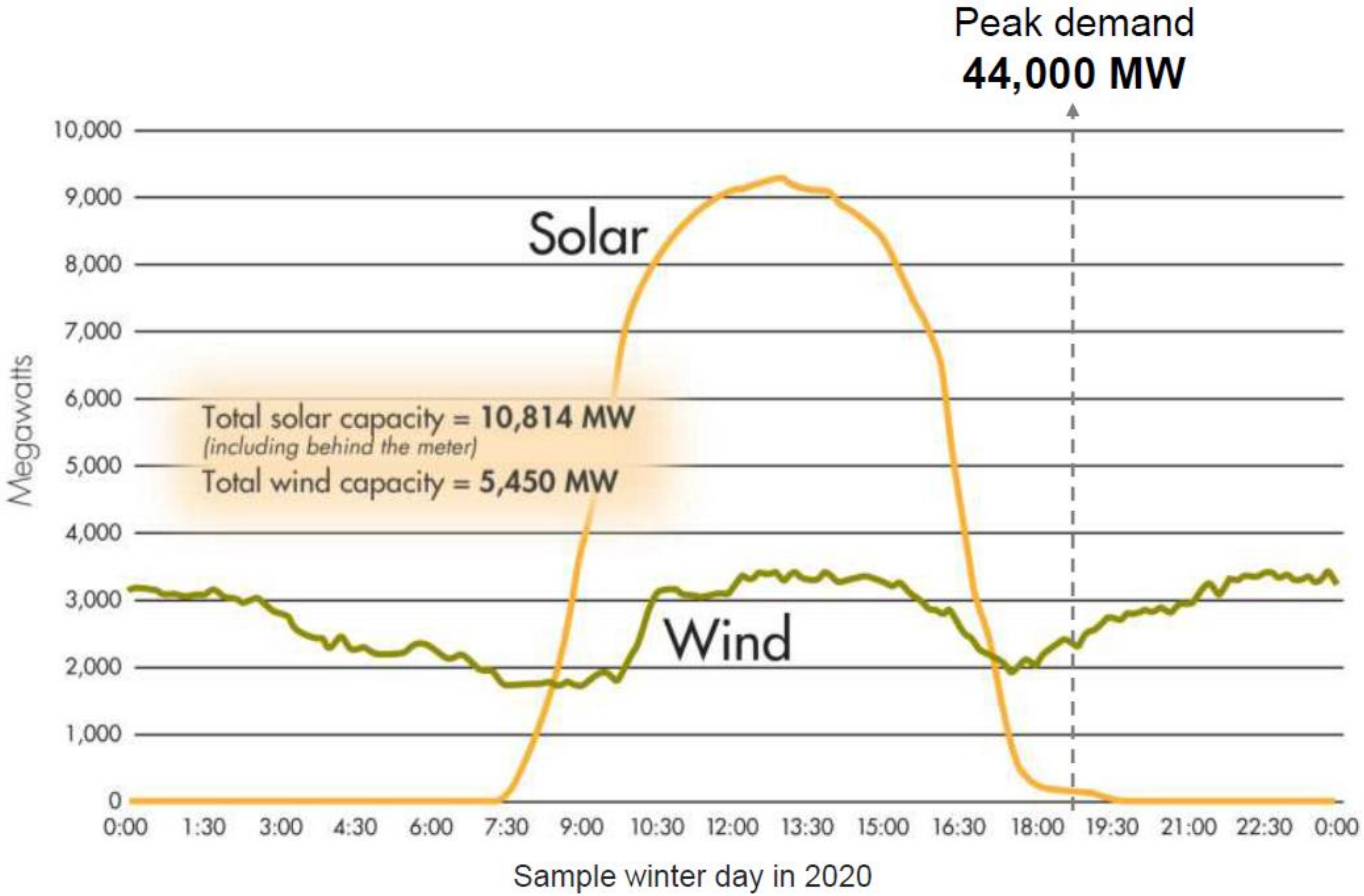
Traditional Demand Response



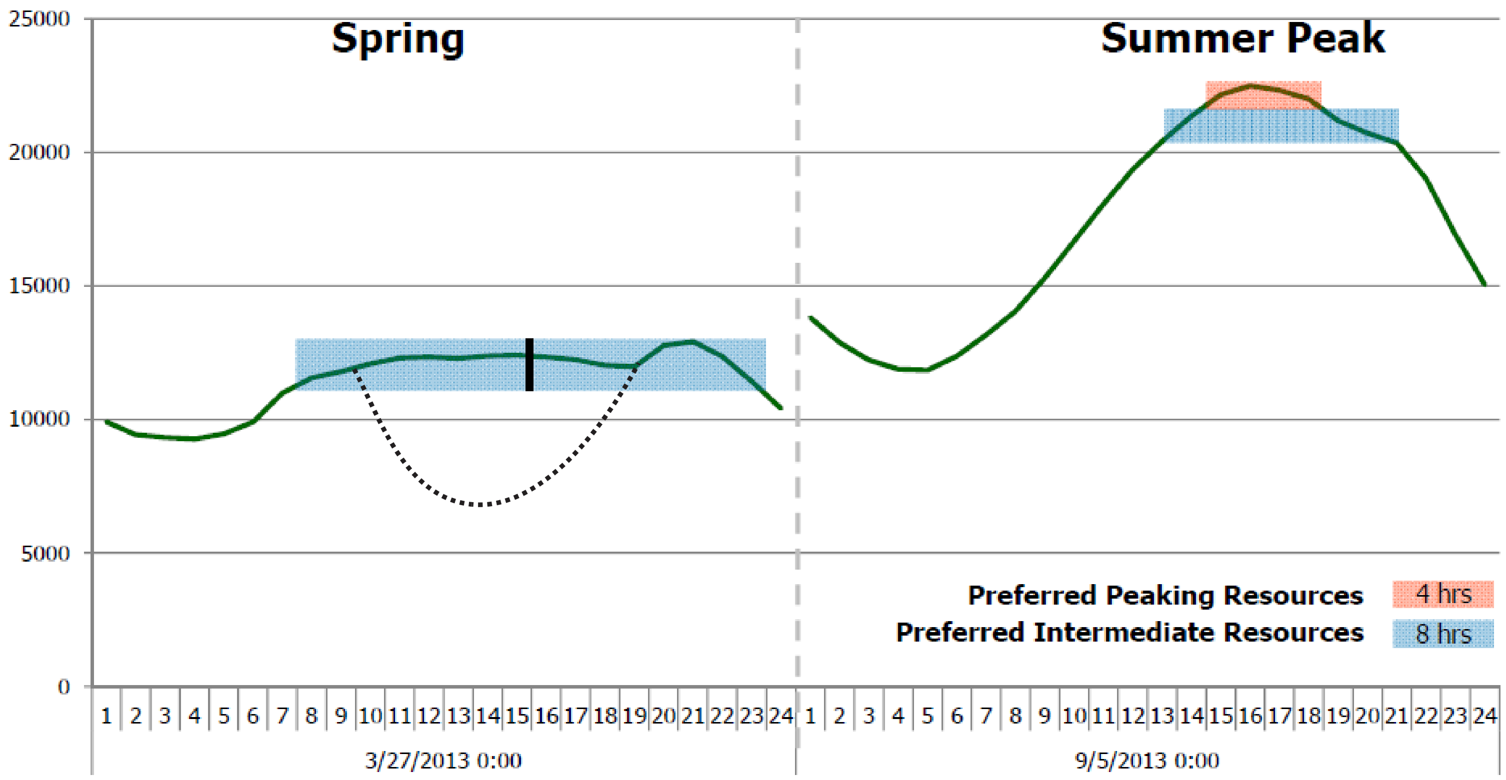
Supply vs. Demand Side Management

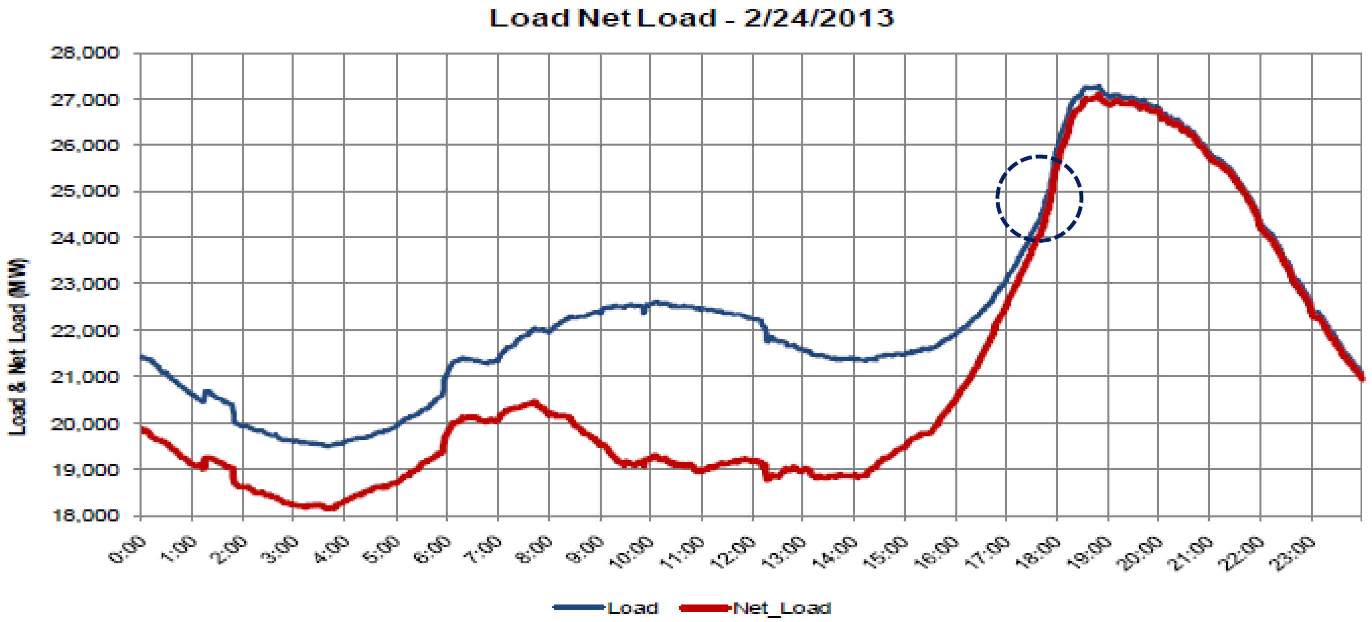
Renewable Resources

Wind and Solar Profiles



DR with Renewables





Load Net Load - 2/24/2013
Load & Net Load (MW)
28,000
27,000
26,000
25,000
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21,000
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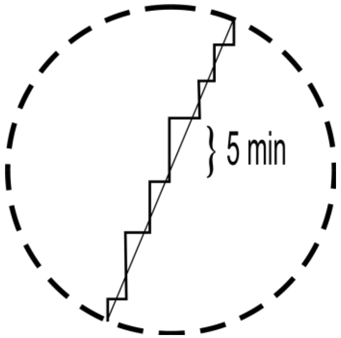
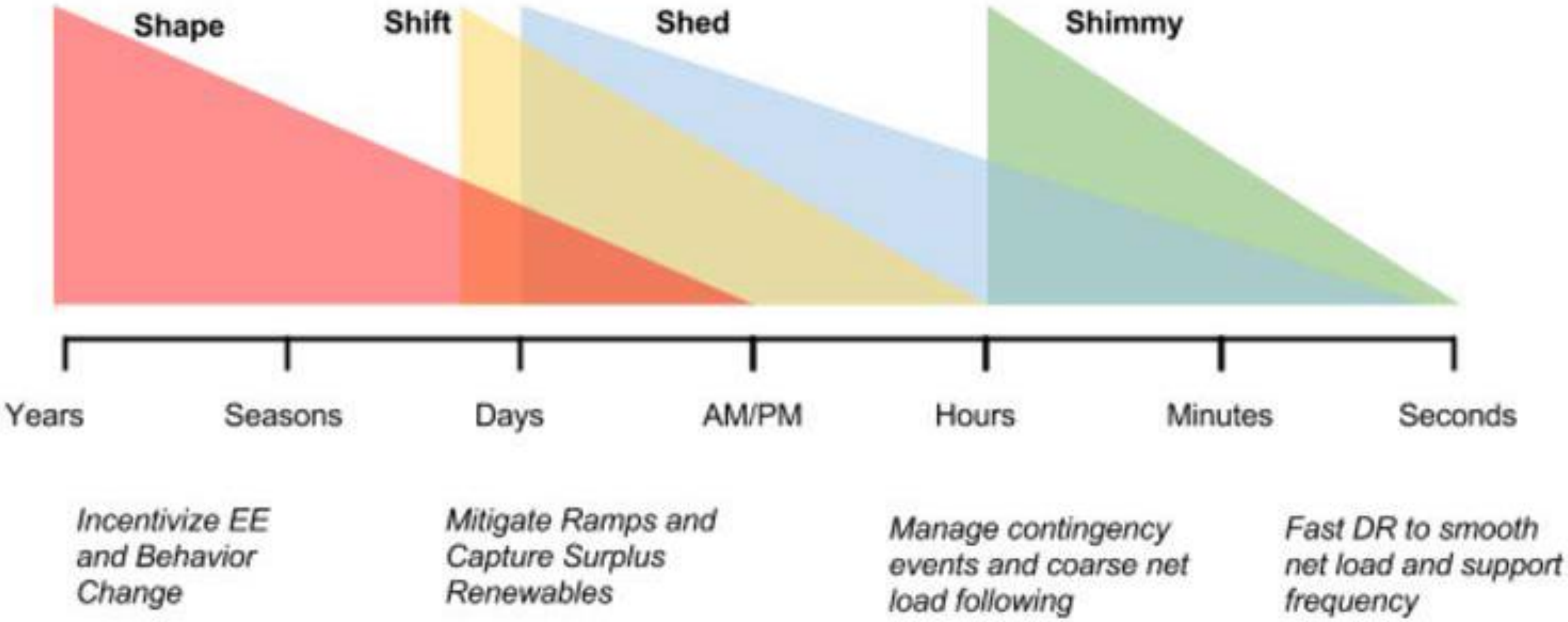
Load
Net_Load



