Transportation Fuel Cell Market Strategies

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

IEA North American Roadmap Workshop

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Source: US DOE 1/28/2014

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- Renewable Hydrogen Projects
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Source: US DOE 1/28/2014

Fuel Cells: Energy Department's Role

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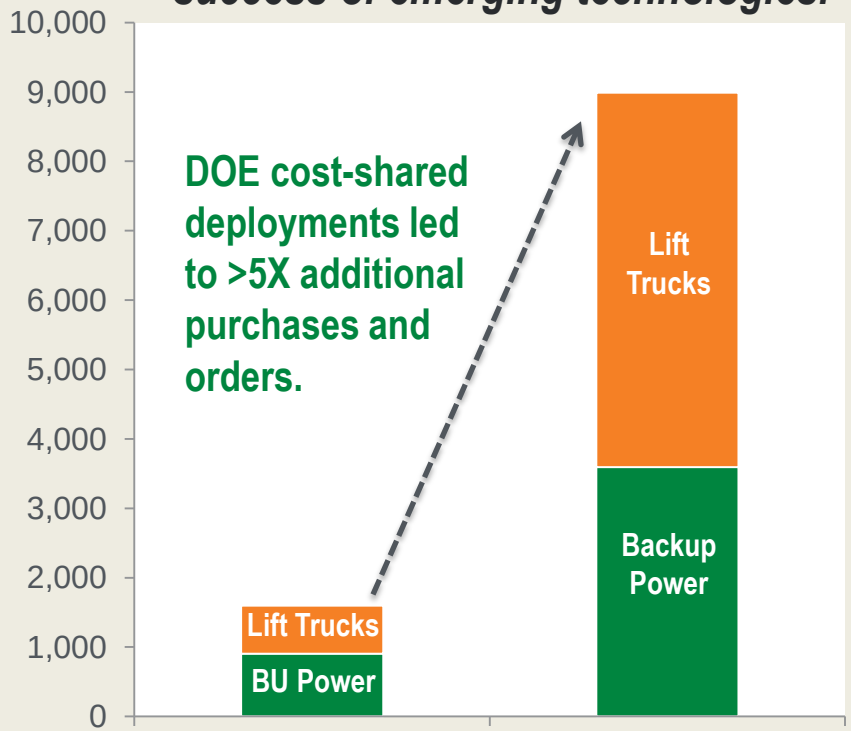
Deployments help catalyze market penetration and ensure continued technology utilization growth while providing data and lessons learned.

Leveraging DOE Funds:

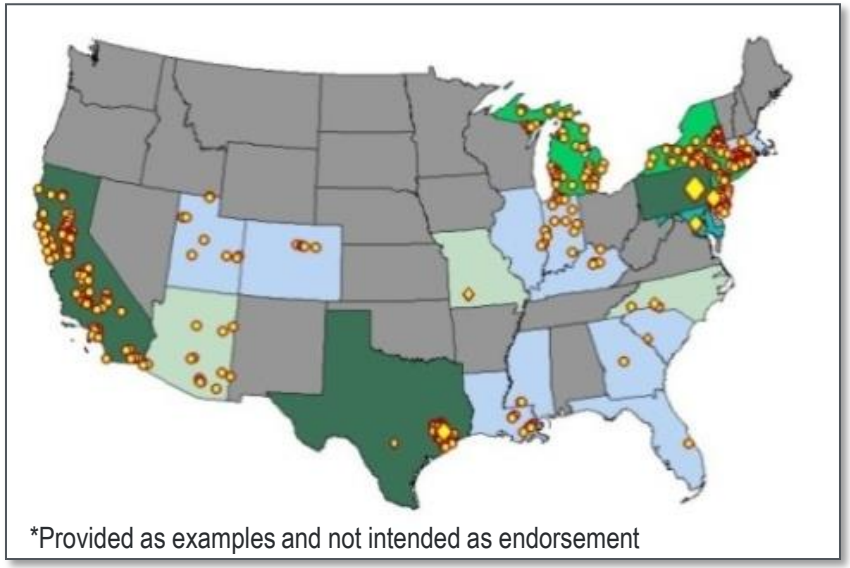
Government as "catalyst" for market success of emerging technologies.



