Accelerating Acceptance of Fuel Cell Backup Power Systems

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H2RA007

plug power®

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OVERVIEW

Timeline

- Project start – June 2009
- Project end – May 2014

Barriers

- Cost
- Affordability
- System reliability
- Market volume

Budget

- Total project funding - $6.7M
- Total project value - $6.7M
- Status: 100% Complete
- Cost Share Percentage – 50%

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 Mgmt

Accelerating the commercialization and deployment of fuel cells, fuel cell manufacturing, installation, maintenance, and support services

Plug Power - Engineering, Testing, Sales, Marketing, Program Mgmt

Supply Chain - DANA, BASF, 3M, etc.

Other Partners – IdaTech, Lakota Solutions, Terawatt, Site 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 hrs)

Decrease fossil fuel dependencies for power generation

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

RELEVANCE

- **Specific Project Objectives During 2013/2014**
  - **Successful backup during simulated outage**
  - **Decommission of 1st site**
  - **Successful permitting of 2nd site**
  - **Commissioning and running of 2nd site**
  - **Decommissioning of 2nd site**

APPROACH

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

Task	Project Milestones	Status
1	Project Management and Reporting	100%
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	100%
6	Reporting	100%
7	Project Closeout	100%

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 5 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

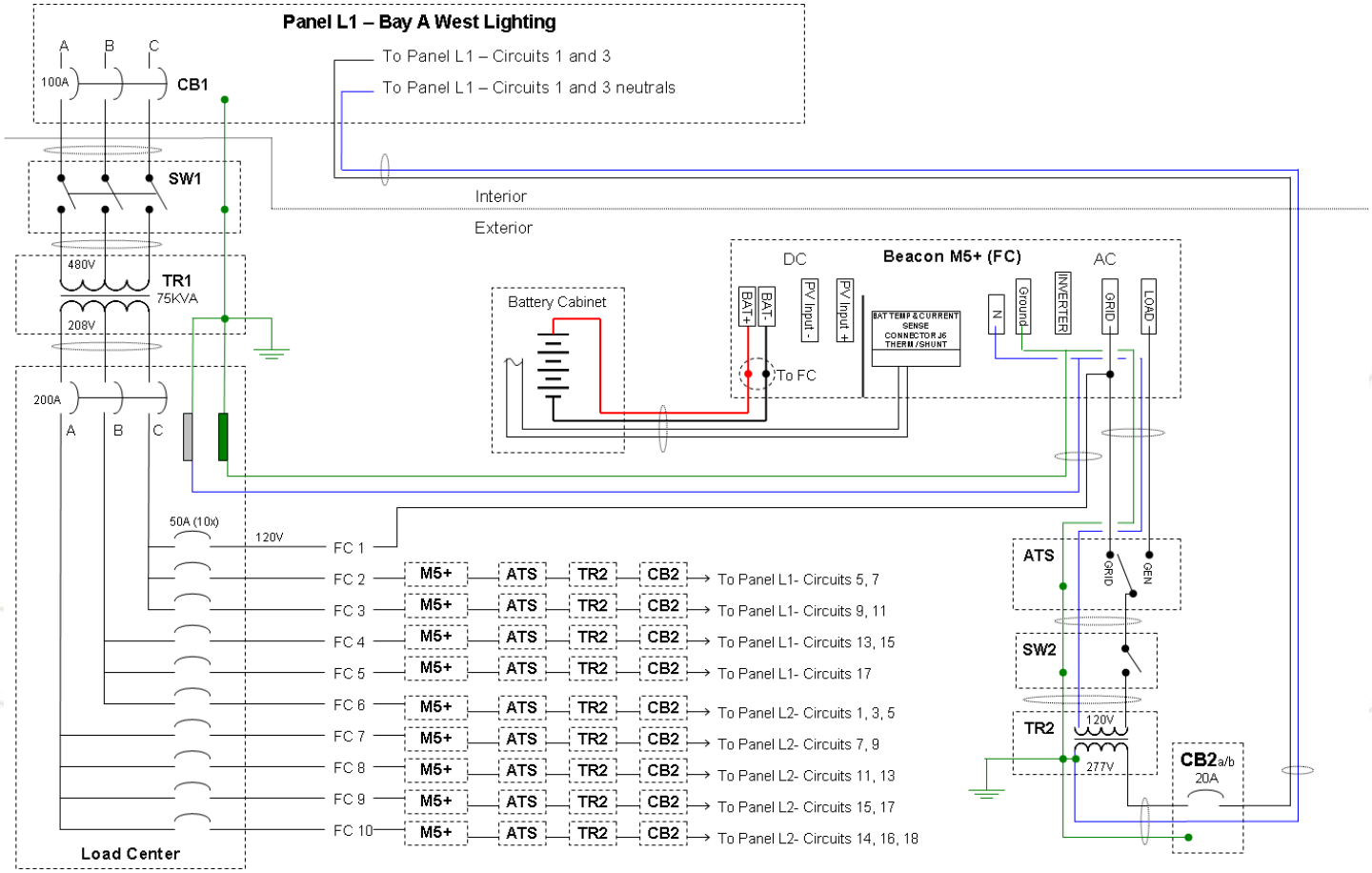
- As of the acquisition, IdaTech ceased to be a program partner.

