Model-Based Online Power Management Solution
A Key Element to any Microgrid Program

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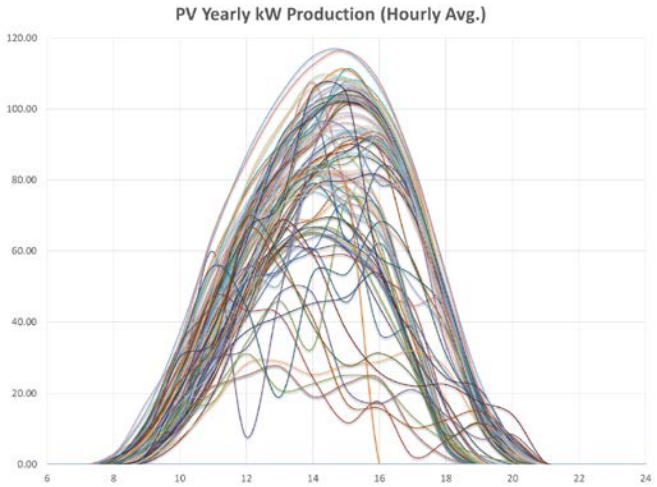
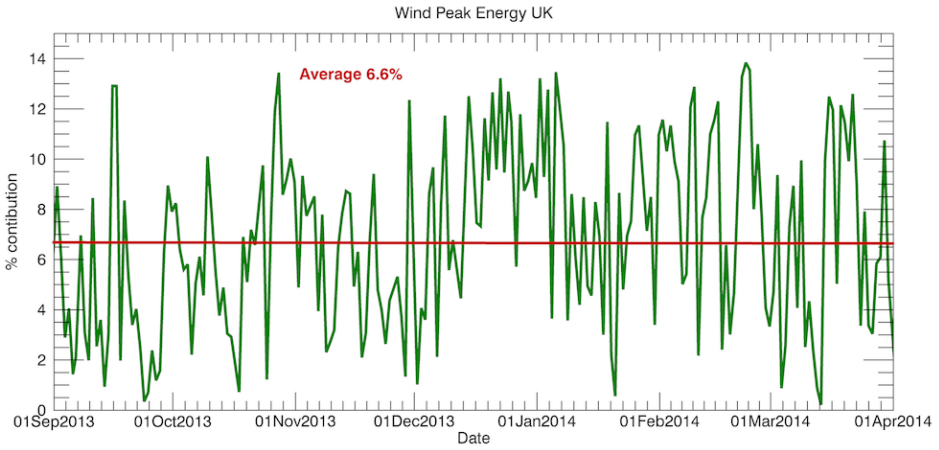
Content

- Why Model-Based Solution for Microgrid
  - Renewable resources are not dependable
  - Challenges of microgrid operation in islanded mode
- Models of Microgrid Elements
- Microgrid Central Controller (MGCC)
- Online Predictive Simulation Analysis
- Advanced Predictive Simulation Applications
- Case Studies

Why Model-Based Solution?

- Renewable resources are not dependable
  - Active power depending on weather
  - May not provide spinning reserve
  - May not provide reactive power support



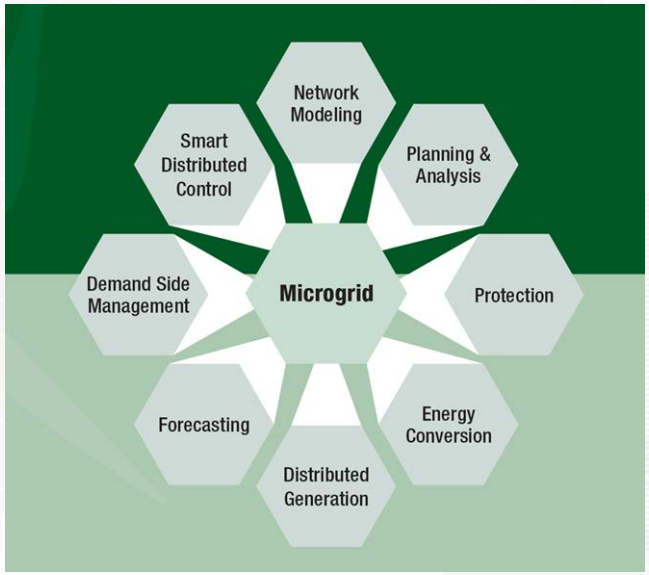


Why Model-Based Solution?