~9,000 ADDITIONAL FUEL CELL LIFT TRUCKS AND BACKUP POWER UNITS PLANNED OR INSTALLED **with NO DOE funding**

Examples of industry* sectors in DOE ARRA projects

- Telecommunications (e.g. AT&T, PG&E. Sprint, etc.)
- Distribution Centers/Warehouses (e.g. FedEx, Genco, Sysco, Wegmans, Whole Foods, etc.)



*Provided as examples and not intended as endorsement

Source: US DOE 1/28/2014

Fuel Cell Vehicle Projects

Fuel cell vehicle fleet deployments will…

Heavy Duty Vehicles

Full-size buses

Drayage Trucks

Waste Hauling Trucks

Medium Duty Vehicles

Shuttle buses

Baggage Tow Tractors

Delivery Vehicles

… and drive down the cost of H2-fuel and demonstrate techno-economic results

Source: US DOE 1/28/2014

Fuel Cell Transportation Projects

Other fuel cell transportation projects include…

Auxiliary Power Units (APUs)

Refrigerated Semi Trucks

Refrigerated Box Trucks

Mobile Specialty Products

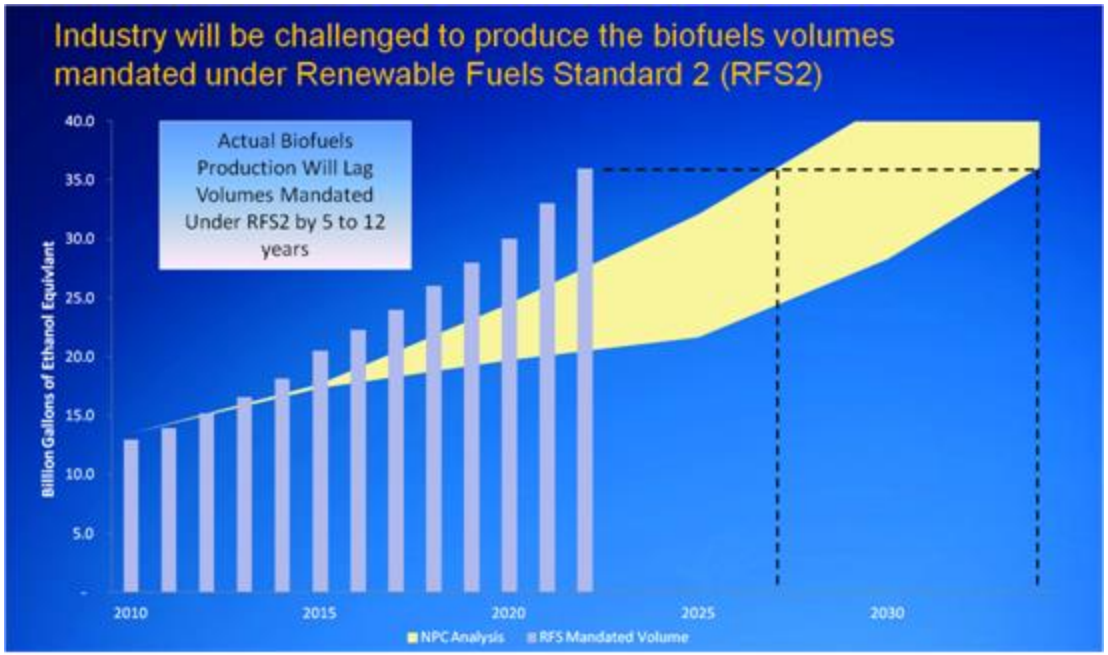
Mobile Light Towers

Mobile Generators

Source: US DOE 1/28/2014

Action: Qualifying Renewable Hydrogen for RFS2

- **The Challenge:** Biofuel supplies at levels to comply with the Renewable Fuels Standard (RFS2) – a growing shortfall is projected



The Opportunity: Qualify Renewable Hydrogen as a Biofuel

* Source: National Petroleum Council; "Advancing Technology for America's Transportation Future;" August 1, 2012: http://npc.org/FTF-80112.html

