

福岡水素エネルギー戦略会議 研究分科会

高压水素 貯蔵・輸送研究分科会/高压水素下における機械要素研究分科会

国内外の水素供給インフラ普及 に向けた取組み

2015年12月21日

水素供給・利用技術研究組合 (HySUT)

山梨 文徳

fu-yamanashi@hysut.or.jp

<http://hysut.or.jp/>



はじめに

水素供給・利用技術研究組合 (HySUT) の概要

The Research Association of **H**ydrogen **S**upply/**U**tilization **T**echnology

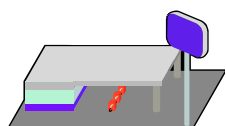
水素供給事業と燃料電池自動車 (FCV) 普及を目指す民間各社により、2015年のFCV一般ユーザーへの普及開始を目指し、試験・研究を通じて事業成立と社会的受容性のための課題を解決する目的で設立

設立：2009年7月31日（期間：2009～2015年度）

組合員

20 社・団体（2015.11.1 時点）

4



[石油会社]

JX日鉱日石エネルギー、出光興産、コスモ石油、昭和シェル石油

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[都市ガス会社]

東京ガス、大阪ガス、東邦ガス、西部ガス

7



[産業ガス・金属材料・機器メーカー]

岩谷産業、太陽日酸、日本エア・リキード、三菱化工機、川崎重工業、日本製鋼所、神戸製鋼所

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[自動車メーカー]

トヨタ自動車、日産自動車、本田技術研究所

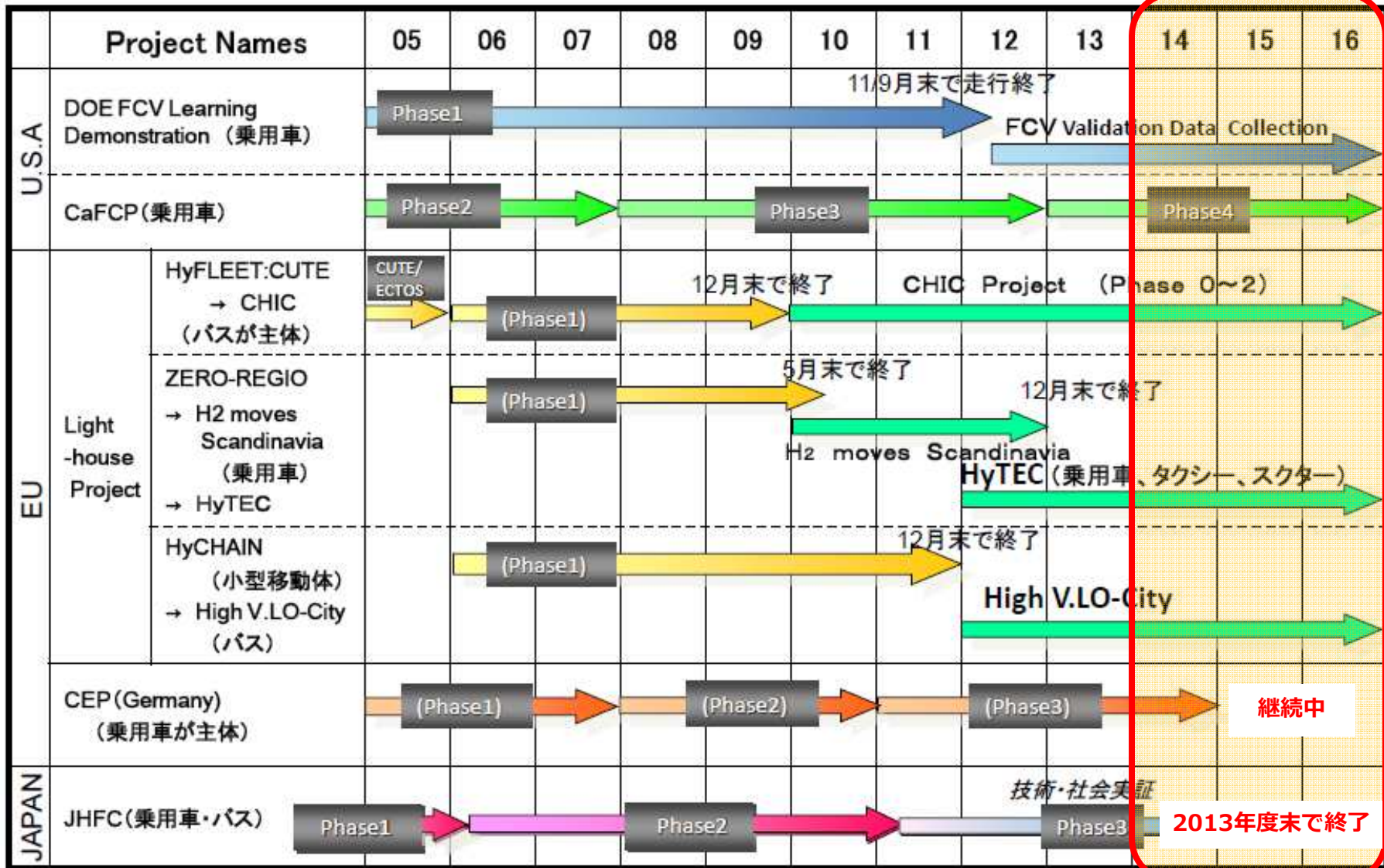
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[関連団体]

