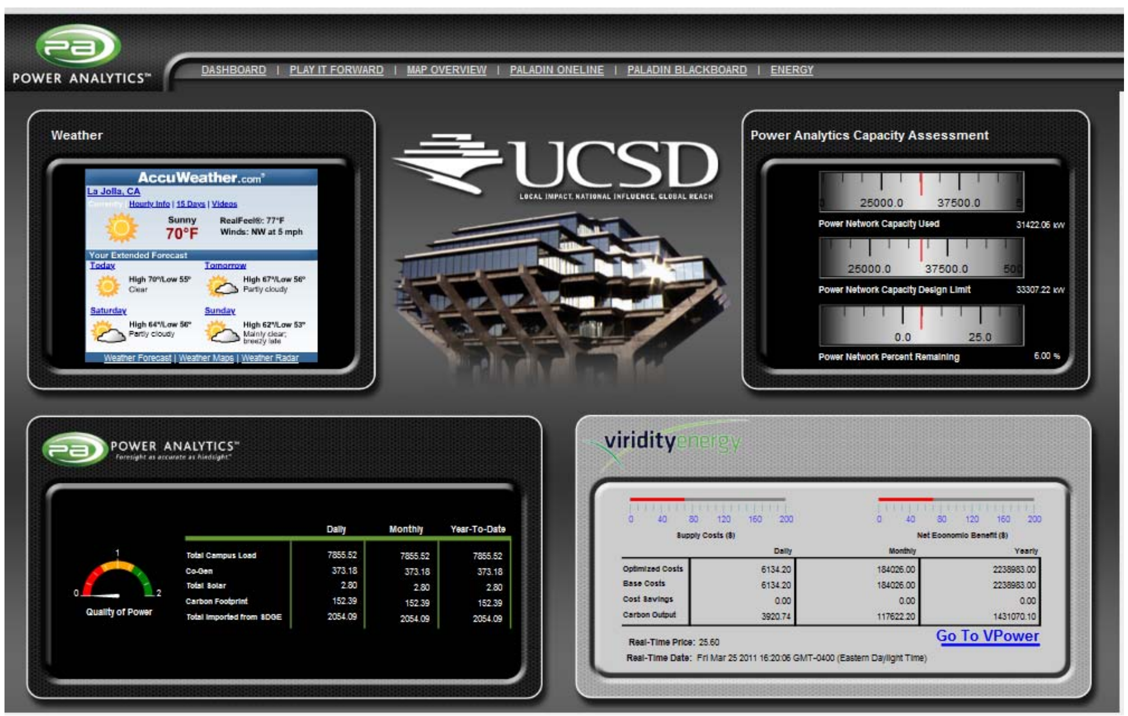
The UCSD Microgrid – A Case Study in Success

Virtual Microgrid Summit

March 15, 2012



Topics Covered

Overview

System Environment

New Technologies

SmartGrid/Microgrid

Conclusions

UC San Diego operates a 42 MW microgrid

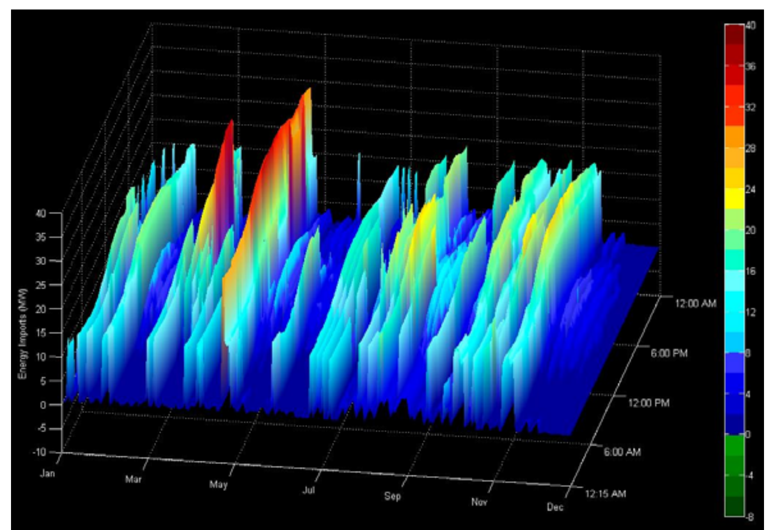
With a daily population of over 45,000, UC San Diego is the size and complexity of a small city.

11 million sq. ft. of buildings, $250M/yr of building growth

Self generate ~ 90% of annual demand

- 30 MW natural gas Cogen plant
- 2.8 MW of Fuel Cells in operation
- 1.2 MW of Solar PV installed, additional 2 MW planned
- Twice the energy density of commercial buildings

UC San Diego grid imports 2007



Creating a *Green* Smart Microgrid

UCSD's Microgrid will embody all 7 Smart Grid Functions envisioned by the Energy Independence & Security Act, 2007

RESCO $2M program with CA Energy Commission will deploy:

- Advanced SmartGrid Power management Systems for microgrids
- Optimizer re- scheduler platform for dynamic market signals allow optimization of storage and supply

Recent Activities:

- 2.8MW fuel cell – commissioned Dec 31
- 300MW of purchased power agreement
- 2nd life battery program
- Hi-penetration solar portal https://solarhighpen.energy.gov/

Viridity completed a webinar on Feb 16, 2012 for an overview of CSI grant currently underway. http://www.calsolarresearch.ca.gov/Funded-Projects/solicitation2-viridity.html

Power Analytics series of (4) webinars for Smartgrid Power Management System technologies begins May 8th, 2012.