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

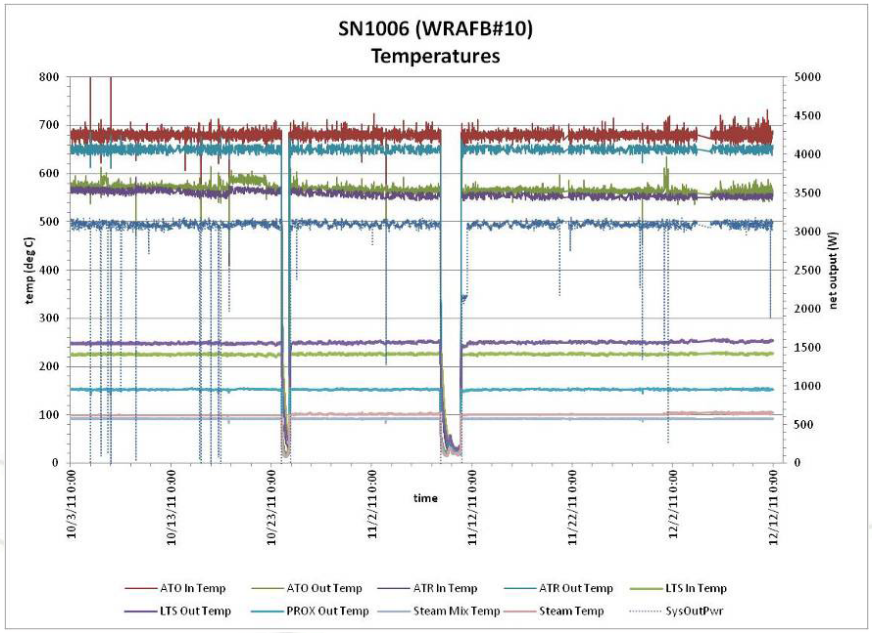
- **Installation**

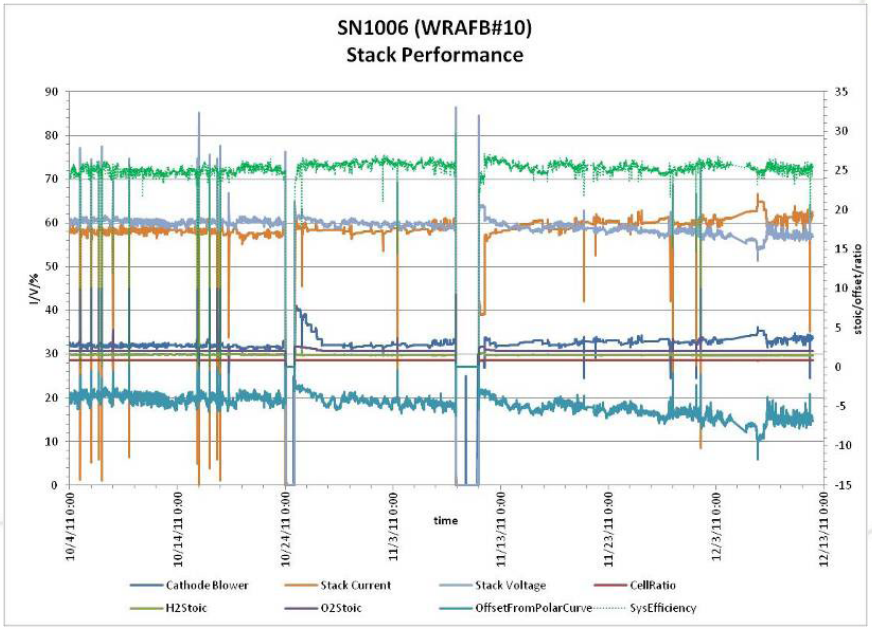
APPROACH - FLEET 1: ROBINS AIR FORCE BASE

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

APPROACH - FLEET 1: ROBINS AIR FORCE BASE

- **Demonstration / Maintenance**
  - Reviewed stack performance, 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

