



How Research and Development can Help Advance Distributed Generation

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11-IEP-1H

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RECD. JUN 29 2011

Overview



- Public Interest Energy Research (PIER) Program
- Active Research and Development Activities
- Future Research and Development Activities

PIER Smart Grid Research Ongoing at all Levels



Transmission



- Phasor Measurement
- Advanced displays
- Advanced comm & controls
- MRTU interface
- Energy Storage
- Renewables

Distribution



- Distribution Automation
- AMI
- Advanced C&C
- MRTU
- Energy Storage
- Renewables

Integration



- Renewables
- Standards
- Protocols
- Reference designs
- Micro Grids
- Automation
- Energy Storage

Consumer

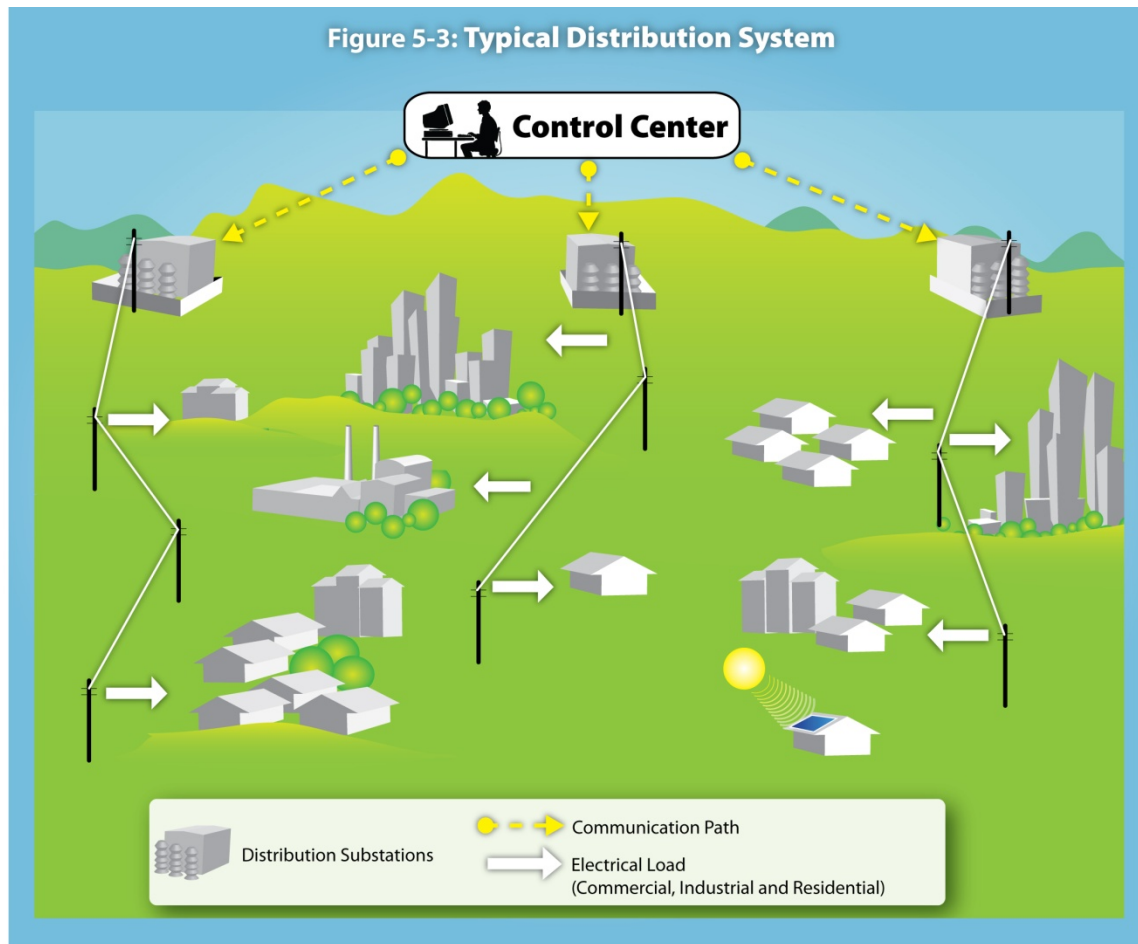


- Automating Demand Response
- AMI
- Dynamic Rates
- Home Area Networks
- Plug in Hybrids
- Renewables
- Energy Storage

