Engineer David Wylie, left, and computer analyst Steve Ramsey work on conservation of energy.
National Energy Peak Leveling Program – 1977
When Demand Meets Supply

The graph illustrates the relationship between demand and supply over time. The x-axis represents the hour beginning, while the y-axis shows the megawatts. The lines indicate different forecasts and actual demand, with labels for day ahead demand forecast, revised demand forecast, and available resources forecast. The actual demand line shows a peak at around 17:00, indicating a high demand period.
Four Years of Drought in CA

100% of CA in “severe drought”; 2015 water year “worst one on record”

Lake Shasta. Current level is 50% of capacity
2015 Summer Hydro Outlook

California gets about 14% of its power from hydroelectric power plants

- 2015 CA hydro outlook is poor; reservoirs at 48% of capacity; estimated loss (derate) of 2,700 MW in generating capacity
- CA snowpack virtually gone for 2015
- CA can buy hydro power from Pacific Northwest, Hoover Dam, and others
- Regardless, there will be adequate power supplies for meeting summer peak conditions despite well below average hydroelectric supply
2015 Operating Reserve Margins

Overall reserve margins in northern and southern California remain healthy

ISO, SP26 and NP26 Operating Reserve Margins at 2015 Summer Peak

Notes:
- Demand based on 1-in-2, or 1-in-10 Weather.
- Outages based on 1-in-2, or 1-in-10 Generation curtailments.
- All Demand Response and Interruptible Load has been utilized.
What is Demand Response?

[Graph showing the concept of Demand Response with time of day on the x-axis and demand on the y-axis.]

Projected energy use before and after a demand response event.
Renewable Resources

- Wind and solar are “intermittent” and stability is more challenging
- When renewable resources are down, DR can serve as backup
- California can generate about 7% of its electricity from wind
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
What’s the “Duck Curve?”

Net load - March 31

- Overgeneration risk
- Ramp need: ~13,000 MW in three hours

- 2012 (actual)
- 2013 (actual)
- 2014
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020
Flexible Resources Will Be Essential to Meeting the Net Load Demand Curve

Total solar capacity = 10,814 MW (including behind the meter)
Total wind capacity = 5,450 MW

Sample winter day in 2020
Sustainable?
Integrated Demand Side Management (IDSM)
Supply vs. Demand Side Management

Generation (supply) ➔ Load (demand)
### DSM Strategies

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy Conservation (EC)</strong></td>
<td>• Behavioral; reduction in use of energy-consuming devices</td>
</tr>
<tr>
<td><strong>Energy Efficiency (EE)</strong></td>
<td>• Reduce kWh or therms by using more efficient equipment</td>
</tr>
<tr>
<td><strong>Distributed Generation (DG)</strong></td>
<td>• Self-generation of power</td>
</tr>
<tr>
<td></td>
<td>• Can be employed year-round or as needed</td>
</tr>
<tr>
<td><strong>Load Shifting (LS)</strong></td>
<td>• Energy use is shifted to off-peak periods</td>
</tr>
<tr>
<td><strong>Peak Management (PM)</strong></td>
<td>• Manage loads to reduce overall peak demand</td>
</tr>
<tr>
<td><strong>Demand Response (DR)</strong></td>
<td>• Reduce load when requested for DR events</td>
</tr>
<tr>
<td></td>
<td>• Occasional (up to 10x/year), called by utility or grid</td>
</tr>
</tbody>
</table>
Load Shifting (LS)
Load Shifting with Thermal Energy Storage (TES)

Peak Demand Without Load Shift: 1400 kW

Peak Demand With Load Shift: 900 kW

Chiller Cooling
Brine Ice Building
Peak Management (PM)
Demand Limiting

Demand Limiting

Peak Period

Load without demand limiting

Load with demand limiting

Monthly set limit

No demand limit on this milder day

kW

Time of day (24 hr)
Demand Response (DR)
What is Demand Response?
A reduction in kWh throughout the year 8,760 hours

