Microgrids – UCSD Smart Grid Course
May 22, 2013

Thomas Bialek, PhD PE
Chief Engineer – Smart Grid

What is a microgrid?

Microgrid Definition:

A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. If desired, a microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.

Microgrid Key Attributes (Defining Characteristics):

- Grouping of interconnected loads and distributed energy resources
- Can operate in island mode or grid-connected if desired
- Can connect and disconnect from the grid if desired
- Acts as a single controllable entity to the grid

Why are microgrids important?

Enables Grid Modernization

- Key component of grid modernization
- Enables integration of multiple Smart Grid technologies

Enhance the integration of Distributed and Renewable Energy Sources

- Facilities integration of combined heat and power (CHP)
- Promotes energy efficiency and reduces losses by locating generation near demand
- Potential to reduce large capital investments by meeting increased consumption with locally generated power. (Local generation may lower investment in the macrogrid)
- Encourages third-party investment in the local grid and power supply
- Potential to reduce peak load

Meets End User Needs

- Ensure energy supply for critical loads
- Power quality and reliability controlled locally
- Promotes demand-side management and load leveling
- Promotes community energy independence and allows for community involvement in electricity supply
- Designed to meet local needs and increase customer (end-use) participation

Supports the Macrogrid

- Enables a more flexible macrogrid by handling sensitive loads and the variability of renewables locally
- Enhances the integration of distributed and renewable energy resources including CHP
- Potential to supply ancillary services to the bulk power system
- Potential to lower overall carbon footprint by maximizing clean local generation
- Potential to resolve voltage regulation or overload issues

Microgrid Opportunities

- Support the integration of renewable resources
- Improve reliability and power quality
- Support emergency operations
- Ability to “ride through” outages
- Optimize energy usage
- Enable participation in new markets for demand response and ancillary services

Microgrid Design

Requirements

- Define microgrid boundary
  - Industrial customer, campus, substation, circuit
- Match load and generation
  - Voltage, frequency and power factor within tolerances
- Define reliability requirements
  - SAIDI, SAIFI, MAIFI and power quality
- Determine seamless transition
  - How long to restore power in island
- Define loads
  - Critical, demand response, peak load
- Determine island duration
  - Typical outage or extreme event
- Define generation needs
  - Renewables, energy storage, fossil generation

Types of microgrids

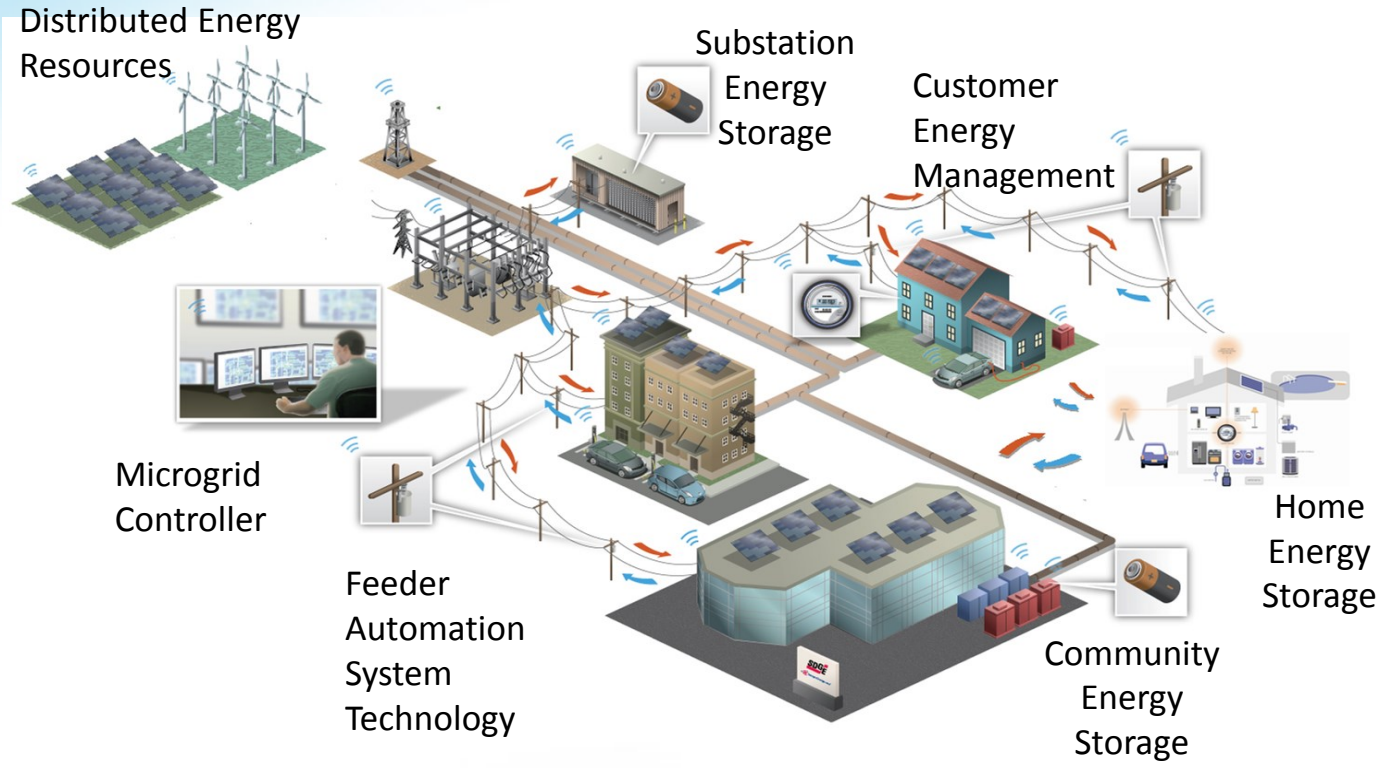
- Utility
  - Borrego Springs
- Military Bases
- Campus Environment
  - UCSD
- Greenfield Development
  - Third World Applications
- Homes