Strategic View – Utility Grid of Today



Figure 5-3: Typical Distribution System

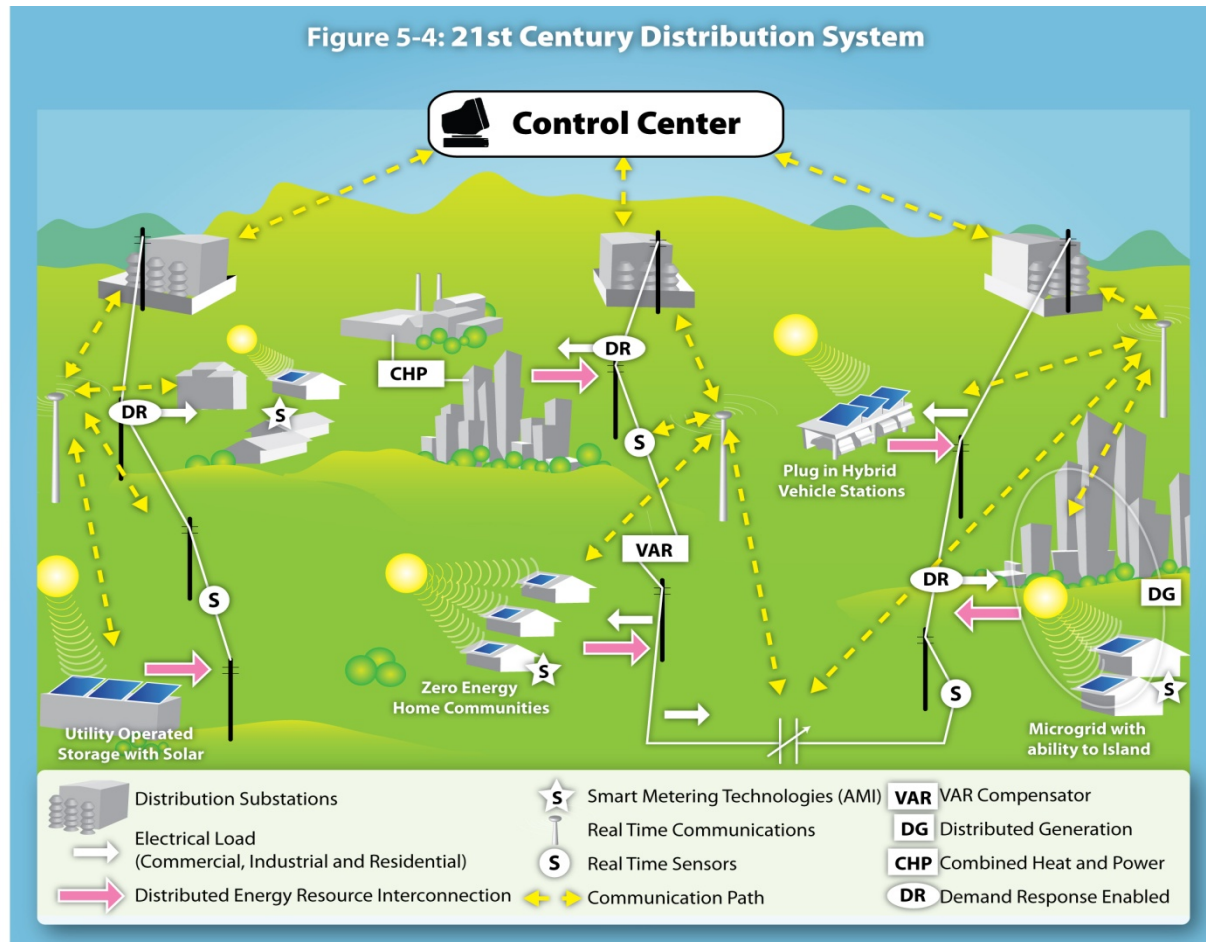


Source: 2007 IEPR

Strategic View: Utility Grid of the Future (Smart Grid)