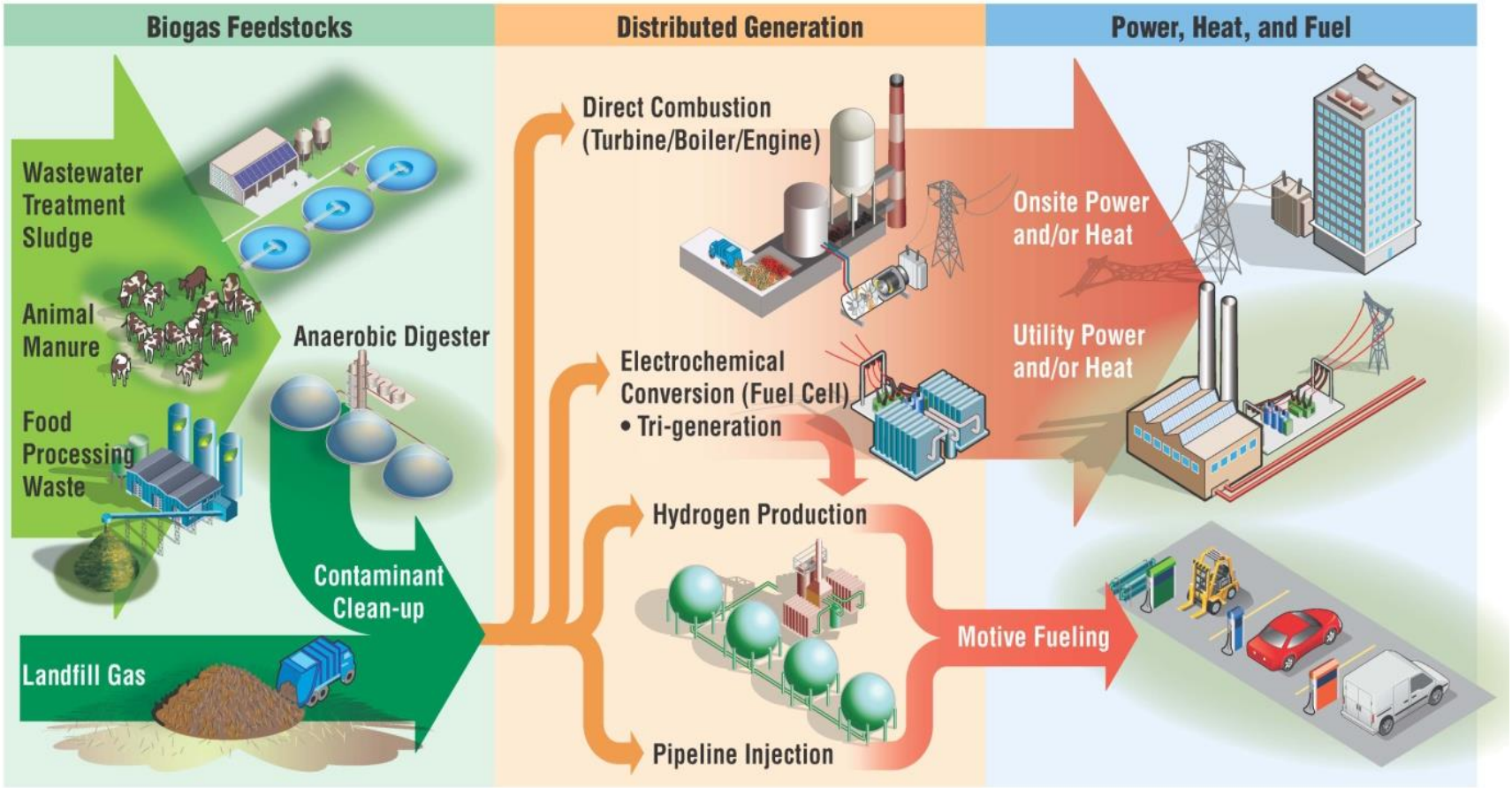
Source: US DOE 1/28/2014

Renewable Hydrogen for RFS2

- The Renewable Fuel Standard (RFS2) mandates that fuel makers meet a minimum percentage of renewable fuel production.
- Renewable fuel credits are called RINs (Renewable Identification Number), and represent 77,000 BTUs of fuel (13 RINs per MMBTU).
- RINs are created when an advanced biofuel is sold as a vehicle fuel.