Actions taken to reduce or shift load during time-of-use on-peak hours (kWh and kW) up to 900 hours during the summer

Reduce load (kW) when requested during unusual events Occasional, called by the utility
Reliability Response DR Programs

Reliability programs:

- Keep the lights on
- Are activated after price response programs to meet emergency energy needs

Reliability programs:

- Agricultural/Pumping Interruptible (AP-I)
- Base Interruptible Program (BIP)
- Summer Discount Plan (SDP)
Price Response Programs

Price response programs:

- Summer Advantage Incentive (SAI) [aka Critical Peak Pricing (CPP)]
- SAI “Light”
- Demand Bidding Program (DBP)
- Capacity Bidding Program (CBP)
- Demand Response Contracts (DRC)
- Aggregator Managed Portfolio (AMP)
- Real Time Pricing (RTP)
- Summer Discount Plan (SDP)
2013 Title 24 Code Requirements for DR

- Lighting DR controls—for buildings larger than 10,000 square feet, must be capable of lowering lighting by at least 15%

- HVAC DR controls—requires Occupant Controlled Smart Thermostats (OCST); capable of remotely using EMS to increase cooling temperature by 4 degrees or more

As DR capable lighting and HVAC controls become baseline requirements in the code, they become ineligible for incentives
Title 24 and Auto-DR

Two types of load-control pathways from DRAS:
- Direct to site through Internet
- Through cloud-based service provider through Internet

Either path can implement wired or wireless solutions:
- Direct pathway devices typically use open protocols
- Cloud service providers typically use proprietary protocols
Two Sources of Funds for DR

Year after Year

DR Program Participation
Revenue from shedding load during DR events

One Time

ADR Technology Incentives
Help pay for hardware and software that enable ADR
North American Regional Transmission Organizations (RTO)

Source: Created in Energy Velocity
WECC Transmission Grid
The Electric Grid

Wholesale

Generation power plant → High voltage transmission → Substation → Load

Retail

System Operator

Wholesale

Generation power plant

High voltage transmission

Substation

Power voltage is "stepped down for distribution"

Retail
Sources for Power Procurement

- Real-time market
- CAISO markets
- Day-ahead market
- SCE-owned generation and power purchase agreements
Major Factors Affecting Supply

Economy
Demography
Weather
Demand Response
Interruptibles

Demand
Target reserve margin
Supply adequacy

Supply
Operating reserve margin

Resource additions and retirements
Local generation
Generator outage
Line outage
Fuel availability
Net import
Procuring Power

- **% Total Demand**
  - **Year-ahead**
  - **Month-ahead**
  - **Days-ahead**
  - **ISO day-ahead market**
  - **ISO real-time market**

- **Energy Procured**
  - **Bilaterally procured energy**
  - **Utility owned energy**

- **ISO market transactions**
Specific Ancillary Services

- Regulation reserve
- Spinning reserve
- Non-spinning reserve
- Supplemental reserve
- Demand response
## ISO Types of Fast and Flexible Capability

<table>
<thead>
<tr>
<th>Operational Needs</th>
<th>Definition</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous ramping</td>
<td>Ability to sustain continuous upward or downward ramps</td>
<td>Ensures sufficient ramping capacity to meet the ISO's largest continuous ramp and multiple ramp conditions</td>
</tr>
<tr>
<td>“Flexible”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load following</td>
<td>Respond to ISO 5-minute dispatch and meet expected operating levels within an hour</td>
<td>Ensures enough capacity with ramping capability available to be dispatched on a 5-minute basis through the ISO real-time dispatch market</td>
</tr>
<tr>
<td>“Fast”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulation</td>
<td>Follow 4-second ISO control signals and meet performance expectations</td>
<td>Ensures the ability to balance net loads and continuously maintain system frequency</td>
</tr>
<tr>
<td>“Faster”</td>
<td></td>
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</tbody>
</table>
CAISO DR Market Products

