

# Accelerating Acceptance of Fuel Cell Backup Power Systems

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May 15, 2013  
H2RA007



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**Today's Fuel Cells for proven, reliable power.**

## OVERVIEW

### Timeline

- Project start – June 2009
- Project end – September 2013

### Budget

- Total project funding - \$6.7M
- Funding in FY09 - \$2.50M
- Funding in FY10 - \$2.56M
- Funding in FY11 - \$0.80M
- Funding in FY12 - \$0.67M
- Status: 97% Complete

### Barriers

- Cost
- Affordability
- System reliability
- Market volume

### Partners

- Robins AFB
- Ft. Irwin, CA
- Construction Engineering Research Laboratory (CERL)
- IdaTech



## RELEVANCE

- **ARRA Objectives Over Project Life**
  - **Create new jobs as well as save existing ones; spur economic activity**  
**Plug Power - Engineering, Testing, Sales, Marketing, Program Management**
  - **Accelerating the commercialization and deployment of fuel cells, fuel cell manufacturing, installation, maintenance, and support services**  
**Plug Power - Engineering, Testing, Sales, Marketing, Program Management**  
**Supply Chain - DANA, BASF, 3M, etc.**  
**Other Partners – IdaTech, site installation support**
  - **Demonstrate market viability and increase market pull of fuel cell systems within our government customers/partners**  
**Increase distributed power generation - deploy 20 GenSys systems**  
**Improve reliability and efficiency of mission critical backup power (>72 hours)**  
**Decrease fossil fuel dependencies for power generation**

## RELEVANCE

- **Specific Project Objectives During 2013**
  - Successful backup during simulated outage
  - Decommission of 1<sup>st</sup> site
  - Successful permitting of 2<sup>nd</sup> site
  - Commissioning and running of 2<sup>nd</sup> site

## APPROACH

- **Installation and Operation of 2 fleets of 10 backup units**

Task	Project Milestones	Status
1	Project Management and Reporting	60%
2	Site Planning and Application Engineering	100%
3	Site Specific Engineering Development	100%
4a	Fleet 1, Build, Test, Ship	100%
4b	Fleet 2, Build, Test, Ship	100%
5	Fleet Operations and Reporting	60%
6	Reporting	60%
7	Project Closeout	0%

## APPROACH

**GenCore.**

### Backup Power

- Hydrogen fueled
- Start time < 1 minute
- Run time = 4 hours



**GenSys™**

### Extended Backup Power

- LPG fueled
- Readily available backup
- **Run time = indefinite**



**GenSys™**

### Continuous Power

- LPG fueled
- Start time = 3 hours
- Run time = indefinite



## APPROACH

- Over the past 4+ years, Plug Power has remained determined to use the program to move the fuel cell market forward in the face of changes within the company and fuel cell industry.



### Plug Power Development

#### 2009-2010: Plug Power lead on Internal Customer Acceptance Testing

*5/10: PP “focus commercial activity on material handling market”  
10/10: PP licensed stationary power technology to IdaTech*



### Collaboration with IdaTech

#### 2010-2012: Plug Power ICAT Testing with IdaTech Field Support and Program Management

- To gain experience with product architecture and problem set; design changes for next iteration
- To gain experience with field service

*5/12: Ballard acquires IdaTech product lines*

- As of the acquisition, IdaTech ceased to be a program partner.