Source: US DOE 1/28/2014

The Biogas-To-Energy Process



The "New" Business Case: Using biogas to provide both electric power and/or heat and transportation fuel

Source: US DOE 1/28/2014

Tri-Generation: System Flow Diagram

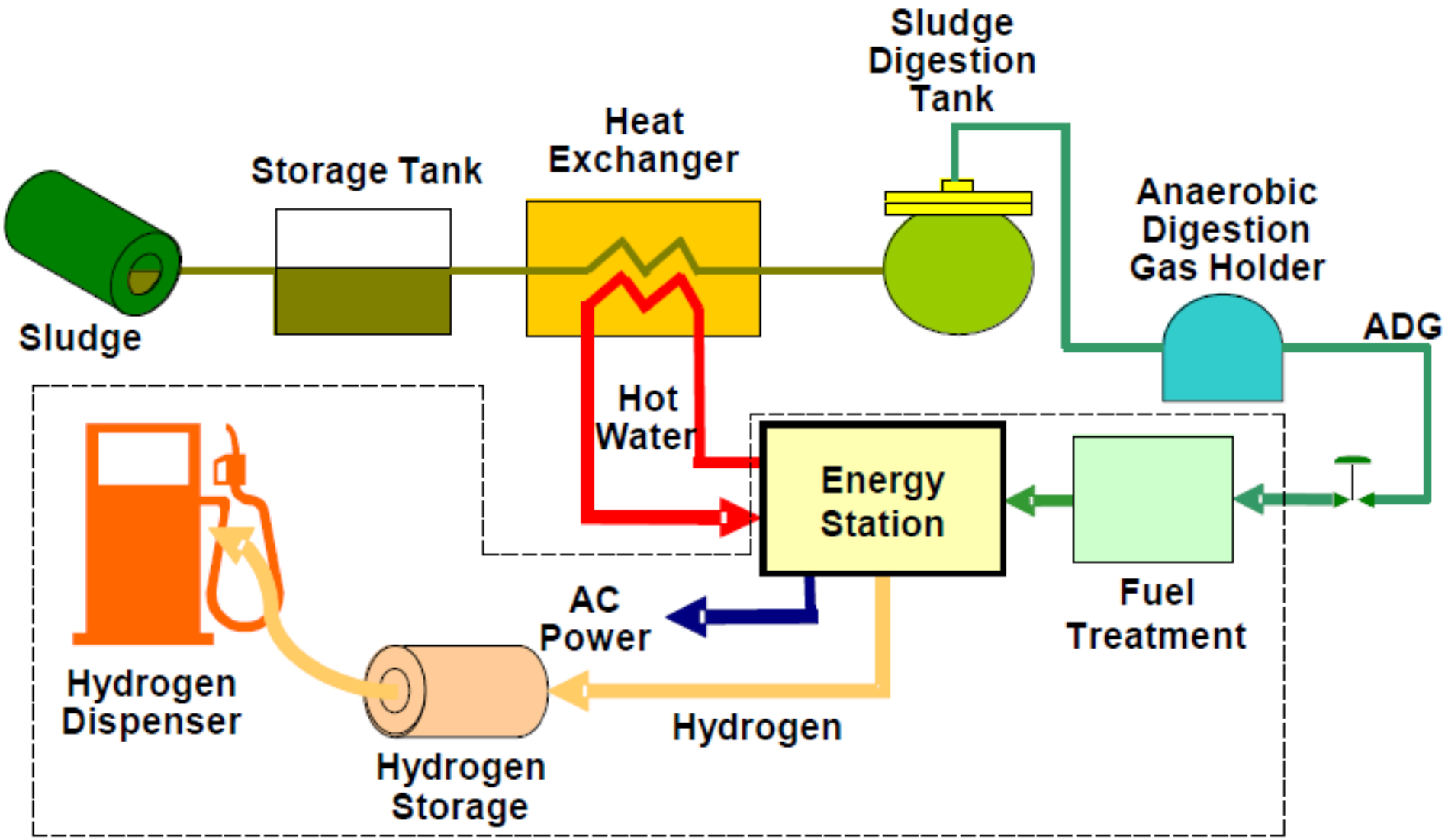
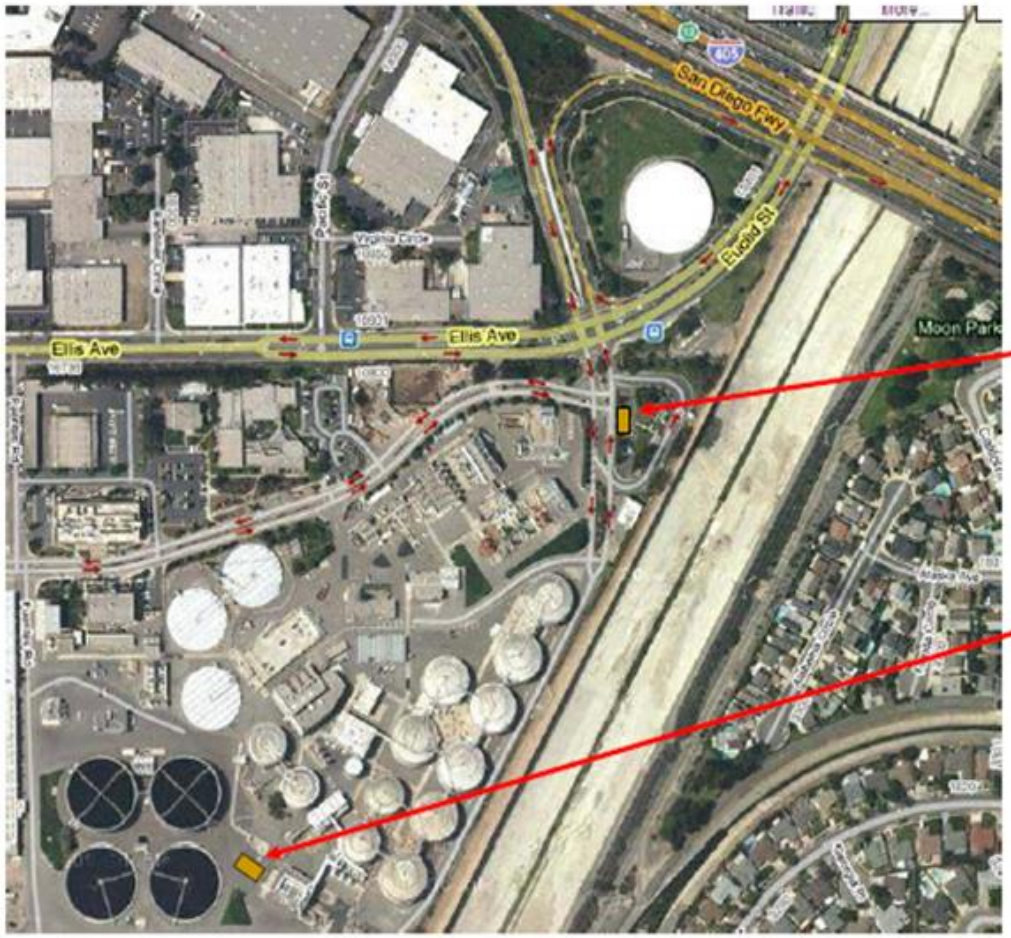


