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

Projected energy use

Demand response event

Time of Day

kW Demand
Supply vs. Demand Side Management
Renewable Resources
Wind and Solar Profiles

Peak demand
44,000 MW

Total solar capacity = 10,814 MW
(including behind the meter)

Total wind capacity = 5,450 MW

Sample winter day in 2020
DR with Renewables

Spring

Summer Peak

Preferred Peaking Resources: 4 hrs
Preferred Intermediate Resources: 8 hrs

3/27/2013 0:00

9/5/2013 0:00
Types of DR

- **Shape**
  - Incentivize EE and Behavior Change

- **Shift**
  - Mitigate Ramps and Capture Surplus Renewables

- **Shed**
  - Manage contingency events and coarse net load following

- **Shimmy**
  - Fast DR to smooth net load and support frequency
# Types of DR

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

Illustrative

Substation Z 66/12 kV Forecasted Net Load

- Increased Capacity Rating (Typical Wires Solution)
- Forecasted Load Profile
- Capacity Rating

Power Flow (MW)

Unadjusted 15-min Interpolated Load (A)
Alter Substation Load Profile Using DER Portfolio
Solar Can Impact Load Profile During Daytime Hours

Illustrative

Substation Z 66/12 kV Forecasted Net Load

- **Solar PV**
- **Capacity Rating**
- **Net Load Profile**
- **Forecasted Load Profile**

Power Flow (MW)

- 0
- 500
- 1000
- 1500
- 2000
- 2500
- 3000
- 3500

Unadjusted 15-min Interpolated Load (A)

0:00 0.45 1.45 2.15 3.30 4.30 5.15 6.00 6.45 7.30 8.15 9.00 9.45 10.30 11.15 12.00 12.45 13.30 14.15 15.00 15.45 16.30 17.15 18.00 18.45 19.30 20.00 21.00 21.45 22.30 23.15
Alter Substation Load Profile with DER Portfolio

Energy Efficiency Programs can Permanently Reduce Load Profile

Illustrative

**Substation Z 66/12 kV Forecasted Net Load**

- **Solar PV**
- **Forecasted Load Profile**
- **Net Load Profile**
- **Capacity Rating**
- **Energy Efficiency**

![Diagram](image-url)

Unadjusted 15-min Interpolated Load (A)

21
Substation Z 66/12 kV Forecasted Net Load

Illustrative

- Solar PV
- Forecasted Load Profile
- Capacity Rating
- Energy Efficiency
- Demand Response
- Net Load Profile

20% Unadjusted 15-min Interpolated Load (A)
Alter Substation Load Profile Using DER Portfolio

Energy Storage can be Dispatched to Prescriptively Reduce Load Profile

Illustrative

Substation Z 66/12 kV Forecasted Net Load

- Solar PV
- Capacity Rating
- Energy Storage
- Energy Efficiency
- Demand Response
- Forecasted Load Profile
- Net Load Profile

- 20% Unadjusted 15-min Interpolated Load (A)
Alter Substation Load Profile Using DER Portfolio

Energy Storage Also Requires Charging Which Will Impact Load Profile

Illustrative

Substation Z 66/12 kV Forecasted Net Load

- Solar PV
- Forecasted Load Profile
- Energy Storage
- Net Load Profile
- Energy Efficiency
- Demand Response

Power Flow (MW)

Capacity Rating

- 20% Unadjusted 15-min interpolated load (A)

25
Alter Substation Load Profile Using DER Portfolio
Customized DER Portfolios Can Address Capacity Needs On Distribution

Illustrative

Substation Z 66/12 kV Forecasted Net Load

Increased Capacity Rating (Typical Wires Solution)

Capacity Rating

Net Load Profile with DER Portfolio Solution

Forecasted Load Profile

Unadjusted 15-min Interpolated Load (A)
Alter Substation Load Profile Using DER Portfolio
Operators Need Visibility to DER Portfolio Performance in Real Time

Illustrative

Substation Z 66/12 kV Forecasted Net Load

Increased Capacity Rating (Typical Wires Solution)
Net Load Profile with DER Portfolio Solution

Solar PV
Forecasted Load Profile
Energy Storage
Energy Efficiency
Demand Response

Power Flow (MW)

Net Load Profile with DER Portfolio Solution

20%
Unadjusted 15-min Interpolated Load (A)
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
HOW STANDARDS PROLIFERATE:
(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC)

SITUATION:
THERE ARE 14 COMPETING STANDARDS.

14?! RIDICULOUS!
WE NEED TO DEVELOP ONE UNIVERSAL STANDARD THAT COVERS EVERYONE'S USE CASES.

SITUATION:
THERE ARE 15 COMPETING STANDARDS.

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

Awarded CEC Grant
GFO-16-304
System Architecture

Existing BEMS

- BEMS CPU and Database
  - Programmable Controller
  - HVAC Equipment
  - Limited HVAC Sensors

Islanded system
Limited storage
Limited processing
Inaccessible data

Continuously Cloud Optimized Building

Connection to Other Web Services
Utility DRAS, Weather, NIST, Facility Calendar, CAISO, DOE’s PortfolioManager, NREL’s PVWatts, DOE’s OpenEI, etc.