ACCOMPLISHMENTS - FLEET 1: ROBINS AFB

Network Outage Simulation

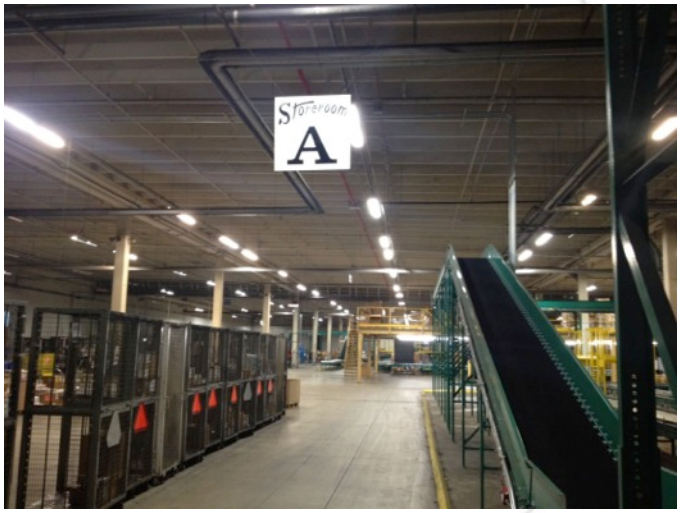
- Outage simulated – Saturday, Jan 19th, 2013, 5:00 PM

- 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 4th, the site has been completely restored.

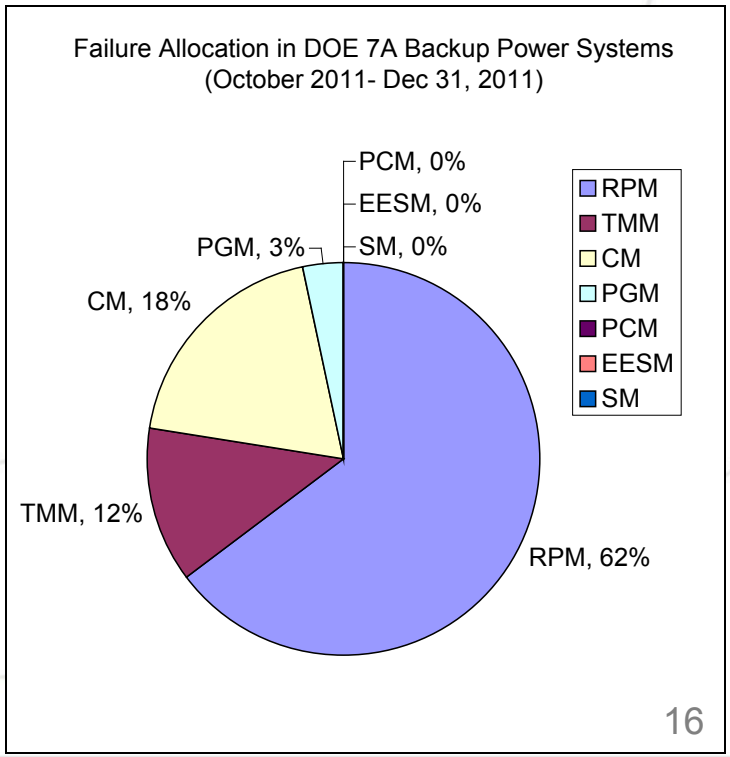
ACCOMPLISHMENTS – FLEET 1: ROBINS AFB

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



ACCOMPLISHMENTS - FLEET 2: FT. IRWIN

- **Fleet Installation and Operation**

- **Operation**
  - **15,187 operating hours**
  - **15.6 MWe-hr produced**

Network Outage Simulation

- Occurred 4/8/14, witnessed by Ft. Irwin personnel

Site Restored

- As of May 9th, 2014, the site has been completely restored.

