

Deployment of a Mobile Hydrogen Fuel Cell Generator for Ports and on Marine Vessels

Joe Pratt
Sandia National Laboratories
Fuel Cell Seminar
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The business case (simplified)

Hydrogen Fuel Cell



Technology development
Lower cost of hydrogen
Economies of scale

Diesel Generator

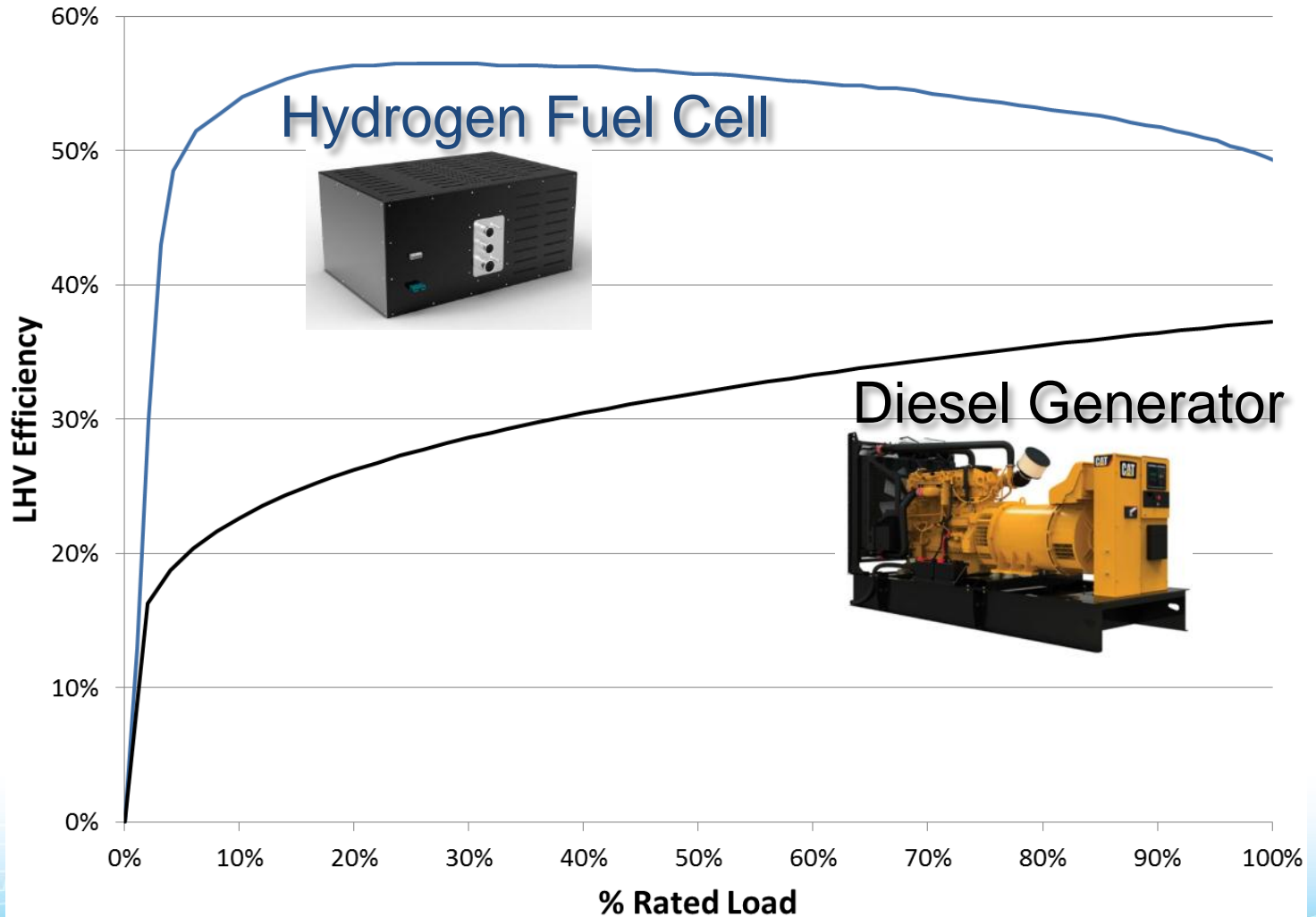


Tighter emissions regulations
Tighter fuel regulations
Higher cost of oil*

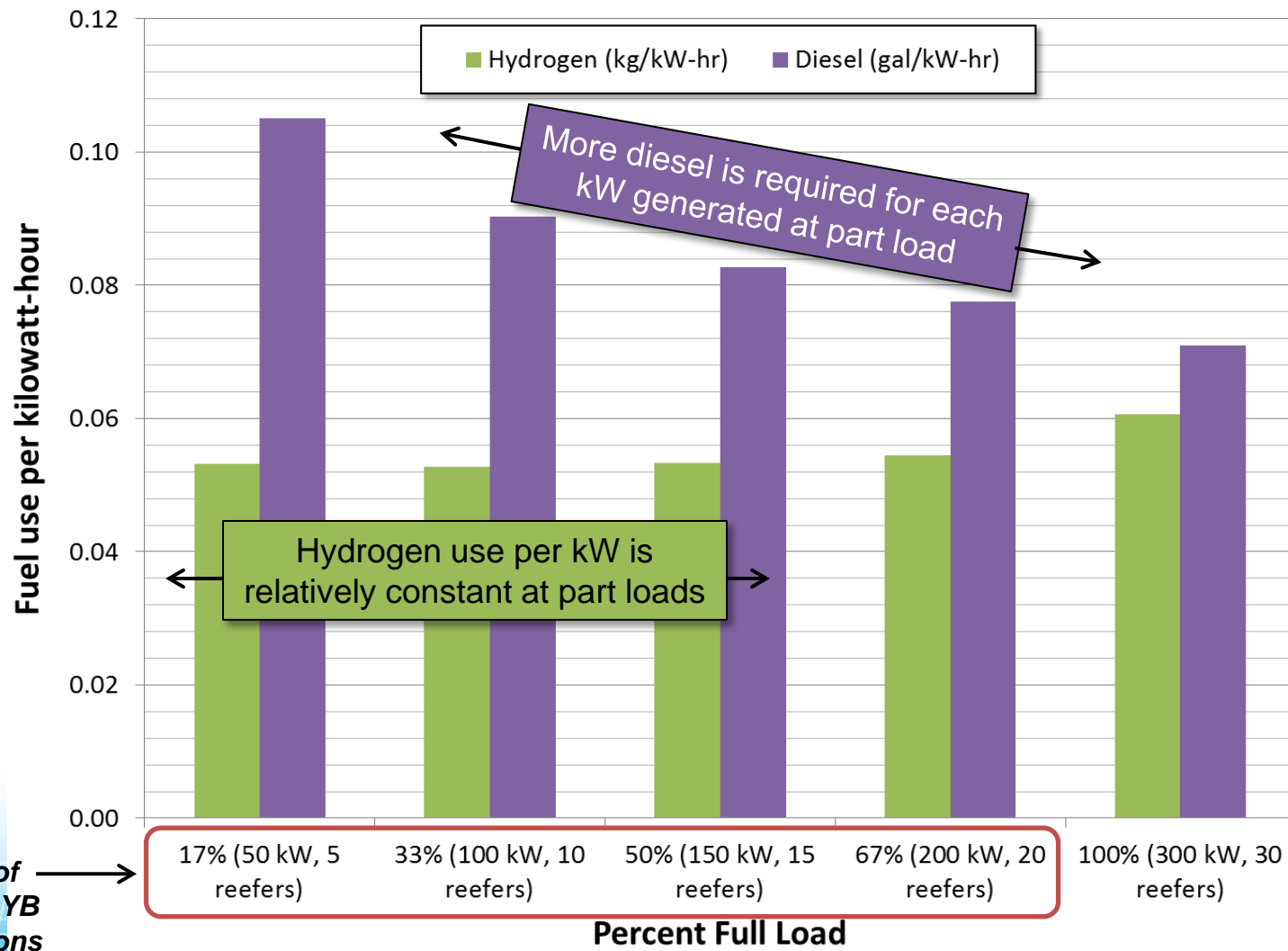
Cost to own and operate

Engine efficiency characteristics are inherently different for the two engine types.