Figure 5-4: 21st Century Distribution System



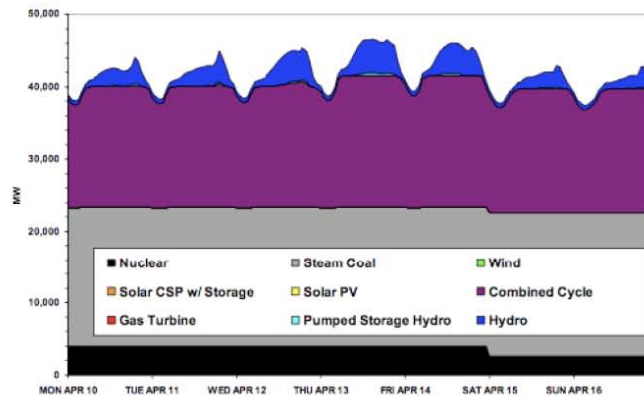
Source: 2007 IEPR

Future Grid Challenges

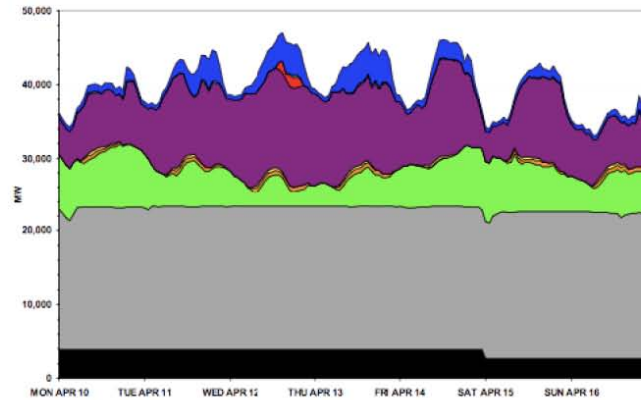


OE - Variable Generation Affects Grid Operations

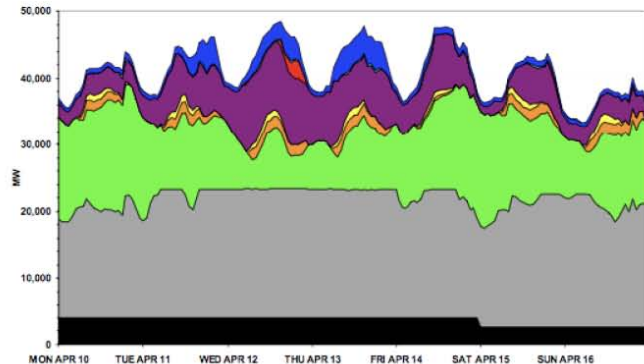
No wind



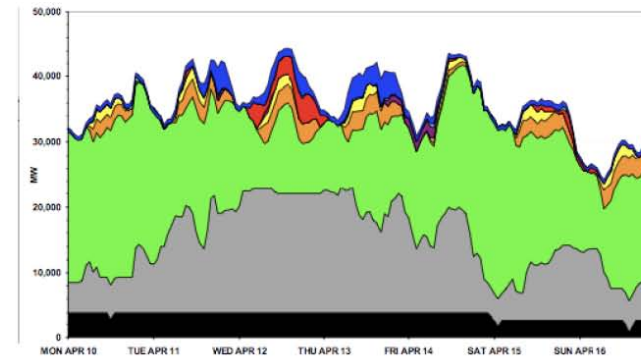
11% renewables



23% renewables



35% renewables



Lew et. al. "How do Wind and Solar Power Affect Grid Operations: The Western Wind and Solar Integration Study". National Renewable Energy Laboratory. (September 2009). p. 6



