EPRI Pre-Conference Workshop

Active distribution system management for integration of distributed resources –

research, development and demonstration needs

December 9, 2008

Hotel LePalais de La Mediterranee

DER Integration including Model Based Coordinated Control

Rich Seguin – Electrical Distribution Design
Haukur (Hawk) Asgeirsson – Detroit Edison

December 9, 2008

Keys to utility DER integration

- Real Management Support is a must
- Name a champion to shepherd the integration
- Change the measure
  - $/kW capacity shortfall not $/kW capacity added
- It's just like a portable substation
- Consider utility, customer, or premium power shared DR
- Effective use of manpower & resources
  - Standardize the design & operation
  - Construct with a generation knowledgeable contractor
- Build community partnerships - a temporary solution with minimum usage
- Communicate, Communicate, Communicate
- DER is distribution capacity! not just generation for generation sake

DTE authored: EPRI Best Practices Guidebook for Integration of Distributed Energy Resources into Utility System Planning

Agenda

- **Background**
  - **DTE**
  - **EDD/DEW**
- **Introduction to GridApps Coordinated Control Project**
- **Coordinated Control Architecture & Algorithms**
- **Summary**

Background

DTE Energy – Detroit Edison
&
Electrical Distribution Design’s
Distribution Engineering Workstation
(DEW)

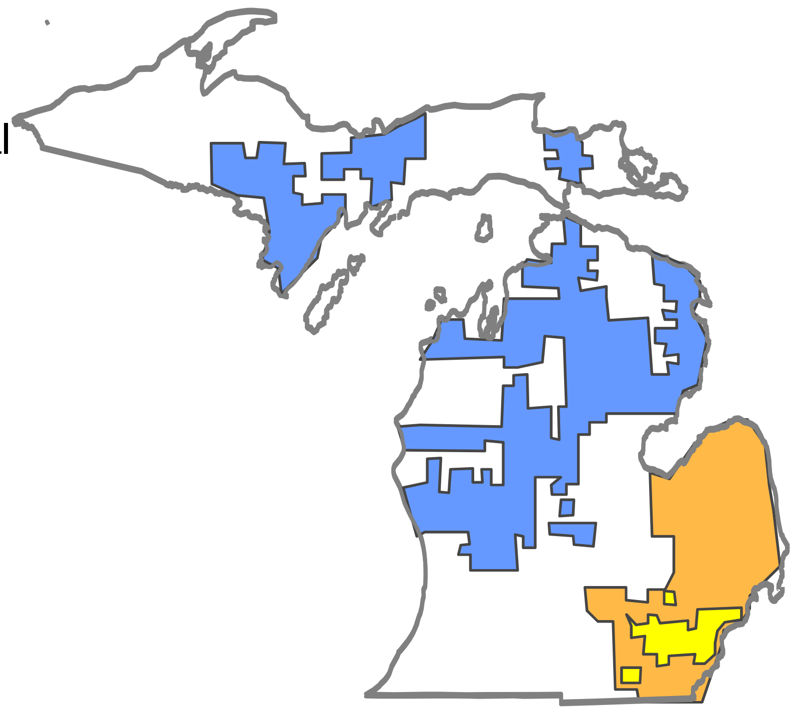
Background - DTE Energy

Detroit Edison

- Tenth largest electric utility in
  the U.S. with 2.2 million customers
- Over 11,000 MW of power generation, primarily coal fired
- 54,000 GWh in electric sales
- ~$3.7 billion in revenue

MichCon

- Eleventh largest natural gas utility in
  the U.S. with1.3 million customers
- 170 Bcf of gas sales
- 12% of national gas storage
  capacity with 130 Bcf of regulated gas storage
- ~$1.7 billion in revenue