Recent Activities (Continued)

- New business models will be identified for integrating up to 1,000 MW of high penetration PV with distributed energy resources (DER) at UCSD.
- New tariffs and incentives will be developed and vetted with SDG&E and the California Independent System Operator (CAISO) and tested on the UCSD Microgrid.
- Integrated cost-benefit analysis of the business models and management strategies

- This project is complementary to the California Energy Commission's Renewable Energy Secure Communities (RESCO) project funded under the Public Interest Energy Research (PIER) program.
- The RESCO project is to develop and test a smart grid master software controller and optimizer/scheduler as well as develop protocols and standards required for the widest possible inter-operability.
- The development of tariffs and incentives to balance costs/benefits is a critical component to advancing PV generation in the state as well as meeting the goals of the CSI Program.

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System Environment

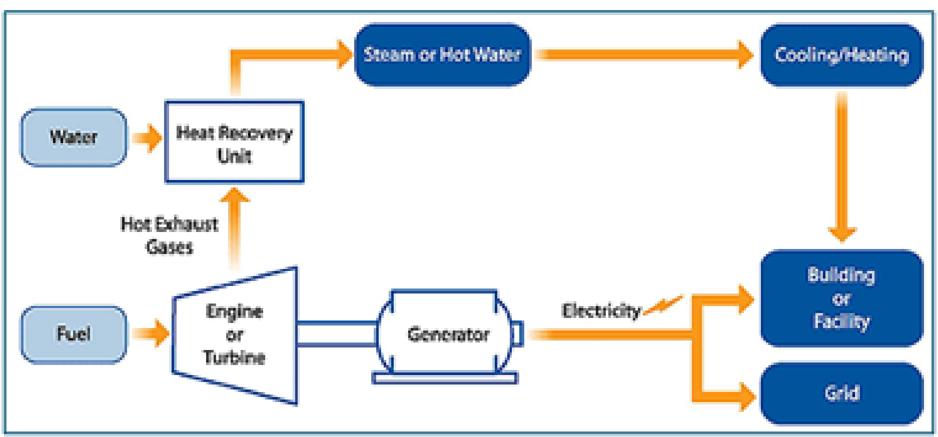
The central plant is rich with dispatchable resources:

- Two (2) 13MV natural gas generators
- One (1) 3MW steam generator
- Three (3) steam driven chillers (~10,000 tons capacity)
- Eight (8) electric driven chillers (~7,800 tons capacity)
- 3.8 million gallons thermal storage tank
- Backup diesel generation
- >1MW solar PV
- ~1MW of DR-ready reducible building load
- Visibility at the building level

Chilled water tank at UCSD campus

- Let's review the concept of 'cogeneration' or 'combined heat and power' systems
- Electricity generated and can be used onsite and/or exported to the grid
- Heat is recovered used for various purposes

