SureSource Power Platforms

CPUC Diesel Alternatives Workshop

August 2020

Challenge Statement - Questions

- **First Question:** Does your solution replace diesel generators by supplying power to all customers at the substation level?
  - Yes. Our fuel cell solutions can replace diesel generators and can serve all customers at the substation level.
- **Secondary Question 1:** Does your solution replace diesel generators as a portable and deployable fleet of temporary generation, or is it a permanent installation at a specific substation?
  - Our solutions are permanent installations.
- **Secondary Question 2:** Can your solutions sustain islanding for 48 and/or 96 hours?
  - Yes. Our solutions are continuous power generators and can operate without interruption
- **Secondary Question 3:** Can your solutions be ready and operational by 2021 and can you provide enough labor and ancillary equipment to execute full-scale deployment?
  - Yes. Based on procurement decisions in September 2020, FCE solutions can be installed and operational in 2021. Certain make-ready milestones of PG&E would be required.
- **Secondary Question 4:** Given the constraints detailed above, how many MW can your solution reasonably cover in 2021. In future years? Under what conditions can your solution be reasonably employed?
  - Given constraints and site factors at the substations, our solutions can reasonably provide up to 12 MW at the indicated substations in 2021. Additional capacity can be planned and installed in 2022 and subsequent years based on expanding siting of permanent generation to sites and areas in proximity to the substations.

Challenge Statement - Appendix B: Permanent Solutions

The Challenge Requested that Participants with Permanent Solutions address:

Scale

- Our solutions are scalable in increments of 1.4 MW.

Cost

- Complete solutions have a net cost range of $3250 to $3500 per kW for a fully installed facility interconnected to utility distribution and fuel supply. Solutions are comparable to life cycle costs of repetitive long term diesel rental.

Commercial Operation

- A typical schedule for delivery of a facility taking into consideration the nine steps to Commercial Operation is 15-18 months from contract. FCE can accelerate to within 12 months with expedited approvals.

Land Requirements

- A typical 2.8 MW fuel cell platform requires approximately 6,500 square feet. A fuel delivery station where required adds approximately 7,000 square feet.

Islanding Requirements

- Summary of compliance with Islanding Requirements is provided as Additional Information

Implementing Alternatives to Diesels - Development Challenge

Optimal PSPS mitigation at substations is impacted by land availability, decision timing and a limiting default scenario of diesel rentals

1) **Substation solutions can be provided from a variety resources, however**
   - Maximized solution delivery is enabled by a multiple project development approach
   - Extending the siting and planning envelope outside the substations using dedicated feeders expands the capacity to serve.
   - Include proximate customers and vulnerable loads in the envelope

2) **Market Response (Technology and Velocity) will be determined by degree of "*Market Make Ready Infrastructure*"**
   - Adoption of diverse solutions require PG&E and regulatory preparation beyond the approved Make Ready Program
     - *Undertake advanced approvals for "substation interconnection"*
     - *Adopt PG&E substation investment to accept multiple market solutions*
     - *Prepare Site Microgrid interface and metering*
     - *Establish procurements over a planning horizon to optimize total offerings*
   - Define Permits and Licensing (by PG&E or developer)
     - *Undertake CEQA approvals, Air permits and Local Permits*

Substation Solutions

Solution Concept - Fort Bragg

Fort Bragg Substation Loads

- Peak Load 13.5, Average Load 10.5 MW

Siting Factors

- Fuel is not available at the site
- Land at substation is limited

Solution Concept

Install 11.2 MW of permanent generation within the parcel of PGE property to the west with a new dedicated feeder (approx. 1000 feet to substation).

Fuel supply would be provided by virtual gas delivery with delivery station at the parcel. Land requirement is approx. 27,500 SF for 11.2 MW and fuel delivery.

Solution can be operated continuously or seasonally in advance of PSPS season. Concept can provide Energy and Resource Adequacy services.

