

MICROGRID CONTROLS

IDEA 2016 ANNUAL CONFERENCE

AGENDA

Overview

Case Study #1 – FDA Campus

Case Study #2 – University of Minnesota

Challenges

Recap/Takeaways

Why a Microgrid Control System?

- Black Start Sequencing
- Parallel / Island Mode Operation
- Automatic Synchronization
- Power Import / Export Control
- Load Shed and Load Restoration
- Alarming and monitoring.

What is a Microgrid Control System?

- Industrial control systems - Programmable Logic Controller (PLC) based.
- Fast response time (in the millisecond range).
- Coupled with an industrial SCADA software package for operator interface and data acquisition purpose.
- Manual control panel(s) to provide control of the microgrid in the event of a loss of the PLC controller.

Key Design Considerations

- Response Time
- Level of Redundancy
- Operator Interface
- Manual Control
- Contractual / Interconnect Agreement with Utility Provider

Case Study #1

FDA Campus White Oak, MD

FDA Central Utility Plant (CUP)



FDA White Oak Campus



CUP-2

CUP-1

SOUTH

CUP-2

- (2) 7.5MW CTG's
- (1) 4.5MW CTG
- (1) 5MW STG
- (2) 2.25MW engine
- (2) HRSG's
- (3) 2,250Ton Centrifugal Chillers
- (1) 2,200Ton Centrifugal Chiller
- (1) 2-Million Gal TES
- (1) 25KPPH Steam Backup Boiler

SE Quad

- (19) Bldg. Breakers

CUP-1

- (4) 4.5MW CTG
- (1) 5.8MW engine
- (2) 2MW engines
- (2) 1,100Ton Absorption Chillers
- (2) 1,100Ton Centrifugal Chillers
- (2) 2,000Ton Centrifugal Chillers
- (3) 14MMBtu/Hr. Waste Heat Boilers
- (3) 10MMBtu/Hr. Backup Boilers





- Load Management System (LMS)
- Power Management System (PMS)
- Manual Control Panel
- Building Load Shed Systems



LMS – Load Management System

- 13.8kV loss-of-source load shedding
- Restoration of 480V loads.
- Load imbalance load shedding at the 480V or 13.8kV level.
- Capacity based load shedding.
- Reactive tie line control.
- 480V breaker shed and restoration control at the building level (19 remote locations).
- Operator assigned breaker priority.

PMS – Power Management System

- Black Start Sequencing.
- Parallel/Islanding Sequencing to automatically sequence breakers and generators.
- Automatic synchronization.
- Import / Export Control and Spinning reserve maintenance.
- Chiller load inhibiting.
- Inter CUP Load Sharing.
- Proactive Tie Line Control.
- Bumpless transfer between manual and automatic generator control.
- Manual synchronization.

Manual Control Panel

- Equipped with analog meters, status lights, and physical switches.
- Allows operators to perform manual breaker control and synchronization of generators, bypassing the LMS and PMS for added redundancy.
- Five (5) separate sections:
 - Main Synch Panel
 - CUP-1 Synch Panel
 - CUP-2 Synch Panel
 - CUP-1 Generator Panel
 - CUP-2 Generator Panel

Manual Control Panel



1. CUP1 Generator Control
2. CUP1 Manual Sync Control
3. Main Sync Control
4. CUP2 Manual Sync Control
5. CUP2 Generator Control