Higher efficiency = Less fuel burned

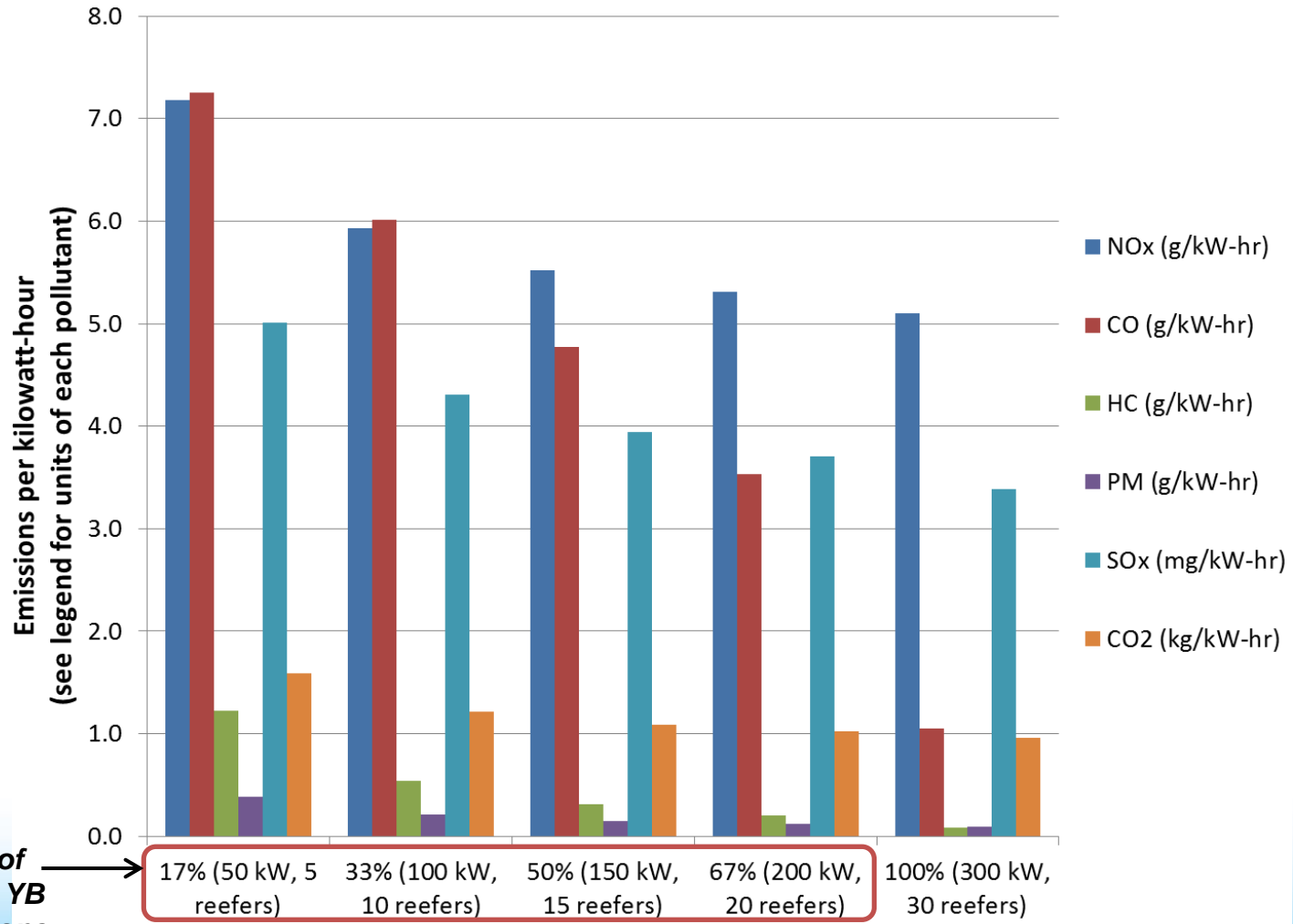


The efficiency differences affect the fuel burn (cost) over the entire range of operation.



Range of normal YB operations →

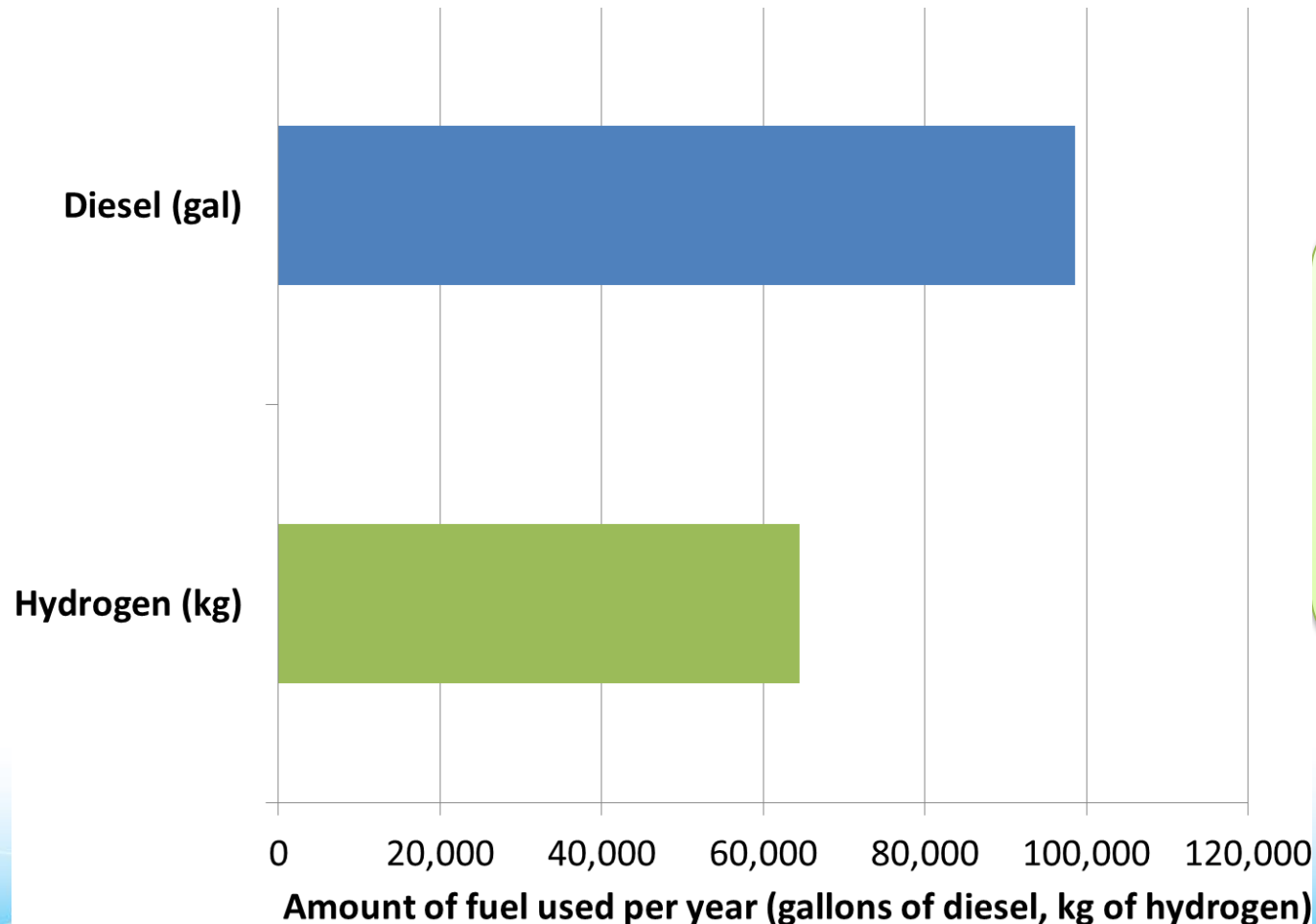
Diesel engine emissions per kilowatt-hour are worse at part load.