- Challenges of Operation in Islanded Mode
  - Hard to maintain voltage and frequency stability
  - Large imbalances between load and generation
  - Strong interaction between controllers of energy resources
  - Use of different generation technologies
  - Low power quality
  - Lack of sufficient reserve margin
  - Smaller short circuit current

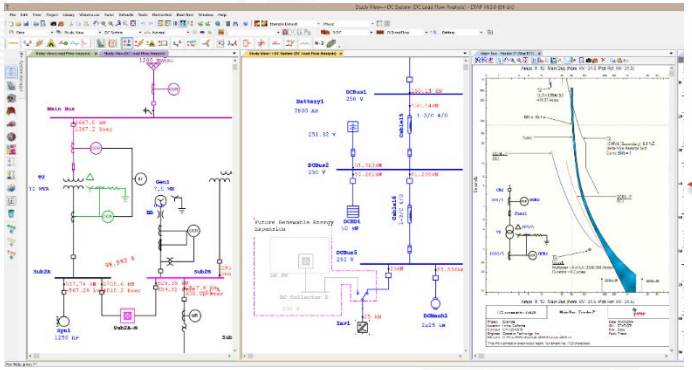
Why Model-Based Solution?

- To effectively and optimally address microgrid challenges
  - Predict microgrid response to any change
  - Predict future state of microgrid
- Utilize model-driven predictive solution to
  - simulate
  - optimize
  - control
  - protect
  - and automate



Microgrid Central Controller (MGCC)

- Combines system modeling & analysis with real-time data
- Predicts outcome of various contingencies, system changes, unplanned failures, etc.
- Provides recommendations and automatically takes corrective action



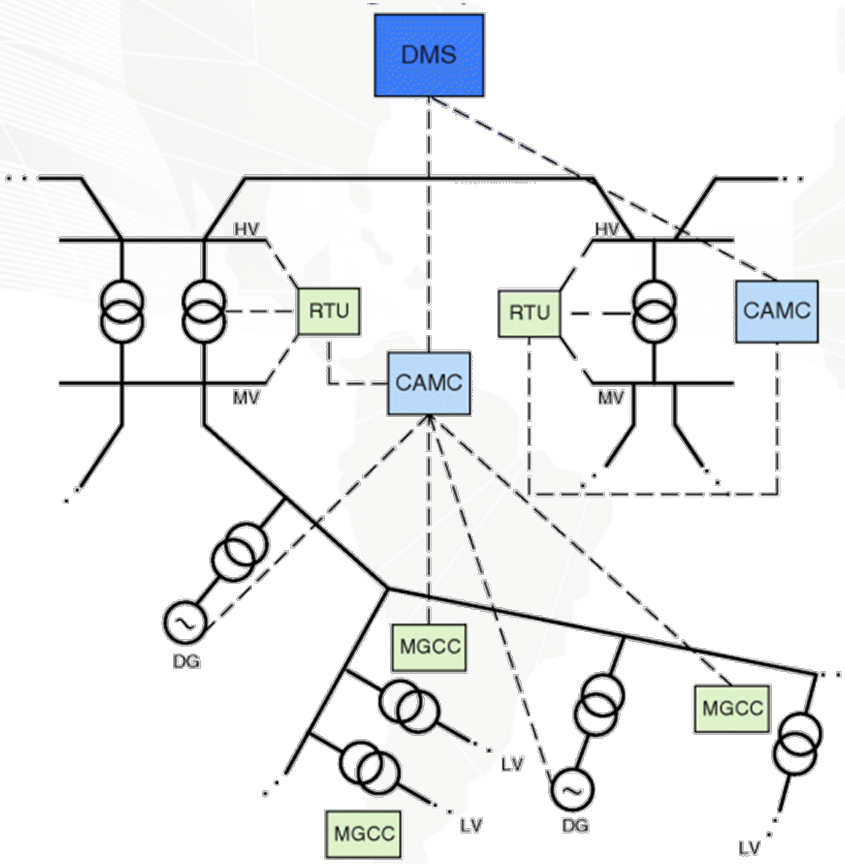
Electrical Design & Analysis Software

Supervisory Control & Data Acquisition

Microgrid Central Controller

Control Architecture for Multi-Microgrids

- Supports dynamic configuration and Multi-Microgrid Control & Management



DMS
- Distribution Management System
- HMI – Yes
- Integrated Control - Yes

CAMC
- Central Autonomous Microgrid Controller
- HMI – Optional
- Coordinated Control - Yes