5 min

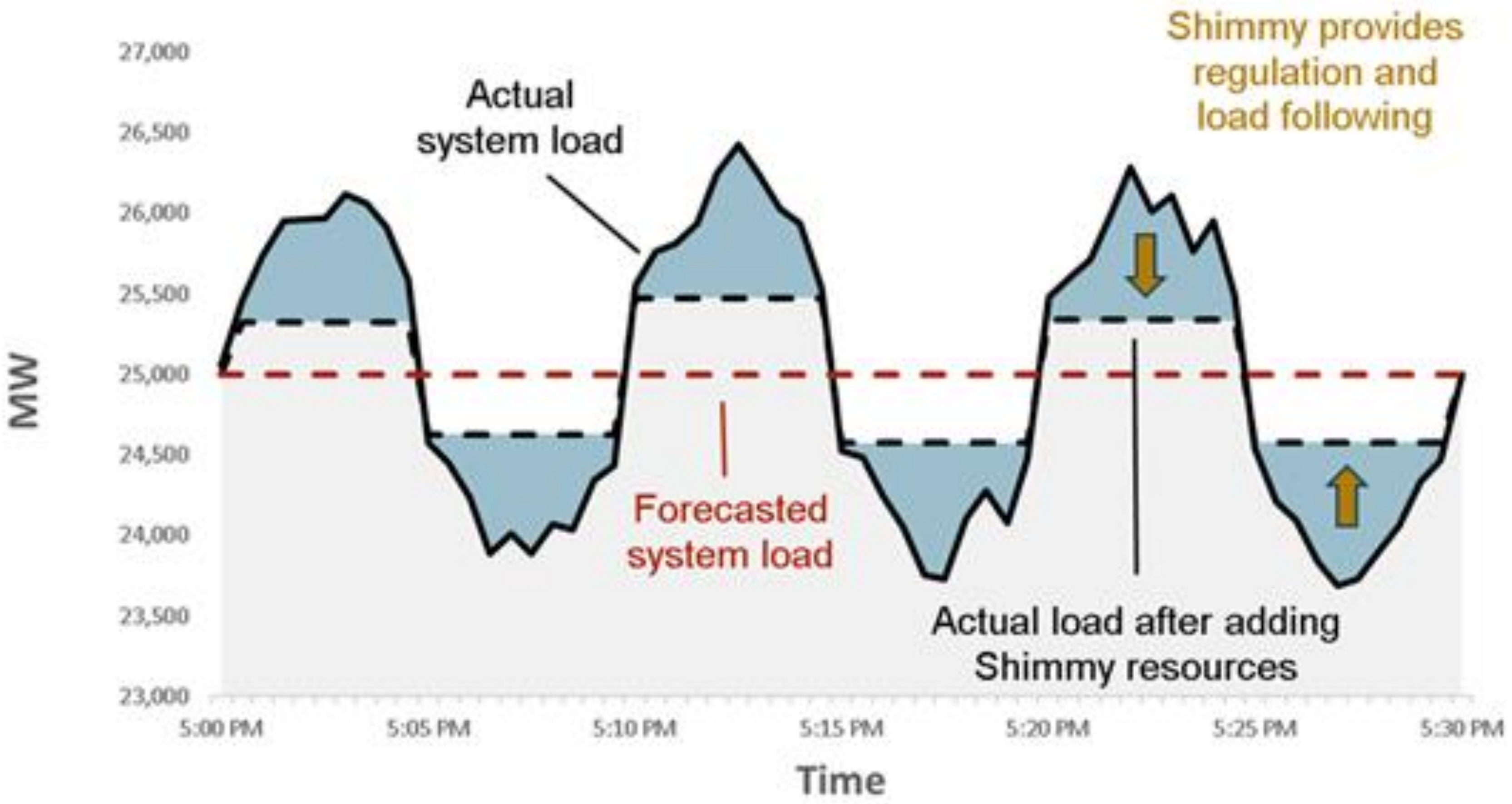
Types of DR


Shape
Shift
Shed
Shimmy
Years
Seasons
Days
AM/PM
Hours
Minutes
Seconds
Incentivize EE and Behavior Change
Mitigate Ramps and Capture Surplus Renewables
Manage contingency events and coarse net load following
Fast DR to smooth net load and support frequency

Types of DR

Service Type	Description	Grid Service Products/Related Terms
Shape	Effect of TOU and CPP rates	Comparable to Shed and Shift, but accomplished through rates
Shift	Demand timing shift (day-to-day)	Flexible ramping DR (avoid/reduce ramps), Energy market price smoothing
Shed	Peak load curtailment (occasional)	CAISO Proxy Demand Resources/Reliability DR Resources; Conventional DR, Local Capacity DR, Distribution System DR, RA Capacity, Operating Reserves
Shimmy	Fast demand response	Regulation, load following, ancillary services

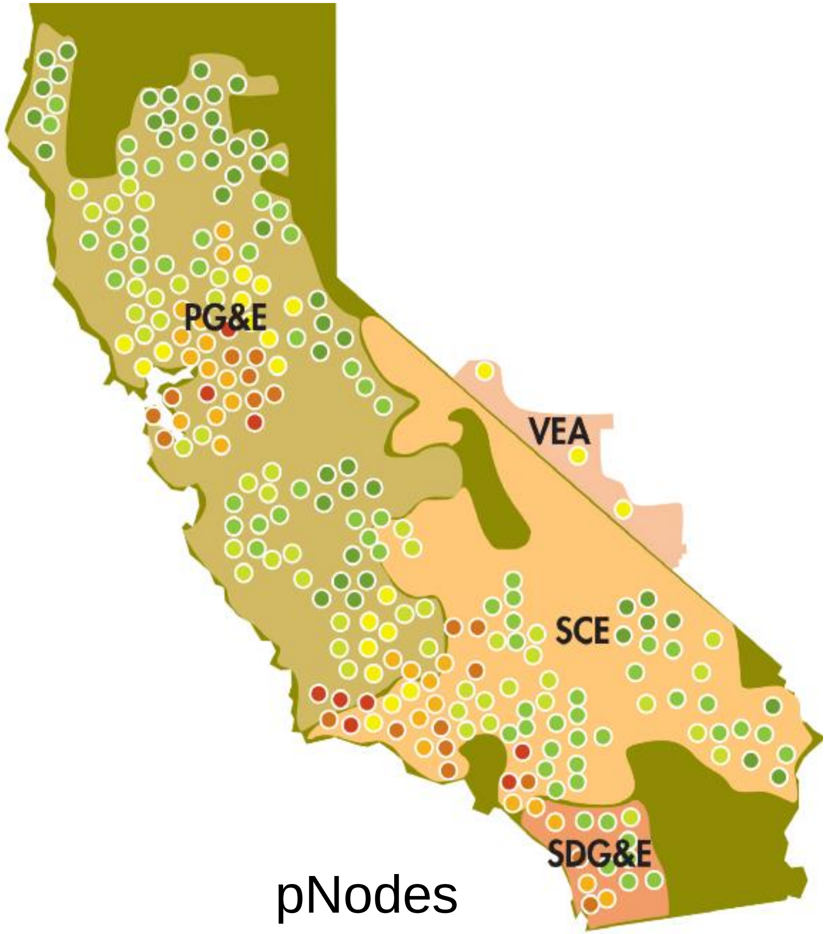
Shimmy



Shimmy provides regulation and load following
Actual system load
Forecasted system load
Actual load after adding Shimmy resources
MW
27,000
26,500
26,000
25,500
25,000
24,500
24,000
23,500
23,000
5:00 PM
5:05 PM
5:10 PM
5:15 PM
5:20 PM
5:25 PM
5:30 PM
Time

Local Marginal Resources

DLAP



pNodes

DR Locational Circumstances

RIGHT TIME

RIGHT PLACE

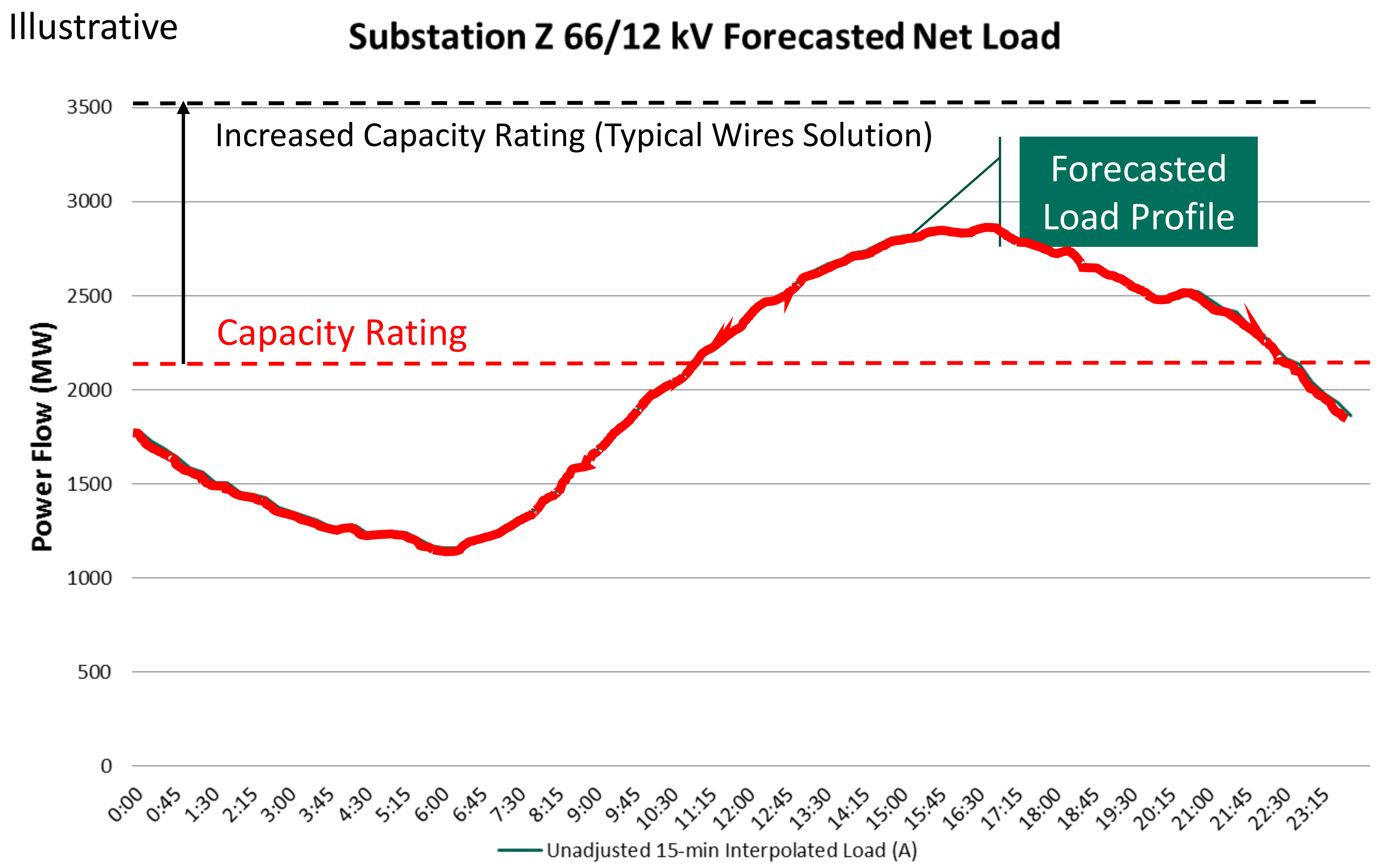
RIGHT CERTAINTY

RIGHT AVAILABILITY

Avoided distribution capacity costs ($/kW-year)