Image source: Air Products

Source: US DOE 1/28/2014

Wastewater Biogas-to-Hydrogen Project: Orange County SD, California

- Operation on ADG: > 3,900,000 SCF processed & used
- Electricity produced: > 800,000 kWh
- Hydrogen produced: > 7,500 lbs (3,400 kg)



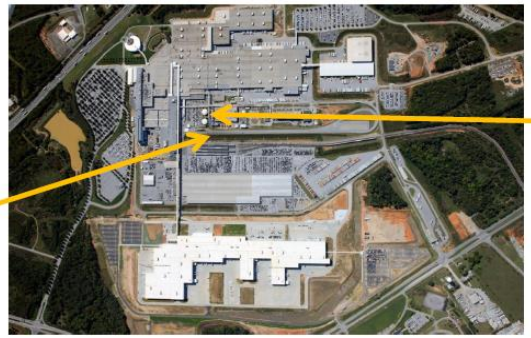
Orange County Sanitation District (OCSD) - site

Renewable H_2 Filling Station

ADG fueled DFC-H2 ® Production Unit

Source: US DOE 1/28/2014

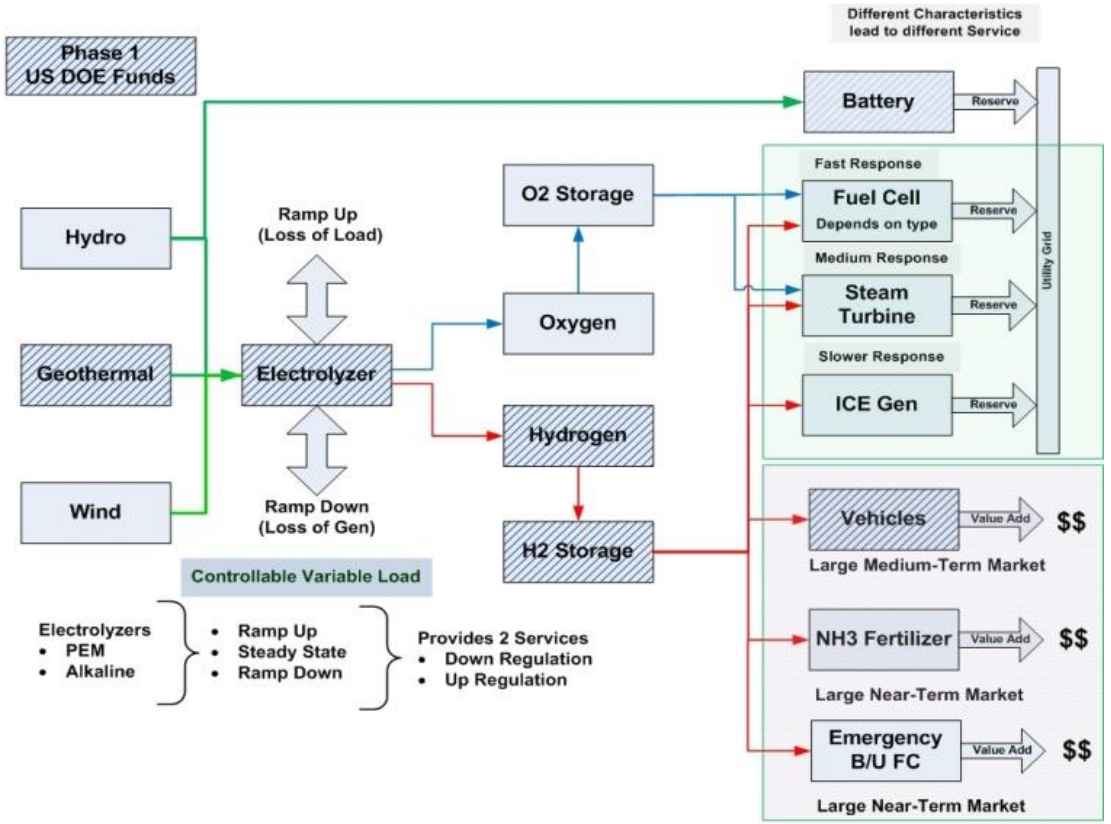
Land Fill Gas to H2 Fuel



Source: US DOE 1/28/2014

Renewable Hydrogen Energy Storage

- Operate 65 kg/day PEM electrolyzer under sustained cyclic operation and evaluate frequency variability response
- Produce hydrogen from renewable energy for transportation fuel - one FC shuttle bus for local community bus and two FC buses for Hawaii Volcanoes National Park (HAVO)
- Compare electrolyzer ramp rate capacities to ramp rates required to impact frequency using 1MW Li-titanate battery
- Conduct performance/cost analysis to identify benefits of integrated system including grid services and off-grid revenue streams
- Status: Hydrogen system complete. Initial operation expected Q4 2014



Partners

US DOE	ONR
State of Hawaii	HNEI
PGV	MTA

Source: US DOE 1/28/2014

Renewable Electricity-to-H2 Fuel

Hydrogen Delivery Process:

H2-fueled shuttle buses

Hydrogen Dispensing under Grid Management Program

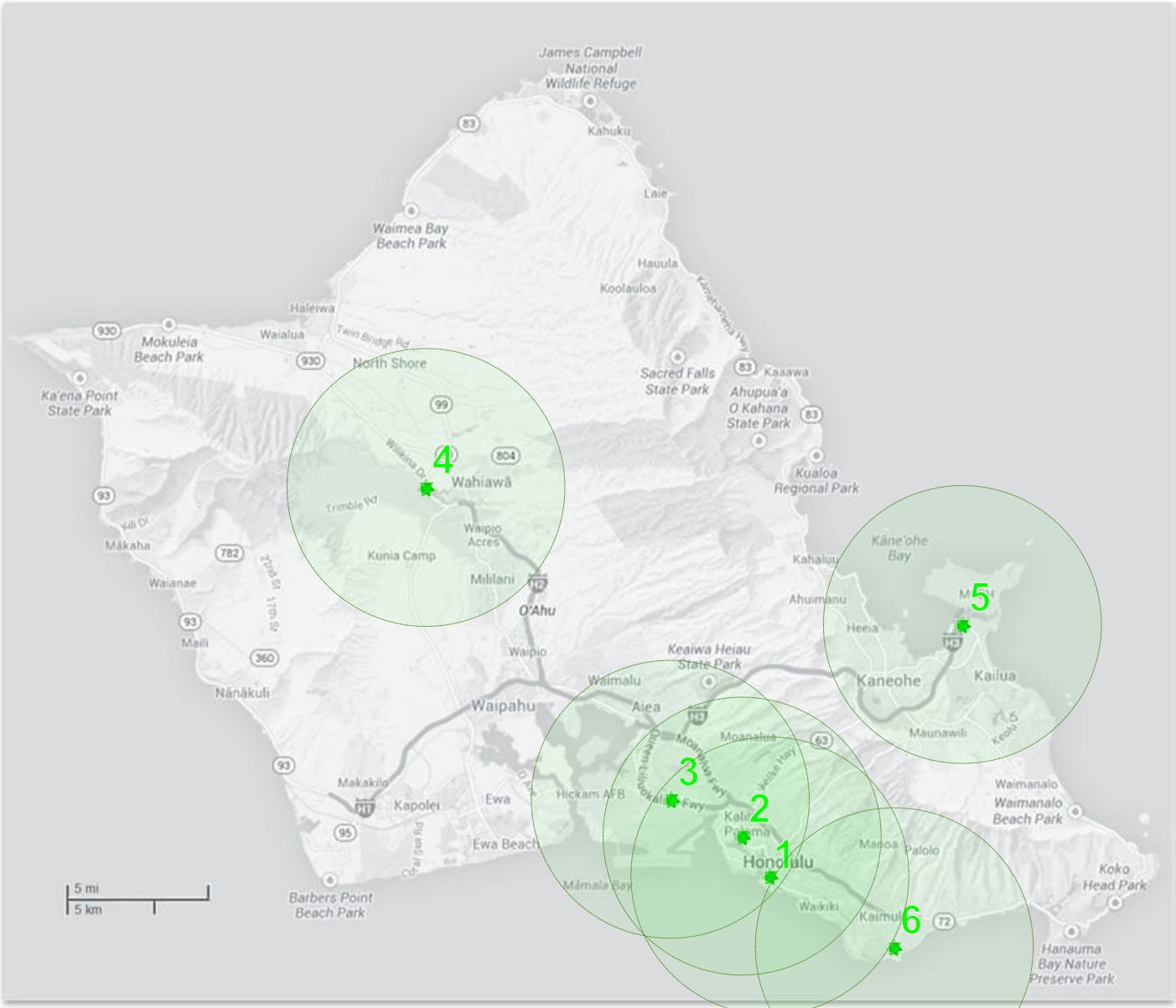
Hydrogen Delivery Trailer uses unique cascade fill process that required no onsite compressor

Hydrogen Dispensing under Hawaii Power Park Program

Geothermal Powered Hydrogen Production

Source: US DOE 1/28/2014

Infrastructure Planning



1: Ft. Armstrong
2: Pier 38
3: Airport
4: Scofield Barracks
5: Kaneohe Bay
6: Diamond Head Guard

5-miles radius

Source: US DOE 1/28/2014

H2 Consumption of Commercial Fuel Cell Technologies

Fuel Cell Technology	Estimated Commercial Availability	Estimated Per Unit H2 Consumption (kg/day)
Material Handling Equipment	Now	1-2
Bus	Now	20-30
Heavy Duty Drayage Truck	Now	15-20
Medium Duty Truck/Bus	2016	5-10
Tow Tractor	2016	3-4
Truck Refrigeration APU	2016	5-6
On-Barge Refrigeration		
* Young Brothers Demo	Now	100
* 90 kW On-Barge Container	2016	100-130
Mobile Generators	2014	1-2
Mobile Lighting	2014	1-2
Light-Duty Vehicles		
* H2I Demonstration	Now	1
* Hyundai, Toyota, Honda	2015	1
* All other auto OEMs	2018	1

- **Many commercial fuel cell transportation technologies are available now. These could be "clustered" readily on Oahu and the Big Island, providing the potential for cost effective H2 usage by the customers and also using available H2 fueling infrastructure.**
- **Most fuel cell technologies would be commercially available by 2016, assuming successful demo project outcomes.**
- **These fuel cell transportation technologies are the "building blocks" for a successful strategy to transition H2I into a beach head for successful early market launch of a Hydrogen Economy for Hawaii.**

Source: US DOE 1/28/2014

Thank You

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For information about the U.S. Department of Energy Fuel Cell Technologies Program:

hydrogenandfuelcells.energy.gov

Source: US DOE 1/28/2014