2013 Solar Ramps will be an issue to manage

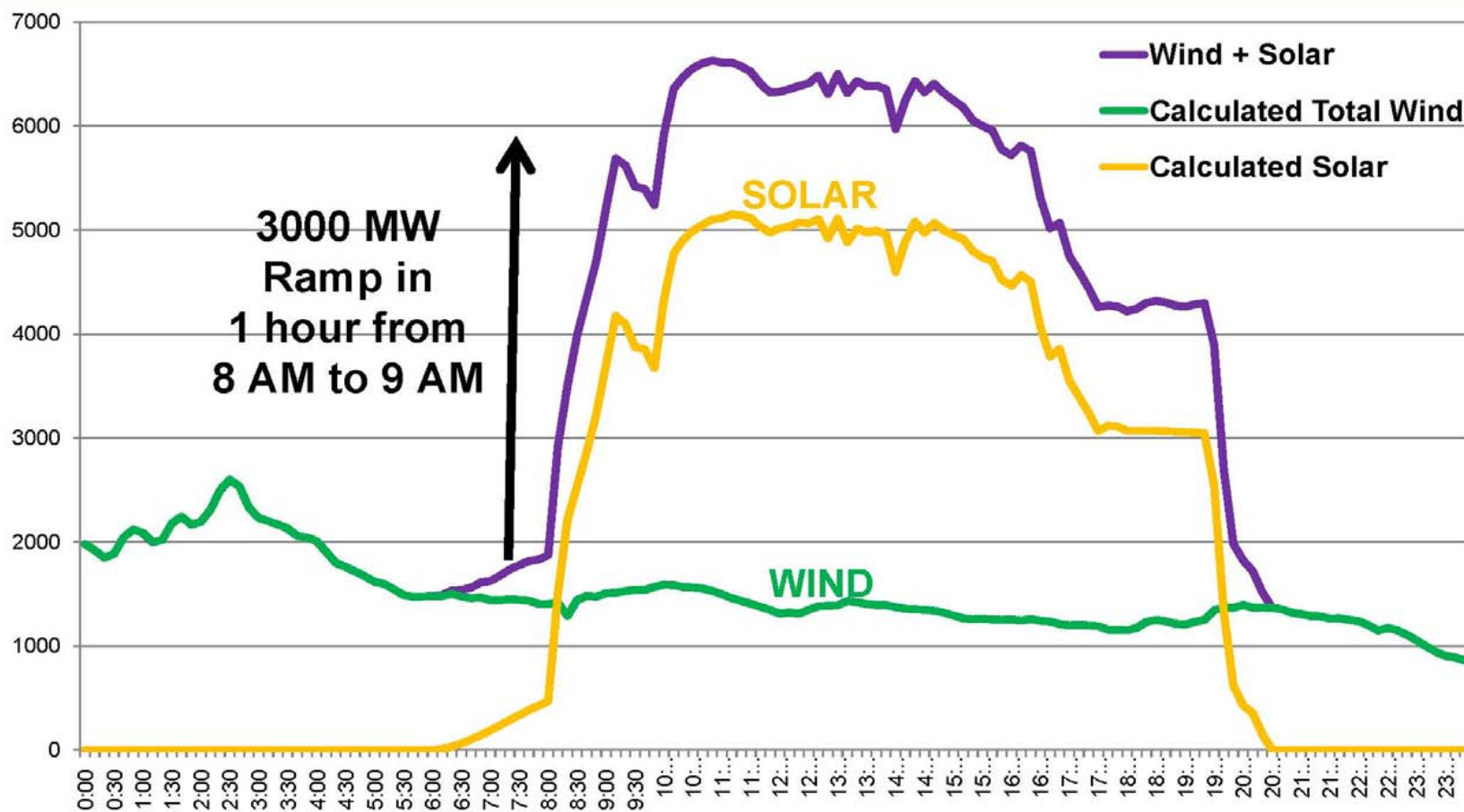


Chart based on March 2010 actual data and escalated to amount of renewables expected in 2013