6

Borrego Springs Microgrid Demonstration Project

Utilize advanced technologies to integrate and manage distributed resources within the Smart Grid

Budget:	$8.0M DOE and $2.8M CEC plus matching funds from SDG&E and partners
Benefits:	• Integrate and leverage various generation and storage configurations • Reduce the peak load of feeders and enhance system reliability • Enable customers to become more active participants in managing their energy use



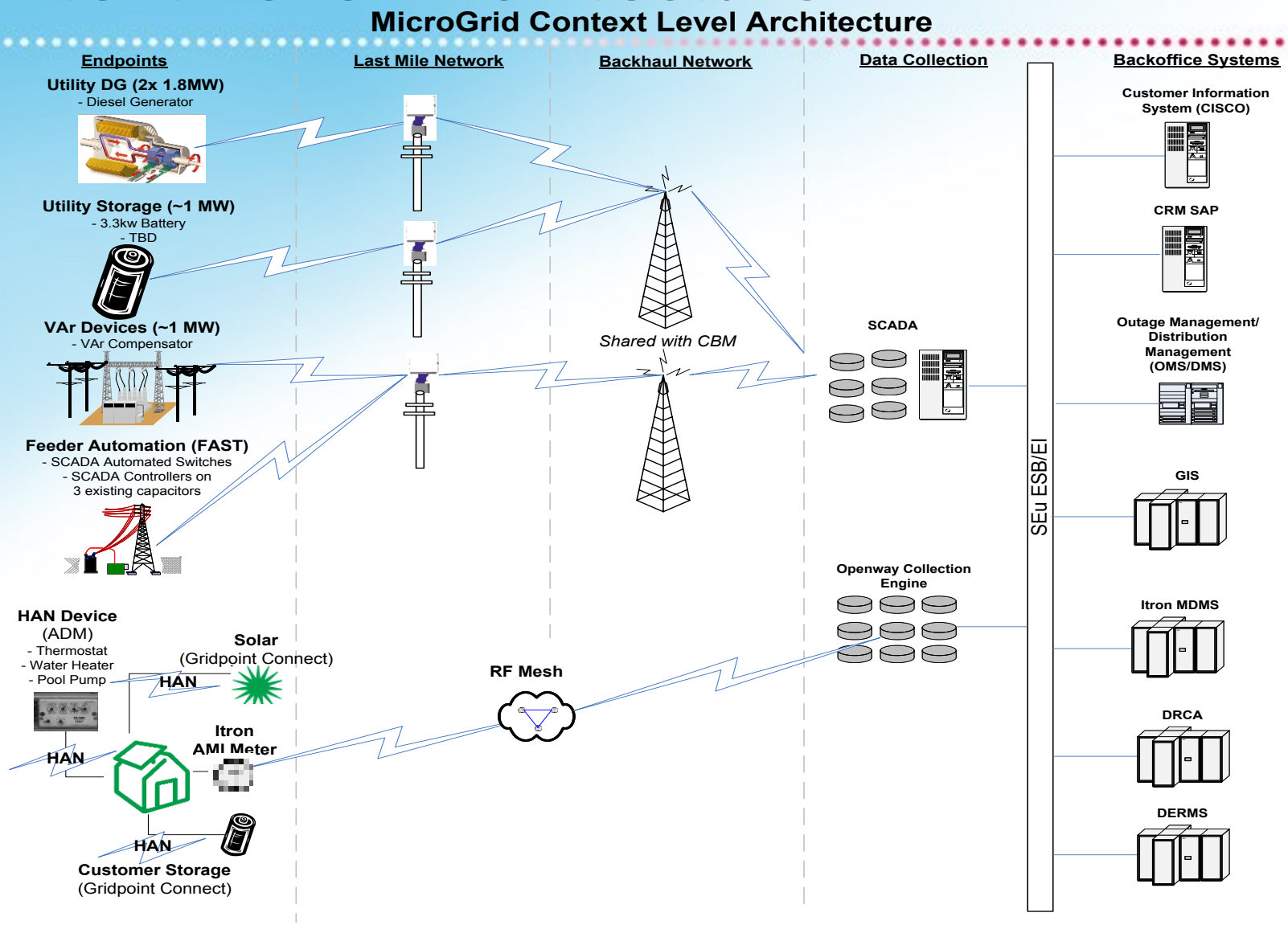
Project strategies

- Design and demonstrate a smart electrical grid that incorporates sophisticated sensors, communications, and controls in the following ways:
  - Intelligently incorporate solar power generators on homes and businesses into the electrical delivery system.
  - Enable coordinated Demand Response (DR) programs whereby heavy electrical use during peak demand periods can be moderated to prevent electrical supply emergencies.
  - Integrate and control multiple distributed generation and electrical energy storage devices to operate the grid in a more cost-effective and reliable manner, benefiting customers and electrical rates.
- This project will proactively identify and apply leading-edge technologies to improve the security and reliability of electricity supply and to lower costs to consumers.