Range of normal YB operations →

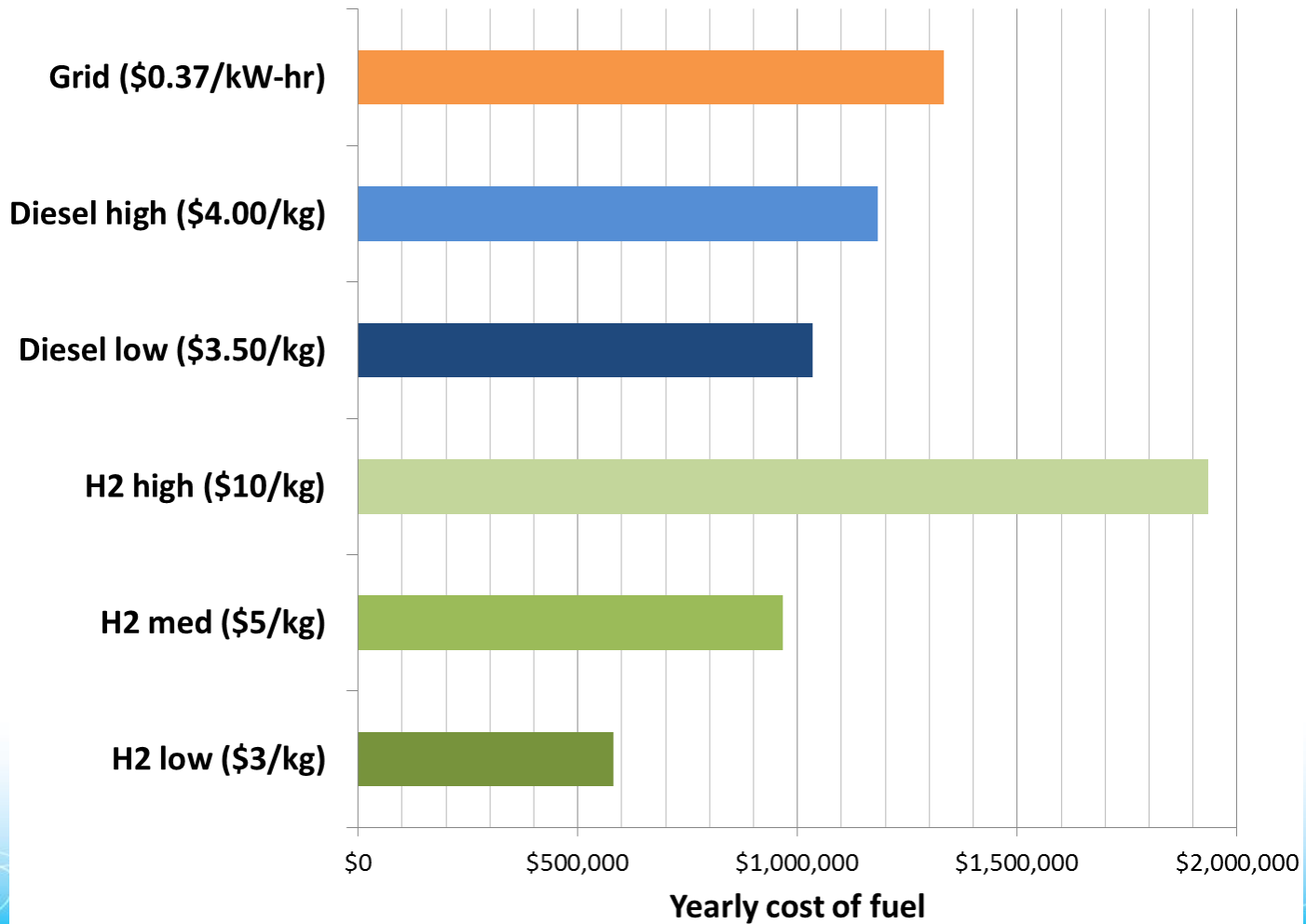
Emissions data, except SOx, from a Caterpillar C15 350 kW genset meeting EPA Tier 3 standards. SOx data assumes all fuel sulfur (15 ppm for ULSD) converted to SOx per EPA guidelines.