MGCC
- Microgrid Central Controller
- HMI - Yes
- Local Control - Yes

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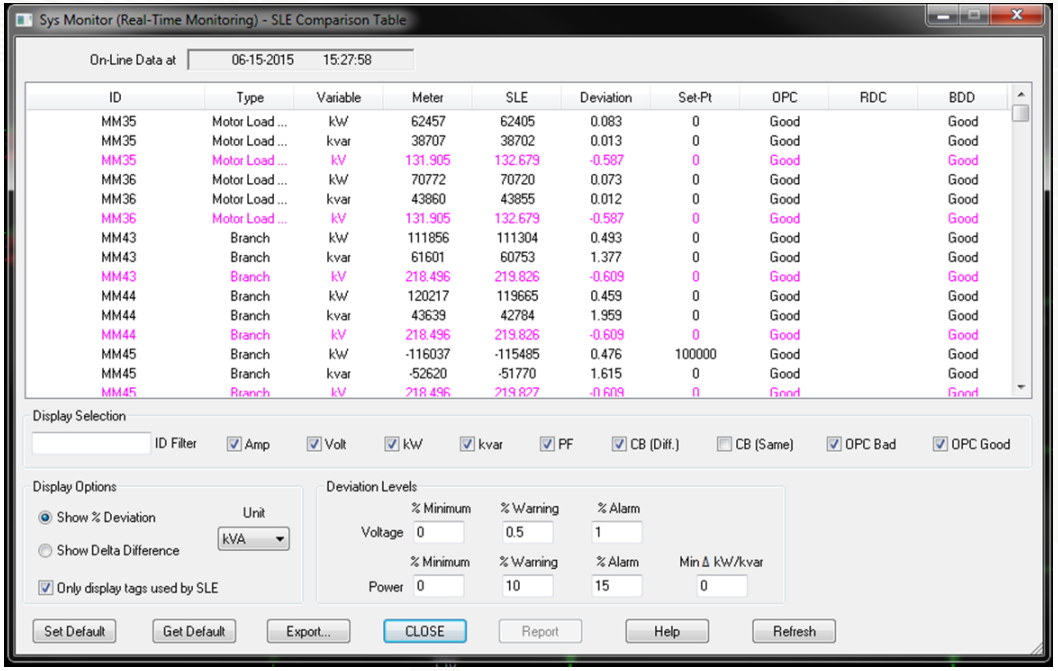
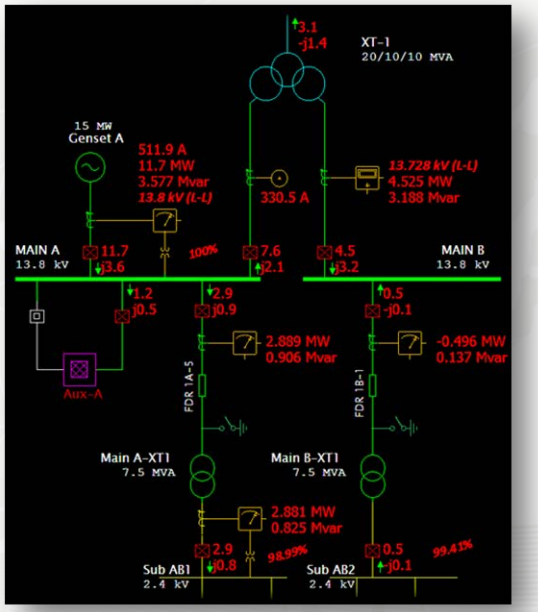
Model Validation & Tuning

- Acquire online data
- Tune load, generation & configuration
- Perform state estimation