General Approach



TECHNOLOGY ELEMENTS

TECHNOLOGY INTEGRATION

SMART GRID



Underground
Cables



Phasor
Measurement



Flywheel Energy
Storage



Automated
Metering
Infrastructure



Demand
Response



Pole Top
Transformers

Research Focus on Developing & Improving Devices

General Approach

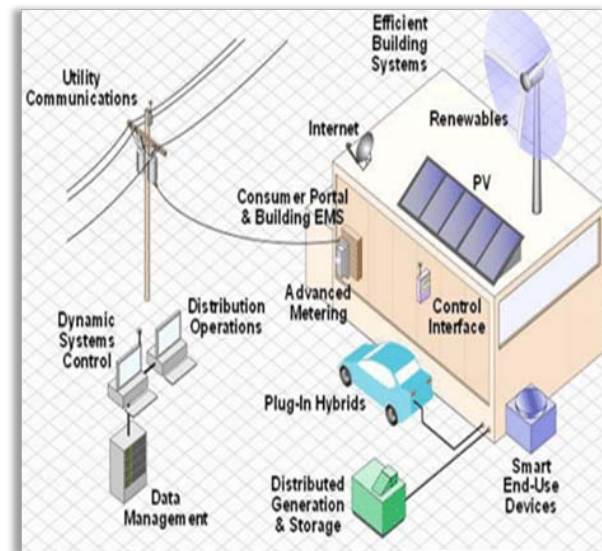


TECHNOLOGY ELEMENTS

TECHNOLOGY INTEGRATION

SMART GRID

- Integration of renewables, PHEV's, and electric energy storage devices
- Grid more reliable and efficient
- Micro Grid scale research
- Partner with Utilities & National Laboratories



Research Focus on Integration of Devices into a grid system

General Approach

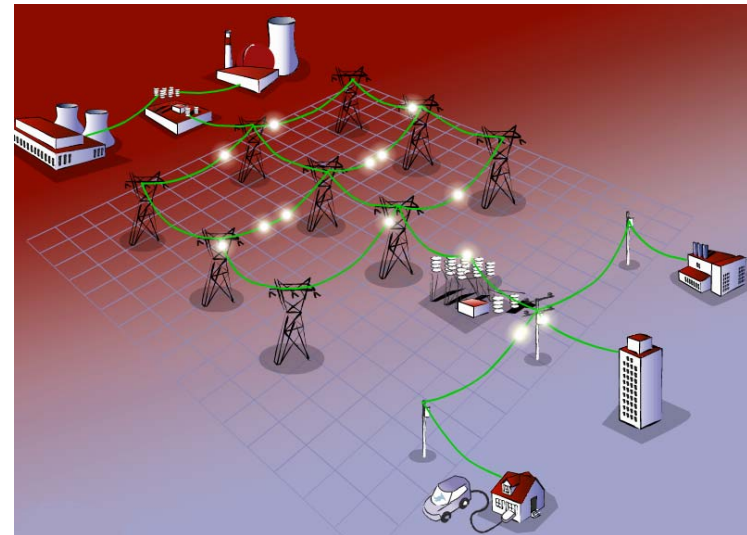


TECHNOLOGY ELEMENTS

TECHNOLOGY INTEGRATION

SMART GRID

- Large scale integration of renewables to meet RPS goals (33%)
- Plug-in-Hybrid's/Electric Vehicle's
- Electric Energy Storage/Auto DR
- More Reliable & Efficient Grid
- Community & Multi-Utility scale project