エンジニアリング協会 (ENAA)、石油エネルギー技術センター (JPEC)

世界中で実証から商用フェーズに移行中

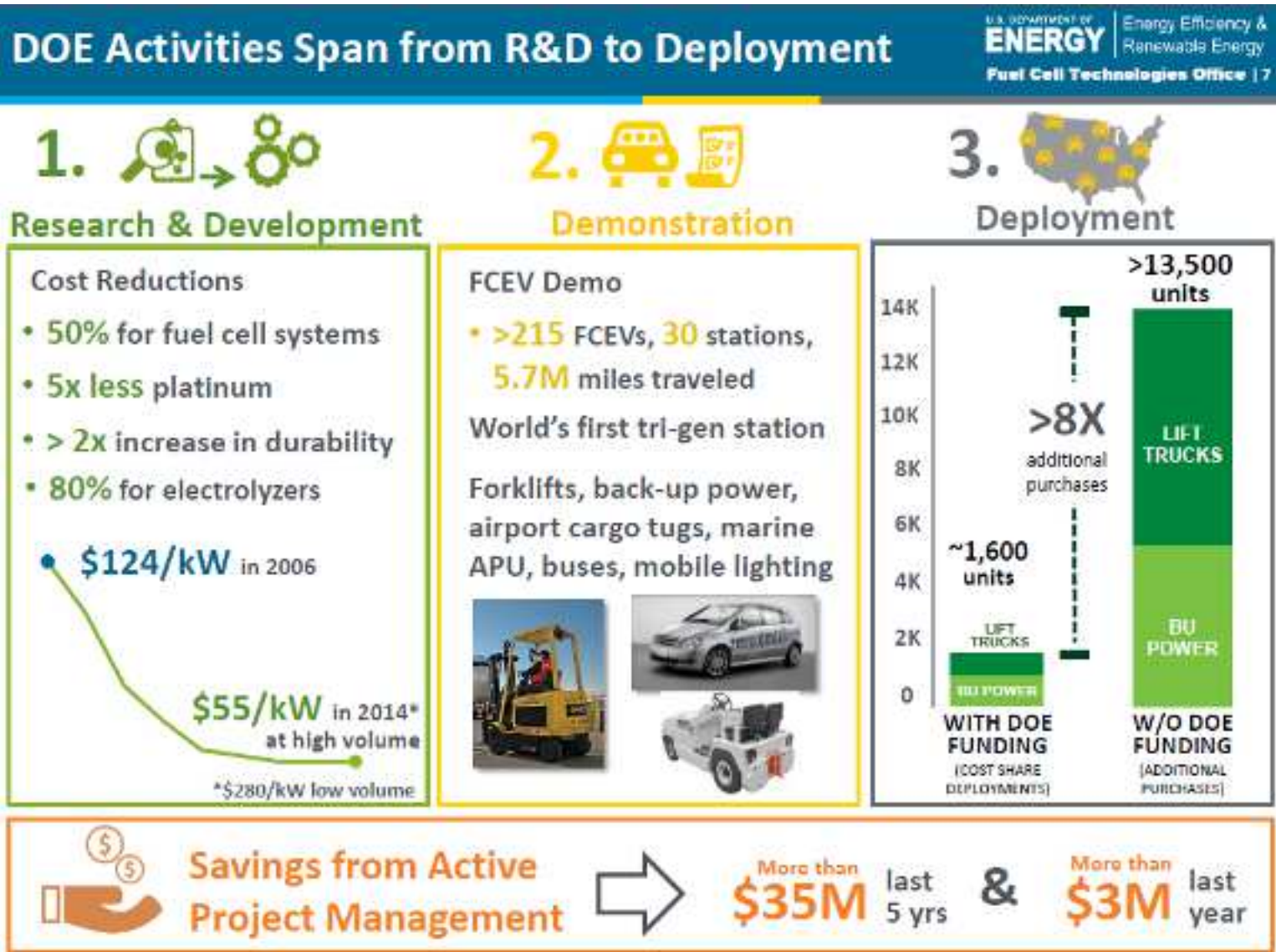


出典：2013.7.26 山梨県自動車販売店協会講演資料（山梨大 丹下先生）



米国の動向

米国 : DOE (エネルギー省) の取り組み



出典 : 2015.6.8 DOE Annual Merit Review Plenary

米国 : DOE Program - Technology Validation

Technology Validation

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

Completed FCEV & Hydrogen Demonstration

with 50-50 DOE-Industry cost share

- >180 fuel cell vehicles and 25 hydrogen stations
- 3.6 million miles traveled; 500,000 trips
- ~152,000 kg of hydrogen produced or dispensed (some of this hydrogen used by vehicles not in the learning demonstration)
- >33,000 refuelings



	Status	Project Target
Durability	~2,500	2,000
Range	196 – 254*	250*
Efficiency	53 – 59%	60%
Refueling Rate	0.77 kg/min	1 kg/min

*Independently validated a vehicle that can achieve a 430 mile range.

