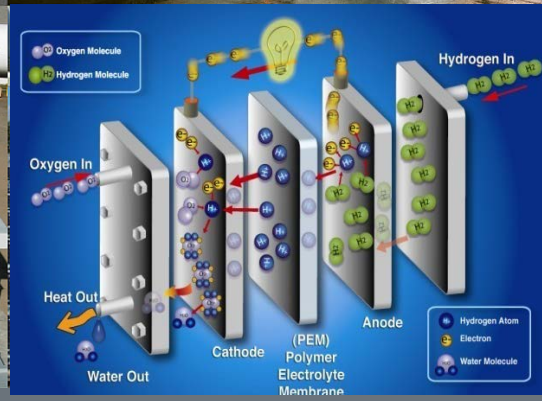
Hydrogen Fueling for Current and Anticipated FCEVs

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

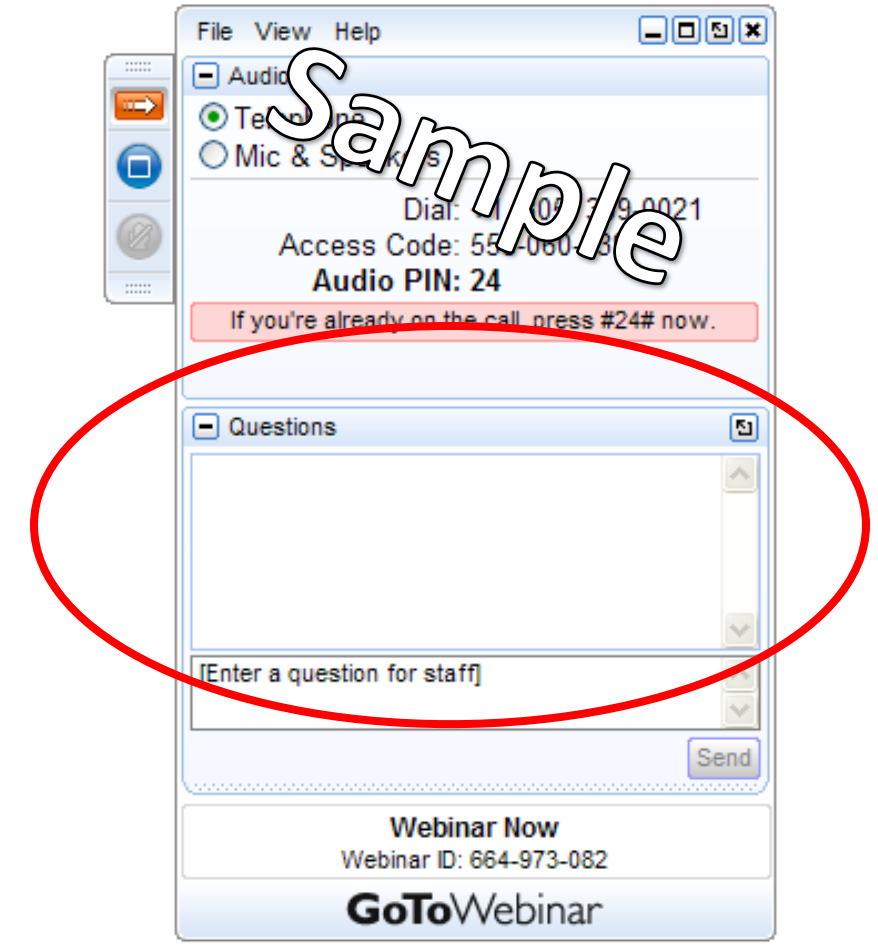


Jason Marcinkoski

U.S. Department of Energy
Fuel Cell Technologies Office

Question and Answer

- Please type your question into the question box



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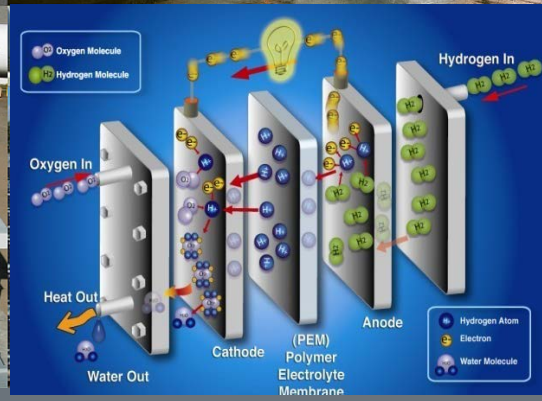


Jason Marcinkoski

U.S. Department of Energy
Fuel Cell Technologies Office

Alternative and Renewable Fuel and Vehicle Technology Program

Hydrogen Refueling Station Selection under PON-13-607

U.S. Department of Energy

June 24, 2014

Sarah Williams

Energy Commission Specialist I

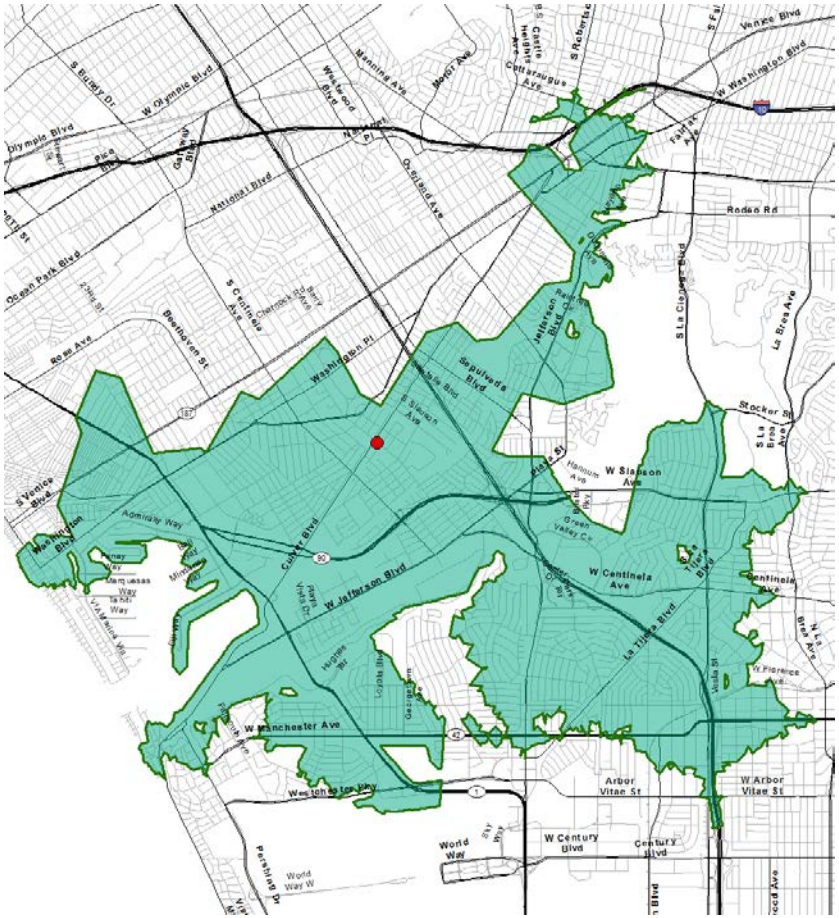
Solicitation Development

- Stakeholder interviews conducted.
- Pre-solicitation public workshops held.
- Draft solicitation concepts released.
- Final solicitation released.

Selected Solicitation Elements

- Specific “Station Location Areas” identified.
- Min. 33% renewable H2 required; more encouraged.
- Projects incentivized for early completion.
- Min. 6-minute drive time between stations.
- 60% single applicant cap.

Sample Station Location Area



Evaluation Process

- Proposals evaluated against scoring criteria.
- Disqualifications determined:
  - Achieves 21 points min. under “Qualifications”
  - 1 station per Station Location Area
  - 6-minute drive time
  - Single applicant cap
- Funding recommendations finalized.

Evaluation Criteria

• Qualifications	30 points
• Market Viability	90 points
• Project Readiness	40 points
• Project Implementation	40 points
• Project Budget	40 points
• Economic Benefits	20 points
• Performance	70 points
• Innovation	20 points
• Sustainability	30 points
Total possible points:	***380***
Min. passing score:	***266 (70%)***

Competitions under PON-13-607

1. Operation and Maintenance Support Grants
2. 100% Renewable Hydrogen Refueling Stations ($3,150,000)
3. Mobile Refuelers ($1,000,000)
4. Station Location Areas (all remaining funds)
5. Unassigned Stations (all remaining funds)

Operation and Maintenance Support Grants

- Provides up to $100,000 per year for up to 3 years.
- Existing, planned, or newly proposed publicly accessible hydrogen refueling stations in California eligible.
- All applications expected to be awarded.
- Stations incentivized for early operational date.