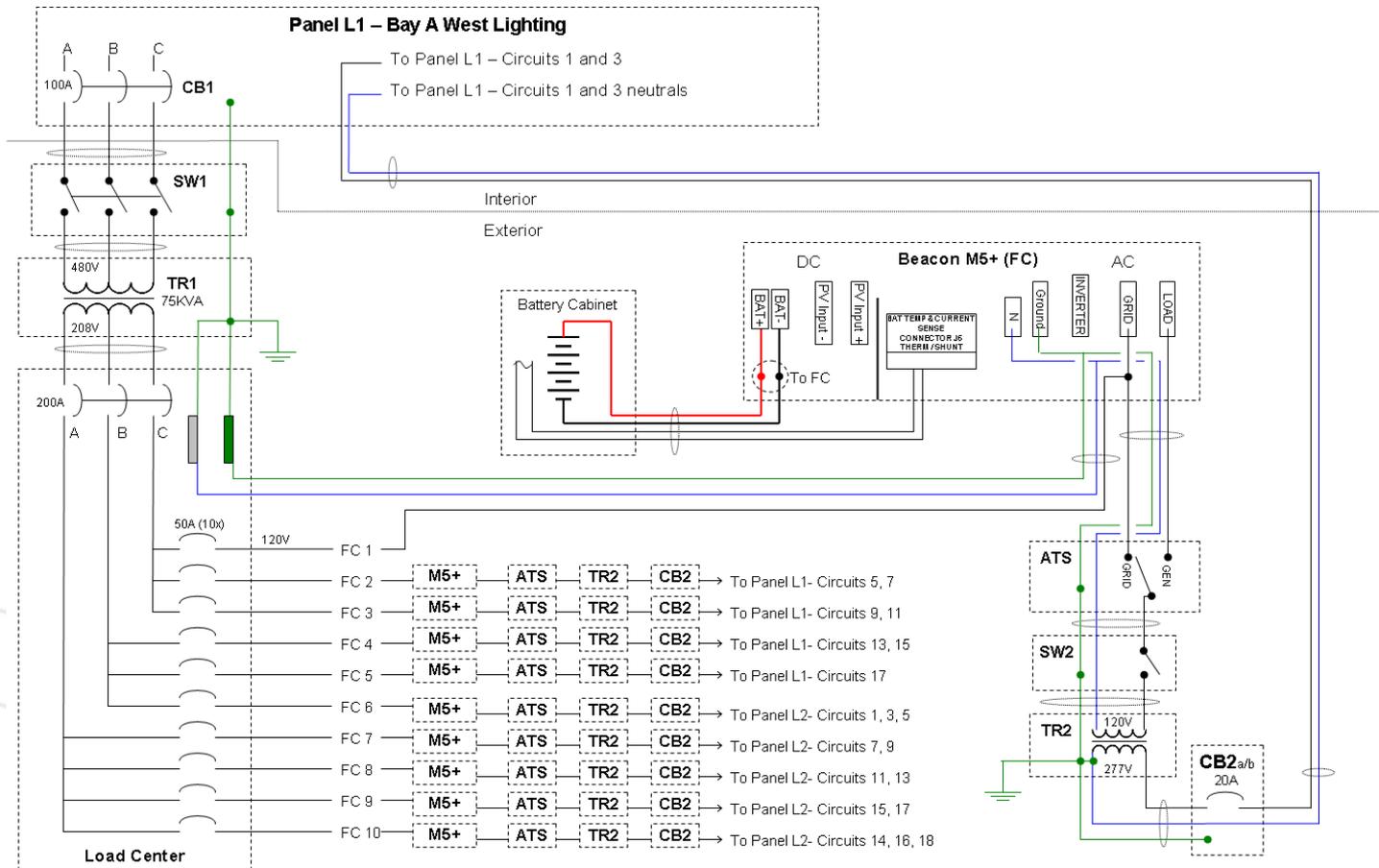
## APPROACH - FLEET 1: ROBINS AIR FORCE BASE

- **Site Identification**
  - Defense Distribution Depot - Robins AFB (DDWG)
  - Backup lighting at Air Logistics Center



# APPROACH - FLEET 1: ROBINS AIR FORCE BASE

- **Site Planning**
  - **Systems provided backup to 3 different load circuits**



# APPROACH - FLEET 1: ROBINS AIR FORCE BASE

- Installation



## APPROACH - FLEET 1: ROBINS AIR FORCE BASE

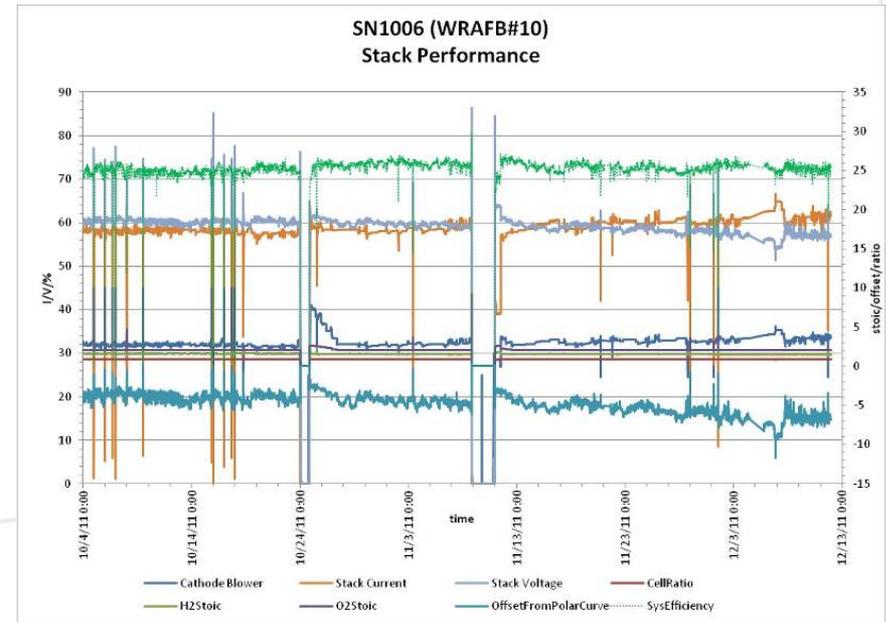
- **Operation**
  - **13,506 operating hours**
  - **39.07 MW-hr electricity produced**
  - **Electrical efficiency = 25.4%**



# APPROACH - FLEET 1: ROBINS AIR FORCE BASE

- Demonstration / Maintenance**

- Reviewed stack performance and reformer performance from onboard data collection.
- Identified failure signatures to aid in recovery before shutdown.