Utility Service Territory

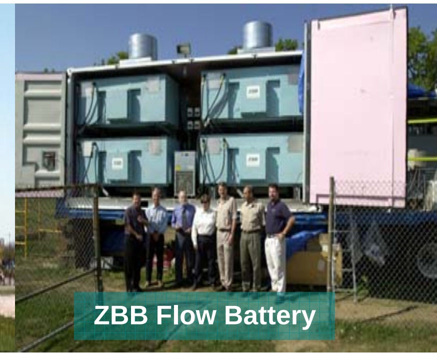
Detroit Edison **MichCon**

Overlap

Distributed Generation at DTE Energy

Technology Testing


Southfield Solar & Future H Power Park


ZBB Flow Battery


Substation Battery Replacement Project

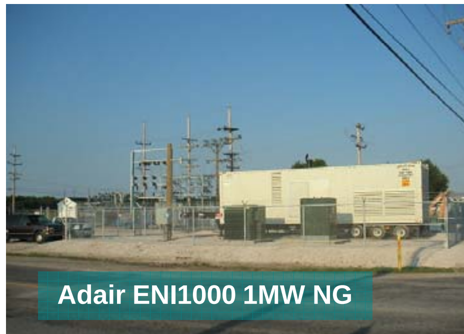
Substation Applications

Temporary & Maintenance

Distribution Solutions

Circuit Applications

Emergency & Temporary


Adair ENI1000 1MW NG


Union Lk ENR2000 2MW Diesel


Substation Islanding ENR2000 2MW Diesel


Emergency ENR2000 2MW Diesel

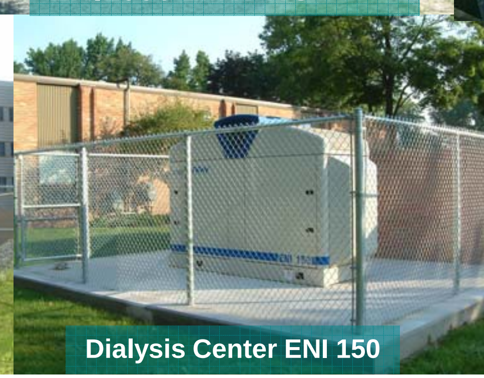

Grosse Ile High School ENI1000 1MW NG


Assumption Church ENI1000 1MW NG

Premium Power

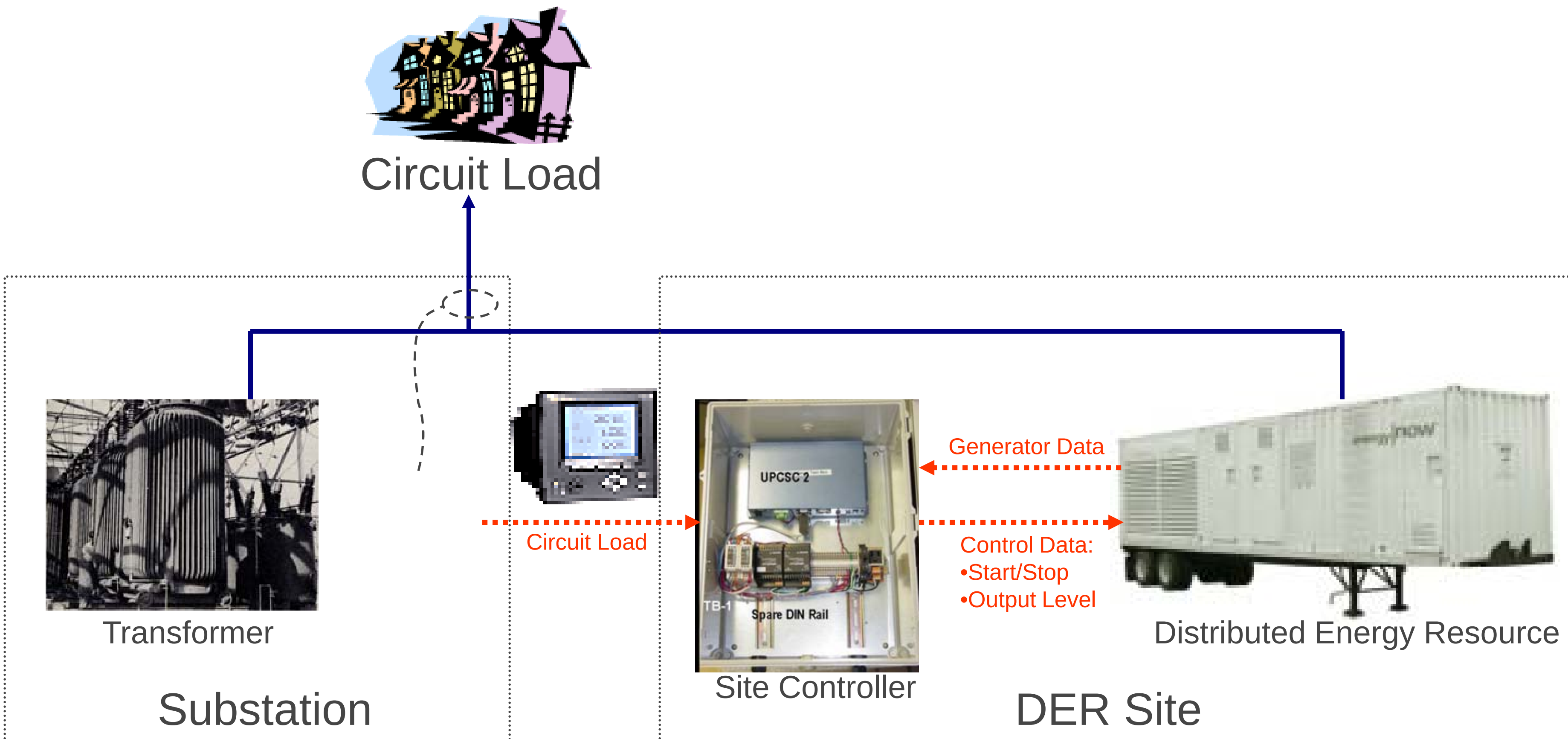
Customer Partnership Applications


Wayne State Univ ENI 75

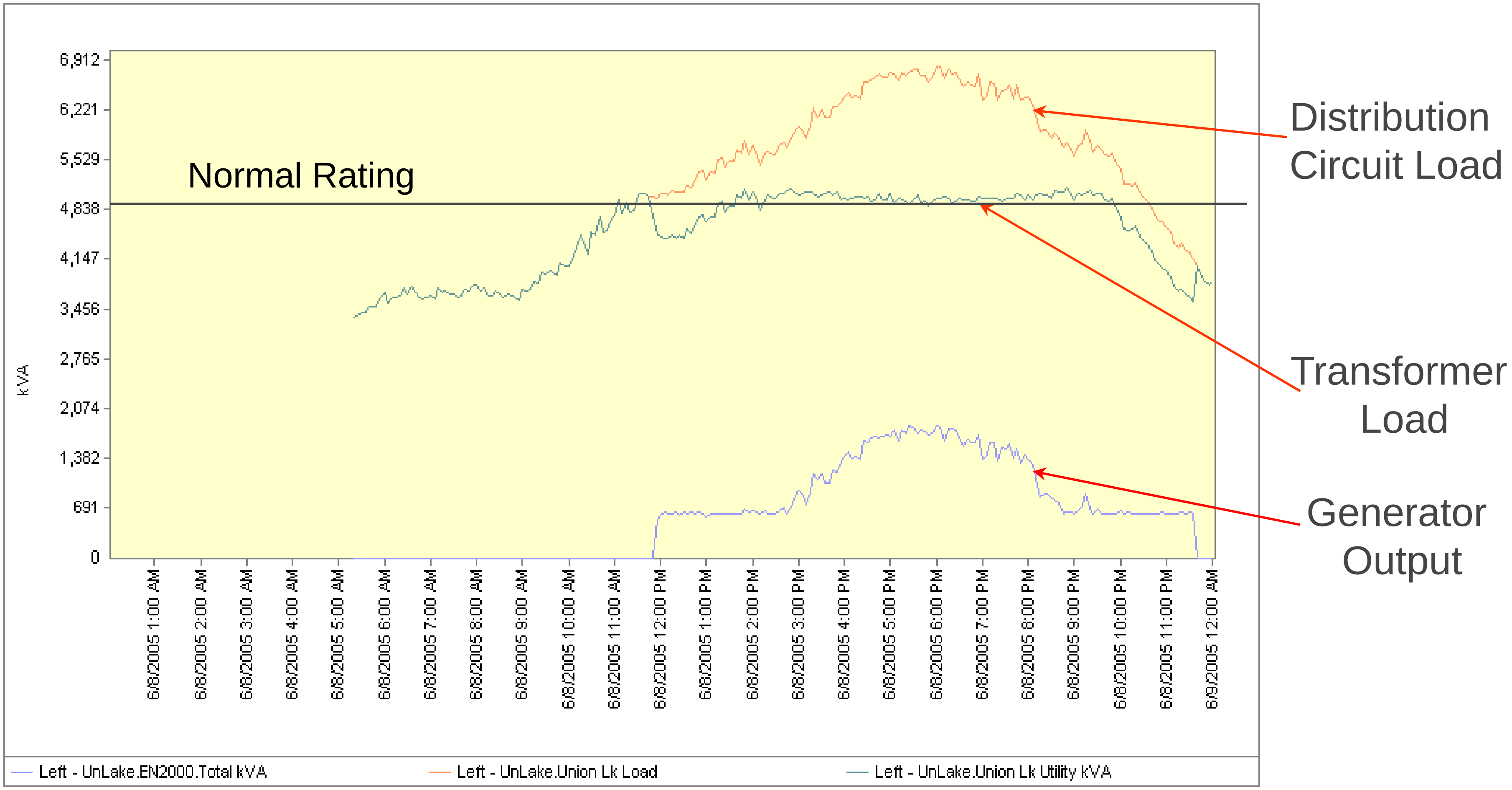

Dialysis Center ENI 150


Service Center ENI 150 & 75

Distribution Solutions - Peak Shaving Architecture



Distribution Solutions - Peak Shaving

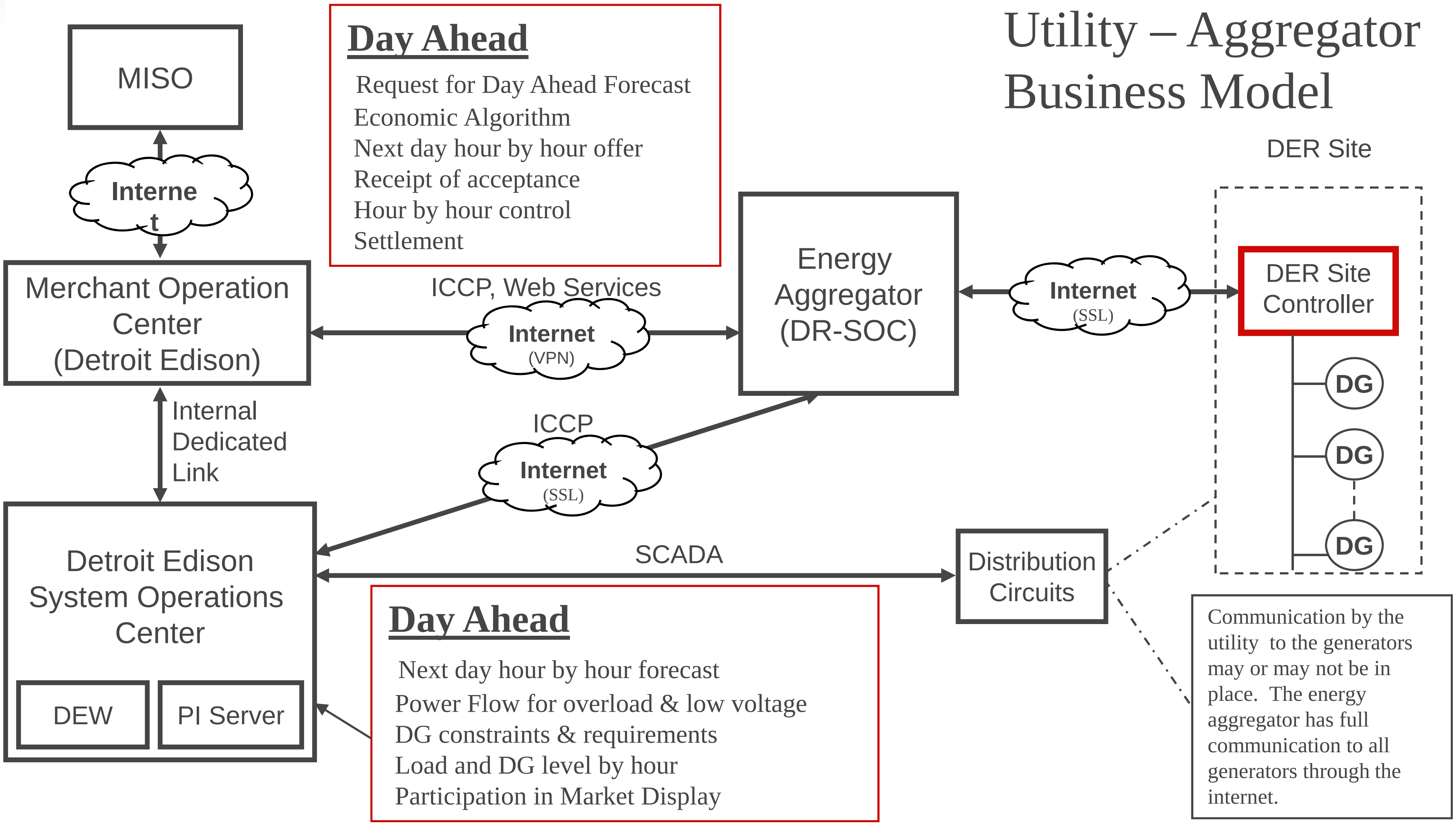


Background
Previous DER Integration Projects

- **DOE DER Integration Phase 1- Proof of Concept**
  - UPCSC Universal Protocol Converter and System Control
  - PI real-time database
  - Tagging procedures
- **DOE DER integration Phase 2 - Aggregation and Sale**
  - Start, control output, stop, aggregate and sale
  - 1st to ever sell Demand Response into MISO Market
  - SSL Security
  - Utility Centered Aggregation
  - Distribution benefit is quantified before sale
- **DOE DER Phase 3 - Advance DER Integration**
  - Quantify Benefits of Customer DG
  - Virtual Generator – Customer Standby Generation
  - Intentional Islanding – 1st ever permanent installation for reliability
- **Authored EPRI Best Practices Guidebook for Integration of Distributed Energy Resources into Utility System Planning**