An example yearly fuel use for assumed YB operations shows the difference between diesel and hydrogen usage.



Six 300 kW gensets operating 4,000 hrs/yr for 1/3-time each load condition: 67% load, 50% load, and 33% load.

The yearly fuel cost estimate shows that the fuel cell is the most cost effective solution if hydrogen can be purchased for \$5/kg or less.



We have built and are deploying a containerized hydrogen fuel cell generator for reefer power on land and sea.



Project Concept

Fuel cell unit replaces diesel generators, reducing fuel cost and emissions.

Project Scope

Design, build, and deploy a containerized fuel cell system to supply portable power for refrigerated containers (“reefers”).

- 100 kW (net) fuel cell and H₂ storage inside a 20-foot container.
- 6-month deployment on land and over the ocean. (Honolulu-Kahului)
- Strategic set of project partners, encompassing both the H₂-fuel cell and maritime communities.

A strong partnership team is critical to success.



U.S. DEPARTMENT OF
ENERGY

*DOE: Project
Sponsor*



*DOT/MARAD:
Project Sponsor*



*Young Bros. and Foss
Maritime: Deployment
Partners*



*Sandia: Technology
Support and Project
Management*



*Hydrogenics: Complete
design, build, and
integration*



*HNEI: Local H₂
Facilitator*



*HCATT: Hydrogen
provider*



*Hydrogen Safety
Panel: Project and
prototype safety
review*



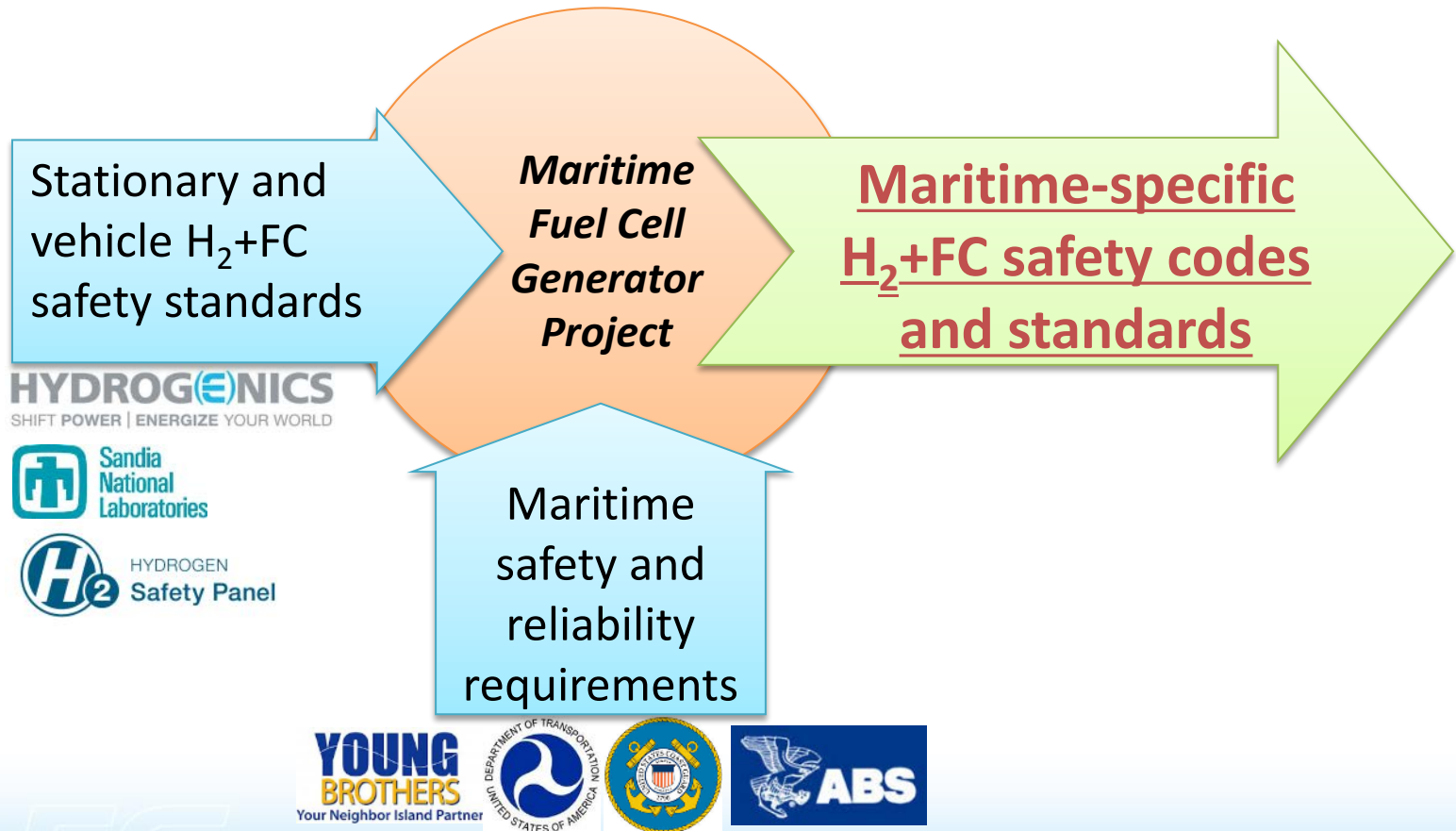
*American Bureau of
Shipping: Maritime
Product Certification*