Modbus, DNP3, OPC, IEC 61850 MMS,
IEC 61850 Buffered Report, ICCP Gateway

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Online Predictive Simulation Analysis

- Simulate circuit breaker operation
- Identify potential operating problems
- Simulate motor starting & load change
- Predict operating time of protective devices
- Predict system response based on operator actions
- Perform “what if” operating scenarios
- Simulate real-time & archived data
- Operator assistance & training

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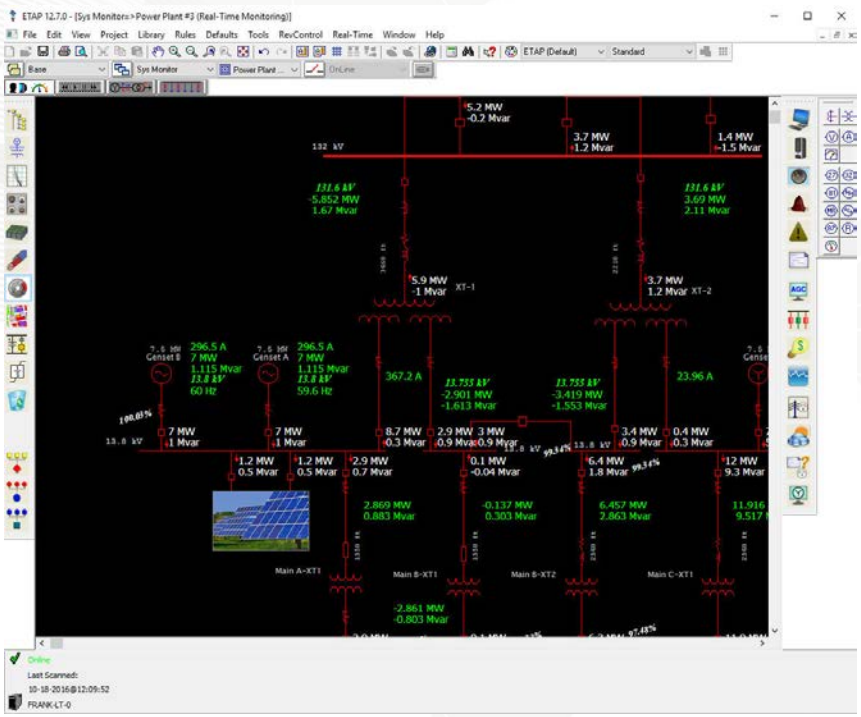
Advanced Predictive Simulation Applications

- Intelligent monitoring
- Sequence of events playback
- Power management applications
- Economic dispatch, unit commitment & generation control
- Load management
- Volt-var optimization
- Intelligent load shedding
- Microgrid real time simulation

Intelligent Monitoring



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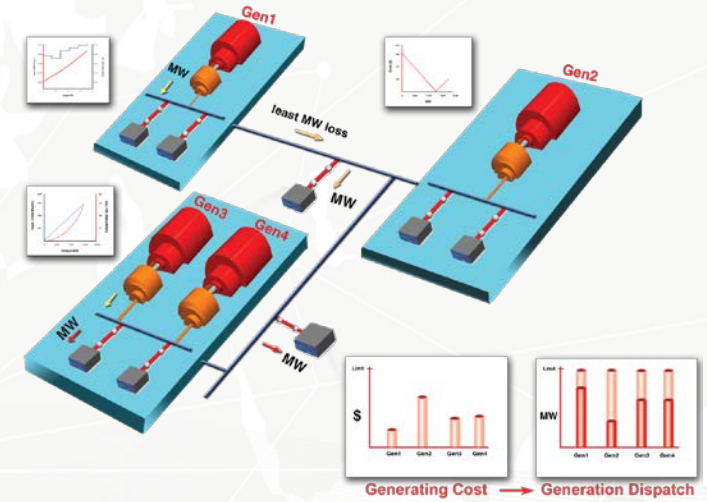
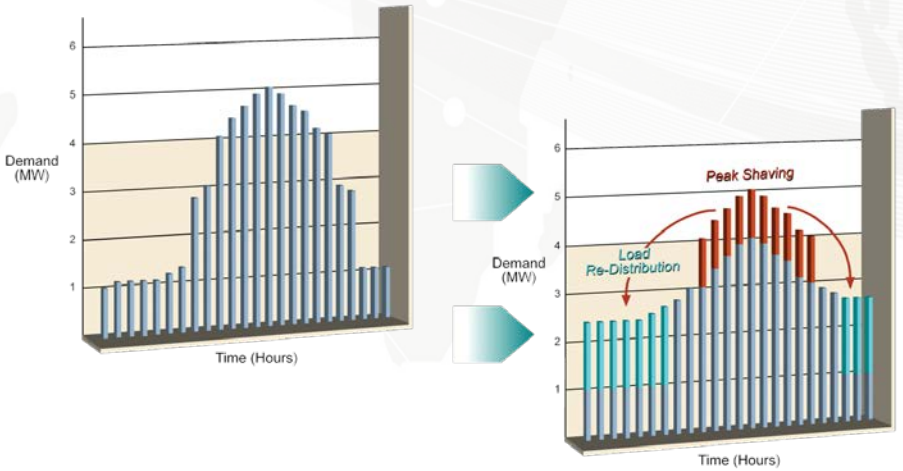
Economic Dispatch & Load Management