ACCOMPLISHMENTS – FLEET 2: FT. IRWIN

Site Decommissioning

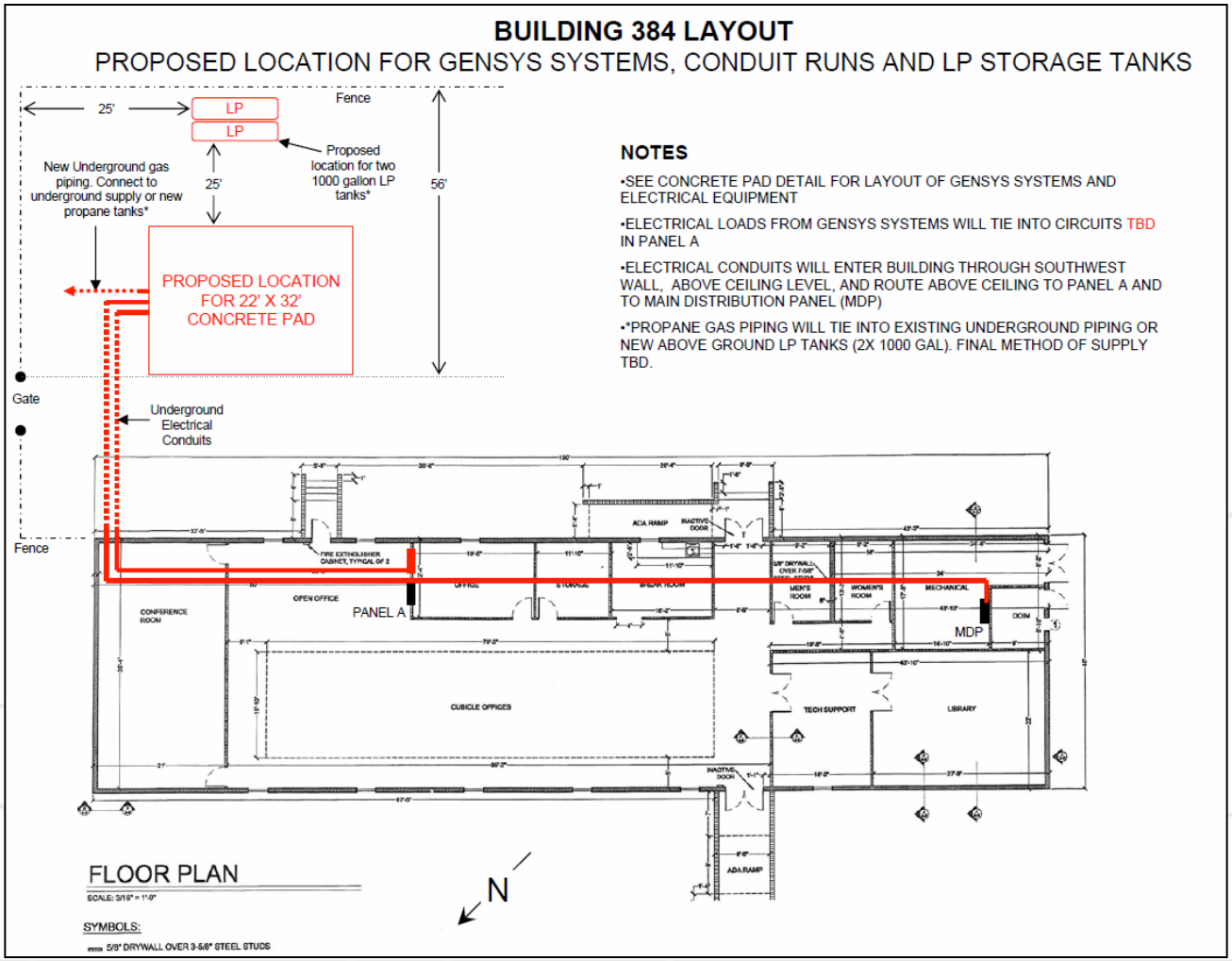
- After collecting data for more than 6 months

Site Restored

- As of May 9th the site has been completely restored.