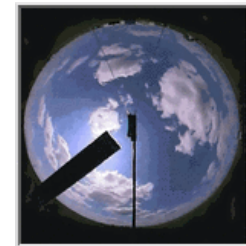
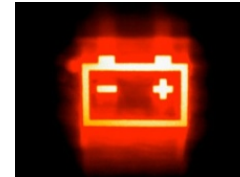


Research Focus on Entire Grid System

On-Going Research



- **Storage**
 - ✓ More than 12 projects (ARRA included)
- **Automated Demand Response**
 - ✓ Ancillary Service
- **Distribution Impacts**
 - ✓ Electric Vehicle Simulator
- **Forecasting**
 - ✓ Short term forecasting (less than 1 hour)



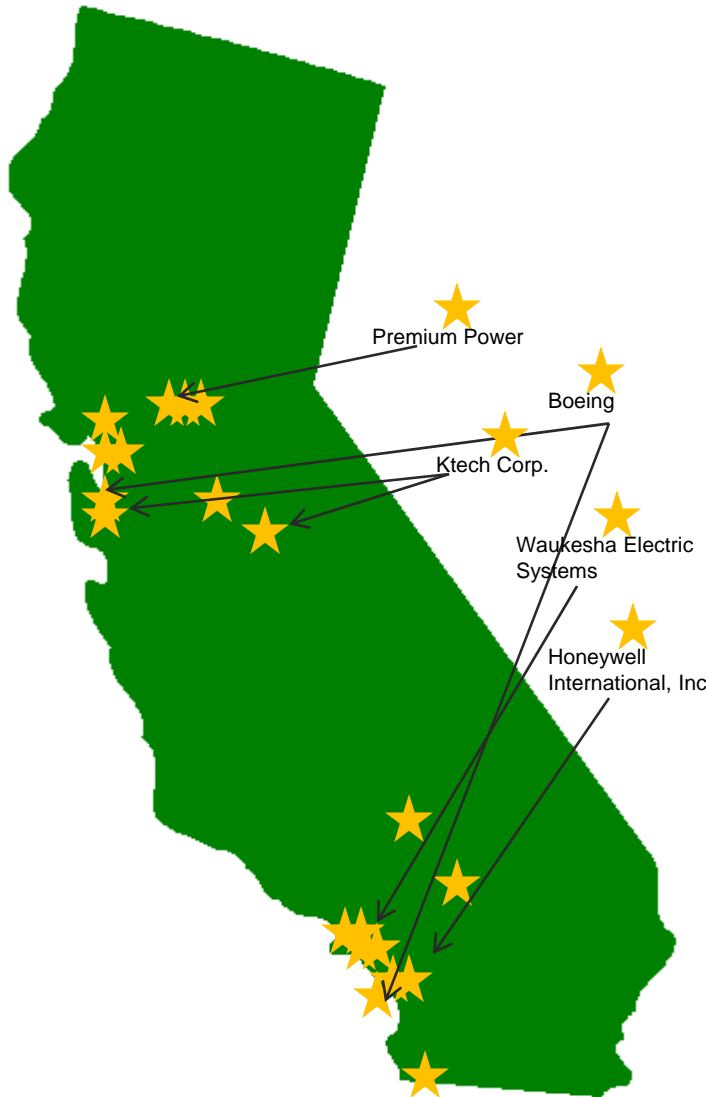
On-Going Research



- **Microgrid Visibility to CAISO**
 - ✓ Providing operation oversight of a microgrid to CAISO
- **Electric Vehicle Integration**
 - ✓ DC Charging from PV (improved efficiency)
- **Distributed Electric Storage System**
 - ✓ DC charging of Storage System from PV (improved efficiency)
- **PV Clustering**
 - ✓ Determining best placement of storage to mitigate renewable impacts