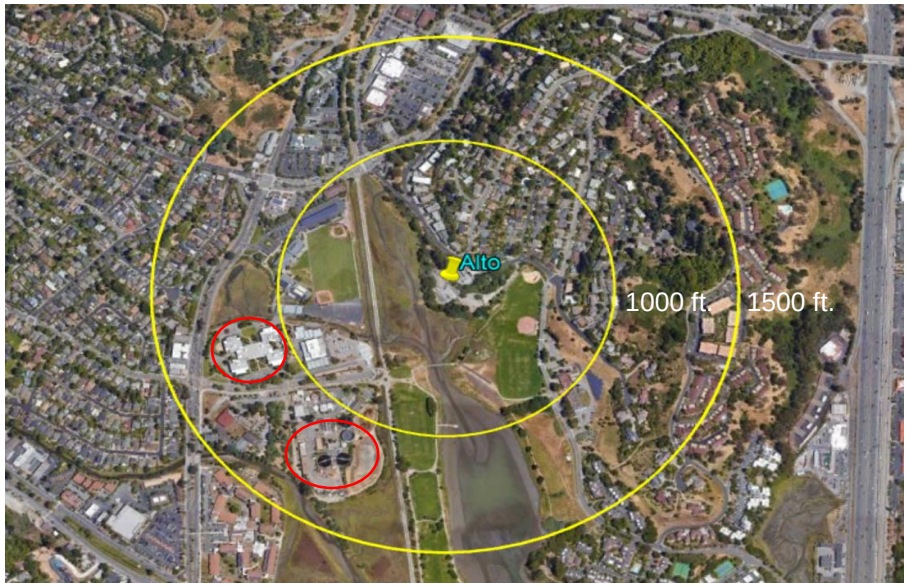
Cost

Comparable to repetitive rental of temporary diesels.

Commercial Operation

As feeder installation and site approvals are key factors, 11.2 MW can be available in 2022.

Solution Concept - Alto



Alto Substation Loads

- Peak Load 31.5 MW, Average Load 21.5 MW

Siting Factors

- Fuel is available to the site
- Land is available, but limited due to wetlands and transmission overhead

Solution Concept

Install 5.6 MW of permanent generation at the site based on available land to the south and east. Land requirement is approx. 20,000 SF.

Implement additional generation at such locations as the Middle School and Water Treatment facility located within 1500 feet of the substation.

Solutions can be operated continuously or seasonally in advance of PSPS season. Concept can provide Energy and Resource Adequacy services.

Cost

Comparable to repetitive rental of temporary diesels.

Commercial Operation

5.6 MW can be in 2021, timing of additional capacity will depend on availability of sites and feeder installation.

Solution Concept - Covelo

Covelo Substation Loads

- Peak Load 2.5 MW, Average Load 1.4 MW

Siting Factors

- Fuel is not available at site
- Land is available at the site

Solution Concept

Install 1.4 MW to 2.8 MW of permanent generation at the site on available land. Fuel supply would be provided by virtual gas delivery with delivery station at the site.

Land requirement is approx. 5,000 SF per 1.4 MW; approx. 5,000 SF for fuel delivery.

Solution can be operated at 1.4 MW continuously or seasonally in advance of PSPS season. Additional 1.4 MW can be operated seasonally. Concept can provide Energy and Resource Adequacy services.

Cost

Comparable to repetitive rental of temporary diesels.

Commercial Operation

2.8 MW can be available prior to October 2021.

Solutions - Cost and Environment factors

Costs Relative to Diesel – 10 MW Site Comparison

- **Economics of a 20 Year Permanent Solution**
- **Continuous Fuel Cell vs Repeated Diesel Rental**
  - Rental is based on Exhibit PG&E-1, scaled to 10 MW
  - Fuel Cell is provided under long term power contract
- **Relative Local Emissions**

Emissions Comparison 10 MW		
Total Criteria Pollutants		
	NOx lb/MWh	
Tier 2 Diesel	11.62	250.6
FCE SureSource	0.01	8.4
Difference (Tier 2 vs FCE) Tons		**242.1**
	PM lb/MWh	
Tier 2 Diesel	0.27	5.7
FCE SureSource	0.00	0.0
Difference (Tier 2 vs FCE) Tons		**5.7**