Gas turbine/engine with heat recovery



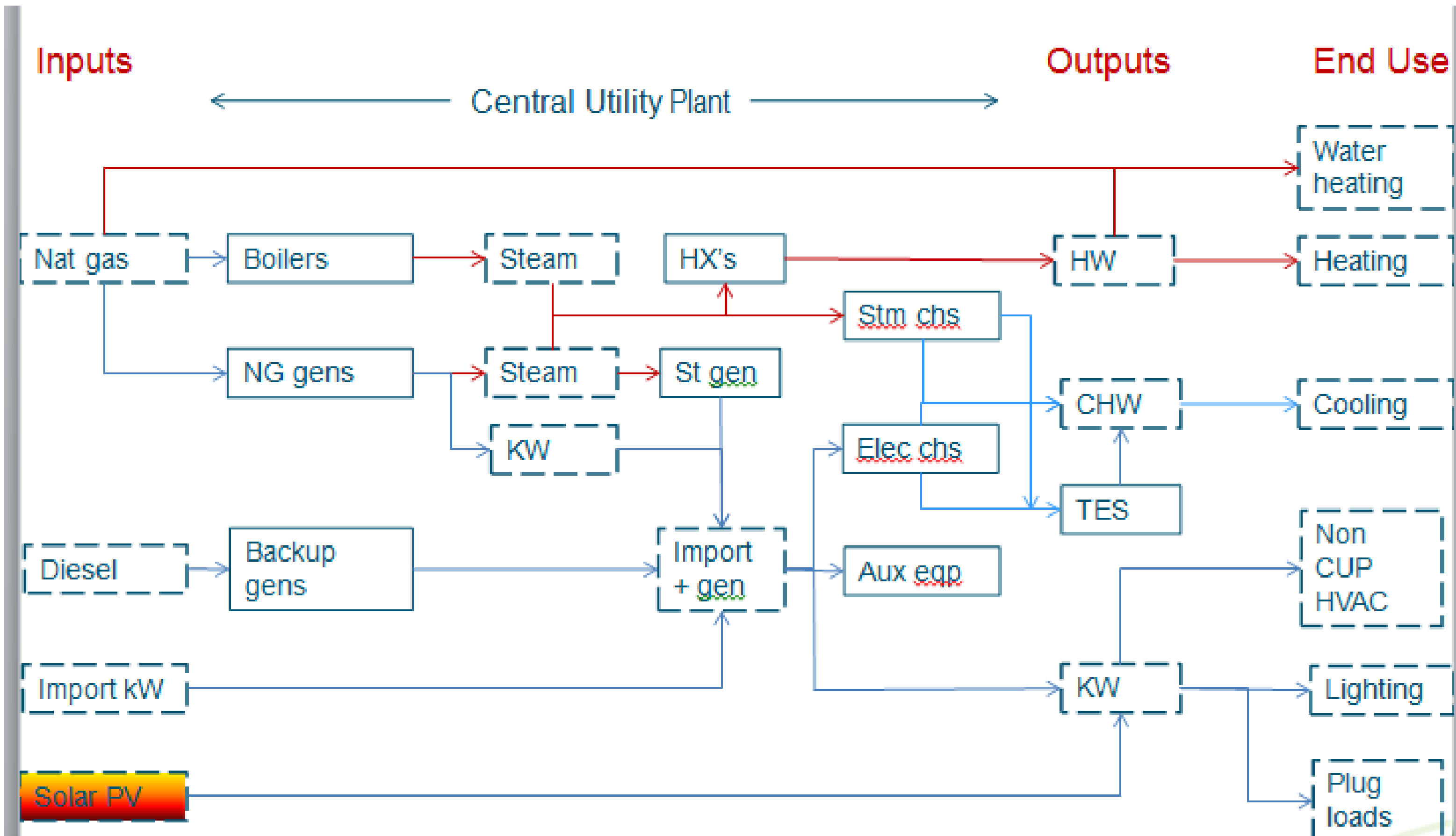
Source: EPA Combined Heat and Power Partnership website. http://www.epa.gov/chp/basic/index.html

Cogeneration is a core component of UCSD's microgrid

Steam chiller at UCSD campus

- The UCSD cogeneration system has the following
  - Natural gas turbine generates electricity for onsite use & steam
  - Steam is used to generate hot water, more electricity (steam turbine) and chilled water (steam-driven chillers)
  - Cogeneration offsets imported electricity, boiler fuel use for generating hot water & chilled water, and electricity consumption required to generate chilled water

Source: http://energy.ucsd.edu/campus/campus.php



Baseline data gives input / output relationships, equipment efficiency, capacity factors, seasonal and diurnal patterns of usage, historical costs.

- UCSD resources can shift load, reduce load and move load between gas and electricity fuels
  - Natural gas generators produce electricity and steam; once on, can go up/down ~ 6 MW
  - Tank can deliver significant portion of campus chilled water needs and can be variably charged/discharged
  - Steam from generators can be used to generate hot water, chilled water and additional electricity in varying amounts
  - Building load can be reduced ~ 1.4 MW for DR events

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Top Items of New Technologies

5. Solar forecasting work – UCSD $1.5MUSD award
4. PV and DC Systems
3. Energy storage – 4MW incentive for $3.5 MUSD
2. OSI – PMU – Moving data between systems
1. Master Software Controller tying systems together (Integration)