## APPROACH - FLEET 2: FT. IRWIN NTC

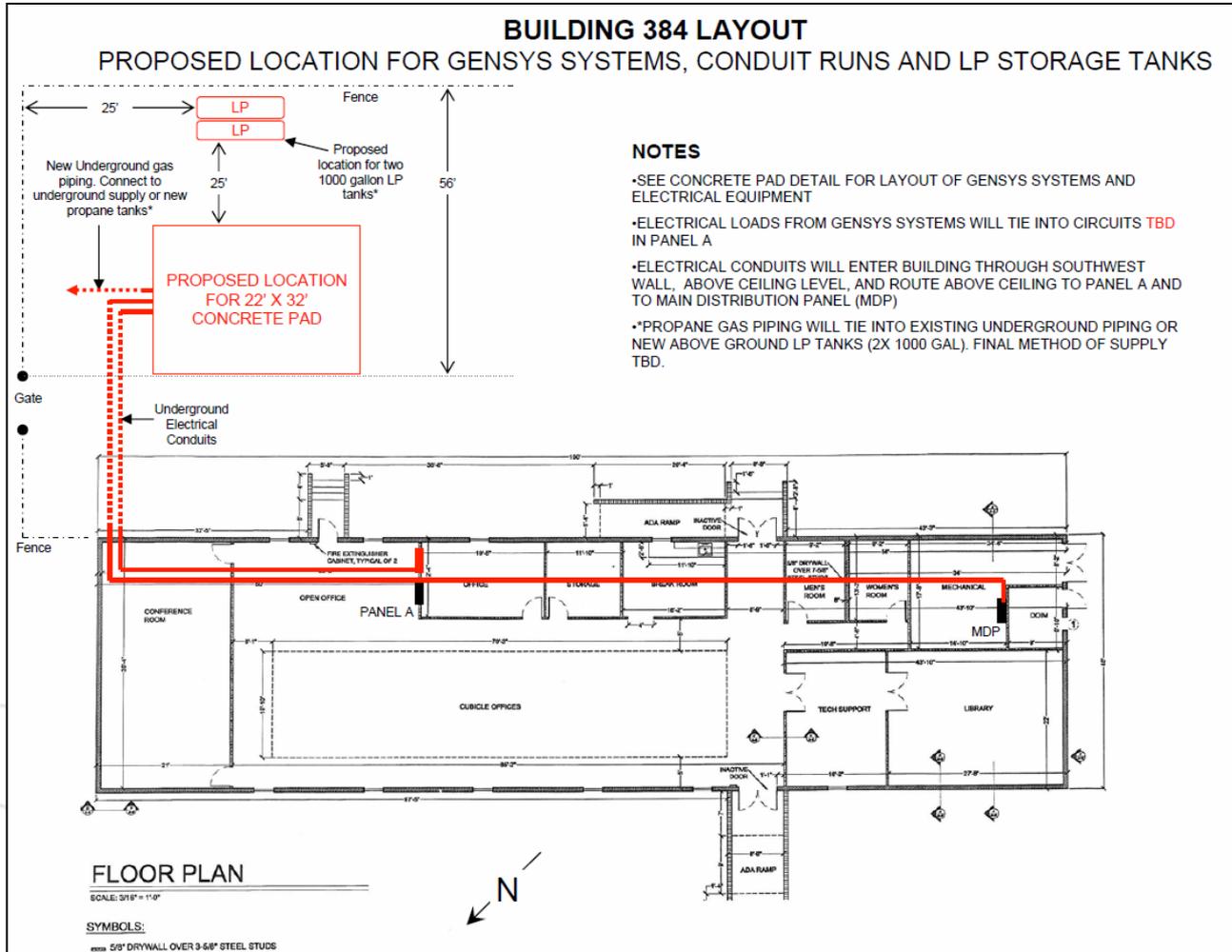
- **Site Identification**

- Engineering building that is critical to be powered if there is an emergency
- There is an interest for this building to have the lowest environmental footprint
- Already include high efficiency lighting and solar light pipes