	Status (NG Reforming)	Status (Electrolysis)	Ultimate Target
H ₂ Cost at Station	\$7.70–\$10.30/kg	\$10.00–\$12.90/kg	\$2.00–\$4.00/kg

Partners: Air Products, BP, Chevron, Daimler, Ford, GM, Hyundai, Kia, UTC Power

Demonstrated World's First "Tri-generation" Station

- Capable of co-producing electricity, hydrogen, and heat -

- Utilizes anaerobic digestion of municipal wastewater (from the Orange County Sanitation District)
- Produces 100 kg/day H₂; generates ~ 250 kW; 54% efficiency co-producing H₂ and electricity
- Nearly 1 million kWh of operation
- >4,000 kg H₂ produced



Partners: Air Products, California Air Resources Board, FuelCell Energy, South Coast Air Quality Management District, UC Irvine

米国 : DOE Learning Demonstration (Technology Validationのひとつ)

(2011/9で走行終了)

FCV参加台数	183 台
水素ステーション数	25 基(内6基70MPa)
FC効率	53 - 59%
航続距離	196 -254 マイル
耐久性	2,521 時間 (最大) (~75,000 マイル相当)



注) Ford, Hyundai/Kiaは、2009年末、それぞれ実証参加終了

出典 : 2013.7.26 山梨県自動車販売店協会講演資料 (山梨大 丹下先生)

米国：実証⇒商用化フェーズへの移行

H₂USA Mission Statement

The mission of H₂ USA is to promote the commercial introduction and widespread adoption of FCEVs across America through creation of a public-private collaboration to overcome the hurdle of establishing hydrogen infrastructure.



出典：2014.6.19 DOE Annual Merit Review Plenary

H₂USAの目標（ゴールの姿）

Goals

- Establishing necessary hydrogen infrastructure and leveraging multiple energy sources, including natural gas and renewables
- Deploying FCEVs across America
- Improving America's energy and economic security
- Significantly reducing greenhouse gas emissions
- Developing domestic sources of clean energy and creating jobs in the United States
- Validating new technologies and creating a strong domestic supply base in the clean energy sector



出典：2014.6.19 DOE Annual Merit Review Plenary

H₂USAの参加メンバー

H₂USA to address H₂ Infrastructure Challenges

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy
Fuel Cell Technologies Office | 22

