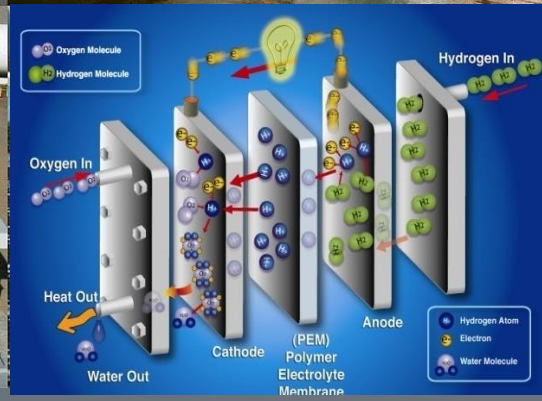
DISCLAIMER

The views and opinions expressed in the Hydrogen Fuel Cell and Battery Electric Vehicle Stakeholder Charrette presentations are that of specific presenters, and may not necessarily represent the position of the Hawaii Strategic Development Corporation or Hawaii State Energy Office.

U.S. DOE All Electric Vehicle Activities

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



Hydrogen Fuel Cell and Battery Electric Vehicle Shareholder Charrette

1/14/2015

Pete Devlin

Manager, Market Transformation Program
U.S. Department of Energy
Fuel Cell Technologies Office

All-of-the-Above Energy Strategy

Fuel Cell Technologies are included in the U.S. "all of the above" energy strategy.

*"We've got to invest in a serious, sustained, **all-of-the-above energy strategy** that develops every resource available for the 21st century."*

- President Barack Obama

"As part of an all-of-the-above energy approach, fuel cell technologies are paving the way to competitiveness in the global clean energy market and to new jobs and business creation across the country."

- Secretary Moniz,
U.S. Department of Energy

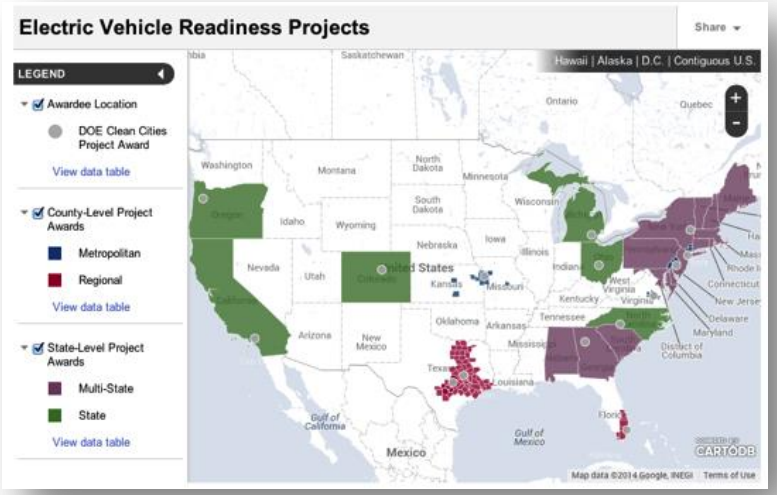
Secretary Moniz at DC Auto Show

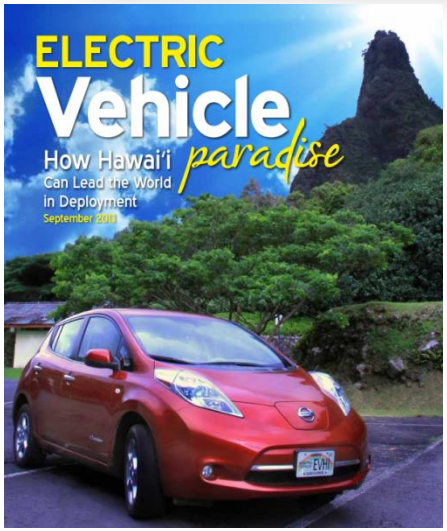
EV Community Readiness Projects

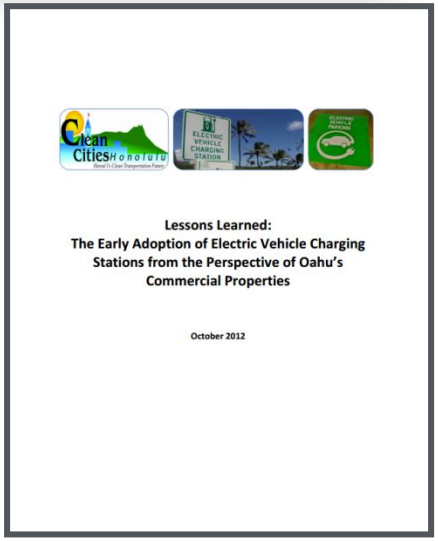
- 16 projects in 24 States
- Activities included—
  - Streamlined permitting processes
  - Revised codes
  - Training emergency personnel
  - Educating the public
  - Developing incentives

"A Guide to the Lessons Learned"

- Synthesizes project findings
- Highlights key activities and outcomes
- Help readers easily connect with relevant resources



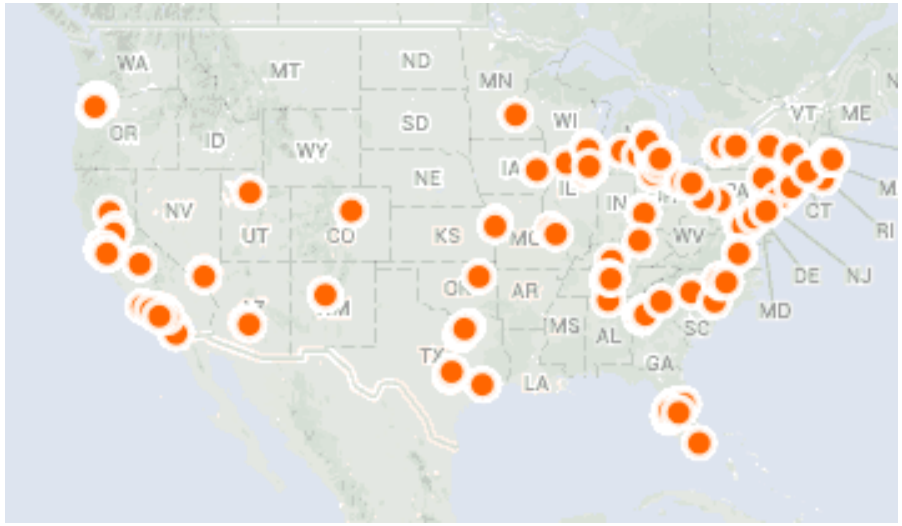




http://maui.hawaii.edu/eva/home

Partner Progress

600,000+
employees

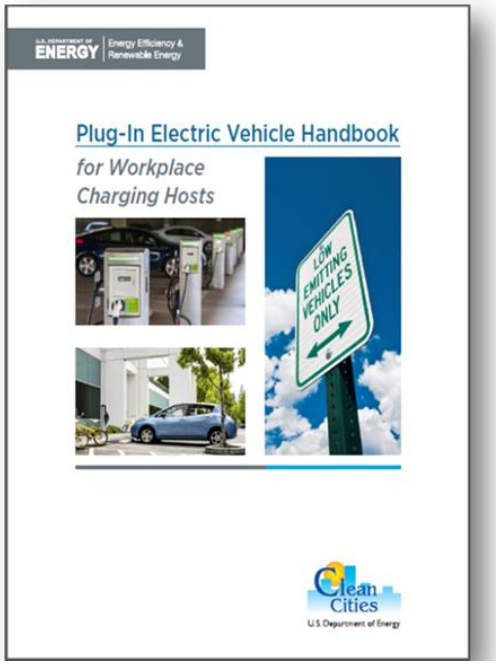


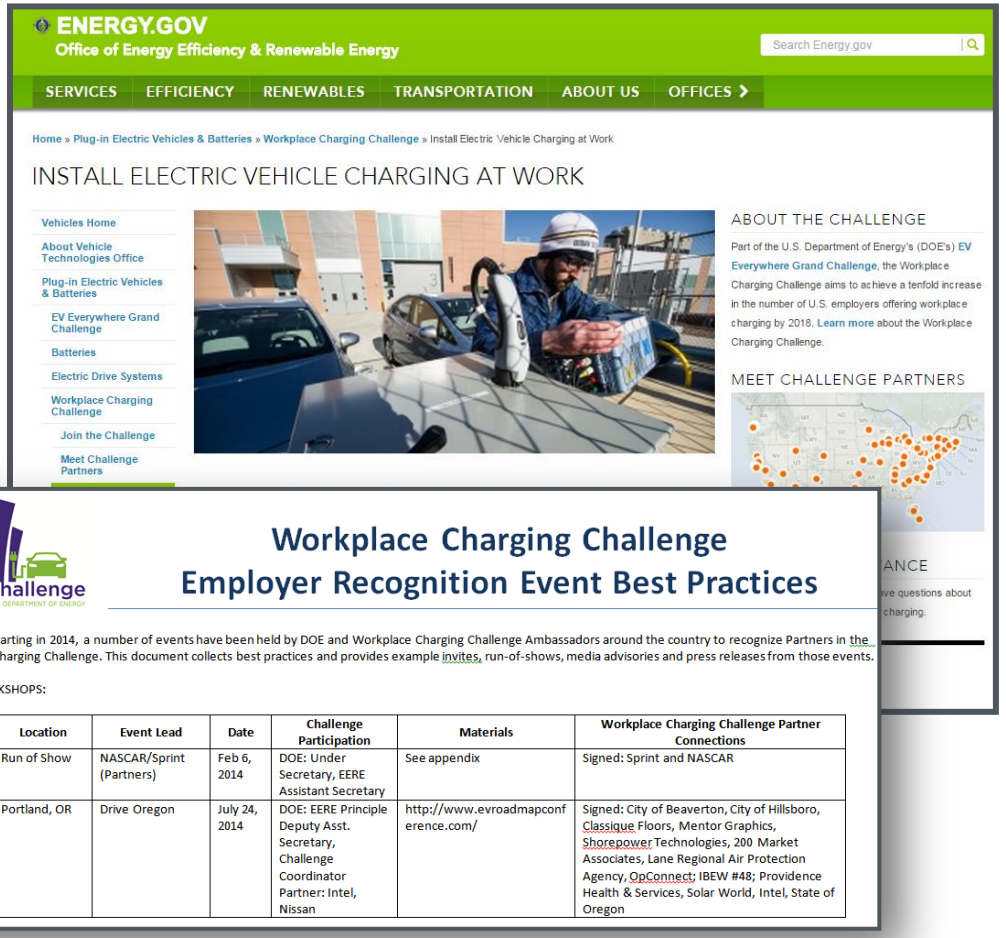
300+
worksites

Workplace Charging Challenge Resources

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

DOE provides technical assistance, a best-practice sharing forum, and recognition





electricvehicles.energy.gov

WorkplaceCharging@ee.doe.gov

"All-of-the Above" Strategic Benefit: Reduced Well-to-Wheels Petroleum Use

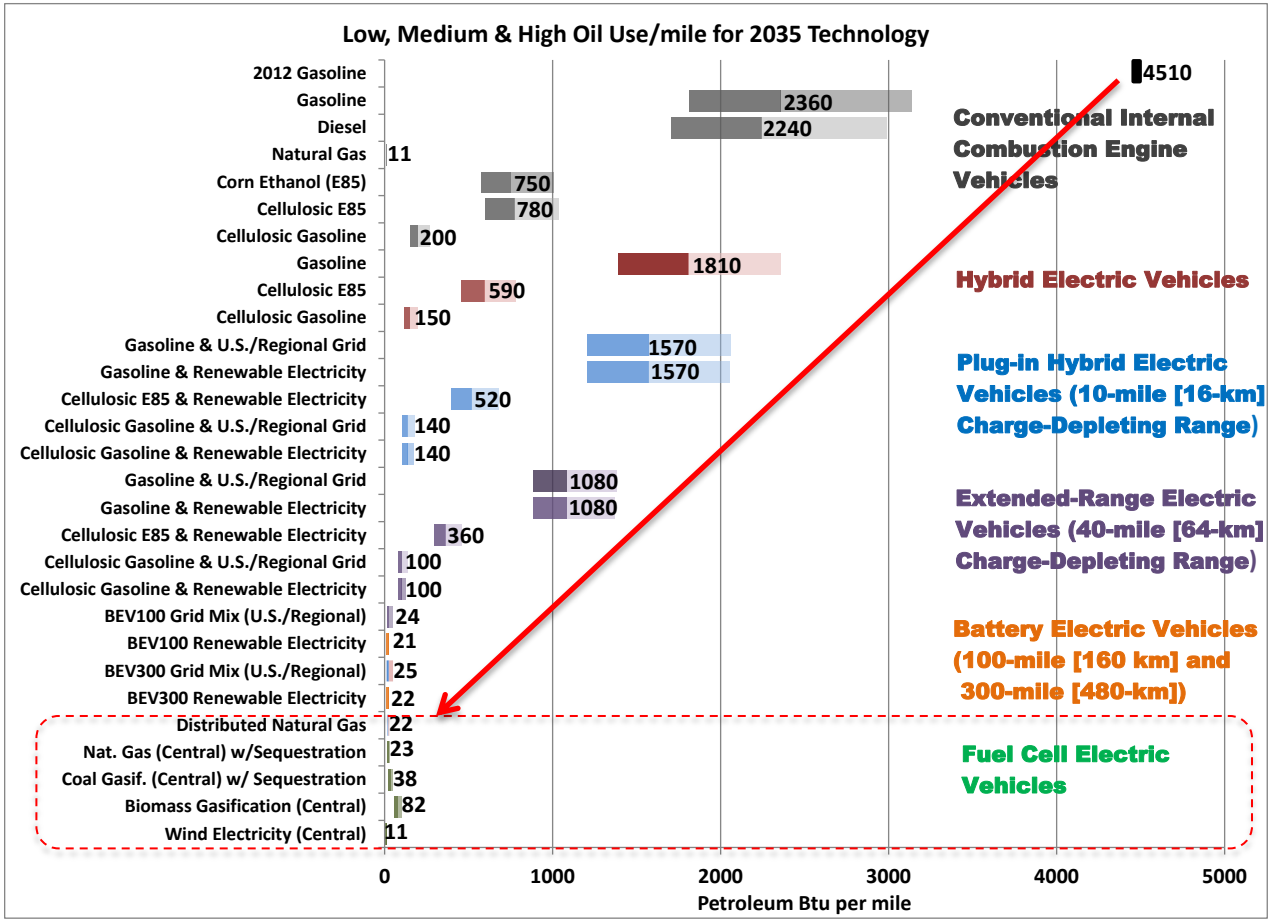
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Analysis by Argonne National Lab, National Renewable Energy Lab and EERE (Vehicles, Fuel Cells, & Bioenergy Technologies Offices) shows benefits from a portfolio of options

- **Updated, peer-reviewed analysis (EERE multi-Office coordination)**
- **BEVs and FCEVs provide the greatest reductions in petroleum use.**

Well-to-Wheels Petroleum Energy Use for 2035 Mid-Size Car

(Btu per mile)



Low/medium/high: sensitivity to uncertainties associated with projected fuel economy of vehicles and selected attributes of fuels pathways, e.g., electricity credit for biofuels, electric generation mix, etc.

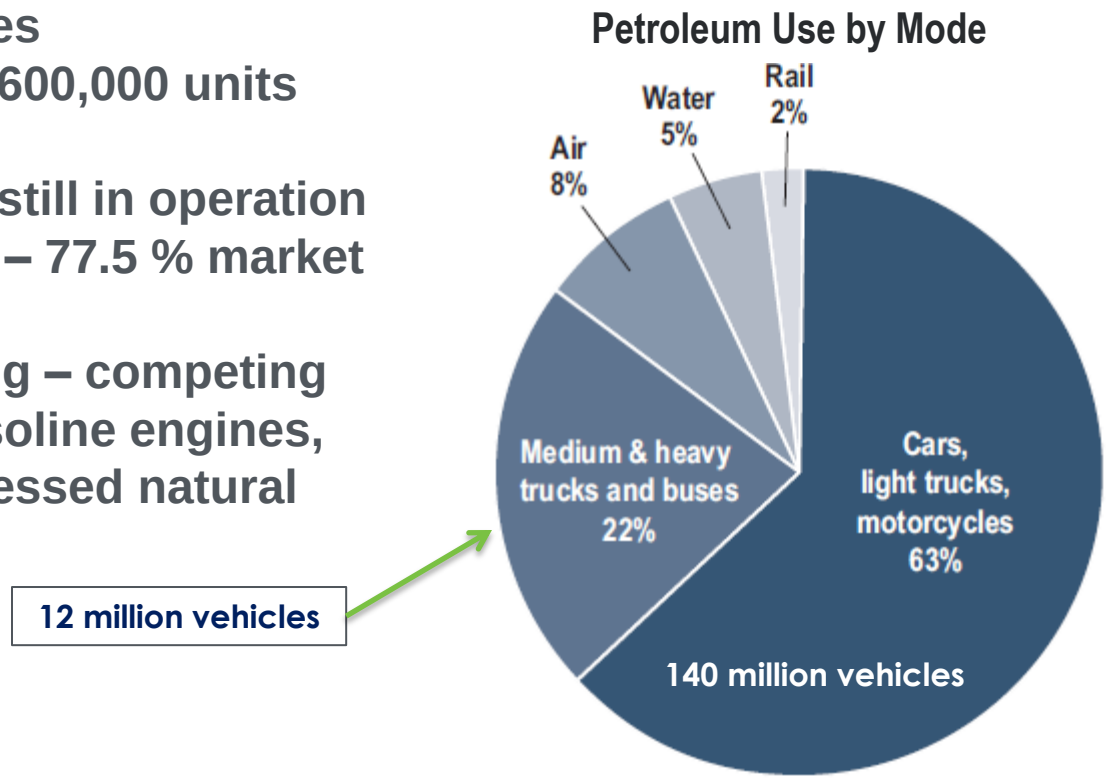
See reference for details:
http://hydrogen.energy.gov/pdfs/13005_well_to_wheels_ghg_oil_ldvs.pdf

Class 3 – 8 Vehicles: U.S. Market Profile

Medium Duty (MD) and Heavy Duty (HD) vehicles (Classes 3-8) consume 22% of the petroleum (Source: Edison Electric Institute)
http://www.eei.org/issuesandpolicy/electrictransportation/FleetVehicles/Documents/EEI_UtilityFleetsLeadingTheCharge.pdf

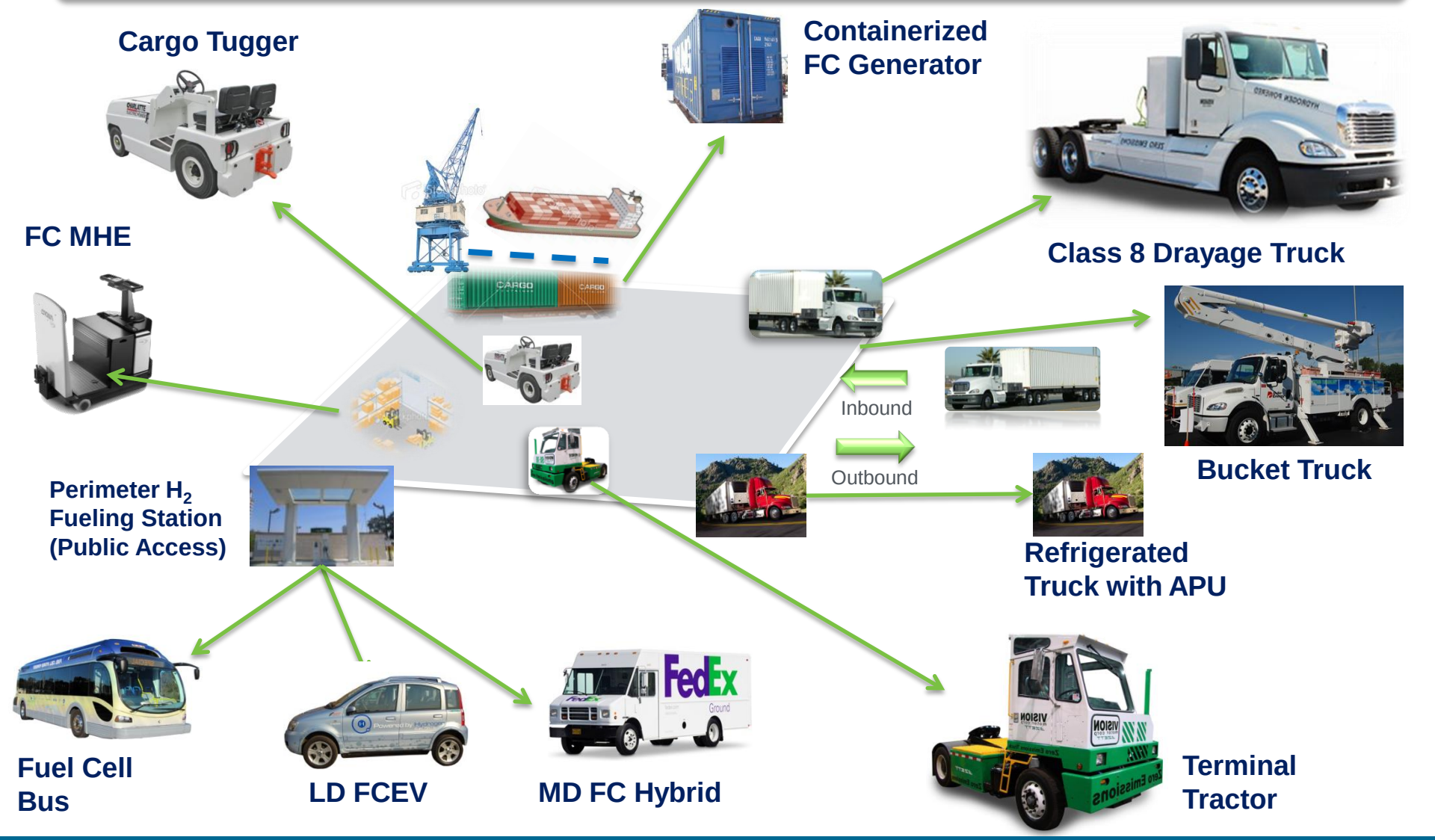
U.S. Class 3-8 vehicles (Source: R L Polk):
https://www.polk.com/knowledge/reports/quarterly_commercial_vehicle_report_march_2014

- 11.9 million registered vehicles
  - New vehicle sales about 600,000 units annually
- 4.2 million pre-2000 vehicles still in operation
- Diesel ICE engines dominate – 77.5 % market share March 2014
  - Diesel ICE share declining – competing technologies include gasoline engines, flex fuel vehicles, compressed natural gas, and plug-in hybrid



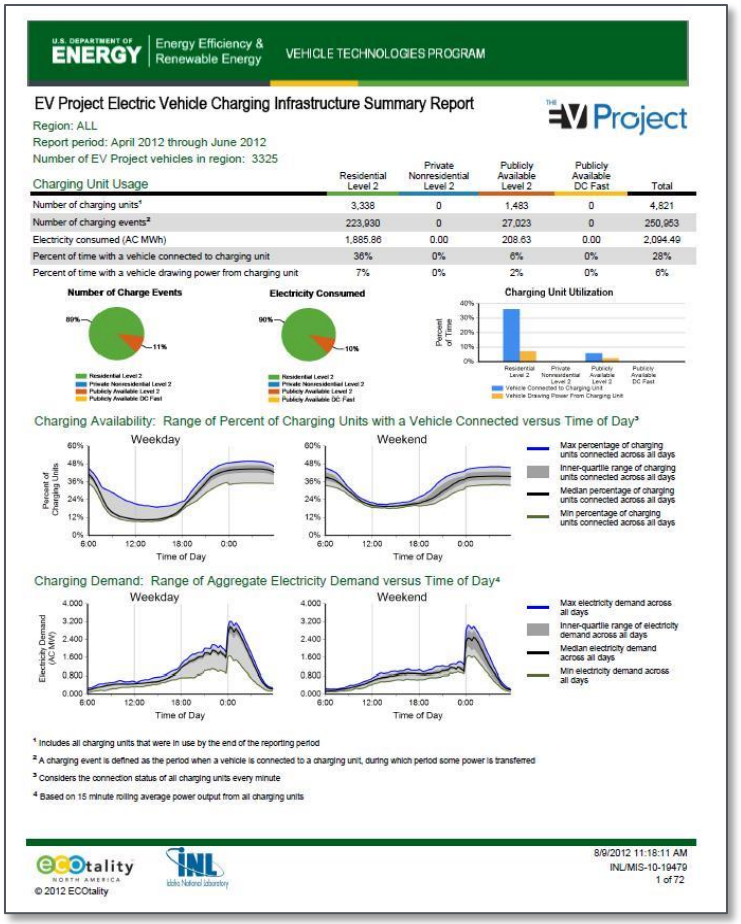
"Clustering" Motive Fuel Cells Can Drive Hydrogen Demand

Fuel Cell Vehicles at a Representative Port-Based Industrial Complex



EV/EVSE Data Collection & Analysis

- **Data collection on thousands of vehicles and EVSEs as part of the Transportation Electrification Initiative:**
  - 2.7 million LDV PHEV/EV charge events on 14,000 EVSE
    - 165,809 PHEV/EV miles and 7,646 charging events documented per day
  - 574,435 medium-duty EV miles documented for 339 trucks in commercial service
  - Testing under varied and extreme thermal conditions
  - Evaluated 13 EVSE and DCFC hardware units
- **Data collected informs deployment planning:**
  - Analysis of charging station utilization by venue/location
  - Effect of utility time-of-use electricity rates and fee structures on consumer charging behavior
  - Other lessons learned: PEV performance, EVSE permitting procedures, installation costs



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy — VEHICLE TECHNOLOGIES PROGRAM

EV Project Electric Vehicle Charging Infrastructure Summary Report

The EV Project

Region: ALL
Report period: April 2012 through June 2012
Number of EV Project vehicles in region: 3325

Charging Unit Usage	Residential Level 2	Private Nonresidential Level 2	Publicly Available Level 2	Publicly Available DC Fast	Total
Number of charging units[1]	3,338	0	1,483	0	4,821
Number of charging events[2]	223,930	0	27,023	0	250,953
Electricity consumed (AC MWh)	1,885.86	0.00	208.63	0.00	2,094.49
Percent of time with a vehicle connected to charging unit	36%	0%	6%	0%	28%
Percent of time with a vehicle drawing power from charging unit	7%	0%	2%	0%	6%

Number of Charge Events — Electricity Consumed — Charging Unit Utilization

Charging Availability: Range of Percent of Charging Units with a Vehicle Connected versus Time of Day[3]

Weekday — Weekend

Charging Demand: Range of Aggregate Electricity Demand versus Time of Day[4]

Weekday — Weekend

[1] Includes all charging units that were in use by the end of the reporting period
[2] A charging event is defined as the period when a vehicle is connected to a charging unit, during which period some power is transferred
[3] Considers the connection status of all charging units every minute
[4] Based on 15 minute rolling average power output from all charging units

ecotality NORTH AMERICA — © 2012 ECOtality — INL Idaho National Laboratory

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INL/MIS-10-19479
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Demonstration results, including lessons learned white papers, technical reports, summary data, and maps are publicly available: *http://avt.inl.gov/*