Building Load Shed Control

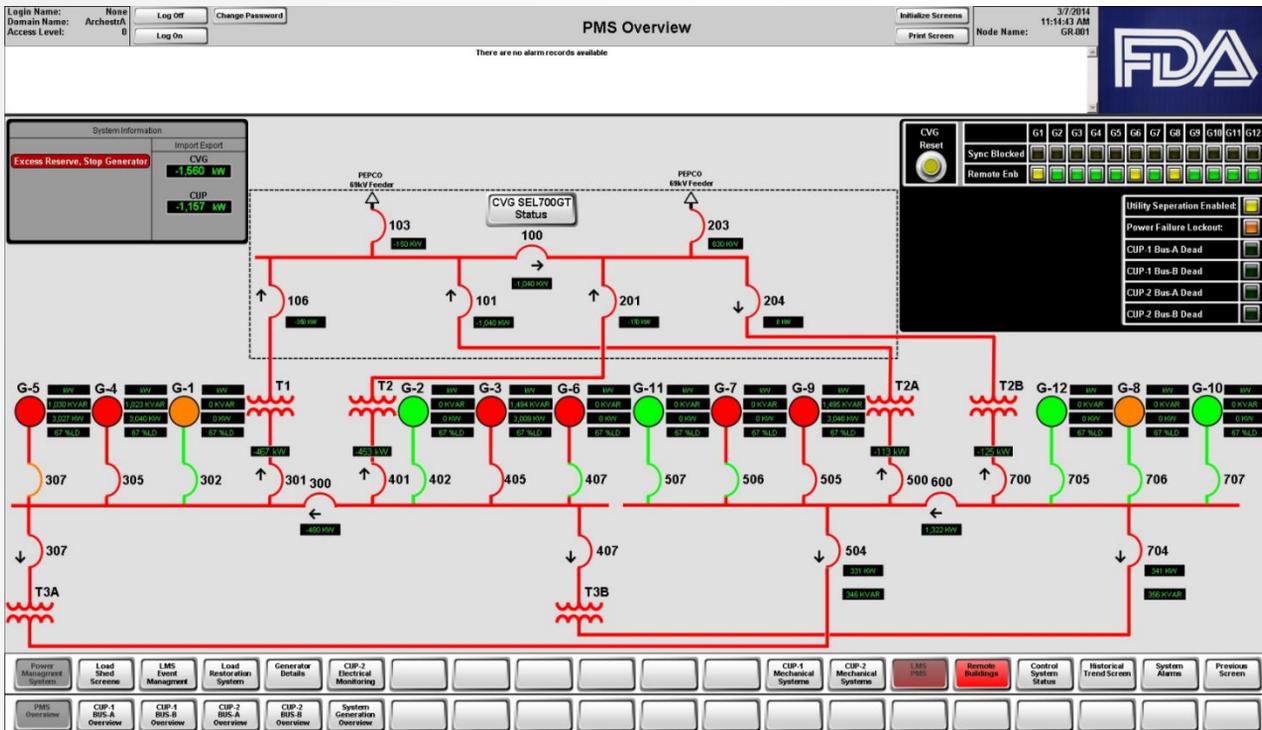
- Nineteen (19) control panels located at each remote building.
- Communicates with PMS/LMS over an Ethernet Ring over Fiber.
- Trips and closes building level breakers based on load shed sequence logic resides in LMS/PMS.
- Each panel has its own PLC processor for added redundancy.