- Minimize fuel costs
- Optimal energy costs
- Fast solution
- Robust algorithms
- Demand-side management
- Time-of-use load shifting
- Intelligent load management





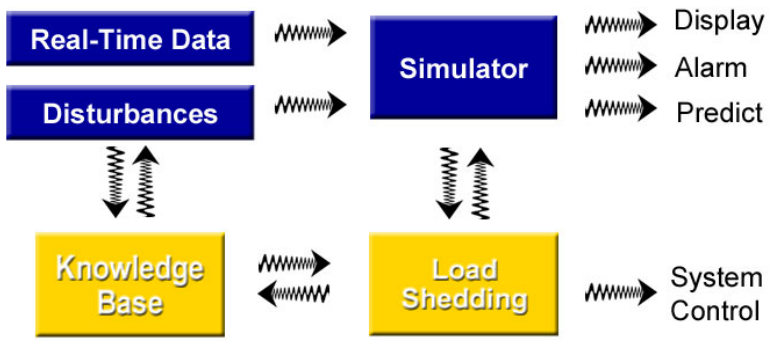
Time-of-Use Load Shifting

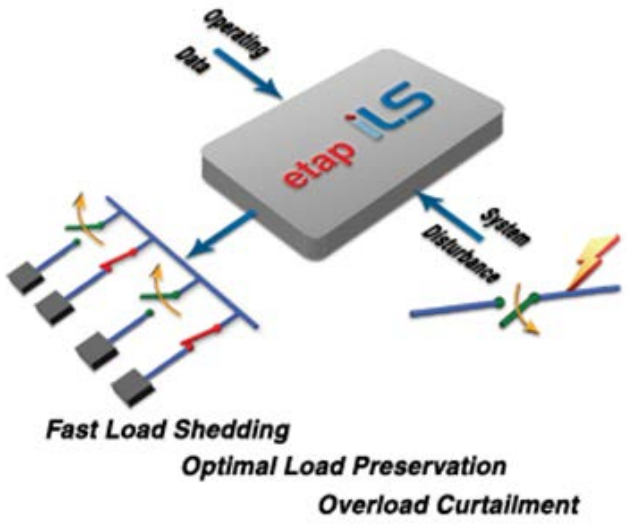
Volt/Var Optimization

- Maximize voltage & flow security indices
- Minimal reactive power losses & electrical demand via CVR
- Optimizes power factor for the entire microgrid
- Based on time-of-day, static load profile, or averaged load
- Control generator and inverter reactive power setpoints
- Control capacitor bank or Static Var Compensator (SVC) setpoints
- Adjust switched capacitors within the specified limits
- Control voltage regulators (transformer tap positions) within the specified limits

Intelligent Load Shedding

- Optimal load preservation & minimum load shedding
- Fast response time & reliable operation <10 ms
- Proactive contingency analysis
- Steady-state & transient response





- Confirm load shedding actions
- Simulate ILS recommendations
- Integrated stability knowledge base