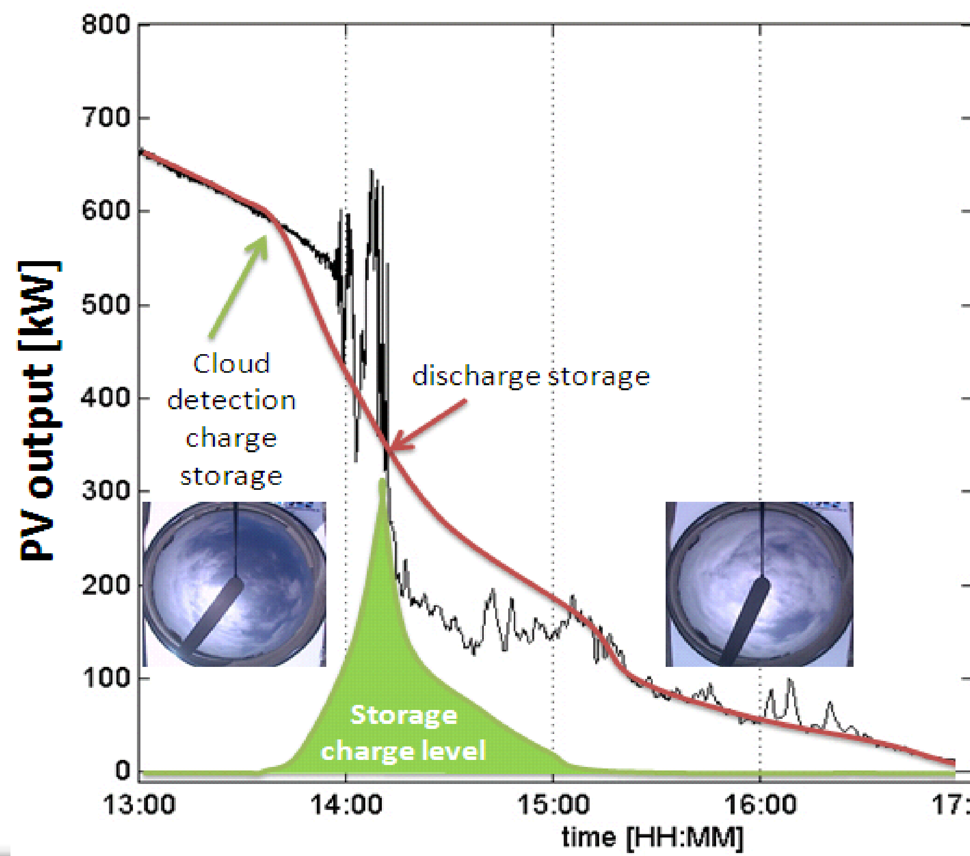
Integration of Solar with Storage Optimization

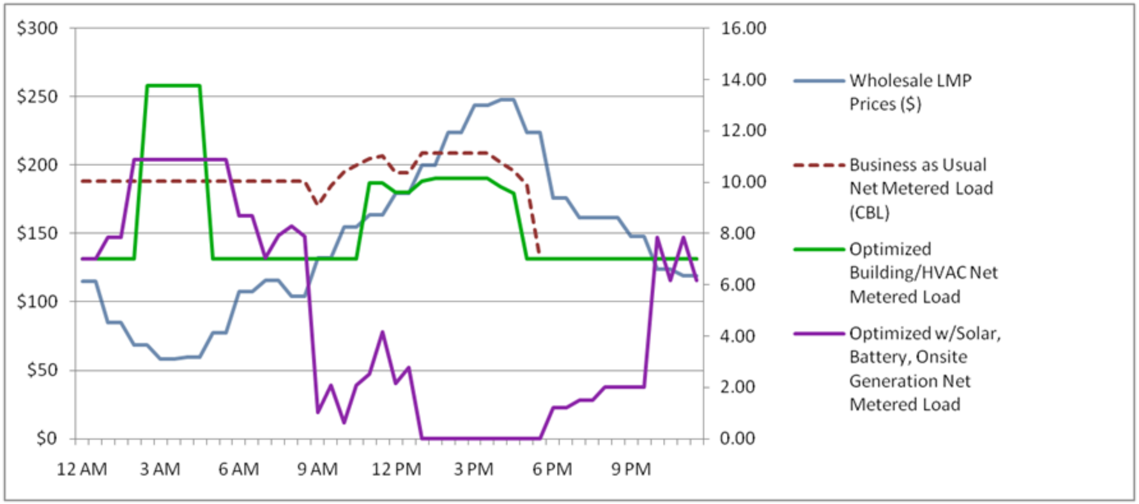
16 advanced weather stations across campus provide dense network of microclimate data

Automated Cloud Detection Alert has the potential to Manage Energy Storage in Real Time

- Automated cloud detection and alert
- Energy storage control based on PV output drop
- Decrease PV ramp rates from 50 kW/sec to 1 kW/sec
- Avoid voltage flicker and power outages

Energy Storage Controller for High PV Penetration





Optimized w/ Solar, Storage, and Onsite Generation Case	
Daily Electricity Bill:	$6,723
Generation Costs:	($13,218)
Supply Savings:	$6,851
Virtual Generation Revenue:	$17,832
Total Daily Economic Benefit:	**$11,465**

Role of the Master Software Controller in the Microgrid

Making load elastic/controllable/price-responsive is facilitated through decentralized 'microgrid' control.