ARRA Smart Grid in California



Total Project Value to CA - \$1.3 Billion

- City of Glendale Water & Power
- Modesto Irrigation District
- Burbank Water & Power
- City of Anaheim
- Electric Power Group (WECC sub-contractor)
- Pacific Gas & Electric (WECC sub-contractor)
- Sacramento Municipal Utility District
- San Diego Gas & Electric
- Honeywell International, Inc. (Headquarters in MA, work being done in Southern CA)
- Los Angeles Department of Water & Power
- Southern California Edison
- Boeing (Headquarters in MO, work being done in Sunnyvale and Huntington Beach, CA)
- Waukesha Electric Systems (Headquarters in WI, work being done in Irvine, CA)
- Primus Power
- SEEO Inc.
- Southern California Edison
- Pacific Gas & Electric
- Amber Kinetics
- Ktech Corp. (Headquarters in NM, work being done in Sunnyvale and Snelling, CA)
- Sacramento Municipal Utility District (sub-contractor to Premium Power, Headquarters in MA)

Energy Storage Technologies Applying Smart Grid Technologies



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Photo Courtesy of Salt America

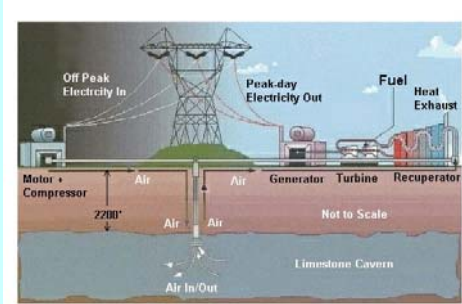


Photo Courtesy of CAES Development Company



Demand Response Automation by Sector



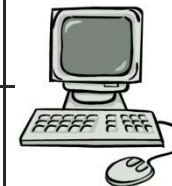
Communicating Thermostat



Demand Response Automation Client



Demand Response Automation Client



DR as Spinning Reserve or Ancillary Service



In normal operations, CAISO routinely sends dispatch instructions to electricity generators to follow changes in electricity demand

Electricity flows from generators over transmission lines to distribution circuits and ultimately to customers' homes

In this demonstration project, CAISO sends test dispatch signals to SCE using the same protocol normally used to dispatch electricity generators

SCE records the time **1** that it receives, via pager or email notification, CAISO's request

SCE sends radio dispatch signals to 1,000+ air conditioning units located in the four test distribution circuits that are part of demonstration and records the time when the signal is sent **2**



14:40:00 **1**



14:40:05 **2**



14:40:15 **3**

A statistically drawn sample of 100 controlled air conditioning units records the time when the curtailment signal is received **3** and sends real-time data on the units' electric power demand using cell phone-based meters

CERTS-SCE Demand Response Spinning Reserve Demonstration

Electricity flowing to each of the four test distribution circuits is recorded in real time **4**