H₂USA

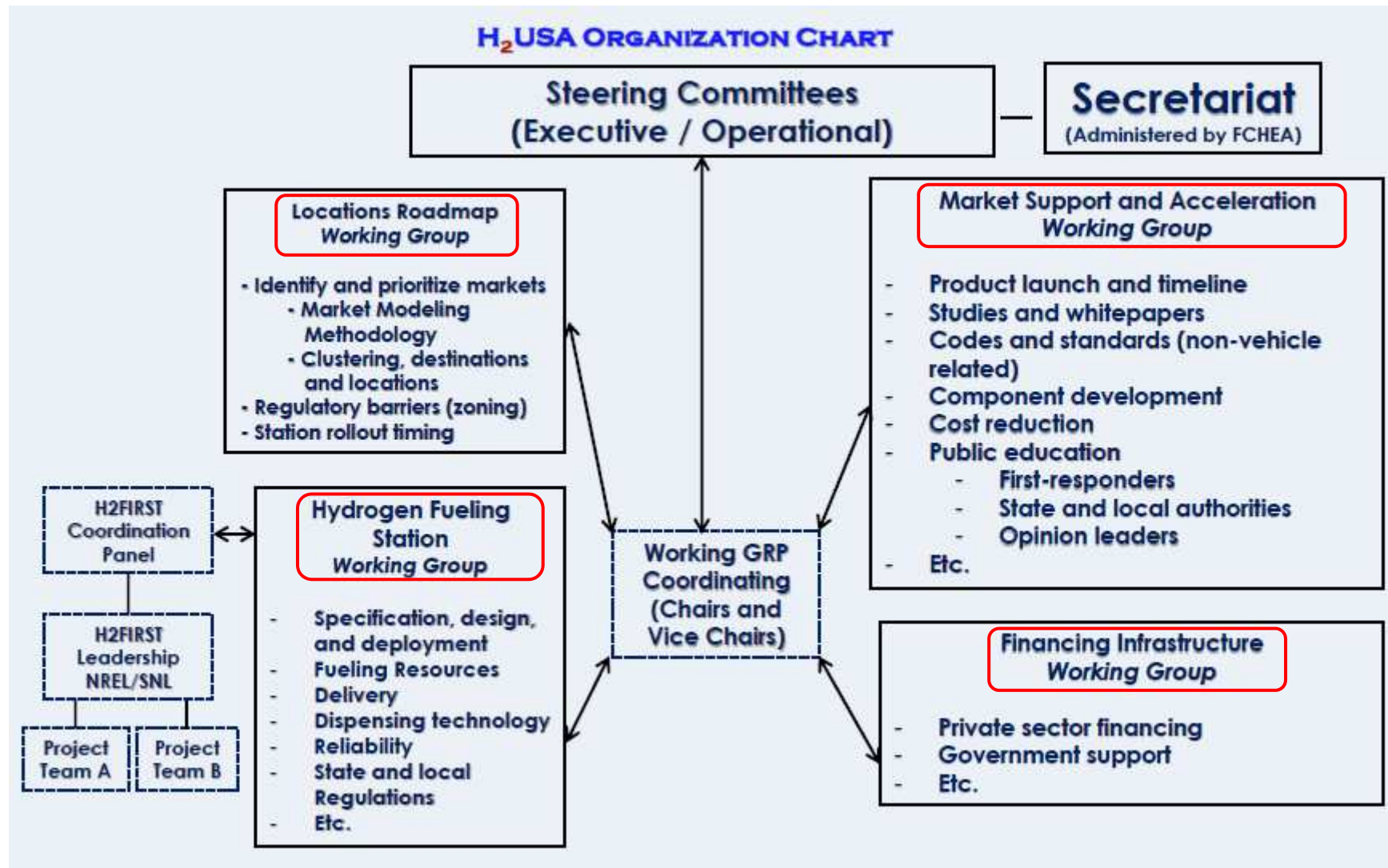


*Representative sample of member logos

Public-Private Partnership with 4X increase in partners since 2013

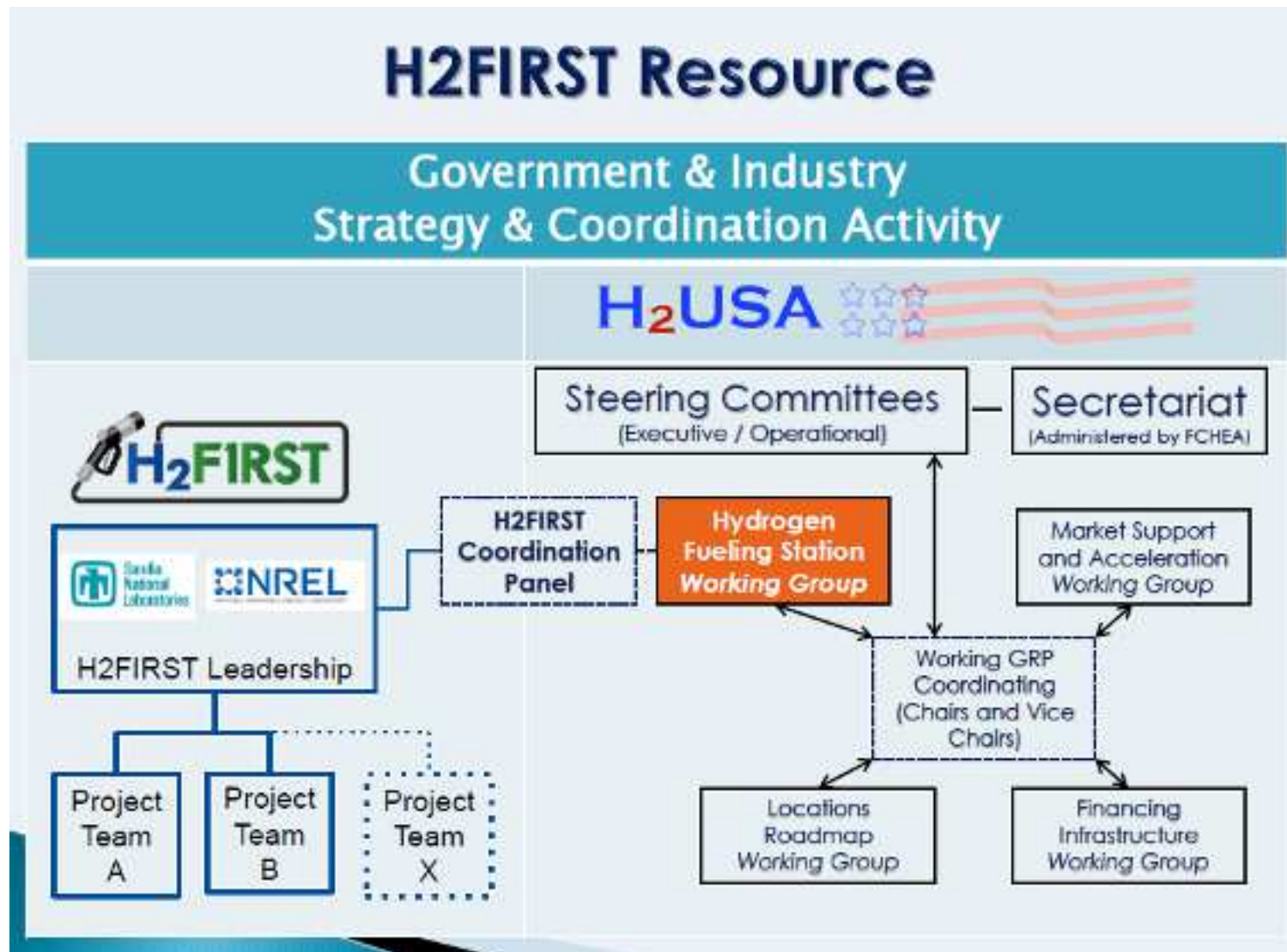
出典 : 2015.6.8 DOE Annual Merit Review Plenary

H₂USAの組織 4つのWGが主体で活動



出典 : 2014.6.19 DOE Annual Merit Review Plenary



















H2FIRST⇒HFSWGの要請によりシステム/部品開発をサポート




出典：2014.6.19 DOE Annual Merit Review Plenary

HFSWG (Hydrogen Fueling Station WG) の主要メンバー

HFSWG Members

Analysis	Stations	Regions	Users
   	       	   <div style="border: 1px solid #008080; padding: 5px; background-color: #e0f2f1;"> <p style="text-align: center;">New Members</p>   </div>	<p style="color: #e67e22;">As Proxy for Customers</p> <p style="color: #e67e22;">HONDA The Power of Dreams</p> <p style="color: #e67e22;">NISSAN</p>  <p style="text-align: center;">Mercedes-Benz</p>