100% Renewable Hydrogen Refueling Stations

- Must dispense 100% renewable hydrogen.
- Max funding per station: $3,150,000.
- Min. match share requirement: 10%
- ~$2.9 million recommended for funding for 2 stations.

Mobile Refueler

- Provides back up refueling to support network.
- Deployed statewide.
- May be used for FCV demos and other events.
- Max. funding per mobile refueler: $1,000,000
- Min. match share: 20%
- ~$1 million recommended for funding for one mobile refueler.

Station Location Area Competition

- Provides capital expense grant funding for stations within or assigned to a station location area.
- Max. funding per station: $2,125,000
- Min. match share requirement: 15%
- $40.5 million recommended for funding for 25 stations.
- Includes 3 additional stations dispensing 100% renewable hydrogen.

Unassigned Station Competition

- Funds hydrogen refueling stations which are ***not*** within or assigned to a station location area.
- Max. funding per station: $2,125,000
- Min. match share requirement: 15%
- ~$2.1 million recommended for funding for 1 station located in Ontario, CA.

Current Status

- Notice of Proposed Awards (NOPA) released May 1, 2014.
- NOPA recommends ~$46.6 million for 28 stations plus 1 mobile refueler.
- Agreements currently under development for approval.
- Solicitation documents available at:

www.energy.ca.gov/contracts/transportation.html#PON-13-607

Recommended Awards

- ***FirstElement Fuel, Inc.*** (19 stations): 7 San Francisco Bay Area, 9 Greater Los Angeles Area, Truckee, Coalinga, and San Diego
- ***Hygen Industries LLC.*** (3 stations): Rohnert Park, Pacific Palisades, Orange
- ***Linde LLC.*** (2 stations): Oakland, San Ramon
- ***Air Liquide LLC.*** (1 station): Palo Alto
- ***ITM Power Inc.*** (1 station): Riverside
- ***Hydrogen Technology & Energy Corp.*** (1 station): Woodside
- ***Ontario CNG Station Inc.*** (1 station): Ontario
- ***Gas Technology Institute***: Mobile Refueler

Existing Stations – Northern California

- Emeryville – AC Transit, Linde Equipment Electrolyzer powered by solar/PV electricity. Hydrogen from the electrolyzer is supplemented with commercially supplied hydrogen delivered by truck to the holding tanks.

Existing Stations – Southern California

- Burbank
- West LA
- Torrance
- Los Angeles-Harbor City
- Fountain Valley
- UC Irvine
- Newport Beach
- Thousand Palms-Sunline Transit

Planned Stations – Northern California

- West Sacramento – Linde – 9/2014
- Mountain View – Linde – 6/2015
- Foster City – Linde – 6/2015
- Cupertino – Linde – 6/2015

May 2014

Northern CA Hydrogen Stations

Open

Emeryville – AC Transit

In Development

Cupertino
Foster City
Mountain View
*West Sacramento

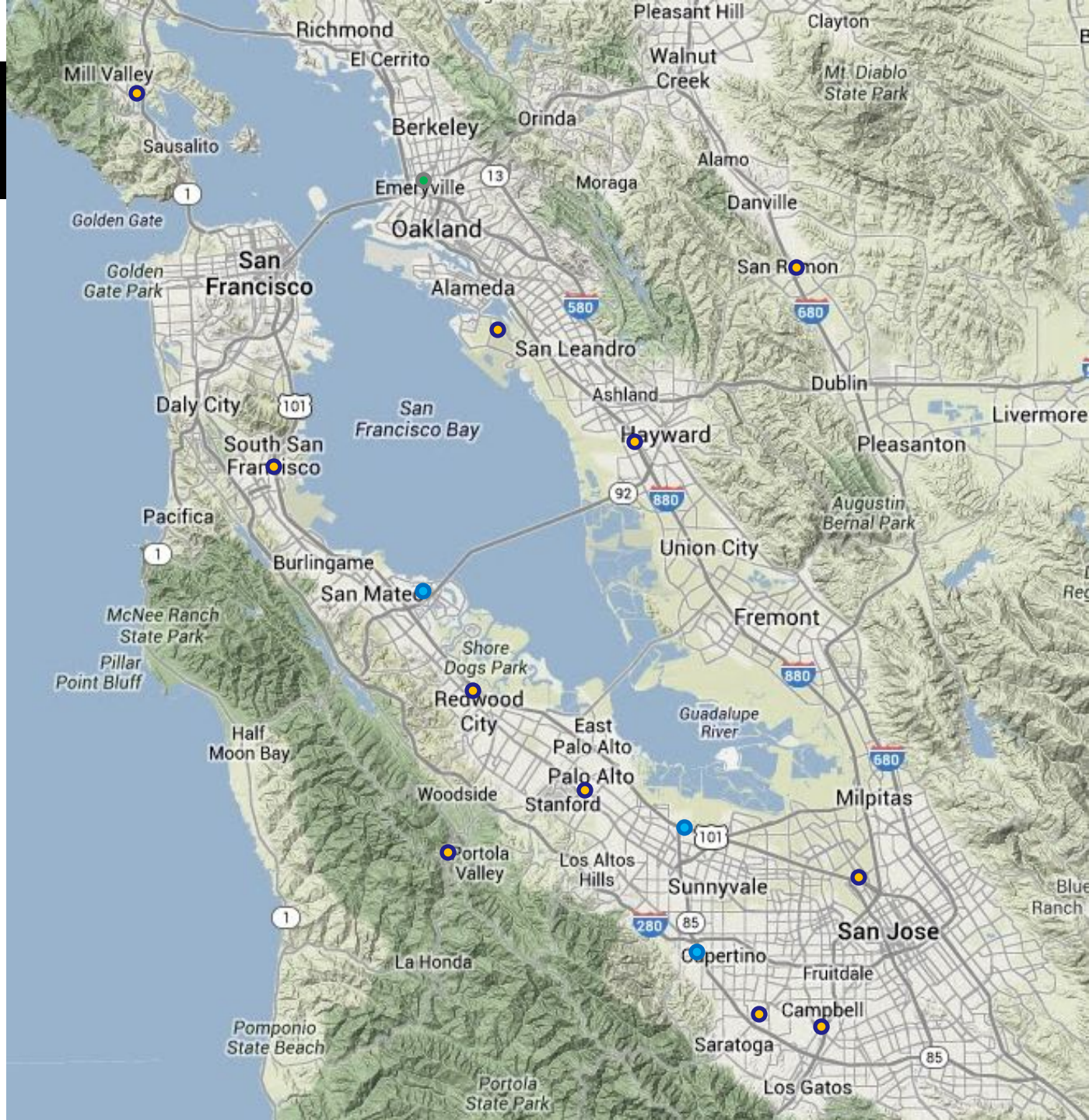
NOPA

Campbell
Hayward
Mill Valley
Oakland
Palo Alto
Redwood City
*Rohnert Park
San Jose
San Ramon
Saratoga
South San Francisco
*Truckee
Woodside

*Not shown on map

California Fuel Cell Partnership
DRIVING FOR THE FUTURE

Managed by BKi



Planned Stations – Southern California

- Beverly Hills – APCI – 10/2014
- Santa Monica – APCI – 12/2014
- Lawndale – APCI – 12/2014
- Redondo Beach – APCI – 12/2014
- Irvine North – APCI – 12/2014
- Diamond Bar – APCI – 7/2014
- San Juan Capistrano – Linde – 11/2014
- Mission Viejo – APCI – 10/2014
- Woodland Hills – APCI – 10/2014
- Chino – Hydrogen Frontier – 10/2014
- Anaheim – Air Liquide – 9/2014

Southern CA Hydrogen Stations

Open

- Burbank
- Fountain Valley – OCSD
- Irvine – UC Irvine
- Los Angeles - Harbor City
- Los Angeles - West LA 1
- Newport Beach – Shell
- *Thousand Palms – SunLine Transit
- Torrance – Shell