Workplace Charging Challenge

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

Goal: Increase the number of employers offering charging by 10x by 2018

150+ Partner employers committing to provide EVSE for employees

300+ Worksites across the country

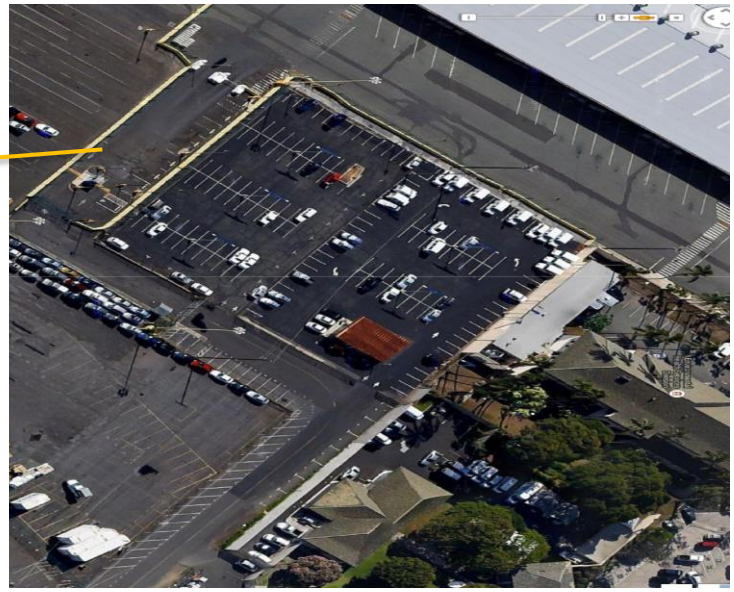
3,000+ EVSE installed or planned for installation

17 Ambassadors promoting and supporting workplace charging

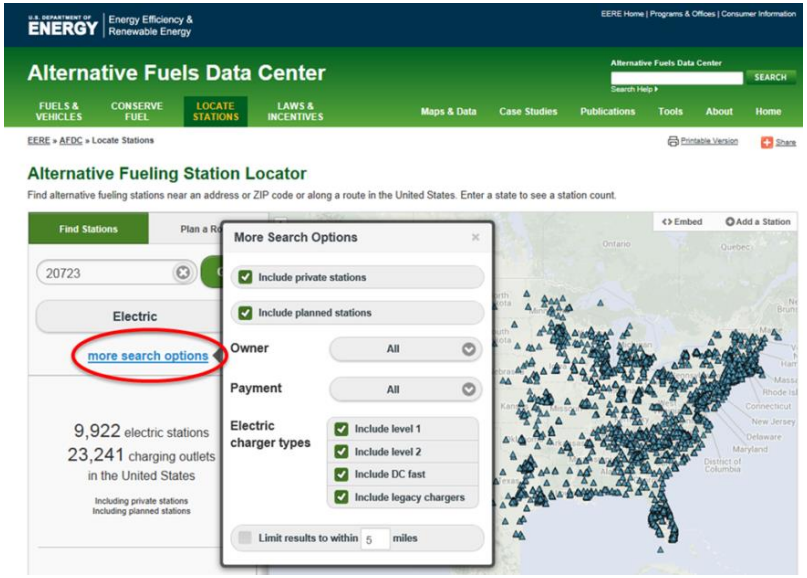
Resources: electricvehicles.energy.gov, WorkplaceCharging@ee.doe.gov

DOE-GSA Feasibility Study: Hydrogen Station in Downtown Honolulu

- 1.4-acre land area at "Fort Armstrong" site in downtown Honolulu.
- Income-producing site improvements include:
  - Hydrogen fueling station – 65 kg/day @ price competitive with gasoline and diesel
  - Covered 175-stall parking structure
  - Solar panels mounted on parking structure roof
  - Solar panels generate about 700 kW per day – used to produce hydrogen



Mission: Advance U.S. energy, economic, and environmental security by supporting local decisions to reduce petroleum use in transportation



www.afdc.energy.gov/locator/stations/

Thank You

Peter.Devlin@ee.doe.gov

Key Dates:

- **FY15 SBIR Applications: February 3, 2015**
- **Annual Merit Review: June 8-12, 2015**

hydrogenandfuelcells.energy.gov

Workplace Charging Challenge

Goal: Increase the number of employers offering charging by 10x by 2018

Partners

- Commit
- Take Action
- Share Progress

DOE

- Assist
- Connect
- Recognize

Ambassadors

- Promote
- Support

A Fuel Cell Industry Emerges

Robert Rose
Breakthrough Technologies Institute
January 14,2015

Fuel Cell Drivers

- High efficiency
- Excellent environmental performance
- Enables other technologies
  - Good fit with renewable energy

- Profit Motive

Economic Motivation

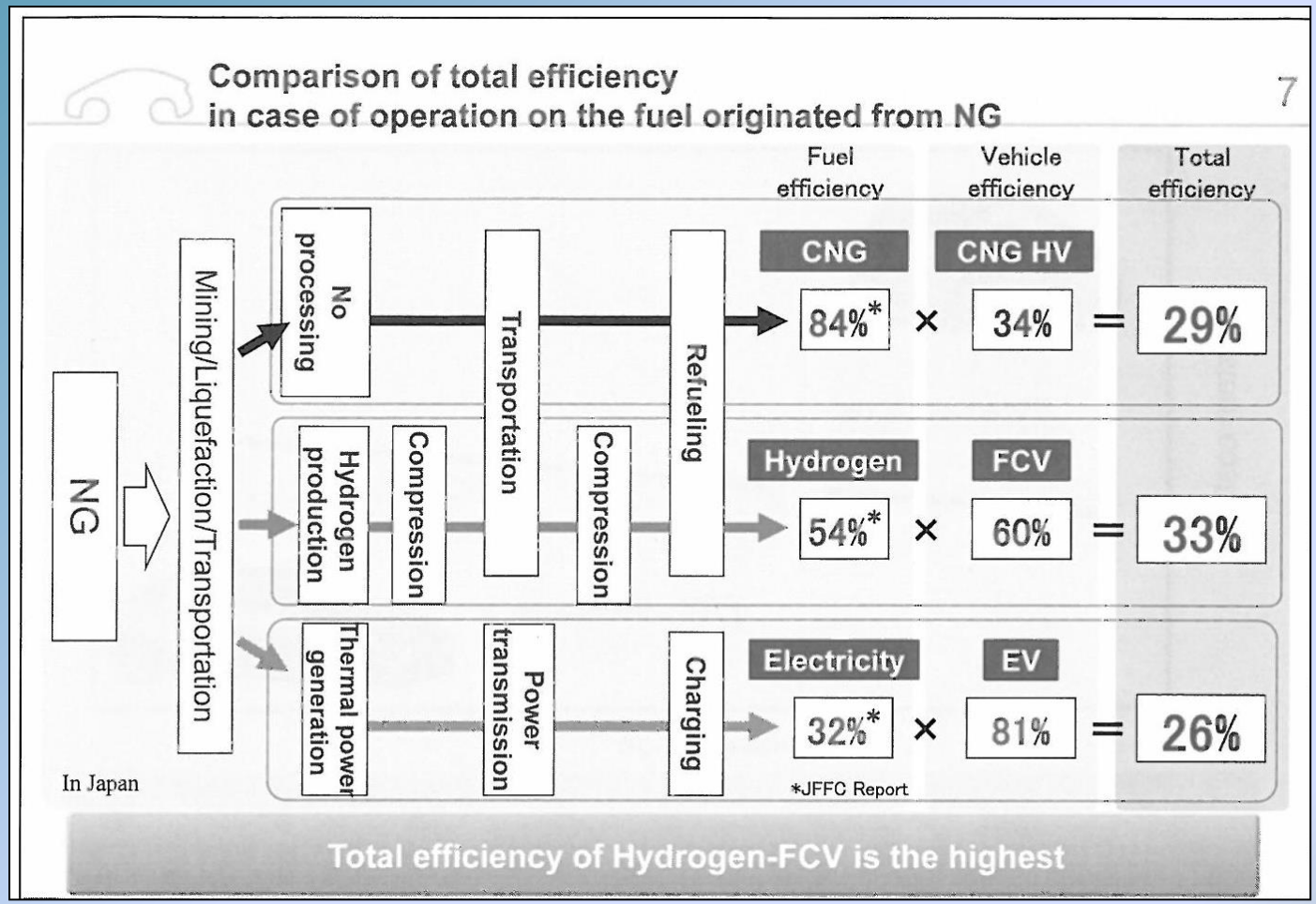
- Jobs and profits
  - 3 million jobs (Korean government)
- Business case in niche markets
- Reliable power: Power failures cost US $18-33 billion in 2013
  - **Reliability:** Power where and when you need it
  - **Resiliency:** Running through increasingly powerful storms
  - **Power Quality:** For modern devices
  - **Security:** Against attack and natural disasters
  - **Affordability:** Predictable pricing, reasonable rates
  - **Efficiency:** Transmission, distribution, generation
  - **Safety:** For customers and workers
  - **Flexibility:** For intermittent generation and self generation
  - **Environmentally friendly:** Reduce noise, emissions

- Changing regulatory environment – focus on customer
  - Japan, NY State

Fuel Cells Fit the New Utility Paradigm

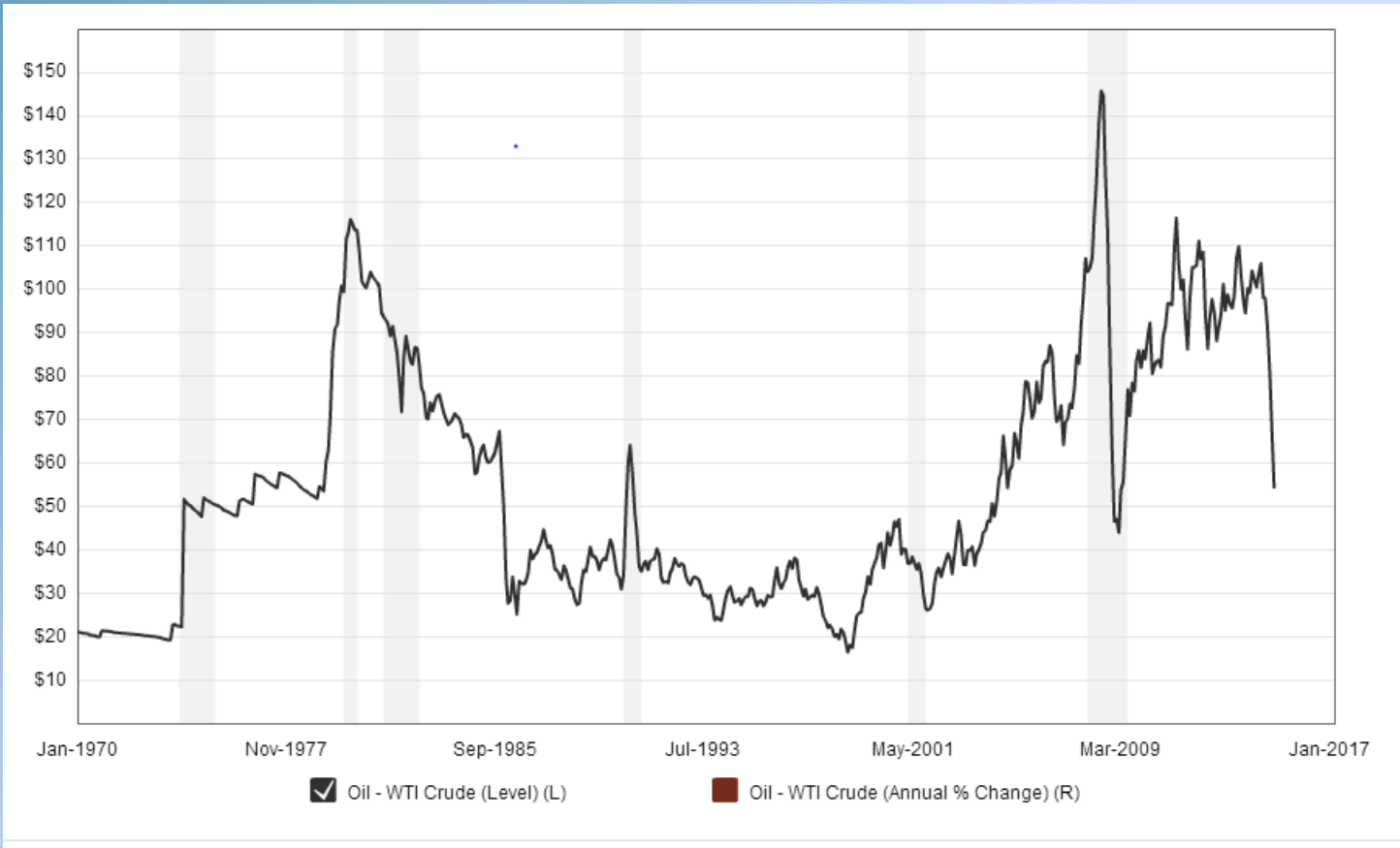
- High efficiency distributed power
  - Decentralized, close to customer
- Long run time backup power
  - Days not hours
- Support for power grid via electrolysis
- Capability to store large amounts of power

Toyota on Efficiency



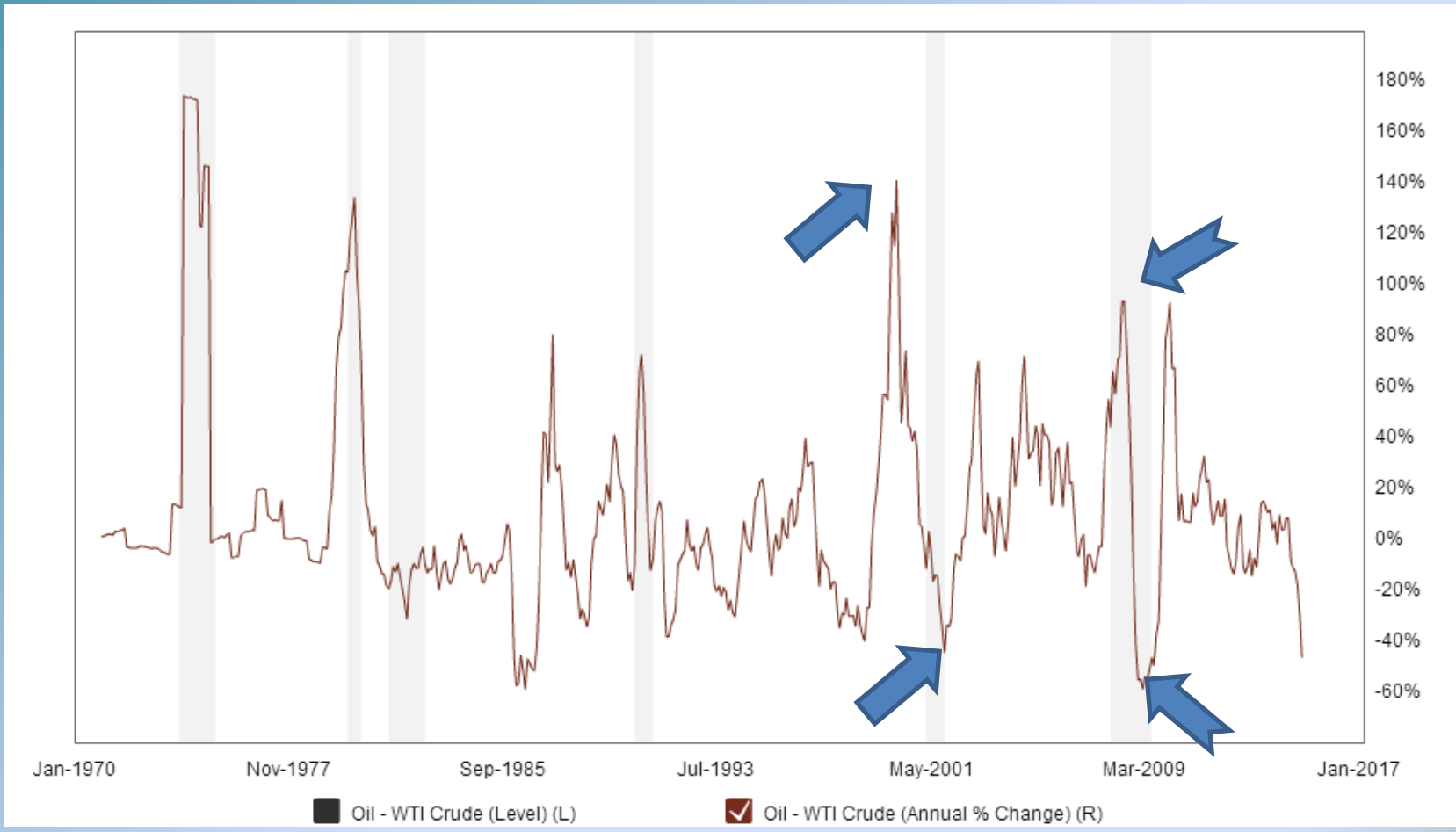
Toyota Corp. 2014

Oil Price Volatility: Prices



Inflation adjusted

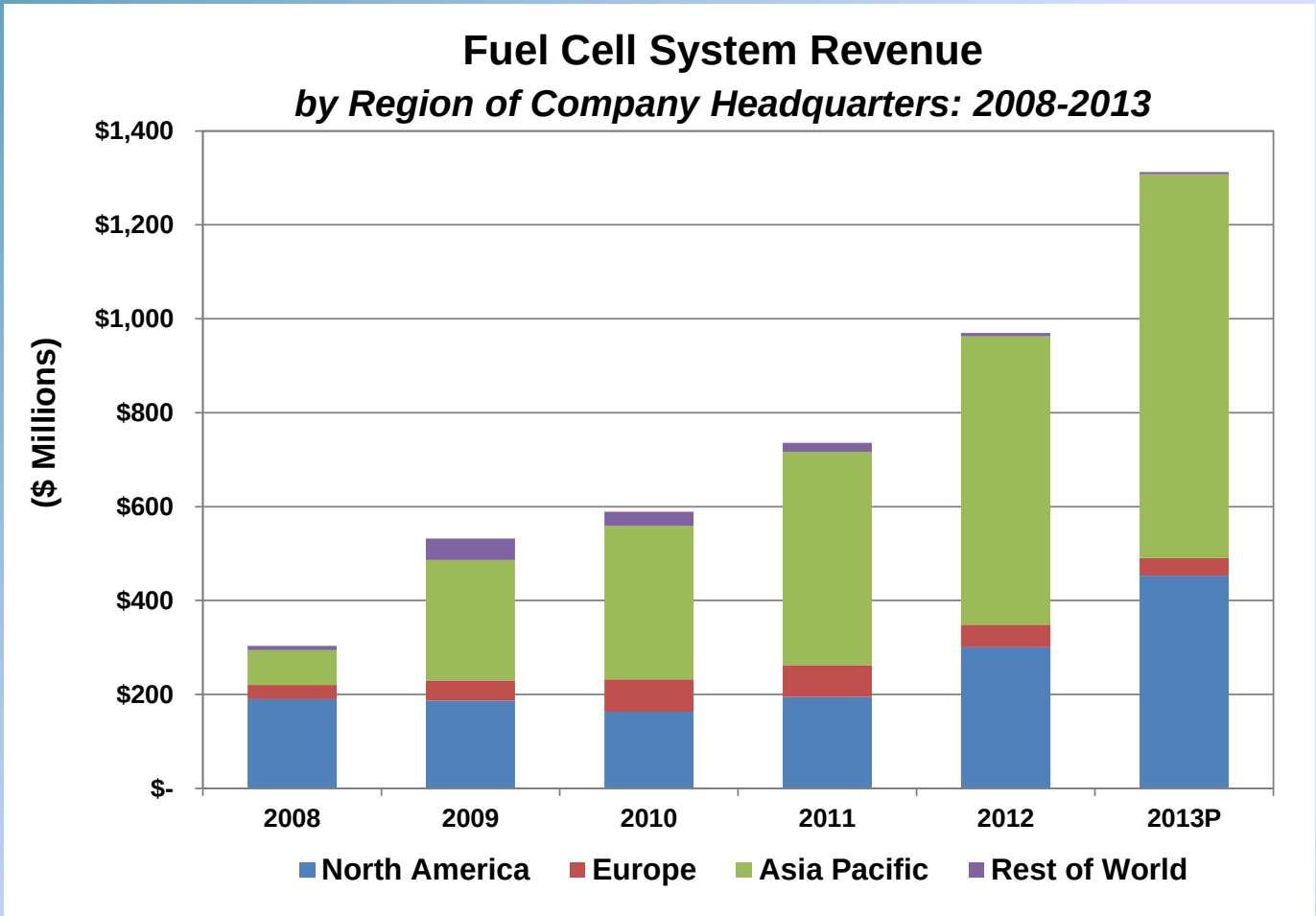
Oil Price Volatility: Price Swings



Short term swing up to 180%

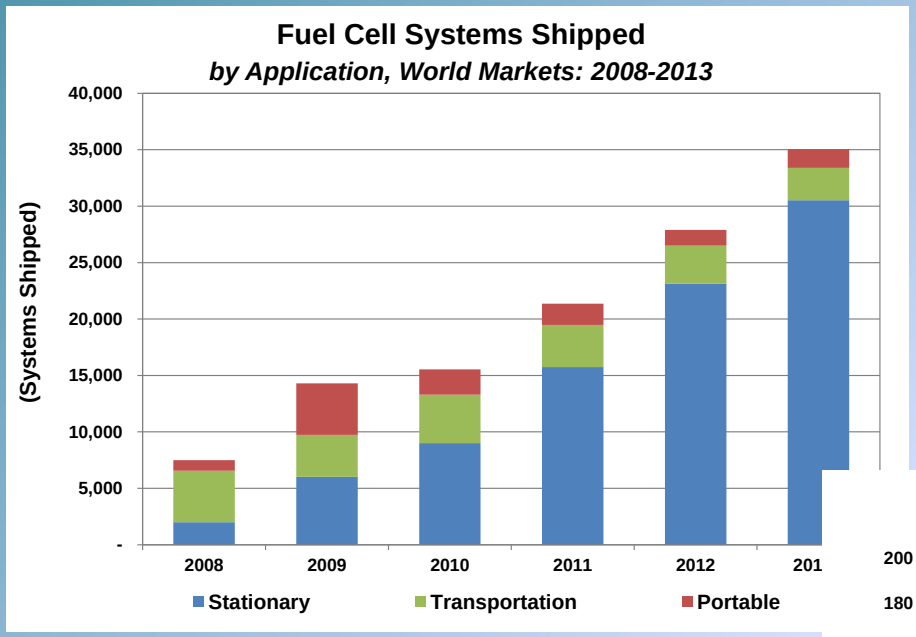
INDUSTRY SNAPSHOT

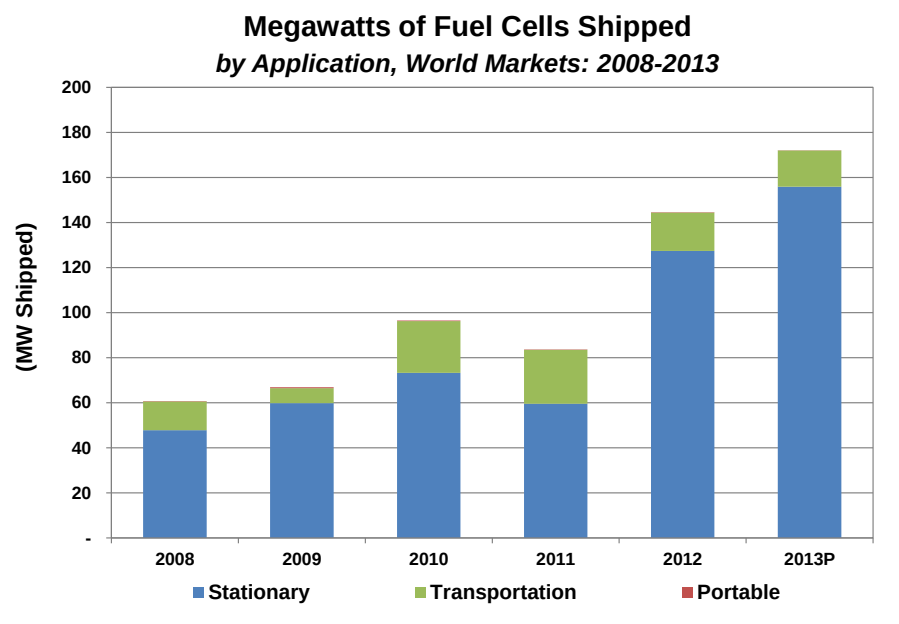
DOE Report: $1.3 Billion Industry



DOE 2013 Fuel Cell Industry Market Report

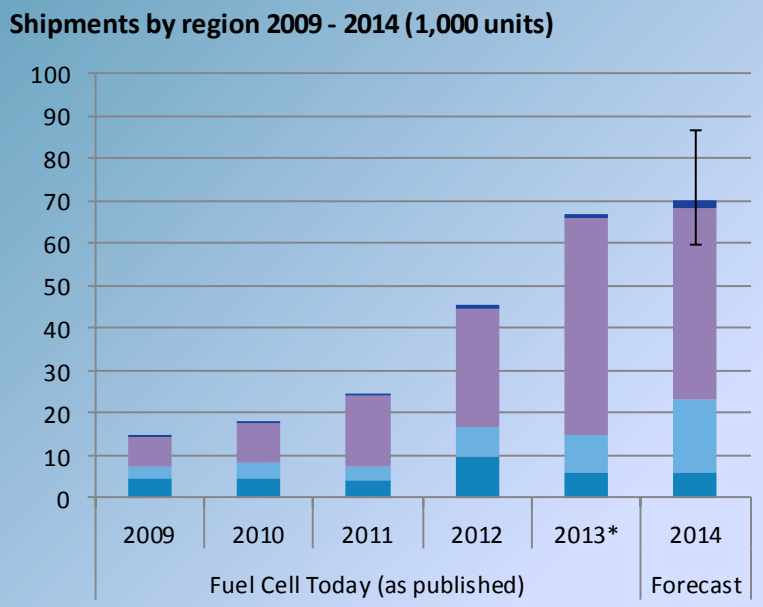
35,000 Systems Shipped, ~ 170 MW

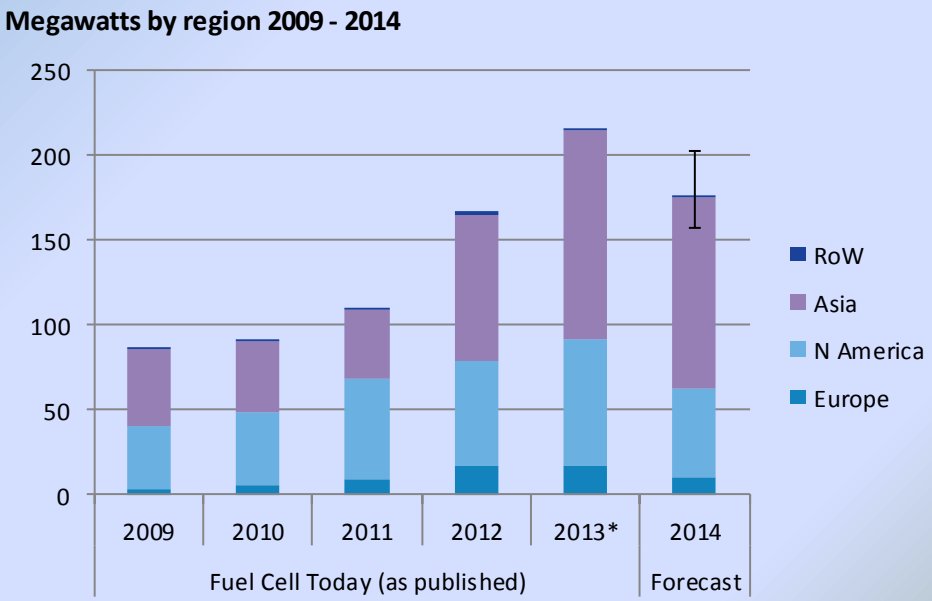




E4Tech 2014 Preview

- Unit shipments are up, megawatts are down
- Ene-Farm and small portable systems drive unit numbers
- Large stationary power in Korea dominates megawatt #s