- **PG&E: $67.70**
- **SCE: $30.10**
- **SDG&E: $52.24**

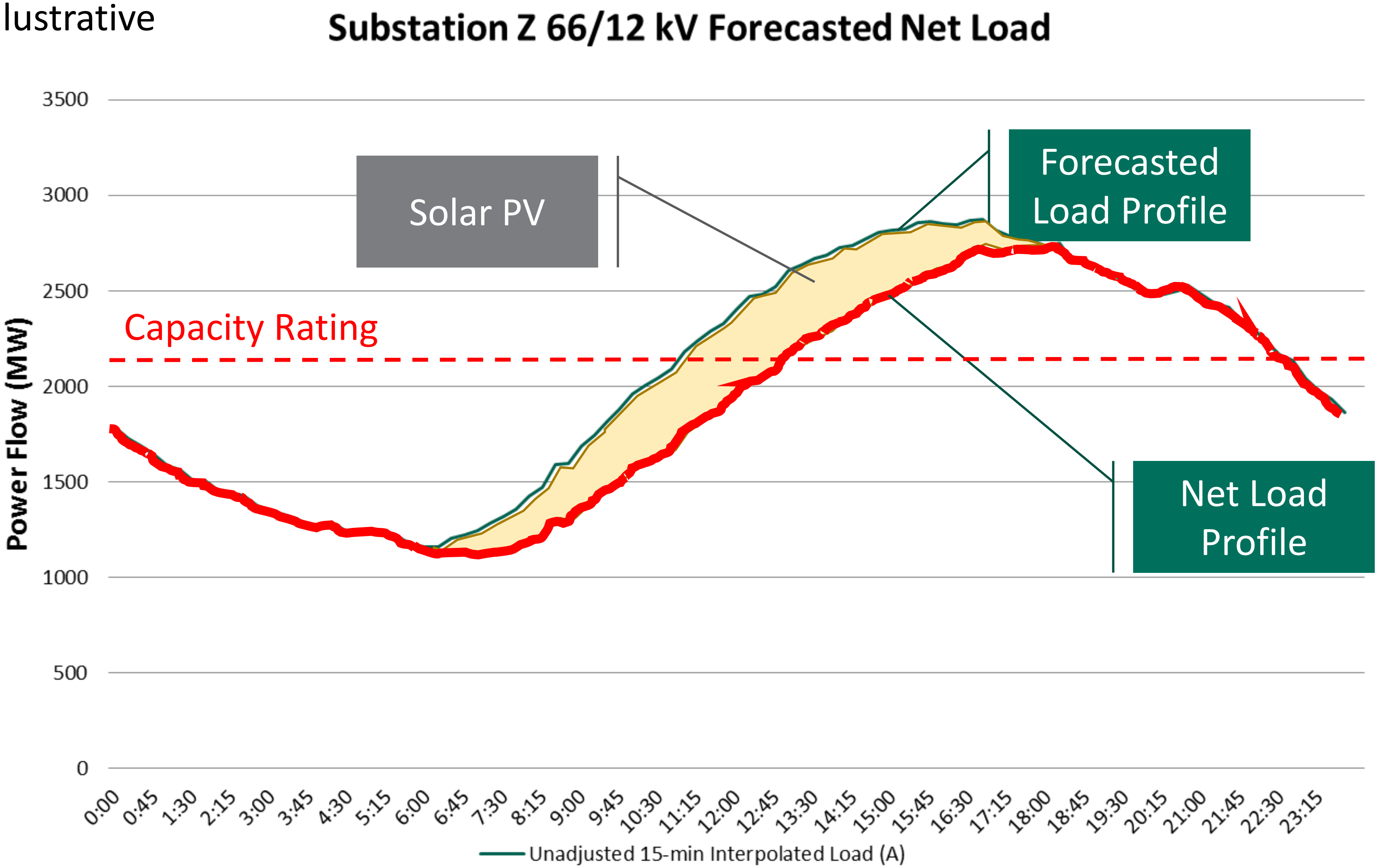
Substation Load Profile with Forecast Overload