Summary of Microgrid Controls and Automation Equipment

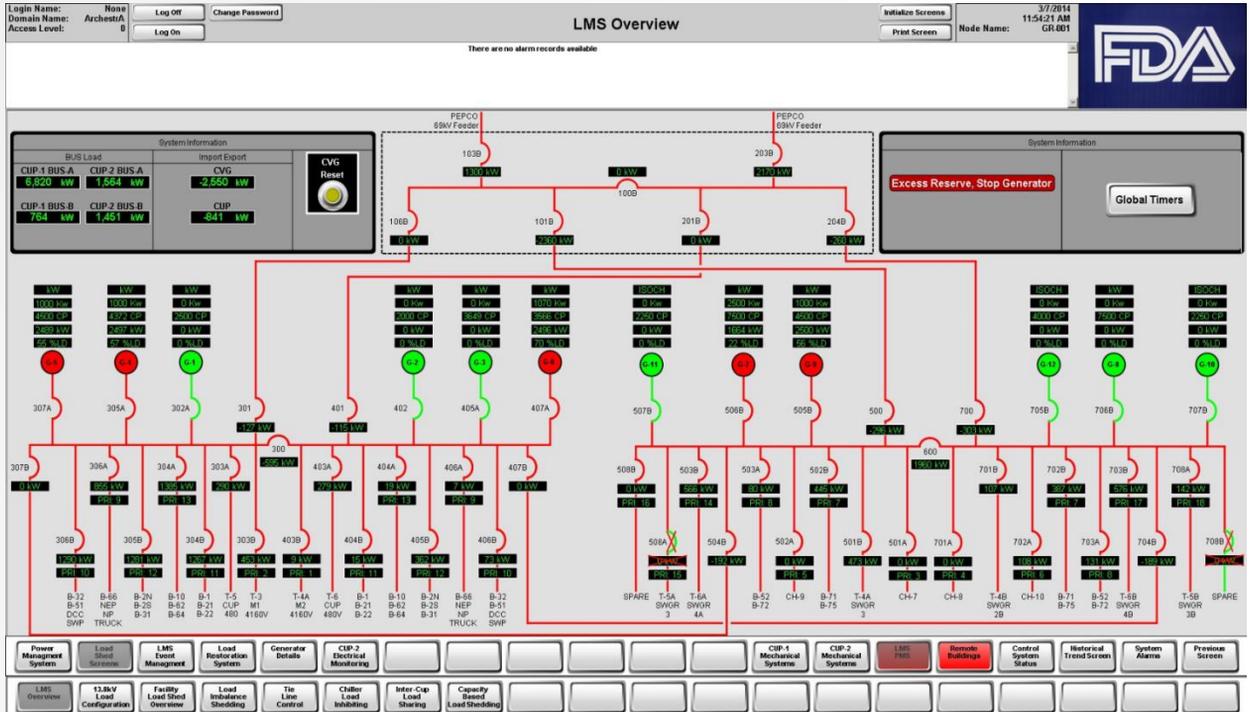


- Plant Control System (PCS) CUP-2:
 - one (1) redundant ControlLogix PLC
 - four (4) remote IO (RIO) panels
- PMS/LMS CUP-1:
 - one (1) RIO panel (PMS)
 - one (1) ControlLogix PLC panel (LMS)
- Manual Control Panel:
 - Five (5) section enclosure
 - one (1) Redundant ControlLogix PLC panel (PMS)
- PMS/LMS CUP-2:
 - one (1) RIO panel (PMS)
 - one (1) ControlLogix PLC panel (LMS)
- Remote Buildings:
 - nineteen (19) CompactLogix PLC panels w/ local displays
- CVG:
 - one (1) CompactLogix PLC