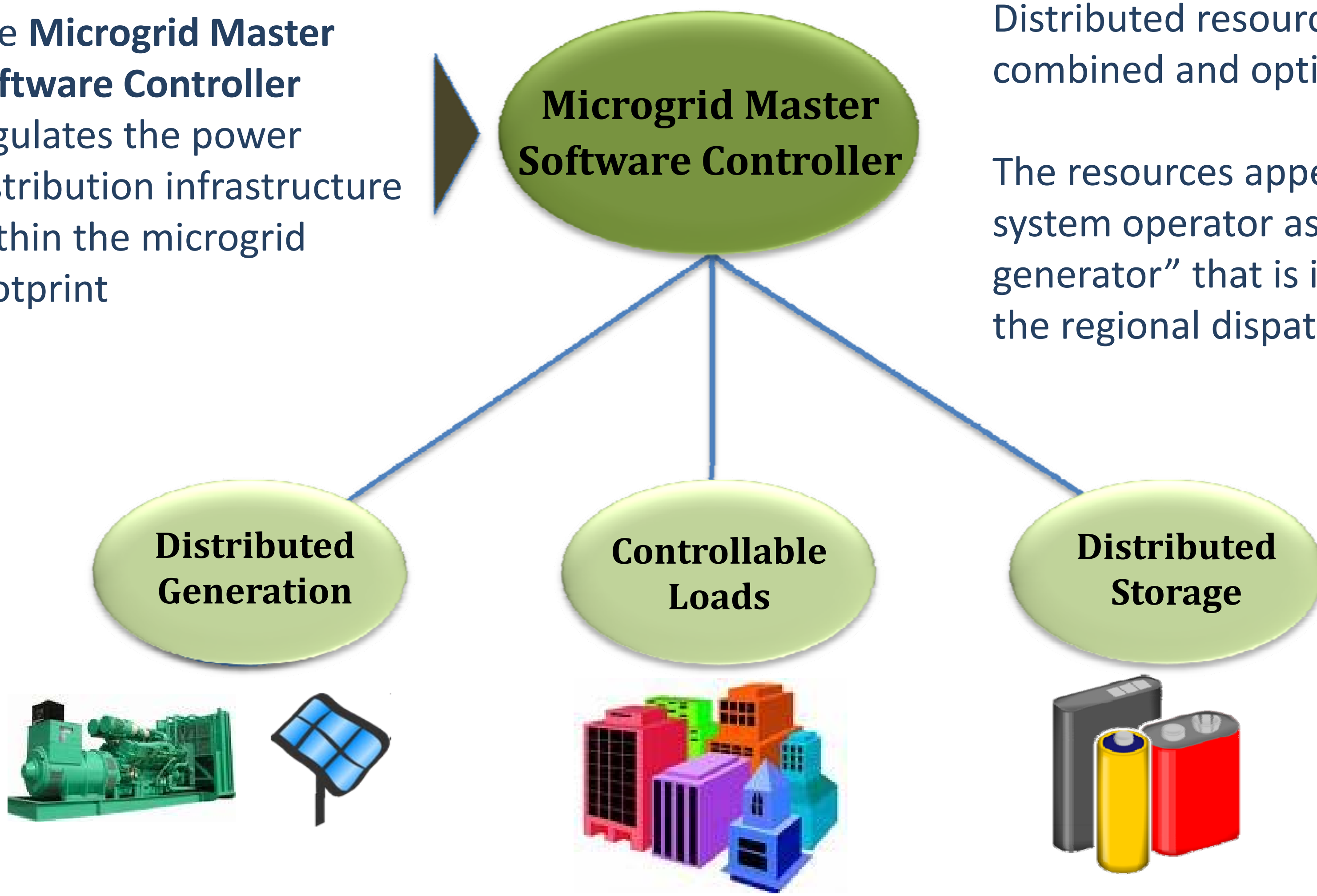
Improving microgrid control:

- can help with transmission congestion constraints
- can improve load participation in DR programs or energy markets (in some cases through load control which looks a virtual generator to the wholesale market)
- can improve grid utilization through the integration of distributed energy generation, including intermittent renewables

Typical microgrid control:

- includes real-time monitoring and control of resources (SCADA)
- advanced analytics to perform load flow analysis and optimization
- interaction with the electric power markets