RD&D Funding 2014

US: $150 M

EU: $120 M ($720 M committed to 2020)

- Matched by industry and other European funding

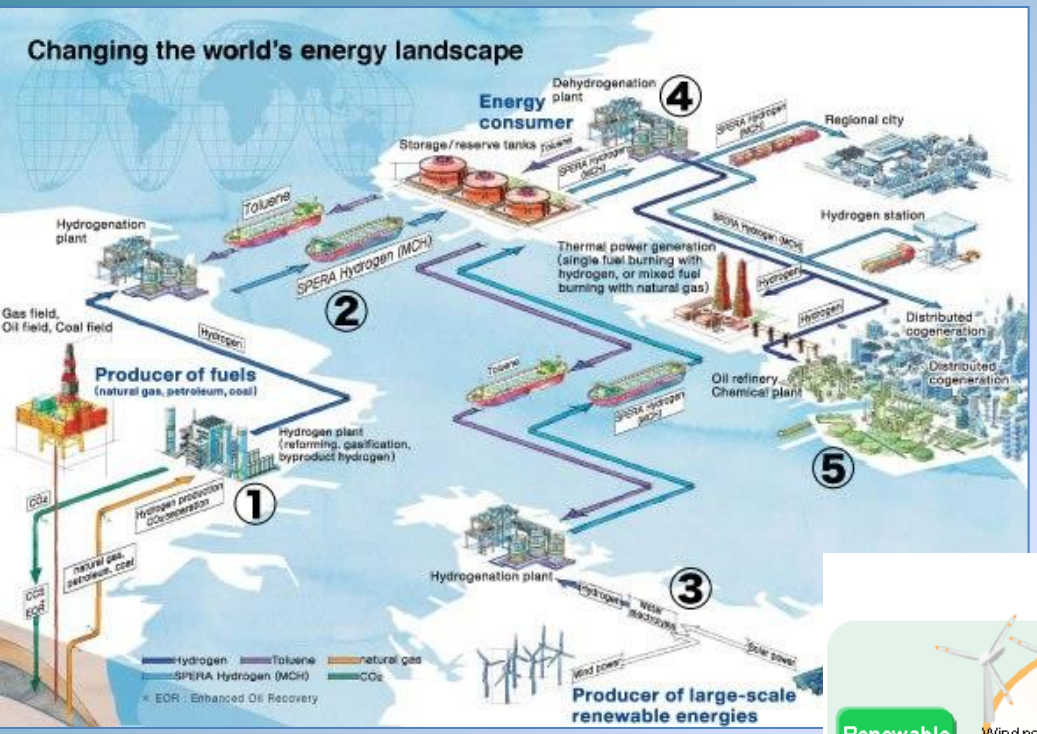
Japan $600 M

Expanded support for hydrogen stations

New Japanese Energy Plan

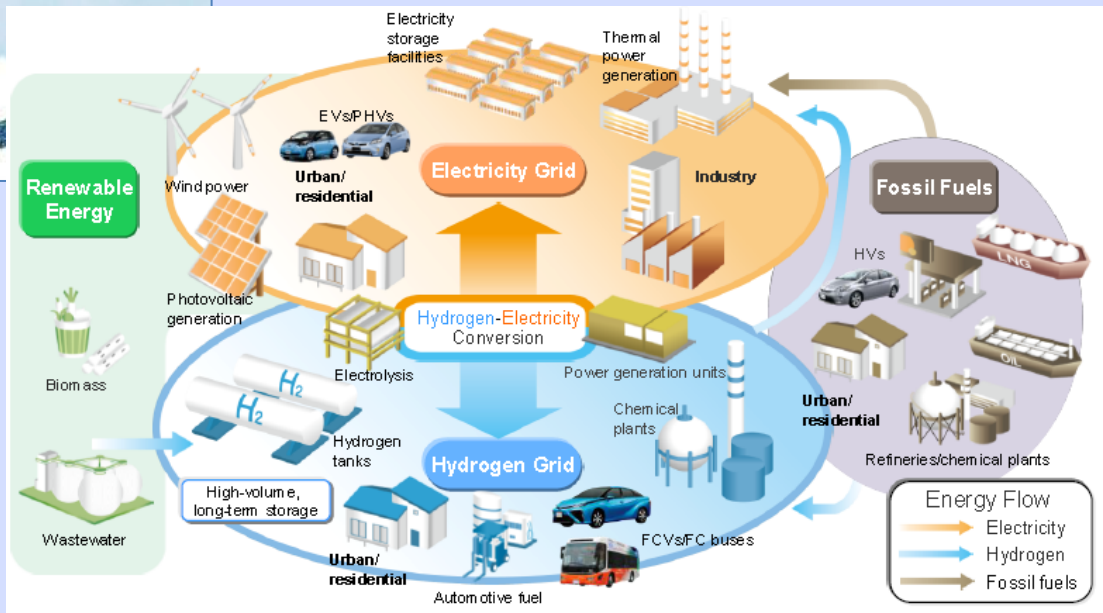
- Minimize reliance on nuclear power
- Increase import of US shale gas/coal (short term)
- Shift to alternative vehicle fuels, renewable generation
- Demand management/conservation
- Develop a new energy model
  - Distributed energy to reduce grid dependence
  - Resiliency
  - Open access and consumer choice
- Remain committed to CO_2 reduction

Hydrogen Has “The Central Role”



- Energy carrier
- Residential fuel
- Vehicle fuel
- Interconnect with renewables/storage

Chiyoda Toluene Strategy



Toyota 2050 Vision

Vehicles

- 50%-70% “new generation vehicles” in new car fleet by 2030
  - Natural gas, battery and FCEV
- Toyota first sales 12/2014, announced expansion of manufacturing capacity
- Price <Land Cruiser
- Honda early 2016
- Subsidy of 2M¥
- proposed

INFRASTRUCTURE PROGRAMS COMPARED

$700 M+ Committed in 2013

- California: $100-$200M (multiyear)
- Japan : $128M (through 2015)
- Europe: $475 M (multiyear)

California H2 station progress

- 10 stations open
- 18 in development, construction or commissioning
- 28 + mobile fueler in process
- http://cafcp.org/stationmap

California Funding to Date = $90 million

- 45 new stations ($72.7 million)
- 3 station upgrades ($6.7 million)
- 4 O&M grants ($1.2 million)
- 1 mobile fueler ($0.9 million)
- Other funding support
  - AC Transit Oakland station ($3 million)
  - CDFA DMS retail dispensing ($4 million)
  - UC Irvine STREET model ($1.5 million)

California Future Funding

- AB 8 signed into law by Gov. Brown
  - Extends funding for important air quality and alternative fuel programs
  - Guarantees $20M annually through 2023 if necessary to achieve 100 hydrogen stations
  - Annual survey, evaluation and reporting
- Funding increases likelihood stations will be in place to support early market FCEVs
  - Legislative reviews based on vehicle sales

Auto Industry Participating

- Toyota
  - $7.2 M in First Element Fuel (CA)
  - 12 Northeast Stations with Air Liquide
  - Making 5600 patents available until 2020
- Honda
  - $13.8 M in First element Fuel (12 stations)

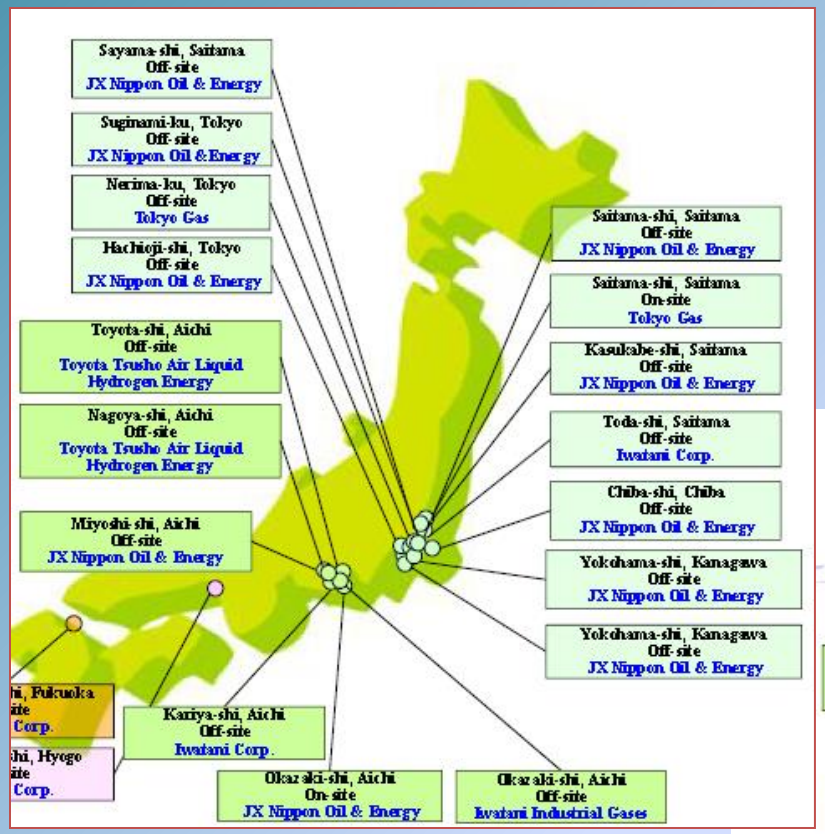
H2USA

- Public-private partnership
  - DOE, Labs, Auto Industry, significant suppliers
- Working groups on stations, locations, financing, market support
- 2015: “image of vehicle volume”
- 2020: “Multiple OEMs deploying vehicles

H2FIRST

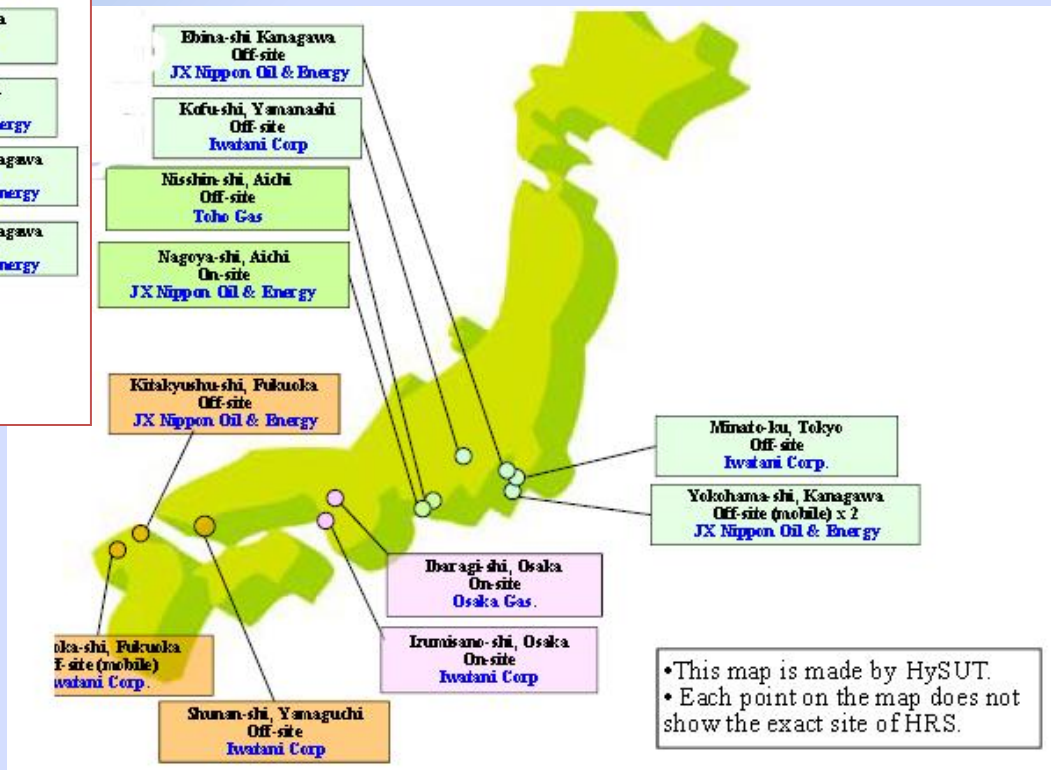
- NREL-Sandia
- Dealing with technical challenges of stations and fueling by “creating opportunities for industry partners to pool knowledge and resources”
- Goals:
  - reduce the cost and time of fueling station construction,
  - increase station availability,
  - improve reliability

Japan H2 Station Status



- 31 stations through 2014
- Shift to commercial partners
- 15 demonstration stations stay open

- 100 by 2015
- 2500 by 2025
- 5 million vehicles



European H2-Station Status
~ 30 in 2014

UK:
- 4 existing
- 1 planned in 2014
- UK H2 Mobility:
  - 65 HRS until 2020
  - 330 HRS until 2025

Netherlands:
- 1 existing
- 3 planned until 2015
- HIT-I and HIT-II
- H2 Mobility NL:
  - 30 HRS until 2017

France:
- HIT-I Partner
- France H2 Mobility:
  - ~150 HRS until 2020 (estimation)

Germany:
- 50 HRS until 2015
- H2 Mobility:
  - 400 HRS until 2023

Sweden:
- 1 existing
- 5 planned until 2016
- HIT-I and HIT-II

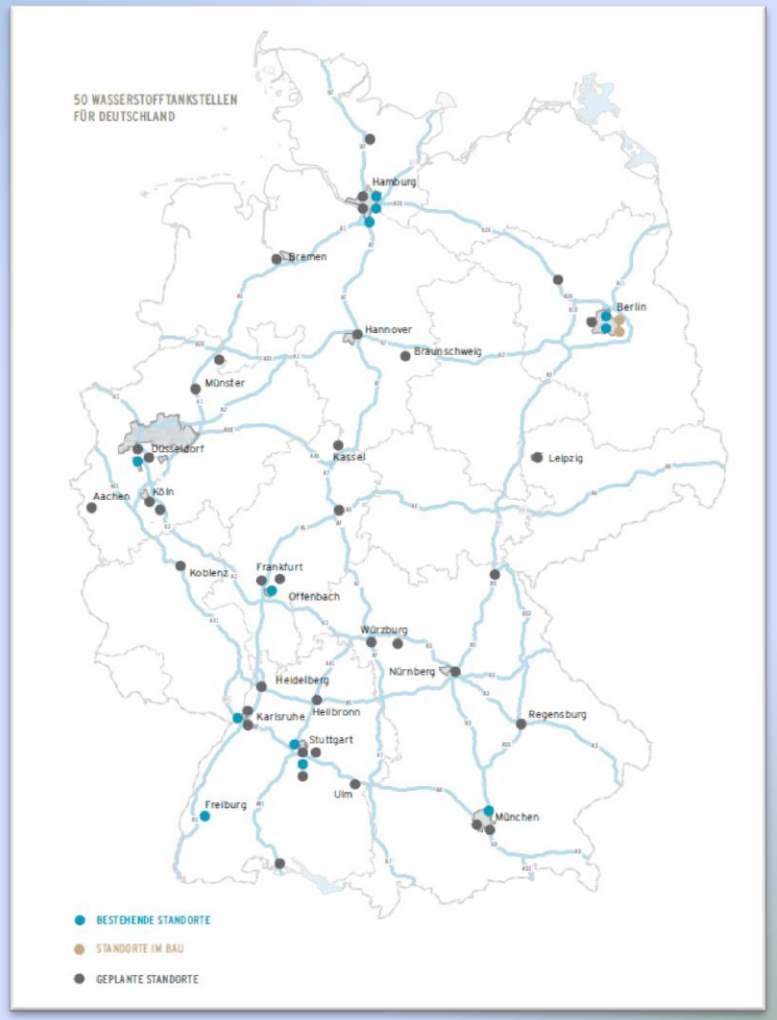
Norway:
- 6 Existing

Denmark:
- 2 existing
- 4 planned in 2014
- HIT-I and HIT-II

Scandinavia:
- SHHP
  - 45 HRS until 2015

50 HRS for Germany

- Joint Letter of Intent to expand German network
- Targets 100 by 2017, 400 by 2023
- € 350 M investment
- Current Status:
  - Location planning finalized
  - Applications in for 23 stations



Final Thoughts

- In Japan industry push -> government cooperation
- Europe evolved model similar to Japan
- Involvement from gasoline retailers
- In U.S., government push in California

- Credits: CAFCP, HySUT, NOW

Eileen Wenger Tutt
Executive Director
CA Electric Transportation Coalition

DBEDT
HAWAII STATE Energy Office

California ZEVs

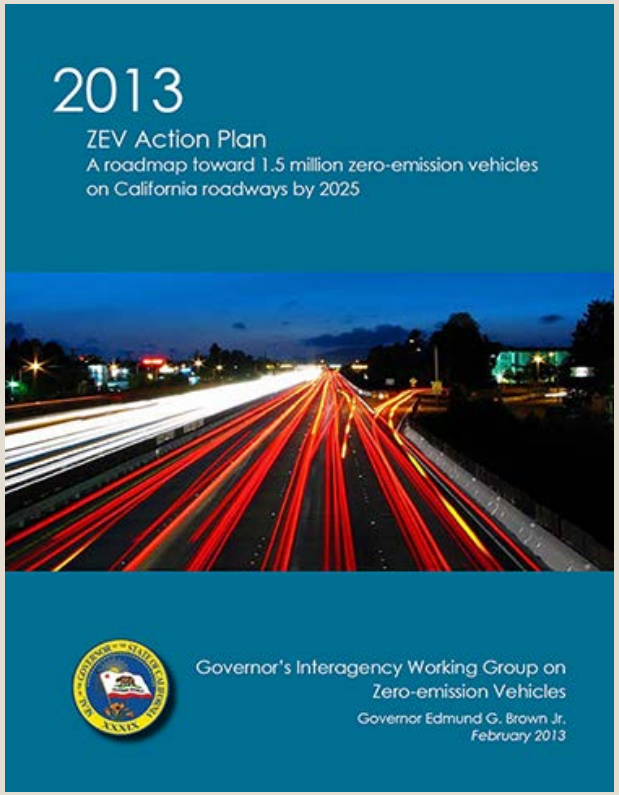
HAWAII HYDROGEN FUEL CELL & BATTERY ELECTRIC VEHICLE STAKEHOLDER CHARRETTE

Air Agency Leadership/Imperative

Context: CA – some of the worst air quality in the nation – challenge to meet NAAQS

- Transportation is biggest emitter
- To meet NAAQS in California by 2050 need 100% of new light duty vehicles to be ZEV by 2040 (2025 in South Coast)
- CARB ZEV Program Leadership

Governor's Support



Executive Order (B-16-2012)

- Directed California to work towards :
  - 1 million ZEVs by 2020
  - 1.5 million ZEVs by 2025
  - Transport related GHG's 80% below 1990 by 2050
- **118,505 ZEV sold in CA in 2014**
- 2015 Inaugural Address: 50% Petroleum reduction by 2030
- Reduce GHGs 80% by 2050 (Executive Order S-3-05)

Legislative Support

AB118 (2007) : Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP), Extended by AB 8 (2013):

Up to $150 Million in Annual State Funding

- California Energy Commission =$100 million/year
  - $20M/year for H2
- CARB = $50 million/year

AB 32 (2006) – Reduce emissions to 1990 levels by 2020 (about 15% compared to BAU)

- defended by voters in 2010

Automaker Support – PEV and FCEV

Public/Private Coordination

CALIFORNIA
PLUG-IN ELECTRIC VEHICLE
COLLABORATIVE

California
FUEL CELL
PARTNERSHIP

CalETC
California Electric Transportation Coalition

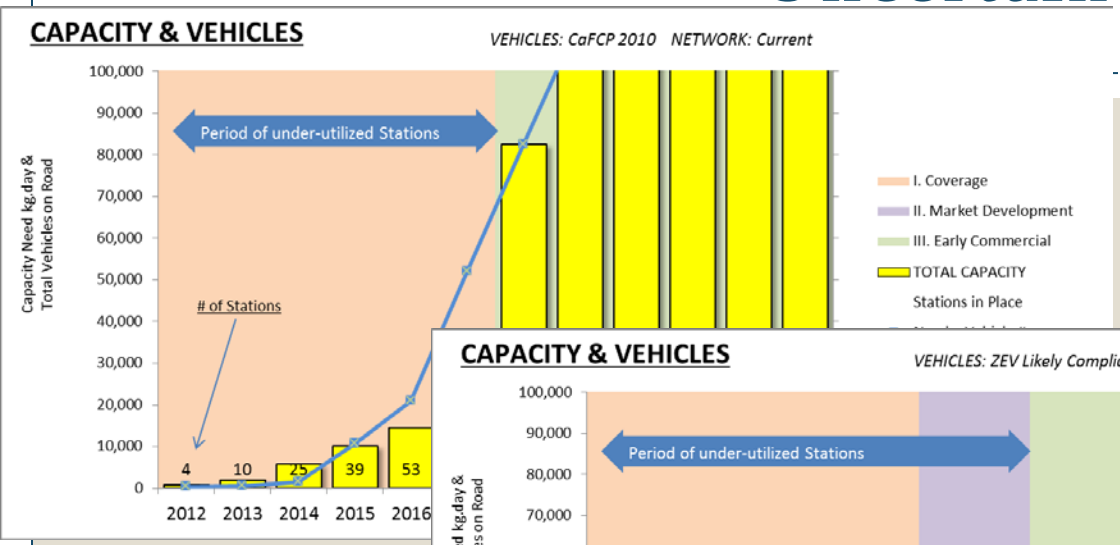
Hydrogen Station Economics

Hydrogen Network Investment Plan

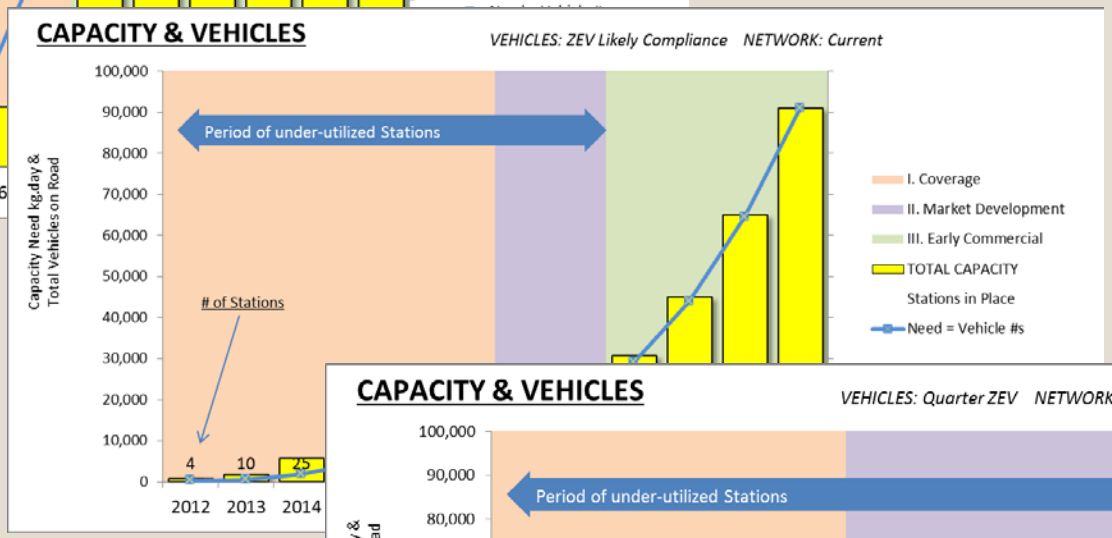
Energy Independence Now

www.einow.org

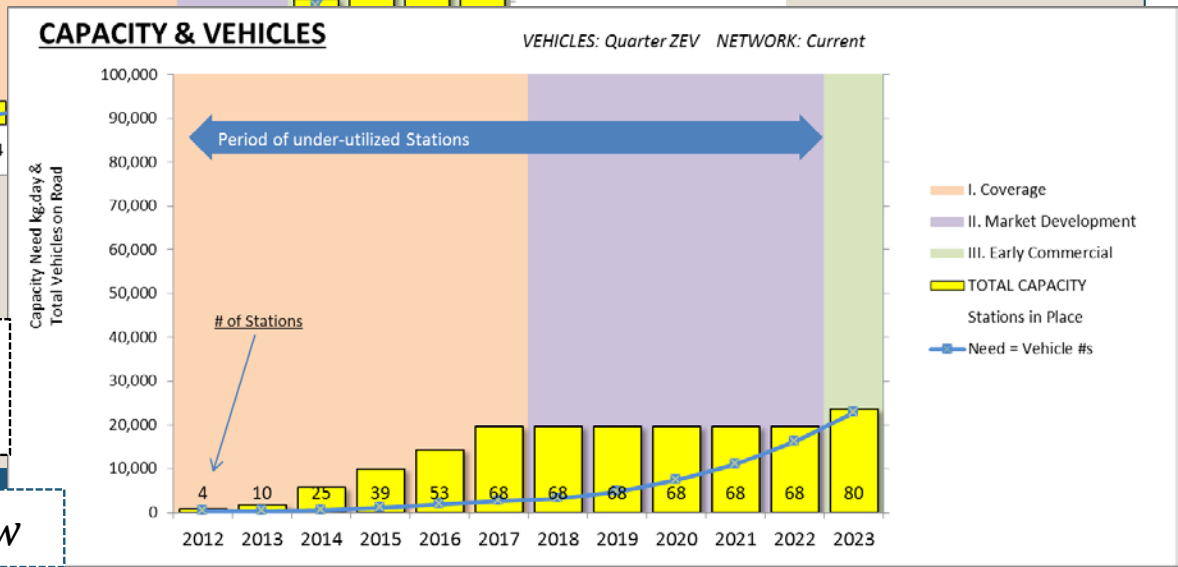
Station Developers Face Significant Marketplace Uncertainty



2010 OEM Surveys



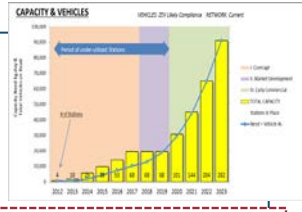
ZEV Likely Compliance



¼ ZEV Likely Compliance

Credit: Energy Independence Now

Capital Cost Share Can Help Enable Economically Viable Stations



Core Market, **ZEV Likely Compliance**, $2m 500kg/day Delivered Gas Station, Built in 2015:

Better for Consumer

Better for Station Provider

Cost Share

Private

Govt. (70%)

Capital Expense of Station

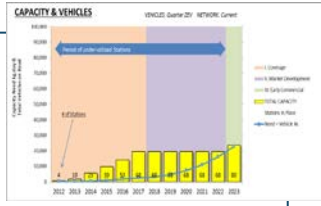
IRR of a 2015 Core Market: 500-DH2 Station — *Vehicle Sale: / Likely Compliance*