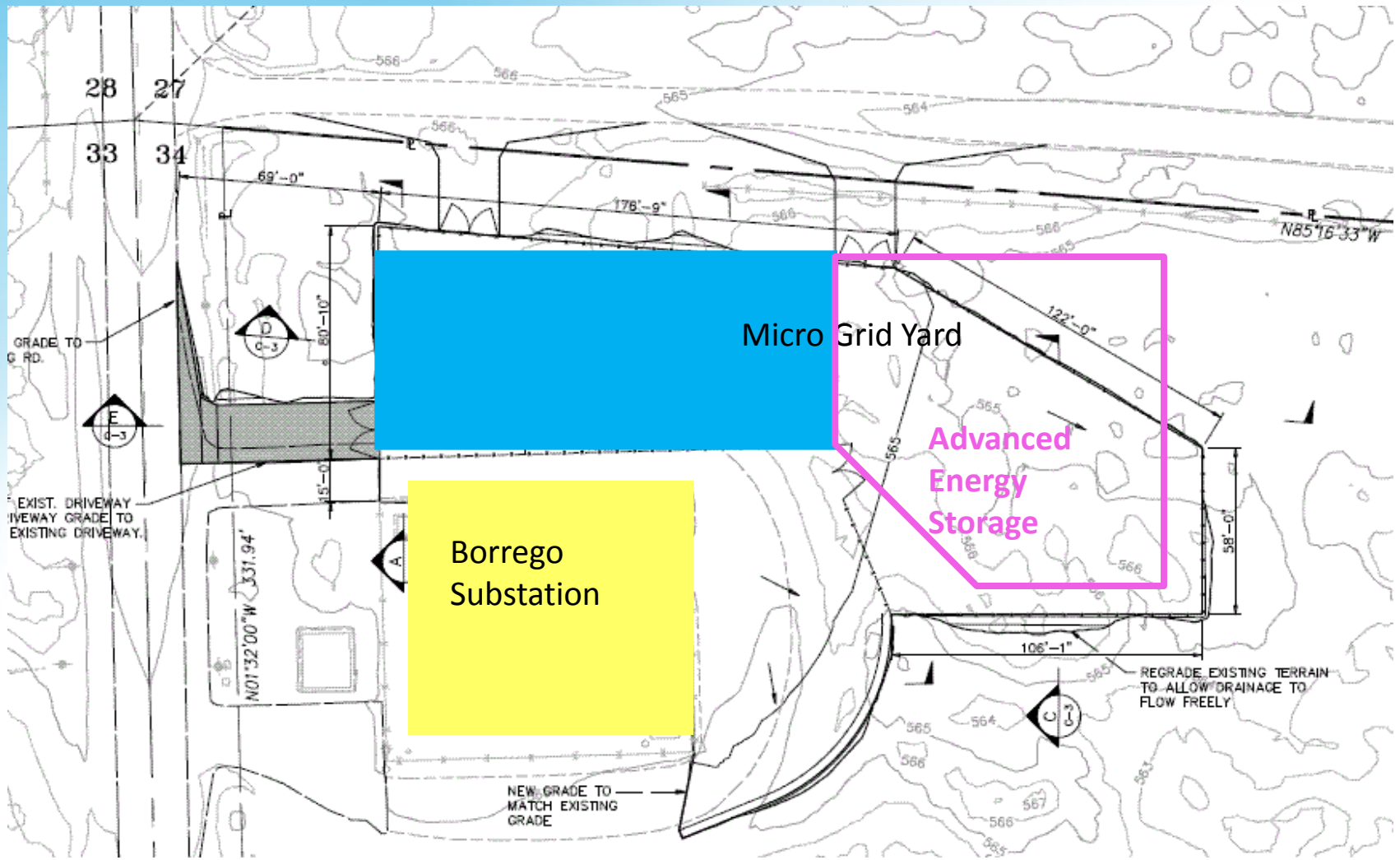
Site Selection – Borrego Springs, CA

- **Key Strengths:**
- Progressive-minded community
- High concentration of customer-owned solar generation
- Potential for reliability enhancements