*US Coast Guard
and USCG Sector
Honolulu: Maritime
codes and standards*



We are assisting the development of maritime codes and standards for hydrogen and fuel cells.



The design is based on stationary and vehicle safety standards and modified to meet maritime requirements; the result is helping inform future codes and standards.

An early and ongoing focus on outreach and education is helping turn reluctance into advocacy.

- Trained over 200 personnel in the classroom
- Trained over 50 (and counting) operational personnel on-site

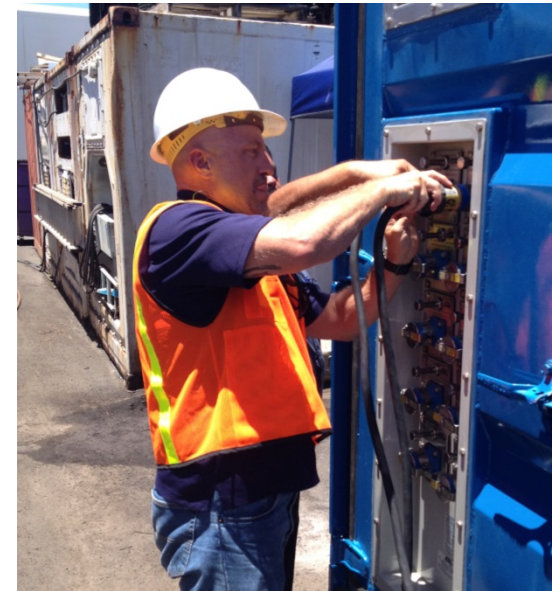


Ribbon Cutting Event – August 28, 2015

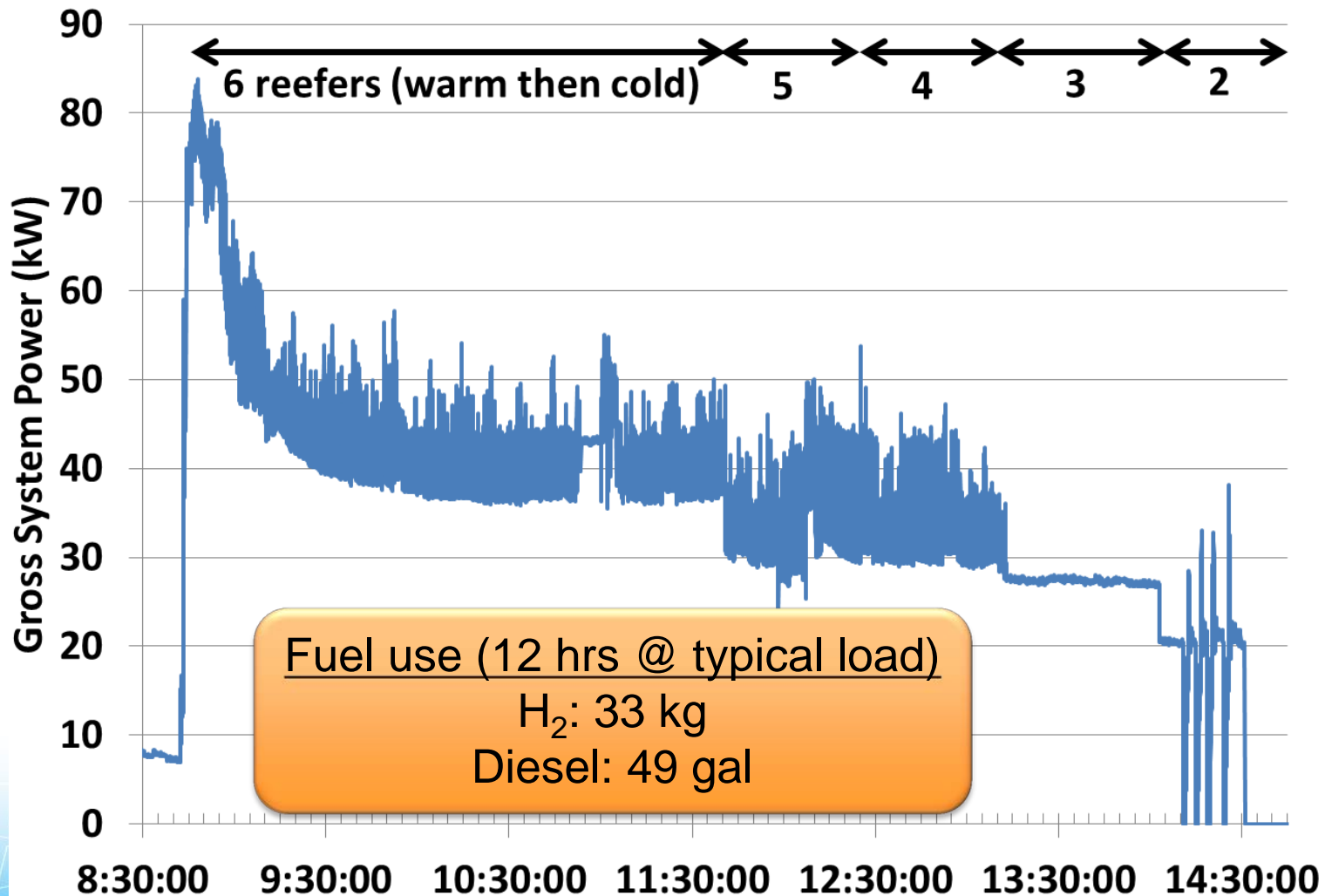
- Young Brother's Port of Honolulu
- 8 Speakers
 - Senator Schatz (HI)
 - Hawaii State Leadership
 - Project Sponsors & Partners
- Demo/Tours of the Unit
- 55 Attendees
 - Energy Industry Early Adopters (business), Military/Government, and Project Partners