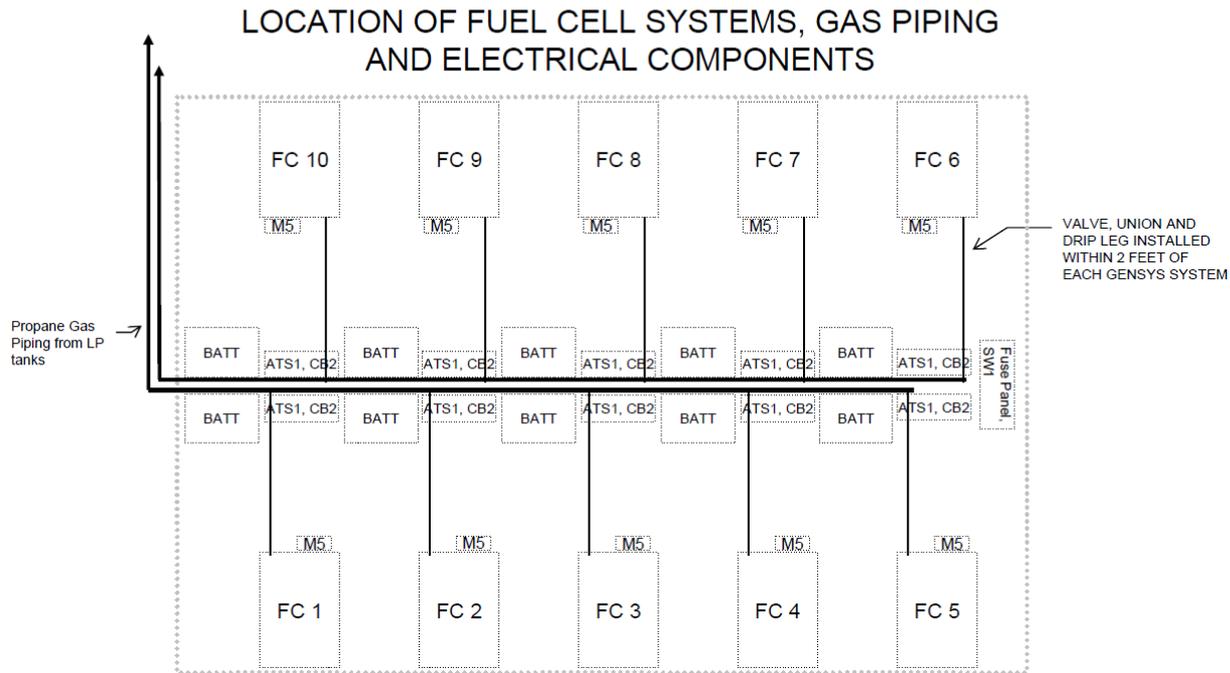
# APPROACH - FLEET 2: FT. IRWIN NTC

- Permit Application: Site Planning



# APPROACH - FLEET 2: FT. IRWIN NTC

- Permit Application: Piping and Electrical Component Diagram**

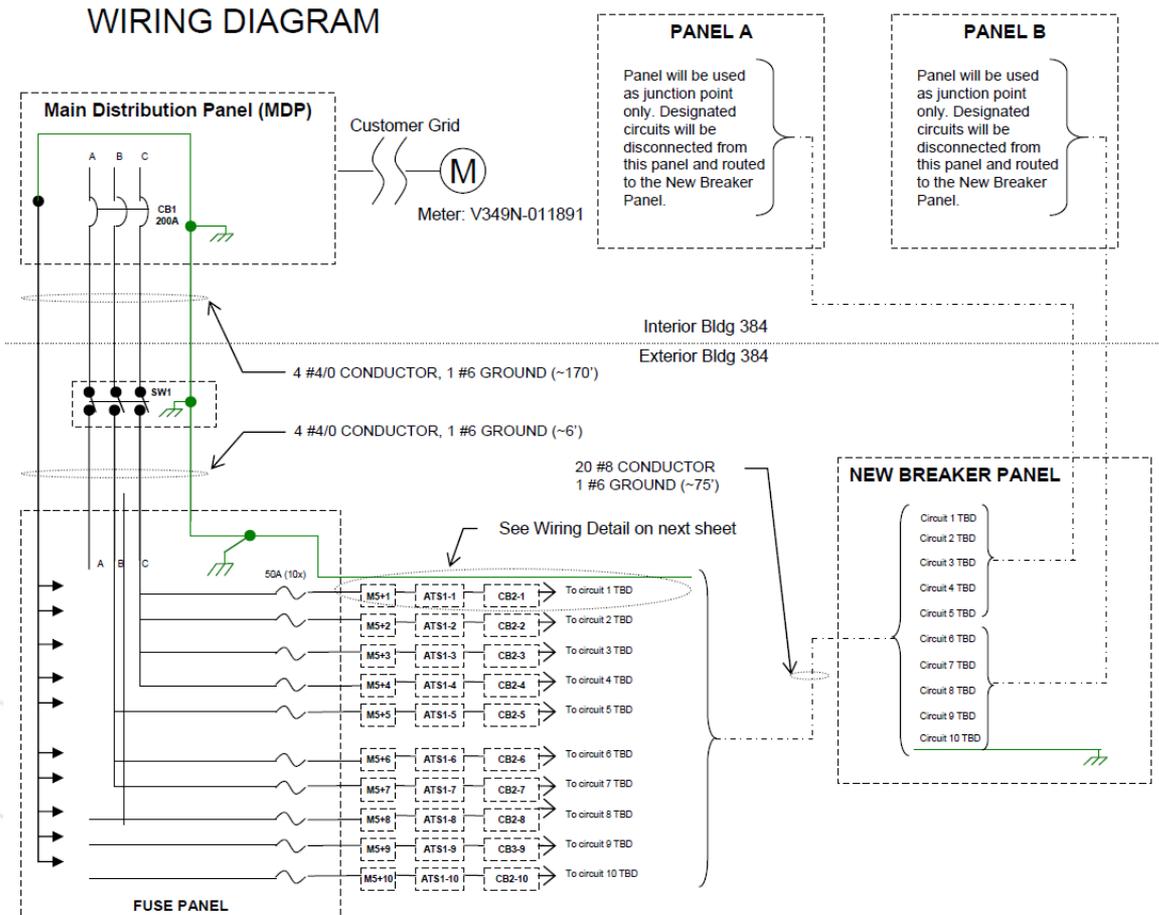


**NOTES**

- TWO 1000 GALLON LP TANKS WILL EACH FEED 5 SYSTEMS
- PIPING WILL BE ROUTED ABOVE GROUND FROM EACH LP TANK TO EDGE OF PAD
- EACH PIPE WILL CONNECT TO ABOVE GROUND HEADER CONNECTED TO 5 SYSTEMS AS SHOWN
- ABOVE GROUND HEADER SHALL BE CONSTRUCTED OF BLACK IRON PIPE AND PAINTED YELLOW