- Opportunity to balance supply and demand to be more self-sufficient
- Extendable to service territory

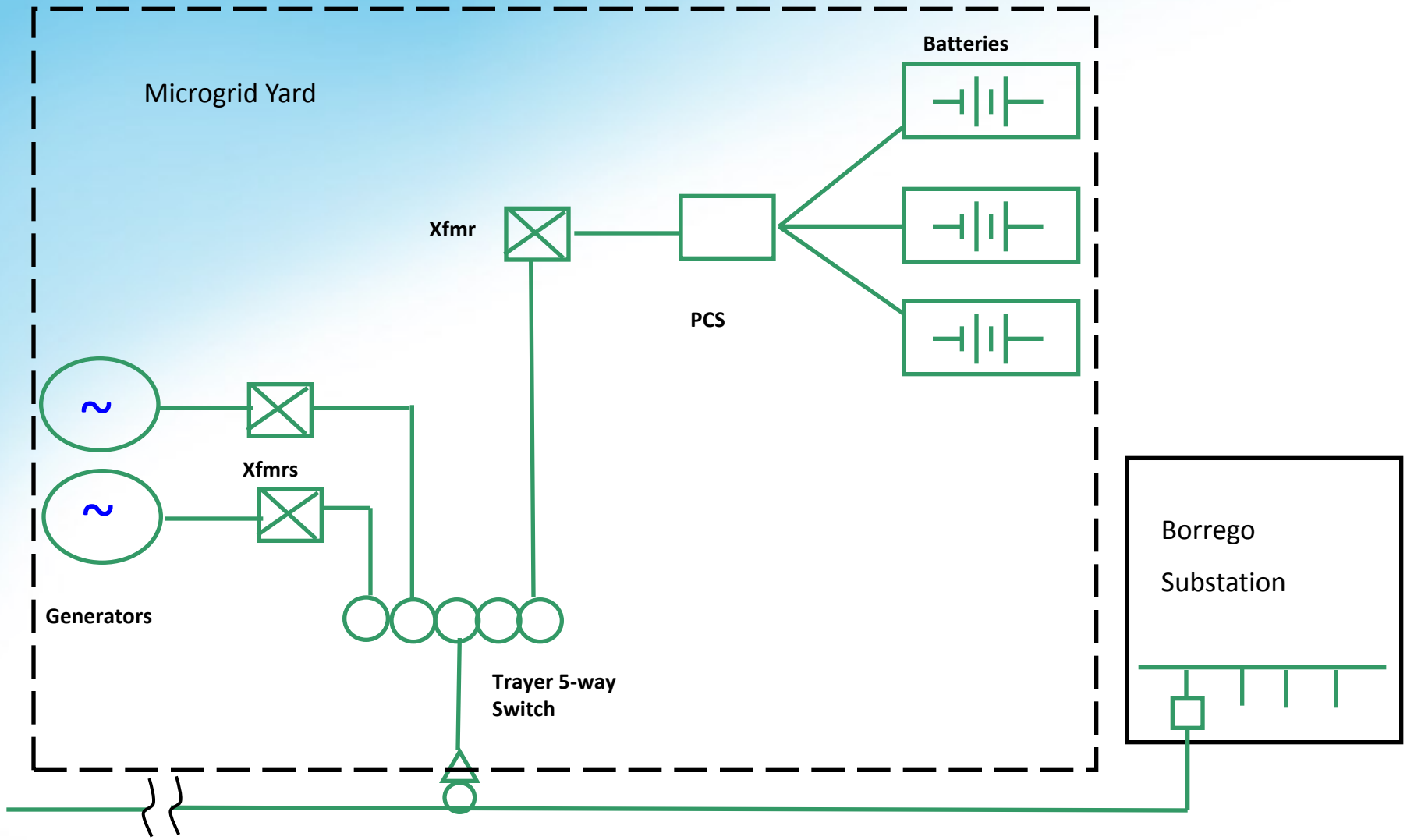
Project Architecture: Context Level Architecture