出典 : 2014.6.19 DOE Annual Merit Review Plenary

H2FIRSTの取り組み

Early Market Challenges



Photo Credits Top: NREL, Middle: NREL, Bottom: Hexagon Lincoln

H₂USA



➤ Station Cost Reduction

- Specification, design, and deployment
- Fueling resources & delivery
- Station and dispensing technology improvement
- State and local regulations



➤ Station Locations

- Identify and prioritize markets
- Regulatory barriers (zoning)
- Station rollout timing

➤ Investment and Finance

- Private sector financing
- Government support

➤ Market Support and Acceleration

- Product launch and timeline
- Codes and standards (non-vehicle related)
- Public education

出典 : 2015.6.8 DOE Annual Merit Review Plenary

H2FIRSTの取り組み

Hydrogen Fueling Infrastructure Research Station Technology

U.S. DEPARTMENT OF
ENERGY | Energy Efficiency &
Renewable Energy
Fuel Cell Technologies Office | 23

Leveraging Expertise of National Labs



&



In Support of

H₂ USA and tasked to deliver:



Outstanding Partnership Award

By the Federal Laboratory Consortium (FLC)
for efforts toward deployment of hydrogen
fueling infrastructure

Reference Station Design

- ✓ Report Delivered with Detailed Station Designs and Cost Estimates

Fuel Contaminant Detection

- ✓ Market Survey and Gap Analysis Complete

HyStEP Device

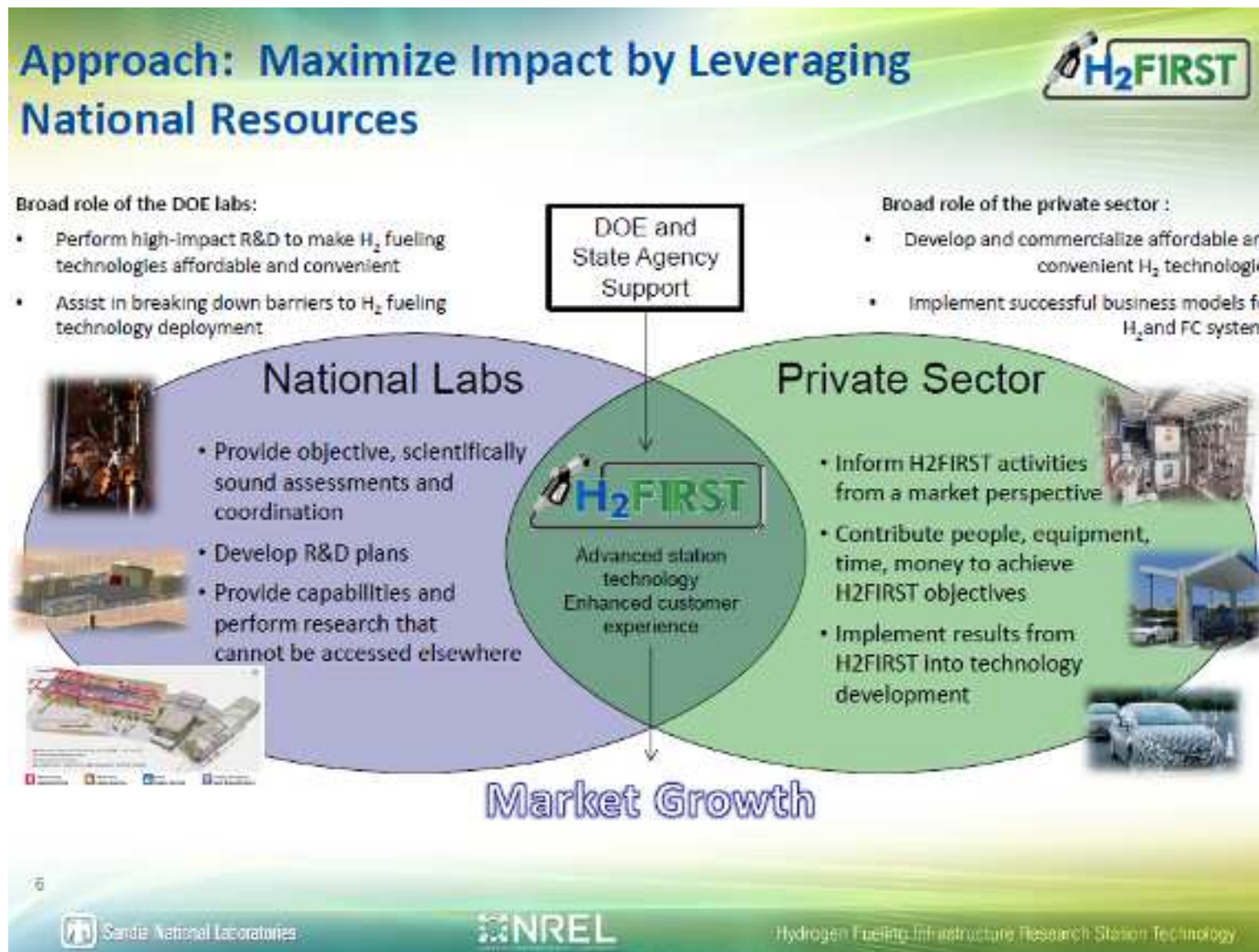
- ✓ Design Complete - Currently Under Construction

- H₂ Station Equipment Performance Device
- H₂First Inaugural Task
- HyStEP will help reduce time required to place H₂ stations in service

DOE's H₂FIRST project supports H2USA goals to address infrastructure

出典 : 2015.6.8 DOE Annual Merit Review Plenary






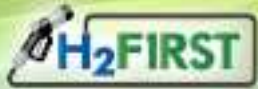
H2FIRSTの活動



出典 : 2014.6.19 DOE Annual Merit Review Plenary

H2FIRSTの活動 : SNL (Sandia National Lab.)