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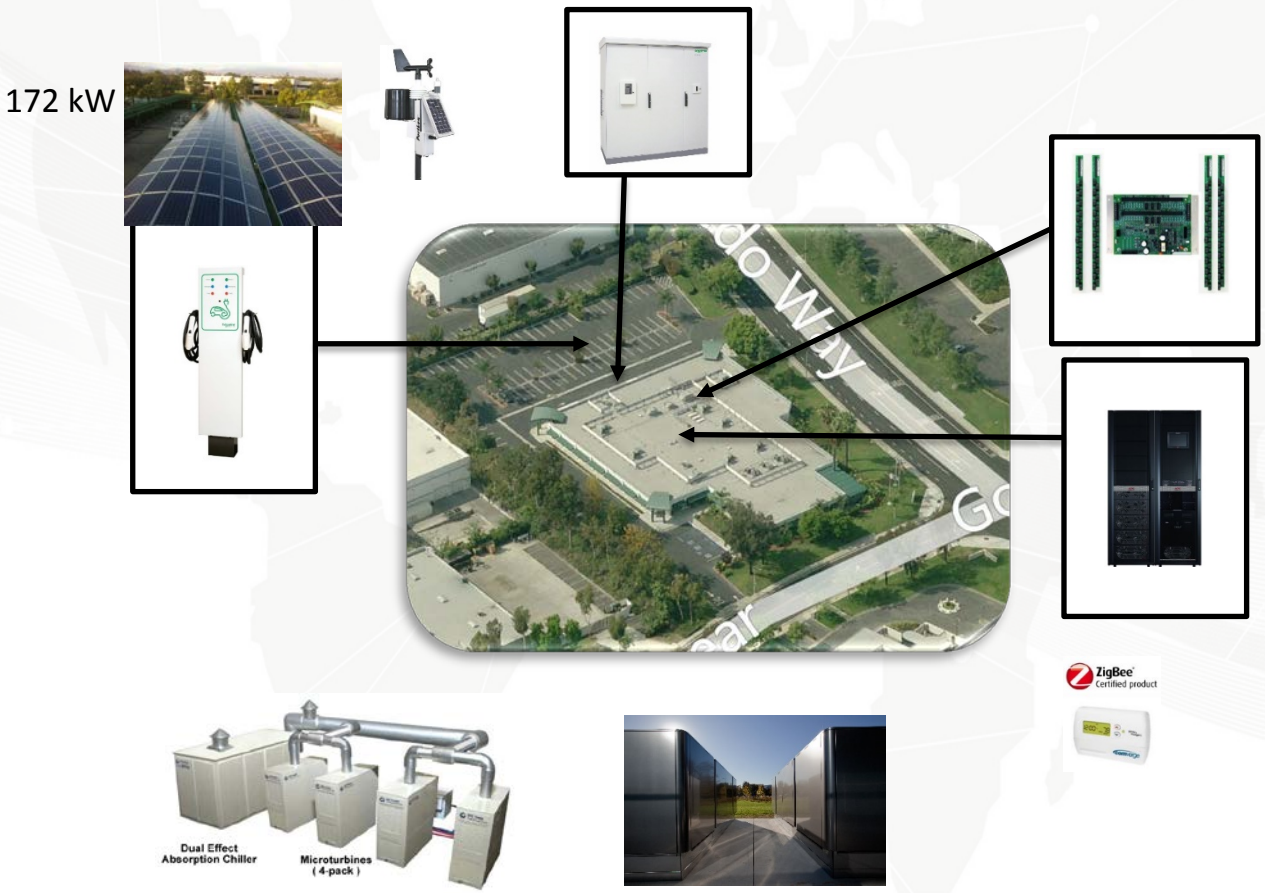
Key Microgrid Projects

- ETAP Corporate Office, Irvine, USA
- University of California, Irvine, USA
- Fukushima Renewable Energy Institute
- Over 20 non-DER Microgrid Projects

ETAP Corporate Office Microgrid Equipment



ETAP Corporate Office Applications & Purpose

- Advanced Monitoring – Improve system visibility
- Energy Accounting – Compare utility bill against measured values
- Automatic Generation Dispatch – Using mix of utility, PV, battery and/or fuel cell
- Automatic Demand Management
- Remote control of equipment
- Verify & Validate ETAP (simulated vs. actual)
- Multiple vendors participating and supplying equipment for this real-world microgrid