Microgrid Yard

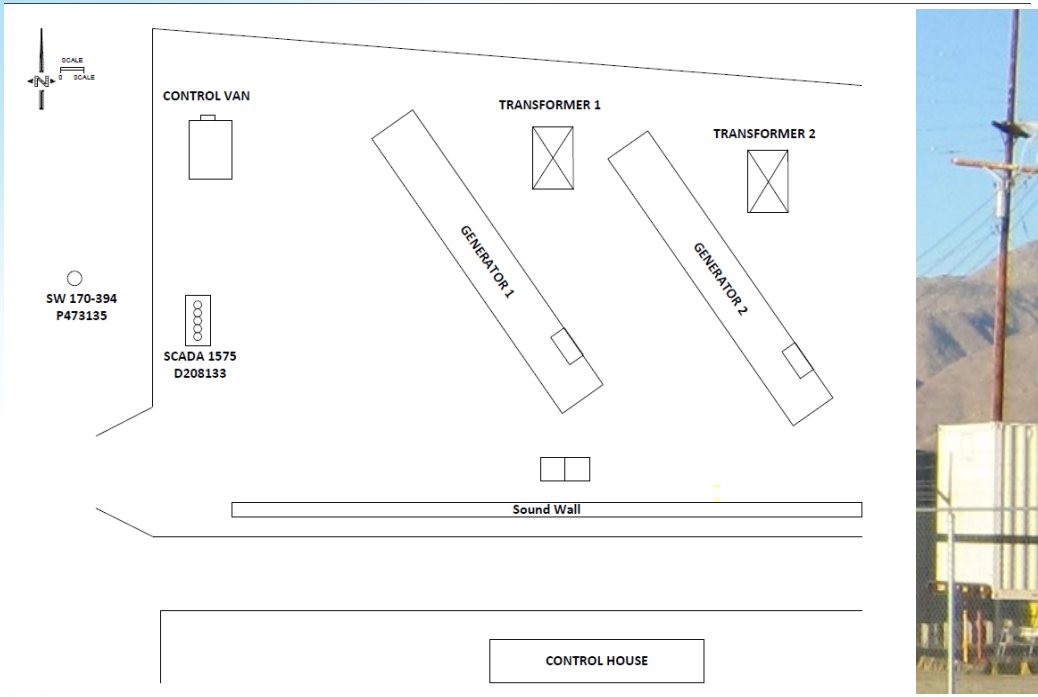


Microgrid Yard- Generator & Battery Configuration



DG – Microgrid Yard

- Two (2) 1.8 MW SDG&E Caterpillar Diesel Generators
- Two (2) 12 kV/480 V Y-Y padmount transformers
- 5-Way Trayer SCADA Switch, SS#1575
- Microgrid Control Van