Alter Substation Load Profile Using DER Portfolio

Solar Can Impact Load Profile During Daytime Hours

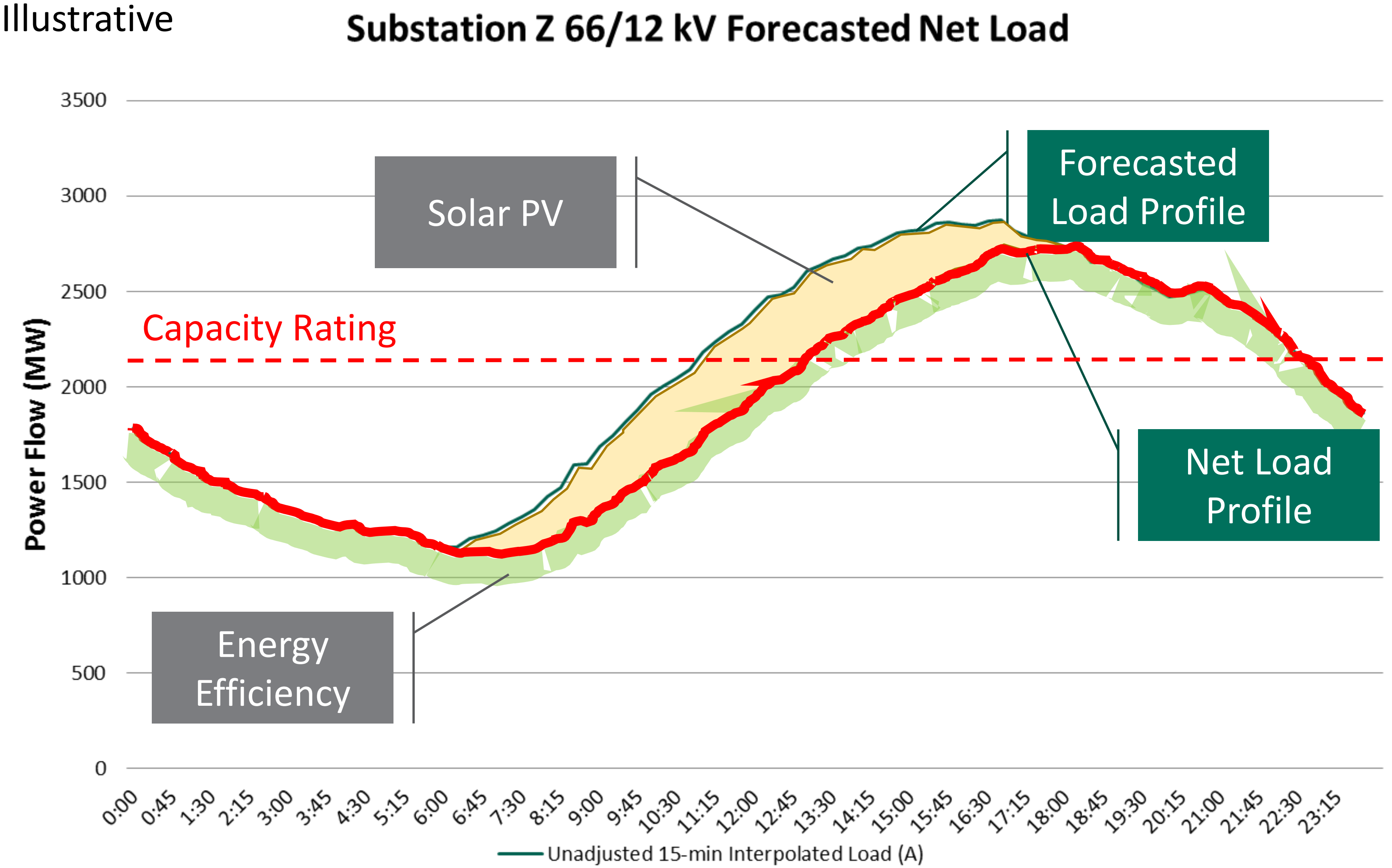
Illustrative



Alter Substation Load Profile with DER Portfolio

Energy Efficiency Programs can Permanently Reduce Load Profile

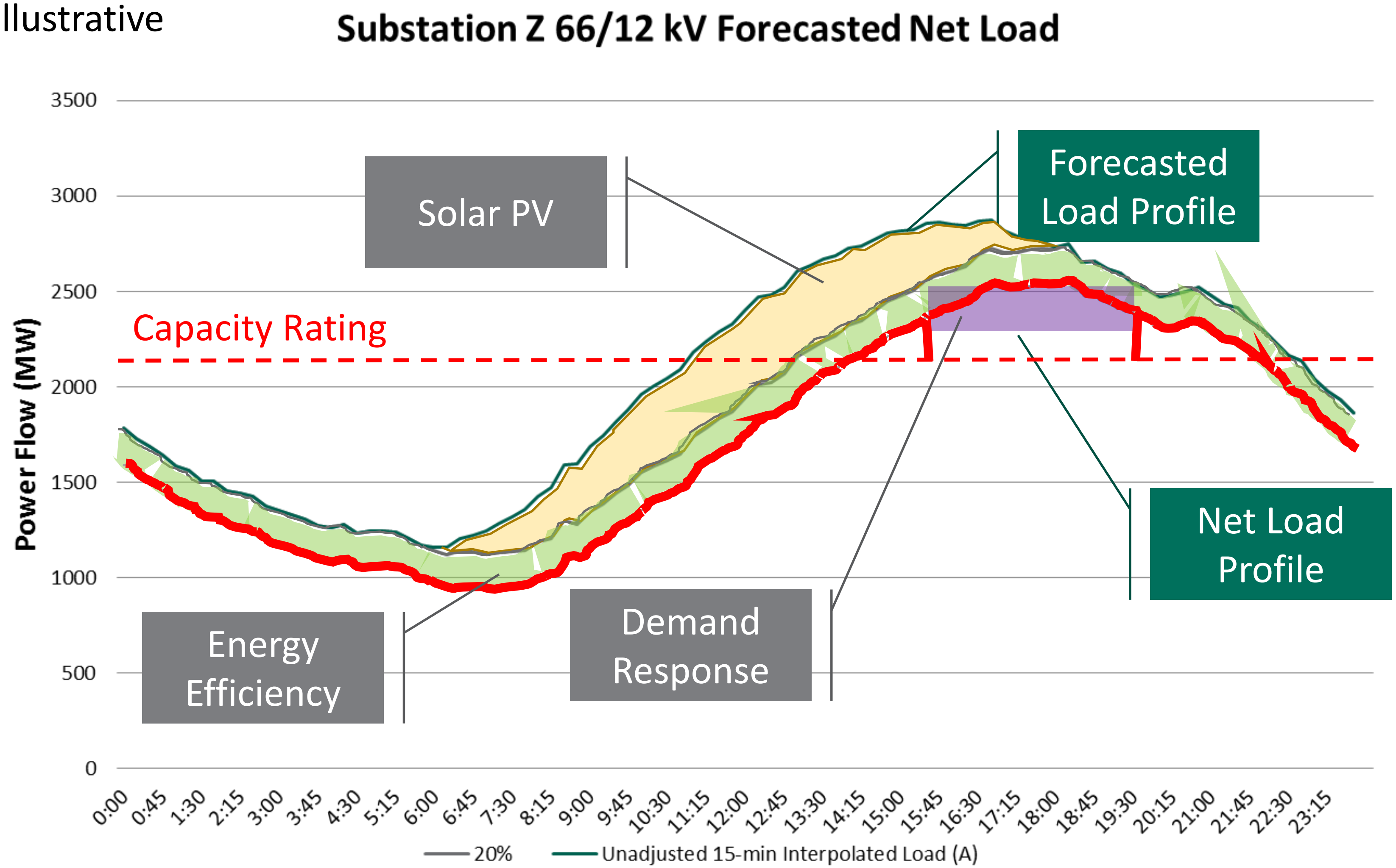
Illustrative



Alter Substation Load Profile Using DER Portfolio

Demand Response Programs can Temporarily Reduce Load Profile

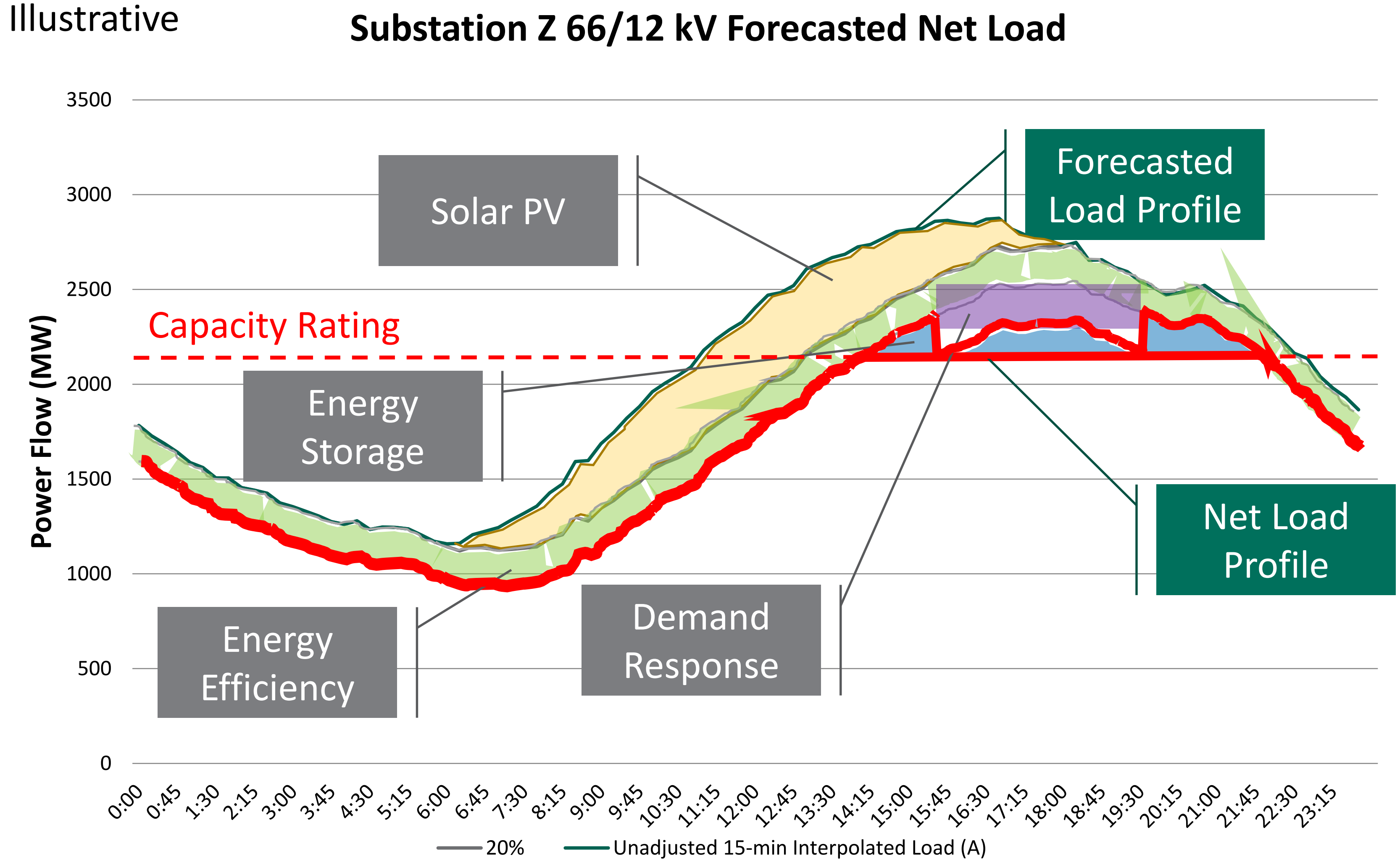
Illustrative



Alter Substation Load Profile Using DER Portfolio

Energy Storage can be Dispatched to Prescriptively Reduce Load Profile

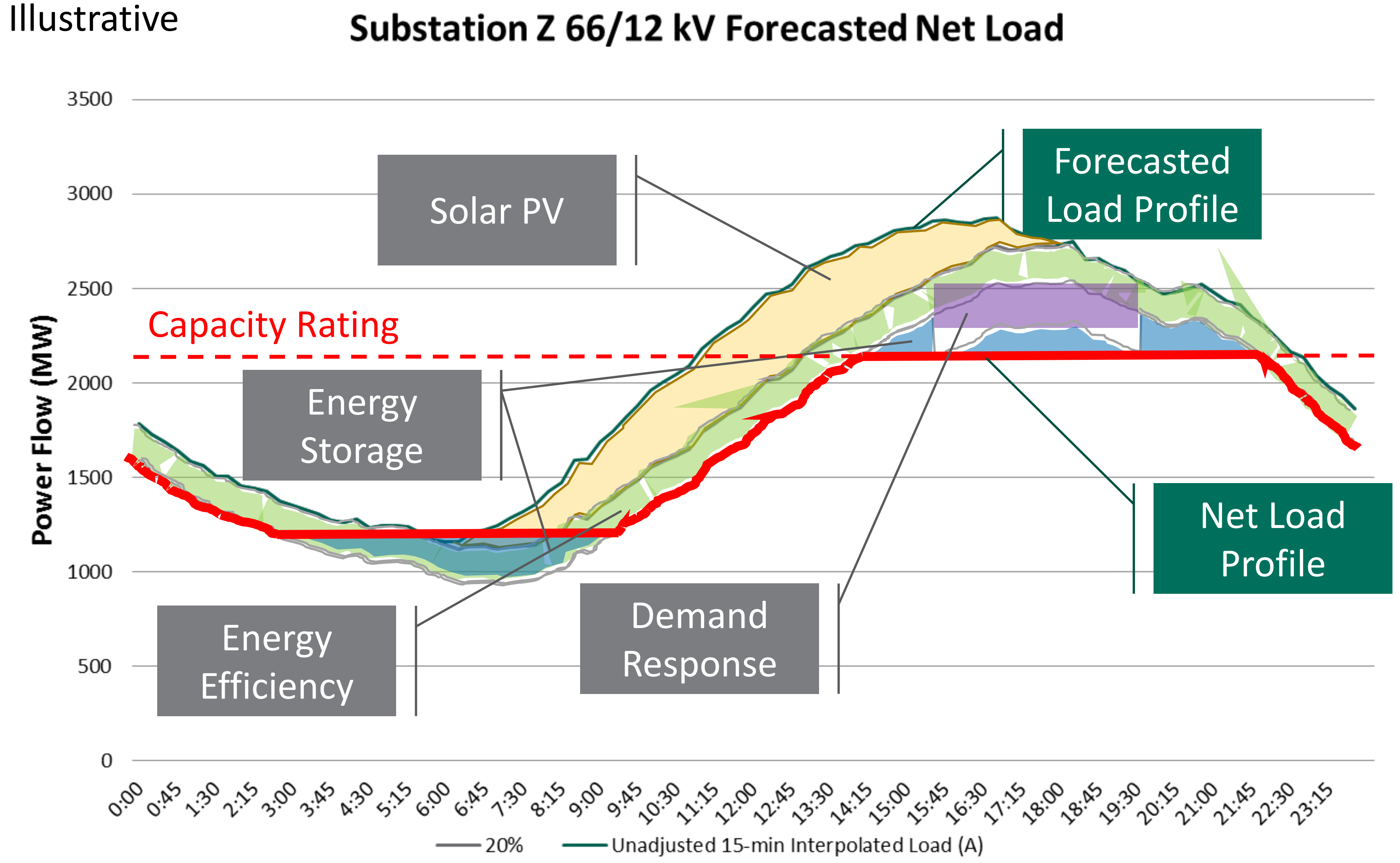
Illustrative



Alter Substation Load Profile Using DER Portfolio

Energy Storage Also Requires Charging Which Will Impact Load Profile

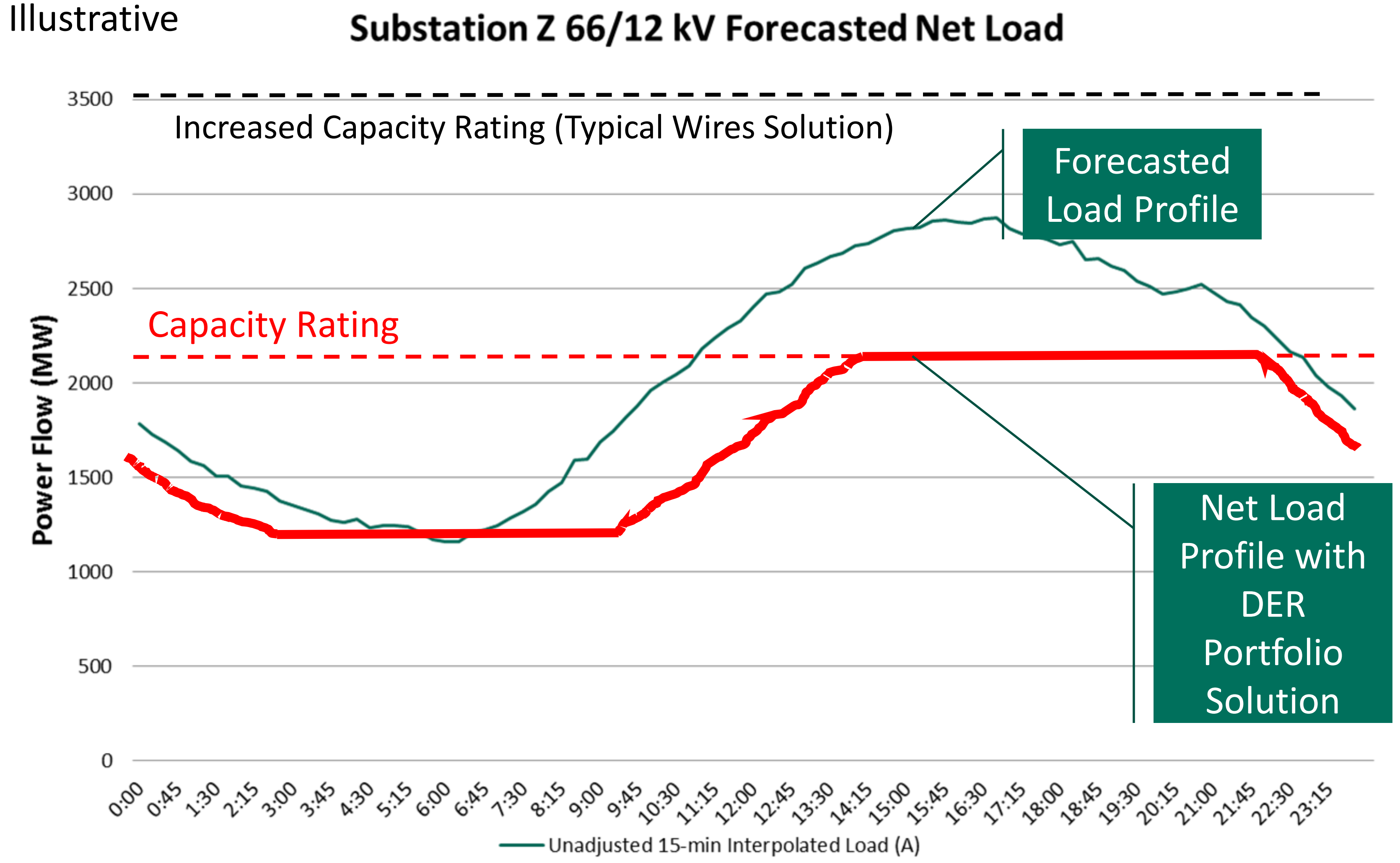
Illustrative



Alter Substation Load Profile Using DER Portfolio

Customized DER Portfolios Can Address Capacity Needs On Distribution

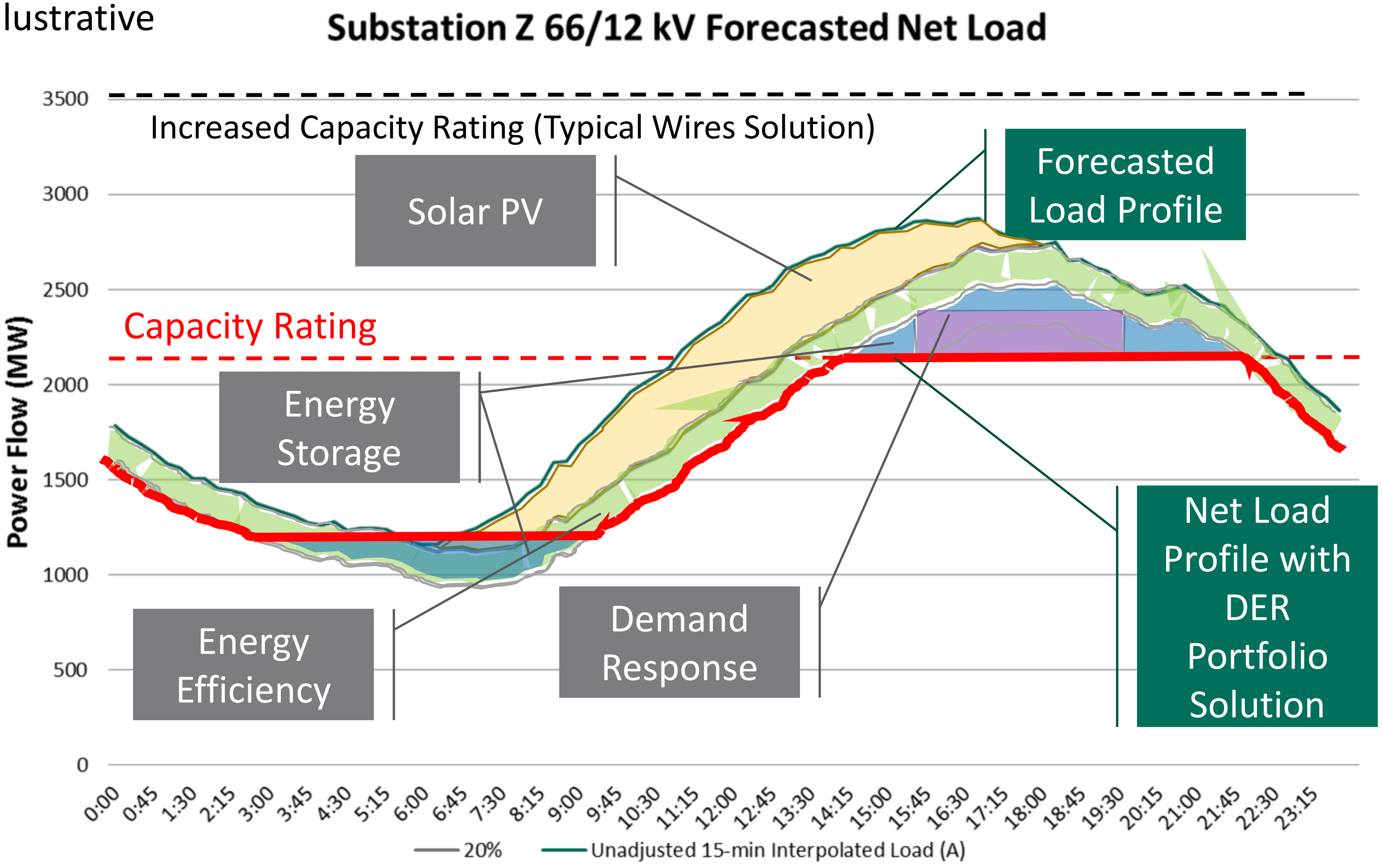
Illustrative



Alter Substation Load Profile Using DER Portfolio