University of California
Irvine Campus (UCI) - Microgrid

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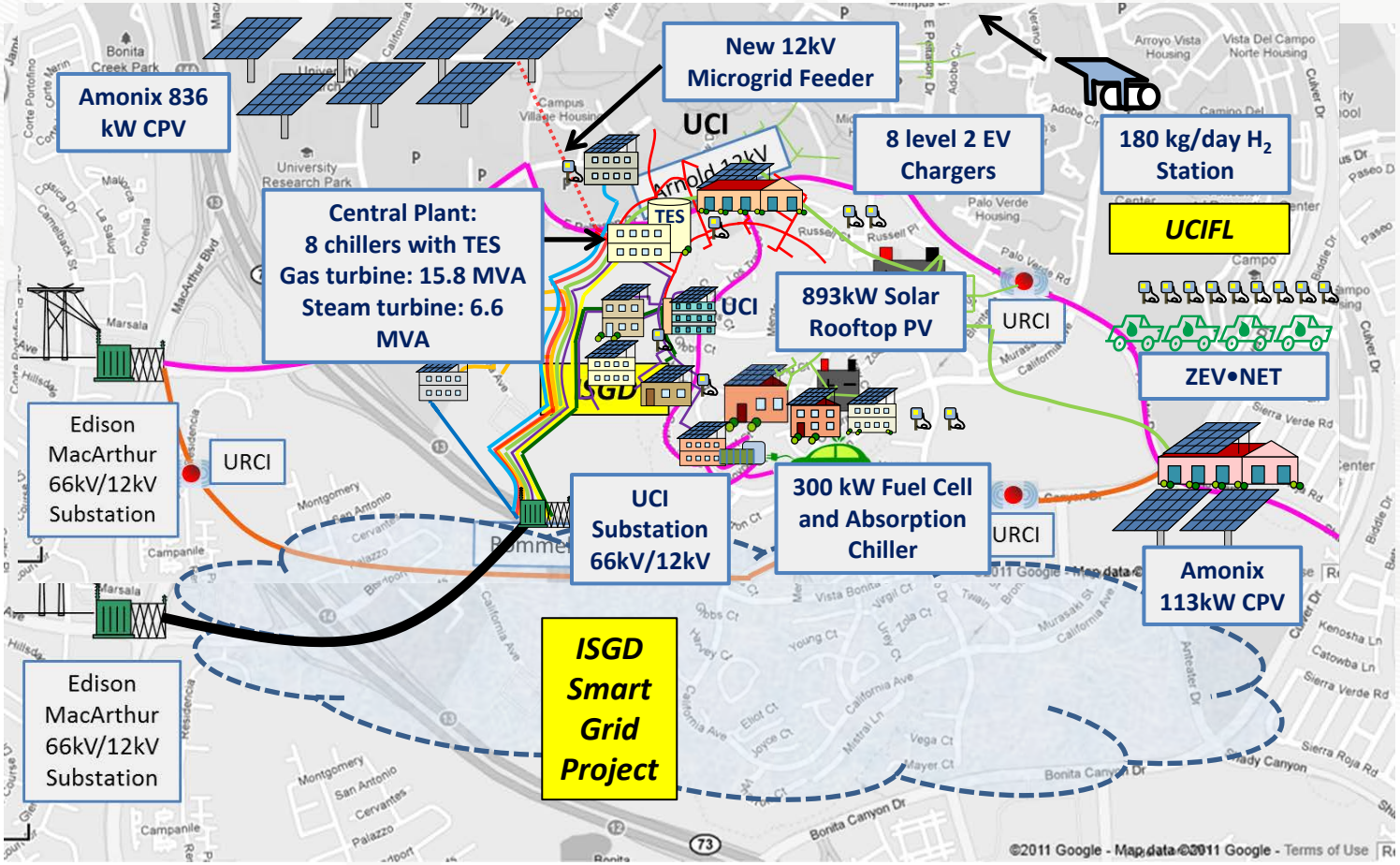
UCI Microgrid