PG&E Gas Available

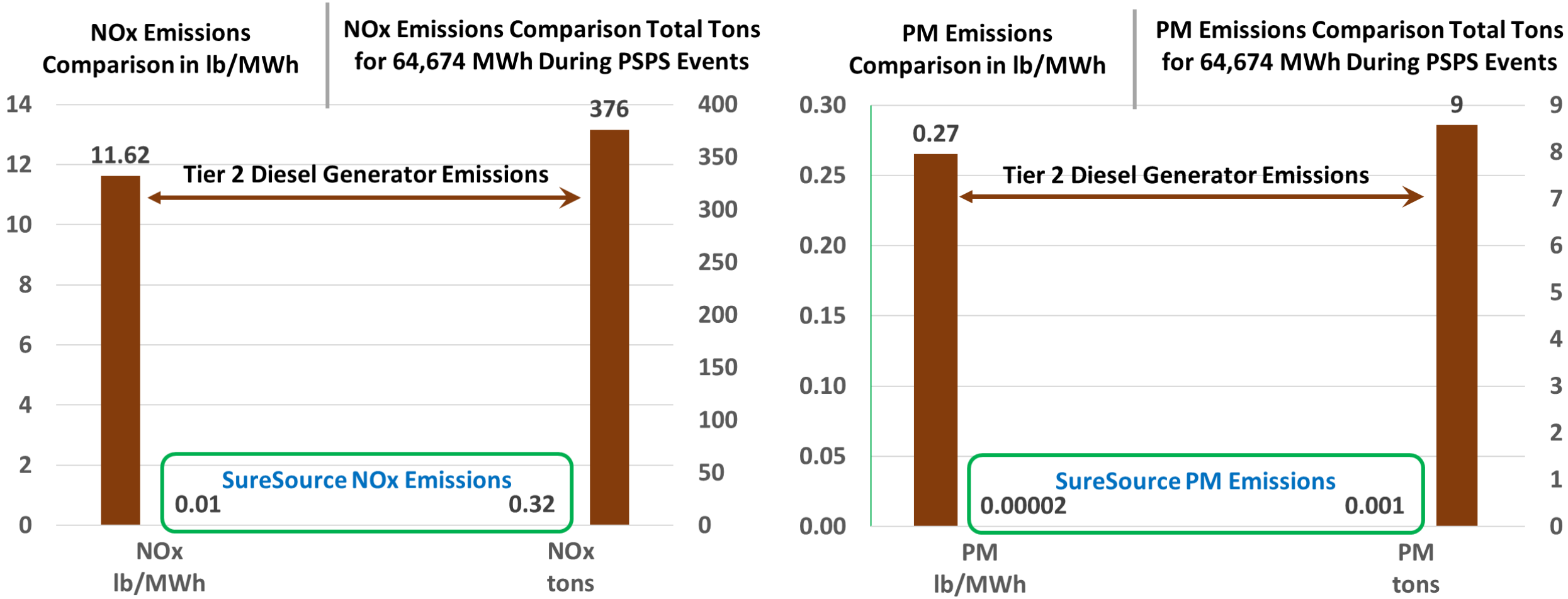
Economic Comparison 10 MW		
11 MW Fuel Cell (20 Years)		
Average MW		10.7
Total MWh		1,689,334
Contract Payments ($000)		
Non Fuel		131,739
Fuel Related		89,121
Total		220,859
Offsets ($000)		
Energy Value	40.00	(82,089)
RA Payment	3.00	(9,371)
Total		(91,459)
Total Solution Costs (including Offsets)		**129,400**
10 MW Diesel - Rental (20 Years)		
Average MW		10
Total MWh		43,116
Contract Payments ($000)		
Non Fuel		134,991
Fuel Related		19,136
Total		154,126
Offsets ($000)		
Energy Value	40.00	(2,095)
RA Payment	0.00	0
Total		(2,095)
Total Rental Costs (including Offsets)		**152,031**
Solution vs Rental - Difference ($000)		**(22,631)**
Average Difference 20 Years ($000)		**(1,132)**

Fuel by Virtual Delivery

Economic Comparison 10 MW		
11 MW Fuel Cell (20 Years)		
Average MW		10.7
Total MWh		1,689,334
Contract Payments ($000)		
Non Fuel		131,758
Fuel Related		124,769
Total		256,527
Offsets ($000)		
Energy Value	40.00	(82,089)
RA Payment	3.00	(9,371)
Total		(91,459)
Total Solution Costs (including Offsets)		**165,067**
10 MW Diesel - Rental (20 Years)		
Average MW		10
Total MWh		43,116
Contract Payments ($000)		
Non Fuel		134,991
Fuel Related		19,136
Total		154,126
Offsets ($000)		
Energy Value	40.00	(2,095)
RA Payment	0.00	0
Total		(2,095)
Total Rental Costs (including Offsets)		**152,031**
Solution vs Rental - Difference ($000)		**13,036**
Average Difference 20 Years ($000)		**652**

SureSource Emissions

99.9% Reduction Compared to Tier 2 Diesel Generator NOx and PM



http://www.aqmd.gov/home/programs/business/business-detail?title=certified-equipment&parent=certified-products

gm/bhp-hr*3.07 = lb/MWh

Thank You

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Additional Information

FuelCell Energy – Company Highlights

COMPANY HIGHLIGHTS[1]

Danbury, CT	Headquarters
300+	Employees
3	Continents
57	Global plant installations
>255 MW	Capacity in Field

REVENUE DRIVERS

SERVICE & LICENSE | ADVANCED TECHNOLOGIES | GENERATION | PRODUCT




UNMATCHED EXPERIENCE

Over 10 million Total MWH generated by SureSource™ plants around the world

Certified to **ISO 9001:2015** & **ISO 14001:2015** ; **ISNET A Rating**

GLOBAL CUSTOMERS

Pfizer, ExxonMobil, Toyota, City of Tulare, LIPA Long Island Power Authority, University of California San Diego, Connecticut State University System, University of California Riverside, American Electric Power, Pepperidge Farm, Radisson, Clearway, Federal Ministry of Education and Research, Pacific Gas and Electric Company, ICOSPO, Southern California Edison An EDISON INTERNATIONAL Company, E.ON, AVANGRID, Connecticut Municipal Electric Energy Cooperative cmeec, FRIATEC, Hartford Hospital Connect to healthier.