- REGULATORS AND MAIN SHUT OFF VALVES SHALL BE INSTALLED AT THE OUTLET OF EACH LP TANK
- SHUT OFF VALVE, UNION AND DRIP LEG SHALL BE INSTALLED AT THE INLET, WITHIN 2 FEET, OF EACH GENSYS SYSTEM
- GAS PIPING MUST BE SIZED TO PROVIDE 110,000 BTUH @ 6 PSI TO EACH GENSYS SYSTEM

# APPROACH - FLEET 2: FT. IRWIN NTC

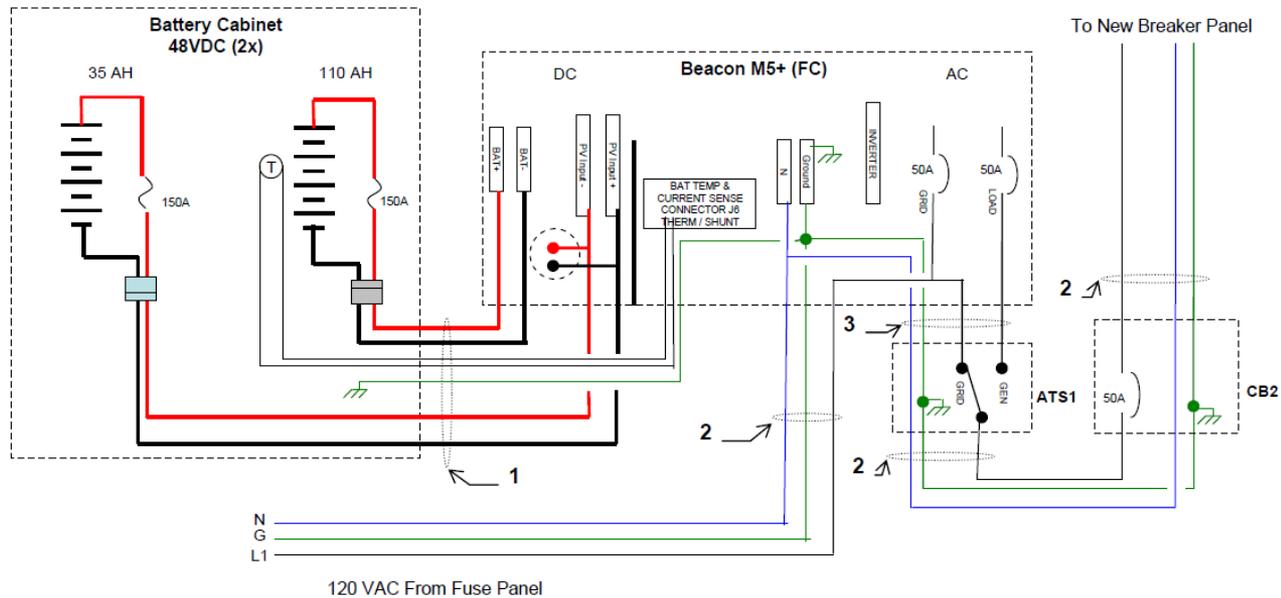
- Permit Application: Electrical Wiring Diagram



# APPROACH - FLEET 2: FT. IRWIN NTC

- Permit Application: Inverter Wiring Diagram**

WIRING DETAIL FOR M5+, ATS1 and CB2 – (10x)