AES – Microgrid Deployment

- **Substation Energy Storage (SES)**
  - One 500 kW/1500 kWh battery at Borrego Sub
- **Community Energy Storage (CES)**
  - Three 25 kW/50 kWh units on circuit 170
- **Home Energy Storage (HES)**
  - Six 4 kW/8 kWh units

AES – Substation Battery

- Manufacturer: Saft / Parker Hannifin
- One 500 kW/1500 kWh battery at Borrego Sub
- Modes of Operation
  - Peak Shaving/Load Following
  - Renewal Smoothing
  - Support Islanding Operation

AES – Community Energy Storage (CES)

- Manufacturer: S&C / Kokam
- 3, 25 kW/50 kWh units connected to 12 kV C170
  - Operated independently and as a fleet
- Modes of Operation
  - Peak Shaving
  - Renewable Smoothing
  - Voltage Support

Li Ion Battery

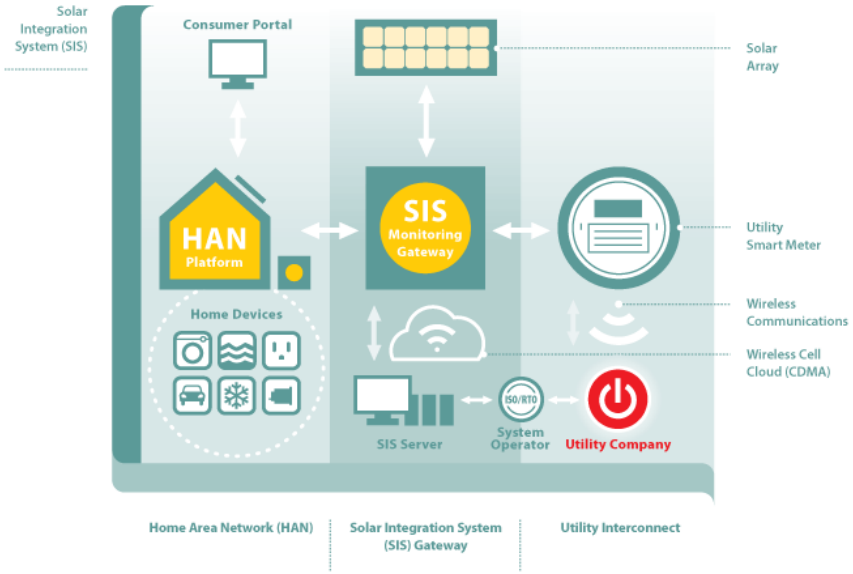
Inverter / PCS

Box Pad For Below-Ground Battery

Residential Energy Storage to Manage Peak Demar

4.2 kW Capacity – 2 hours

Charge/Discharge commands via HAN system



Devices in the Home

- Broadband-to-ZigBee Gateway (EMS)
- In Home Display (IHD)
- Programmable Communicating Thermostat (PCT)
- Plug Load Controller (PLC)
- Range Extender
- Load Control Switch (LCS)

Home-Area-Networks Capable of Respond
Price and Reliability Events

Energy Storage
Devices that maintain reliability of the electric grid by storing energy for use at a later time.

HVAC
Communicates with your thermostat to efficiently adjust the temperature based on your home needs.

SmartMeter
An advanced meter which communicates via Zigbee© signal with smart devices in the home.

Smart Appliances
Appliances that have been modernized to monitor and automatically adjust how they operate according to your preferences.

Programmable Communicating Thermostat
A thermostat that connects to your Smart Meter which, based on personal settings, manages your heating and cooling costs.

Solar Panel
An array of panels that absorb sunlight to generate electricity for your home.