	If long term Hydrogen Retail Price								
	$8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00
$1,000k	-0.8%	14.0%	24.4%	33.0%	41.0%	48.9%	56.8%	64.6%	72.4%
$1,100k	-2.0%	12.8%	22.8%	30.9%	38.6%	45.9%	53.1%	60.5%	67.6%
$1,200k	-3.0%	11.6%	21.3%	29.1%	36.4%	43.2%	50.0%	56.9%	63.6%
$1,300k	-4.0%	10.3%	19.9%	27.6%	34.5%	40.9%	47.3%	53.7%	60.1%
$1,400k	-4.9%	9.1%	18.6%	26.1%	32.7%	38.9%	44.9%	50.9%	57.0%
$1,500k	-5.7%	8.0%	17.5%	24.8%	31.1%	37.1%	42.8%	48.5%	54.1%
$1,600k	-6.5%	6.9%	16.4%	23.6%	29.7%	35.5%	40.9%	46.3%	51.6%
$1,700k	-7.2%	5.9%	15.4%	22.5%	28.4%	33.9%	39.2%	44.3%	49.4%
$1,800k	-7.9%	5.0%	14.4%	21.4%	27.2%	32.5%	37.6%	42.5%	47.4%
$1,900k	-8.5%	4.1%	13.4%	20.4%	26.1%	31.2%	36.2%	40.8%	45.5%
$2,000k	-9.2%	3.3%	12.4%	19.4%	25.1%	30.0%	34.8%	39.3%	43.8%
$2,100k	-9.7%	2.5%	11.5%	18.5%	24.1%	28.9%	33.6%	38.0%	42.3%
$2,200k	-10.3%	1.8%	10.6%	17.6%	23.2%	27.9%	32.4%	36.7%	40.8%
$2,300k	-10.8%	1.1%	9.8%	16.8%	22.3%	26.9%	31.3%	35.5%	39.5%
$2,400k	-11.3%	0.4%	9.0%	16.0%	21.4%	26.1%	30.3%	34.3%	38.3%

**O&M Support not Included*

Credit: Energy Independence Now

...But not if market adoption is slow



Core Market, **Quarter ZEV**, $2m 500kg/day Delivered Gas Station, Built in 2015:

Better for Consumer ⟷ Better for Station Provider

Cost Share: Private / Govt. (70%)

Capital Expense of Station

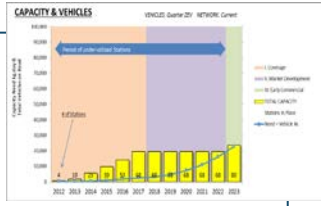
IRR of a 2015 Core Market: 500-DH2 Station — *Vehicle Sale:* *Quarter ZEV*

Capital Expense of Station	If long term Hydrogen Retail Price $8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00
$1,000k	-20.5%	-8.7%	-2.0%	2.8%	6.8%	10.4%	13.7%	16.7%	19.6%
$1,100k	-20.8%	-9.1%	-2.4%	2.4%	6.3%	9.7%	12.9%	15.8%	18.6%
$1,200k	-21.2%	-9.4%	-2.8%	1.9%	5.7%	9.1%	12.2%	15.0%	17.6%
$1,300k	-21.5%	-9.9%	-3.2%	1.5%	5.2%	8.5%	11.5%	14.2%	16.8%
$1,400k	-21.8%	-10.4%	-3.6%	1.1%	4.8%	8.0%	10.9%	13.5%	16.0%
$1,500k	-22.1%	-10.8%	-3.9%	0.7%	4.3%	7.4%	10.3%	12.9%	15.3%
$1,600k	-22.4%	-11.2%	-4.3%	0.3%	3.9%	7.0%	9.7%	12.2%	14.6%
$1,700k	-22.7%	-11.6%	-4.7%	0.0%	3.5%	6.5%	9.2%	11.7%	14.0%
$1,800k	-22.9%	-12.0%	-5.1%	-0.4%	3.1%	6.1%	8.7%	11.1%	13.4%
$1,900k	-23.2%	-12.4%	-5.5%	-0.8%	2.7%	5.7%	8.2%	10.6%	12.8%
$2,000k	-23.4%	-12.7%	-5.9%	-1.1%	2.4%	5.3%	7.8%	10.1%	12.3%
$2,100k	-23.7%	-13.1%	-6.4%	-1.5%	2.0%	4.9%	7.4%	9.7%	11.8%
$2,200k	-23.9%	-13.4%	-6.7%	-1.9%	1.7%	4.5%	7.0%	9.2%	11.3%
$2,300k	-24.1%	-13.7%	-7.1%	-2.2%	1.4%	4.2%	6.6%	8.8%	10.9%
$2,400k	-24.3%	-14.0%	-7.5%	-2.6%	1.0%	3.8%	6.2%	8.4%	10.5%

**O&M Support not Included*

Credit: Energy Independence Now

Market Assurance Grants (O&M) can buffer against slow rollout



Core Market, **Quarter ZEV**, $2m 500kg/day Delivered Gas Station, Built in 2015:

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Capital Expense of Station	If long term Hydrogen Retail Price								
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$1,000k	-7.9%	5.1%	12.8%	18.6%	23.6%	28.0%	32.1%	36.0%	39.7%
$1,100k	-9.0%	3.8%	11.3%	16.9%	21.5%	25.8%	29.7%	33.2%	36.7%
$1,200k	-9.9%	2.6%	9.9%	15.4%	19.8%	23.8%	27.5%	30.9%	34.2%
$1,300k	-10.8%	1.4%	8.7%	14.0%	18.3%	22.1%	25.7%	28.9%	32.0%
$1,400k	-11.6%	0.4%	7.6%	12.8%	17.0%	20.6%	24.0%	27.1%	30.1%
$1,500k	-12.4%	-0.6%	6.6%	11.7%	15.8%	19.3%	22.6%	25.6%	28.4%
$1,600k	-13.1%	-1.5%	5.7%	10.7%	14.7%	18.1%	21.2%	24.1%	26.9%
$1,700k	-13.7%	-2.4%	4.8%	9.8%	13.7%	17.0%	20.1%	22.9%	25.5%
$1,800k	-14.3%	-3.1%	4.0%	8.9%	12.8%	16.1%	19.0%	21.7%	24.2%
$1,900k	-14.8%	-3.9%	3.2%	8.1%	11.9%	15.1%	18.0%	20.6%	23.1%
$2,000k	-15.4%	-4.5%	2.4%	7.4%	11.1%	14.3%	17.1%	19.6%	22.0%
$2,100k	-15.9%	-5.2%	1.6%	6.7%	10.4%	13.5%	16.2%	18.7%	21.1%
$2,200k	-16.3%	-5.8%	0.9%	6.0%	9.7%	12.7%	15.4%	17.9%	20.2%
$2,300k	-16.8%	-6.4%	0.3%	5.3%	9.0%	12.0%	14.7%	17.1%	19.3%
$2,400k	-17.2%	-6.9%	-0.3%	4.7%	8.4%	11.4%	14.0%	16.3%	18.5%

Add Market Assurance Grant (e.g. O&M Support)

Credit: Energy Independence Now

CEC's Strong Solicitation

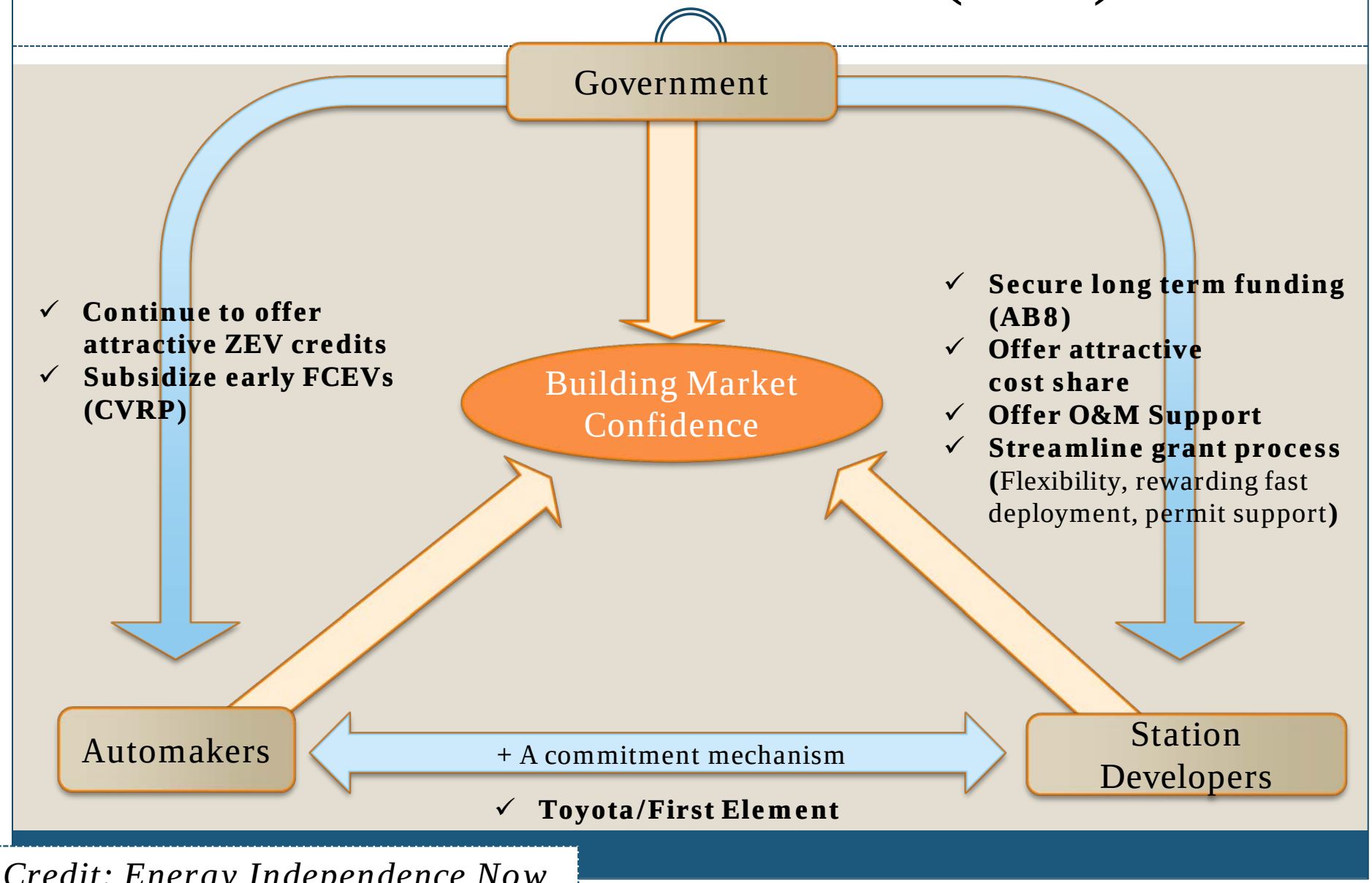
Offer (PON 13-607):

- Up to 85% of Capital Cost (90% for Renewable)
- Up to $100K/year for 3 years for O&M
  - Funding contingent on station operational date

Response:

- 28 Stations & 1 Mobile Fueler Awarded
- 32 other stations with passing scores
  - $46.6M awarded, $103M requested

A to do list from 2013 (EIN):



Credit: Energy Independence Now

Translating to Hawaii

- California has gone to great lengths to start the market - our goal is for everyone to benefit from this
  - Sharing lessons learned, driving down costs, building supply chain/experience
- Ingredients for FCEV success in Hawaii
  - Strong Leadership/Champions – from Govt. and/or Industry
  - Strong Support – from Govt. and Industry
  - Funding (public and/or private) to enable stations to succeed until H2 sales take over

California H2 – still work to do

- High Level Attention – monthly H2 Policy Meetings
- Working closely with DOE – C&S, station commissioning, H2USA, etc.
- Every step uncovers new challenges – we hope to help other jurisdictions plan/learn from our efforts

Supporting Station Permitting

- Community Outreach & Response
- Tracking & Troubleshooting

Last Updated	Permit Status	Station & Task Name	Who has the ball?	Projected Capacity (kg/day)	Stn. Developer	Address	Start Date	Estimated Operation Date	Station Deadline	Progress Status	Pie Visual	Comments	Commissioning
		Permit Report Card:								32		pre-funding/contracting	
Permitted to Build*		14								14		Funding/contracting/site control complete	
Permit apps submitted		7								1		Permitting Complete	
Permit app to be submitted		37								4		Construction Complete*	
		**Includes one bus-only station (Oakland). All others = light duty*								9		Commissioned and open	
												**Includes one bus-only station (Oakland)*	
10/28/14		**Diamond Bar - SCAQMD**	Station Developer	180	Air Products	21865 E. Copley Drive, Diamond Bar, CA 91765	06/02/10	12/01/14		Commissioning		Commissioning process has resumed in earnest. Assuming all proceeds as expected, commissioning expected to be complete in November.	63%
10/28/14		**Irvine - UCI (upgrade)**	Station Developer	180	Air Products	19172 Jamboree Rd., Irvine CA 92612	06/02/10	01/30/15		Permit - Submitted		Addressing final comments. Key challenge remaining = power supply approach. UCI has changed its requirements - both parties working toward a resolution.	
10/28/14		**Irvine - Walnut Ave.**	Station Developer	180	Air Products	5410 Walnut Ave., Irvine CA 92604	06/02/10		**12/31/14**	Permit Submitted		Received full comment package back from City on 10/7/14. Developer working the response, expect to re-submit early November. Review uncovered a planning issue - the project will require a CUP. This is a 3-4 month process.	
10/28/14		**Lawndale - Inglewood Ave.**	Station Developer	180	Air Products	15606 Inglewood Ave., Lawndale, CA 90260	06/02/10		**12/31/14**	Design		Detailed Site Plan in process. On target for early November submittal to City.	
10/20/14		**Los Angeles - Beverly Blvd**	City/County	180	Air Products	7751 Beverly Blvd., Los Angeles, CA 90036	06/02/10	12/31/14	**12/31/14**	Permit Submitted		Fire, Electrical have been approved. Building is ready to issue once real estate documentation is buttoned up (the site's old documentation needs to be updated - a minor issue).	
10/28/14		**Los Angeles - West LA 2**	Station Developer	180	Air Products	11261 Santa Monica Blvd., Los Angeles, CA 90025	06/02/10	01/20/15	**12/31/14**	Under Construction		Construction has begun (Contractor on-site October 20th). Tenants taking	

Codes & Standards

- **California Fire Code**
  - Adopted NFPA 2 (2011 Version) in 2014 (effective 2015)
    - Being put to use in the field now

- **CA Permitting Guidebook**
  - Incorporating Public Comments
    - Next draft by March 2015 (living document)
  - Feed into H2USA and other State efforts

California's New 2014 Accuracy Classes* and Tolerances for Hydrogen Fuel

Accuracy Class	Acceptance Tolerance	Maintenance Tolerance
2.0	1.5%	2.0%
3.0 installed before 2020*	2.0%	3.0%
5.0 installed before 2020*	4.0%	5.0%
10.0 installed before 2018*	5.0%	10.0%

* No new installations after the end of the designated calendar year unless regulations are further amended. Existing installations allowed to operate until decommissioned.

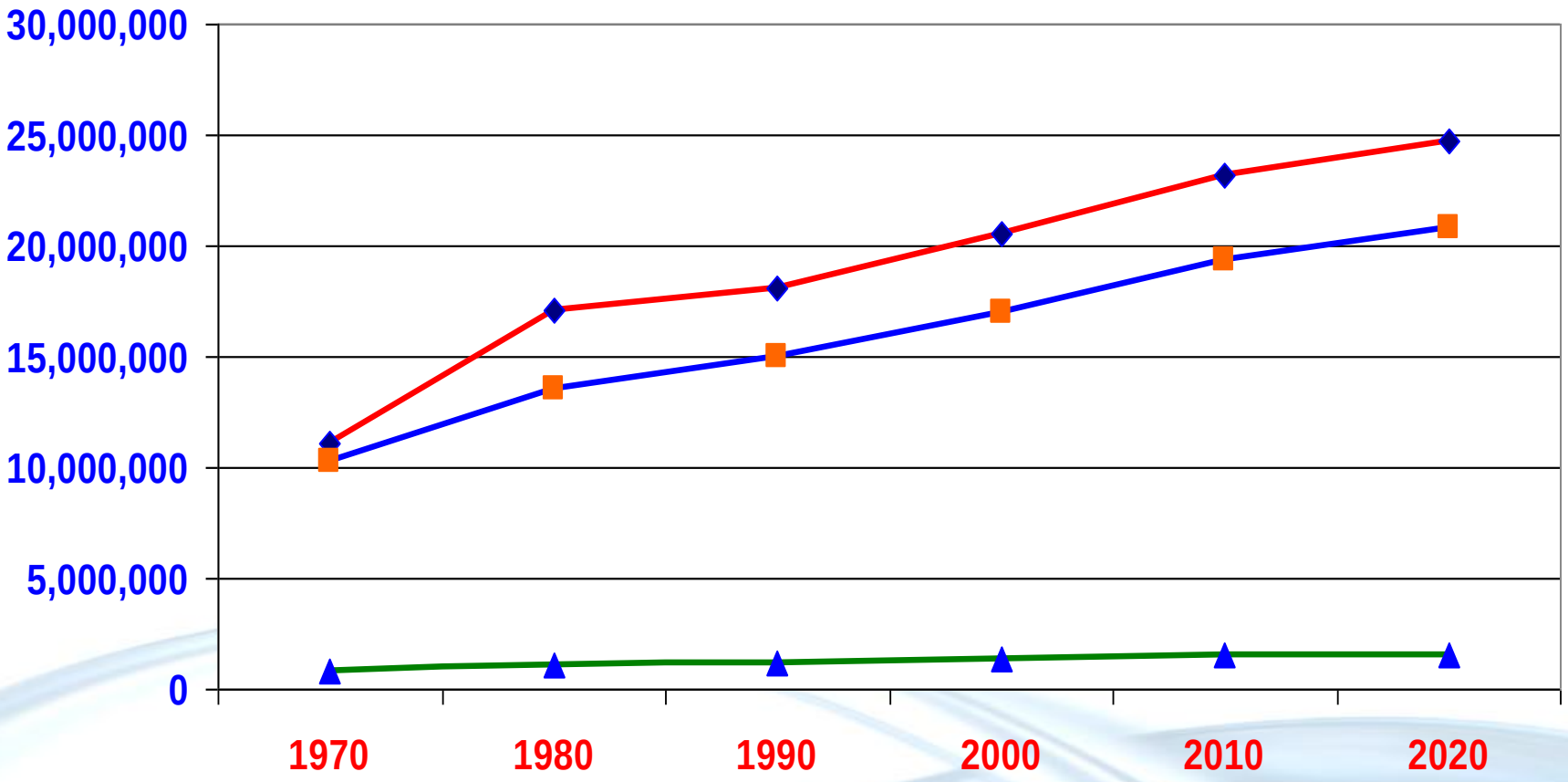
Thank You

Tyson Eckerle
ZEV Infrastructure Project Manager
tyson.eckerle@gov.ca.gov
916-322-0563

ZERO-EMISSION BUSES
Prospects, Challenges, and Policy Directives

Jaimie Levin, Sr. Project Manager

BAY AREA TRANSIT MARKET SHARE



Source: SF Bay Area MTC

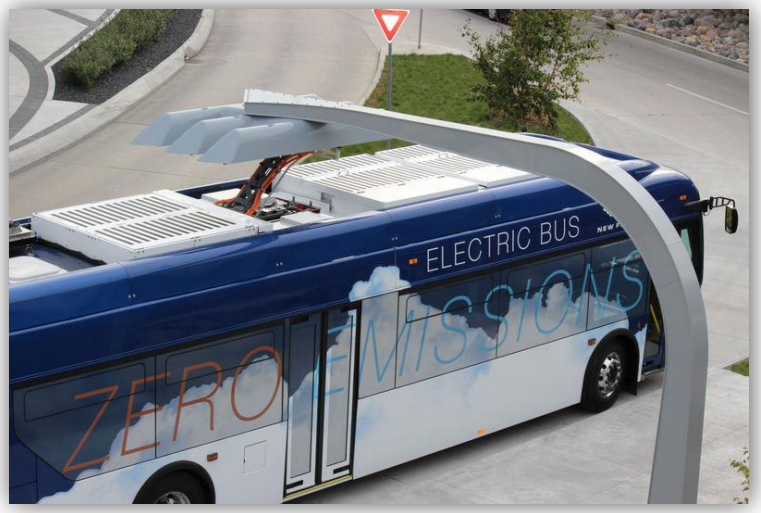
TRAVEL-TO-WORK MARKET SHARE

Metropolitan Area	Public Transit Market Share: 2000	1990	Change: 1990 - 2000
New York/Northern NJ/Long Island	24.9%		
Chicago/Gary/Kenosha	11.5%		
San Francisco/Oakland/San Jose	**9.5%**		
Washington/Baltimore	9.4%		
Boston/Worcester/Lawrence	9.0%		
Philadelphia/Wilmington/Atlantic City	8.7%		
Honolulu	8.3%		
Seattle/Tacoma/Bremerton	6.8%		
Pittsburgh	6.2%		
Portland/Salem	5.7%		
California - Transit Share	**5.1%**		
California - Drive Alone Share	**71.8%**		
United States - Transit Share	**4.7%**	**5.3%**	**-0.5%**
United States - Drive Alone Share	**75.7%**	**73.2%**	**2.5%**

Source: U.S. Census Journey to Work: 2000

ABOUT CTE

Center for Transportation and the Environment



- Nonprofit 501(3)(c)
- Atlanta, Berkeley, Los Angeles
- Facilitate funding and management of research, development, demonstration, and deployment of alternative fuel and advanced vehicle technology projects
- Federal Transit Administration, Departments of Energy, Defense, & Interior, NASA, EPA, CEC, SCAQMD . . .

CALIFORNIA PROJECTS

- AC Transit FCB Support
- Long Beach BEB Procurement
- UPS FC Truck Conversion
- NorthCAT: Alt. Fuels and Advanced Vehicles Technologies Center
- Light-Duty H_2 Fueling Stations
- SCAQMD ZE Drayage Truck

TECHNOLOGY OVERVIEW
ZERO-EMISSION BUSES

BEB
Depot Charge

- Overnight
- Battery Swap

BEB
On Route Charge

- Conductive
- Inductive

Hydrogen
Fuel Cell Bus

- Fuel Cell Power
- Central Fueling

Combination

Depot Charge with On Route Opportunity charging as needed

BENEFITS OF ELECTRIC DRIVE

Potential Benefits	Description
Emissions Reduction	**Criteria and GHG**
Performance	Smooth acceleration and regenerative braking; better handling and ride
Noise Reduction	Quiet internal and external operation
Maintenance Costs	Electric-drive simplicity, reliability, and durability
Energy Efficiency	Batteries (90%) and Fuel Cells (60%)
Clean Technology	No carbon-based emissions or toxicity
Total Cost of Ownership (TCO)	Reduced costs over life of vehicle

BENEFITS OF FUEL CELL ELECTRIC BUSES

Potential Benefits	Description
Emissions Reduction (W-T-W)	**Criteria (near 100%) and GHG (43% to 100%)**
Clean Technology	No toxicity
Performance	Smooth acceleration and regenerative braking; better handling and ride
Noise Reduction	Quiet internal and external operation
Deployment Flexibility	"Range Independence" Striving for Standardization
Maintenance Costs	Electric-drive simplicity, reliability, and durability
Fuel Economy	80% to 2X better than diesel
Total Cost of Ownership (TCO)	Reduced costs over life of vehicle

FUEL CELL BUS PERFORMANCE

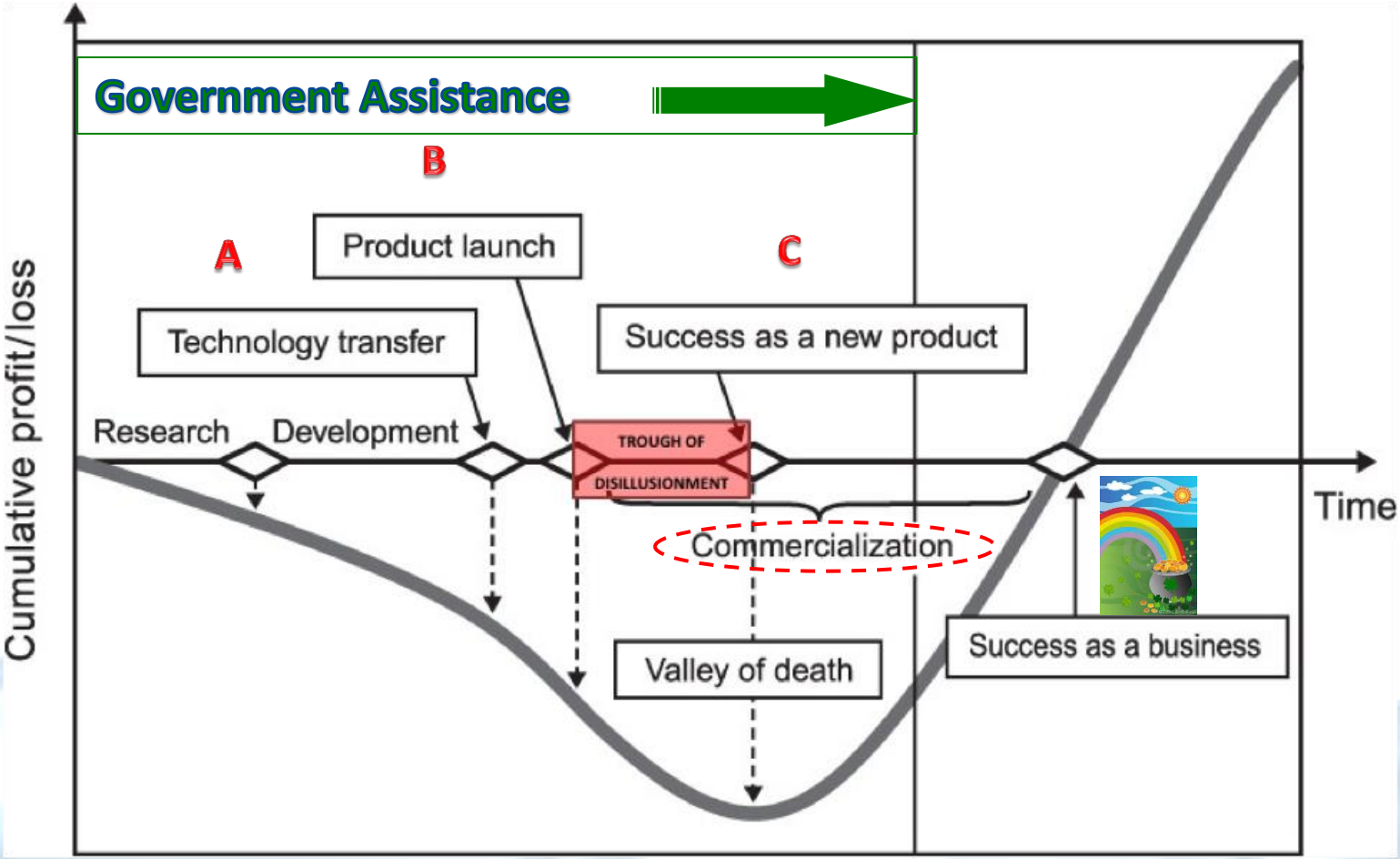
- AC Transit (12 Buses since 2011)
  - Lead FC: 18,300 hours (4,000 to 6,000 hours)
  - 1 million miles (1/3/2015)
  - 166 to 178 miles/day (3,300 to 4,000 mi/mo)
  - Lead Bus: 98,000 miles; 41,000 mi 2014
  - Availability >85%
  - Reliability > 15,000 miles per Roadcall
  - Five Stations: > 200,000 kilograms

- BAE Systems – Buy America Compliant
  - 3 Buses at SunLine, Lead Bus: 90,000 miles
  - Seven Buses in Production (SunLine, Boston, Michigan, New York, and Ohio)
  - Performance meets End-user Expectations

CHALLENGES

Challenges	Description
Capital Costs	Significant marginal costs for vehicles and Infrastructure
Infrastructure	BEB: Standardization FCEV: Scalability
TCO – Risk Avoidance	Risk associated with costly component replacements for Emerging Technologies
Availability/Reliability/Utilization	Emerging Technology: “Performance Sustainability”
Maintenance Costs	Expected reductions have yet to be realized over time
Fuel Costs	Demand charges and cost of hydrogen
Scalability	Expanded fleets of 50, 100, or more
Deployment Flexibility	Range and fleet standardization

SURVIVING THE VALLEY OF DEATH



ZERO-EMISSION POLICY COMMITMENT

Mercedes-Benz MAN SOLARIS VANHOOL VDL BUS & COACH

500 – 1000 ZEB 2020

JOINT Press Release, 12th November 2014 12:15

European bus manufacturers and leading mayors step up for fuel cell electric buses

European bus manufacturers and city representatives announce the commercialisation of fuel cell electric buses for urban transport in Brussels

California Environmental Protection Agency
Air Resources Board

CARB$200 Million/Yr Cap and Trade

FISCAL YEAR 2014-15
FUNDING PLAN
FOR THE
AIR QUALITY IMPROVEMENT PROGRAM
AND
LOW CARBON TRANSPORTATION
GREENHOUSE GAS REDUCTION FUND INVESTMENTS

Release Date: May 23, 2014
Board Consideration: June 26, 2014

11/1/2014 Hydrogen Cars, Coming Down the Pike - NYTimes.com

The New York Times | http://nyti.ms/1CsyWz4

SUNDAYREVIEW | EDITORIAL

Hydrogen Cars, Coming Down the Pike

By THE EDITORIAL BOARD NOV. 29, 2014

The once-distant promise of clean, affordable hydrogen-powered cars is starting to become a reality.