Demand for Clean, Reliable Electricity Driving Adoption of Fuel Cell Technology

FuelCell Energy - Full capability to deliver Microgrids

FCE platforms can address the full range of microgrid types

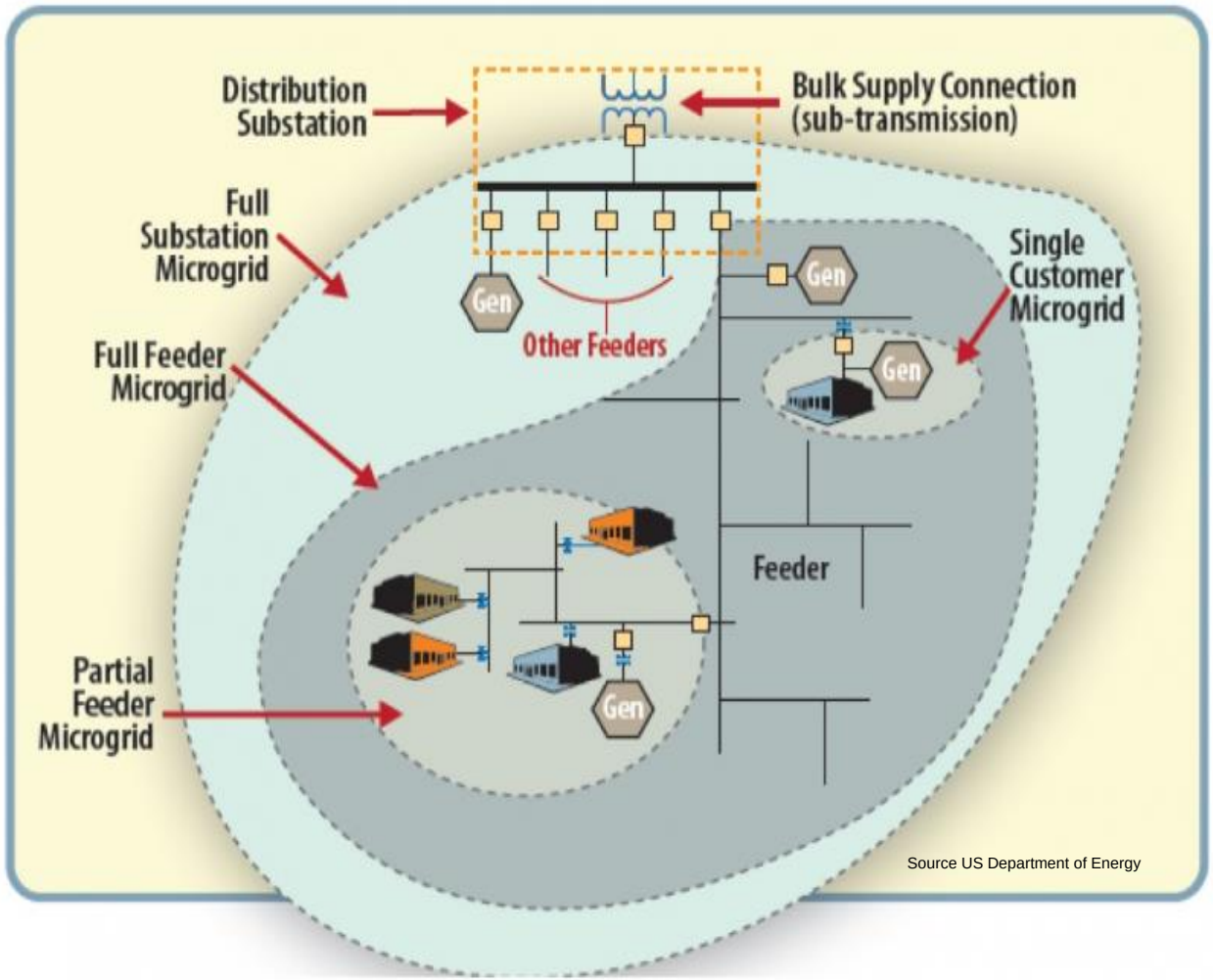
Regardless of type of microgrid, FCE has the <u>capability</u> to provide a complete solution:

- *Fuel Cell Power Plant*
- *Microgrid Design and Integration*
- *Operation and Maintenance*

FCE's capability is backed by <u>experience</u> in Utility and Customer Microgrids:

- *UC San Diego (SCM)*
- *University of Bridgeport (SCM)*
- *Navy Submarine Base New London (FSM)*
- *Avangrid Woodbridge (FFM)*
- *Santa Rita Jail (SCM)*