Operators Need Visibility to DER Portfolio Performance in Real Time

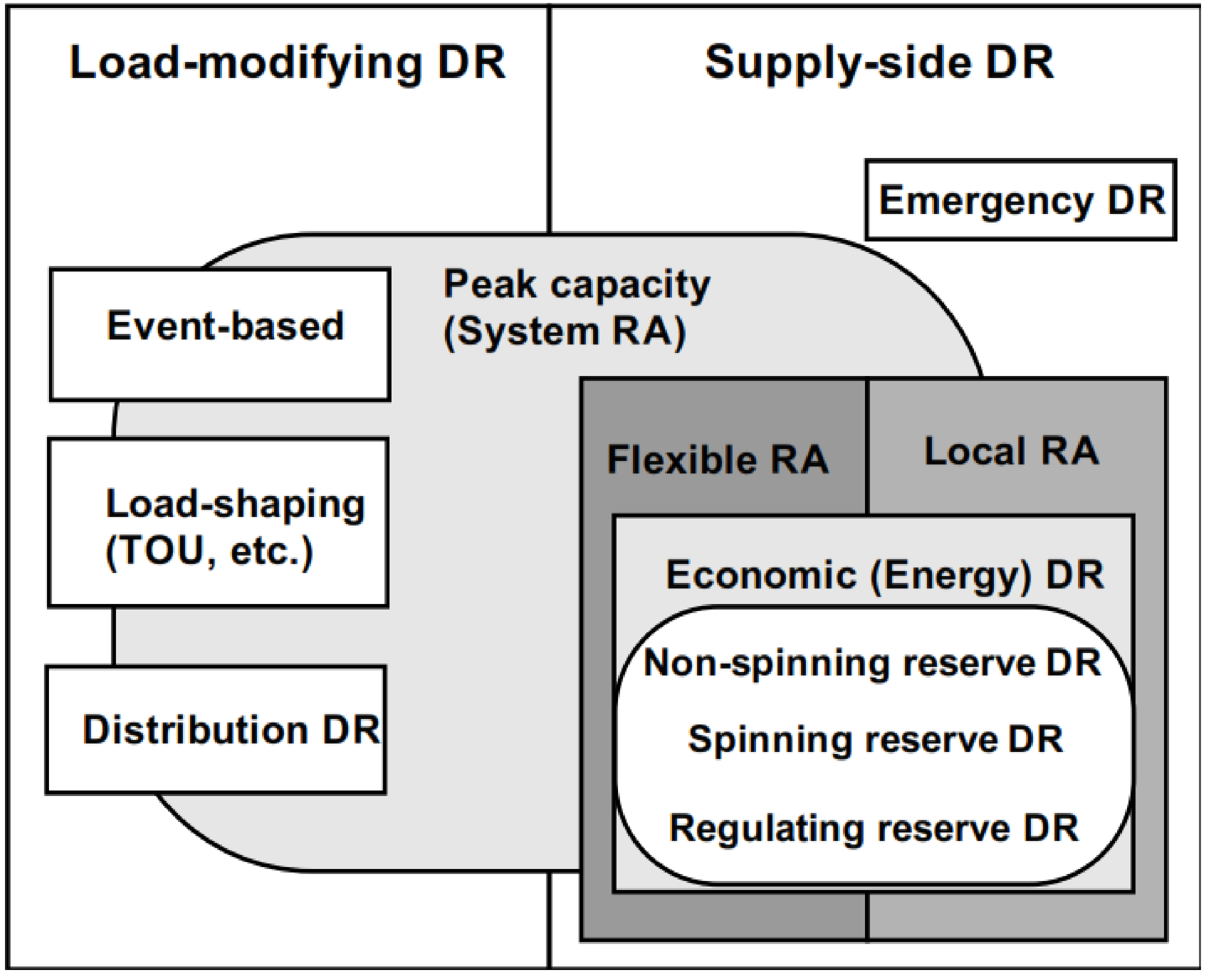
Illustrative



Batteries for Energy Storage

Load shifting thermal energy storage application

Multiple Product Participation



Cloud-Based Continuously Optimizing Buildings

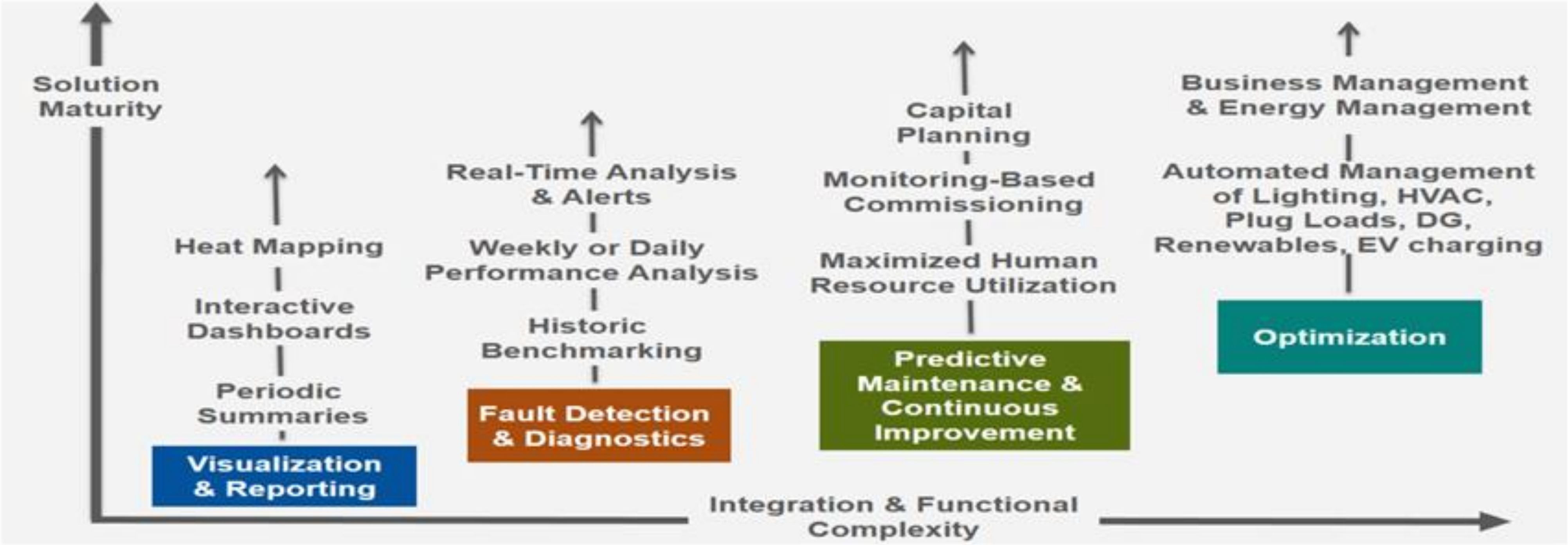
Michel Kamel, Ph.D.
CTO
MelRok LLC

Status Quo

- Disconnect between commissioning and O&M of a building
- Building energy management systems (BEMS) are islanded
- Growing knowledge gap between systems and operators
- Limited use of advanced systems (e.g. VFDs)
- BEMS do not come ‘fully loaded’
- BEMS require costly, and often unaffordable, use of experts
- BEMS are typically undermanaged

=> Energy Inefficiencies and Losses

Path to Optimization



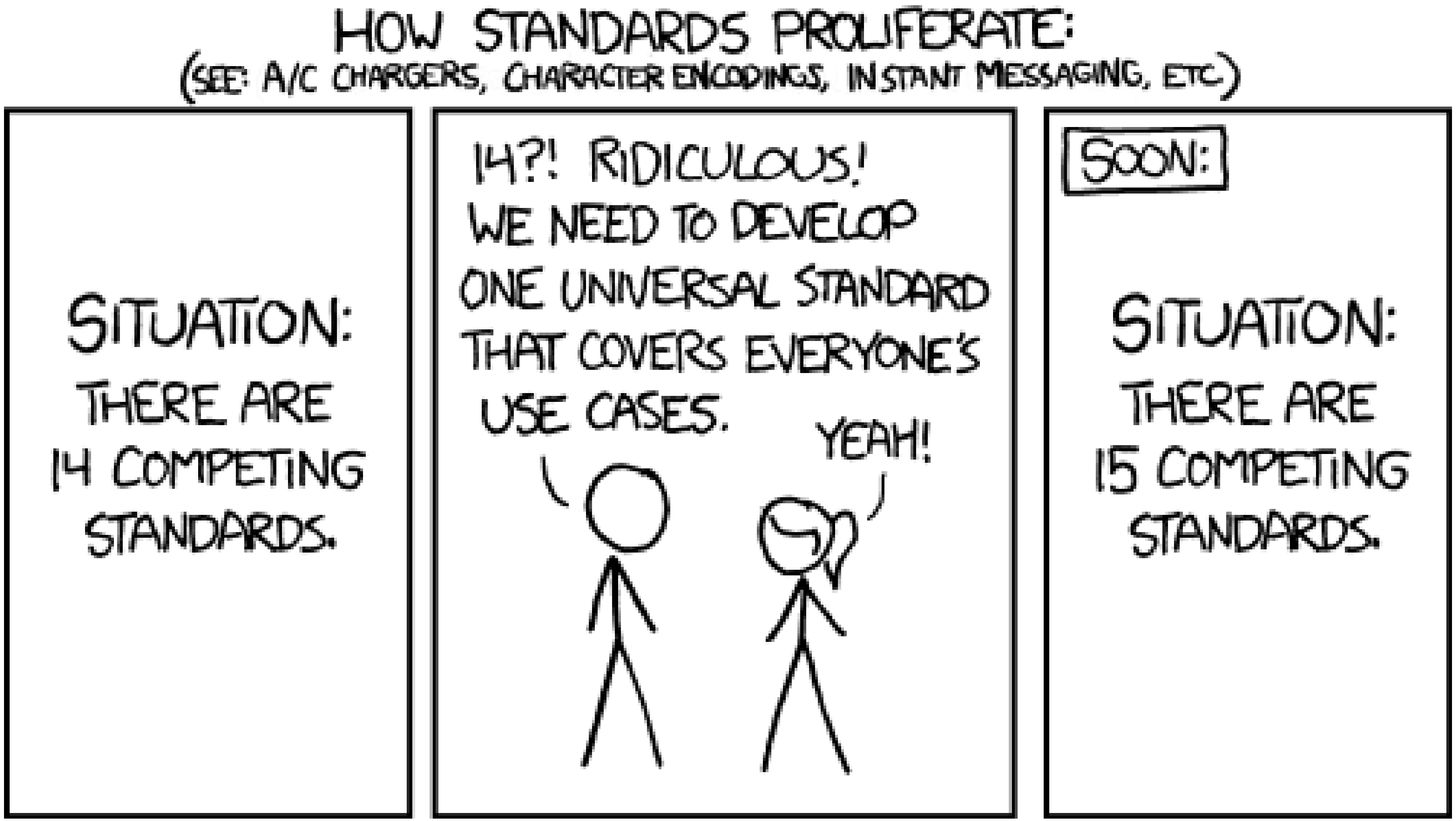
Source: Navigant Research 2016

New Requirements

- Automated Data Accessibility
- Integration of growing IoT sensors and devices
- Cybersecurity
- Hands-Free Operations
- Knowledge sharing capability
- Grid interaction