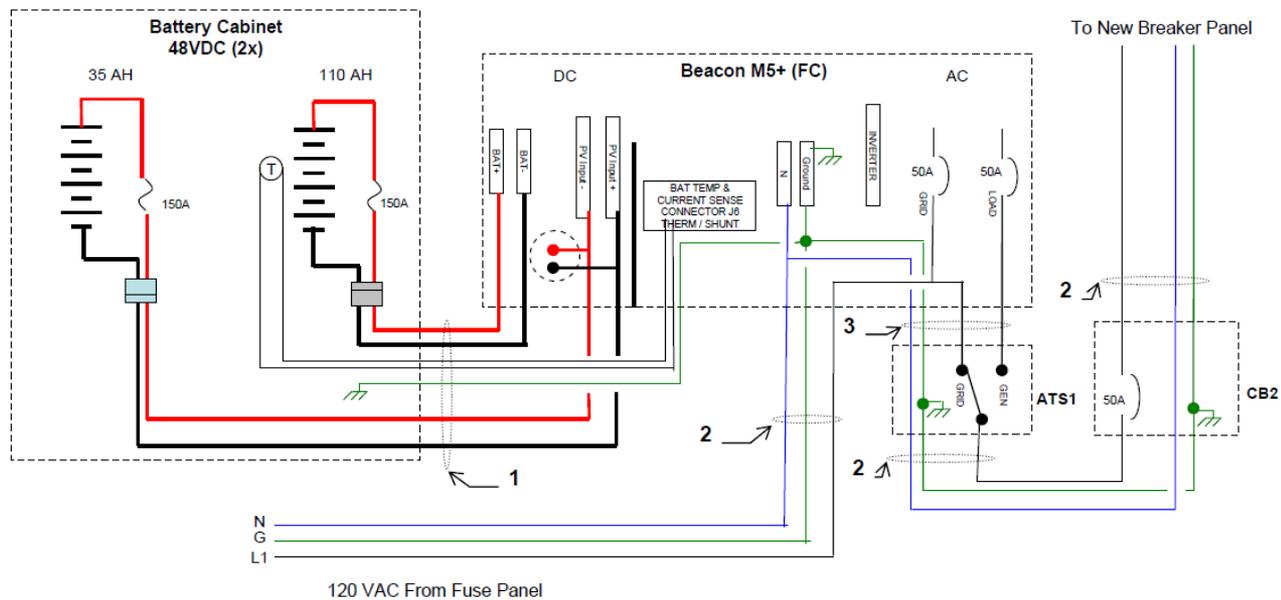


WIRE SIZING	
1	4 #1/0 CONDUCTOR, 1 #6 GROUND 1 THERMISTOR WIRE (INCLUDED WITH M5 INVERTER)
2	2 #8 CONDUCTOR, 1 #10 GROUND
3	3 #8 CONDUCTOR, 1 #10 GROUND

# APPROACH - FLEET 2: FT. IRWIN NTC

- Inverter Wiring Diagram**

WIRING DETAIL FOR M5+, ATS1 and CB2 – (10x)