Some critics of hydrogen cars say they remain expensive and impractical compared with electric vehicles, which can be plugged into the existing electricity system. But that is shortsighted. The real competition for hydrogen-powered and electric vehicles is the gas guzzler. There is little doubt that the world will need many transformative technologies to deal with climate change.

Meet The New York Times's Editorial Board »

A version of this editorial appears in print on November 30, 2014, on page SR8 of the New York edition with the headline: Hydrogen Cars, Coming Down the Pike.

© 2014 The New York Times Company

Jan. 08, 2015

Toyota HINO Next-Gen FCEB

Toyota Motor Corporation
Hino Motors, Ltd.

New Toyota, Hino Fuel Cell Bus to Service Route in Toyota City

Toyota City, Japan, January 8, 2015—Toyota Motor Corporation and Hino Motors, Ltd. have developed a new Toyota Fuel Cell System-equipped* bus, which is scheduled to service the Toyota Oiden bus route in Toyota City from January 9.

CEC $100 Million//Yr Thru 2014 DMV

2015-2016 INVESTMENT PLAN
UPDATE FOR THE ALTERNATIVE AND RENEWABLE FUEL AND VEHICLE TECHNOLOGY PROGRAM

CALIFORNIA ENERGY COMMISSION
Edmund G. Brown Jr., Governor

JANUARY 2015
CEC-600-2014-009-SD-REV

NEW FLYER

May 29, 2014

$900,000 FCEB – 40 Buses

Erik White
Chief of The Mobile Source Control Division
California Air Resources Board
1001 I Street, 7th Floor
Sacramento, CA 95812

Re: 40' Fuel Cell Electric Bus Price Target

Dear Mr. White,

In recent discussions with Jaimie Levin of the Center for Transportation and the Environment (CTE), and Jeff Grant, Ballard Power Systems, it's come to my attention that CARB may benefit from our input on the feasibility of a fuel cell bus price target under $1 million for a 40' bus. I'd like to summarize my comments and views on the subject for you to share with the staff at the California Air Resources Board.

12

SUSTAINING THE MOMENTUM

- Substantial Investment by FTA and California ($45 million)
- Bus Models and Fueling Infrastructure are Working Well
- Supplier Investments
  - BAE Systems/El Dorado 40' Bus
  - New Flyer 60' Articulated Bus
  - Fuel Cell Suppliers: Ballard, U.S. Hybrid, Hydrogenics
  - Industrial Gas Companies (AL, AP, Linde)

- Leveraging Core Product: Series Hybrid, All-Electric Drive
- Increasing Volume Production – Buses and Fuel Supply
- Building A Supply Chain
- Sustained Funding in Support of Larger Fleets (CARROT)
- Regulatory Impetus (STICK)

INTERNATIONL FUEL CELL BUS WORKSHOP
SUNLINE TRANSIT – FEBRUARY 25-26TH

14


US Hybrid
Power your fleet with US Hybrid's powertrain components
to provide cleaner, quieter, and lower cost operation
Dr. Abas Goodarzi, President
Honolulu Hawaii
Jan 14, 2015

US Hybrid Group

www.ushybrid.com		www.usfuelcell.com		www.magmotor.com	
US Hybrid **HQ: Torrance, CA**		**US FuelCell** **South Windsor, CT**		**Magmotor Corporation** **Worcester, MA**	
Year Established	1999	Year Established	2013	Year Established	1876 (Acquired by US Hybrid in 2008)
Core Competency	Electric Powertrain for Electric, Hybrid and Fuel Cell Heavy Duty Vehicles	Core Competency	Fuel Cell Power Plant	Core Competency	Servo Motors and Drives Automation, Robotic and Semiconductor Mfg.


Torrance, CA

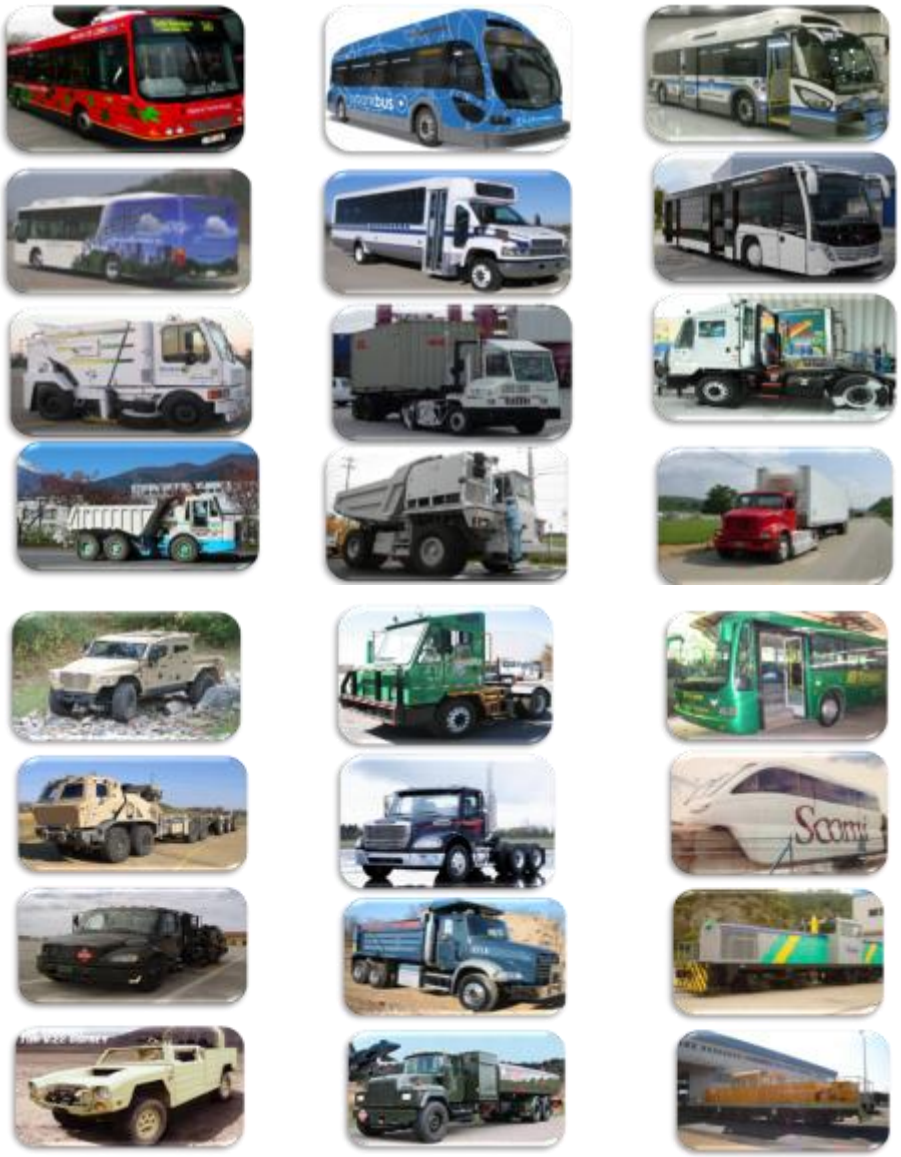

Torrance, CA


Honolulu, HI


South Windsor, CT


Worcester, MA

US Hybrid's Business Focus is Powertrain for Commercial Vehicles

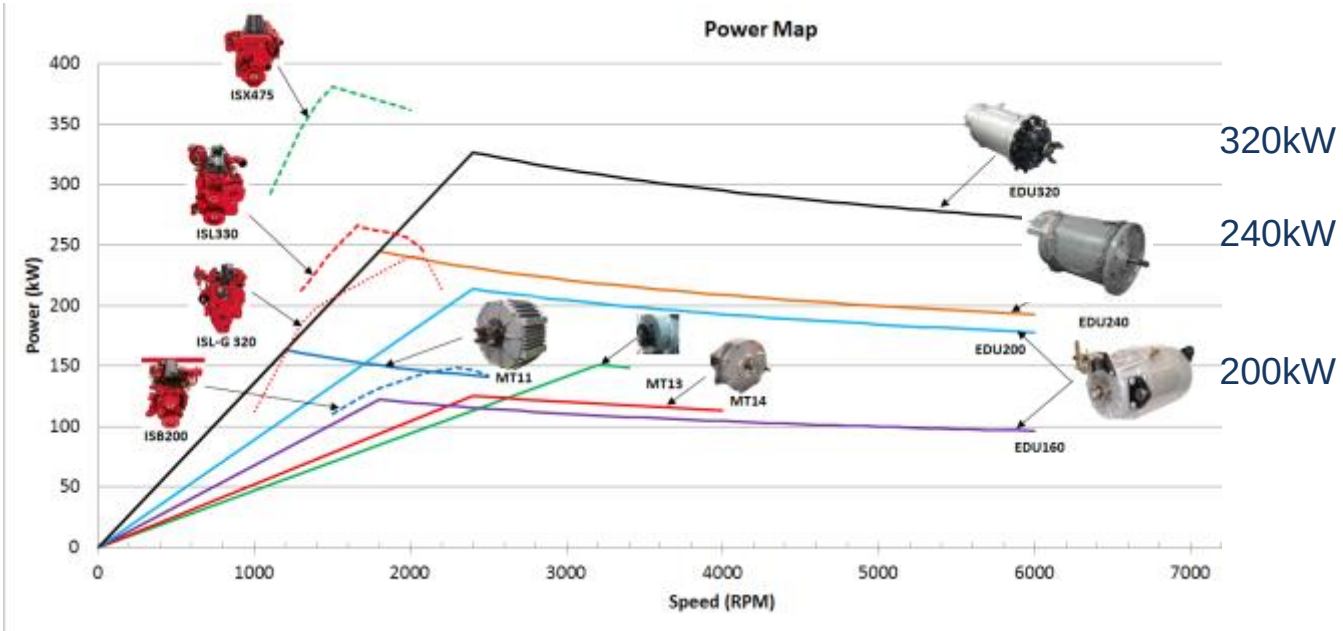


US Hybrid's Business Focus is; Heavy Duty Commercial Vehicles

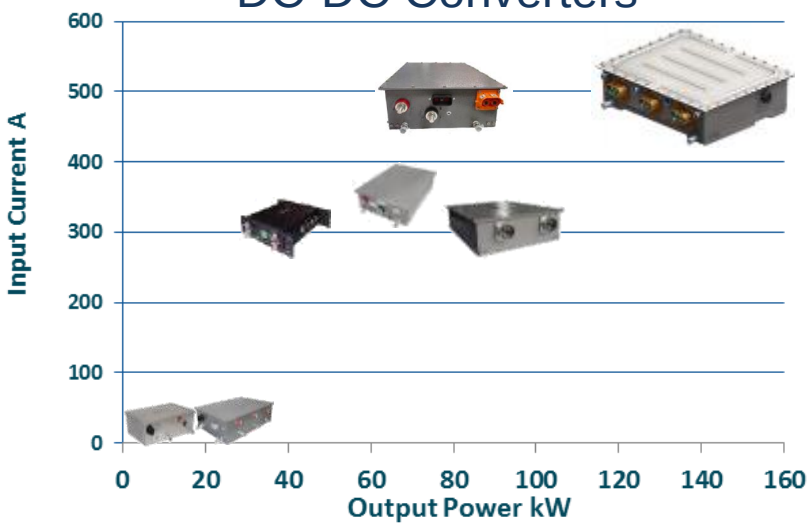
Class	6	7	8
Category	Medium	Heavy	Heavy
Weight Range (GVWR)	19,501-26,000	26,001-33,000	>33,000
Examples	Shuttle Bus Bucket Municipality	Delivery Constructions Agriculture Mining	Transit Bus Drayage Refuse

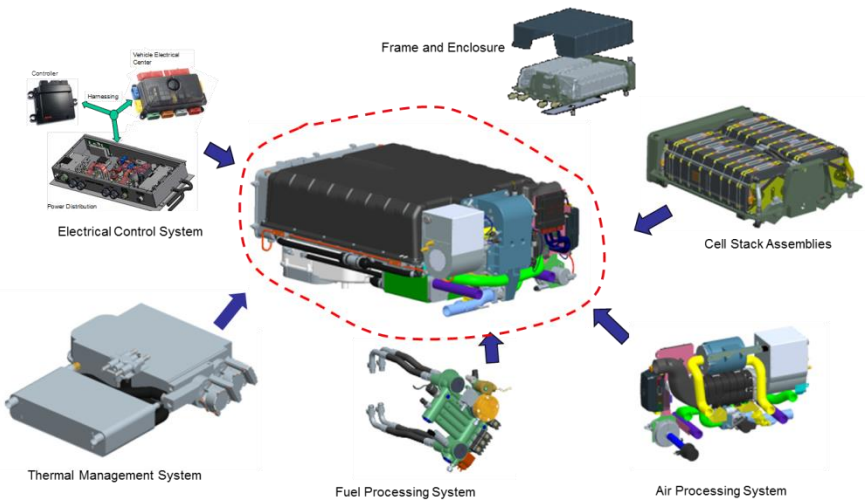
Monorail
Sao Palo Brazil
KL Malaysia
Mumbai, India

Core Competency: Electric Powertrain Production



DC-DC Converters



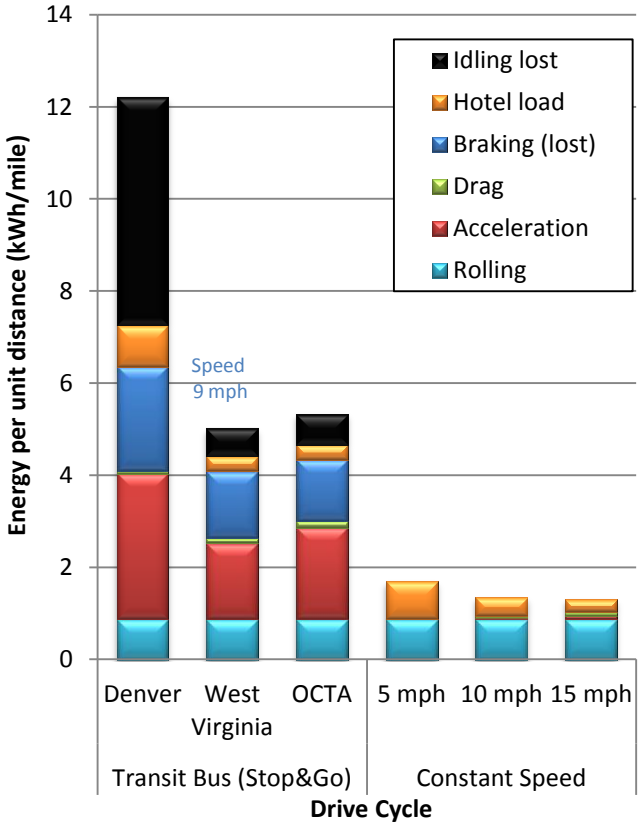


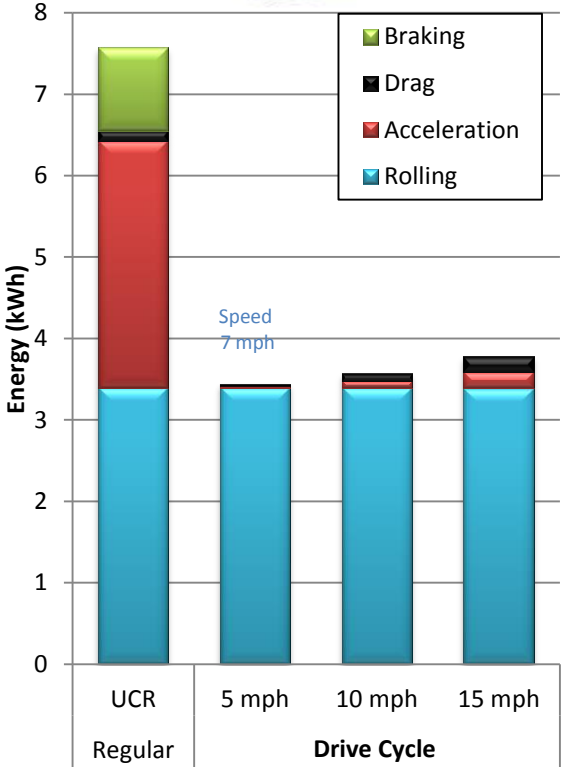
More than 50% of energy is wasted due to traffic

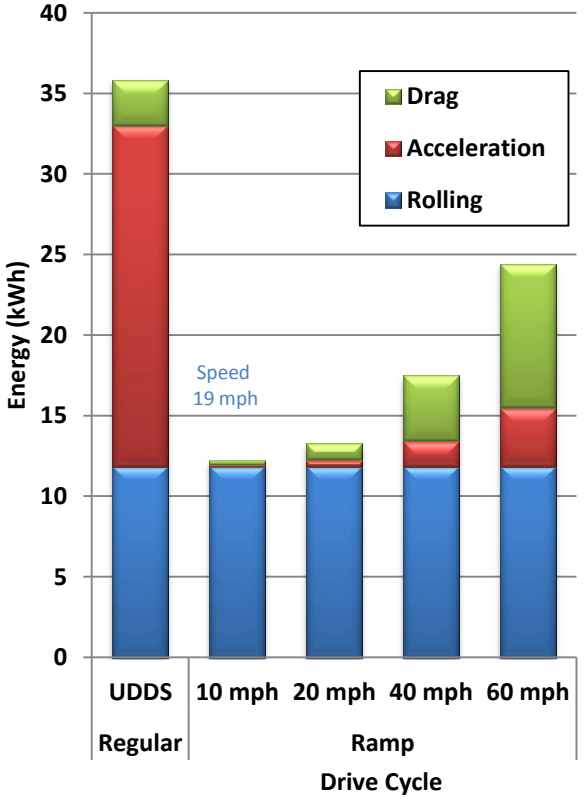
GVWR
20,450 kg

GVWR
36,300 kg

GVWR
29,545kg





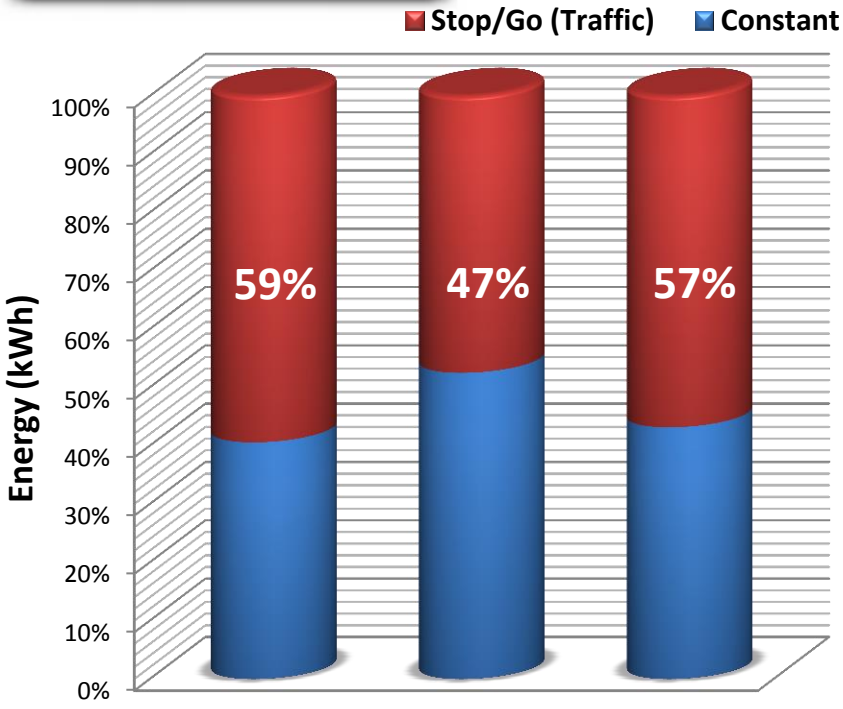


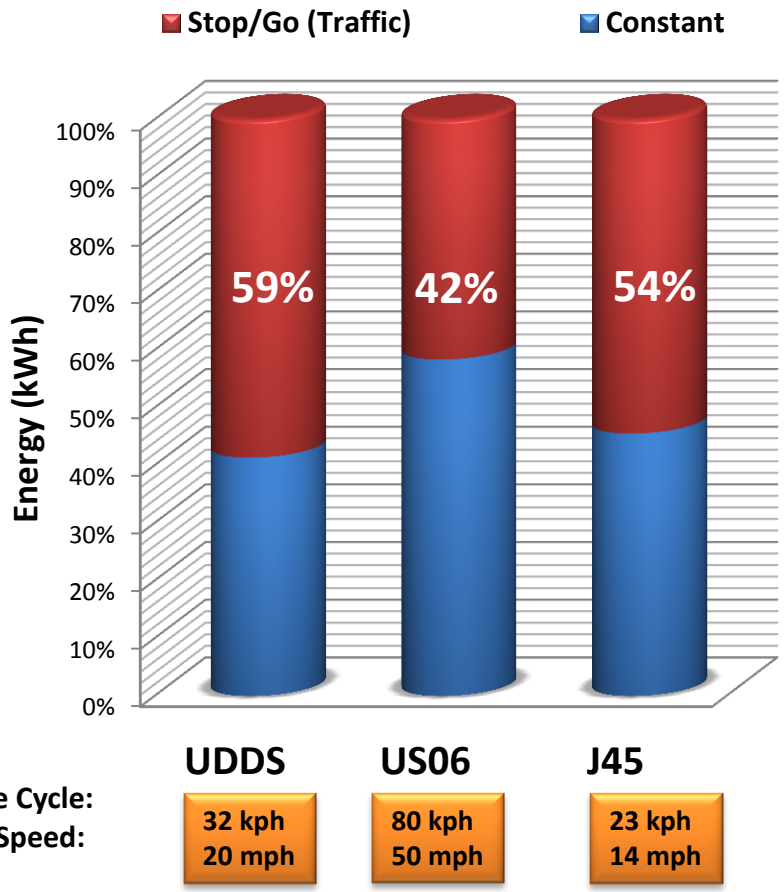
Transportation Engineering and energy Planning

More than 50% of energy is wasted due to traffic

GVWR
1,800 kg

GVWR
910 kg





Leader in Fuel Cell Vehicles Integration

20kW Fuel Cell Bus

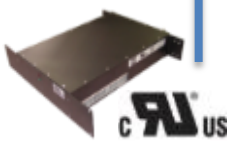
60kW FC Cargo Van

H2 Ride Shuttle Bus

FC Shuttle and Truck Commercialization

2003 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

BOP to UTC



R12 Refueler

30kW FC

Isolated DC-DC Transit Bus

Dump Truck

Specialty Trucks and Transit

UTC Power
A United Technologies Company

1960s | 1970s | 1980s | 1990s | 2000s | 2010s

Apollo

Demos: Homes, Buildings Utilities

Space Shuttle Orbiter

200/400 kW Commercial Production

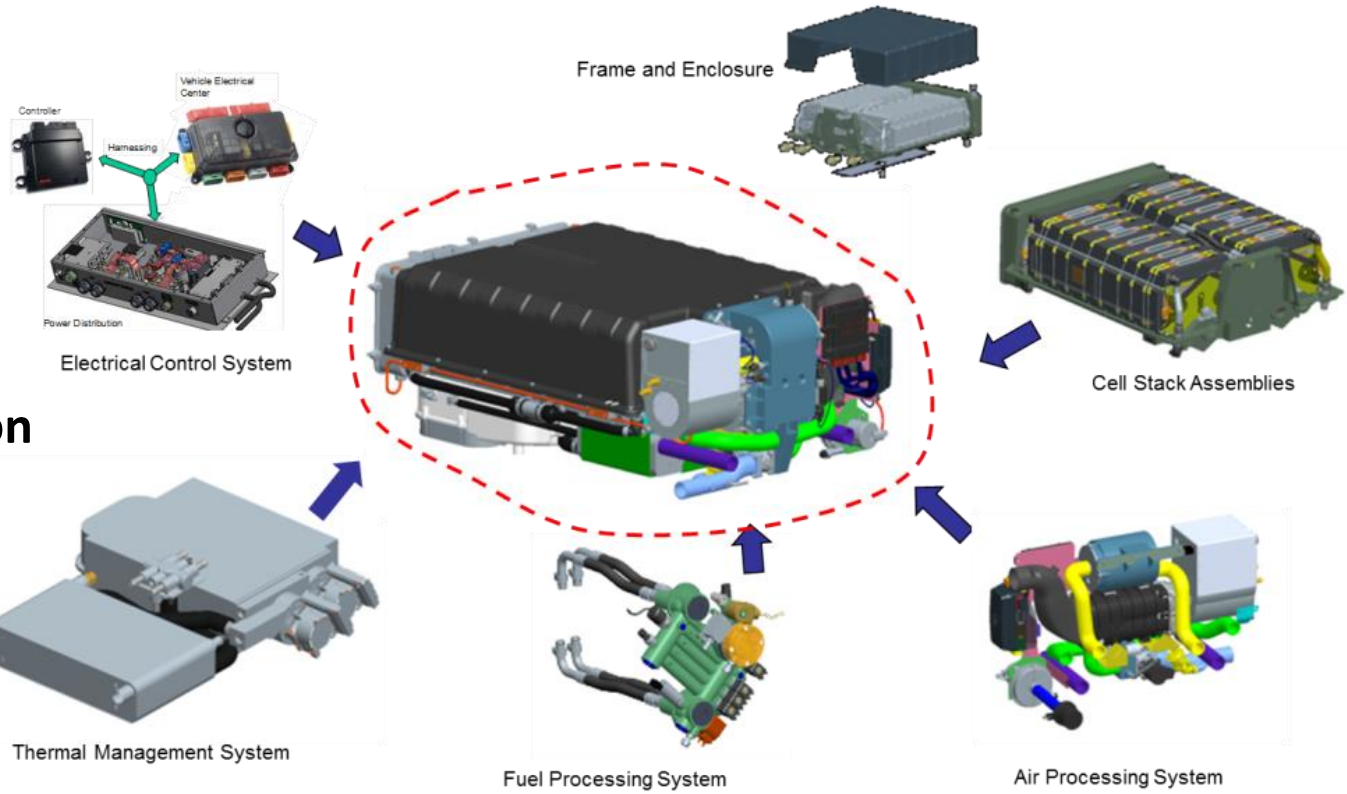
2013

US Hybrid Acquired UTC PEM Fuel Cell

Over 50 years of Technology Research & Product Development

Why Fuel Cell Engine

- **Diesel:** 37.1 kwh/gal (Energy content), Engine Output: **4.5 kWh/kg**
- **Gasoline:** 32.9 kWh/gal, (Energy content), Engine Output: **2.8 kWh/kg**
- **Hydrogen:** 39.7 kWh/kg, (Energy content), FC Engine Output: **15 kWh/kg**
  (1kg H2 =11 gal @5000 psi, same as 2 gal of diesel fuel)
  - **Energy Storage Density:**
    - Lead Acid 0.025 kWh/Kg
    - NiMh 0.06 kWh/Kg
    - Li-Ion 0.11 kWh/Kg