Enabling Technologies

- Real-time connectivity to multi-protocol energy systems
- Real time integration of enhanced sensing technologies
- Secure big data pipelines to building energy systems
- Streamlined real-time cloud-based energy optimization engines
- Secure transmission of control messages to site devices



http://xkcd.com/927/

XKCD Randall Monroe

Tech Mix: Repurposing Proven Technologies

FM Signal

Metropolitan Coverage

Fully Secure / Penetrating / Ubiquitous

- Applications: Secure IoT Messaging, Secure Metropolitan Wide ADR, Emergency IoT Channel, etc.

Within Reach: First Implementation 2018

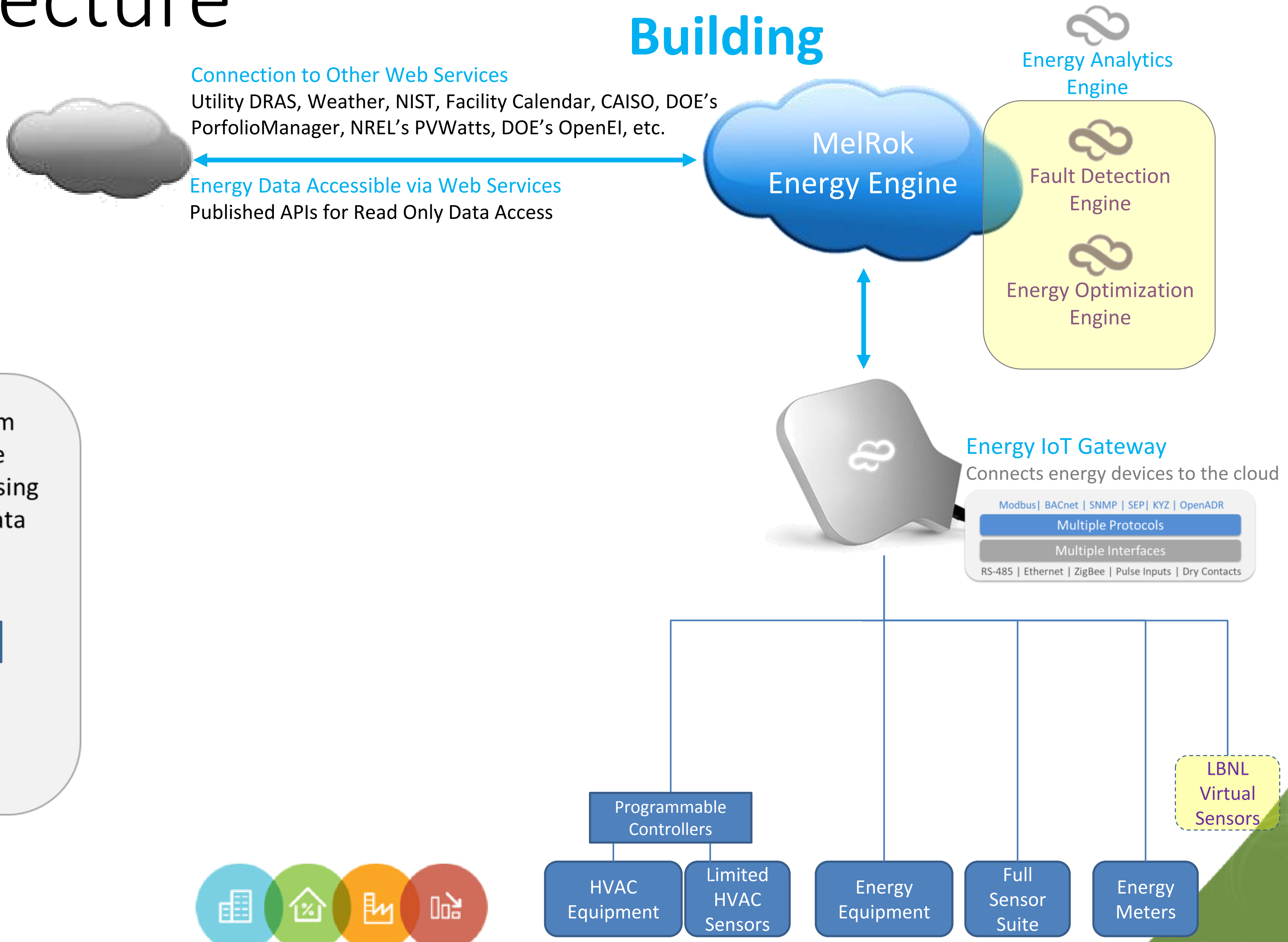
- Pomona College: 5 Cloud Optimized Buildings + 5 Cloud Assisted Buildings

Pomona College MelRok Energy IoT™ Berkeley Lab ZNEAlliance

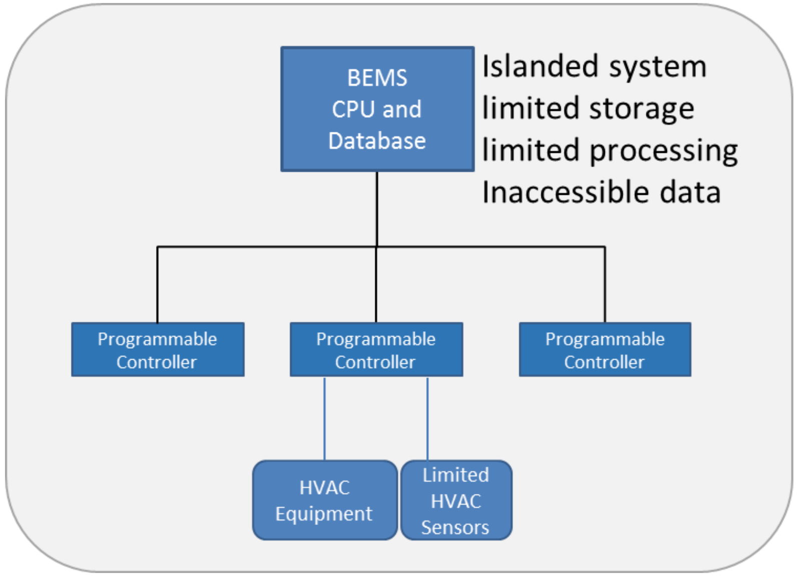
Awarded CEC Grant
GFO-16-304

System Architecture

Continuously Cloud Optimized Building



Existing BEMS



Existing BEMS

Thank You

Michel Kamel, Ph.D.

CTO

MelRok LLC

Advanced Controls and Demand Response for Packaged HVAC Units

- Results from two studies
- The next five years of Demand Response

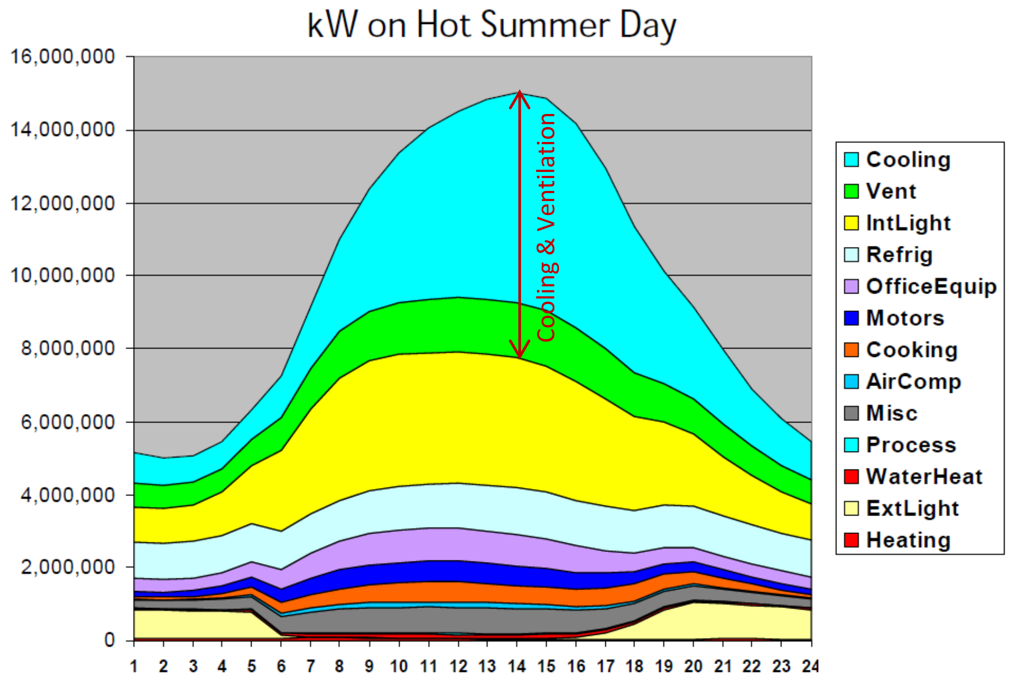
Emerging Technology Summit

Alternative Energy Systems Consulting | Antonio Corradini, P.E.

April 2017 | Ontario, CA

Composition of Peak Demand in CA

- Non-Coincident peak demand potential in CA (absolute demand potential for all connected loads) was 61GW in 2015 and is expected to grow roughly 1% every year[1]
- Cooling and ventilation is responsible for approximately 50% of peak demand in commercial buildings – more than 10% of total peak demand in CA

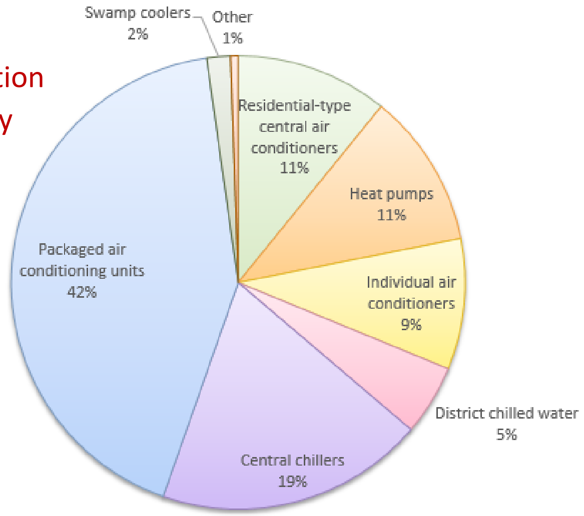


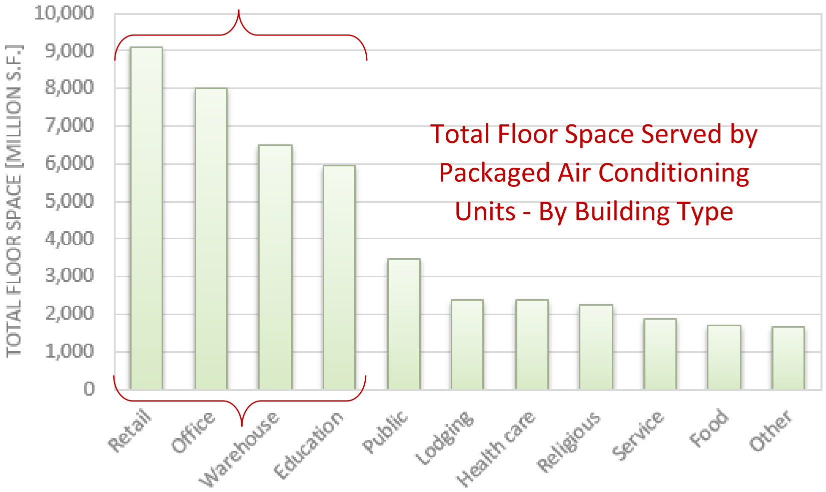
Typical Composition of Coincident Peak Load in California [2]