UCI Requirements

- Where and how do we plan additional renewable assets?
- How do we measure kW and kvar available capacity, manage load growth while maintaining system reliability?
- How can we maximize generation usage and mix?
- Can we safely maintain critical load given mix of generation under islanded mode
- How do we decide the optimal switching between multiple feeders to balance feeders and loads?
- Quick and easy to use model validation tools to benchmark the microgrid model for improved decision making and situation awareness
- Demand response for reliability and economics

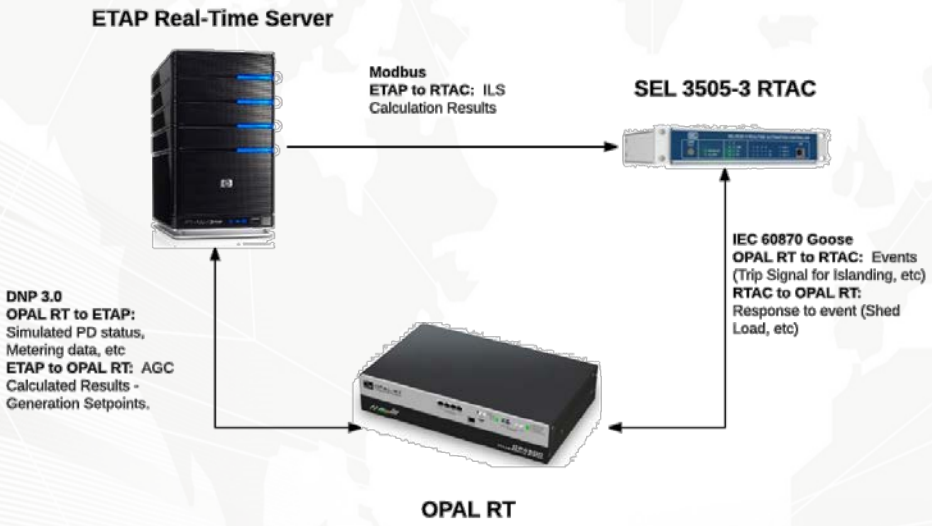
UCI Requirements

- Include static and dynamic behavior of the microgrid components such as inverters, Co-gens, fuel cells, etc.
- Optimize the overall network not just localized improvements
- Utilize real-time, historical, and forecasted data for optimization routines
- Provides an easy to use operator interface
- Complete system situational awareness using limited metering points
- Integrate with existing smart grid circuits
  - Optimize network under grid connected mode
  - Ensure critical load is running under islanded mode

Microgrid Controller Suite

- PowerStation Management System (PSMS)
  - Monitor and Control Real-Time Environment
- Intelligent Load Shedding (ILS)
  - Quickly respond to changing events in the system (Islanding, loss of generation)
- Automatic Generation Control (AGC)
  - Adjust asset operating conditions in Real-Time to optimize on pre-defined objectives
    - Minimize Cost, Losses

Test Environment



Operational Environment

- Offline Simulation
  - Unbalanced Load Flow, Time Domain Load Flow
  - Transient Stability
  - Optimal Power Flow
- PowerStation Management System
  - Real-Time Data collection from MelRok hardware via BacNET protocol
  - State and Load Estimation
  - Predictive Simulation
  - Data Archival

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Next Step

- Optimization in Real Environment
  - Implementation of Objectives from Test Environment into Operation
  - Implement SCADA Capabilities (Alarming, Emailing, HMIs, Web User Interface)
  - ADMS Modules (Volt-Var Optimization, Switching Optimization, Fault Isolation and Service Restoration, etc)
- Requirements / Obstacles
  - Additional monitoring equipment for higher visibility at key points
  - Additional controllable assets
  - Integration with controllable, renewable assets
  - Integration with process assets (HVAC, etc).
  - Integration with weather monitoring / forecasting system.

Summary

- Model-based solution to enable predictive simulation
- Offer models for conventional and new energy resources
- State estimation & model verification to ensure simulation accuracy
- Load and generation forecast to predict future state & optimize microgrid
- Online monitoring, power management and web applications
- Conventional and advanced applications to perform offline and predictive online simulation
- Microgrid offline and real time simulation
- Several case studies and projects