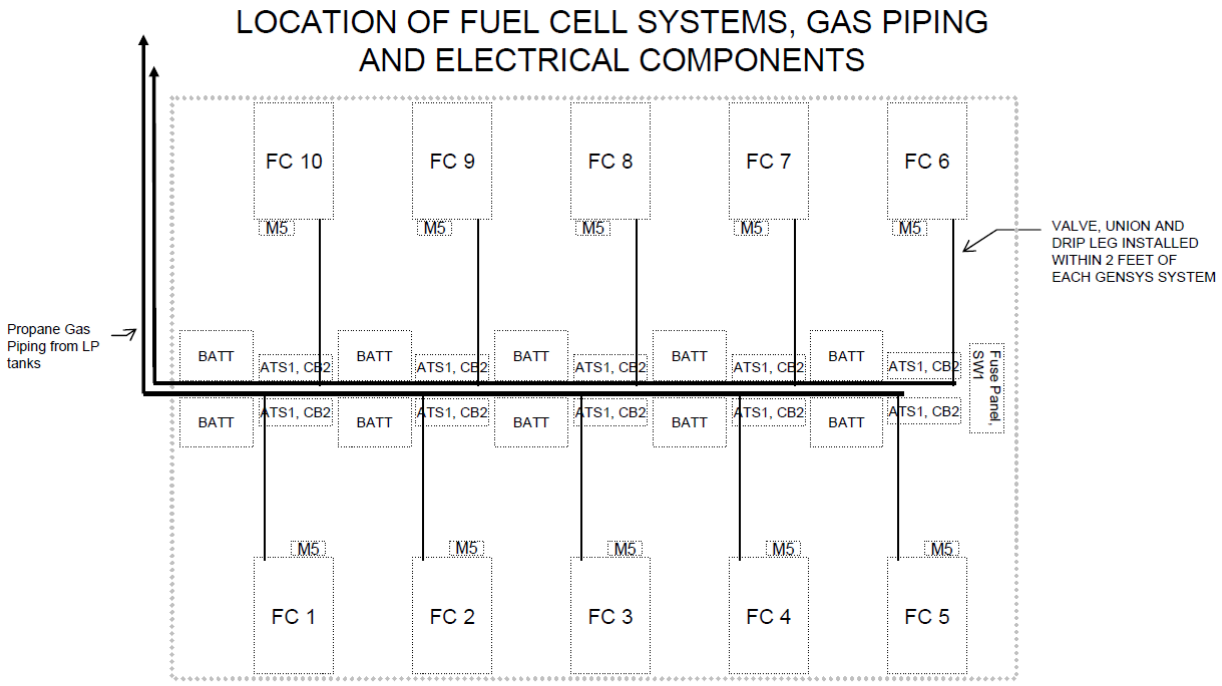
APPROACH - FLEET 2: FT. IRWIN NTC

- **Permit Application: Site Planning**



APPROACH - FLEET 2: FT. IRWIN NTC

- **Permit Application: Piping and Electrical Component Diagram**