Note: ("SCM", "FSM" and " FFM) – abbreviations of type from chart



Multi-Level Microgrid: Including Gas Turbine and Solar PV Integration

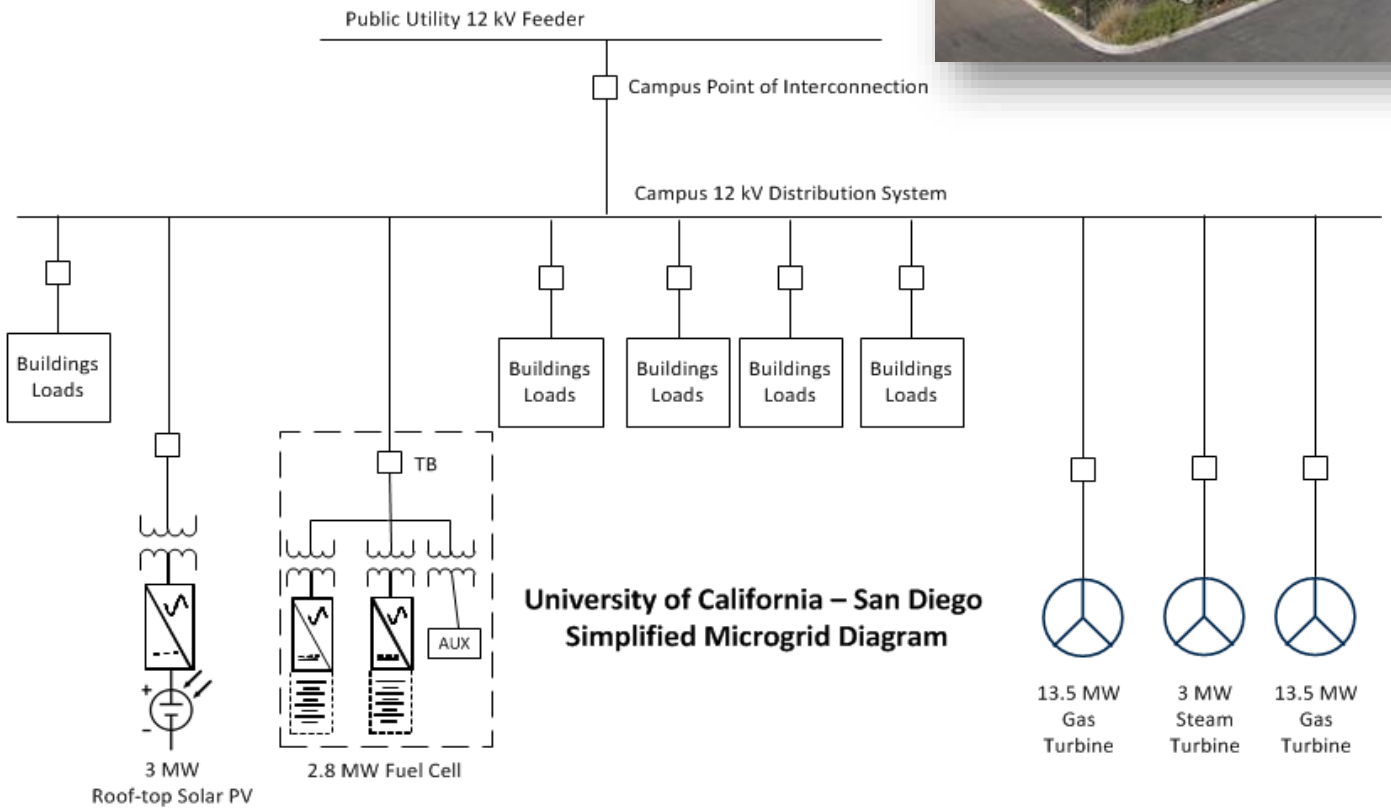
University of California San Diego

Generator Dominant

- 2.8 MW Fuel Cell
- 3 MW roof top solar
- 30 MW gas turbine
- Microgrid continues to evolve with components added and integrated over time

Operation

- Load following by turbine-generator
- Fuel Cell baseload contribution. (treats turbine generator as grid)
- Solar PV intermittent contribution