Accomplishment: Supporting Capabilities – CIRI
Materials Science & Engineering Science Focus



CIRI Capabilities

- Materials and Components
 - Materials testing in high-pressure H₂ at variable temperature
 - Customized testing on metals and non-metals
 - Weld research and development
 - Full-scale component testing in H₂
- Systems Engineering
 - Full-scale H₂ station breadboard for system optimization
 - Real world equipment evaluation and innovation platform

Status

- Assessing HyReF (full-scale component testing and H₂ station breadboard) planned for 2015

Sandia National Laboratories | NREL | Hydrogen Fueling Infrastructure Research Station Technology

出典 : 2014.6.19 DOE Annual Merit Review Plenary

H2FIRSTの活動 : NREL (National Renewable Energy Lab.)

Accomplishment: Supporting Capabilities – ESIF & DERTF Testing & Analysis Focus 



Energy Systems Integration Facility

Distributed Energy Resources Test Facility

Capabilities

- On-site hydrogen generation (electrolyzers)
- High pressure component testing
- Flexible, renewable-ready hydrogen energy storage platform
- Advanced hydrogen sensor testing
- 700-bar and 350-bar (nom) dispensing
- Research Electrical Distribution Bus (REDB) capability for grid integration
- Physical and photo-electrochemical material characterization
- Systems integration & device under test platforms

Research Station Status

- 700-bar research station construction for basic system architecture started and expected completion in July 2014



12 Photo credit: NREL (April 2014)

出典 : 2014.6.19 DOE Annual Merit Review Plenary

米国：各州の取り組み

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

Several states have major hydrogen and fuel cell programs underway.

5/29/2014: 8 states approve Action Plan to put 3.3M zero-emission vehicles on roads by 2025

States include California, Connecticut, Massachusetts, Maryland, New York, Oregon, Rhode Island, & Vermont

- Represents a new vehicle market penetration of ~15%


Northeast (e.g. MA, NY, CT)


Preliminary Plans:

H2 coalitions established in CT & MA

Initial-stage meetings held with several states (CT, MA, NY, RI) to develop action plans to deploy FCEVs -- incl. LDVs and MD & HD bus and truck fleets.

3 H2 stations in Boston metro by CYE 2014 -- assessing federal properties for siting new H2 stations using FULs





California

Fuel Cell Electric Vehicles (FCEVs) and Fuel Cell Buses (FCBs)

- > 560 vehicles in operation since 1999 — ~230 currently operating
- > 6 million miles driven
- > 1 million passengers on fuel cell buses


H₂ Station Investment

- \$51.5M invested (CARB and CEC)
- ~\$13M invested by SCAQMD
- ~\$46.6M for 28 stations and 1 mobile refueler (CEC PON 13-607)
- \$20M planned annually thru 2023 for at least 100 stations (AB8)

Hawaii

Agreement signed by 12 stakeholders—including GM, utilities, H2 providers, DOD, DOE—to establish hydrogen as a major part of the solution to Hawaii's energy challenges.

- **15 GM FCEVs** currently in demonstrations with military
- Renewable hydrogen (from wind and geothermal energy) used for buses on Big Island
- Goals include a multi-site public access refueling infrastructure by 2020 to support initial deployments of FCEV and FCB fleets
- Completed Fort Armstrong feasibility study to create H2 fueling station in downtown Honolulu on GSA property.



出典：2014.6.19 DOE Annual Merit Review Plenary



米国の動向

カリフォルニア州の取り組み

米国/カリフォルニア : CaFCP (California Fuel Cell Partnership)

(Phase3は2012で終了)



期間	1999～2012年
参加メーカー・機関	34社
参加自動車メーカー	8社
参加車両(累積)	225台(内バス13台)
水素ステーション数	33基(内20基計画中)
総走行距離	500万マイル以上

注) Ford は、2009年2月、メンバー脱退



出典 : 2013.7.26 山梨県自動車販売店協会講演資料 (山梨大 丹下先生)

米国/カリフォルニア：実証⇒商用化フェーズへの移行

CaFCPは Road Map（導入シナリオ）作成が主要業務と変化

State Initiatives -California U.S. DEPARTMENT OF ENERGY Energy Efficiency & Renewable Energy



A CALIFORNIA ROAD MAP
Bringing Hydrogen Fuel Cell Electric Vehicles to the Golden State
COMMERCIAL LAUNCH OF FCEVS
CONNECTIONS
RESOURCES
IN STATIONS
CALL CENTER

FCEVs and Fuel Cell Buses

- > 560 vehicles in operation since 1999 — ~230 currently operating
- > 5 million miles driven
- > 1 million passengers on fuel cell buses



H2 Station Investment

- 20 stations — including planned/funded
- ~\$34M invested (CARB and CEC)
- \$5.5M invested by SCAQMD
- ~\$29M available (CEC solicitation closed)
- \$20M for 2013/14 (CEC)