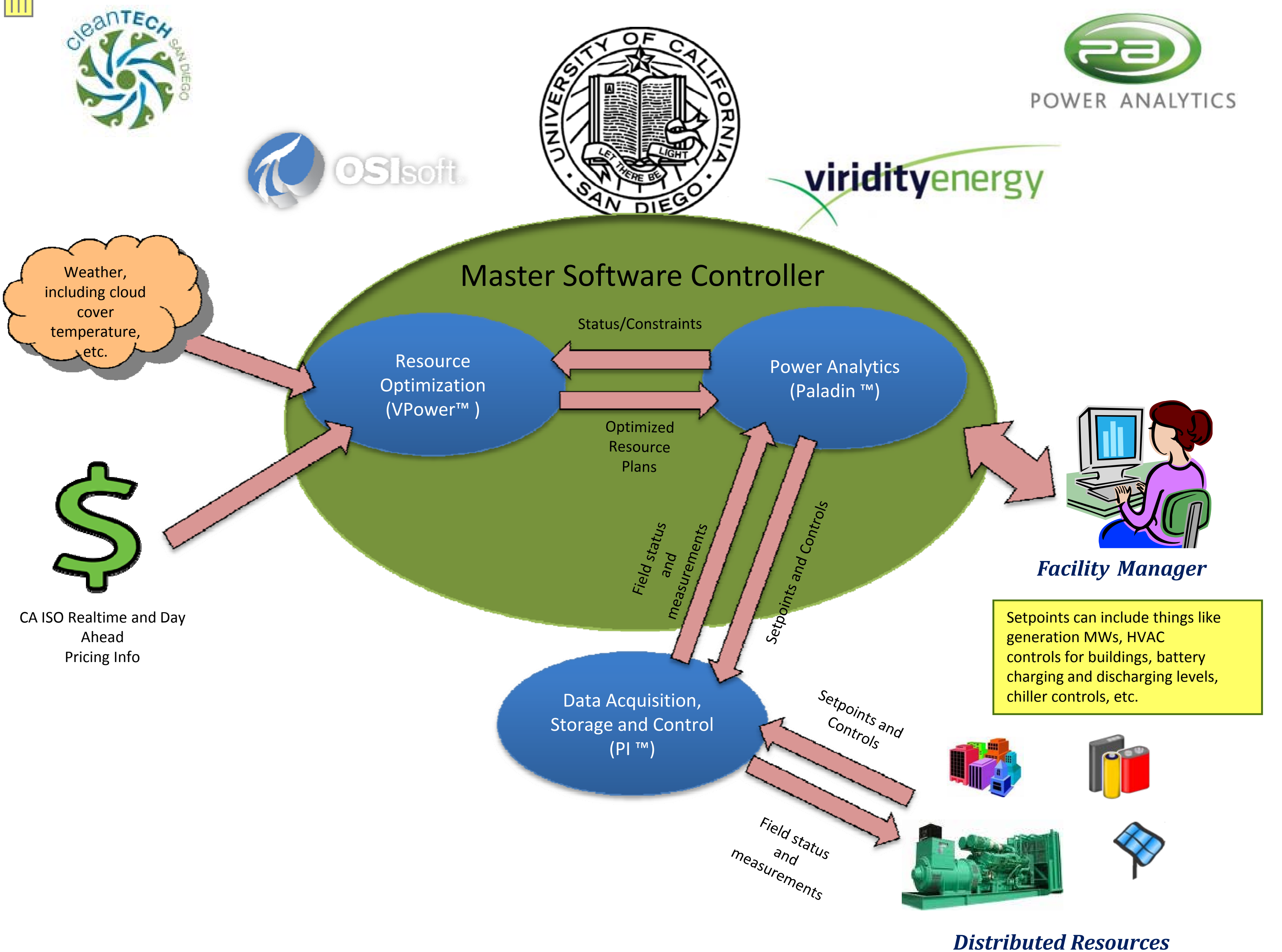
The **Microgrid Master Software Controller** regulates the power distribution infrastructure within the microgrid footprint



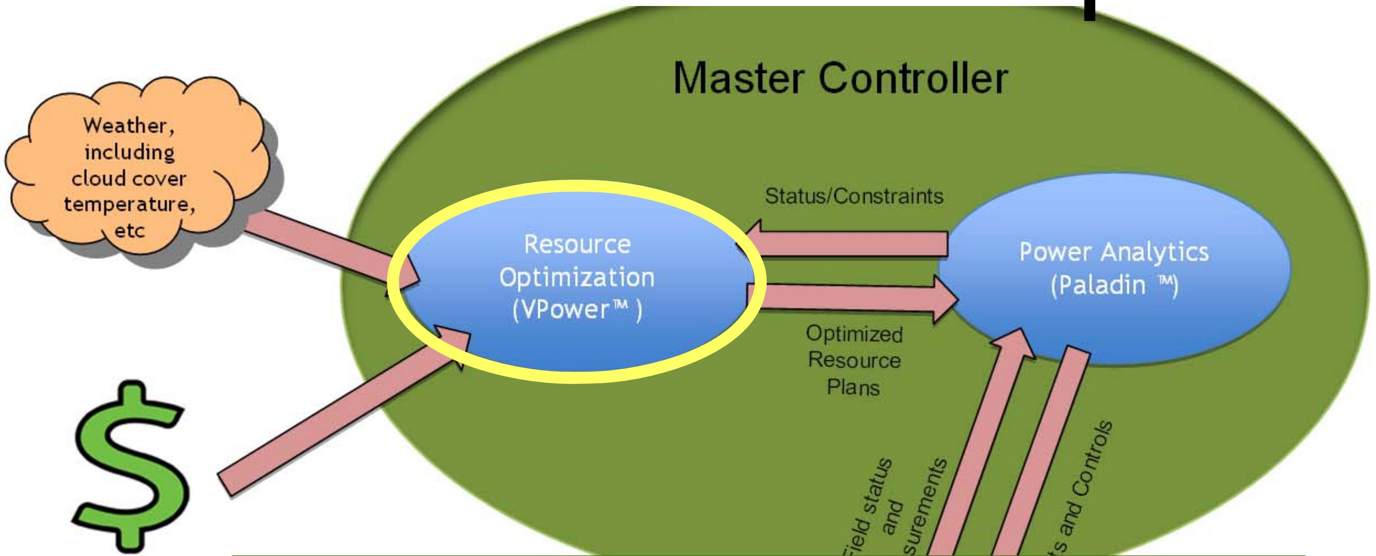
Distributed Resources

Distributed resources need to be combined and optimized

The resources appear to the system operator as a "virtual generator" that is integrated into the regional dispatch