Municipal/Utility Microgrid: Efficient CHP with Remote Load Sequencing

Town of Woodbridge, CT

Project structure

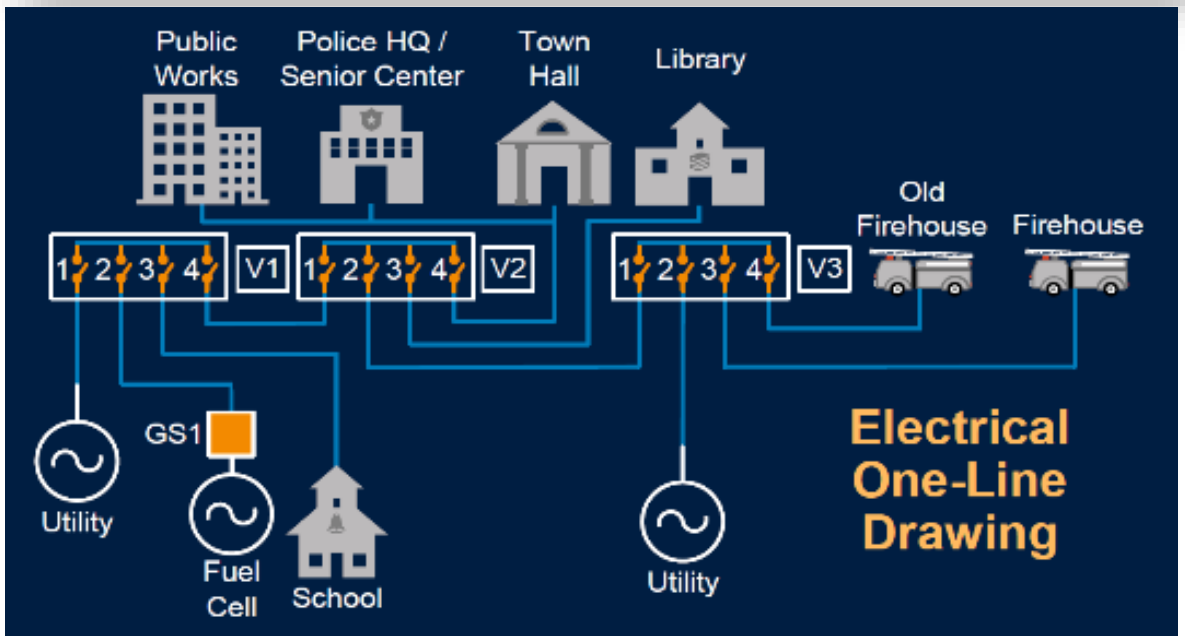
- Supplies grid in regular operation
- If a grid disruption microgrid ensures power for 6 critical town buildings

Configuration

- 2.2MW fuel cell, Utility owned
- Grid-interconnected
- Black-Start capability
- CHP - Heat to high school

Microgrid Operation

- "Drop & Pickup"
  - *Microgrid controller sequences critical loads*
  - *Inverter follows microgrid load*
  - *Load Leveler maintains fuel cell power constant*