<http://cafcp.org/stationmap>

14 | Fuel Cell Technologies Office eere.energy.gov

出典：2013.6.24-26 International Workshop on Hydrogen Infrastructure and Transportation

米国/カリフォルニア : 水素ステーション導入シナリオ (CaFCP Road Map)

既設または建設・計画中的水素ステーション



Station	Current Status
Beverly Hills	Planned – 2013
Burbank	Operational
Diamond Bar	Upgrade (2013)
Emeryville	Operational
Fountain Valley	Operational
Harbor City	Planned – 2012
Hawthorne	Planned – 2013
Hermosa Beach	Planned – 2013
Irvine #2	Planned – 2013
Irvine #1	Upgrade (2012)

Station	Current Status
Laguna Niguel	Planned – 2013
Los Angeles	Planned – 2012
Newport Beach	Operational
San Francisco	Planned – 2012
Santa Monica	Planned – 2013
Torrance	Operational
West Los Angeles #2	Planned – 2013
West Los Angeles #1	Operational
West Sacramento	Planned – 2013

現時点で58か所（建設中含む）
商用は4か所

FCV市場拡大・展開に基づく水素ステーションの展開プラン

Year	Start of Year (Station Total) ¹⁰	Added Stations ¹¹	Number of FCEVs in CA ¹²
2012	4	4	312
2013	8	9	430
2014	17	20	1,389
2015	37	31	5,000-15,000
2016	68	Market Needs	10,000-30,000
2017	>84	Market Needs	53,000
2018	>100	Market Needs	>53,000

出典 : CaFCP HP – A California Road Map (Overview)

米国/カリフォルニア : CaFCPの様々な活動

Safety, Codes and Standards

- J2601 (FCEVs) and TIR J2601/2 (FCEBs)
- NFPA 2- Hydrogen Technologies Code
- International Fire Code → California Fire Code
- CSA HGV 4-series (station components and systems)
- CDFA DMS - metering+ quality
- ISO/TC 197- new WG 24 for hydrogen stations plus other station component WGs (compressors, dispensers)

Support harmonization with
International SC&S development

First Responder Education

- Focus on early market communities
- Thousands of first responders reached in California
 - Fire department acceptance helps community acceptance
 - AHJ education advances permitting process
- Lesson learned: repeat often, high turnover/transfers between departments and regions
- CaFCP program foundation of developing National outline



SOSS

- Provide customers with “real time” station status
- Improvements - more functionality, sustainable
- Important during early launch period
- More stations as they open



Permit Workshops

- Program developed with NREL and other stakeholders
- Provide education and real world experience BEFORE they receive their first permit applications
 - Review existing hydrogen related codes and regulations
 - Review real HRS permit applications - hands-on
 - Increase comfort & knowledge of fuel and application
- Expanded approach - April 14th “Leaders Workshop”, followed by multiple local permit workshops.



出典 : 2014.5.12 CaFCP/CEC-HySUT Meeting

米国/カリフォルニア : 現在の水素ステーションProfiles / Map

Prof.: <http://cafc.org/toolkits/stations>
 Map: <http://cafc.org/stationmap>

Hydrogen Fueling Station | Burbank September 2012

Station Information
 Address: 440 W. Orange Avenue
 Burbank, CA 91502
 Station Status: Open to public
 Hours of Operation: 24/7
 H2 Provider: Air
 Fuel Pressure: 5,000/10,000 psi
 Supply Capacity: 100 kg/day
 Fueling Up to 10 cars/day
 Fuel Price: Contract
 Operations Contact: Hydrogen Frontier
 440 Orange Blvd, Suite 2
 Burbank, CA 91502
 Website: Hydrogen Frontier
 Open to Public: March 2008 (2nd gen.)



Hydrogen Fueling Station | Emeryville - AC Transit September 2012

Station Information
 Address: 1500 14th St.
 Emeryville, CA 94608
 Station Status: Open to public
 Hours of Operation: 24/7
 H2 Provider: Air
 Fuel Pressure: 5,000/10,000 psi
 Supply Capacity: 22 kg/day (2000 psi max)
 Fueling Up to 20 cars/day
 Fuel Price: Contract
 Operations Contact: AC Transit
 1500 14th Street, Emeryville, CA 94608
 Website: AC Transit
 Open to Public: April 2012

Hydrogen Supply/Equipment
 • Designed by: Air Products
 • Installed by: Air Products
 • Maintained by: Air Products




Hydrogen Fueling Station | Harbor City - Mebtahi September 2012

Station Information
 Address: 202815 Western Ave.
 Harbor City, CA 90710
 Station Status: PUBLIC
 Hours of Operation: 24/7
 H2 Provider: Air
 Fuel Pressure: 5,000/10,000 psi
 Supply Capacity: 100 kg/day
 Fueling Up to 20 cars/day
 Fuel Price: Contract
 Operations Contact: Mebtahi Station Services
 202815 Western Ave, Harbor City, CA 90710
 Website: Mebtahi - Torrance Coastal Cities
 Open to Public: April 2012

Hydrogen Supply/Equipment
 • Designed by: Air Products
 • Installed by: Air Products
 • Maintained by: Air Products

Station Contact
 Site of Sharetech
 Alameda Station/Hub
 2028 Western Ave.
 Harbor City, CA 90710
 415-421-4248
 alameda@sharetech.com