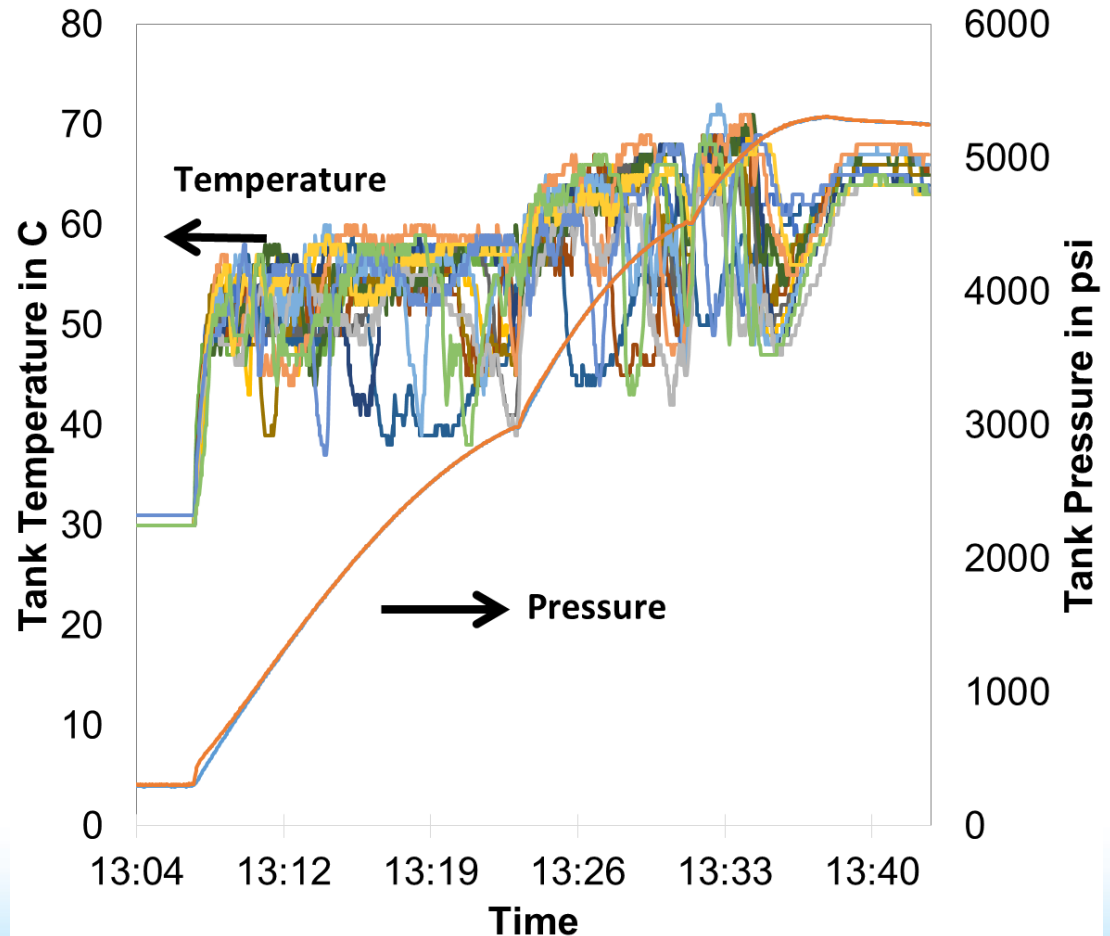
The generator is used to power refrigerated containers with capacity for 10 reefers at a time.



The system power varies directly with the number of reefers and their temperature.