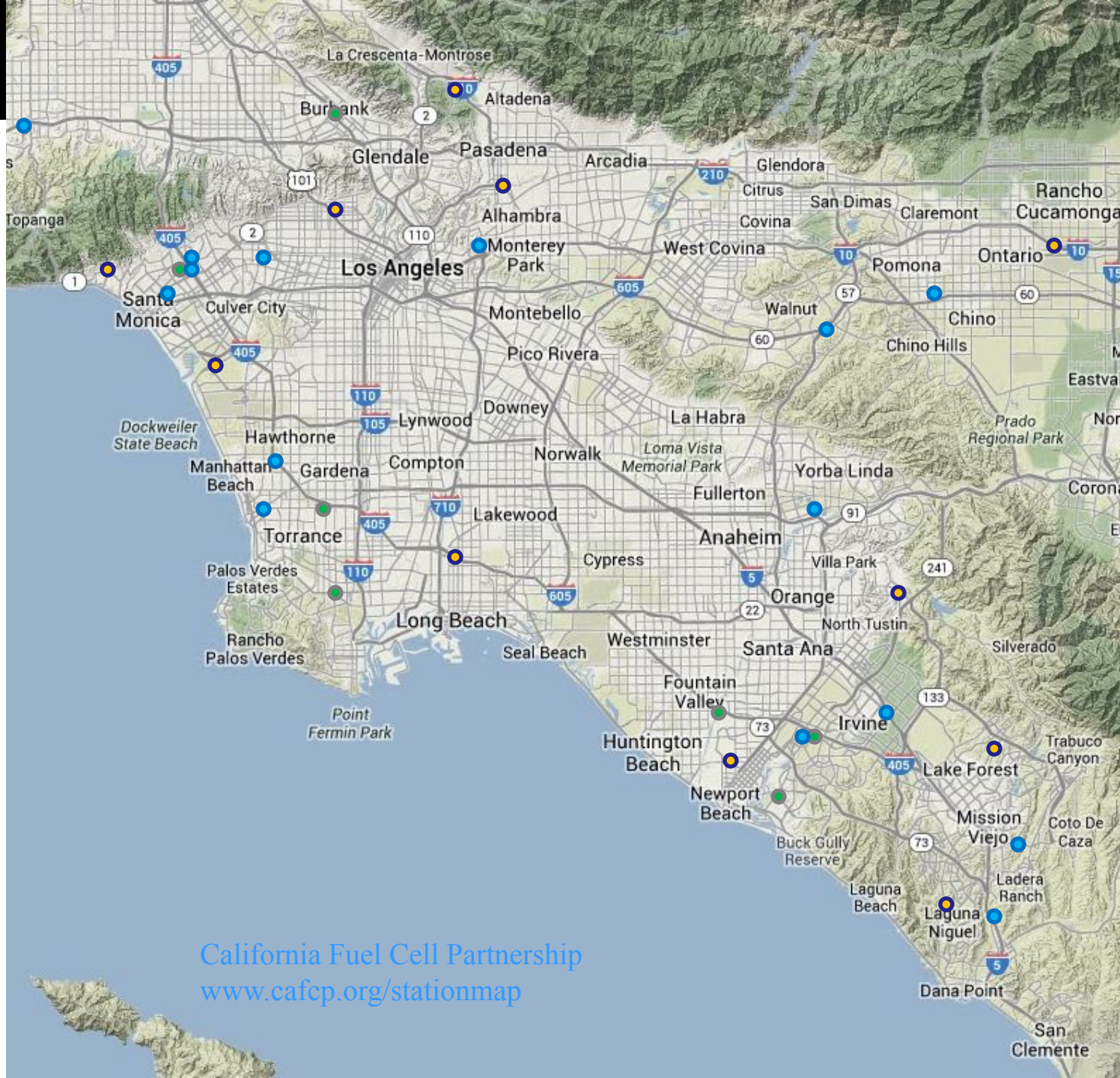
In Development

- Anaheim
- Chino (upgrade)
- Diamond Bar (upgrade)
- Irvine - UC Irvine (upgrade)
- Irvine - Walnut Ave.
- Lawndale
- Los Angeles – Cal State LA
- Los Angeles - West LA 2
- Los Angeles – Westwood
- Los Angeles - Woodland Hills
- Los Angeles - Beverly Blvd.
- Mission Viejo
- Redondo Beach
- San Juan Capistrano
- Santa Monica 1

NOPA

- *Coalinga
- Costa Mesa
- La Canada Flintridge
- Laguna Niguel
- Lake Forest
- Long Beach
- Los Angeles - 9
- Los Angeles -10
- Ontario
- Orange
- Pacific Palisades
- *Riverside
- *San Diego
- *Santa Barbara
- South Pasadena

**Not shown on map*



California Fuel Cell Partnership
www.cafcp.org/stationmap

*Overview and Launch of JOBS H2**

(JOBS and economic impacts of Hydrogen)

* Developed with the support of DOE's Office of Fuel Cell Technologies

Marianne Mintz and Jerry Gillette, Argonne

Catherine Mertes and Eric Stewart, RCF

June 24, 2014

RCF Economic & Financial Consulting, Inc.

Argonne NATIONAL LABORATORY

Agenda/Outline

- Overview of JOBS H2
  - Approach
  - Metrics
  - Illustrative results
  - Sensitivities
- User resources
- Next steps
- Open discussion (Q&A)

Overview

Why JOBS H2?

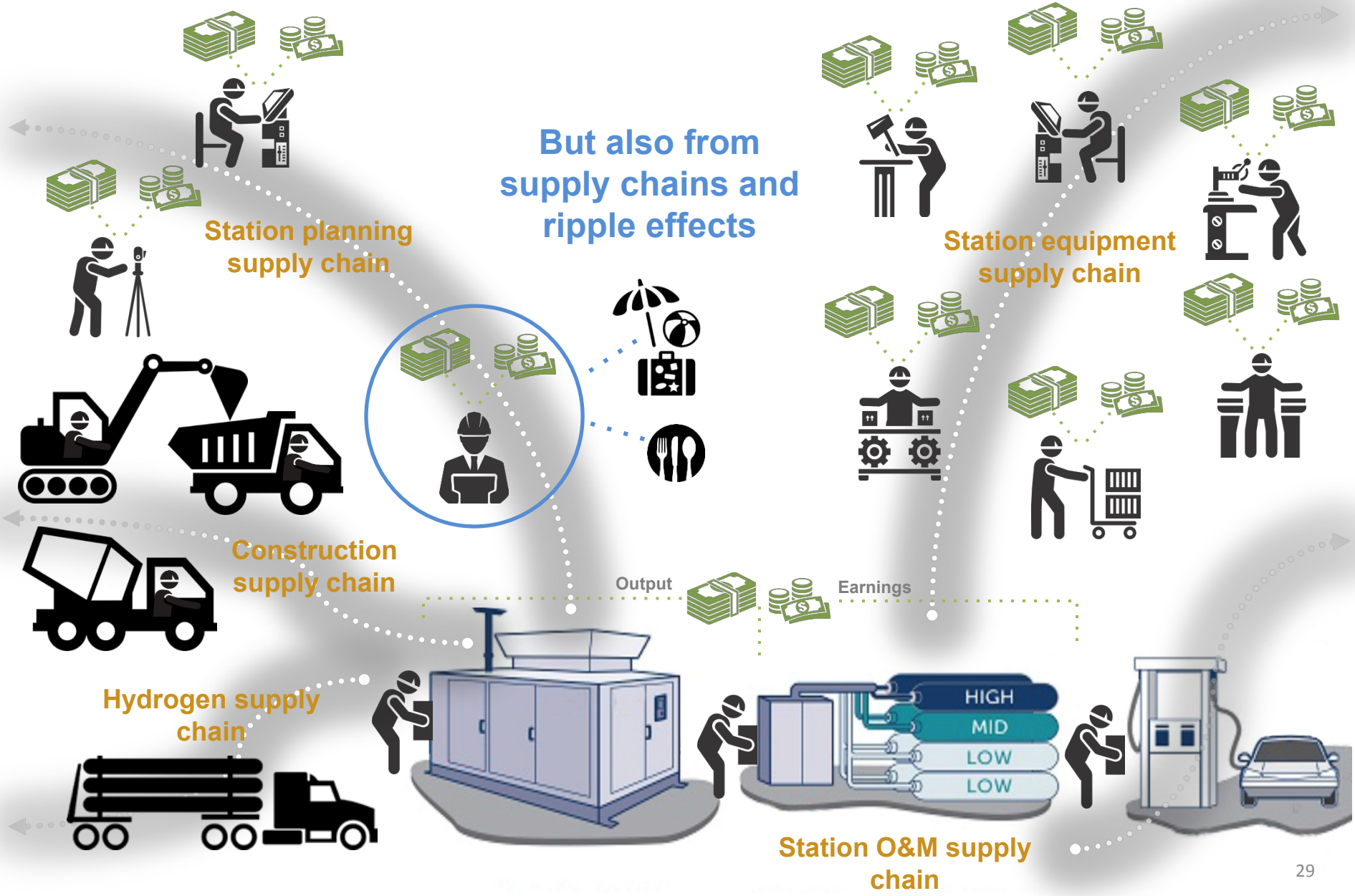
- Provide consistent platform to analyze employment and other economic impacts of hydrogen (H2) infrastructure investments
- Analyze fuel cell and infrastructure deployment
  - For particular programs/projects or scenarios
  - To provide input for R&D priorities
- Support stakeholders

What is JOBS H2?