- Participating Load – an entity providing Curtailable Demand
- Proxy Demand Resource (PDR)
- Reliability Demand Response Resource (RDRR)
- Non-Generator Resource (NGR)
CAISO Day-Ahead Market

- Determines unit commitments
- Analyzes unit must-run needs and mitigates bids if necessary
- Produces the least cost energy while meeting reliability needs
- Determines hourly market clearing prices at DLAP and pNode
Non-Generator Resource (NGR)

- A new ISO resource type that can operate continuously between generation and load
- Modeled as a generator with positive and negative energy
- Are constrained by an upper and lower capacity (MW) limit to inject or withdraw energy at a sustainable rate (ramp rate)
- Are constrained by an energy (MWh) limit to inject or withdraw energy on a continuous basis
Ramping up, ramping down

Recognizes a resource can move from load to generation
Energy Storage Technologies

Energy storage technology examples:

- Flywheel
- Lithium Ion battery
- Sodium Sulfur battery
- Flow batteries
- Compressed air energy storage
- Pumped hydro
- Electric Vehicles
Batteries

- Batteries and controls are getting more efficient
- Battery prices are expected to fall rapidly
- Programs need to accommodate batteries on the grid
California’s Energy Storage Targets

Procurement targets resulted in approximately 2,000 MW of storage projects in the ISO interconnection queue.

<table>
<thead>
<tr>
<th>Storage Grid Domain</th>
<th>2014</th>
<th>2016</th>
<th>2018</th>
<th>2020</th>
<th>Total</th>
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<tbody>
<tr>
<td><strong>Point of Interconnection</strong></td>
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<td>Southern California Edison</td>
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<td>Transmission</td>
<td>50</td>
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<td>85</td>
<td>110</td>
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<tr>
<td>Distribution</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>65</td>
<td>185</td>
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<tr>
<td>Customer</td>
<td>10</td>
<td>15</td>
<td>25</td>
<td>35</td>
<td>85</td>
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<tr>
<td><strong>Subtotal SCE</strong></td>
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<td>120</td>
<td>160</td>
<td>210</td>
<td>580</td>
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<tr>
<td>Pacific Gas and Electric</td>
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<td>85</td>
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<tr>
<td><strong>Subtotal PG&amp;E</strong></td>
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<td>San Diego Gas &amp; Electric</td>
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<tr>
<td>Distribution</td>
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<tr>
<td>Customer</td>
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<tr>
<td><strong>Subtotal SDG&amp;E</strong></td>
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<td>30</td>
<td>45</td>
<td>70</td>
<td>165</td>
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<tr>
<td><strong>Total - all 3 utilities</strong></td>
<td>200</td>
<td>270</td>
<td>365</td>
<td>490</td>
<td>1,325</td>
</tr>
</tbody>
</table>

Source: CPUC, Decision Adopting Energy Storage Procurement Framework and Design Program
### DR Value Categories

<table>
<thead>
<tr>
<th>Services</th>
<th>Energy</th>
<th>Environmental</th>
<th>Other categories</th>
</tr>
</thead>
</table>
| • Reliability  
  • Ancillary Services (and distribution equivalents)  
  • Grid support (Voltage, VAR, phase balancing)  
  • Resiliency | • Improved capacity factors (e.g., more MWh)  
  • Avoided peak energy costs  
  • Avoided greenhouse gases (GHG)  
  • Avoided Renewable Energy Credits (RECs)  
  • Avoided emission permits  
  • Fuel price hedging value | • Clean Air Act compliance  
  • Avoided physical impact on habitats  
  • Secondary value of resources (e.g., EVs providing DR)  
  • Value of combining DER (portfolio optimization)  
  • Facilitating the growth of other preferred resources  
  • Energy and water security | • Avoided O&M costs  
  • Matching load to generation profiles  
  • Avoided overgeneration due to renewables  
  • Social, e.g., economic and employment benefits |
Thank You!

David Wylie, P.E.
ASWB Engineering