Microgrid Controls Operator Interface



Microgrid Controls Operator Interface



Microgrid Controls Operator Interface



Login Name: None
 Domain Name: ArchestrA
 Access Level: 0

13.8kV Load Configuration

3/7/2014
 11:13:21 AM
 GR001

There are no alarm records available

Load Shed Only Reclosing of 13.8kV Breakers
 Enable Disable

Cup LV Feeder Breaker Re-closing

Reconfiguration Timer
 55 Sec

Name	Loads Serviced	Load	Default Load	Priority	Disable	Available
403B	T-4A / M2 / 4160V	10 kW	1,000 kW	1	<input type="radio"/>	<input checked="" type="radio"/>
303B	T-5 / T-6 480V	464 kW	600 kW	2	<input type="radio"/>	<input checked="" type="radio"/>
601A	CH-7	0 kW	1,000 kW	3	<input type="radio"/>	<input checked="" type="radio"/>
701A	CH-8	0 kW	1,000 kW	4	<input type="radio"/>	<input checked="" type="radio"/>
602A	CH-9	127 kW	1,000 kW	5	<input type="radio"/>	<input checked="" type="radio"/>
702A	CH-10	123 kW	1,000 kW	6	<input type="radio"/>	<input checked="" type="radio"/>
602B / 02B	B-7 / 175	806 kW	1,200 kW	7	<input type="radio"/>	<input checked="" type="radio"/>
603A / 03A	B-8 / 272	296 kW	1,200 kW	8	<input type="radio"/>	<input checked="" type="radio"/>
606A / 06A	B-66 / NE / NP / TRUCK	850 kW	1,200 kW	9	<input type="radio"/>	<input checked="" type="radio"/>
606B / 06B	B-32 / 6 / D / C / SWB	1,336 kW	1,200 kW	10	<input type="radio"/>	<input checked="" type="radio"/>
604B / 04B	B-1 / 2 / 122	1,286 kW	1,200 kW	11	<input type="radio"/>	<input checked="" type="radio"/>
606B / 06B	B-2 / N2 / 5 / 31	1,529 kW	1,200 kW	12	<input type="radio"/>	<input checked="" type="radio"/>
604A / 04A	B-10 / 6 / 264	1,399 kW	1,200 kW	13	<input type="radio"/>	<input checked="" type="radio"/>
608B	T-6A / SWGR-3	596 kW	0 kW	14	<input type="radio"/>	<input checked="" type="radio"/>
608A	T-5A / SWGR-3	0 kW	0 kW	15	<input type="radio"/>	<input checked="" type="radio"/>
608B	SPARE	0 kW	0 kW	16	<input type="radio"/>	<input checked="" type="radio"/>
708B	T-6B / SWGR-4B	596 kW	0 kW	17	<input type="radio"/>	<input checked="" type="radio"/>
708A	T-5B / SWGR-3B	159 kW	1,000 kW	18	<input type="radio"/>	<input checked="" type="radio"/>
708B	SPARE	0 kW	1,000 kW	19	<input type="radio"/>	<input checked="" type="radio"/>

Event To Disable
 Loss of 401 Disable
 Loss of 301 Disable
 Loss of 500 Disable
 Loss of 700 Disable
 Loss of 300 Disable
 Loss of 600 Disable
 Loss of 504 or 307B Disable
 Loss of 704 or 407B Disable
 Loss of G1 Disable
 Loss of G2 Disable
 Loss of G3 Disable
 Loss of G4 Disable
 Loss of G5 Disable
 Loss of G6 Disable
 Loss of G7 Disable
 Loss of G8 Disable
 Loss of G9 Disable
 Loss of G10 Disable
 Loss of G11 Disable
 Loss of G12 Disable