Background

Communication Architecture in place from DOE 1 & 2
(No human intervention required)



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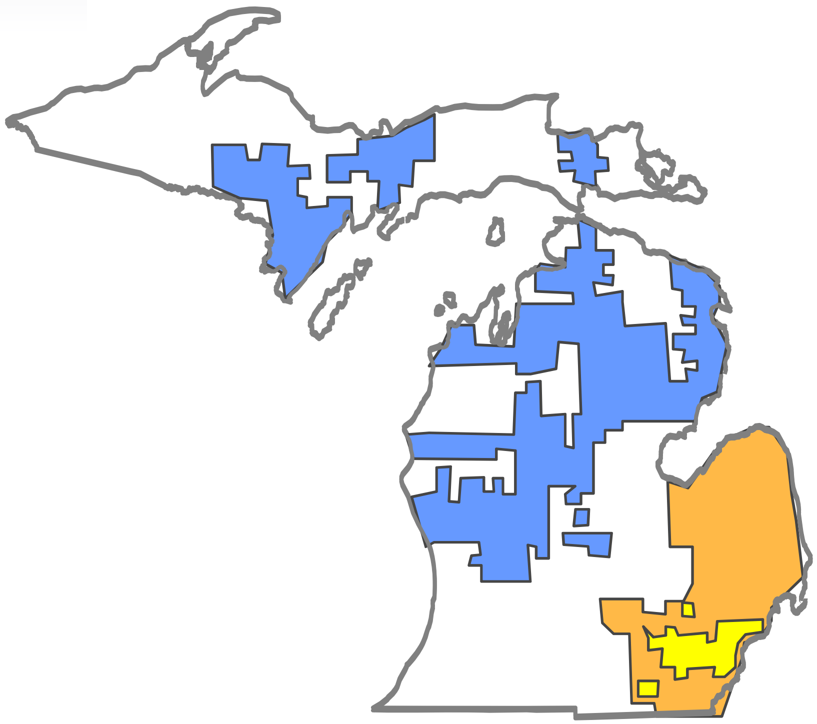
Background – DOE 3

DTE Energy - Detroit Edison Virtual Generator



Utility Service Territory

Detroit Edison   MichCon

Overlap

Customers: 2.2 million

System Peak Load: 12,762 MW
Annual Sales: 56,000 GWH
- **37% Commercial**
- **29% Residential**
- **29% Industrial**
- **5% Wholesale & Interconnection**

Distributed Generation: 1.2 GW
or 10 % of Peak Load
(Includes > 100kW units)

Primary Service Database

500kW > DG > 100kW	50MW
20MW > DG > 500kW	590MW

Loss Saving & Released Capacity (50Hrs)

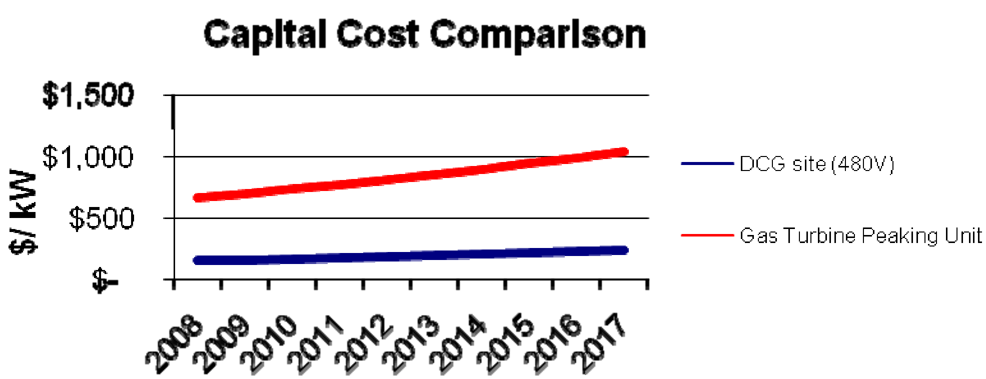
70 MW Loss Saving	$ 700 K
570 MW of Released Capacity	$ 225 M

Background

Why does adding DG make sense compared to purchasing from the market or adding CTs?

Ten year modeling indicates that from 0 to 250 hours of highest summer peak run time, DG is the most cost effective option for meeting capacity needs and higher cost purchased power. DG minimizes the risks of availability and delivery associated with purchase power

- For 0 to 100 hours DG is minimally 42% cheaper than CTs and 20% cheaper than purchased power.
- For 101 to 250 hours DG is minimally 20% cheaper than CTs and 2% cheaper than purchased power.



Detroit Edison hours of exposure to Purchased Power

Year	≥ $100/MWh	≥ $200/MWh	≥ $300/MWh
2006	360	45	12
2007	826	94	19

Background

Electrical Distribution Design (EDD) & Distribution Engineering Workstation (DEW)

Virginia Tech   Blacksburg, Virginia

Professor Dr. Robert Broadwater – President EDD

Background

EDD’s DEW DER Analysis Capabilities

- Employs iterators instead of matrices, naturally supporting distributed computation
- Topology changes do not affect speed of iterator based algorithms as they do matrix based algorithms
- Ability to model the power delivery system from the transmission and sub-transmission systems through to the distribution primary and secondary systems
- Ability to solve large models e.g. DTE’s 3,000,000 node model
- Plug and play modeling for synchronous, induction and inverter DERs
- Time varying power system calculations with DERs
- Support interdisciplinary modeling, e.g. electric, fluids, even economics.

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Control Comparison

Time Clock
Cap Set at the time of installation individually controlled rarely changed unless a problem is noticed

Data-Based
Predetermined sequentially control for head of circuit needs.

Model-Based *
Caps act as a team together with other active devises to maximize capacity and efficiency for the entire circuit not just circuit head.
Responsive to configuration changes both planned and unplanned.

* Can be used to determine which legacy components should be modernized for monitoring and control

Transition to the smart grid of the future

GridApps Coordinated Control Project Goal

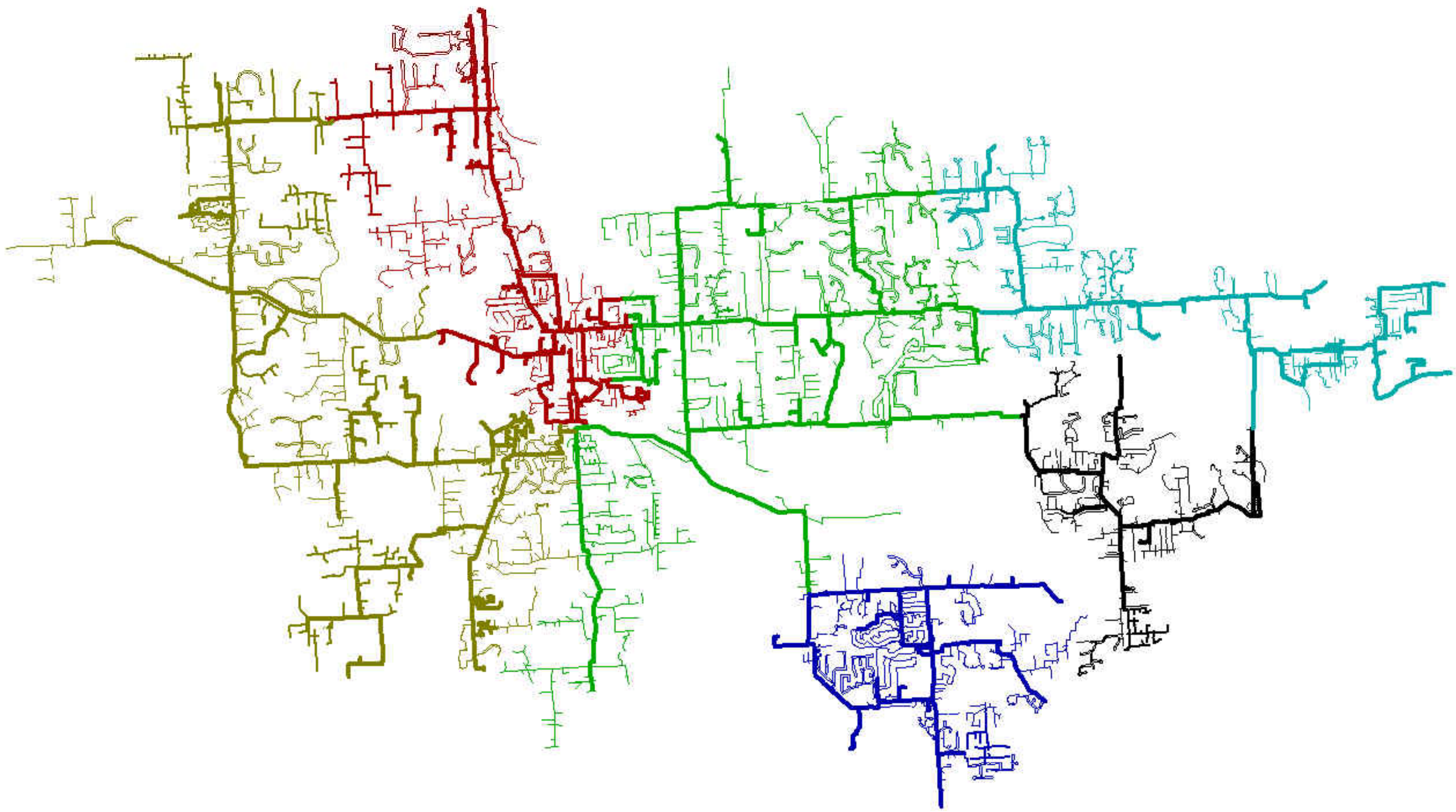
Create a model-based coordinating control where:

Device controls are merged and work as a team to either reduce losses or maximize capacity.