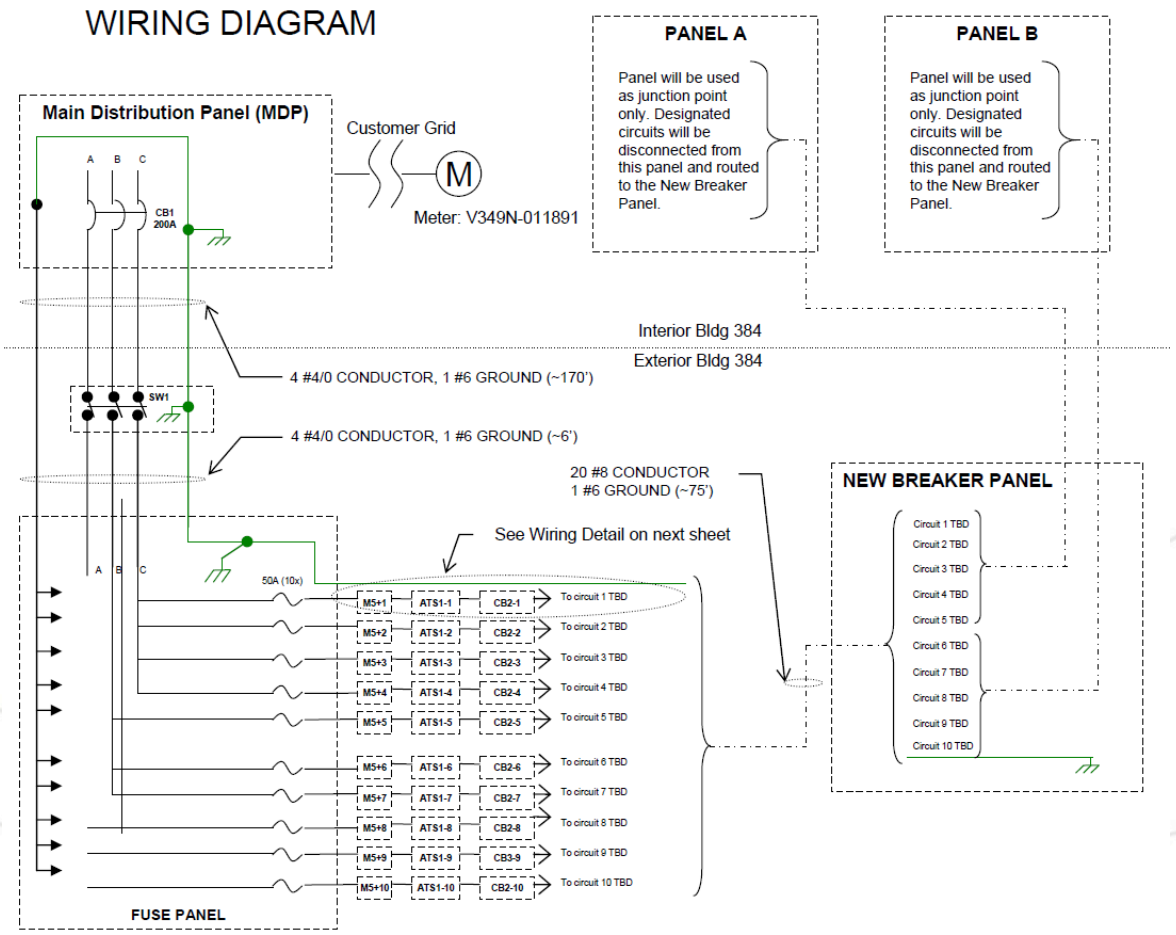


NOTES

- 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

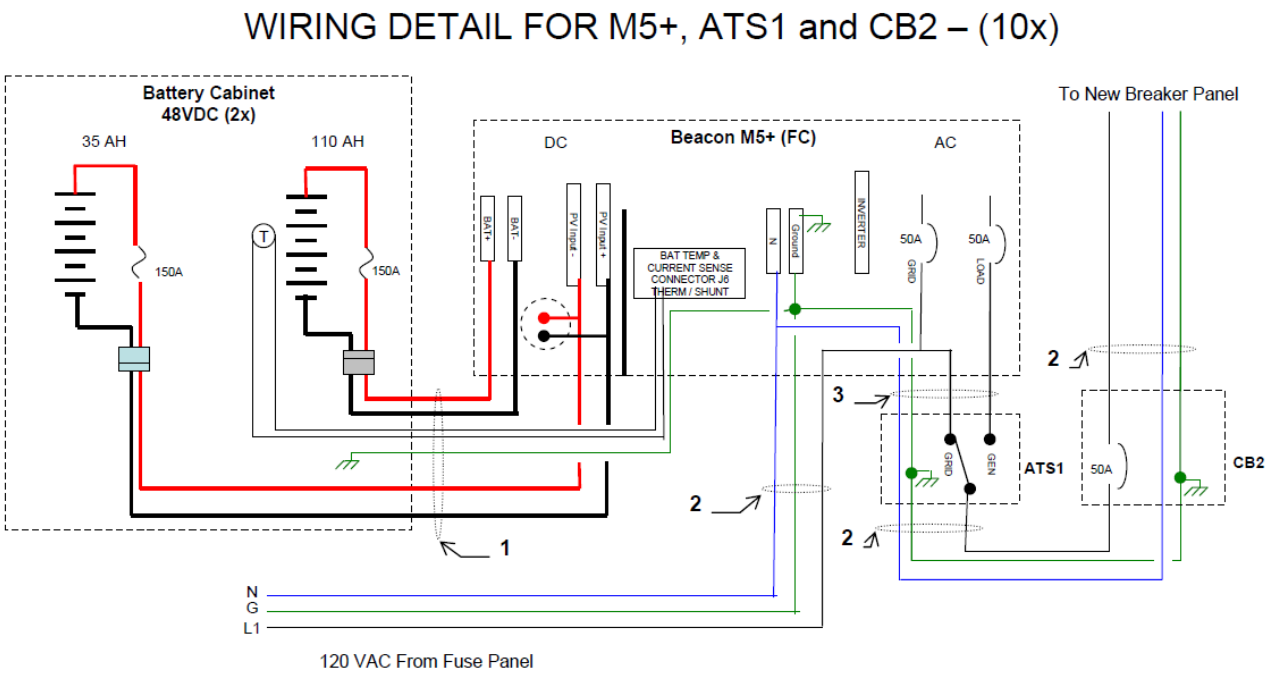
APPROACH - FLEET 2: FT. IRWIN NTC