- **Zero Tail Pipe Emission**
- **Most Efficient Engine**

1kg of H2 (7miles/kg) > 2-Gallons Diesel (3.8mpg) 40' Transit Bus

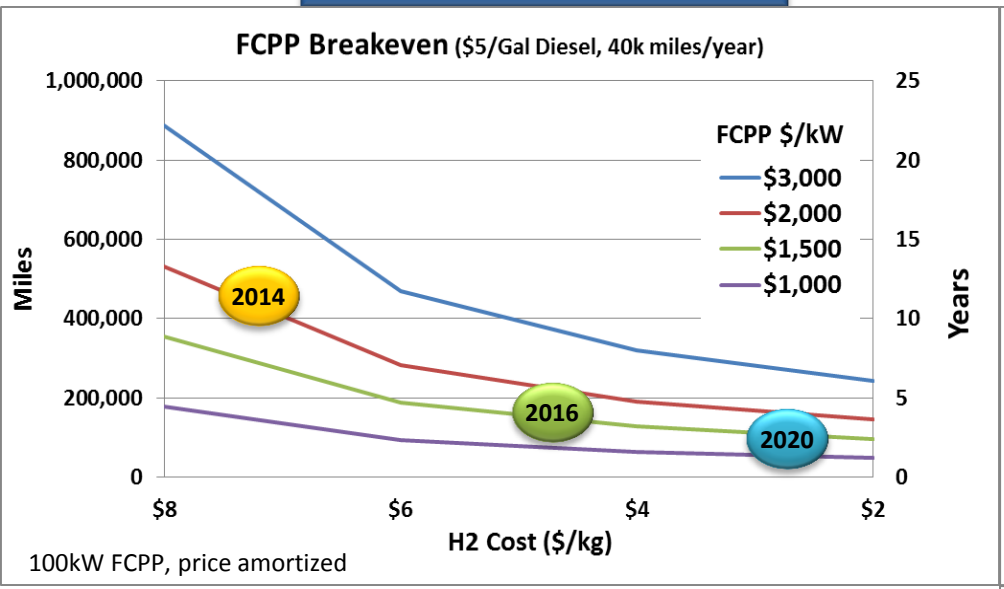
1kg of H2 (12miles/kg) > 2.5-Gallons Gasoline (5 mpg) Shuttle Bus

Well to Wheel Fuel Economy for Commercial Vehicles
Most Efficient Engine with Zero tail pipe Emission

Vehicle Type	Driveline Config.	Energy Efficiency % Well to wheel	Fuel Saving FC vs. CNG
Transit Bus 	Diesel	27%	
	Hybrid	32%	
	CNG	26%	CNG
	Electric	30%	
	Fuel Cell	39%	H_2 12%
Shuttle Bus 	Diesel	27%	
	Hybrid	32%	
	CNG	26%	
	Electric	30%	
	Fuel Cell	39%	13%
Drayage Truck 	Diesel	22%	
	Hybrid	27%	
	CNG	22%	
	Electric	27%	
	Fuel Cell	39%	17%
Refuse Truck 	Diesel	23%	
	Hybrid	28%	
	CNG	23%	
	Electric	27%	
	Fuel Cell	39%	16%
Street Sweeper 	Diesel	25%	
	Hybrid	29%	
	CNG	24%	
	Electric	28%	
	Fuel Cell	39%	14%

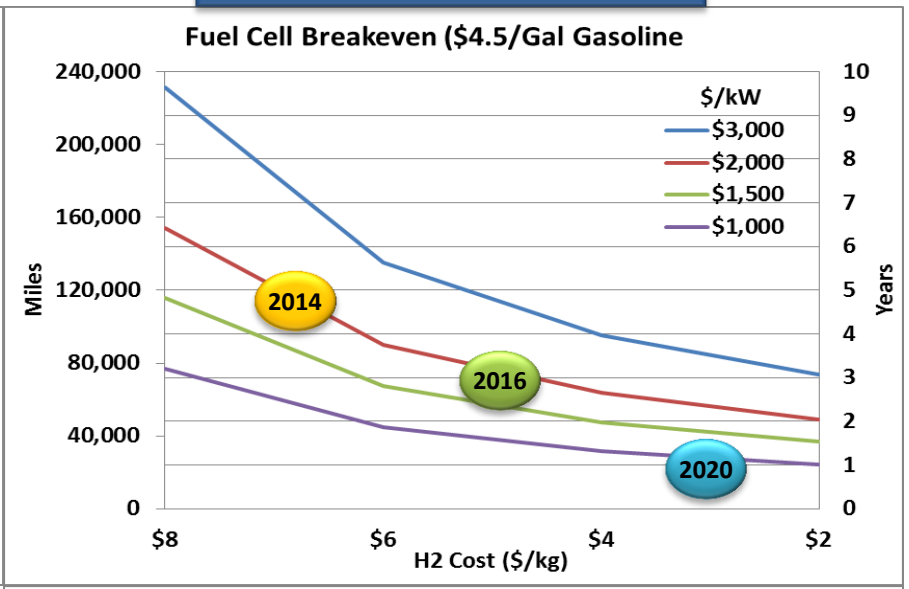
FC Powertrain Economic for Commercial Vehicles

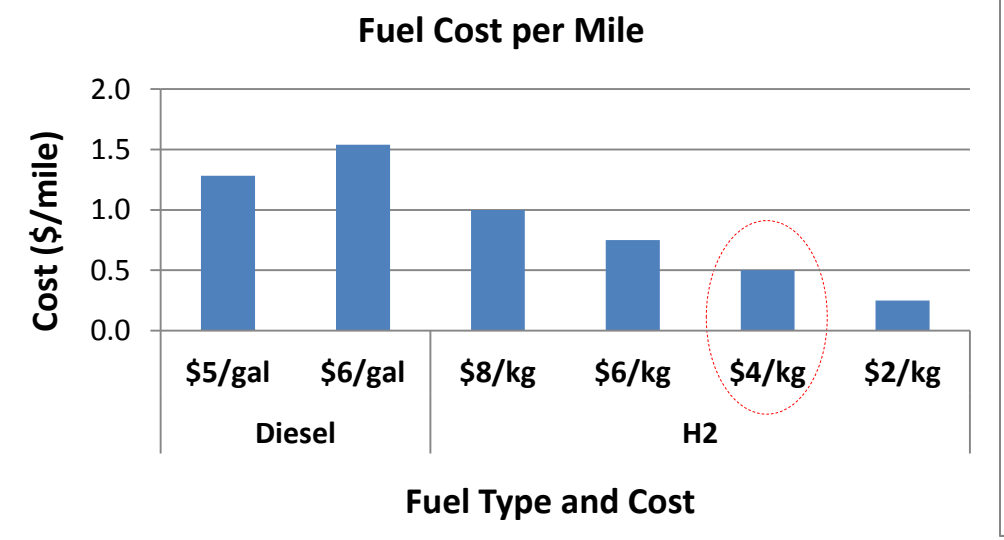
40’ Transit & Drayage Truck

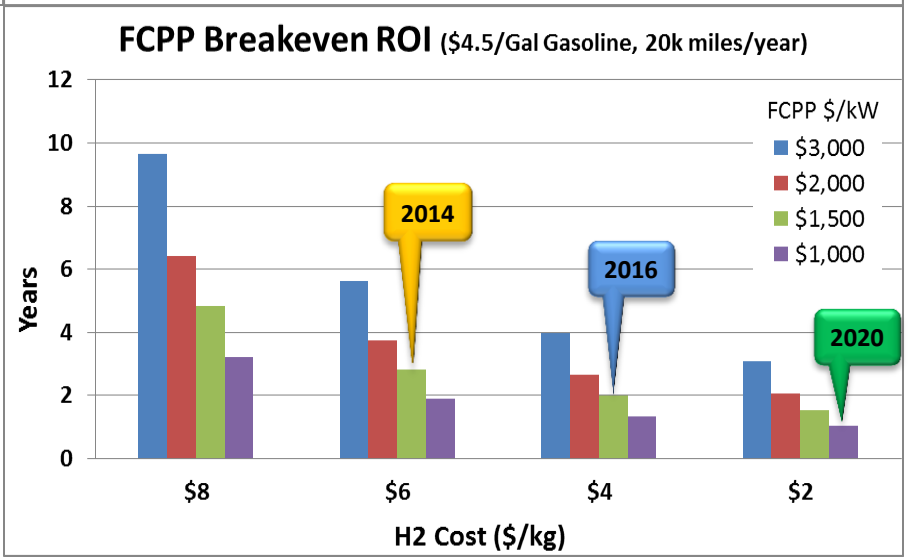


100kW FCPP, price amortized

Shuttle Bus & Delivery Trucks

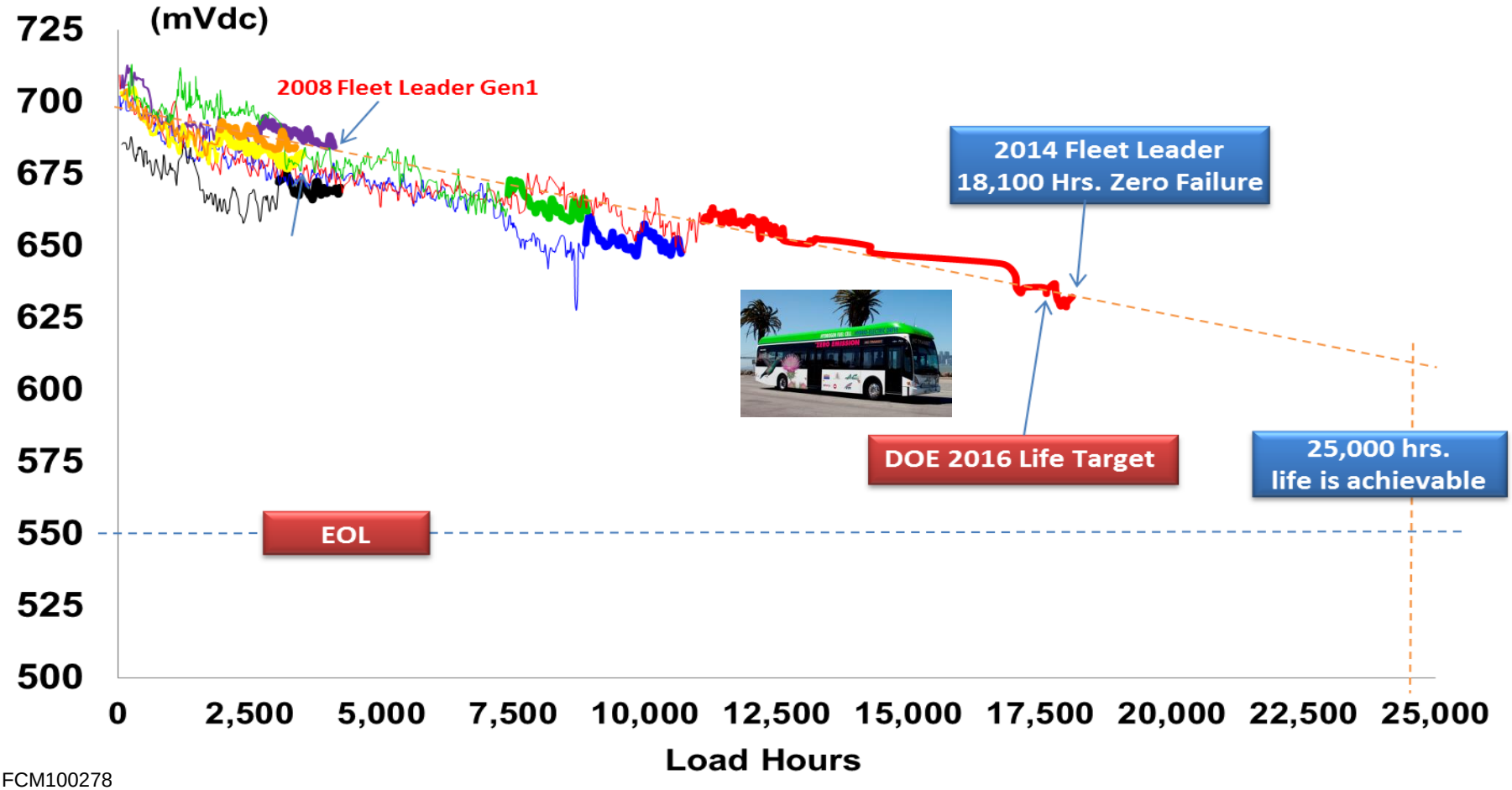






Fuel Cell Engine Proven Reliable for Transit Bus Fleet

- Current leader 18,300+ hrs., zero stack failure (Dec 2014)
- Total fleet hrs. = 126,900+ hrs. (12 power plants)
- Exceeded DOE lifetime target of 18,000 hrs. and 25,000 hrs. life is achievable
- Implemented Preventative Maintenance Program to Extend Life



FCM100278

Thank you!













Breakout Session 1: Hydrogen



Moderators

Mitch Ewan

HNEI

Hydrogen Systems Program Manager

Stan Osserman

HCATT

Executive Director

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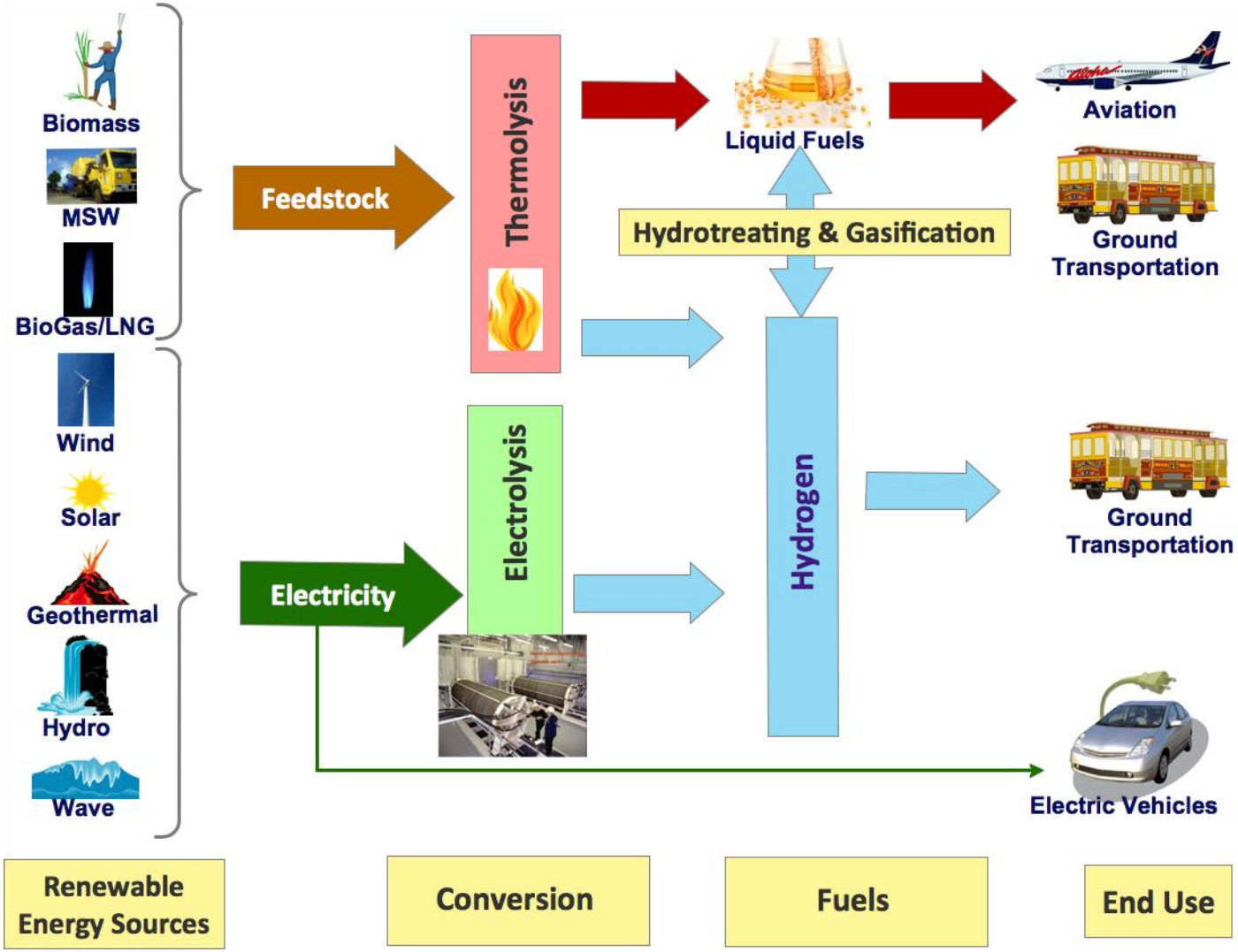
Hawai'i Natural Energy Institute
University of Hawai'i at Mānoa

Objective

Discuss feasibility of implementing hydrogen infrastructure across the State of Hawaii

Background

Renewable Fuels Pathways (simplified)



HI Ground Transportation ~ 500 million gpy

Primary Resource Needs (H2-FC)

- **Biomass to Hydrogen**
  - **Sustainable growth at 20 dry tons per acre**
  - **Hydrogen yield, 70 kg/dry ton(NREL)**
- **Electricity to Hydrogen**
  - **36kw-hr/kg thermodynamic limit**
  - **60% efficient to compressed H2**
- **Assume H2-FC vehicles 2x efficiency of current vehicle fleet.**
- **Displacement of 20% of ground transportation fuel**
  - **100 million gal liquid fuel ~ 50 million kg H2)**
  - **35,000 acres “good” agricultural land (dedicated HC&S), or**
  - **3000 GW-hrs/yr of electricity (~30% of current state electrical generation)**

Scale of need requires portfolio of solutions

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Scale Introduces Many Challenges

- ✓ **Resources - land use issues - competing use of resources e.g. electricity vs fuel, food vs fuel, etc.**
- ✓ **Political will - supportive policy (HCEI)**
- ✓ **Community support - permitting (DBEDT)**
- ✓ **Financing – strategic partners**
- ✓ **Technologies constantly changing/improving**
  - ➢ **Strategic projects to validate viability**
  - ➢ **Energy infrastructure is very capital intensive**
  - ➢ **"Almost There" is not sufficient to attract private investment, complicates planning process**

Role of Demonstration Projects

- Validate performance and durability of emerging technology in real world environments
- Identify areas for focused, high impact research by government and private industry
- Address/develop appropriate codes and standards
- Familiarize community with technology
- Demonstrate safety of systems
- Inform legal and insurance industries
- Help policy makers to make informed decisions

Significant efforts underway, programs becoming more focused, alternative technologies such as hydrogen, looking promising, but much to be done to get to commercial scale – resource availability becomes key.

Strategic Focus for Hawaii (H2)

- ✓ **Demonstrate cost effective infrastructure to produce, distribute, and dispense hydrogen;**
- ✓ **Focus on fleet vehicles starting with public transportation & county trucks;**
  - ➢ **Central fueling - 30 kg per day per bus;**
  - ➢ **Public benefit - tax dollars support public transportation needs;**
- ✓ **Industry will take care of the vehicles;**
- ✓ **Support early heavy users of hydrogen to develop a hydrogen market;**
- ✓ **Private industry will take over when it sees it can make money.**

Building Blocks for Infrastructure Development

1. **Policies & Plans**
2. **Resources**
3. **Political Will**
4. **Strategic Projects**
5. **Community Support**
6. **Strategic Partners**

We are addressing all 6 of these in Hawaii!

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POLICIES & PLANS

It is Hawaii State Policy to Establish a Hawaii Hydrogen Economy

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Hawaii Renewable Hydrogen Policy (HRS 196-10)

Transition Hawaii to a renewable hydrogen economy by:

- **Conducting strategic R&D, testing & deployment of renewable hydrogen technologies to make informed decisions;**
- **Conducting engineering & economic evaluations & near-term project opportunities;**
- **Conducting electric grid reliability & security projects to increase penetration of renewable energy on Big Island;**
- **Conducting hydrogen demonstration projects including infrastructure, storage, refueling hydrogen vehicles;**
- **Promoting Hawaii renewable hydrogen resources to potential partners & investors.**

Hawaii Clean Energy Initiative (HCEI)

Most Aggressive Clean Energy Goals in the United States

40% RENEWABLE
+ 30% EFFICIENCY
= 70% CLEAN ENERGY

Hydrogen for transportation and grid support could make an important contribution to meeting HCEI goals.

Hawaii's sun, wind, land & sea resources can provide limitless amounts of hydrogen – forever!

Strong Support from US DOE

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Resources

Hydrogen Investment Capital Special Fund (HRS 211F-5.7)

- ✓**Objectives:**
  - **Provide seed capital and venture capital for private and federal projects for research, development, & testing;**
  - **Implement the Hawaii Renewable Hydrogen Program;**
  - **Any other purpose deemed necessary to carry out the purposes of the Hawaii Renewable Hydrogen Program.**
- ✓**Sources of Funds**
  - **Appropriations made by the legislature;**
  - **Contributions from public or private partners;**
  - **All interest earned on or accrued to moneys deposited in the special fund.**

Barrel Tax (HRS 243-3.5)

- ✓ **Enacted in 2010**
- ✓ **$1.05 per barrel of oil excluding air transportation;**
- ✓ **Generates ~$27 million per year;**
- ✓ **60% goes to General Fund;**
- ✓ **40% goes to:**
  - ➢ **Oil Spill emergency clean-up fund**
  - ➢ **State energy office**
  - ➢ **State Department of Agriculture**
  - ➢ **Energy Systems Development Special Fund (HNEI)**
- ✓ **Hydrogen projects have received funding from HNEI allocation;**
- ✓ **Potential source for Hydrogen Fund replenishment.**

Need to make a compelling case

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Political Will

Consistent Long-Term Political, Policy, and Financial Support

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Hydrogen Program Needs to be Cost Effective

- **Program needs to be seen as providing cost effective solutions/benefits:**
  - **What problems can hydrogen fix?**
  - **Is it affordable?**
- **Competing for scarce resources:**
  - **Long term vs. short term;**
  - **Do we fund hydrogen or air conditioners for schools? The kids are suffering today!**
- **Need success stories;**
  - **Technology validated;**
  - **Affordable.**
- **Need champions.**

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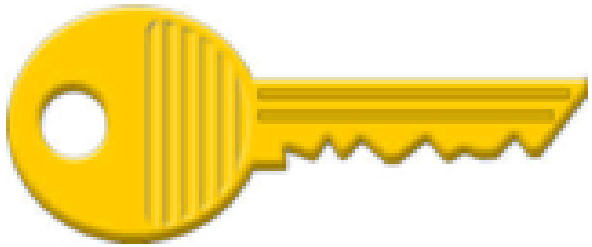
Must Keep Community Informed

- ✓ Need to justify investment of taxpayer dollars to the taxpayer;
- ✓ Public needs to see an immediate benefit to them:
  - ➢ Public transportation vs. perception of supporting "rich man's toys";
  - ➢ Leverage public infrastructure for private transportation for early adopters.
- ✓ Workforce development for the new jobs created;
- ✓ First Responder training. Helps address safety concerns;
- ✓ Legal and insurance industries need to be educated;
- ✓ Active public outreach campaign

PROJECTS

Projects Need to be Strategic



Need to demonstrate the economic viability and benefits of the technology. Will not get investment until the numbers work out relative to other options.