The control is responsive to configuration changes.

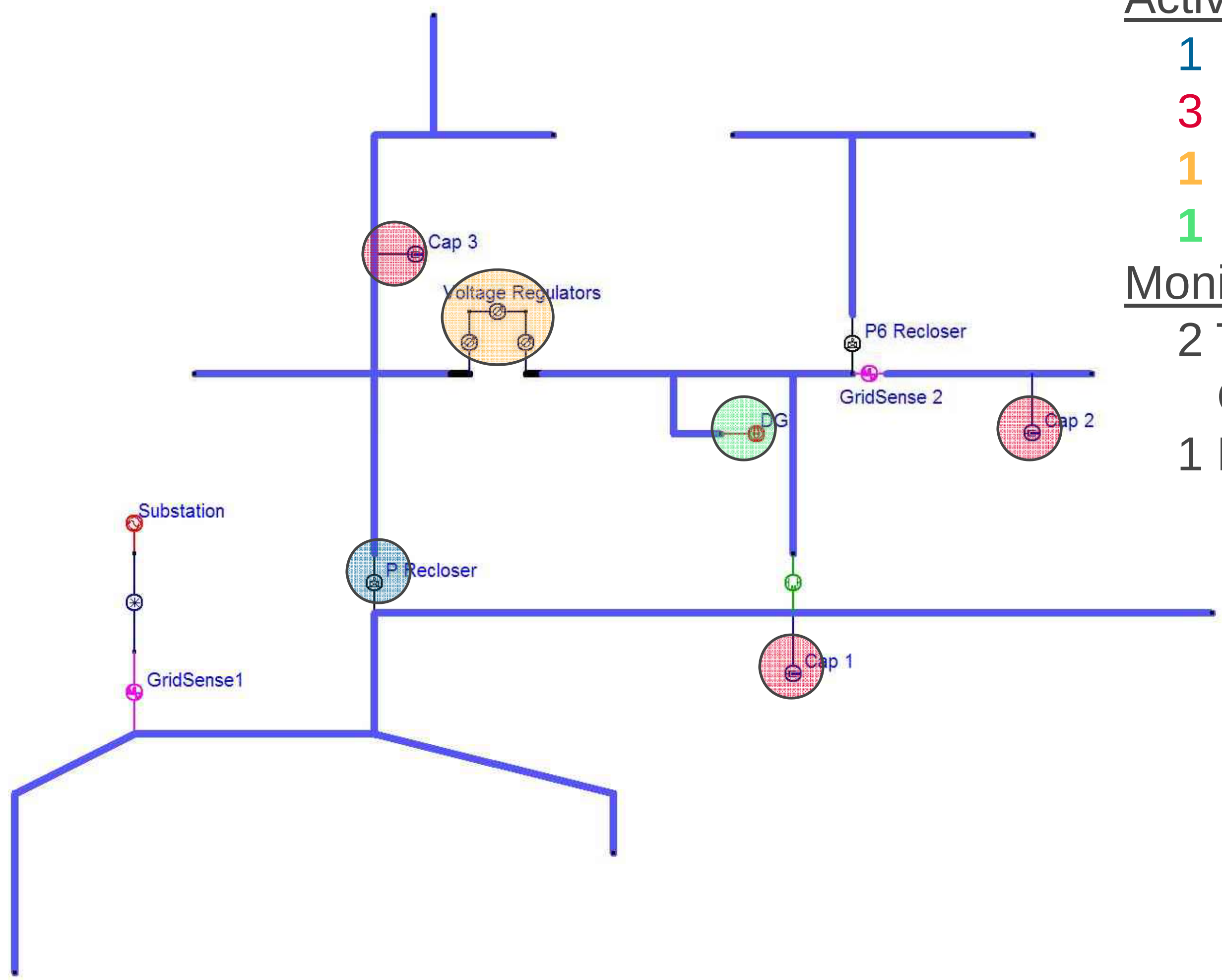
The local scheme can readily work with control requests from the transmission or generation for support.

Existing System of Circuits



Green is our study circuit

Schematic of Existing Circuit



<u>Active Devices</u>

1 Recloser

3 Switched Caps

1 Sets of Volt Regulators

1 DG

<u>Monitoring only sites</u>

2 Three phase sets of GridSense monitors

1 Kyle Retrofit 3ph

Current Active Device Operation

- DG - Operated in automatic load following mode, with fixed unity power factor, to avoid circuit overload.

- Capacitors – Time Clock Controls via radio, with times typically set at the time of installation and rarely changed

- Voltage Regulators – Fixed Voltage Set Point with a specific dead band use for local voltage support

- Reclosers – Fixed settings with no real time monitoring

All control is independent, done device by device, does not respond to configuration changes (Shutdowns studied usually for overload only)