Disable

Generator Loss Load Shed Disable / Enable
 Enable Disable
Disabled

Load Shed Status
 CUP1 Bus A Load Shed
 Inactive Disabled Enable Command

CUP1 Bus B Load Shed
 Inactive Disabled Enable Command

CUP2 Bus A Load Shed
 Inactive Disabled Enable Command

CUP2 Bus B Load Shed
 Inactive Disabled Enable Command

Shed Event Alarm **Shed Event Alarm Ack**

Shed Offset
 0 kW

Power Management System

Load Shed Screens

LMS Event Management

Load Restoration System

Generator Details

CIP-2 Electrical Monitoring

CIP-1 Mechanical System

CIP-2 Mechanical System

LMS PMS

Remote Buildings

Control System Status

Historical Trend Screens

System Alarms

Previous Screens

LMS Overview

13.8kV Load Configuration

Facility Load Shed Overview

Load Imbalance Shedding

Tie Line Control

Chiller Load Inhibiting

Inter-Cup Load Sharing

Capacity Based Load Shedding

Microgrid Controls Operator Interface



Login Name: keithc
Domain Name: FDA_CUP
Access Level: 9999

Log Off
Log On

Change Password
Admin Data

Generator Control Panel

Initialize Screens
Print Screen

Node Name: 2/12/2014 11:24:47 AM OWS-001

2/12/2014 11:24:42 AM G18_SYNCAlarms_PIM_Comm_Failed	PIM_System	G18-707: Communication Failure To Protective Relay	Normal	UNBRK_RTR	500
2/12/2014 11:25:06 AM BCC_COP_System_Invokd_CMRMode	BrkDCC	Switch Status Object Mode (0-Normal 1-CallerAlarm)	Normal	UNBRK_RTR	200
2/12/2014 18:29:26 AM Load_Share_Stat2.SYVICMax_Alarm	LMS_System	CIP-1 & CIP-2 Both Paralleled To The Utility: Max Alarm Status	Alarm	UNBRK	500
2/12/2014 18:27:38 AM GEN7.SYVICStatus.VWithin_H0x_Limit	Generators1_52	Generator 7: Within H0x Limit Status	Not Within	UNBRK	500
2/12/2014 18:27:38 AM GEN7.SYVICAlarms.Fault	Generators1_52	Generator 7: General Fault	Alarm	UNBRK	500

CUP-1 GENERATORS

GEN1	GEN2	GEN3	GEN4	GEN5	GEN6
kW	kW	kW	kW	kW	kW
0 kW	0 kW	4678 kW	4524 kW	4673 kW	0 kW
0kVAR	0kVAR	2297kVAR	1510kVAR	1563kVAR	0kVAR
0AMPS	0AMPS	160AMPS	117AMPS	153AMPS	0AMPS
4900CAP	0CAP	4300CAP	4500CAP	4500CAP	4900CAP
0% LD	0% LD	100% LD	101% LD	100% LD	0% LD
Start/Stop	Start/Stop	Start/Stop	Start/Stop	Start/Stop	Start/Stop
Line Control					
E-Stop	E-Stop	E-Stop	E-Stop	E-Stop	E-Stop
Fault	Fault	Fault	Fault	Fault	Fault

BLUE
RUNNING

RED
BREAKER
CLOSED

CLEAR
READY TO
SYNC

GREEN
READY TO
RUN

CUP-2 GENERATORS

GEN7	GEN8	GEN9	GEN10	GEN11	GEN12
kW	kW	kW	ISOCH	ISOCH	ISOCH
0 kW					
0kVAR	0kVAR	0kVAR	0kVAR	0kVAR	0kVAR
0AMPS	0AMPS	0AMPS	0AMPS	0AMPS	0AMPS
7900CAP	7900CAP	4900CAP	2250CAP	2250CAP	7900CAP
0% LD					
Start/Stop	Start/Stop	Start/Stop	Start/Stop	Start/Stop	Start/Stop
Line Control					
E-Stop	E-Stop	E-Stop	E-Stop	E-Stop	E-Stop
Fault	Fault	Fault	Fault	Fault	Fault

Power Management System	Load Management System	LMS Event Management	Electrical Systems Restoration	Generator Control	CIP-2 Electrical Monitoring						CIP-1 Mechanical Systems	CIP-2 Mechanical Systems	LMS Tools	Permits Building	Control System Status	Historical Trend Screen	System Alarms	Previous Screen
Generator Control Panel	Generator 1 Overview	Generator 3 Overview	Generator 4 Overview	Generator 5 Overview	Generator 6 Overview	Generator 7 Overview	Generator 8 Overview	Generator 9 Overview	Generator 10 Overview	Generator 11 Overview	Generator 12 Overview	CIP-1 Generator Control						



Microgrid Controls Operator Interface



Login Name: None
Domain Name: ArchveA
Access Level: B

Log Off Change Password

Log On

System Generation Status

There are no alarm records available

Initialize Screens 3/7/2014 11:26:19 AM
Print Screen GR001

Node Name:

Generator	Spinning Reserve Priority	kW Setpoint	Total Real Power	Capacity Used	Spinning Reserve	Mode	Available	Reserve
GEN1	2	70 %	0 kW	2,500 kW	0 kW	kW Mode	●	0 kW
GEN2	1	26 %	0 kW	2,000 kW	0 kW	kW Mode	●	0 kW
GEN3	4	53 %	2,726 kW	3,649 kW	928 kW	kW Mode	●	928 kW
GEN4	5	53 %	2,751 kW	4,372 kW	1,000 kW	kW Mode	●	1000 kW
GEN5	6	53 %	2,762 kW	4,500 kW	1,000 kW	kW Mode	●	1000 kW
GEN6	3	15 %	930 kW	3,566 kW	1,500 kW	kW Mode	●	1500 kW
GEN7	10	91 %	0 kW	7,500 kW	0 kW	kW Mode	●	0 kW
GEN8	11	30 %	0 kW	7,500 kW	0 kW	kW Mode	●	0 kW
GEN9	9	53 %	2,754 kW	4,500 kW	1,000 kW	kW Mode	●	1000 kW
GEN10	7	100 %	0 kW	2,260 kW	0 kW	Isoch Mode	●	0 kW
GEN11	8	85 %	0 kW	2,260 kW	0 kW	Isoch Mode	●	0 kW
GEN12	12	19 %	0 kW	500 kW	0 kW	Isoch Mode	●	0 kW

Spinning Reserve System

Spinning Reserve System 0 kW

CUP-1 Bus-A 46,347 kW

CUP-1 Bus-B 46,347 kW

CUP-2 Bus-A 46,347 kW

CUP-2 Bus-B 46,347 kW

Bkr-301 Reserve 10,414 kW

Bkr-401 Reserve 10,407 kW

Bkr-500 Reserve 10,042 kW

Bkr-700 Reserve 10,056 kW

Maintain Spinning Rsv

Disable Enable

Disabled

G-12 Reserve Usage

Don't Use Use

Not Using G-12 Reserve

Time Between Gen Start Preset

15 Sec

Maintain Spin Reserve Alarms

	Reset		Reset
CUP-1 Gen Start	<input type="checkbox"/>	Bus-A Bus-C Gen Start	<input type="checkbox"/>
CUP-1 Bus-A Gen Start	<input type="checkbox"/>	Bus-A Bus-B Bus-C Gen Start	<input type="checkbox"/>
CUP-1 Bus-B Gen Start	<input type="checkbox"/>	Bus-A Bus-B Bus-D Gen Start	<input type="checkbox"/>
CUP-2 Gen Start	<input type="checkbox"/>	Bus-A Bus-C Bus-D Gen Start	<input type="checkbox"/>
CUP-2 Bus-A Gen Start	<input type="checkbox"/>	Bus-B Bus-C Gen Start	<input type="checkbox"/>
CUP-2 Bus-B Gen Start	<input type="checkbox"/>	Bus-B Bus-D Gen Start	<input type="checkbox"/>
CUP-1 CUP-2 Gen Start	<input type="checkbox"/>	Bus-B Bus-C Bus-D Gen Start	<input type="checkbox"/>

Power Management System	Load Shed Screens	LMS Event Management	Load Distribution Systems	Generator Details	CIP-2 Electrical Monitoring	CIP-1 Mechanical Systems	CIP-2 Mechanical Systems	LMS Tools	Recycle Buildings	Control System Status	Historical Trend Screens	System Alarms	Previous Screens
PMS Overview	CIP-1 BUS-A Operator	CIP-1 BUS-B Operator	CIP-2 BUS-A Operator	CIP-2 BUS-B Operator	System Generation Operations								

Microgrid Controls Operator Interface



Login Name: None
 Domain Name: Archesta
 Access Level: 0

Log Off
 Change Password
 Log On

Building Breaker Configuration

Initialize Screens

3/7/2014
 11:21:36 AM
 GR-001

Print Screen

Node Name:



There are no alarm records available

Name	Critical	Sev Type	Pri	Rest Time	Max kW	Min kW	Aut To	Stk	Shd	Enb	Aut To	Rest	L	D	Rest	Enb
DCC-GSHP	---		1	0	50	30										
FCB6-A18			2	0	50	20										
FCB6-A11			3	0	50	40										
FCB6-A40			4	0	50	40										
FCB6-A24			5	0	50	40										
FCB6-WP-A1			6	0	25	10										
FCB6-WP-A1			7	0	25	10										
FCB7-B11		R	8	3065	110	90										
FCB7-B13		L	9	3060	37	30										
FCB7-B12		L	10	3055	37	30										
FCB7-LB11		M	11	3050	73	60										
FCB7-LB10		R	12	3045	147	125										
FCB7-LB09		R	13	3040	37	30										
FCB7-LB08		M	14	3035	147	125										
FCB7-LB07		M	15	3030	147	125										
FCB7-LB06		M	16	3025	147	125										
FCB7-LA11		L	17	3020	55	45										
FCB7-LA10		R	18	3015	168	150										
FCB7-LA07		M	19	3010	112	100										
FCB7-LA02		M	20	3005	224	200										
FCB7-LA01		R	21	3000	168	150										
FCB6-B13		R	22	2765	22	15										
FCB6-B14		M	23	2760	53	45										
FCB6-B12		L	24	2755	18	15										
FCB3-A23		MDS	25	2705	26	20										
FCB6-B11		R	26	2750	22	15										
FCB3-B10		R	27	2745	26	20										
FCB6-B10		M	28	2745	53	45										
FCB3-B10		K	29	2750	14	10										
FCB6-B08		L	30	2740	18	15										
FCB3-B14		M	31	2745	42	35										
FCB6-B07		R	32	2735	22	15										
FCB3-B13		L	33	2740	14	10										

Reconfiguration: Enable Disable

20 Min Load Restore Threshold: Pri:

Sort Mode: Sort By:

Service Name Descriptions

Building Electrical Systems: Building LMS Systems: Building Electrical System: Building LMS System: Control System Status: Historical Trend Screen: Systems Alarms: Previous Screens



www.thermosystems.com

Microgrid Controls Operator Interface



Login Name: default Login **Current User Has View Only Access** Friday, March 07, 2014 12:02:50 PM

Exit To Windows Change Password Logout **MODE CONTROL**

MANUAL ISLAND MODE TRANSFER

UTILITY ISLAND

UTILITY CUP-1 UTILITY CUP-2 CUP-1 ISLAND CUP-2 ISLAND

UTILITY CONNECTED

ISLAND MODE NOT AVAILABLE BECAUSE:
ISLAND MODE CONTROL IN AUTO
FACILITY ISLANDED
INSUFFICIENT SPINNING RESERVE

UTILITY MODE NOT AVAILABLE BECAUSE:
ISLAND MODE CONTROL IN AUTO
FACILITY NOT ISLANDED

IMPORT / EXPORT CONTROL

ISLAND EXPORT LEVEL: 200 kW
CUP# EXPORT LEVEL: -929 kW 1000 SP

Negative-Export; Positive-Import

ISLAND MODE CONTROL

AUTO MAHUAL

OVERRIDE 100% SPINNING RESERVE

ON OFF

PARALLEL SPLIT SEQUENCE DISABLE

ENABLE DISABLE

SWITCH TO UTILITY ON UNIT FAILURE

ENABLE DISABLE

UTILITY RECLOSE TIMER PRESET (SEC): 5

ELECTRICAL OVERVIEW NETWORK OVERVIEW **MODE CONTROL** CUP-1 ACCESSORIES CUP-2 ACCESSORIES SYSTEM HEALTH ALARMS

Case Study #2

University of Minnesota Minneapolis, MN



- 25 MW Combustion Turbine Generator
- 13.8 kV Main Switchgear
- Eleven (11) 13.8kV feeder breakers to CHP plant and campus loads
- Connected to Utility (XCEL) via two (2) main breakers