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2010 to 2020 Renewable Hydrogen Plan

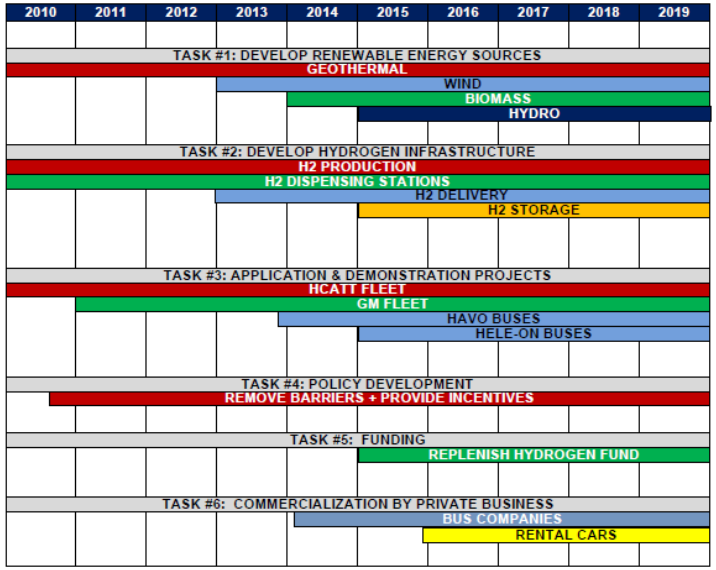
Critical Success Factors

- Rising oil prices stimulate the search for alternatives
- Public support for protecting the environment
- Availability of primary renewable energy sources
- General Motors roll-out in Hawaii
- Toyota Roll-out in Hawaii
- Private industry recognizing business opportunities
- Political will and leadership
- Dedicated funding

START

2010

- HCEI
- 1 Oahu Gas Station
- Several supportive policies
- 4 Large-scale demo projects
  - HCATT
  - H2 Power Park
  - Renewable H2
  - GM FCV Rollout



TARGETS

2020

- Fleet of 5,000 FCVs
- 3 major car companies
- 10 Oahu gas stations
- 10 Hawaii gas stations
- 1 Geothermal hydrogen plant
- 2 Wind Hydrogen Plants
- 1 FCV Rental car company
- 50 H2 buses Oahu & BI
- Near-commercial H2 distribution

Challenges

- Economic viability
- Large investment required to build H2 infrastructure
- Renewable energy sources need to be developed on a large scale
- Transportation applications need to be economically viable
- Legislative funding needs to be consistent
- Sense of urgency
- Barriers and inertia hard to overcome

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Major Tasks

Task 1: Develop Large-Scale Renewable Energy Sources:

- **Geothermal, solar, wind, hydro and biomass.**

Task #2: Develop Hydrogen Infrastructure

- **Hydrogen Production, storage, delivery, dispensing stations**

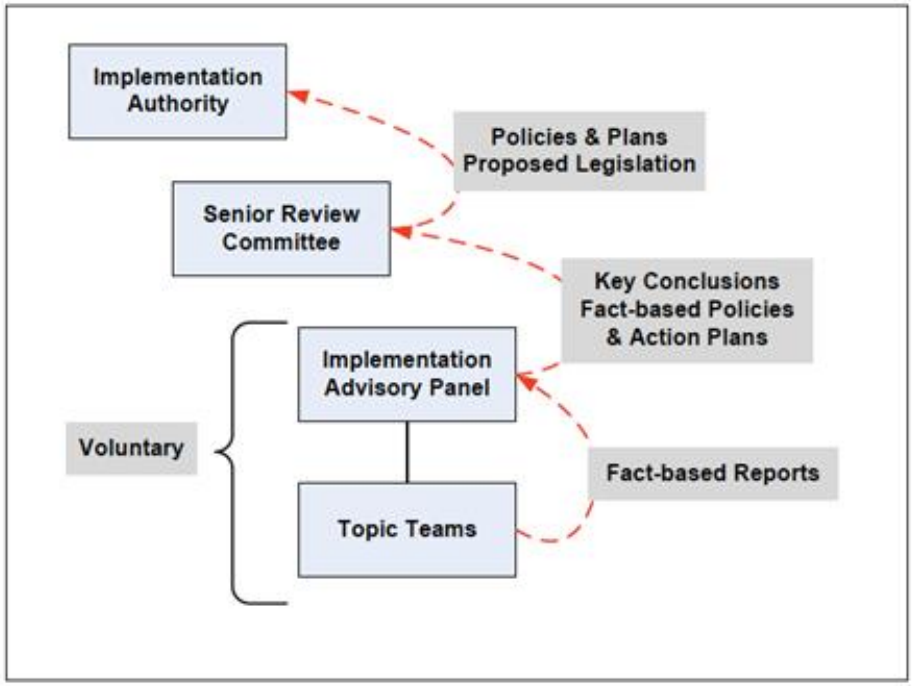
Task #3: Support Application & Demonstration Projects

Task #4: Policy Development

Task #5: Funding

Task #6: Commercialization by Private Business

Implementation Organization



- ✓ **Implementation Authority – State Energy Office**
- ✓ **Senior Review Committee**
- ✓ **Implementation Advisory Panel**
- ✓ **Topic Teams**

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Fuel Cell Transportation Technologies

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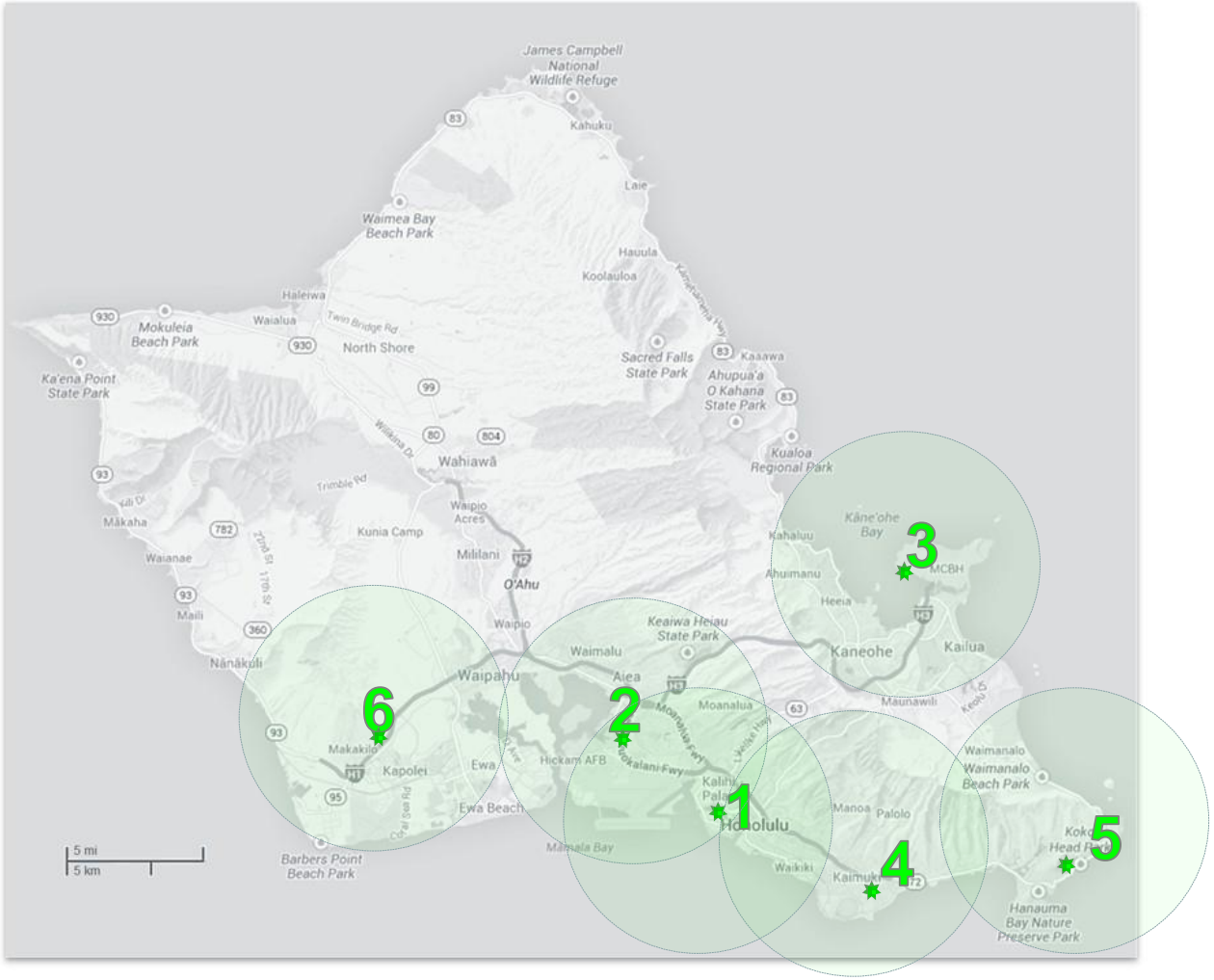
Potential Oahu Locations



1: Ft. Armstrong
2: Airport
3: Kaneohe Bay
4: Diamond Head Guard
5: Sandy Beach WWTP
6: HPower Trash Plant

5-miles radius

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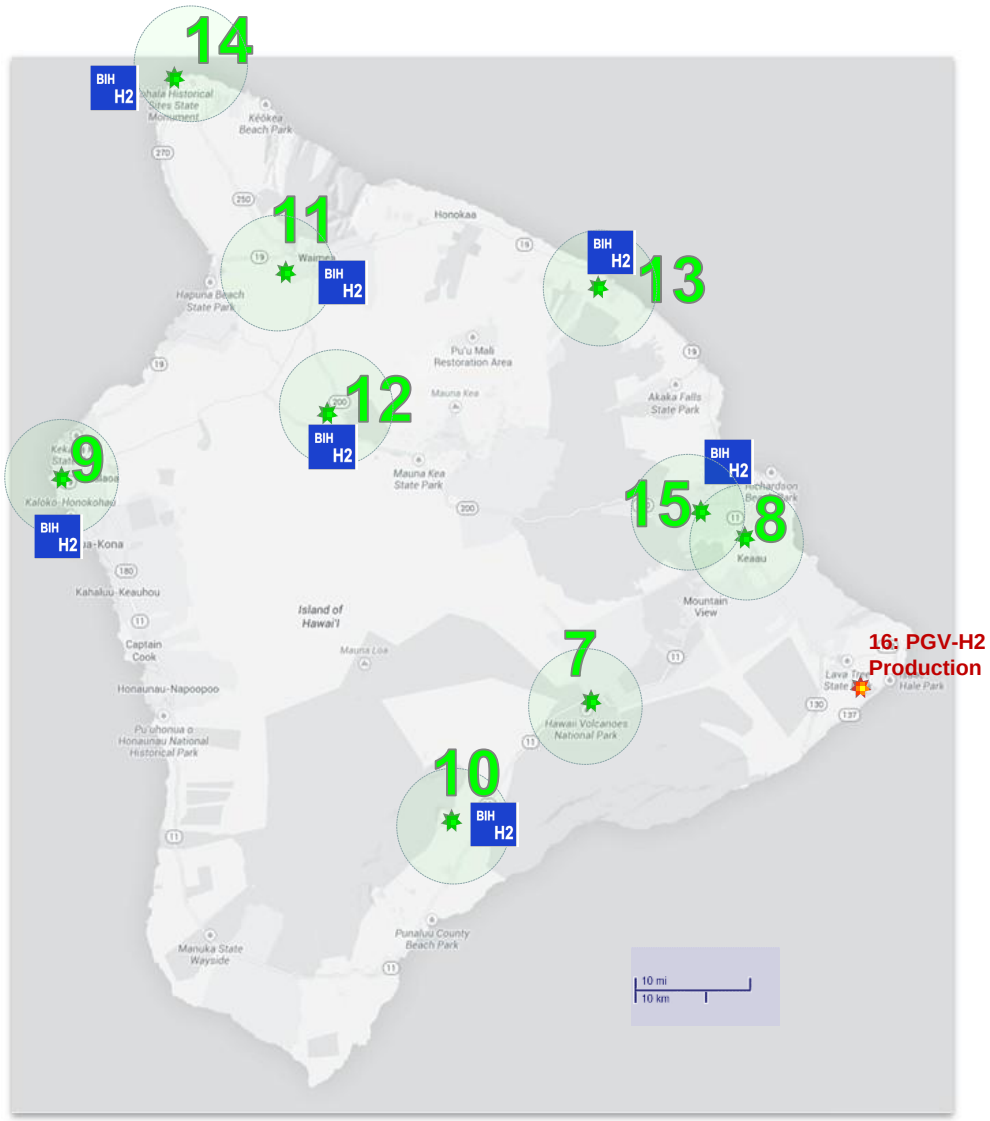
Potential Big Island Locations



7: Volcano National Park
8: Hilo Airport
9: Kona Airport/NELHA
10: Kau Coffee Mill Hydro
11: Parker Ranch
12: Army Training Area
13: Hamakua Coast
14: Hawe Wind
15: UH Hilo
16: PGV Production

5-miles radius

BIH H2 — Big Island Hydrogen Station

Note: no dispensing @ PGV
5 tube trailers would be used to distribute H_2 to dispensing sites.

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Potential Hydrogen Legislation

- ✓ Hydrogen Implementation Authority
- ✓ Hydrogen Investment Capital Special Fund
- ✓ City & County Honolulu Hydrogen Station
- ✓ County of Hawaii MTA Hydrogen Station
- ✓ Hydrogen Purity Test Station
- ✓ First Responder Equipment
  - ➢ Burn Props
  - ➢ Thermal Imaging Cameras
- ✓ Electric vehicles definition to include FCEV
- ✓ FCEV reporting & procurement requirements

Specific Goals

- ✓ **Status of hydrogen in Hawaii**
- ✓ **Fueling needs and installation timeframe**
- ✓ **Shortfalls and Remedies**
  - ➢ **Role of Government, OEMs**
- ✓ **Hydrogen/Electricity suppliers**
- ✓ **Energy security & assurance**
- ✓ **Economic development opportunities**

AGENDA

EVStructure
RetroFit Hawai'i

- Introduction/EvStructure Background
- Education and Planning are Key
- The Barriers & Costing Examples
- AOAO/ HOA case study, Solutions, Summary



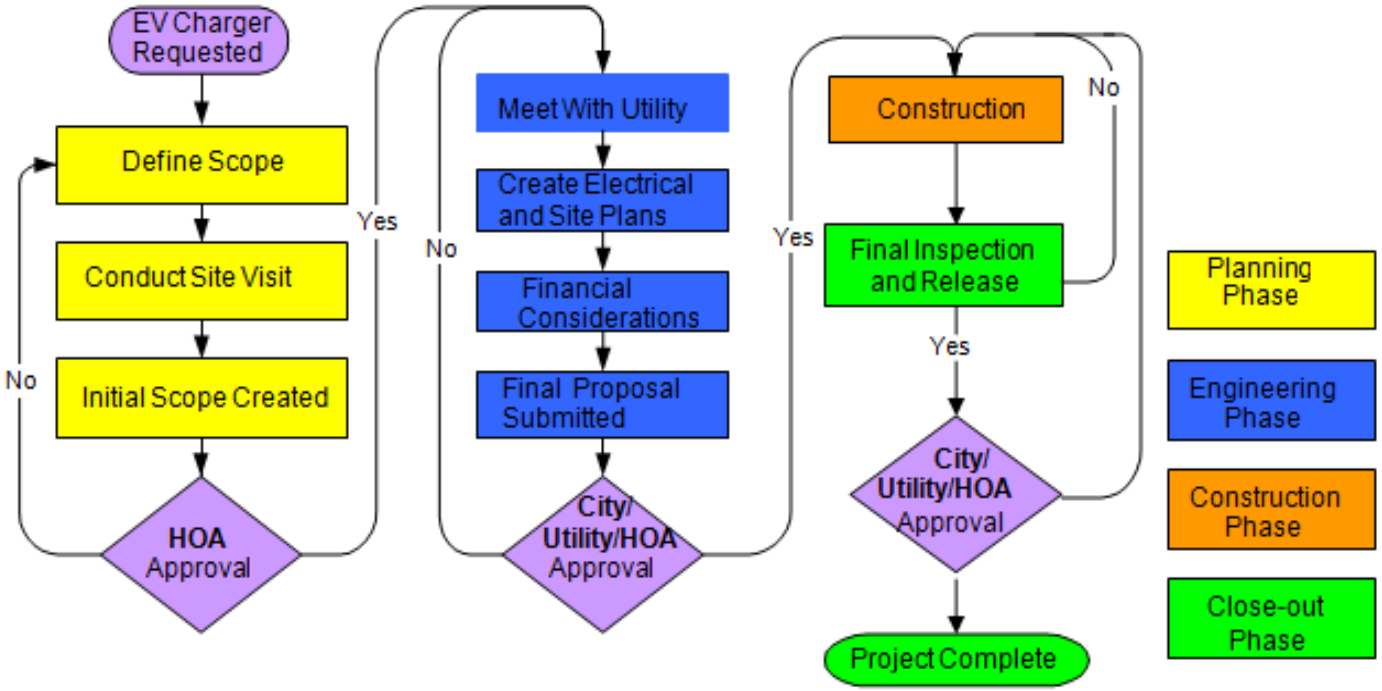
The Ev Structure Company is a local expert with nation-wide experience in the electric vehicle industry. We are a proud member of Honolulu Clean Cities and work as a strategic partner with various State and Non-profit entities working to expand the industry in Hawaii. Since 1998 after have installing the 1st charging station in Pasadena, CA for the Rav 1 program we have become an independent authority on Electric Vehicle Service Equipment (EVSE) and Charging Station Electrical Infrastructure.

Our partners and clients include: Action Properties, Hawaiiana, Enterprise Rental Car, Kohl's Retail Chain, BMW, SPX –GM, Chevy VOLT, the OpConnect Network, Green Lots, Car Charging Group (formerly Blink Network), ABM, NRG Deployment Partners. We are the go-to resource for Cities, Municipalities and Universities nationally. We provide EV readiness programs with a "cradle to grave" plan.

Our Specialty Services include: Objective expert advice and sourcing to the HOA, AOAO, Multi Unit Dwelling Communities, info on EV Charging Station options, acquisition, business models, policy, financial impact, tax and grant incentives and installation requirements for standard grid, smart grid and/or PV solar implementation with Solar Car Port Structures.

Our team works with: Commercial and residential property management staff, HOA/ AOAO homeowner's board, attorneys, real estate companies, and municipalities. We provide a full analysis of EV Charging Station Infrastructure, and can create a detailed EV readiness plan including site plans, energy auditing load calculations, equipment leasing & acquisition, cost analysis, EVSE MNF selection, engineering, ongoing KWH monitoring billing services and equipment service support.

EVSE is a Need. A New Curb Appeal & Amenity That Requires Good **Planning**



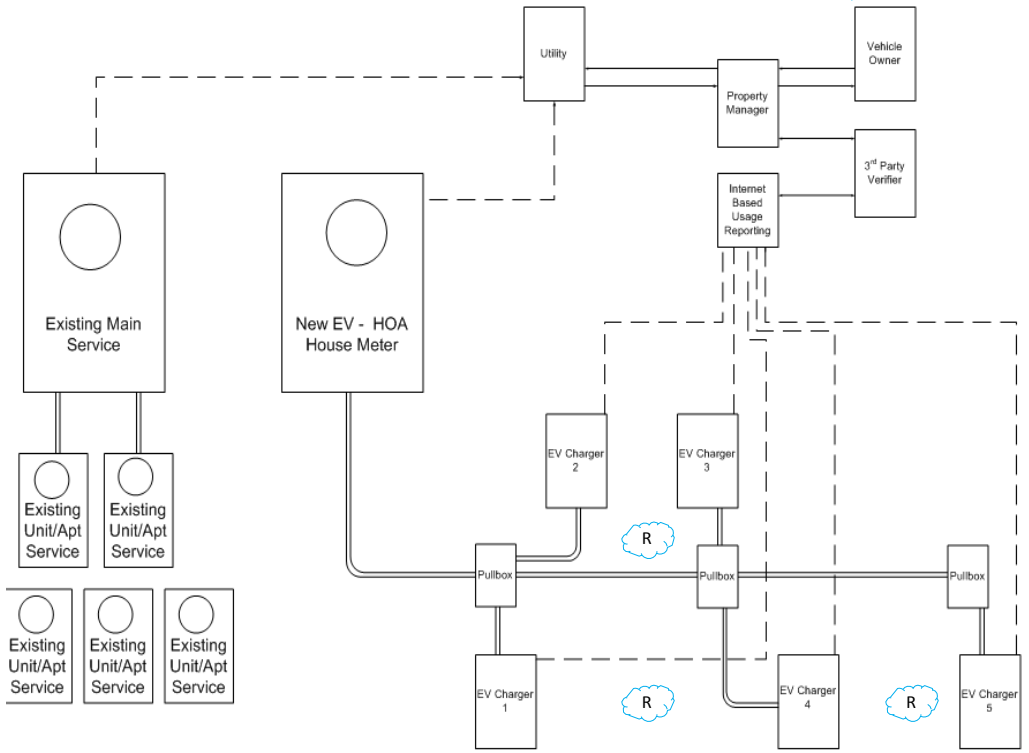
EVSE Units may require RF repeaters for underground wireless data communication

Phase 1
- Receive Work Order
- Define Scope
- Schedule Site Visit
- Project Analysis / Needs Assessment
- Document Preparation

Phase 2
- Meet with Utility
- Engineering
- Establish Billing/Invoicing/Costing Considerations for Usage
- Cost Proposal

Phase 3
- Approvals
- Construction
- Quality Control

Phase 4
- Final Inspection
- Close-out



Experience with 730+ buildings nationwide… most buildings can only accommodate 6 Level II EVSE chargers

Example of Challenges to Electric Vehicle Charging in AOAO Multifamily & Mixed Residential Buildings

Case Study: An AOAO In Honolulu Hawaii USA.

Mixed Building:

- 250 Condo Units, 2 Retail stores
- 1 Tesla S BEV owner No place to Charge
- Year built: 2000

Parking:

- 500 spaces (mixed 1 and 2 tandem spaces per unit)
- 5 guest spaces (a negative per unit)
- 2 levels subterranean; 2 levels above-ground
- No street parking

Electrical:

- All original electrical work (2000)
- Constrained by transformer size
- AOAO fees pay for common area electricity
- Individually metered units located on each floor

Electrical Engineering Phase 1 Prescription

1)Transformer Load Measured for one week for peek Capacities 2)Retro fitted common area with new LED Lighting ,Recommended PV

Result

Freed up 60 amps, Now Capacity for (10) Level II and or (15) 110 outlets, Common Area Charger and opportunity for Solar Carport for top deck Phase 2 - Estimate to Install of 1 duel common are EVSE $23,459.00

New Construction

206 Units 480 Deeded Parking 10 Guest stalls 11 EV Owners
Falls under Laws Hawaii ACT186-089

AOAO Case Study

JOB NAME: One Ala Moana
Honolulu, HI

Developer : Howard Hugh's Corp., Kobayashi Group, The MacNaughton Group
Project Management Co.: P3 Managment
Sales and Commissioning Company- EvStructure/ retrofithawaii
Start Date- 3/10/13
Date of Completion approx. 11/1/14
Permit Closed TBD

Result- Tremendous Project Savings, Happy New Homeowners with this Amenity

Cost Break Down saved :

1. Engineer drawing for site layout, single line and installation for plan check, meet with city to submit and obtain approval $ 1,500.00
2. Coring ,Installation Labor and Material (Includes 100kVa Transformer) $ 12,000.00
3. (3)x Opconnect Mark II Duel EVSE w/ Cord Management $ 21,990.00
5. Paint parking stall for EV and install wheel stops $ 1,200.00
6. 1 EvGauge KWH Data Management 3,700 plus 15.00 a mo. mgmt Per driver

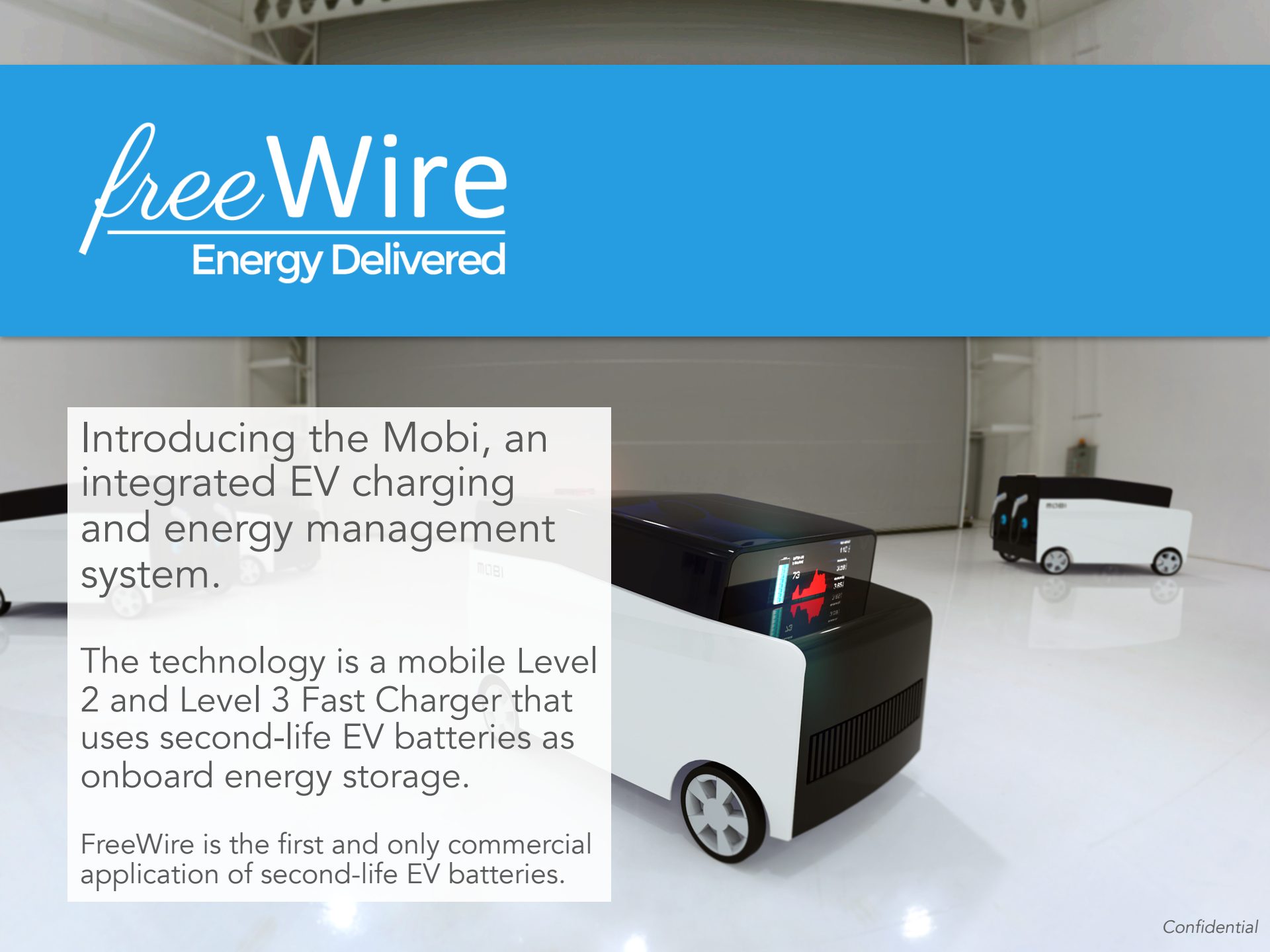
Project Total $23,190.00 **Total Saved specked into initial planning $24,000 +**

Summary

- Electric Vehicles are here and in demand
- EDUCATION is A MUST: HOA/AOAO/MUDs, Attorneys, Reserve companies, Architects, Electricians, Commercial and Residential Property Managers, EV Drivers, Senators and Representatives, etc. need to be informed and prepared.
- People don’t plan to fail, they fail to plan; EVSE MNF operating agreements must be customized to conform to the properties
- Properties need to prepare for EVSE Electrical Infrastructures and installations for enough 110v dedicated circuit outlets and or sufficient transformers sizing for Common area EVSEs. (Reserve Studies)
  - Implementing new standards in building codes for new buildings is an opportunity to increase infrastructure options in commercial and residential buildings
- Innovative solutions: Battery storage; Freewire

freeWire

Energy Delivered



Introducing the Mobi, an integrated EV charging and energy management system.

The technology is a mobile Level 2 and Level 3 Fast Charger that uses second-life EV batteries as onboard energy storage.

FreeWire is the first and only commercial application of second-life EV batteries.

The Problem

Companies and utilities are struggling to keep up with the demands of EV charging.

Electric vehicle adoption is rising dramatically, and the current model of "dumb" stationary chargers imposes serious challenges.

CITRIX Google intuit MARVELL

Low Utilization

Low vehicle turnover as employees refuse to rotate out of spots.

(Avg = 2 cars / day / spot)

Difficult Installation

Requires boring concrete across a parking lot to run conduit.

(Plus permits & licenses)

Low Scalability

Complex and lengthy process to scale up charging capacity.

(CapEx & 6 months install)

High Infrastructure Cost

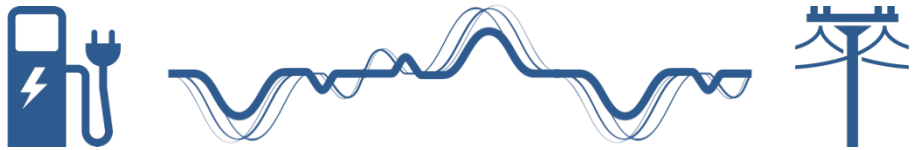
Installation cost, infrastructure upgrades, and permitting – over $200k to set up 10 stations.