Funding/Financing
 Total: \$2.5 million
 Govt: \$88 - \$1.7 million (68/4/19)
 Private/Coast share: Capital Investments Group
 Public funding period: April 1, 2011-March 30, 2014

Other Station Details
 • Land Owner: Mebtahi
 • Funding agreement required




Hydrogen Fueling Station | Torrance - Shell September 2012

Station Information
 Address: 2621 W. 189th Street
 Torrance, CA 90501
 Station Status: Open to public

Hydrogen Fueling Station | Newport Beach - Shell September 2012

Station Information
 Address: 1401 S. Broadway Blvd
 Newport Beach, CA 92660
 Station Status: Open to public
 Hours of Operation: 24/7

Funding/Financing
 Total: \$463,271
 Govt: \$240,000
 Private/Coast share: Air Products
 Toyota - Land owner
 Public funding period: Three years

Other Station Details
 • Funding agreement required
 • Location has a consistently learning center






米国/カリフォルニア : CEC (California Energy Commission) ⇒商用化に向け、州政府として様々なサポート



CALIFORNIA ENERGY COMMISSION

California Policy Support for Hydrogen Station Development

Legislative Funding and Policy Support

- AB 8 Reauthorization: \$20 million per year with goal of developing 100 station network

Governor's Office Support

- Hydrogen stations and fuel cell vehicles integral part of ZEV Mandate and ZEV Action Plan:
 - Support 1.5 M ZEVs by 2025
- GoBiz and Office of Planning and Research Support

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出典 : 2014.5.12 CaFCP/CEC-HySUT Meeting

米国/カリフォルニア：CECを中心とした活動



CALIFORNIA ENERGY COMMISSION

California Policy Support for Hydrogen Station Development

California Air Resources Board

- Initial Hydrogen Highway Funding
- Part of ZEV Regulation compliance strategy
- Low Carbon Fuel Standard credits available

California Department of Food and Agriculture: Division of Measurement Standards

- Development of regulations and standards to allow for retail sale of hydrogen as a motor fuel

South Coast AQMD

- Co-funded initial California hydrogen stations through DOE Technology Validation Program

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出典：2014.5.12 CaFCP/CEC-HySUT Meeting

米国/カリフォルニア：補助金の概要



CALIFORNIA ENERGY COMMISSION

Hydrogen Station Funding

Funding to Date = \$90 million

Public Station Funding

45 New Stations	= \$72.7 million
3 Station Upgrades	= \$6.7 million
4 Station O&M Grants	= \$1.2 million
1 Mobile Refueler	= \$0.9 million



Other Funding Activities

AC Transit Fuel Cell Bus Station	= \$3 million
CDFA Div of Weights and Measures	= \$4 million
Retail Dispensing Fuel Standards	
UC Irvine STREET Model	= \$1.5 million
<u>GoBiz</u> Ombudsman Support	

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出典：2014.5.12 CaFCP/CEC-HySUT Meeting

米国/カリフォルニア：補助金の概要



CALIFORNIA ENERGY COMMISSION

H2 Station Grant Summary

日本の商用HRSの
1/3~1/2程度の規模

Developer	No. of Stations	Technology and Type	Capacity (kg/day)	100% Renewable H2
First Element	17	Delivered H2	180	
	2	Delivered H2	180	Yes
Air Products	10	Delivered H2	180	
Linde	7	Delivered Liquid H2	350	
Air Liquide	1	Delivered H2	180	
	1	Delivered H2	180	Yes
HyGen	3	On-Site Electrolyzer	130	Yes
ITM	2	Electrolyzer + Delivery	100	Yes
Ontario CNG	1	On-Site Electrolyzer	136	
HTEC	1	Electrolyzer + Delivery	135	

45HRSsの内訳

出典：2014.5.12 CaFCP/CEC-HySUT Meeting

米国/カリフォルニア：計量 CDFAが中心となって活動 California Department of Food & Agriculture

Station Testing



CDFA DMS Hydrogen Field Standard



What is one of the primary goals?



出典：2014.5.12 CaFCP/CEC-HySUT Meeting

米国/カリフォルニア：品質

CDFAが中心となって活動
California Department
of Food & Agriculture

Current Hydrogen Fuel Quality Standards

Title 4. Business Regulations

Division 9. Division of Measurement Standards, Department of Food and Agriculture

Chapter 6. Automotive Products Specifications

Article 8. Specifications for Hydrogen Gas Used in Internal Combustion Engines
and Fuel Cells

§ 4181. Specifications - Hydrogen Fuel Used in Internal Combustion Engines and Fuel Cells. Hydrogen fuel used in internal combustion engines and fuel cells shall meet the most recent version of SAE International J2719, "Hydrogen Fuel Quality for Fuel Cell Vehicles".

Purchased 2 Hydrogen Quality Sampling adapters from GTI
to follow ASTM D7606.



出典：2014.5.12 CaFCP/CEC-HySUT Meeting

HRS Location in South California (LA area)



LA-Santa Monica Blvd. HRS (LA)

4か所ある商用HRSの1つ
(クレジットカードで支払い可能)

カードル水素
SS隣接タイプ
運用：APCI



水素ステーション全景



Santa Monica HRS (LA)

現在、機器の最終調整&検定中
来年早々にOpen?

カードル水素
SS隣接タイプ
運用：APCI



水素ステーション全景