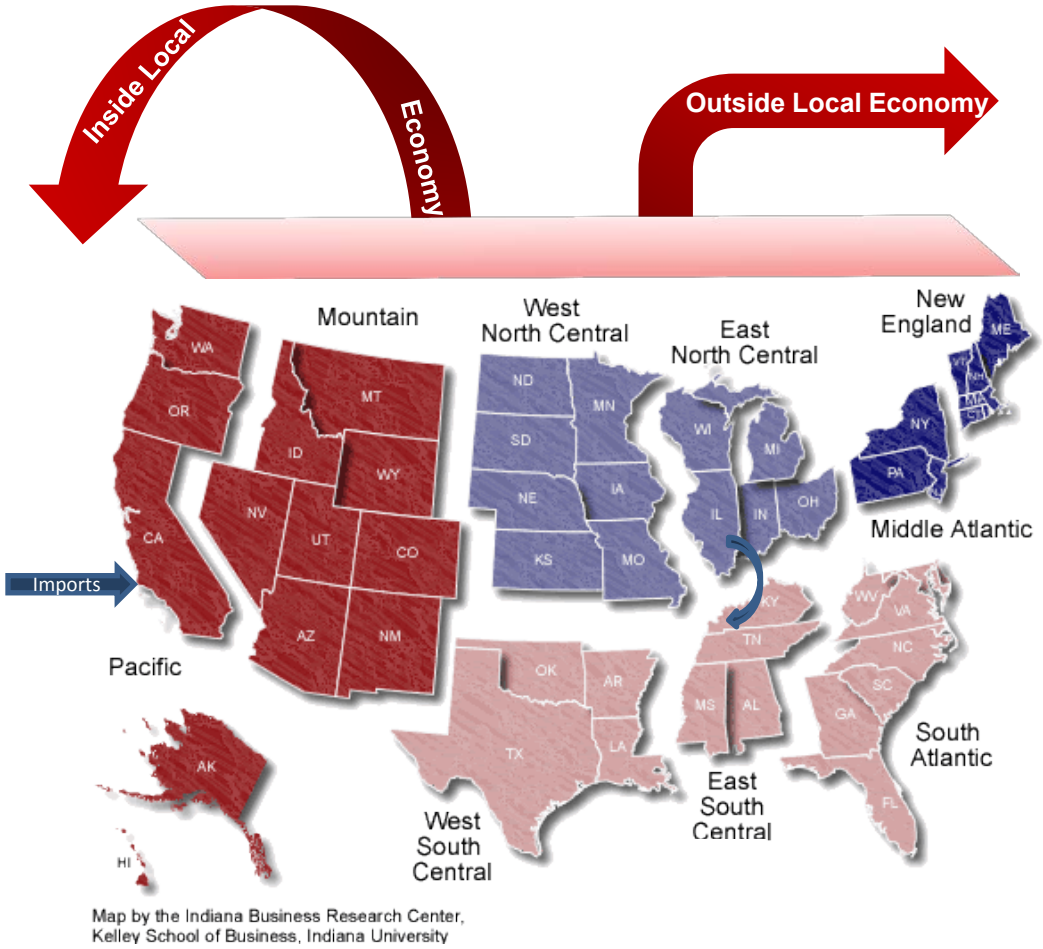
- JOBS and economic impacts of Hydrogen (JOBS H2) is a spreadsheet-based tool to estimate economic impact of user-defined scenarios
- Models economic impact via supply chains & induced effects
- Can be run with default values or user inputs
- Uses input-output methodology to convert dollars spent into economic impacts using relationships from USDOC/BEA Regional Input-output Modeling System (RIMS)

Jobs are created from equipment production/installation, station construction, and fuel supply chains (direct + indirect jobs) as well as from ripple effects (induced jobs).

H_2 stations create jobs not only on site



JOBS H2 facilitates regional analyses



Map by the Indiana Business Research Center, Kelley School of Business, Indiana University

- RIMS multipliers for 60 different geographies reflect variations in overall size & composition.
- In-region or local shares (LS) of expenditures account for variations in sourcing H2 fuel, equipment, and station development expenses.
- Site prep, installation, O&M and retailing have > LS.
- H2 fuel, permitting, station design/engineering, equipment production have < LS.

Jobs occur where expenditures occur. High LS of station development & operation expenditures create most jobs.

JOBS H2 user interface defines scenarios

Step 1 - Station Capacity				
Notes: Please enter a value for the maximum total station capacity. This entry impacts various default station expenses and other values used in the model.				
Category	***User-specified value***	**Default**	**Notes**	**Value used in model**
Maximum total station capacity (kg/day)		200	Default station expenses and other model values based on 100-400 kg/day	200

Step 2 - Project Development Timeframe				
Notes: Please enter the number of years station development expenditures are incurred.				
Category	***User-specified value***	**Default**	**Notes**	**Value used in model**
Project development timeframe		2	Value can be 1 or 2 years.	2

Step 3 - Number of New Stations Completed Each Year			
Notes: Please enter the number of new stations which will be completed by the end of the given year. (Example: If two stations will begin construction in 2013 but will be completed in 2014, please enter "2" in the cell corresponding to 2014.)			
Year	***User-specified value***	**Notes**	**Value used in model**
2014		The current total per station development expense including pre-construction development, construction, installation, equipment, and shipping expenses in 2014$ is: **$2,145,600**	-
2015	25		25
2016	25		25
2017	25		25
2018	25		25
2019	25		25
2020	25		25

STATION DEVELOPMENT RELATED EXPENSES

All dollar values are in 2014$. All user-specified entries must be entered in 2014$.

Step 4a - Station Equipment Expenses (uninstalled) and Quantities						
Notes: In this step specify the expenditure and quantity for each equipment category. To enter detailed information on the Dispenser, please use the "Dispenser-INPUTS" sheet. Equipment expenses are in 2014$ and should not include the costs for shipping and installation. Shipping expenses can be specified in Step 4b. Installation and other station development expenses can be specified in Step 5. If per unit expenses or quantites are specified in Step 4a, these entries will supercede Total Equipment Expense values in Step 4 for that piece of equipment.						
Equipment Category	**Equipment Expense ($/unit)**	**Equipment Quantity (units/station)**	**Equipment Expense ($/unit)**	**Equipment Quantity (units/station)**	**Equipment Expense ($/unit)**	**Equipment Quantity (units/station)**
	User-specified value	***User-specified value***	**Default**	**Default**	**Value used in model**	**Value used in model**
Dispenser	$85,200		$85,200	1	$85,200	1
Refrigeration System			$115,700	1	$115,700	1
Compressor			$189,300	3	$189,300	3
Electrical Equipment		1	$139,100	1	$139,100	1
Cascade		1	$210,300	1	$210,300	1

INFO | USER GUIDE | DISCUSSION OF DEFAULT VALUES | START | **Station Development-INPUTS** | Dispenser-INPUTS | Stations Dev

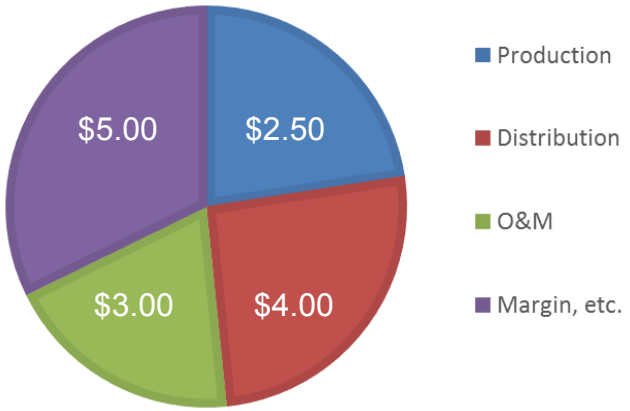
Illustrative scenario demonstrates model capabilities