Multi-Generator Microgrid

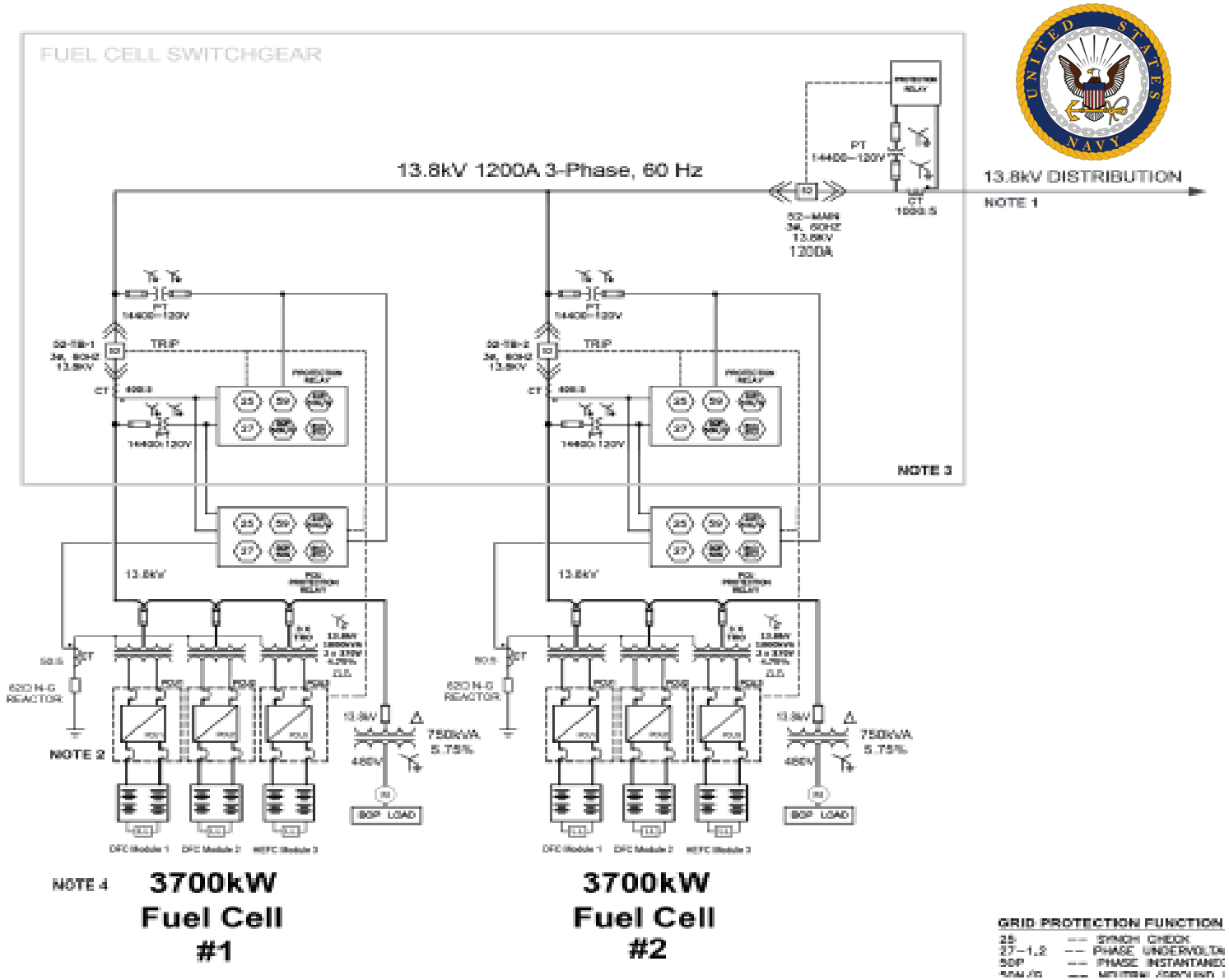
US Navy Submarine Base New London

Configuration

- Two (2) 3.7 MW Fuel Cells
- Parallel operation with existing on-site generation
- Support critical operations in event of utility outage
- Direct connection to Utility Substation
- Project currently under construction

Microgrid Operation

- “Drop & Pickup”
  - Inverter follows microgrid load
  - Load Leveler maintains fuel cell power constant



Challenge Statement - Appendix D: Islanding Requirements - Protection

Requirement Category	Requirement	Acceptance Criteria	Summary	FCE Compliance
Protection	Projects must have generator and/or system relays that can be modified to accommodate over and under voltage protection settings at PG&E's request	Have necessary utility grade protection and control equipment that can be modified by PG&E	This is required to ensure proper power quality supplied to connected customers.	FCE controls are adjustable during operation
	Minimum number of machine generators must be running and online during islanding to provide adequate system fault duty	Meet the minimum number supplied by the utility as required in short circuit modeling assumptions	This is required to ensure fault detecting devices have the proper amount of system fault energy to be able to detect hazardous fault conditions	FCE solution can supply required system fault duty
	Generators must have ability to generate short circuit fault duty for various fault types to allow traditional overcurrent protection to be used to successfully detect and clear utility primary faults. Generator must have ability to generate 3-phase short circuit of at least 250% of the nameplate MVA rating. Generator must have ability to sustain 3-phase fault duty for 10 seconds, Line-Line (L-L) fault duty for 5 seconds and Line-Ground (L-G) fault duty for 2 seconds.	Generating sources meet the requirement defined	This is required to ensure fault detecting devices have the proper amount of system fault energy to be able to detect hazardous fault conditions	FCE solution meets short circuit fault duty requirement using black start generator with fuel cell
	Generators and step-up transformers must be designed such that faults within the island are cleared to ensure the safe operation of the generator while serving the utility loads.	Vendor provided equipment meets PG&E protection criteria for safe and reliable operation	This is required to ensure employee and public safety in the event of a fault condition on the system	FCE has experience and background in utility scale generation

Challenge Statement - Appendix D: Islanding Requirements - Synchronizing

Requirement Category	Requirement	Acceptance Criteria	Summary	FCE Compliance
Synchronizing	The system shall have the ability to make small frequency adjustments for PG&E to passively resynchronize the island back to the normal utility source grid.	Control systems in place to be able to make these required adjustments	This allows for the generation island to support real-time adjustment to meet power quality criteria for the islanded load. This also is required to ensure the island can be re-paralleled to the utility grid.	FCE controls are adjustable during operation
	The system shall have the ability to make small voltage adjustments in order for PG&E to passively resynchronize island back to normal utility source grid.	Control systems in place to be able to make these required adjustments	This allows for the generation island to support real-time adjustments to meet power quality criteria for the islanded load. This also is required to ensure the island can be re-paralleled to the utility grid.	FCE controls are adjustable during operation
	The system shall maintain steady state generator terminal voltage within one percent (1%) of the set point using automatic voltage regulation (AVR) base and have the ability to set the generator terminal voltage within the specified range as specified within PG&E Electric Rule 2.	Vendor meets 1% steady state voltage regulation requirement.	This is required to ensure proper power quality supplied to connected customers.	FCE design and operation meets PG&E interconnect requirements
	During islanded operation, the Project shall hold a voltage target within [+ / - 5%] of the system nominal voltage as dispatched by PG&E.	Vendor can make necessary adjustments up to +/- 5% while operating in island mode.	This is required to ensure proper power quality supplied to connected customers.	FCE controls are adjustable during operation
	The system shall have the ability to set alarm thresholds to notify operator of over or under voltage conditions. These thresholds shall be set by mutual agreement between PG&E and vendor operations.	Control systems in place to be able to make these required adjustments	This is required to ensure proper power quality supplied to connected customers.	FCE has alarm and warning protocols in place with 24/7 remote monitoring for dispatch as needed