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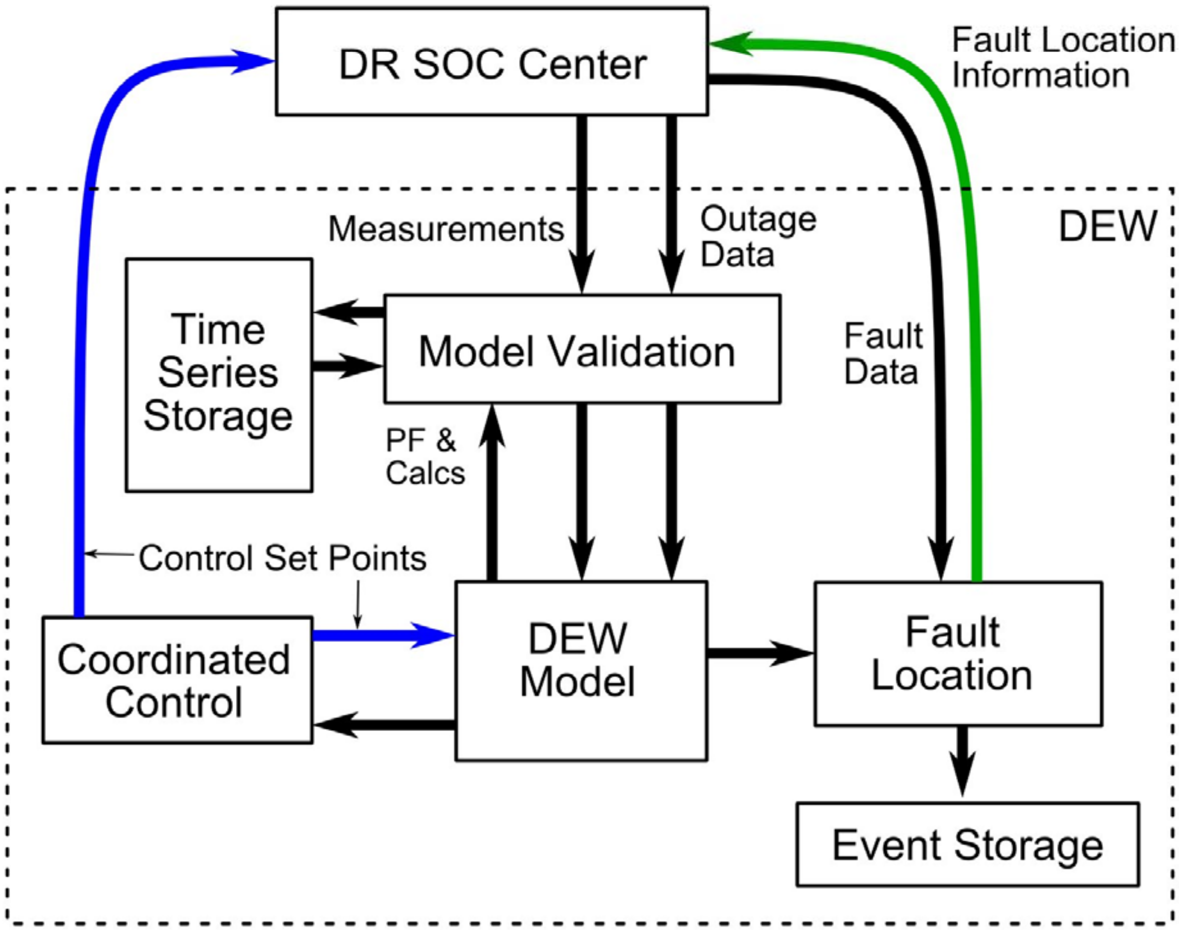
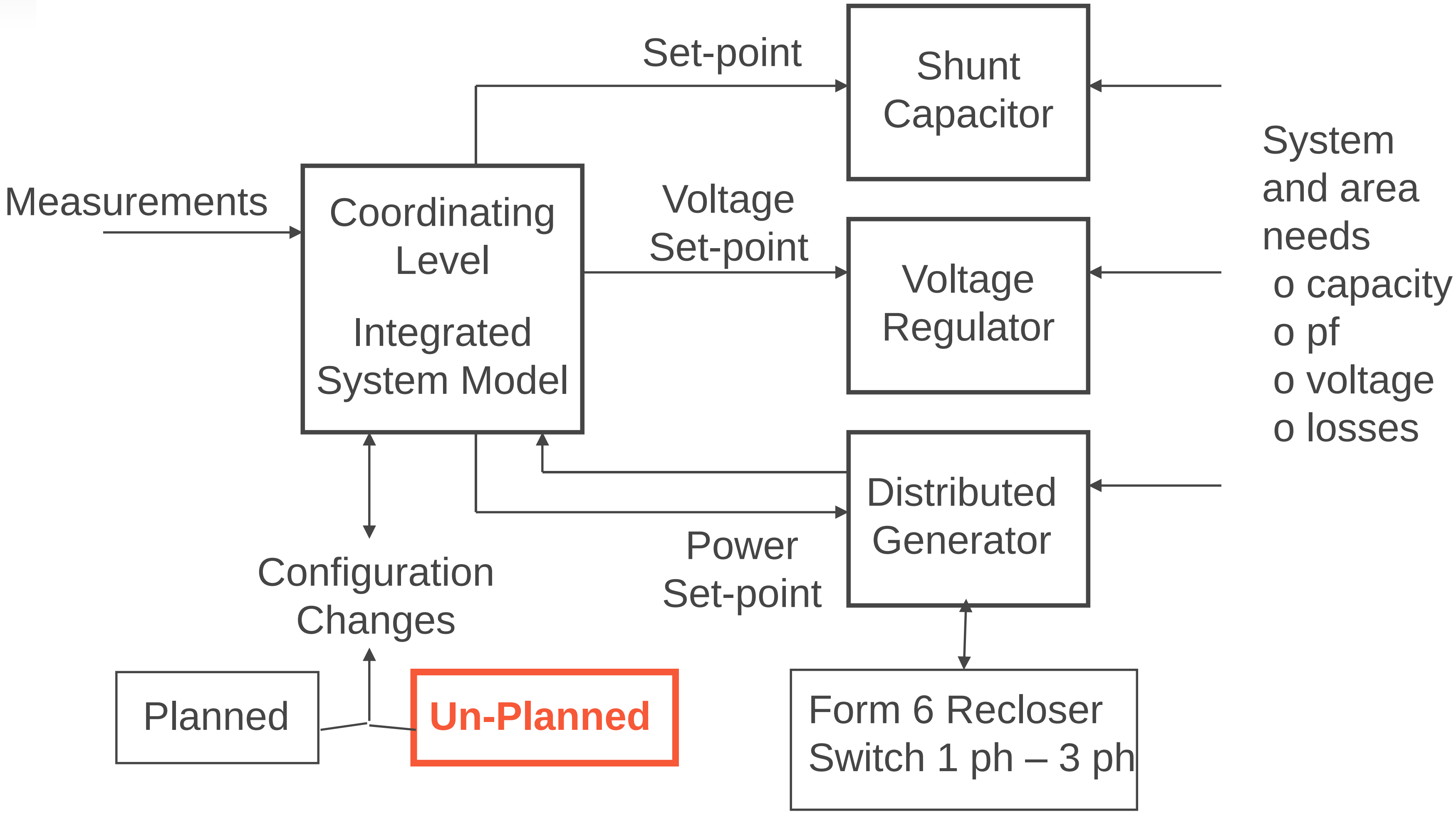
DEW Data Flow



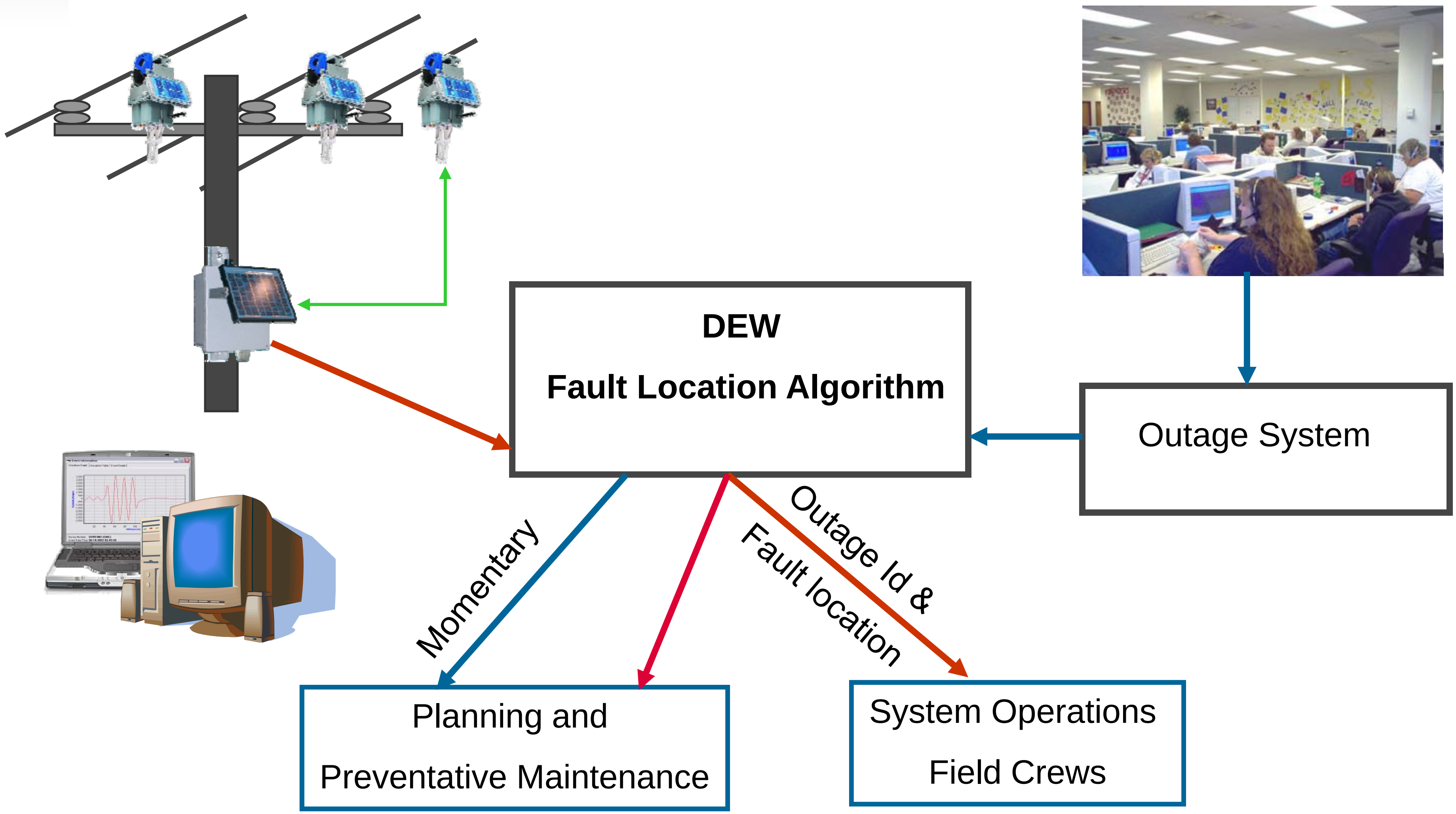
Control Overview

- Coordinated – utilize all active devices on the circuit
  - 3 Switched Shunt Capacitors, 3 Single Phase VR, DG
- Configurable - automatically discover active control devices
  - Devices that are no longer controllable / active
  - Reconfigurations
    - Planned / Unplanned
- Hierarchal Control
  - Coordinated Controller supplies set points for local controllers
  - Local controllers handle transients
  - Fail safe operation (based on loss of communication)
- Objectives:
  - Minimize Losses during normal operation
  - Maximize capacity during Capacity Constrained Operation

Model-based Coordinated Control



Merge outage calls – Identify outage area and refine fault location



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Summary of Coordinated Control

Merge device controls for <u>Model-based</u> management of capacity and efficiency (responsive to configuration changes)

- Capacity Constrained (only a few hours per year)
  - Mission is to resolve the capacity shortfall regardless of losses
  - DG has air permit has max number of hours as a constraint
- System Normal (most of the year)
  - Mission is to minimize losses
  - Max number of switching operations is a constraint
  - Fail safe default setting for loss of communication
- Abnormal System (shutdowns and outages)
  - Capacity Constrained
  - Non Capacity Constrained