Illustrative Scenario Inputs

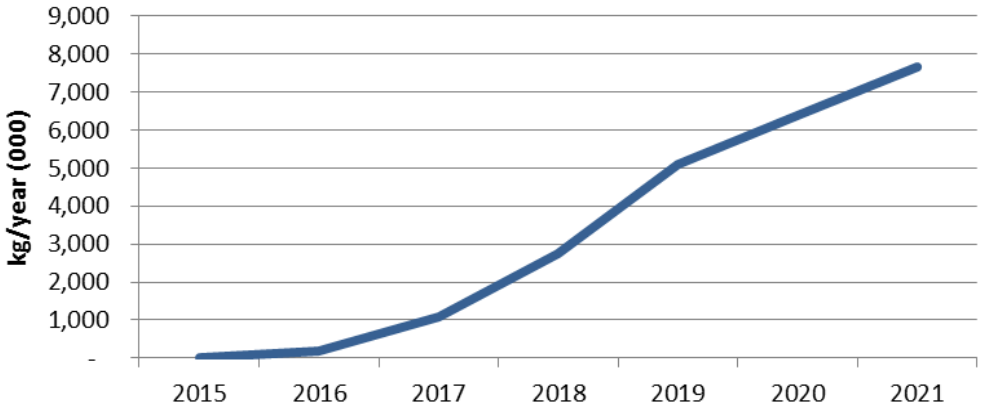
Region = US	New 200 kg/d stations completed	Stations in operation	Utilization (%)	Local share (LS)* of expenditures
2015	25		--	100
2016	25	25	10	100
2017	25	50	30	100
2018	25	75	50	100
2019	25	100	70	100
2020	25	125	70	100
2021	--	150	70	100

*Excluding 700-bar dispenser nozzles, all of which are assumed to be imported.

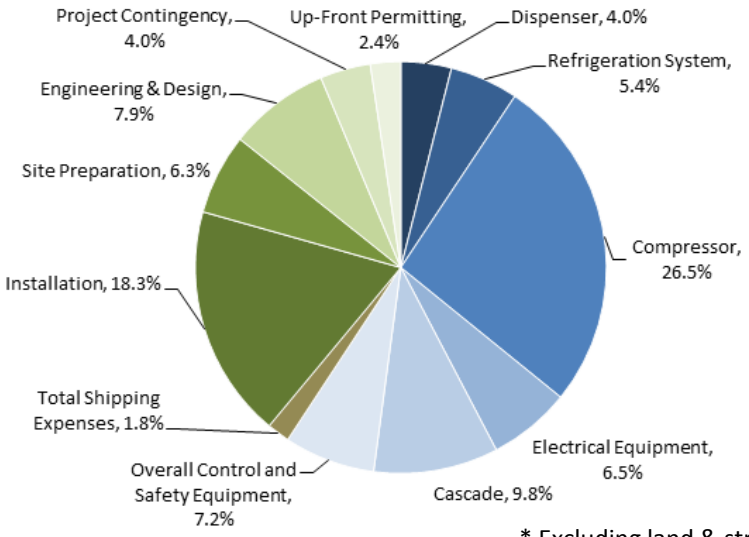
Hydrogen retail price



Resulting H2 fuel sales

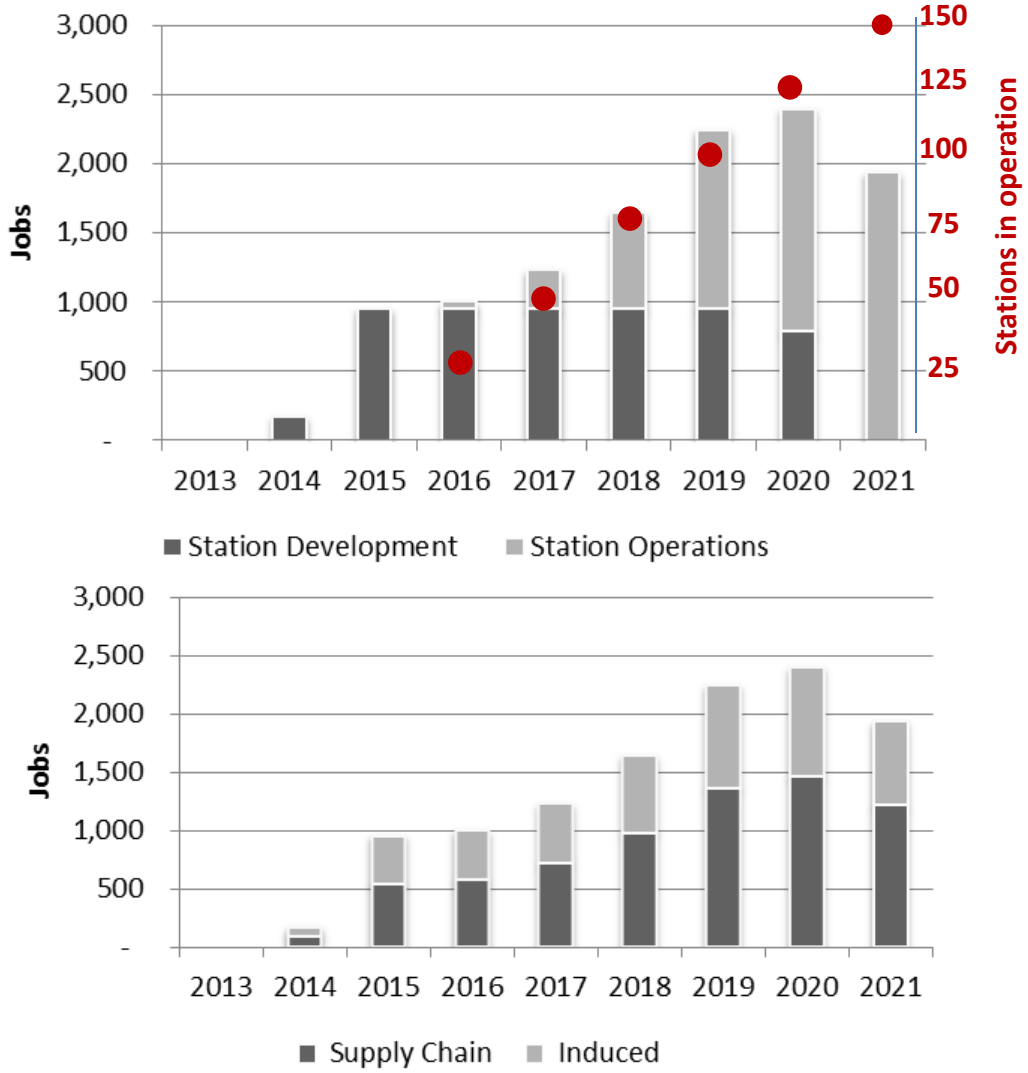


Total Station Expenditures ($2.1m)*



* Excluding land & structures.

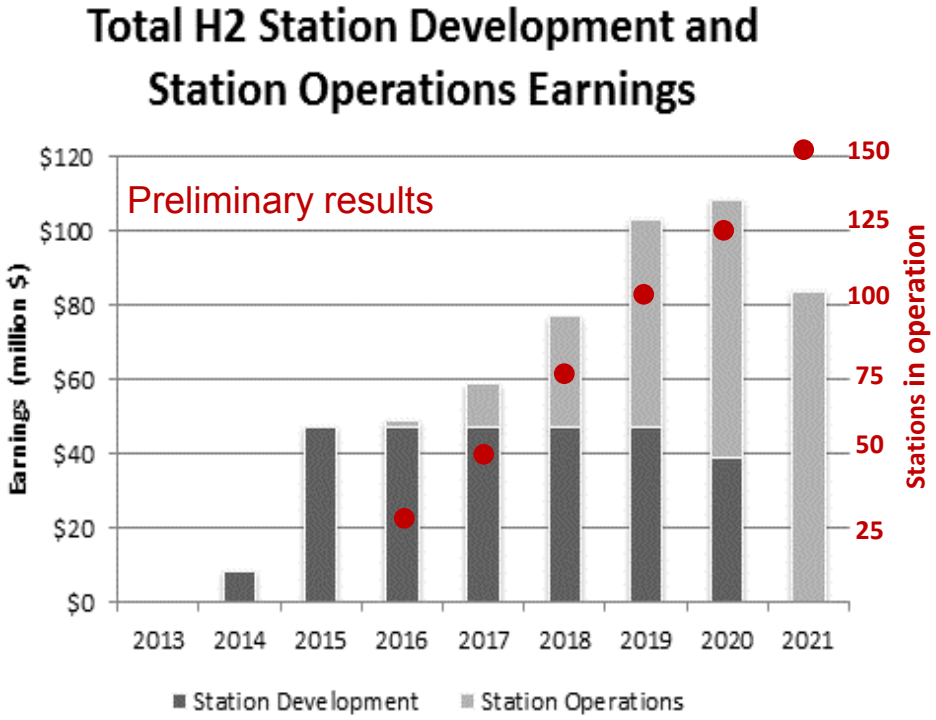
In illustrative scenario, initial jobs come from station development, then from station operation