Single Line Diagram



Log In Name: None
 Domain Name: Archista
 Access Level: 0

Log Off
 Log On

Change Password
 Admin Data

Main CHP One-Line

Initialize Screens
 Print Screen

Node Name: PCS-HIS-01

S:13:08:36
 1:46:29 PM

Generator System	Cooling System	Fuel System	Steam System	Miscellaneous
Value1 #####	Value1 #####	Value1 #####	Value1 #####	Value1 #####
Value2 #####	Value2 #####	Value2 #####	Value2 #####	Value2 #####
Value3 #####	Value3 #####	Value3 #####	Value3 #####	Value3 #####
Value4 #####	Value4 #####	Value4 #####	Value4 #####	Value4 #####

The diagram illustrates the electrical connections for the Main CHP One-Line system. It features a central CTG-1 21 MW generator connected to two MCHP Switchgear units (1 and 2) via busbars. MCHP Switchgear 1 (13.8 KV) includes breakers for MHP-13 (to SE Plant), MHP-12 (to Fulton), MHP-11 (to 4TH Street), and a Spare. MCHP Switchgear 2 (13.8 KV) includes breakers for MHP-22 (to 4TH Street), MHP-23 (to 4TH Street), and a Spare. A central MCHP Generator Circuit Breaker is connected to both switchgear units. The system also includes a 5KV RVSS, a Grounding Transformer, and a Diesel Generator (225 KW / 313 KVA) connected to a Critical Systems Switchboard and a 150 KVA Load Bank. Various transformers (T1A, T2A) and switchboards are also shown.

Facility Overview

Main CHP One-Line

CTG System

Steam System

Fuel System

Cooling System

Chemical System

Miscellaneous Systems

Thermal System

PCS System Status

Historical Trend Screens

Manual Override Alarms

Process Alarms

Pretreat Screens



- Load Management System (LMS)
- Power Management System (PMS)
- Synchronizing Panel



LMS – Load Management System

- 13.8 kV feeder breaker load shed control with priority assignment
- Bus and electrical load distribution connection state management
- Ampacity (A) based load shed response
- Frequency (Hz) based load shed response
- Capacity (kW) based load shed response
- Dead bus detection



PMS – Power Management System

- Manual restoration of feeder breakers after load shed event
- Feeder breaker restoration calculation – advisory only
- Plant kW export control with minimum generator load override
- Monitoring and alarming of main switchgear



Synchronizing Panel

- Monitoring and control of the medium-voltage distribution system and onsite generation system.
- Connect and integrate local control between the switchgear, generator, tie breakers, and CTG generator control panels.
- Provide manual and automatic synchronization of generator.

Summary of Microgrid Controls and Automation Equipment



- Plant Control System (PCS) :
 - one (1) redundant ControlLogix PLC
 - Seven (7) remote IO (RIO) panels
- PMS/LMS:
 - one (1) enclosure housing both LMS and PMS ControlLogix PLCs
- Synchronizing Panel:
 - One (1) control panel with synchronizer and manual lights and switches.

CHALLENGES

- Systems can become very complex.
- Keeping it simple enough to operate, yet robust enough to handle many different operating and failure scenarios.
- Contractual/interconnect agreement with utility provider can become a constraint in the design of a microgrid control system.

CHALLENGES

- Testing and commissioning of systems can be difficult to coordinate to cover all failure scenarios.
- Requires partnership between in house electrical systems expertise and control systems vendors with microgrid and power management experience.

RECAP & KEY TAKEAWAYS

- The addition of a LMS/PMS microgrid control system provides fast response to minimize generation overload and critical equipment power loss.
- PLC based LMS/PMS can respond quickly from detection of generation loss to shedding of breakers (< 50 msec).
- Automatic breaker restoration control, if required, can ensure power to critical areas be restored within a short window (< 10 sec) of power loss.

RECAP & KEY TAKEAWAYS

- Manual Control Panel provides operational resiliency, allowing operators to control the generation manually, if required.
- Integration with all generators, protective relays and power meters into a single operator interface allows operators to monitor and operator the system efficiently and reliably.

Q & A