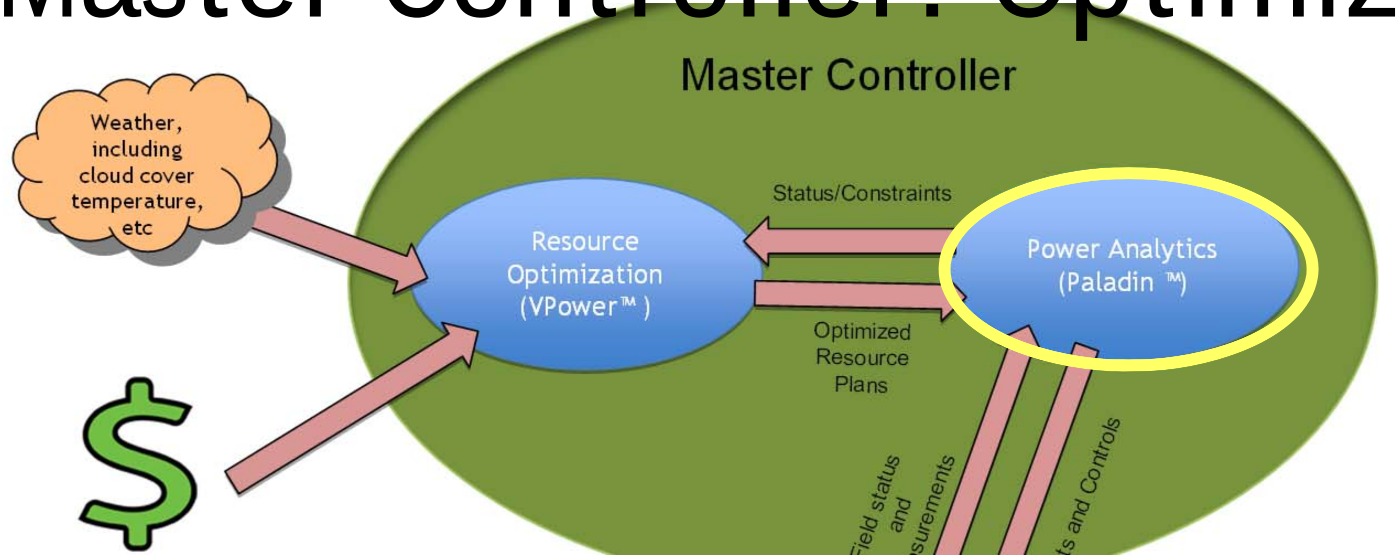

cleanTECH SAN DIEGO
OSIsoft
UNIVERSITY OF CALIFORNIA SAN DIEGO
LET THERE BE LIGHT
POWER ANALYTICS
viridityenergy
Master Software Controller
Weather, including cloud cover temperature, etc.
Resource Optimization (VPower™)
Status/Constraints
Power Analytics (Paladin ™)
Optimized Resource Plans
Field status and measurements
Setpoints and Controls
CA ISO Realtime and Day Ahead Pricing Info
Facility Manager
Setpoints can include things like generation MWs, HVAC controls for buildings, battery charging and discharging levels, chiller controls, etc.
Data Acquisition, Storage and Control (PI ™)
Setpoints and Controls
Field status and measurements
Distributed Resources

Master Controller: Optimization



- VPower resource models include
  - Electric (including renewables like solar) and steam generators
  - Chillers and heat exchangers
  - Electric and thermal storage devices
  - Fixed and interruptible load
- VPower study cases are prepared with
  - Resource parameters and efficiency rates
  - Period-by-period operator-entered over-rides (if desired)
  - Electrical and thermal (hot/chilled water) requirements
  - RT or DA electric energy price data from CAISO
  - Weather forecasts
- Economically optimized cases schedule the resource output (MMBTU and MW) to minimize costs subject or maximize revenues while meeting thermal and energy requirements.
- Each day, multiple cases can be prepared to investigate the impact of various inputs, scenarios, etc.

Master Controller: Optimization



- The Master Controller handles the data exchange between VPower and Paladin.
- It passes VPower's economically optimized schedules to Paladin where they are checked for reliability.
- Paladin models the electric network in detail, and determines if the feeder and equipment energy flows are within their appropriate ratings.
- Paladin notifies VPower if any schedule modifications are needed for microgrid reliability, including optimization constraints to be included.