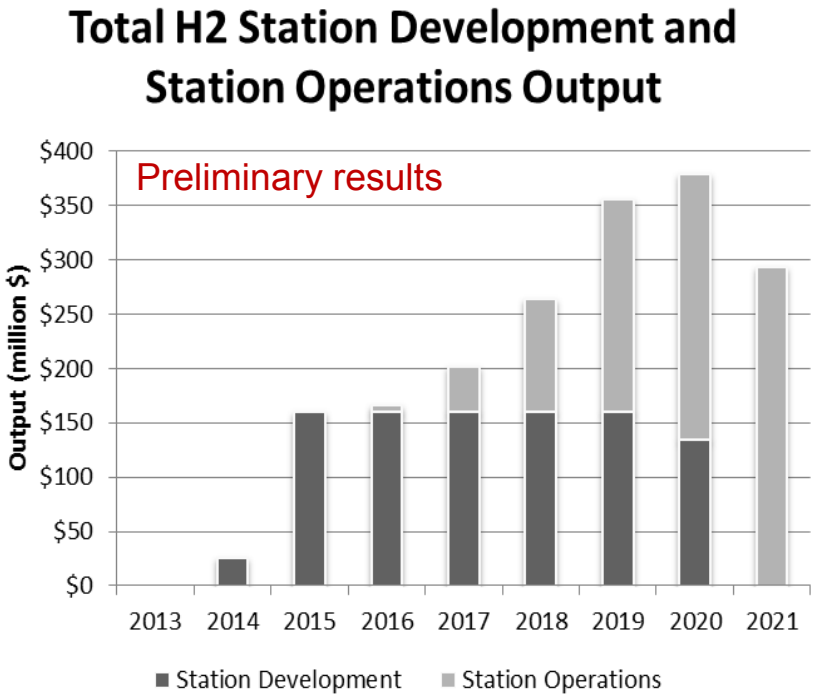


- Developing 25 stations/year results in ~1000 jobs/year for planning, construction, equipment production, installation, etc.
- Total jobs peak at ~2400 when last stations are completed
- Nearly 2000 jobs associated with operating 150 stations continue indefinitely
- Induced jobs account for ~40% of total in pre-operation, somewhat less during operation

Earnings and output in illustrative scenario show a similar pattern

- Earnings grow to over $100 million in the final year of station completion (2020)
- Gross output grows to over $375 million in 2020
- In the illustrative scenario all impacts associated with station operation continue at the same level beyond 2021





*Station development jobs are most sensitive to local share (LS) of expenditures**

Base case for sensitivity analysis:

- (100) 200 kg/day stations
- Census Region 5-South Atlantic
- Middle scenario (fewer stations, different region & years of operation than illustrative scenario)

Base Case (2080 jobs):

LS 100%: installation, site prep

50%: eqpt, contingencies, design/engineering

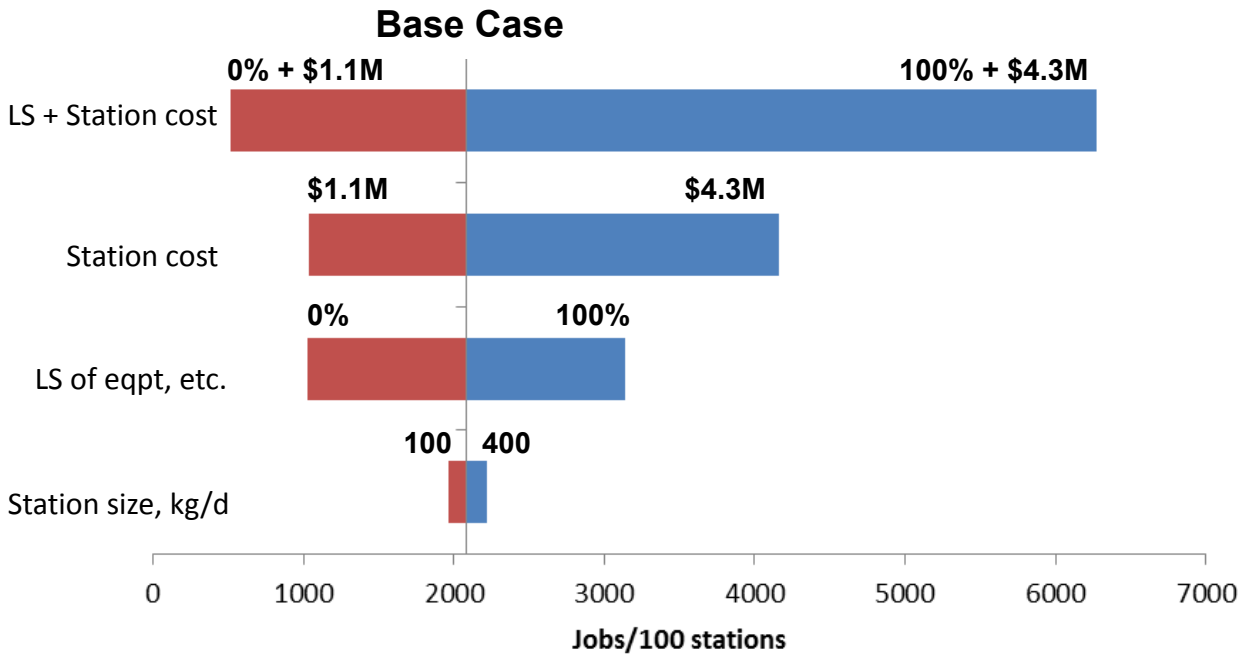
Station size: 200 kg/d

Station cost: $2.1M

Preliminary results

Station development jobs:

- 1-2 year duration
- Planning, construction, equipment production, installation supply chains + induced
- High local share and high cost put most $ into economy & create most jobs
- In JOBS H2, default 100 kg/d station costs nearly as much as 200 kg/d



LS = Share of expenditures to suppliers within region.