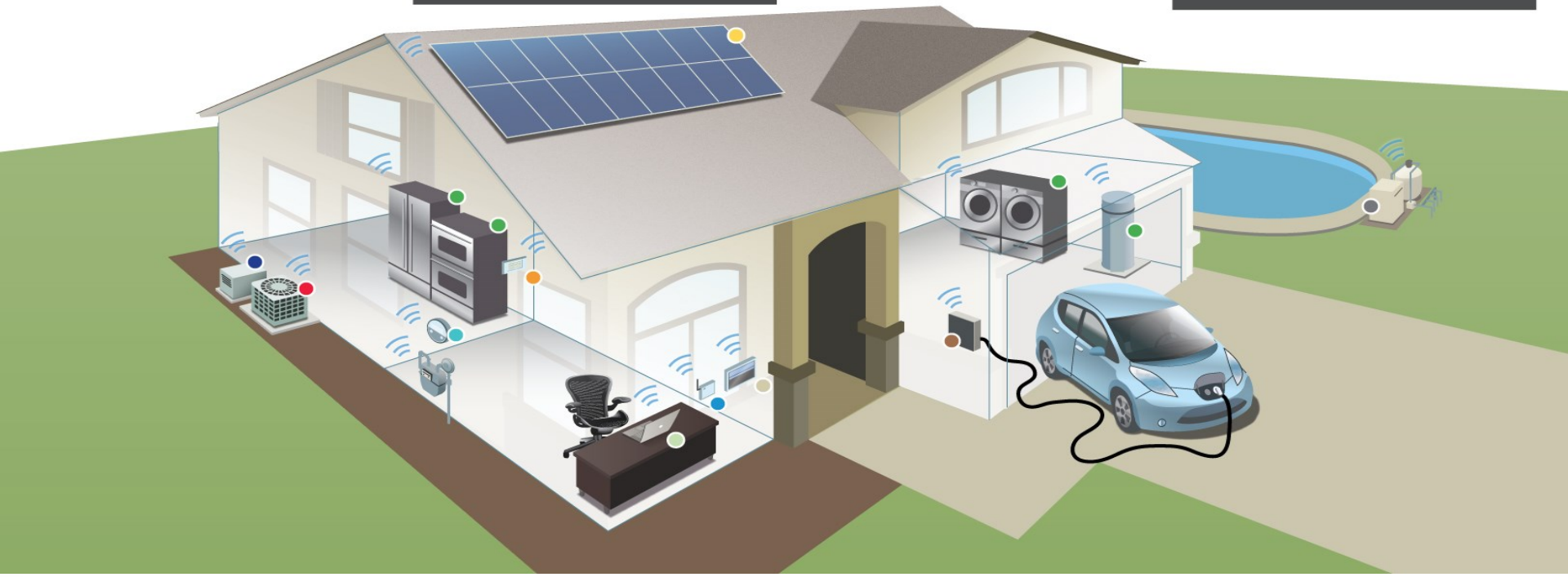
Interactive User Portal
An online tool that allows consumers to view and manage their energy consumption in real time from a computer. It works in conjunction with a gateway to receive updates through the internet and allows you to control your smart devices remotely.

Gateway
A device that allows Smart Appliances in the consumer's home to communicate with a Smart Meter owned by the utility.