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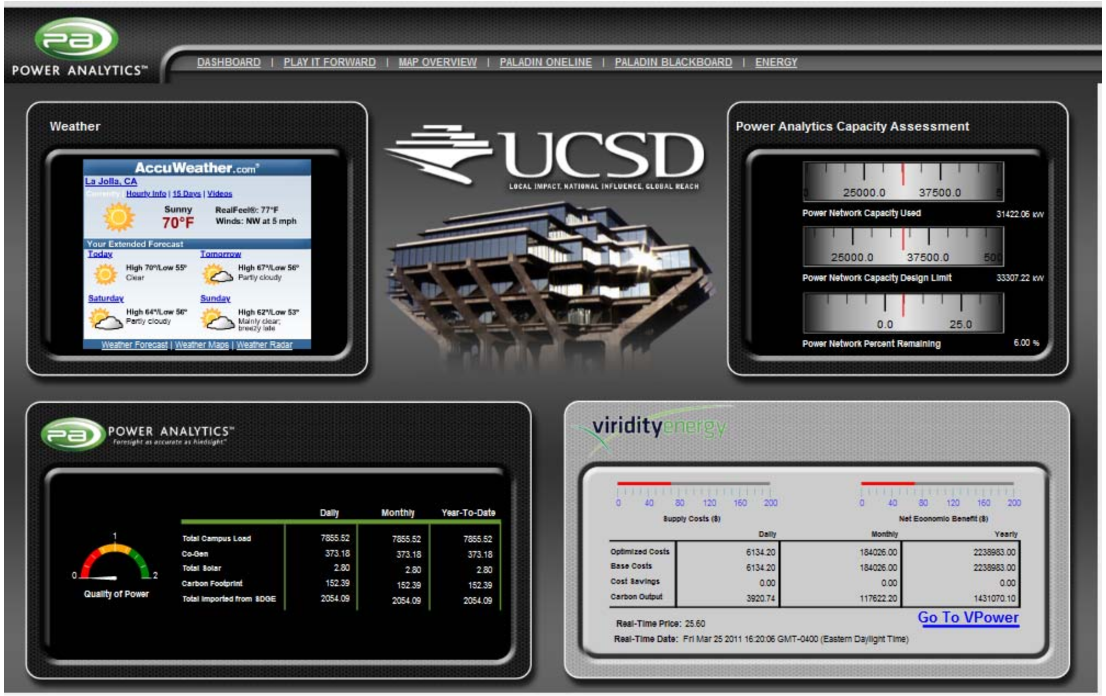

SmartGrid/Microgrid

A microgrid can be defined as a localized grouping of electricity sources and loads that normally operates connected to and synchronous with the traditional centralized grid (macrogrid) but can disconnect and function autonomously as physical and/or economic conditions dictate

- Key Factors for a successful Microgrid:

  - Data is the key to knowing the energy usage and capabilities within your system
  - Data must be displayed and reported in a user-friendly environment to make informed decisions regarding the electrical network.
  - Three key technologies together create a single platform for an optimized, reliable, flexible ‘smart’ microgrid, unlike any other. OSI-PI, Power Analytics, and Viridity
  - Knowing the energy usage and capabilities within your system to make informed decisions regarding the electrical network provides the ability for the microgrid to consider economics, carbon footprint, or other customer parameters that is coupled with a power flow assessment to provide an optimized and reliable solution.
  - The UCSD microgrid case study demonstrates the success of the integration and management of local resources in conjunction with the ability to be parallel with the grid, independent from the grid, the ability to go back and forth based on data driven decisions as well and responding to grid stability issues. This action with the grid can be viewed as a throttle instead of a switch, giving the ability to continuously process make/buy decisions for energy.

- Spreadsheet model developed to analyze the cases using real UCSD load data from June-Oct 2011
  - Consistent with campus thermal and elec needs
  - Loading order consistent with UCSD operations
  - Efficiencies & capacities from baseline effort used

Results of preliminary business analysis:

Estimated energy costs between June 1 and October 31 2011 for the idealized scenarios							
$Millions		Electrical		Gas		Total	Savings
Full import	$	6.8	$	1.3	$	8.1	0%
Full import and thermal storage	$	6.7	$	1.3	$	8.0	1%
Cogeneration	$	1.0	$	5.3	$	6.3	22%
Cogeneration & thermal storage	$	0.8	$	5.3	$	6.1	25%

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The UCSD success story is an ongoing process. Some key important lessons learned include:

- Data Gathering Takes time
- System Interoperability is crucial to success
- Additional Capacity can be added
- UCSD provides an ideal incubator for controls strategies including:
  - Work on solar forecasting
  - 2nd life battery program

Forward thinking into the future

- Expand the model of UCSD campus resources
- Propose strategies for the integration of high penetration PV solar systems
- Propose tariffs and incentives for Distributed Energy Resources (DER) technologies and Load Management Strategies
- Establish Baseline performance for UCSD DER operation under current rates and incentives

Significant changes for microgrids into the future include:

- Power Management Software is anticipated to be part of power solutions, and operate closely with power equipment and hardware
- Energy efficiency is crucial pertaining to power and energy
- Power management and data mining will play a significant role in smartgrids and microgrids into the future

For additional information, the presenters contact information is on the next slide

Additionally, there is a 6-minute overview video available on the UCSD Living laboratory; http://blog.rmi.org/the_ucsd_microgrid_showing_the_future_of_electricity_today

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Questions and Comments

Thank You!