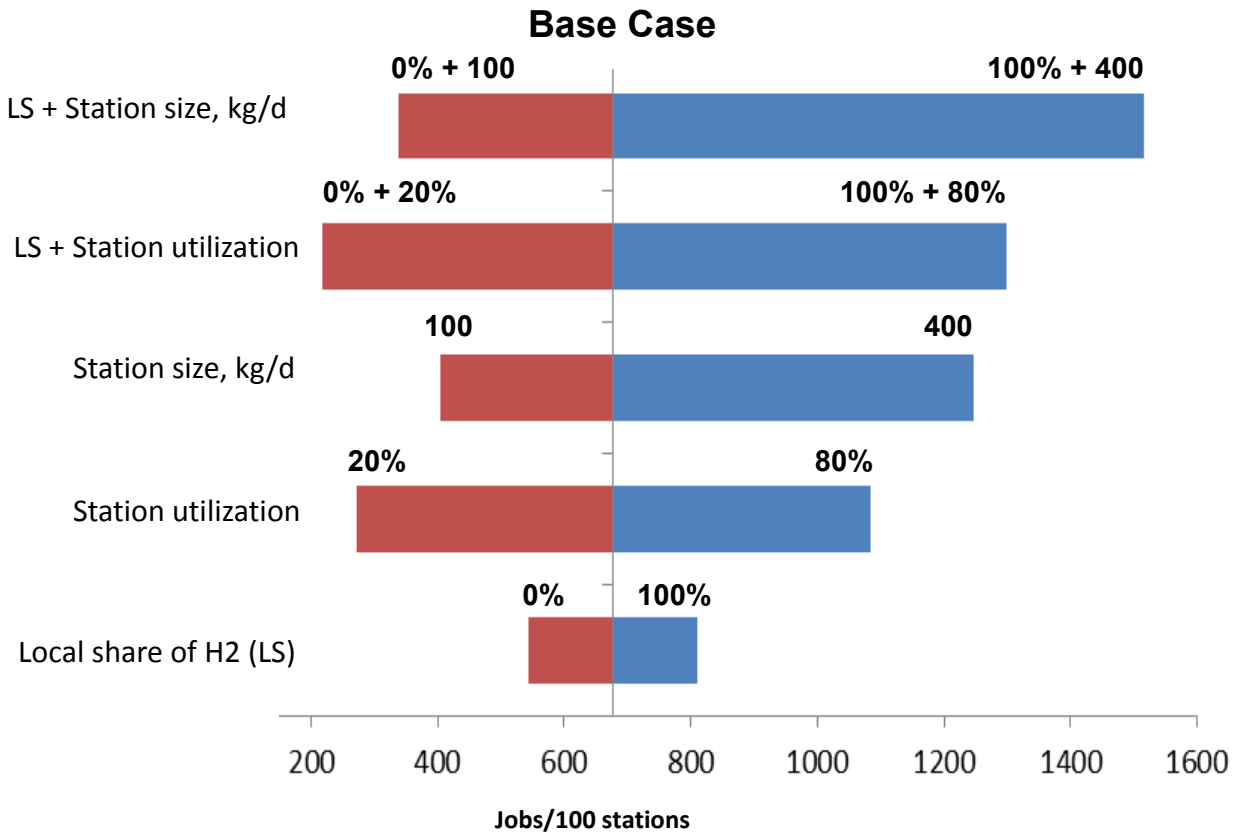
Station operation jobs are most sensitive to station throughput

Station operation jobs:

- Multi-year duration
- Associated with H2 production & delivery, station O&M supply chains + induced
- High throughput stations with high local share (LS) put most $ into local economy & create most jobs
- Less sensitive to local share because all cases assume local O&M expenses

Base Case (680 jobs):
LS 100%: O&M, retail
50%: H2
Station size: 200 kg/d
Station utilization: 50%

Preliminary results

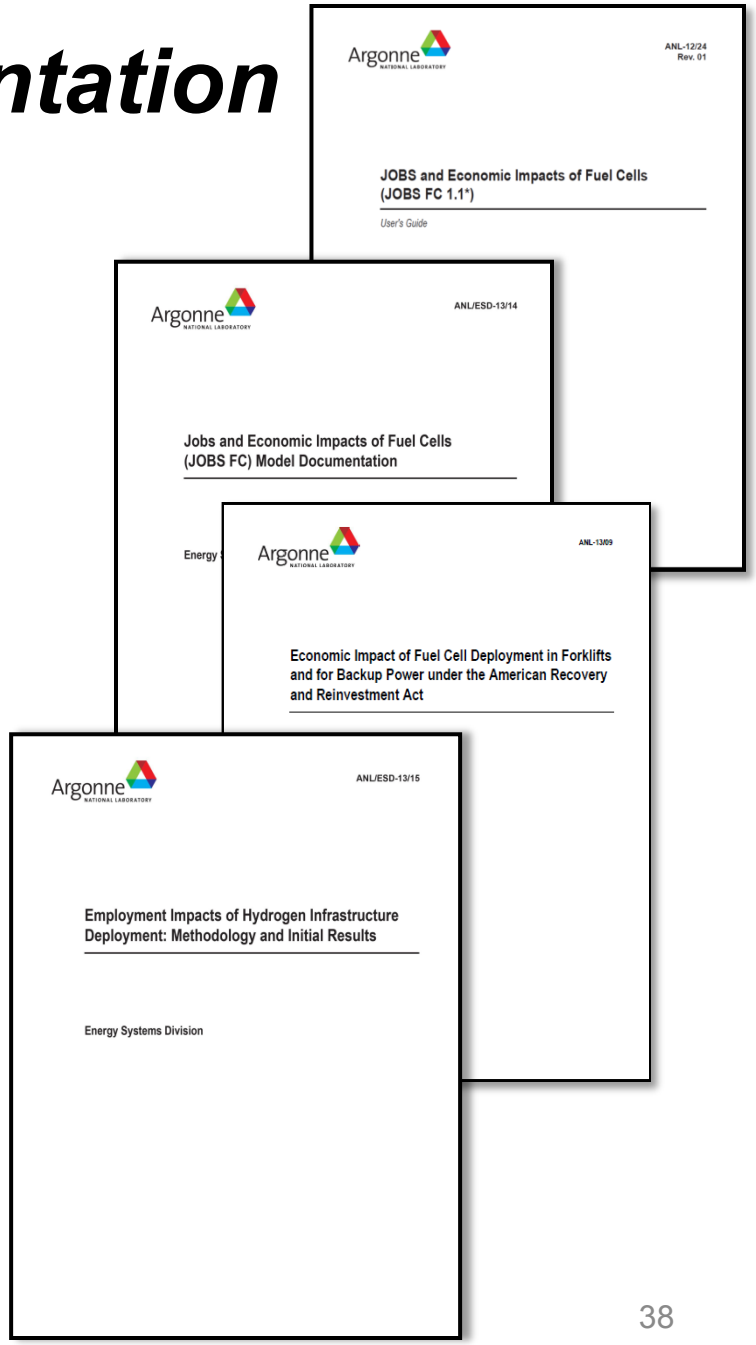


LS = Share of expenditures to suppliers within region.

User Resources

JOBS Reports & Documentation

- JOBS FC 1.1:
  - Users' Guide (ANL-12/24 Rev. 01)
  - Documentation (ANL/ESD-13/14)
  - ARRA analysis (ANL-1309)
  - EERE webinar 12/11/12 (http://www1.eere.energy.gov/hydrogenandfuelcells/webinar_archives_2012.html#date121112)
- JOBS H2 1.0:
  - Methodology (ANL/ESD-13/15)
  - EERE webinar 6/24/14
- http://JOBSFC.es.anl.gov website → http://jobsmodels.es.anl.gov



JOBSmodels site hosts JOBS H2 and JOBS FC

Argonne NATIONAL LABORATORY

Transportation Technology R&D Center

U.S. DEPARTMENT OF ENERGY

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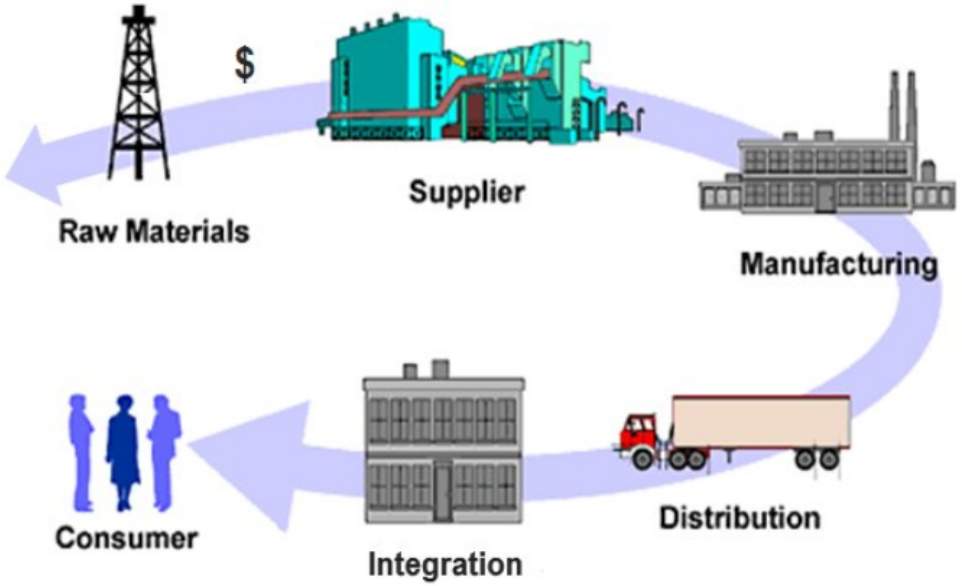
Argonne Home > Transportation Technology R & D Center > Modeling_simulation >

- Alternative Fuels
- Autonomie
- Batteries
- Engines
- Green Racing
- GREET
- Hybrid Electric Vehicles
- Hydrogen & Fuel Cells
- JOBS Models
  Publications
- Materials
- Modeling, Simulation & Software
- Plug-In Hybrid Electric Vehicles
- PSAT
- Smart Grid
- Student Competitions
- Transportation Research and Analysis Computing Center
- Working With Argonne
- Contact TTRDC

JOBSMODELS TRACK EXPENDITURE FLOWS

JOBS FC and JOBS H2 are spreadsheet-based tools that use anticipated dollar flows within an economy to estimate economic impacts. As goods and services required to deploy fuel cells and hydrogen infrastructure in a user-defined scenario are bought and sold, employment, earnings and economic output are produced which in turn generate additional employment, earnings and economic output.