1. http://docketpublic.energy.ca.gov/PublicDocuments/15-IEPR-03/TN207439_20160115T152221_California_Energy_Demand_20162026_Revised_Electricity_Forecast.pdf
2. http://www.energy.ca.gov/ab758/documents/2012-10-08-09_workshop/presentations/Day-2/AB-758_Market_Characterization_and_Scenarios_2012-10-09.pdf

Composition of Cooling Loads in Commercial Buildings

Cooling Energy Consumption in Commercial Buildings by Equipment Type





Total Floor Space Served by Packaged Air Conditioning Units - By Building Type

Packaged Air Conditioning Units

1) Are the largest energy consumer in commercial buildings in the US[1], accounting for 42% of total energy consumed by cooling equipment.
2) Serve more than 40% of commercial floor space in the US[1], primarily small and medium commercial buildings (retail, offices, education, food service)
3) Comprise more than 75% of commercial cooling systems in CA[2]

1. CEUS 2012
2. http://www.etcc-ca.com/sites/default/files/reports/et12pge3101_indirect_evap_coolers_retrofit_to_existing_rtus.pdf

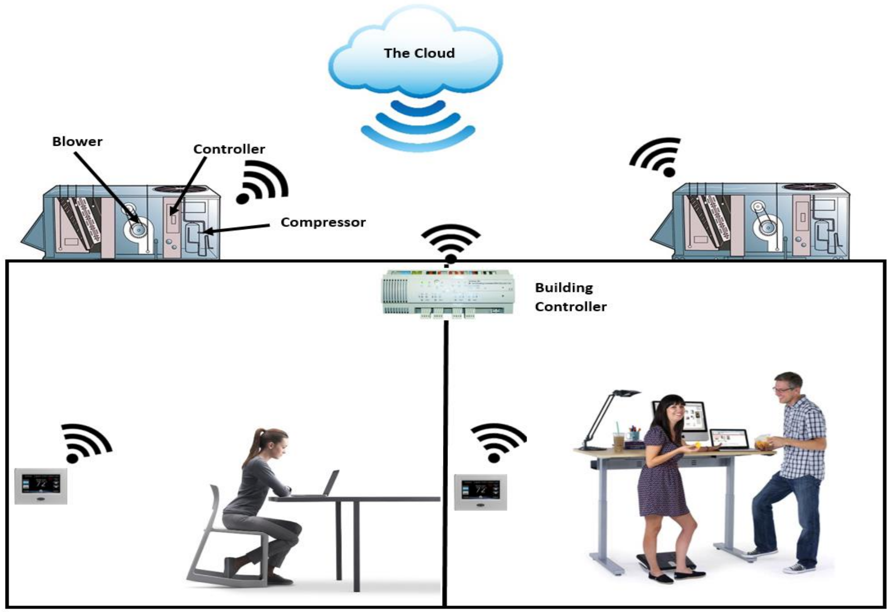
Can Packaged Units Reduce Peak Demand?

Assolutamente!

(Absolutely!)

Studies have shown demand reduction of 10-30% per package unit and up to 50% total facility load for facilities with multiple units.

Case Study 1 – Cloud Based Controls



RTU Control Retrofit

- Thermostat Replacement
- Addition of RTU Component Control Modules
- Thermostats and RTU Control coordinated and linked to cloud through Building Controller
- Enables cloud based Optimization, Demand Limiting and Demand Response functionality.

Optimization Objectives and Results

- Reduced coincident peak demand
- Situational demand response capability
- Reduced energy consumption
- Equal or greater occupant comfort
- Increased compressor life through reduced cycling

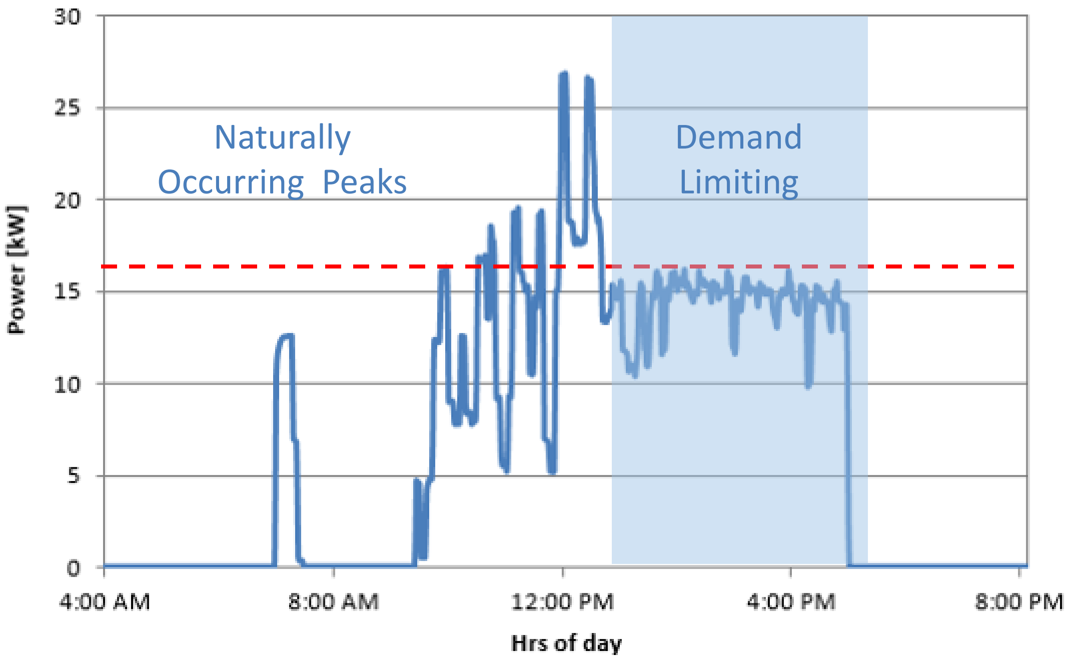
Case Study 1 – Evaluation Sites

Office Buildings Located in SDG&E territory

Building Features	Building 1	Building 2
Year built	1998	1960s
Size	Approx. 12,000 ft^2	26,000 ft^2
Climate Zone	10	10
Occupancy type	Office/Laboratory	Office
Occupancy Schedule	Monday – Friday 08:00-17:00	Monday – Friday 08:00-17:00
Existing EMS	None	None
Air-side System	Single Zone, Constant Volume	Single Zone, Constant Volume
Mechanical System	(6) Packaged Heat Pumps, 3-5 tons	(10) Packaged DX/furnace Units 2-7.5 tons

Case Study 1 - Functionality

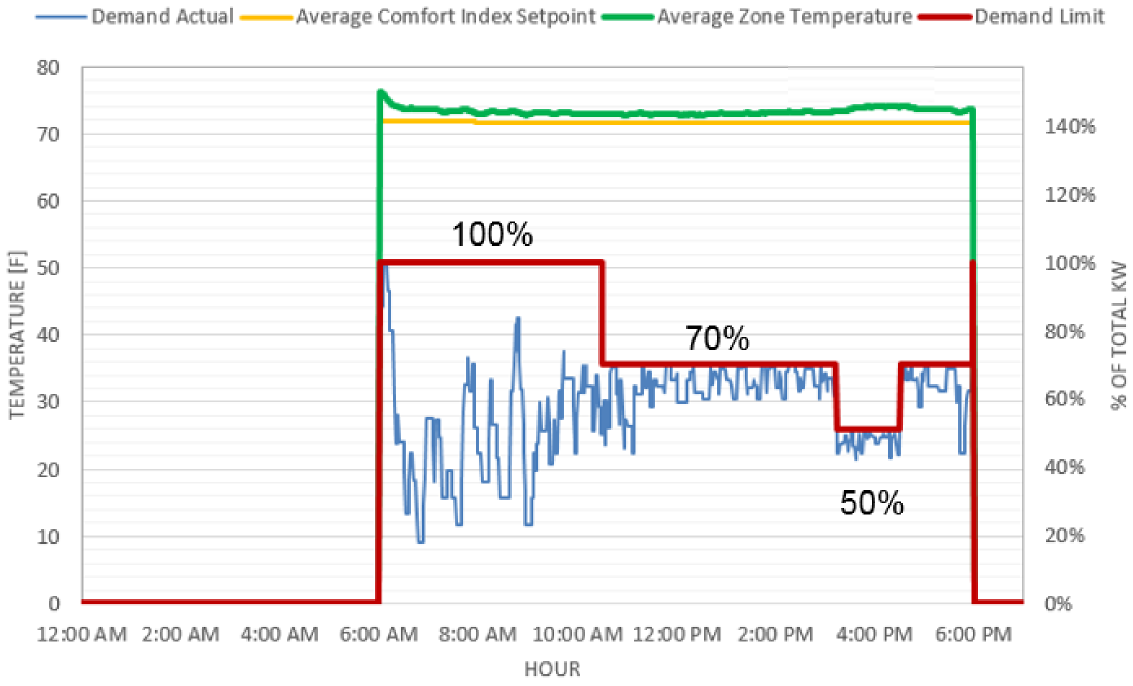
Case Study 1 - Building 1 of 2
Demand Limiting While Maintaining Comfort



1. The control algorithm allows a user specified kW-cap or % reduction across all controlled RTU’s.
2. The specified total demand is maintained below the kW-cap by coordinated cycling of compressors within the facility. The cooling set point is unchanged and is maintained.
3. Graphic illustrates naturally occurring 27kW peak and 35% reduction via demand limiting during on-peak hours.

Case Study 1 - Functionality

Case Study 1 - Building 2 of 2
Demand Limiting + Demand Response and Managed Impact to Comfort



1. At Building 2, demand reduction capability was tested to its limit.
2. Zone temperature was kept at the setpoint with 30% demand reduction.
3. When 50% demand reduction was commanded, the average indoor air temperature began to increase approximately 1°F per hour.

Case Study 2 – VFD Retrofit with Cloud Based Controls

energy solutions for a changing world

Advanced Retrofit Controller (ARC) Technology

RTU Equipment and Control Retrofit

- VFD Supply Fan Retrofit
- Thermostat Replacement
- Addition of RTU Component Controls
- Cloud based user interface with trending, scheduling, and control capabilities.
- Enables continual VFD supply fan optimization and event based thermostat setback to provide for Demand Response

Optimization Objectives and Results

- Optimization of RTU performance at part-load conditions
- Reduced speed at lower heating/cooling stages and ventilation-only mode
- Situational demand response capability
- Reduced energy consumption

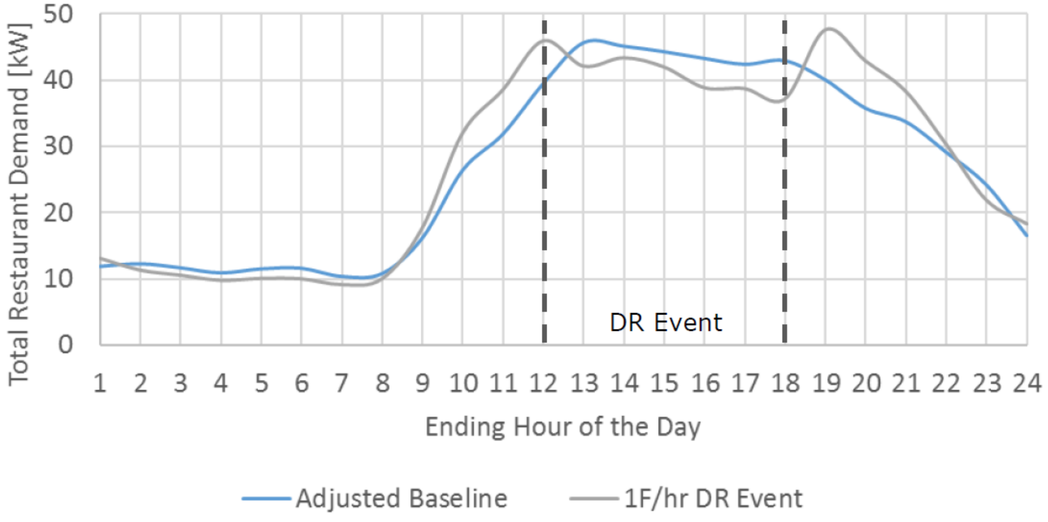
Case Study 2 – Evaluation Sites

Fast-food Restaurants located in SDG&E territory

Building Features	Building 1	Building 2
Size	2,500 ft^2	2,000 ft^2
Climate Zone	10	7
Occupancy type	Fast-food Restaurant	Fast-food Restaurant
Annual Operating Hours	4,700 hours	5,430 hours
Existing EMS	None	None
Air-side System	Single Zone, Constant Volume base case. Retrofit to VFD Supply Fans.	Single Zone, Constant Volume base case. Retrofit to VFD Supply Fans.
Mechanical System	(3) Packaged DX/furnace, 7.5-10 tons	(3) Packaged DX/furnace Units, 5-10 tons