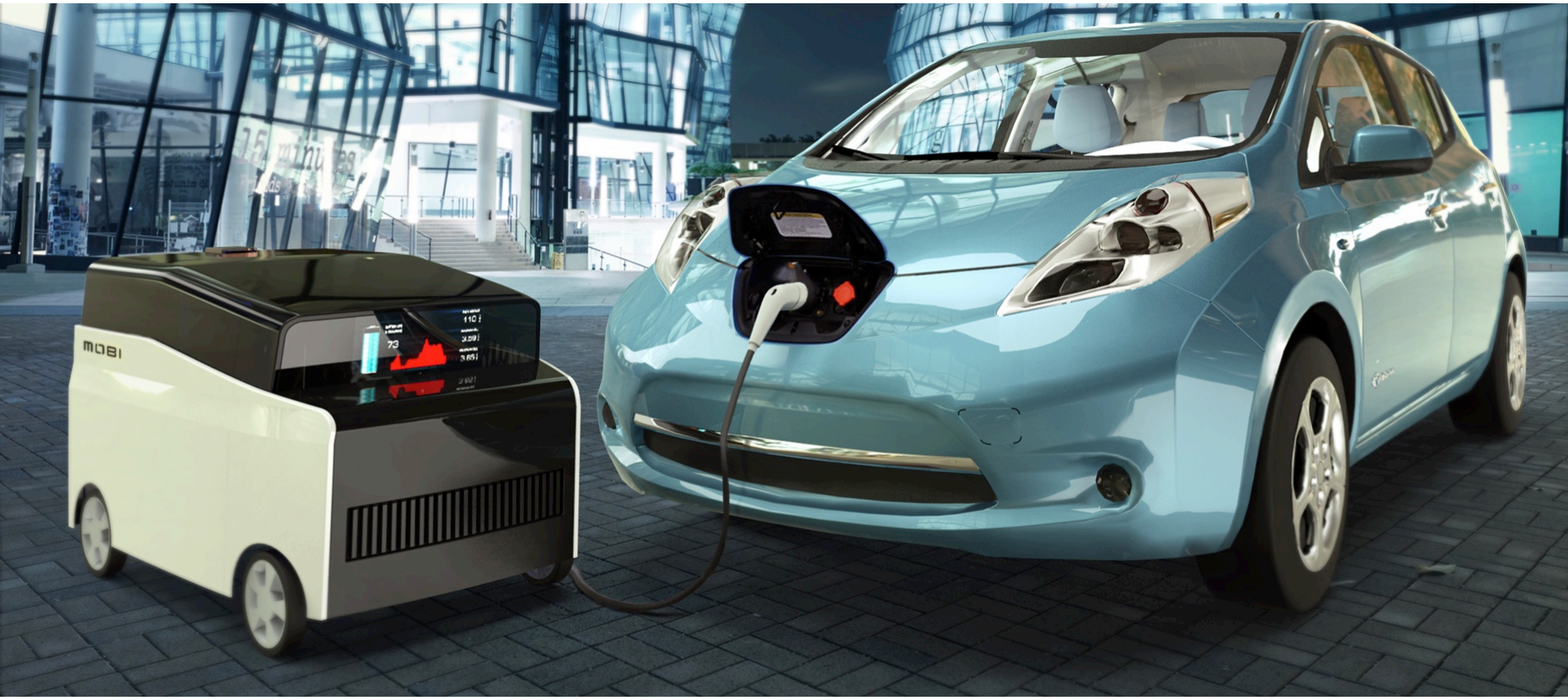
Productivity Loss

Employee productivity is drained due to swapping cars & spots during the workday.

The Solution: Mobi Charger

The first solution that integrates EV charging with grid-level and building-level energy management.





1

Technology:
The Mobi Charger

2

Business Model:
Charging as a Service

3

Energy Platform:
Smart Energy Platform

Introducing the biggest innovation in EV charging, energy storage, and energy management.

EV Charging
Dual Level 2 +
Level 3 Fast Charging.

Energy Storage
48kWh of lithium-ion
batteries onboard.

Energy Management
Automated demand response
and building management.

1

Technology:
The Mobi Charger

2

Business Model:
Charging as a Service

3

Energy Platform:
Smart Energy Platform

1

Technology:
The Mobi Charger

2

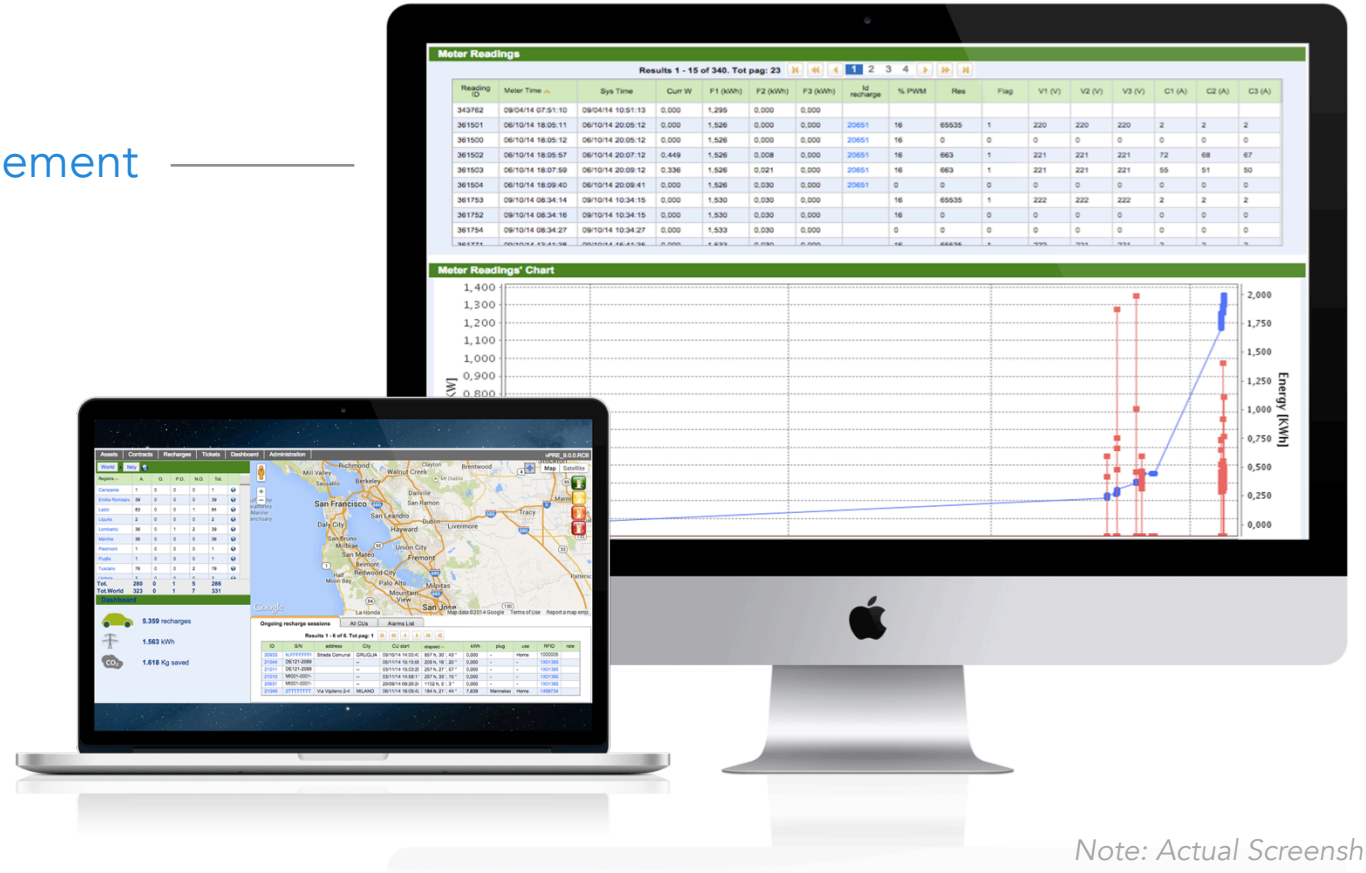
Business Model:
Charging as a Service

3

Energy Platform:
Smart Energy Platform

Grid Operators & Utilities
Property Owners
Facilities Managers

Active Energy Management



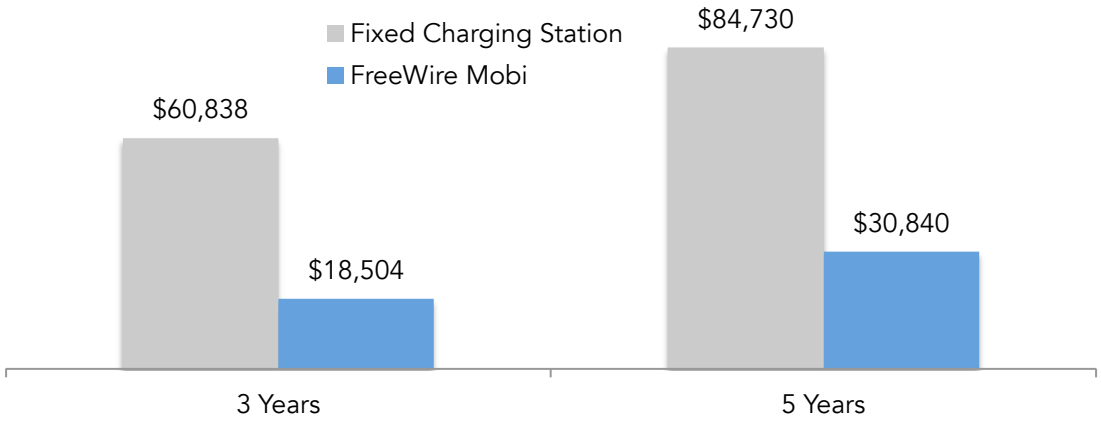
Note: Actual Screenshots

Economics

Cost per EV per Month
(includes energy costs)

	Level 2	Level 3
Fixed Charging Station	$311	$1,087
FreeWire Mobi	$347	$514

Total Cost of Ownership (per EV) – Level 3



Hawaii

State-specific barriers to increased EV infrastructure:

(1) EVs are not concentrated in specific locations.

(2) Lack of state-level funding and incentives to deploy charging infrastructure.

(3) Multi-unit dwellings: no one's figured it out.

Solution? Create artificial demand until you reach a tipping point.

freeWire

Thank You

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jawann@freewiretech.com

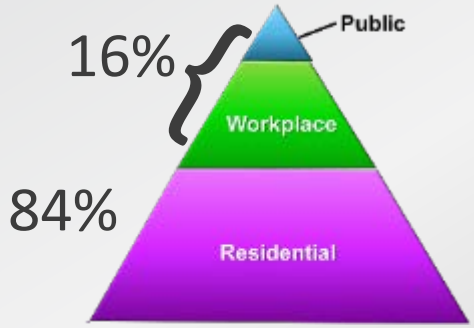
Alex Keros

Manager, Advanced Vehicle & Infrastructure Policy

Home vs. Work vs. Public Charging

- Overall EV drivers:

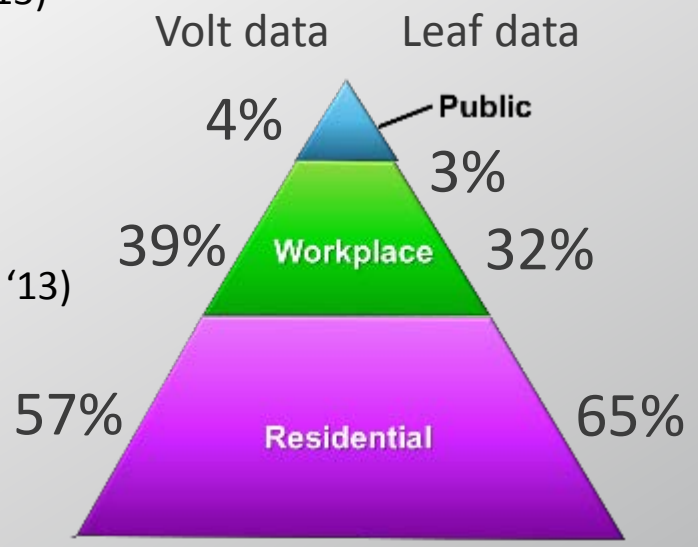
  Study Period 1/1/2012 – 12/31/2013
  - 84% of all charging events are at home
  - 16% not at home



- When workplace charging is available to an EV driver:

  (96 Volts with access to workplace charging Jan '13 – Dec '13)
  - 57% of charging events are at home
  - 39% at work
  - 4% at other locations (e.g. public)

  (707 Leafs with access to workplace charging Jan '12 – Dec '13)
  - 65% of charging events are at home
  - 32% at work
  - 3% at other locations (e.g. public)

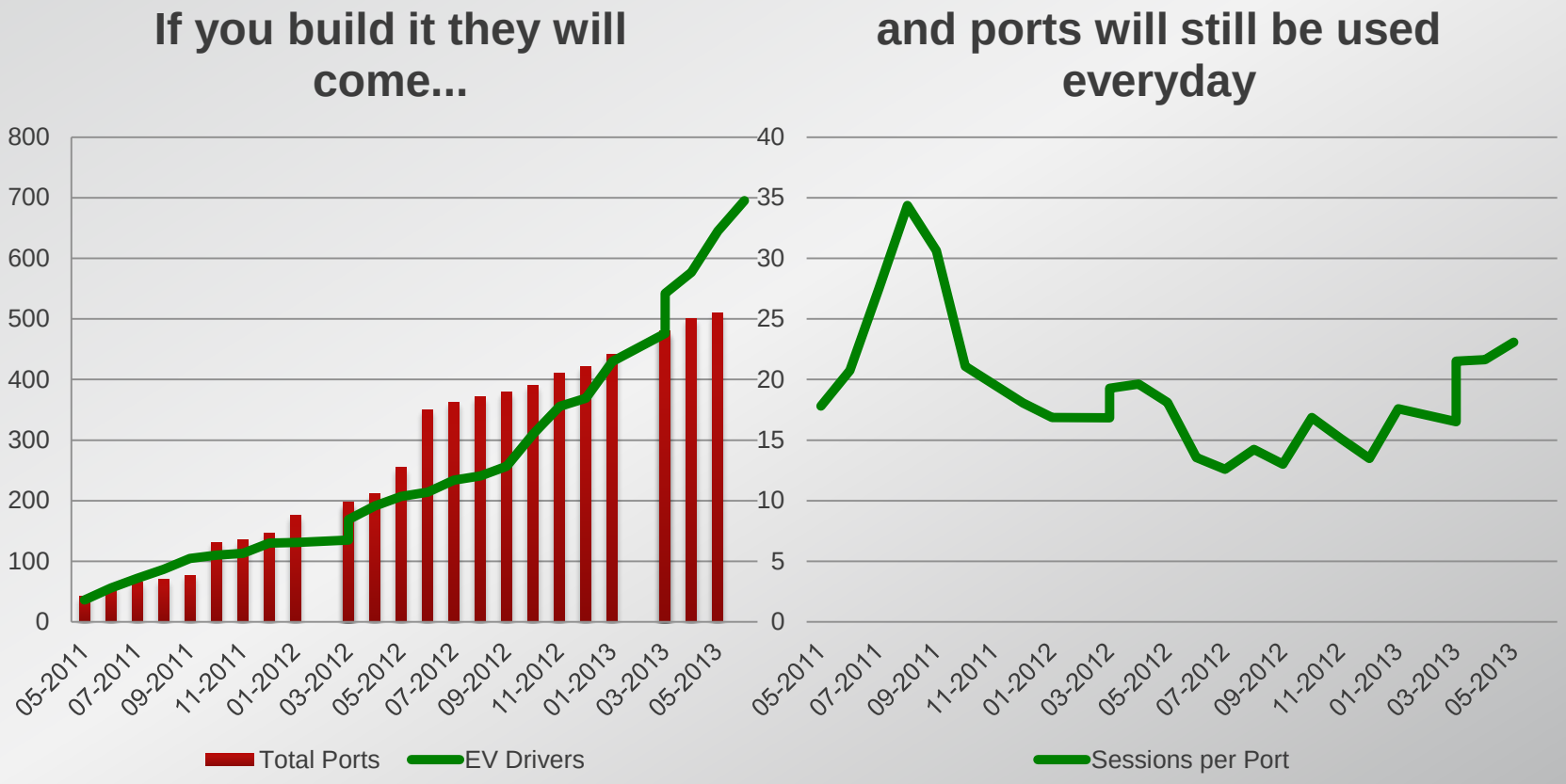


Residential and workplace charging provide the vast majority of all charging.

Source: John Smart, INL, EV Project; Link to all reports = http://avt.inel.gov/librarybydate.shtml

Case Study: Major CA Workplace Customer

- ***Infrastructure investment stimulates EV adoption!***



432 GM WORKPLACE CHARGING STATIONS
Including 21 Assembly Plants

(23% Solar; 2 ADA friendly; 400 add'l private; 63% 240V and 37% 120V)

Michigan 278

New York 51

California 32

Ohio 30

Indiana 8

Connecticut 2

Illinois 2

Maryland 8

Arizona 2

Kansas 2

Kentucky 12

Texas 3

Georgia 2

Also: Chevrolet and Cadillac dealers have installed approximately 5,900 charge stations at their locations for owner use – 17 of these dealerships use solar charging canopies.

DOE's Workplace Charging Challenge Partners

➔ Goal is tenfold increase in 5 years!

General Motors | Stakeholder Collaboration

California FUEL CELL PARTNERSHIP — DRIVING FOR THE FUTURE

A California Road Map: The Commercialization of Hydrogen Fuel Cell Vehicles

The realization of fuel cell electric vehicles and supporting infrastructure requires a road map for investments in fuel cell electric vehicles and hydrogen fueling stations.

June, 2012

CALIFORNIA PLUG-IN ELECTRIC VEHICLE COLLABORATIVE

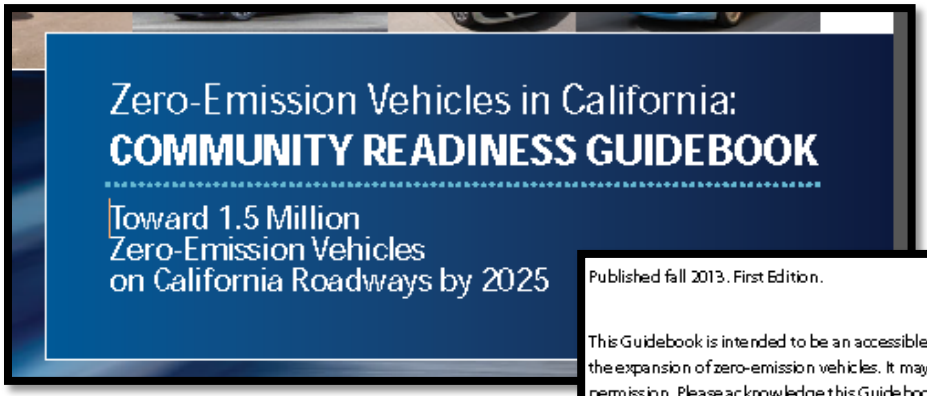
Streamlining the Permitting and Inspection Process for Plug-In Electric Vehicle Home Charger Installations

APPROVED

Report and Recommendations, Version 2
July 2012

GOVERNOR'S OFFICE OF PLANNING AND RESEARCH · STATE OF CALIFORNIA

THE GREAT SEAL OF THE STATE OF CALIFORNIA



Published fall 2013. First Edition.

This Guidebook is intended to be an accessible informational resource that supports the expansion of zero-emission vehicles. It may be reproduced and distributed without permission. Please acknowledge this Guidebook as a source of information when using its content in other documents or presentations.

General Motors | EPRI/Utility Collaboration

- Largest existing auto-utility collaborative effort -- formed in 2007
- Over 50 utility members and the Electric Power Research Institute (EPRI)
- Focus areas: Vehicle-to-Grid Technology, Aligned Messaging and Policy Priorities, New Business Opportunities (EV-to-Grid)

Role of Utilities | Summary

A growing PEV market benefits everyone

- Individual benefits: fuel savings, quiet and exciting ride & handling
- Society benefits: energy security, environment (local air, climate), and grid reliability
- Utility benefits: a smart load that drives new revenue to keep rates low

Utilities need to be active participants in growing the PEV market

- This is a "learning" transition and requires hands-on experience to shape next steps
- The PEV market will not escape "niche" unless utilities (and regulators) get involved

Active role in home (including MUDs) and workplace charging

- PEVs are already very smart and will do most charging at home – as the PEV market grows, utilities will want to ensure good load balancing across the service territory (off-peak EV rates, smart charging)
- Workplace charging is key to growing PEV awareness and corporate relationships are key to utilities - a utility will want to ensure healthy corporate engagement

Active role in PEV outreach and education

- Utilities are trusted 3rd parties and operate at a local level – key for building awareness

Longer term – pilot projects

- Utilities need to explore the role of PEVs in ancillary services, V2H, V2G, and battery secondary use to address growing issues in renewables, intermittency, storage, outage

What Infrastructure strategies are most important during the market launch of PEVs?

Simplicity & Flexibility.

Necessary Outcome:

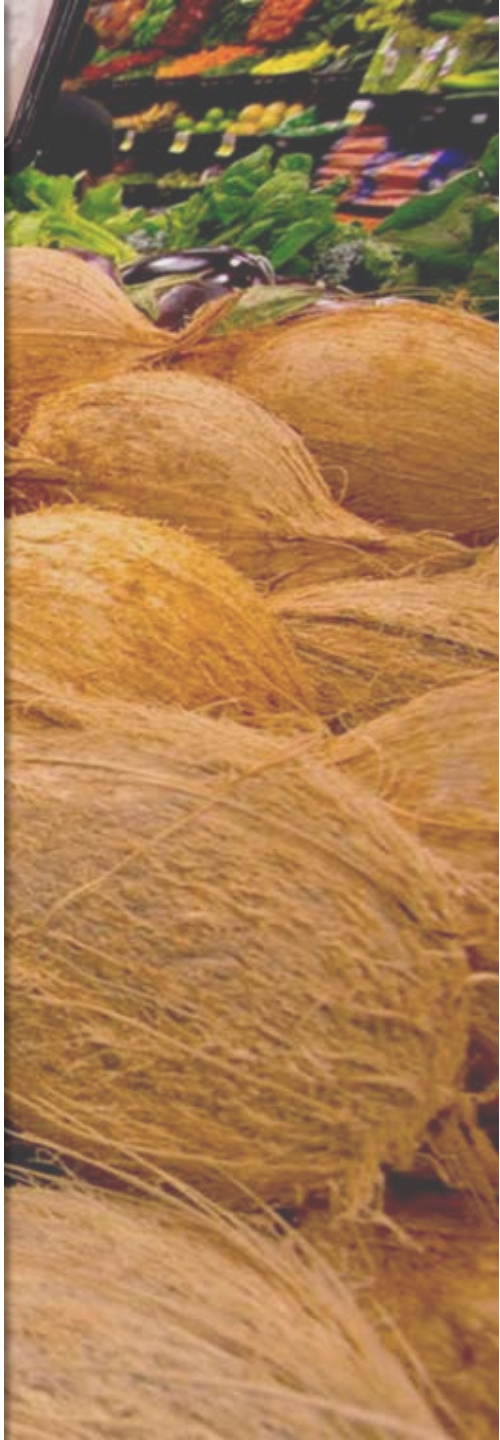
Customers looking for easy solutions.

Investing in a More Sustainable Hawai‘i

HCEI 2.0

January 14, 2015

ulupono INITIATIVE



Who is the Ulupono Initiative?

- Founded in 2009, we are a Hawai‘i-focused impact investment firm that uses for-profit and non-profit investments to help catalyze large-scale, replicable change toward a more self-sufficient Hawai‘i by focusing on:

Our Founders:
Pam & Pierre Omidyar

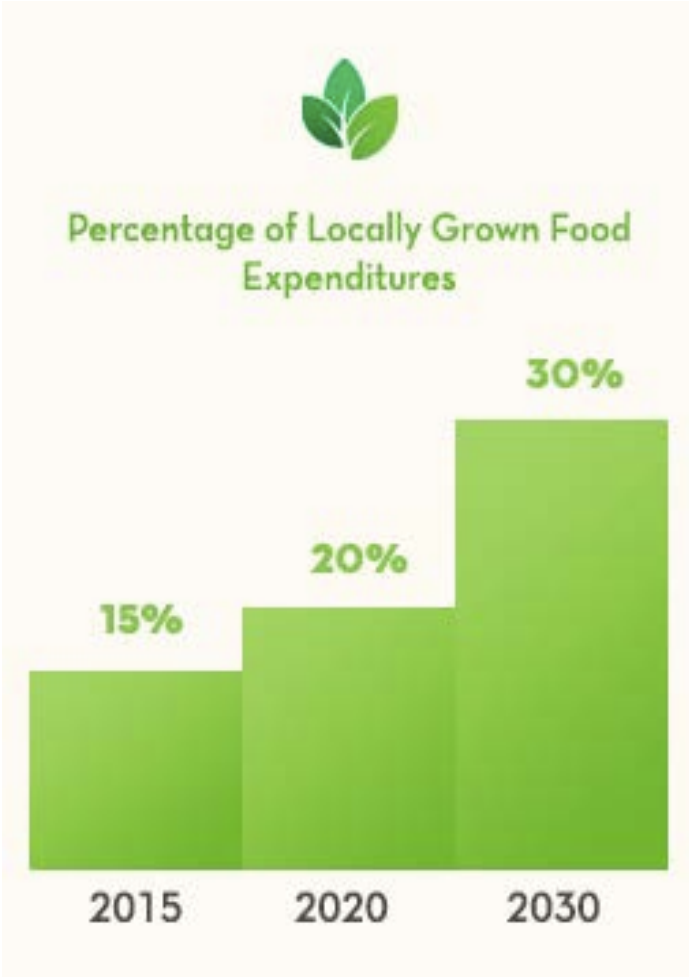
More Locally Produced Food

More Renewable Energy

Waste Reduction

Our Goal: Increase Locally Grown Food

- By 2030, we want 30% of our food grown locally.

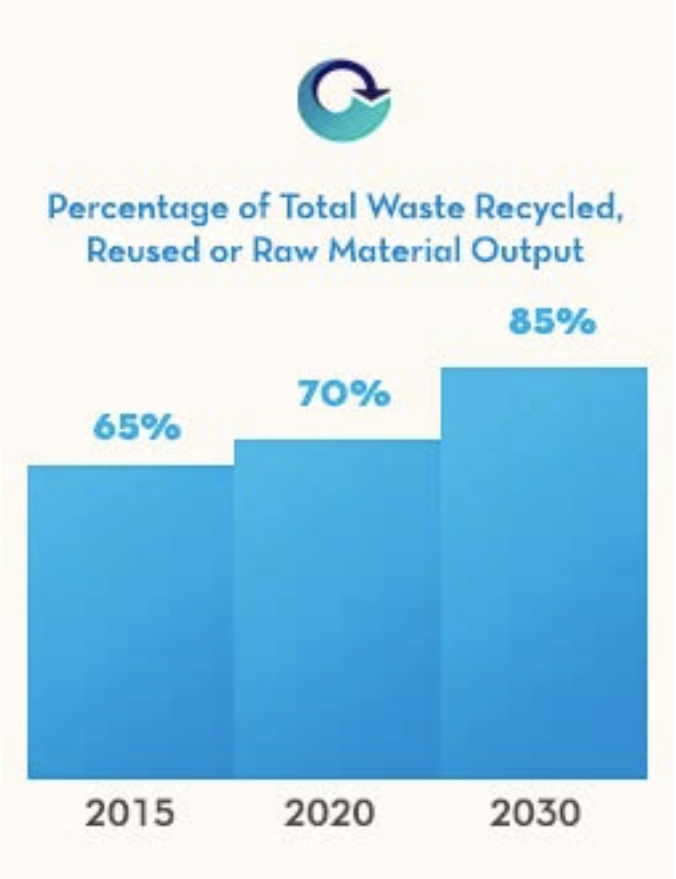


Our Goal: Locally Produced Clean, Renewable Energy

- By 2030, we want 60% locally produced clean, renewable energy.

Our Goal: Reduce, Recycle and Reuse Waste

- By 2030, we want 85% total waste recycled, reused or raw material input.



Projects We Support

- Hawai‘i Dairy Farms
- Hawai‘i School Garden Network
- Honolulu Seawater Air Conditioning, LLC.
- Paniolo Cattle Company
- MA‘O Organic Farms
- Re-use Hawai‘i
- SolarCity

Transportation Efforts

Biofuels

HAWAI'I BioEnergy

Phycal

EV Infrastructure

VOLTA

opconnect
Electric Vehicle Charging System

Policy Support

VMT Reduction

Way Sine

Bikeshare Hawai'i

Policy Support (Carshare)