As shown in the following illustration, as fuel cell or hydrogen infrastructure related production proceeds down the supply chain . (clockwise, from the extraction and supply of raw and finished materials, to the manufacture and assembly of components, to the distribution and integration of finished products) , expenditures flow up the chain (counterclockwise) to the respective economic sectors. Fuel cell and hydrogen infrastructure related expenditures include the purchase of the fuel cell and fueling infrastructure, energy and expenses associated with installing and operating the fuel cell and fueling infrastructure. As these dollars flow through the economy they provide jobs and income to individuals and establishments directly involved in the provision of fuel cells and hydrogen infrastructure (direct jobs), to individuals and establishments further up the supply chain (indirect jobs), and to an array of service and support industries whose growth is induced by the re-spending of those dollars in the economy (induced jobs).

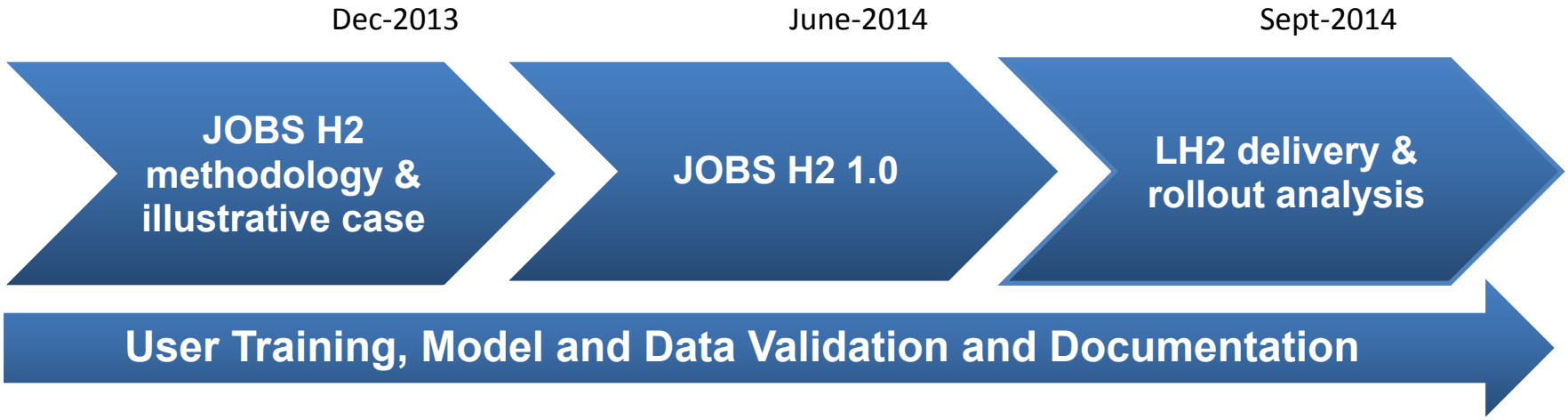


JOBSmodels also hosts resources

- User guides
  - print format
  - video format
- Publications/presentations
- Webinar presentations
- Webinar links

Next steps

JOBS H2 development and analysis

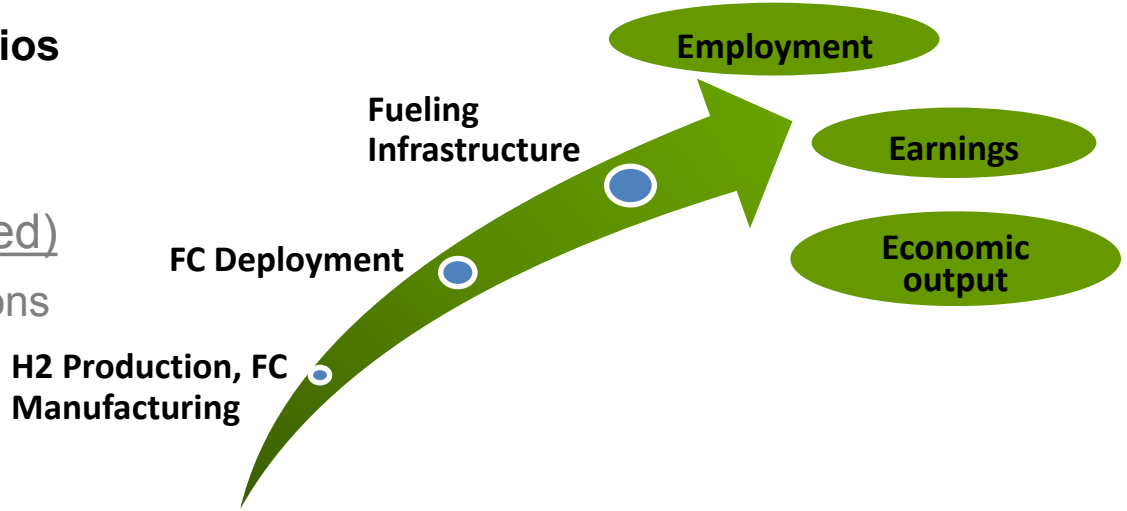


Planned model expansions/analyses:

- **LH2, 400+ kg/d**
- **Alternative rollout scenarios**
- **Uncertainty analysis**

Future possibilities (not funded)

- Novel station/pathway options
- Distributed H2 production
- FC applications in vehicles



Stakeholders provide key advice/expertise

JOBS H2 Advisory Group

- Public agencies
- Station developers
- H2 and FC industry
- Fuel suppliers
- Researchers

Assistance/role

- Defaults (data/analyses)
- Functionality/granularity
- Future directions/needs
- Beta testing
- Validation

Sample comments:

- *Downtime due to learning, availability of spare parts can be significant…*
- *Which parameters are results most sensitive to? How might that change with new technology?*
- *Installation costs can vary greatly from one station to another….*

Parameter	Stakeholder input (default)			
Stn size (kg/d)	100-400	(200)	multiple	500, 1000
Pressure (bar)	350	(700)	500 for trucks	
Analysis years	(2014-2021)	2014-2023		
Local shares (%)	(stn eqpt = 0) 0-100	(stn dvpmt = 0) 0-100	(H2 fuel = 0) 0-100	(O&M/other = 100) 0-100
Utilization (%)	(annual average)	(10, 30, 50, 70)	0-100	
Stn development	1 year	(2 years)	Part years	

() = JOBS H2 1.0 default xxx= not in JOBS H2 1.0

Summary

- JOBS models provide consistent platforms to analyze employment and economic impacts of alternative hydrogen and fuel cell investments.
- JOBS H2 is a free, downloadable spreadsheet model currently available at http://jobsmodels.es.anl.gov.
- Stakeholders have provided critical input and validation.
- Thanks to DOE's Fuel Cell Technologies Office for their continued support, to our stakeholder advisory group for their technical assistance, and to you for your attention.

mmintz@anl.gov

This work was supported by the Fuel Cell Technologies Office in the USDOE's Office of Energy Efficiency and Renewable Energy, under Contract DE-AC02-06CH11357. We thank Fred Joseck and Greg Kleen for their support.

Key metrics/definitions

- Economic output = Σ goods + services produced over time
- Earnings = Σ wages + salaries + proprietor's income over time
- Employment = Σ jobs held by workers over time (not census)
- Job = 1 year of work (FT or PT) for one person
- Supply chain jobs = direct jobs + indirect jobs
- Direct jobs = jobs directly involved in producing, shipping, installing equipment; station construction/pre-construction; station operation; fuel sales
- Indirect jobs = jobs that supply inputs to direct jobs
- Induced jobs = jobs associated with re-spending by supply chain job-holders
- Pre-operational jobs = limited-duration jobs associated with station construction and pre-construction
- Operational jobs = longer-duration jobs associated with station operation

Thank You

Jason.Marcinkoski@go.doe.gov

hydrogenandfuelcells.energy.gov