Challenge Statement - Appendix D: Islanding Requirements - Frequency and Load

Requirement Category	Requirement	Acceptance Criteria	Summary	FCE Compliance
Frequency	The system shall maintain nominal frequency at 60 Hz as specified within PG&E Electric Rule 2. Additionally, PG&E shall require the facility to be able to maintain steady-state frequency response of plus or minus one percent (+/- 1%) of 60 Hz from minimum load to maximum load.	Control systems in place to maintain 60 Hz +/- 1%	This is required to ensure proper power quality supplied to connected customers.	FCE system meets PG&E requirements
	The system shall have the ability to set alarm thresholds to notify operator of over or under frequency conditions	Control systems in place to be able to make these required adjustments	This is required to ensure proper power quality supplied to connected customers.	FCE system incorporates alarm thresholds
Load	The Project shall meet the full microgrid load with no transmission energy supply for a minimum of two consecutive days (48 continuous hours) without any customer load drop, optimally load could be met for four consecutive days (96 continuous hours). While in microgrid operations, the Project's generation shall follow load to meet customer demand, while maintaining appropriate power quality (as defined above in Voltage and Frequency Requirements) and shall meet peak and minimum customer demand throughout microgrid operations.	Generation stays online without any uncontrolled shutdowns or trips for duration specified	This requirement is to meet the overall objective of electric reliability and resilience of the islanded loads.	FCE project is sized to space available. Demand response and additional FCE systems can be deployed serving key load centers on feeders to reduce peak loading needs at substation.
	The Project shall demonstrate N-1 capability such that the loss of a single engine will allow the island to continue to function within the operational parameters described in voltage and frequency requirements above.	One unit is taken out at peak load and generation island stays online	This requirement is to meet the overall objective of electric reliability and resilience of the islanded loads.	As a baseload system, FCE system would be operational, switching to islanded at grid loss
	Generation stays online without any uncontrolled shutdowns or trips with 10% load imbalance levels	The Project shall carry maximum load with a load imbalance up to ten percent (10%).	This requirement is to meet the overall objective of electric reliability and resilience of the islanded loads.	As a baseload system, FCE system would be operational, switching to islanded at grid loss

Challenge Statement - Appendix D: Islanding Requirements - Cold Load, Black Start and Inrush

Requirement Category	Requirement	Acceptance Criteria	Summary	FCE Compliance
Cold Load, Black Start, and Inrush Requirements	The Project shall be able to provide cold load pick-up with the capability of adding dead load segments of distribution grid and maintain electrical properties while in island operation.	Generation stays online without and uncontrolled shutdowns or trips while energizing portions of the distribution circuitry	This requirement is to meet the overall objective of electric reliability and resilience of the islanded loads.	FCE can meet this requirement as demonstrated in FCE microgrid enabled plants.
	The worst-case load acceptance/rejection value will be thirty percent (30%) of total online generation. If block loading is necessary to restore a portion of the island, PG&E will communicate with the Project to start additional engines if needed. All load pickups will be active and reactive loads.	Generation stays online without and uncontrolled shutdowns or trips while energizing portions of the distribution circuitry	This requirement is to meet the overall objective of electric reliability and resilience of the islanded loads.	FCE includes load leveler in microgrid configuration to operate with up to 100% load changes
	The Project shall demonstrate black start capability without parallel operation to the electric grid.	Generation can start and become available to restore loads without any parallel interaction with the existing utility grid	This requirement is to meet the overall objective of electric reliability and resilience of the islanded loads.	Black start generator included with FCE microgrid offering
	Generator installations must provide black start capability and must be able re-energize previously de-energized distribution feeders with no additional energy sources (distribution or transmission sources) and must be capable of handling high in-rush current. The cold load pickup capability for generators should be 60% of the generator name plate capacity. (Depending on the feeder configuration and technology used, a pickup capability lower than 60% may be acceptable)	Generation can start and become available to restore loads without any parallel interaction with the existing utility grid	This requirement is to meet the overall objective of electric reliability and resilience of the islanded loads.	Black start generator included with FCE microgrid offering. FCE system operates at baseload output with load leveler adjusting to deploy power for cold loads or absorb power during load loss