Energy Data Accessible via Web Services
Published APIs for Read Only Data Access

Energy IoT Gateway
Connects energy devices to the cloud

MelRok Energy Engine

Energy Analytics Engine
Fault Detection Engine
Energy Optimization Engine

Energy Engine
Programmable Controllers
HVAC Equipment
Limited HVAC Sensors
Energy Equipment
Full Sensor Suite
Energy Meters

Existing BEMS

LBNL Virtual Sensors

PVWatts
PortfolioManager
OpenEI
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
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.
- Cooling and ventilation is responsible for approximately 50% of peak demand in commercial buildings – more than 10% of total peak demand in CA.

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
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
Office Buildings Located in SDG&E territory

<table>
<thead>
<tr>
<th>Building Features</th>
<th>Building 1</th>
<th>Building 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year built</td>
<td>1998</td>
<td>1960s</td>
</tr>
<tr>
<td>Size</td>
<td>Approx. 12,000 ft²</td>
<td>26,000 ft²</td>
</tr>
<tr>
<td>Climate Zone</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Occupancy type</td>
<td>Office/Laboratory</td>
<td>Office</td>
</tr>
<tr>
<td>Occupancy Schedule</td>
<td>Monday – Friday 08:00-17:00</td>
<td>Monday – Friday 08:00-17:00</td>
</tr>
<tr>
<td>Existing EMS</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Air-side System</td>
<td>Single Zone, Constant Volume</td>
<td>Single Zone, Constant Volume</td>
</tr>
<tr>
<td>Mechanical System</td>
<td>(6) Packaged Heat Pumps, 3-5 tons</td>
<td>(10) Packaged DX/furnace Units 2-7.5 tons</td>
</tr>
</tbody>
</table>
Case Study 1 - Functionality

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

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

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
### Fast-food Restaurants located in SDG&E territory

<table>
<thead>
<tr>
<th>Building Features</th>
<th>Building 1</th>
<th>Building 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td>2,500 ft²</td>
<td>2,000 ft²</td>
</tr>
<tr>
<td><strong>Climate Zone</strong></td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td><strong>Occupancy type</strong></td>
<td>Fast-food Restaurant</td>
<td>Fast-food Restaurant</td>
</tr>
<tr>
<td><strong>Annual Operating Hours</strong></td>
<td>4,700 hours</td>
<td>5,430 hours</td>
</tr>
<tr>
<td><strong>Existing EMS</strong></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>Mechanical System</strong></td>
<td>(3) Packaged DX/furnace, 7.5-10 tons</td>
<td>(3) Packaged DX/furnace Units, 5-10 tons</td>
</tr>
</tbody>
</table>
Case Study 2 – DR Scenario 1

**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.

### Site DR Event Baseline [kW] DR Reduction [kW] Demand Reduction [%]

<table>
<thead>
<tr>
<th>Site</th>
<th>DR Event Baseline [kW]</th>
<th>DR Reduction [kW]</th>
<th>Demand Reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>43.9</td>
<td>3.5</td>
<td>8.1%</td>
</tr>
<tr>
<td>2</td>
<td>39.6</td>
<td>3.2</td>
<td>8.2%</td>
</tr>
</tbody>
</table>
Case Study 2 – DR Scenario 2

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.

<table>
<thead>
<tr>
<th>Site</th>
<th>DR Event Baseline [kW]</th>
<th>DR Reduction [kW]</th>
<th>Demand Reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>51.0</td>
<td>10.0</td>
<td>20%</td>
</tr>
<tr>
<td>2</td>
<td>47.1</td>
<td>12.2</td>
<td>26%</td>
</tr>
</tbody>
</table>
• 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.
Case Study – Numeric Summary

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

1. Operating hours varied significantly between the two applications, contributing to the energy savings difference
Market Challenges and Opportunities for Advance Package Unit Controls

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.
Alternative Energy Systems Consulting
acorradini@aesc-inc.com
(760)931.2461 x114
Demand Response: Looking into the Crystal Ball

Emerging Technologies Summit
April 20, 2017
Ontario, California
Demand Response: An enablement platform to transform DERs into Grid Responsive Loads

- **Encourage the adoption of new DERs**
- **Enable device automation**
- **Customers can earn a new revenue stream, on top of energy bill savings**

**Behind-the-Meter (BTM) DER Technology Programs**
- DG e.g. Batteries
- Alt Fuels e.g. EVs
- EE e.g. Smart Thermostats

**DR Enabling Technologies (ADR)**
Communication, Control & Visibility of Connected BTM Devices

**Demand Response Providers’ Programs**
Notify Participating Customers when Load Flexibility is Valuable to the Grid

BTM = Behind the Meter
### Supply Side Pilot II

- Participants elect their capacity, availability, and opportunity cost.
- Pilot facilitates the integration of DR resources into the CAISO wholesale markets.

### Excess Supply Pilot

- Explore how customers can contribute to the realignment of supply and demand by shifting their load consumption in situations of overgeneration from the integration of renewable energy on the grid.

### DR Auction Mechanism Pilot

- 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

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

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

### PG&E Supply Side Pilot Construct
- Customer/Aggregator participates as the DRP
- PG&E provides operational functions like SC

### Rule 24 for DRAM & non-DRAM participants
- Customer / Aggregator handles all DRP and SC operational functions
- PG&E is not privy to this information

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

Sam Piell
samantha.piell@pge.com