DEW's Coordinated Control has two modes of operation:

- **<u>Real-time Mode</u> used to control of all active devises**
- **<u>Planning Mode</u> used to justify retrofitting legacy devices &/or targeting the adding of new devices and control**

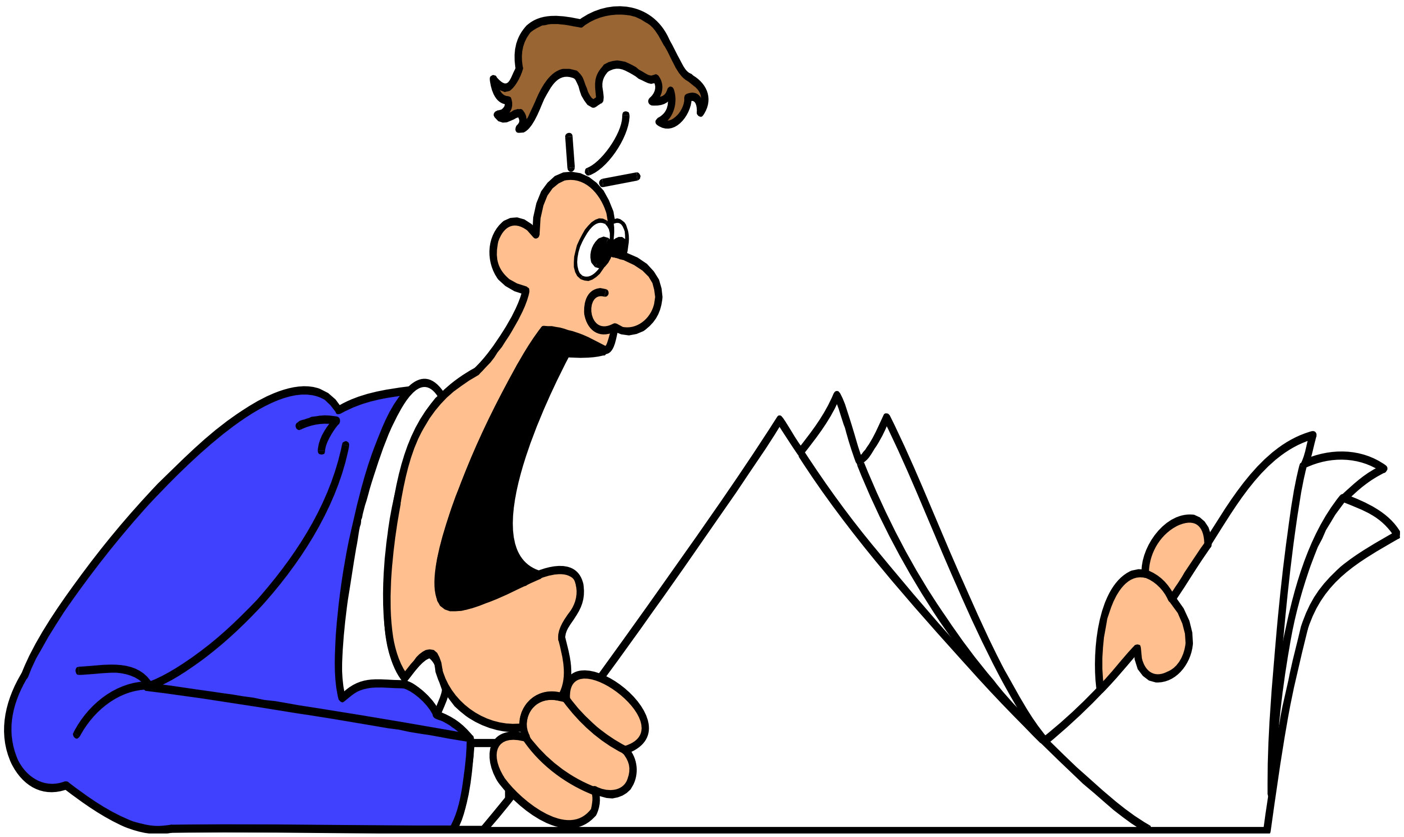
Benefits

- Provides an incremental mechanism for upgrading the system
- Better circuit modeling
- Retrofit for data and some control
- All fault sensing merged with outage calls for fault locating
- Coordinated Control Architecture & Algorithms can be applied to any circuit
- Operating more efficiently and intelligently
  - Circuit/Substation released capacity
  - Circuit/Substation loss savings

Future Work

- Continue Coordinated Control Project to Integrate load control and AMI
- Outage identification and fault location project to integrate all outage and fault sensing devices including AMI
- Integrate newables including NRELs “in my back yard” for renewables
- PHEV / Storage Penetration Studies

Questions

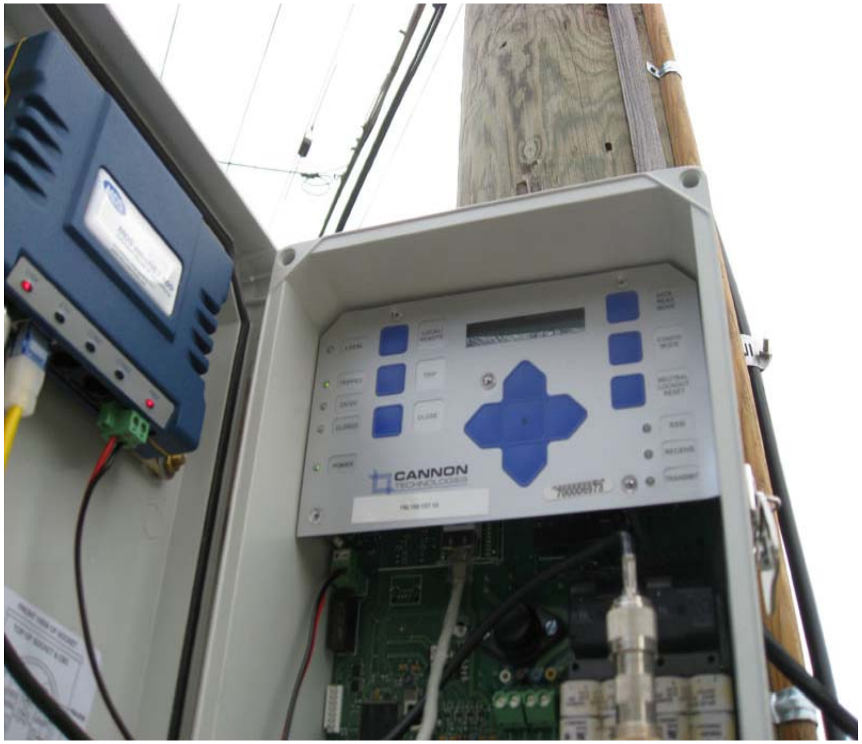


Hardware Summary

- Retrofits:
  - Capacitors – Cannon CBC 7024
    - added remote control, neutral current sensing, and local voltage control backup, and communication
  - Voltage Regulators – Cooper CL-6A
    - added remote control, monitoring, and communication
  - Kyle Recloser – Cannon
    - Monitoring and communication
- New Hardware:
  - Form 6 Recloser – NOVA
    - remote control (triple / single), monitoring, and communication
  - GirdSense LineTracker and Data PAC
    - fault information, monitoring, and communication