- **Permit Application: Electrical Wiring Diagram**



APPROACH - FLEET 2: FT. IRWIN NTC

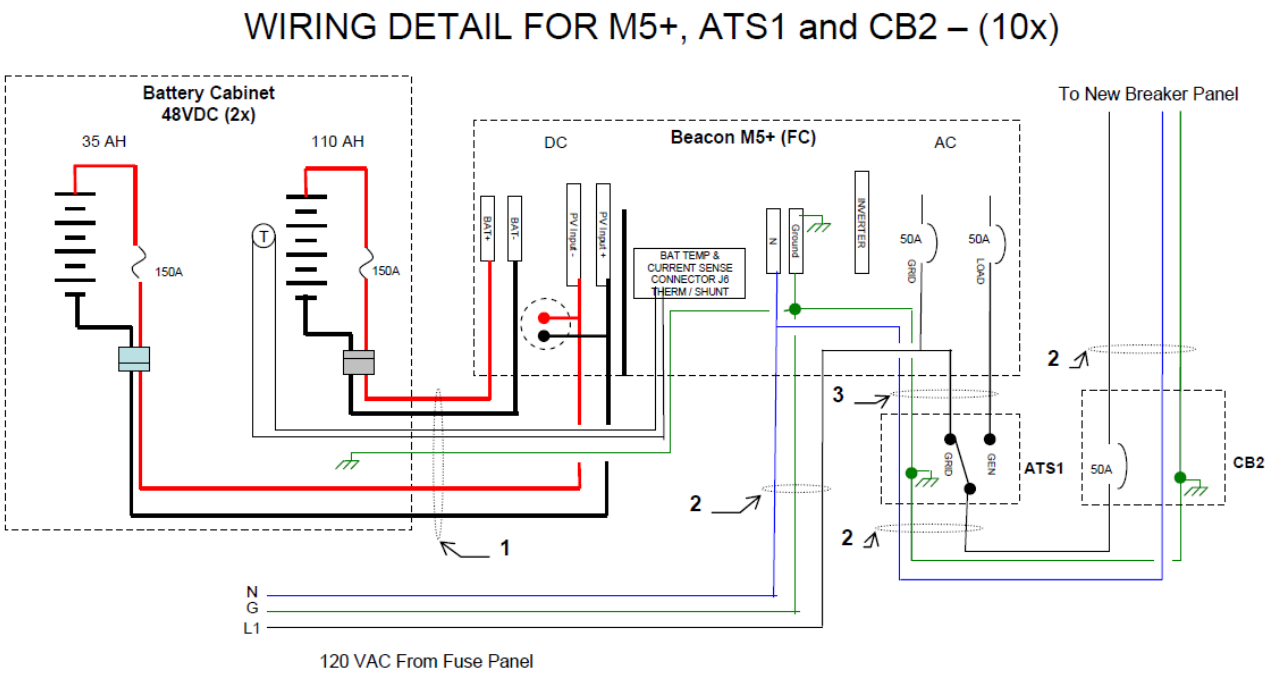
- **Permit Application: Inverter Wiring Diagram**