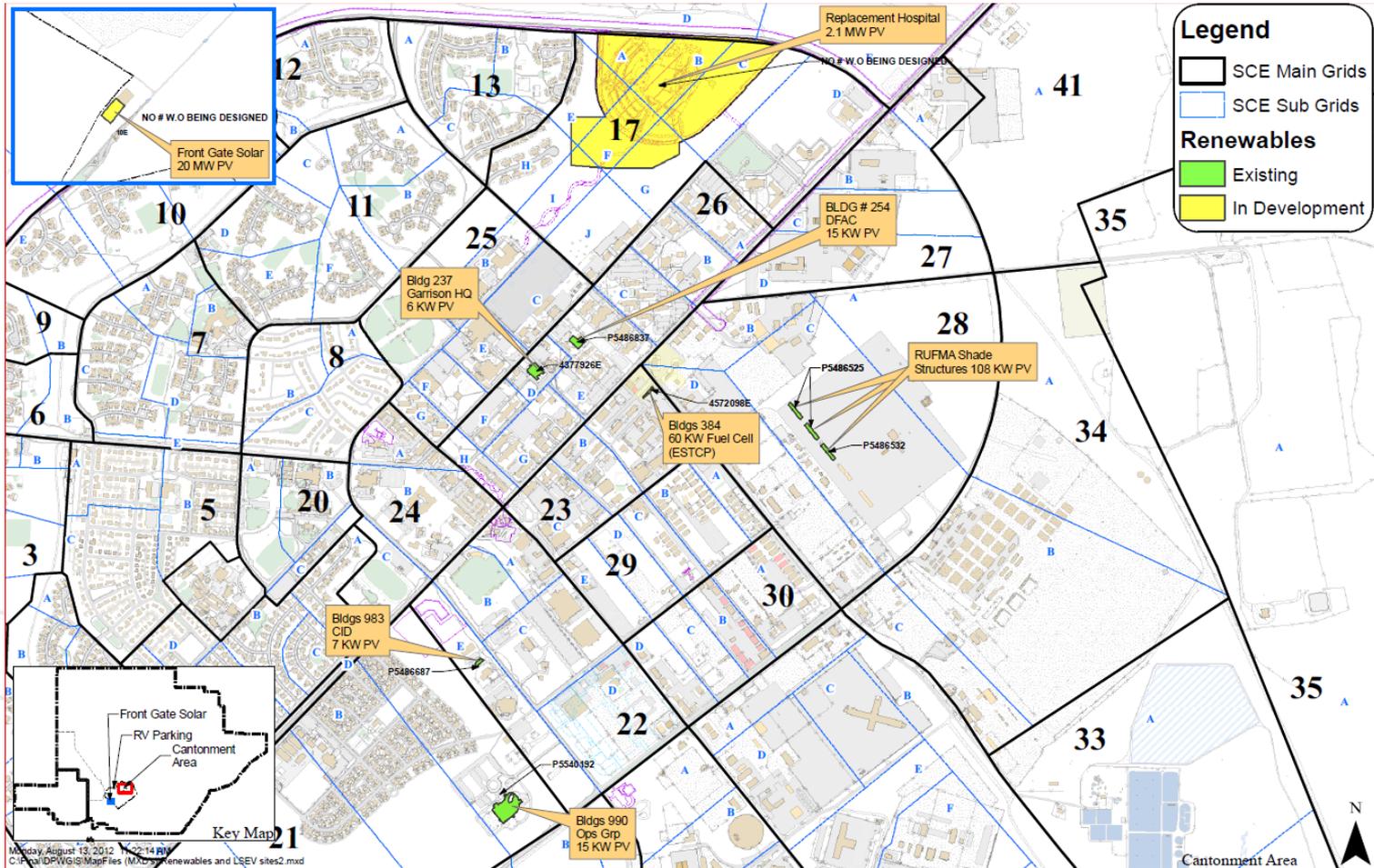


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# APPROACH - FLEET 2: FT. IRWIN NTC

- Permit Application:

## Map of Existing Renewable Energy Currently Installed at Fort Irwin



## APPROACH - FLEET 2: FT. IRWIN NTC

### Permitting application in process

- Provided the following:
  - Generating Facility Interconnection Application
  - Scope of Work for Fuel Cell Installation
    - Project Scope
    - Description of Work
    - Proposed Location and Build Layout
    - Concrete Pad Detail
    - Equipment Grounding Detail
    - Location of Fuel Cell Systems, Gas Piping, and Electrical Components
    - Site Electrical Wiring Diagram
    - Inverter Electrical Wiring Diagram
    - Equipment List and Specification
    - Contractor Requirements
  - Building Plans for Original Construction of Building 384
  - Map of Existing Renewable Energy Currently Installed at Fort Irwin
  - Safety Plan and Emergency Procedure for GenSys Fuel Cell Fleet at Fort Irwin Building 384

## APPROACH - FLEET 2: FT. IRWIN NTC

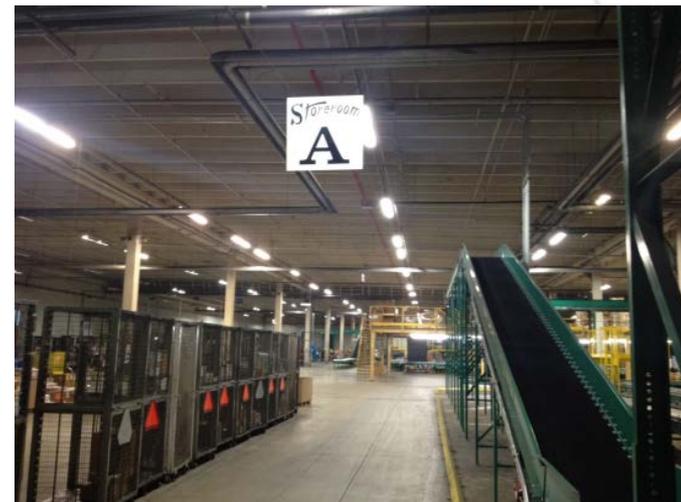
### Additional Information Needed by Utility

- **Entire map of Fort Irwin's interconnected generation** - A complete and comprehensive single line diagram of the entire generating facility's electrical configuration will be required. This application requires substantially more detailed information to ensure compliance of all tariffs and standards.
- **Single Line Diagram** - comprehensive diagram of the complete electrical configuration of the entire facility
- **Three Line Diagram** - detailed protection study; phase and polarity identification
- **Elementary Diagram** - comprehensive representation of the entire facility containing information of all components electrically connected
- **Plot Plan Drawing** – needs update to include physical location and distances of all components
- **Relay Diagram** - Diagrams and written descriptions regarding protective relays that will be used to detect faults or abnormal operating conditions for distribution system
- **Proposed Relay Settings** - Demonstrate how the unscheduled and uncompensated export of real power from a Generating Facility (GF) for a duration exceeding two seconds but less than 60 seconds will be accomplished; for the proposed transfer switch, details to ensure that the automatic transfer switch and scheme comply with Rule 21 requirements
- **Relay test report** will be required once the proposed relay settings have been reviewed and approved by Protection Engineering
  - Once we have these documents, Field Engineering can proceed with the technical review, at which point we will be able to ascertain if additional information will be required.