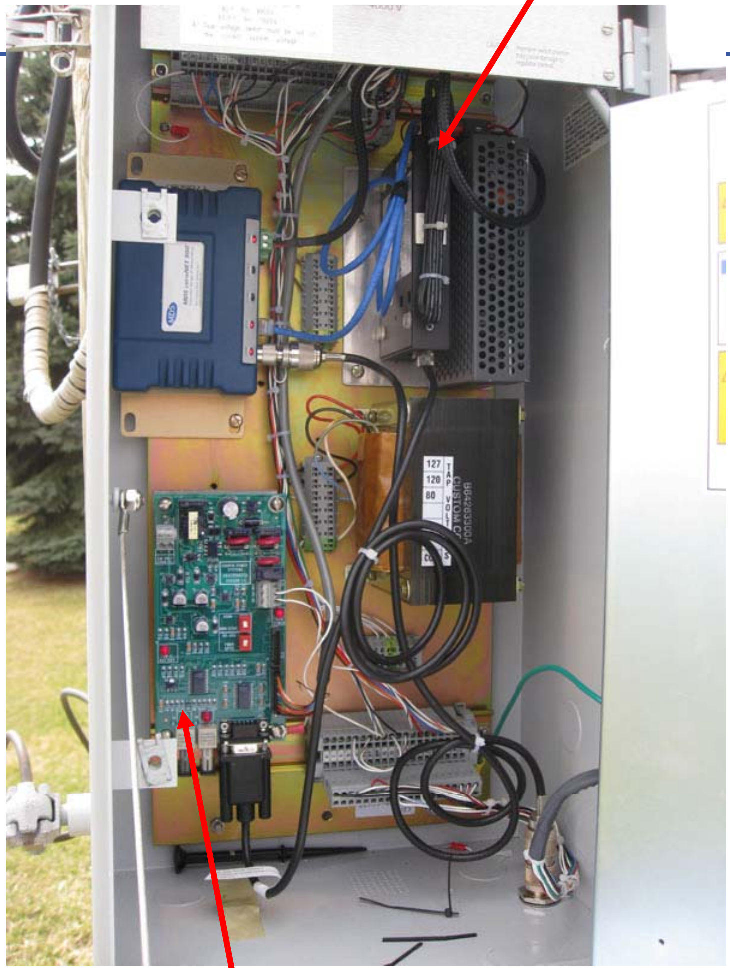
Capacitor Banks

Installed Cannon CBC-7000 on three Cap Banks



Voltage Regulators

Installed Cooper CL-6 on three regulators



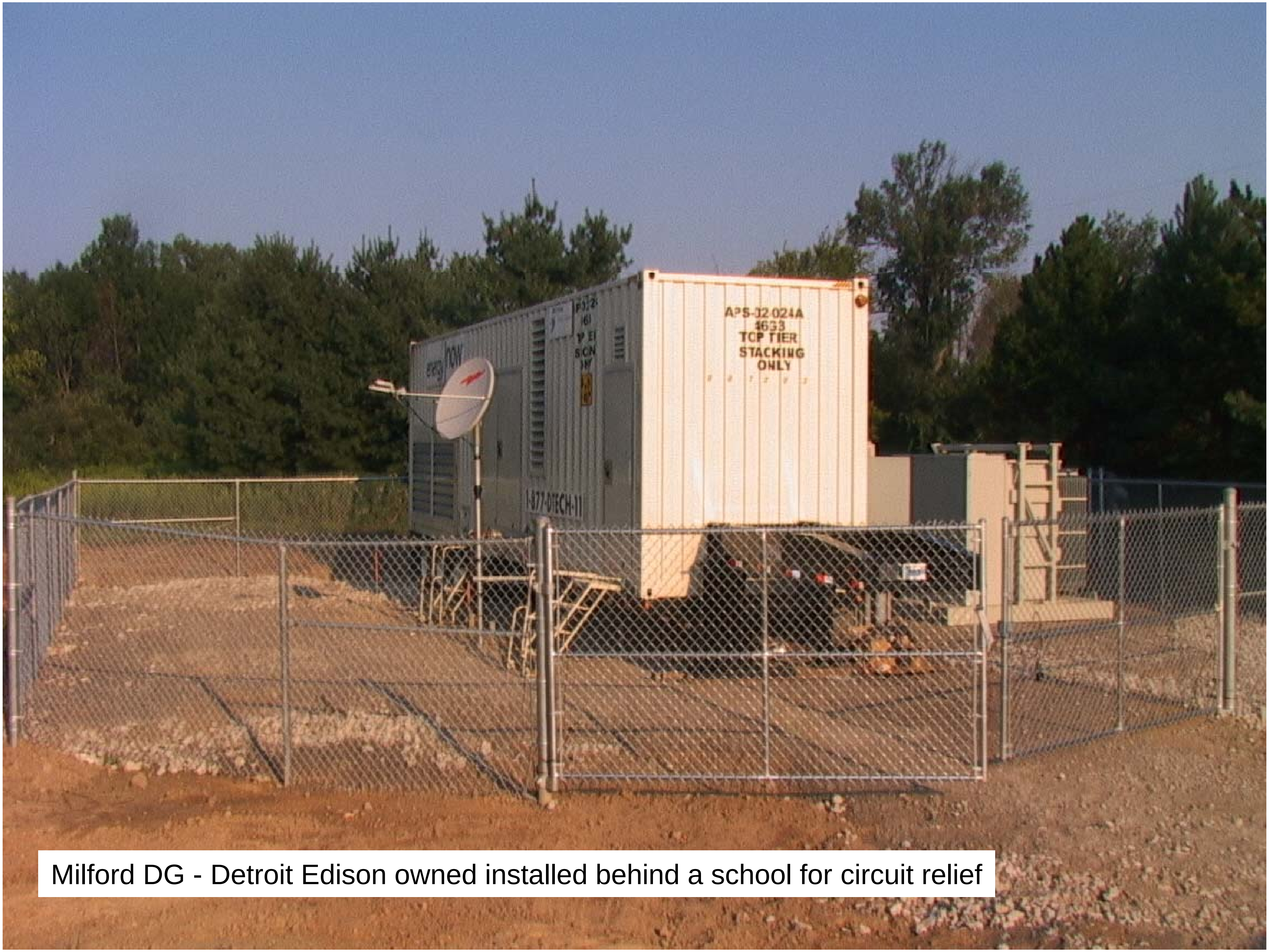
Digi Port Server

Comm board (supports fiber or serial)

Kyle Recloser (P6) with SubGate

Slip-On Bushing CT

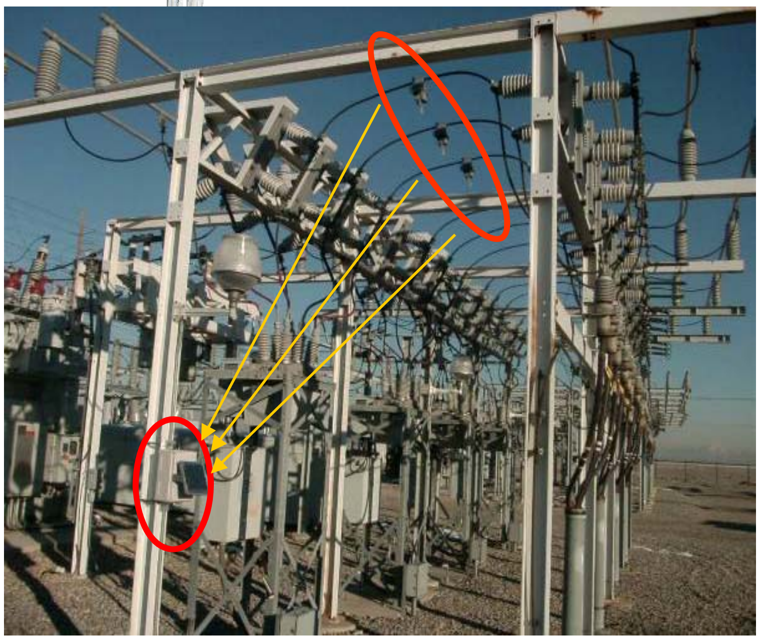
SelectComm module



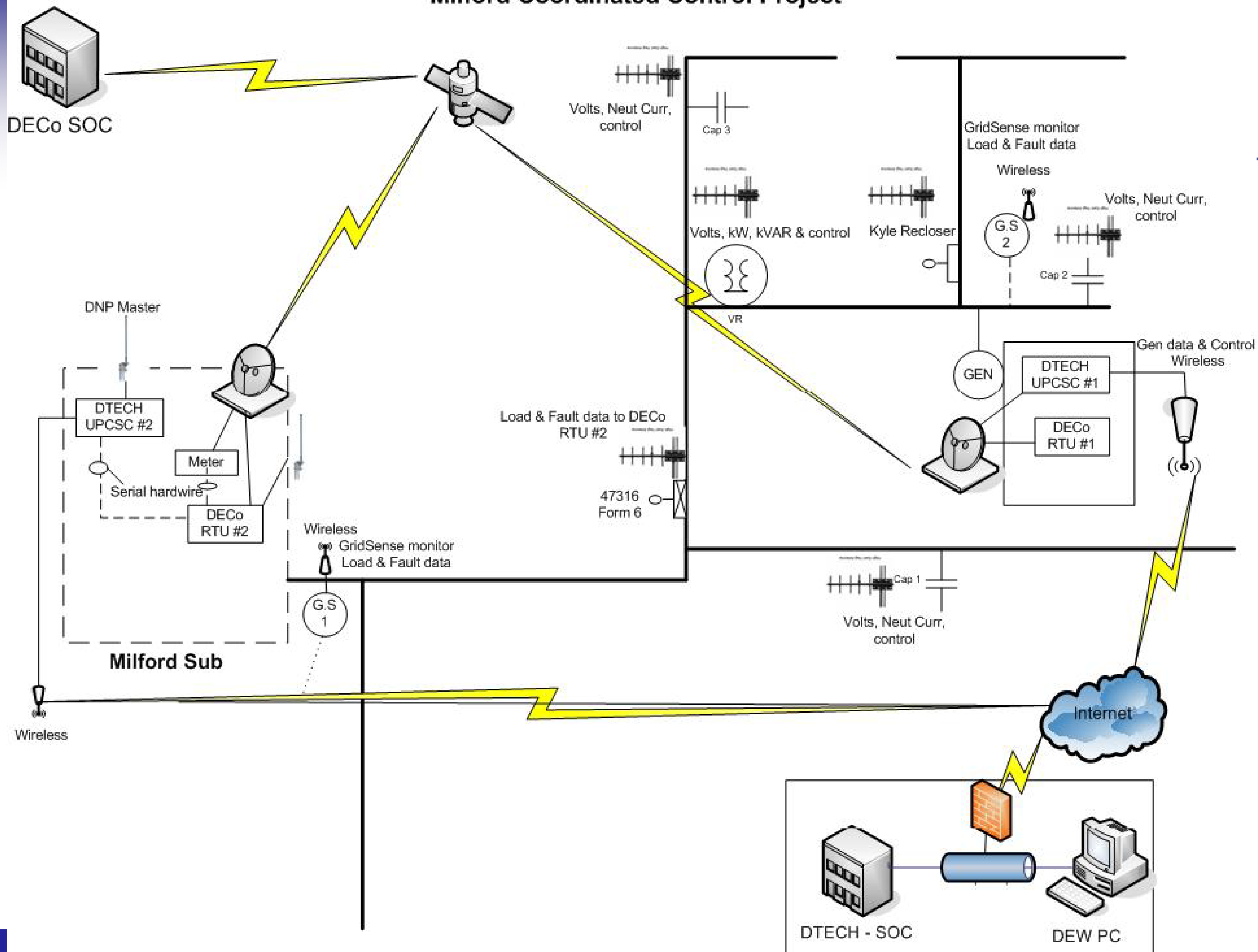
Milford DG - Detroit Edison owned installed behind a school for circuit relief