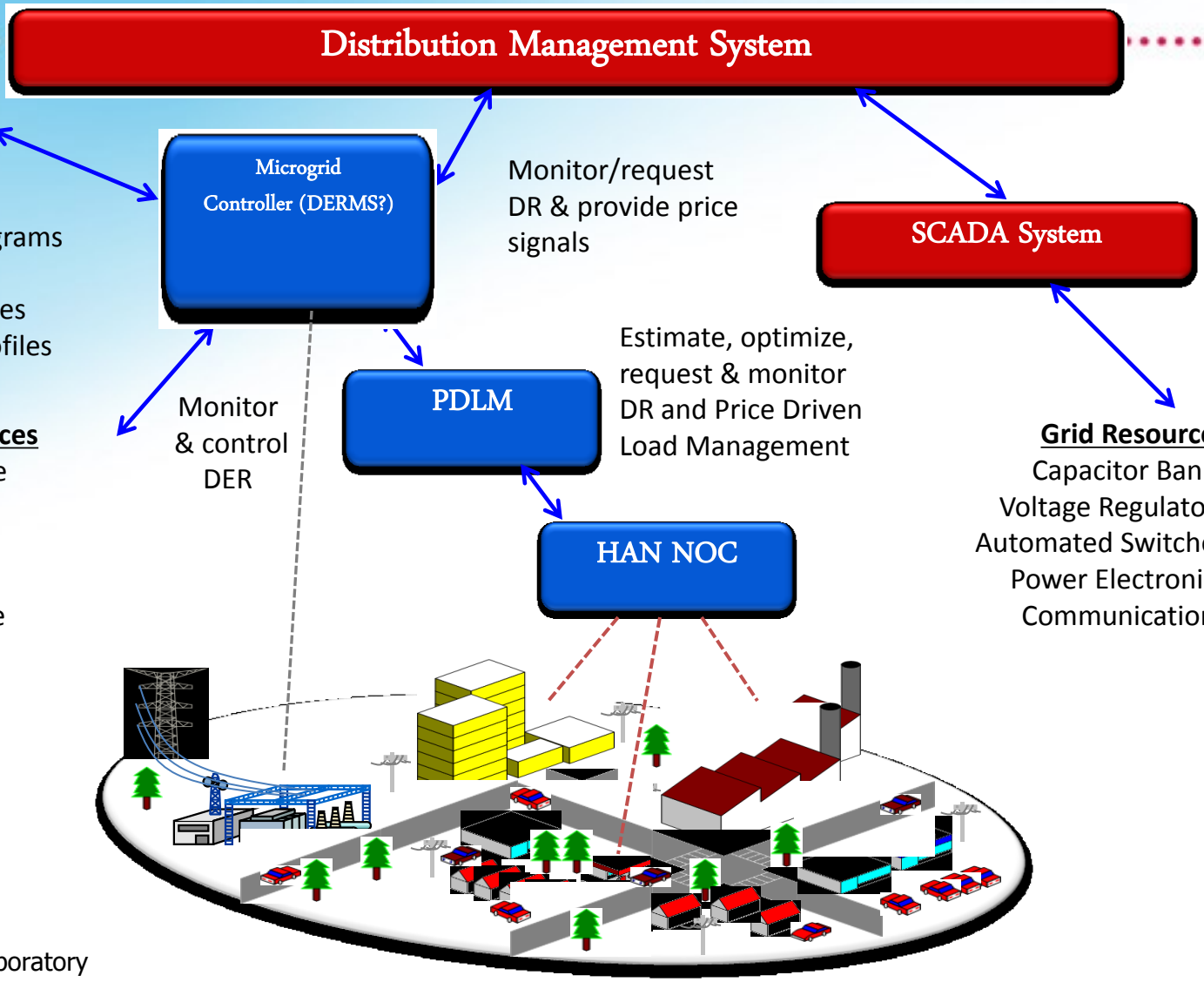
In Home Energy Display
A device that connects to a Smart Meter which provides real-time feedback on energy use and costs.

Electric Vehicle Charging Station
Equipment that charges an electric vehicle. When connected to the home area network, it will allow a user to program settings through the internet to charge their car.

Pool Pump
When connected to the home area network, the pump can be controlled through the internet, allowing users to program settings remotely.



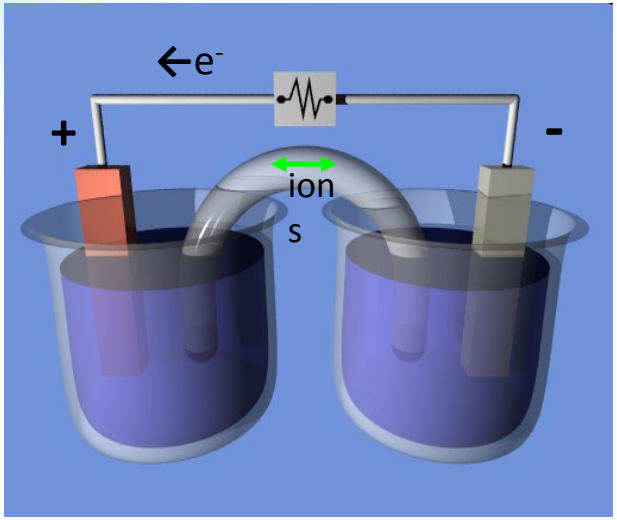
Managing a Microgrid



National Energy Technology Laboratory

Challenges

- Silo Coordination
- Operational Coordination
- Permitting
- New Technology
- Standards
- Security – Cyber and Physical
- Customer Participation



Significance and Impact

- First large scale utility microgrid
- Actually island real customers
- Alternative service delivery model
- Prove advanced technologies for future applications
- Establish model to be used by other utilities

Acknowledgements

Acknowledgement: "This material is based upon work supported by the Department of Energy [National Nuclear Security Administration] under Award DE-FC26-08NT02870 and DE-FC26-08NT01904.

Questions ?


Thank you.
Thomas Bialek
Chief Engineer, Smart Grid
tbialek@semprautilities.com
www.sdge.com/smartgrid/