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**



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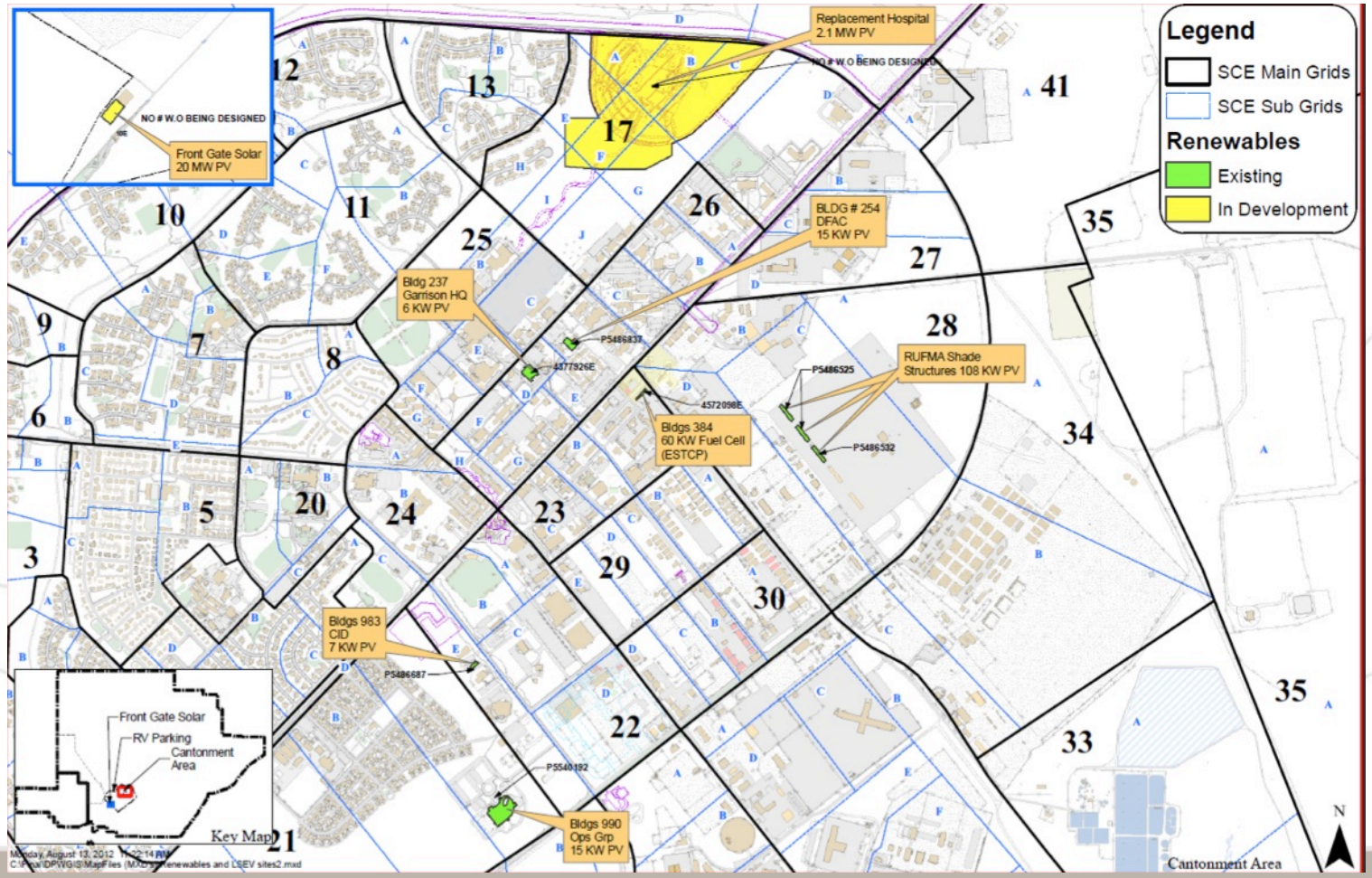
APPROACH - FLEET 2: FT. IRWIN NTC

- **Permit Application:** *Map of Existing Renewable Energy Currently Installed at Ft. 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 Requested 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 complete electrical configuration of 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

LESSONS LEARNED FROM PERMITTING PROCESS

Lesson #1: Misinterpretation of site configurations can heavily stall alt power sites

- The permitting process was held up by non-compliance to a rule that was not published or in Rule 21, which calls out Net Metering situations.

- The grid-parallel configuration (with transfer switch) was not acceptable because the utility believed the site would take 40 car batteries' worth of power off the grid at night (low cost) and put it on the grid during the day (high price).

- We were given a list of drawings/reports that could not be collected or generated for the site.

LESSONS LEARNED FROM PERMITTING PROCESS

Lesson #2: More charges may impact *grid-parallel* backup value propositions.

- Utilities are now charging a standby charge.
  - Customer Charge (flat)
  - Energy Charge – different rates for time of use (on peak, mid peak, off peak)
  - Demand Charge – related to the maximum amount of energy used
  - **Standby Charge – "…represents the entire reserved capacity needed for SCE to serve the customer's load regularly served by the customer's generating facility when such facility experiences a partial or complete outage." [Reserve Capacity]**

- **This Standby Charge will likely affect the value propositions for backup, intermittent, or potentially other alternative power sources by adding another charge to what is expected to be removed from the grid.**

SUMMARY

Relevance:

- 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:

- Final reporting
- Project close-out

POWERAHEAD

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