## ACCOMPLISHMENTS - FLEET 1: ROBINS AFB

### Network Outage Simulation

- Outage simulated – Saturday, Jan 19th, 2013, 5:00 PM
- Fuel cells powered the lighting in the building without issue.
- Commercial utility power was turned off - main disconnect switch SW1
- Within ~20s, the relays transferred and lighting was restored by fuel cell system power
- Network outage simulation was roughly 30 minutes



## ACCOMPLISHMENTS - FLEET 1: ROBINS AFB

- **Site Decommissioning**
  - After collecting data for 16 months



- **Site Restored**
  - As of April 4<sup>th</sup>, the site has been completely restored.

# ACCOMPLISHMENTS – FLEET 1: ROBINS AFB

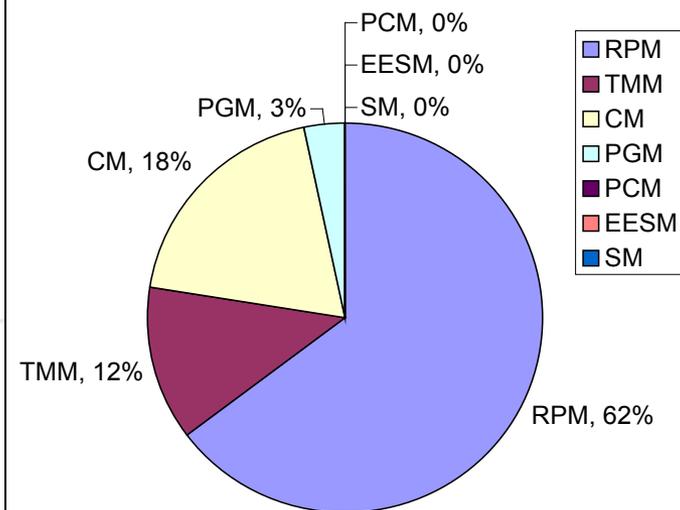
## Definition of failure modes, failure signatures / symptoms for early detection and recover

- RPM: ATO timeout waiting for catalyst activation
- CM: Electronic board failures, some possible connection to software.
- RPM: Loss of fuel flow (related to flow meter/valve issues)
- TMM: Coolant Leak, loss of coolant
- RPM: Anode Air Pump failed to start, known issue
- RPM: Gas leak during commissioning
- CM: Unknown, attributed to electronic boards
- RPM: Fuel Flow, issue with occasional dropout or flow spikes
- PGM: Max Low Cell Trips, stack protection due to either CO or cell performance
- RPM: Desulfurization needed excessive time for conditioning/equilibration.
- CM: Firmware update and boot failure

### Module Acronyms

RPM	Reactive Processing
TMM	Thermal Management
CM	Controls & Electronics
PGM	Power Generation
PCM	Power Controls
EESM	Electrical Energy Storage
SM	Structure

Failure Allocation in DOE 7A Backup Power Systems (October 2011- Dec 31, 2011)



## ACCOMPLISHMENTS - FLEET 2: FT. IRWIN

- Fleet installed and ready to go once permitting is received



## FUTURE WORK

- Work continues with utility to gain permit

<b>7A Backup Power Reliability Testing Remaining Tasks</b>	
<b>Task</b>	<b>Completion Date</b>
Gain permit from Southern California Edison (SCE)	TBD
Run Ft. Irwin fleet in backup mode	Contingent upon permitting
Simulate network outage	
Quarterly reporting	
Decommission 10 systems at Ft. Irwin	
Restore Ft. Irwin facility to original condition	
Report on cost analysis	
Final reporting and project closeout	

## SUMMARY

### Relevance:

- **Jobs Created: 11.6 person-years**
- **Continued investment into stationary/backup**

### Approach:

- **Extended back-up power via stationary power micro-grid**

### Collaborations:

- **IdaTech**
- **Robins Air Force Base**
- **Ft. Irwin National Training Center**

### Future Work:

- **Operate the Ft. Irwin**
- **Quarterly and final reporting**
- **Project close-out**

Topic 6A	2009	2010	2011	2012
Q1		7.4	2.7	0.6
Q2		6.5	1.7	0.3
Q3	12.0	3.1	1.4	0.05
Q4	8.0	2.0	0.4	0.3
Total	20.0	19.0	6.1	1.3

## COLLABORATION



**GenSys Blue Fuel Cell Development  
ICAT Testing  
Program Management**



**Field Support (2010 – 2012)  
Program Management  
Data Analysis  
Field Service**



**Robins Air Force Base  
Site Host  
Backup of Air Defense Logistics Building**



**Ft. Irwin National Training Center  
Site Host  
Backup of critical Engineering building**

# POWER AHEAD



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