14:40:15 **4**

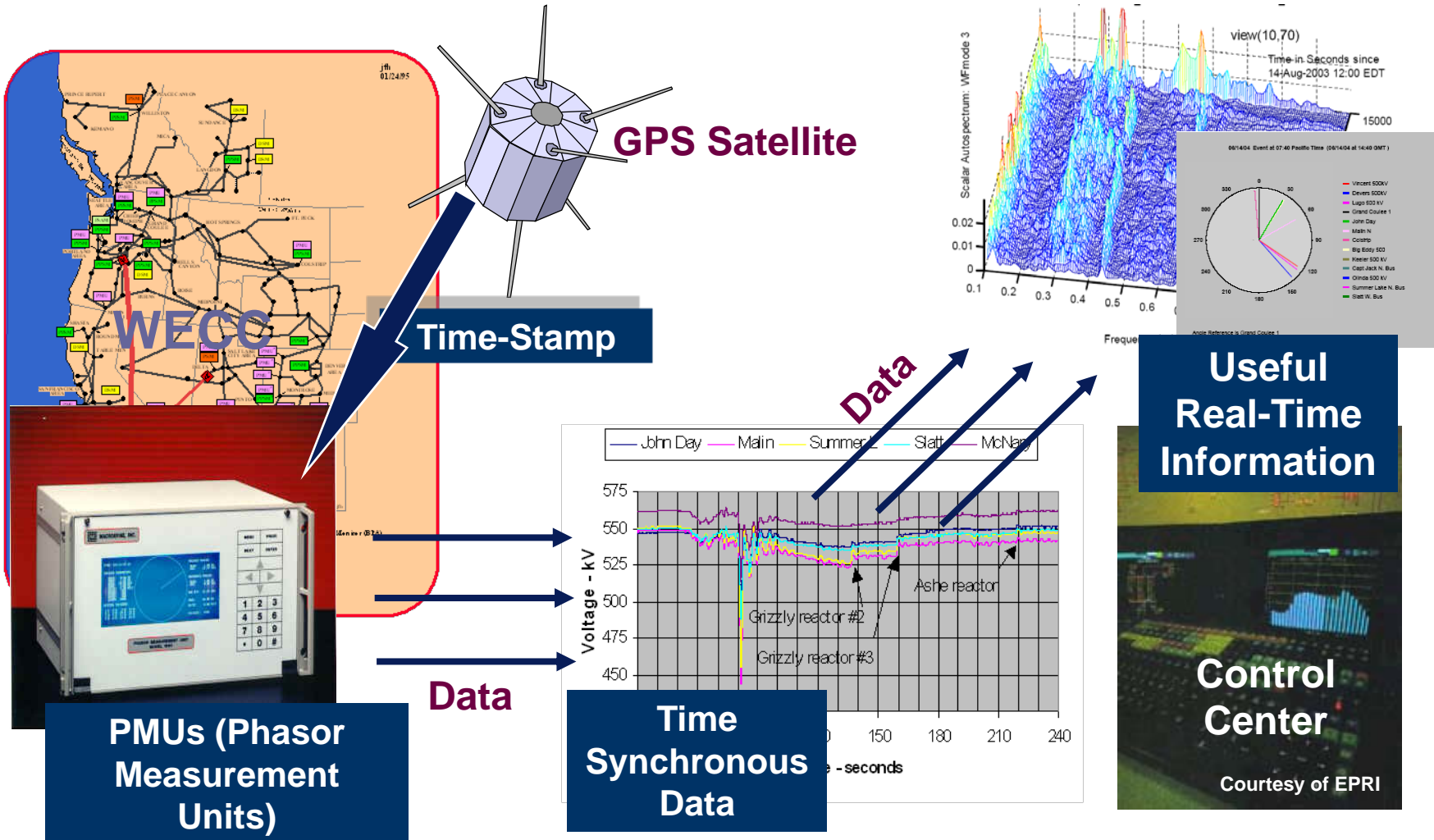


Distribution Research To Meet Goal of 20,000MW

- Characterization of sample feeders
- Local DG impact assessment
- Information sharing /build partnerships
- Coordinated data analysis
- Feeder modeling for future DG and EV impact predictions
- Implementation of broader feeder monitoring where indicated
- Distributed resource behavior specifications
- Distribution system Research Road Map



Synchrophasor Measurement – The Heart of the Smart Grid Transmission



Ultimately, Smart Grid required for maximum renewables deployment.

Integrating Demand Response & Energy Storage

- **DRRC:**
 - ✓ Open Automate DR
 - ✓ National Standards Development
 - ✓ Estimating 2020 Capabilities
- **Lawrence Livermore National Lab**
 - ✓ Modeling Entire California Grid
 - ✓ Assessing Energy Storage/Auto-DR/New Generation Needs
- **Energy Storage**
 - ✓ AB2514 Activities
 - ✓ California ARRA Energy Storage Projects
 - ✓ Assessing Energy Storage Need to Meet RPS

Follow-up Questions



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