The generator is filled at the Hickam AFB hydrogen station. Can fill (75 kg, 350 bar) in 20 minutes.



The unit is part of Hydrogenics' commercial development strategy for containerized PEM fuel cell solutions.

Development Process

- 2013: Hickam AFB
 - Gen 1: 66kW, Backup power
- 2014: Raglan Mine
 - Gen 2: 200kW, Baseload power
- **Early 2015: Maritime**
 - **Gen 2+H: 100kW with H₂ storage, Portable Power**
- Mid-2015: Kolon
 - Gen 2: 1 MW (of 10 MW total), Baseload power



Commercial Path Forward

- Leveraging the improve power density and integrated H₂ storage design of the Gen 2 Containerized H₂ Fuel Cell Generator open new markets

One fuel cell system feeding multiple applications



Remote communities



Cold ironing or alternative power





RTGC



Peak power generation



Portable power



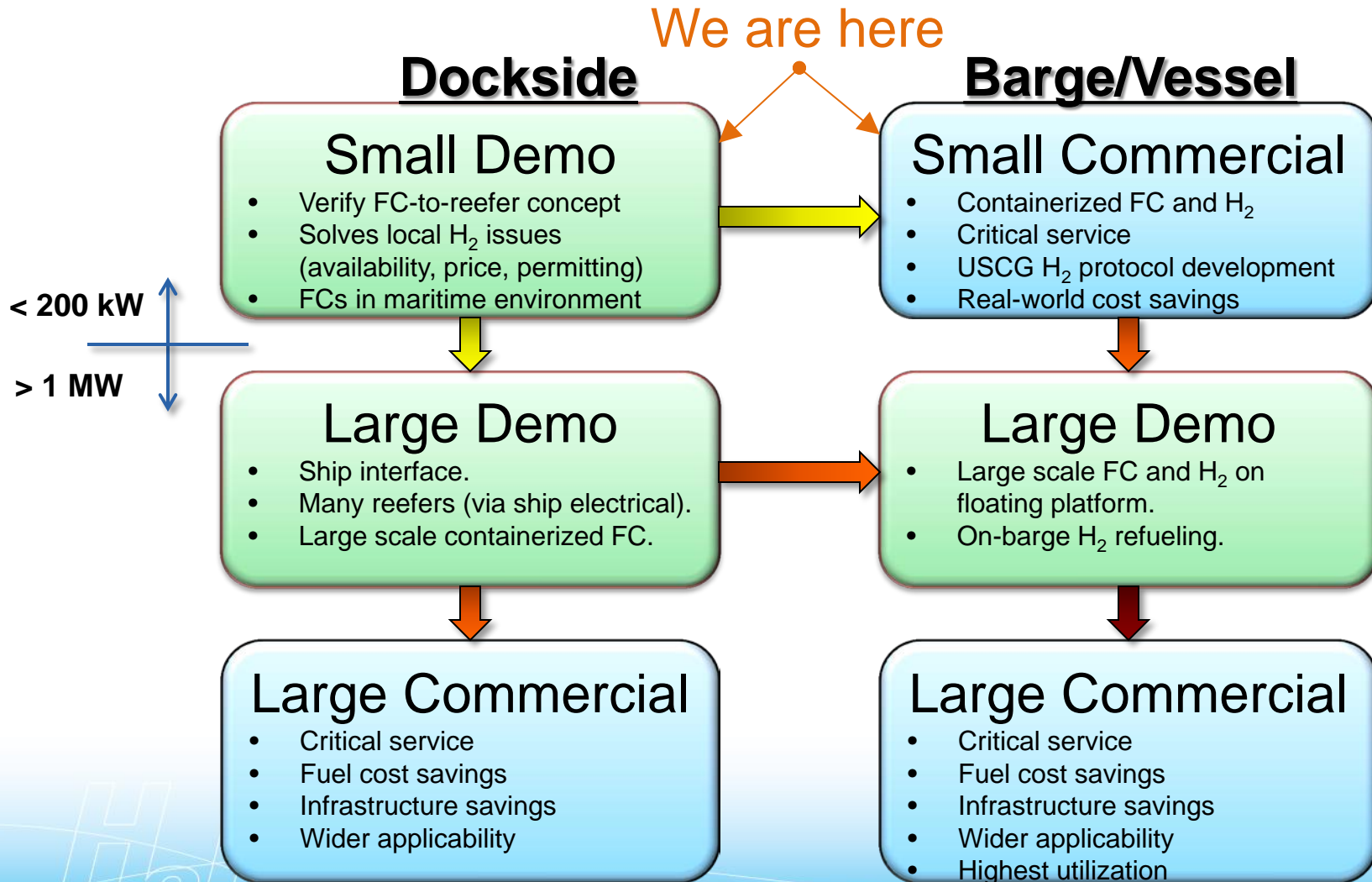
Containerized diesel generators and fuel



Backup power for essential facilities/loads

Slide by Hydrogenics, used with permission

This project is a stepping stone and helps to refine the technology.



Looking forward to more discussion...

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