Case Study 2 – DR Scenario 1

Site	DR Event Baseline [kW]	DR Reduction [kW]	Demand Reduction [%]
1	43.9	3.5	8.1%
2	39.6	3.2	8.2%



Scenario 1

- Six Hour Demand Response Event
- Fast Food Restaurant

Event Strategy

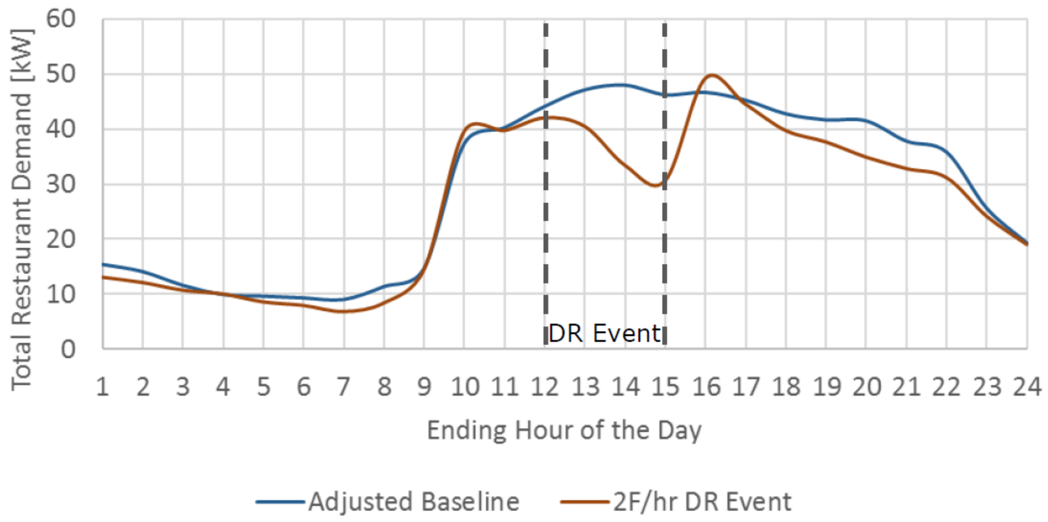
- 1°F per hour setpoint increase for 6 hours, cumulative 6°F increase
- Remote monitoring and control via web based user interface during DR event hours.

Considerations

- No complaints received from staff or patrons.
- This could point out fast food as a viable segment for this mode of control in that staff are subject to kitchen heat and guests are entering temperature controlled space from outdoor peak day conditions.
- In both cases the ambient drift is relatively inconspicuous.

Case Study 2 – DR Scenario 2

Site	DR Event Baseline [kW]	DR Reduction [kW]	Demand Reduction [%]
1	51.0	10.0	20%
2	47.1	12.2	26%



Scenario 2

- Three Hour Demand Response Event
- Fast Food Restaurant

Event Strategy

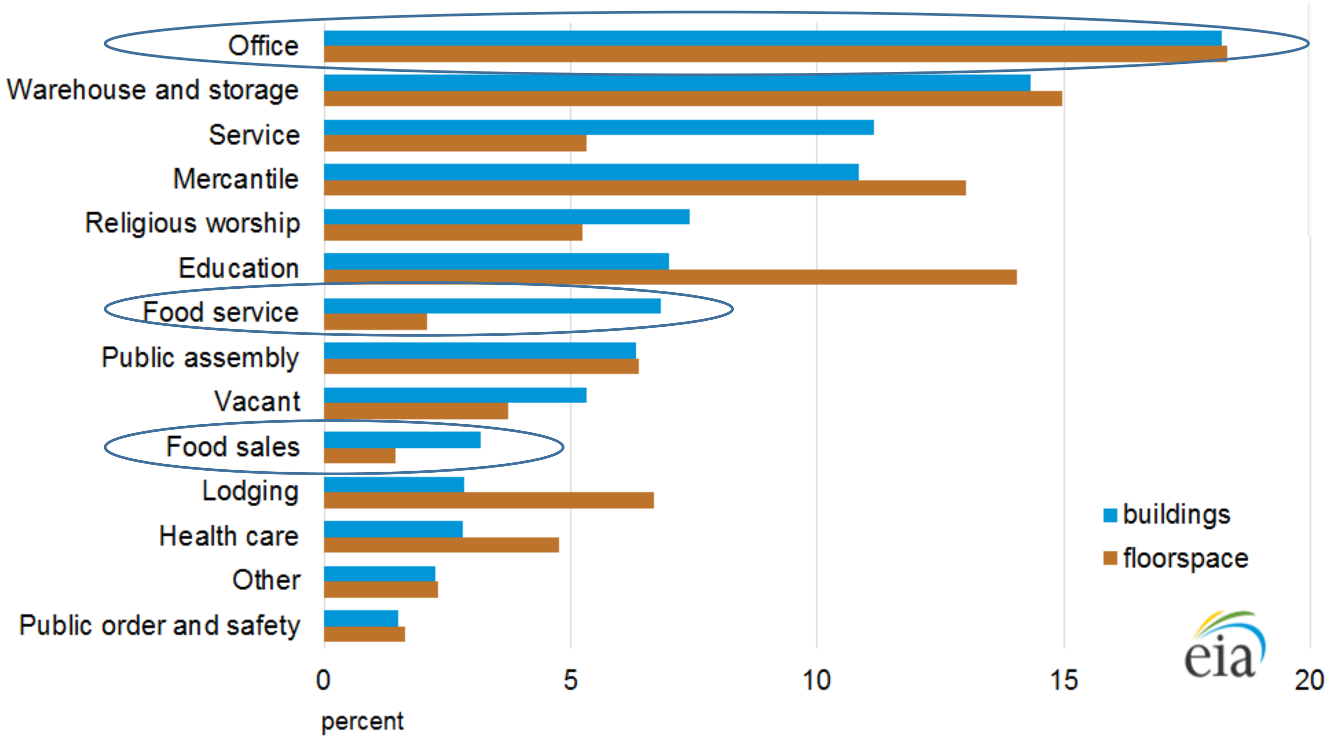
- 2°F per hour setpoint increase for 3 hours, cumulative 6°F increase
- Remote monitoring and control via web based user interface during DR event hours.

Considerations

- No complaints received from staff or patrons.
- =/> 20% demand reductions for 3 hour event vs. 8% for six hour event points out opportunity for needle peak event design or rolling 3 hour block strategies to optimize capacity.

Package Unit Market - Commercial Office and Food Sale and Service Opportunity

- Commercial office space represents the largest volume of package units.
- Food sales and service represent the highest EUI.
- Together they are logical segments for program focus utilizing advanced package unit controls.



Source: U.S. Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey

Case Study – Numeric Summary

Data Point	Case Study 1 Controls	Case Study 2 Controls + VFD
Total RTU capacity [tons]	25.0 Tons	22.5 Tons
Project costs [$]	$3,500	$16,000
Annual energy savings [kWh][1]	3,000 kWh	20,000 kWh
Demand Reduction during a DR event [kW]	10 kW	11 kW
Average Electricity billing rate [$/kWh]	$0.15 kWh	$0.10 kWh
Simple payback with EE incentive only [yr.]	7.2	7.2
Simple payback with DR incentive only [yr.]	3.0	16.1
Simple payback with EE and DR incentive [yr.]	1.8	4.5

1. Operating hours varied significantly between the two applications, contributing to the energy savings difference

Market Challenges and Opportunities for Advance Package Unit Controls

energy solutions for a changing world

Opportunities

- Package units have tremendous DR, EE and Peak Load Management potential.
- Technology enabled solutions have made complex optimization strategies very executable.
- Facility operators are beginning to recognize building intelligence as a key component of their future operations.
- Cost effectiveness is achievable at the facility and utility level.

Challenges

- Mode of achieving performance gains and savings is difficult for facility operators to understand.
- Skilled application engineering, financial packaging and proof of savings are required to implement.
- HVAC and controls distribution channels are only beginning to recognize and pursue advanced control opportunities.
- Cost effectiveness requires combining the cost benefits of DR, EE and Coincident Peak Management.

Thank you for your time and attention.

Antonio Corradini, P.E.

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Demand Response: Looking into the Crystal Ball

Emerging Technologies Summit

April 20, 2017

Ontario, California

Together, Building a Better California

Demand Response: An enablement platform to transform DERs into Grid Responsive Loads

DR + ADR =
BTM DER enablement platform

Behind-the-Meter (BTM) DER Technology Programs

- DG
  e.g. Batteries
- Alt Fuels
  e.g. EVs
- EE
  e.g. Smart Thermostats

Encourage the adoption of new DERs

DR Enabling Technologies (ADR)

Communication, Control & Visibility of Connected BTM Devices

Enable device automation

Demand Response Providers' Programs

Notify Participating Customers when Load Flexibility is Valuable to the Grid

Customers can earn a new revenue stream, on top of energy bill savings

BTM = Behind the Meter

DR Pilots to Inform the Future

Supply Side Pilot II	Excess Supply Pilot	DR Auction Mechanism Pilot
» Participants elect their capacity availability and opportunity cost » Pilot facilitates the integration of DR resources into the CAISO wholesale markets	» Explore how customers can contribute to the realignment of supply and demand by shifting their load consumption in situations of over generation from the integration of renewable energy on the grid	» Procure from third-party DR providers resources that meet Resource Adequacy requirements » Enable and test the viability of third-party DR provider direct participation into the CAISO energy markets

Demand Response to enable end-uses to serve as grid-responsive assets

Examples of DRET Assessments

Support DR Integration into Wholesale Markets

- Telemetry White Paper and Lab Study
- Statistical Sampling and Alternate Baselines

Explore program models for using connected devices for DR

- TDSM Smart Thermostat Assessment

Support Implementation of DR Codes and Standards

- Title 24 Outreach
- OpenADR Alliance support

Understand ability of various technologies and behavior patterns to support load curtailment

- Analysis of 2013 Electric Vehicle Charging Load Data and Potential as a Demand Response Resource

Example DRET Assessment: Telemetry

Goal: Evaluate Technologies' Ability To Meet CAISO Telemetry Requirements for PDR Resources

Old Standards

Telemetry requirements were designed for generators, not for DR.

New Requirements

CAISO requires for Energy PDRs of 10 MW or above & ancillary services of any amount.

Identifying a scalable solution for telemetry is a key to integrating Demand Response into the CAISO market.

Telemetry Lab Test: Two off the shelf HAN devices were tested

Rainforest EAGLE	Universal Devices ISY
• Designed to give customers real-time price and usage info • Simple install • PG&E certified HAN • Open ADR 2.0b *Enabled* • ~$100 per unit	• Designed as a full-fledged EMS to provide automation, control and real time monitoring of end-use devices • Involved install • PG&E certified HAN • Open ADR 2.0a/2.0b *Certified* • ~$330 per unit

Example DRET Assessment: Title 24 Outreach

Goal: How do we best conduct outreach to market actors that can influence adoption of Title 24 DR Requirements?

Material Development

- PowerPoint Presentation
- Website
- Fact Sheet
- Newsletter

Outreach Activity

- Industry leader coordination
- Utility stakeholder coordination
- In-person meetings
- Live webinars
- Recorded webinar

Market Feedback

- Determine preferences
- Assess acceptance
- Determine effectiveness
- Evaluate relevance

Assessment findings suggest a disconnect between the specific DR code requirements and market actors' understanding of how they can actually support customer and grid needs.

Appendix

Enable Participation in the CAISO Markets

Multiple channels to integrate with CAISO

Aggregators
(CCAs/ESPs with DR resources, 3rd Parties)

Direct Customers
(Retail Bundled/Unbundled)

PDR Integration of PG&E Retail DR Programs

Customer / Aggregator joins PG&E retail programs (E.g. CBP)
PG&E assists and handles DRP and SC operational functions

DRP | SC → CAISO

PG&E Supply Side Pilot Construct

Customer/Aggregator participates as the DRP
PG&E provides operational functions like SC

DRP | SC → CAISO

Rule 24 for DRAM & non-DRAM participants

Customer / Aggregator handles all DRP and SC operational functions
PG&E is not privy to this information

DRP | SC → CAISO

CAISO

Example Home Device Architecture

Eagle 200 – Plugged into TP link powerline adaptor

Eagle - plugged into main internet router

PG&E Meter for entire premise

~75 Feet

Thank you

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