GridSense

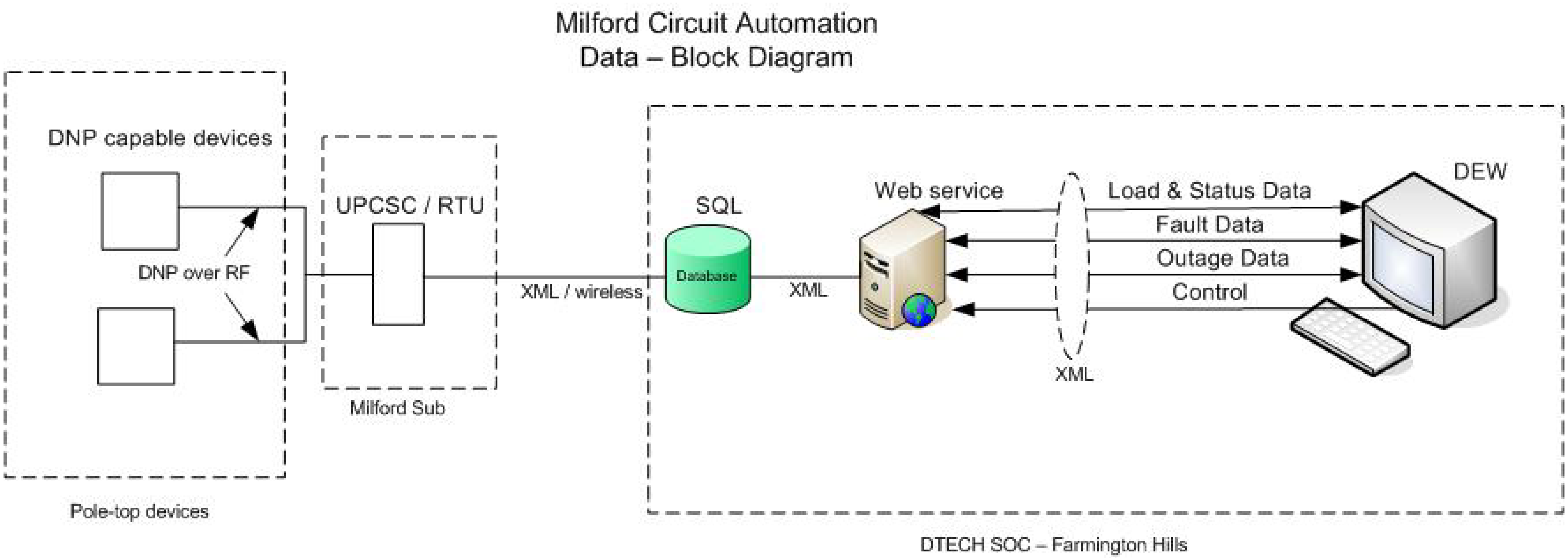
Installed 2 GridSense 3 phase sets of Line Trackers for monitoring and fault location

Milford Coordinated Control Project



Data Transfer Overview



Coordinated Control Introduction

Model Validation
or
How good is the model?

NREL/CEC Voltage Regulation Results

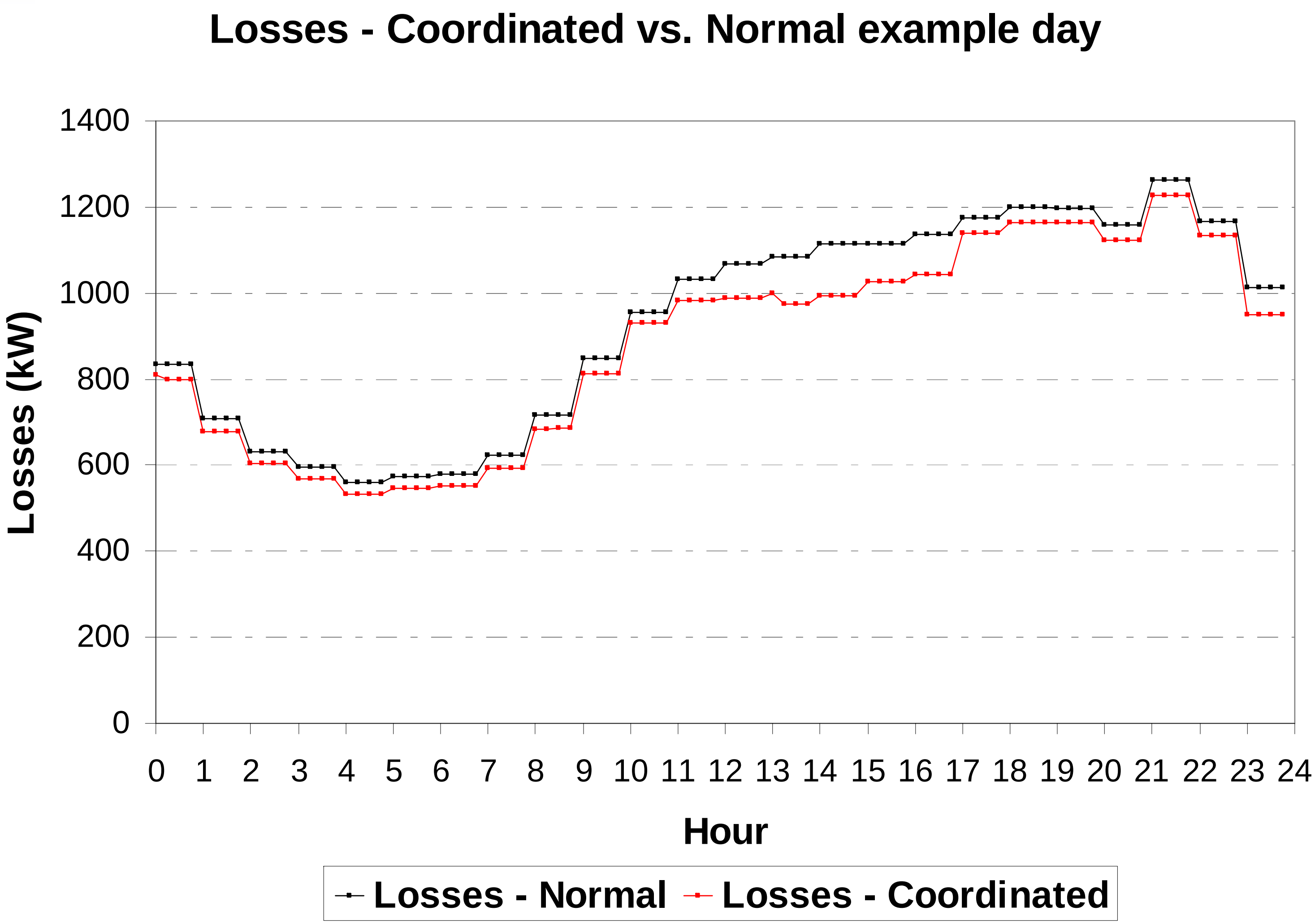
Milford Field Verification
Less than 4% error internal to circuit

The table below shows the circuit peak day (7/17/06 at 17:43) percent variance between the field measured data and the simulated data for the major locations on the circuit.

Location	Node	Current	Voltage	P.F.
Start of circuit	**1**	**2.2%**	**0.3%**	**5.7%**
Generator	**10**	**2.3%**	**1.1%**	**0.0%**
Voltage Regulator	**9**	**3.7%**	**0.2%**	**2.4%**
Capacitor 1	**6**	**3.0%**	**0.7%**	**--**
Capacitor 2	**12**	**2.0%**	**1.5%**	**--**
Capacitor 3	**13**	**3.9%**	**1.2%**	**--**

The variance indicates the simulation data closely matches the measured data and is less than 4% for most comparisons.

Study Mode - Loss Savings



Estimated Loss savings $5K per year

Study Mode - Released Capacity