*Employment Impacts of Fuel Cell Deployment in Early Markets**

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Outline

- Overview of JOBS FC model (JOBS and economic impacts of Fuel Cells)
  - Approach
  - Functionality
- Employment impact of fuel cell deployment under American Recovery & Reinvestment Act (ARRA)

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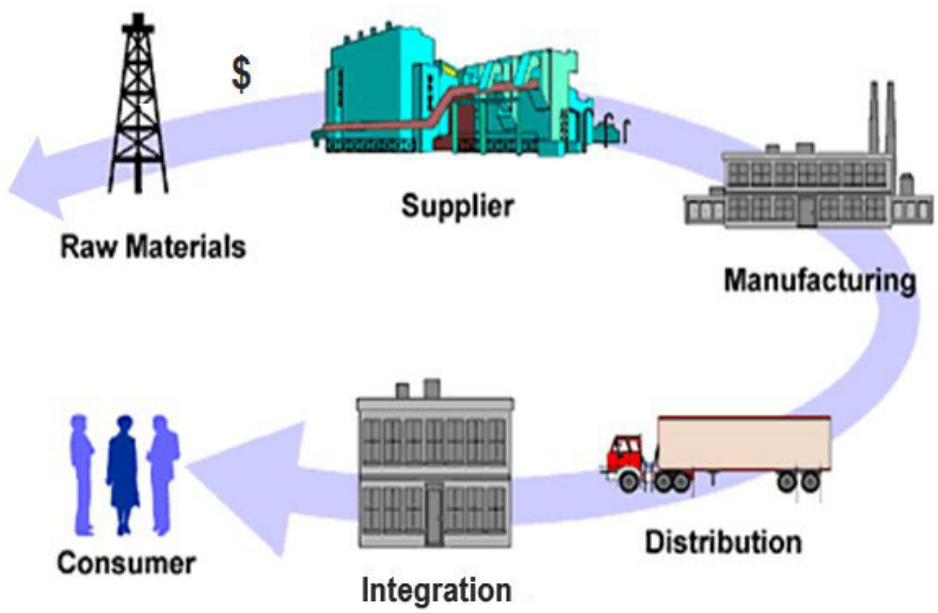
JOBS FC models input-output effects of FC deployment (JOBS and economic impacts of Fuel Cells)

- JOBS FC is a user-friendly **spreadsheet-based** tool that calculates direct, indirect and induced job creation, wages and sales resulting from FC production, installation, operation and fueling.
- JOBS FC uses Regional Input-Output Modeling System (RIMS II) **multipliers** to capture effect of expenditures on earnings, output and employment.
- JOBS FC models jobs created by 3 technologies, 3 applications, multiple FC capacities (**defaults or user input**).



Jobs are created at each stage in FC production, fuel infrastructure, O&M and fuel supply chains (**direct + indirect**) plus from re-spending dollars in economy (**induced**)

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JOBS FC models expenditure flows thru the supply chain

King, J. 2011, *Fuel Cell-Powered Lift Truck FedEx Freight Fleet Deployment*, DOE Annual Merit Review, 2011.

Courtesy of Ballard Power Systems.

- **Fuel Cell Application Cost Breakdown**
  - **FC Fueling**
    - Reforming
    - Fueling Equipment
    - Fuel Storage
  - **FC O&M**
    - Maintenance
    - Operating Labor
  - **FC Manufacturing**
    - Facility Cost
      - Building and Structures
        - materials
        - labor
        - equipment
      - Machinery and Tooling
      - Land
    - Production Costs
      - Stack
        - MEA
          - electrodes
          - electrolyte membrane
          - GDL
          - catalyst
          - labor
        - Bipolar Plates
        - End Plates
        - Tie rods
        - Current Collectors
        - Gaskets
        - Manifolds
        - Labor
      - BOP
      - System Assembly Labor
      - Utilities
      - General Expenses
    - Testing
  - **FC Shipping**
    - Packing
    - Modal Costs
      - Rail
      - Truck
    - Handling
  - **FC Installation**
    - Site Preparation
    - Infrastructure
      - Transportation Access
      - Utilities
      - Buildings
    - Electrical
      - On-Site Power
      - Grid Connection

Courtesy of BMW Manufacturing Co., LLC

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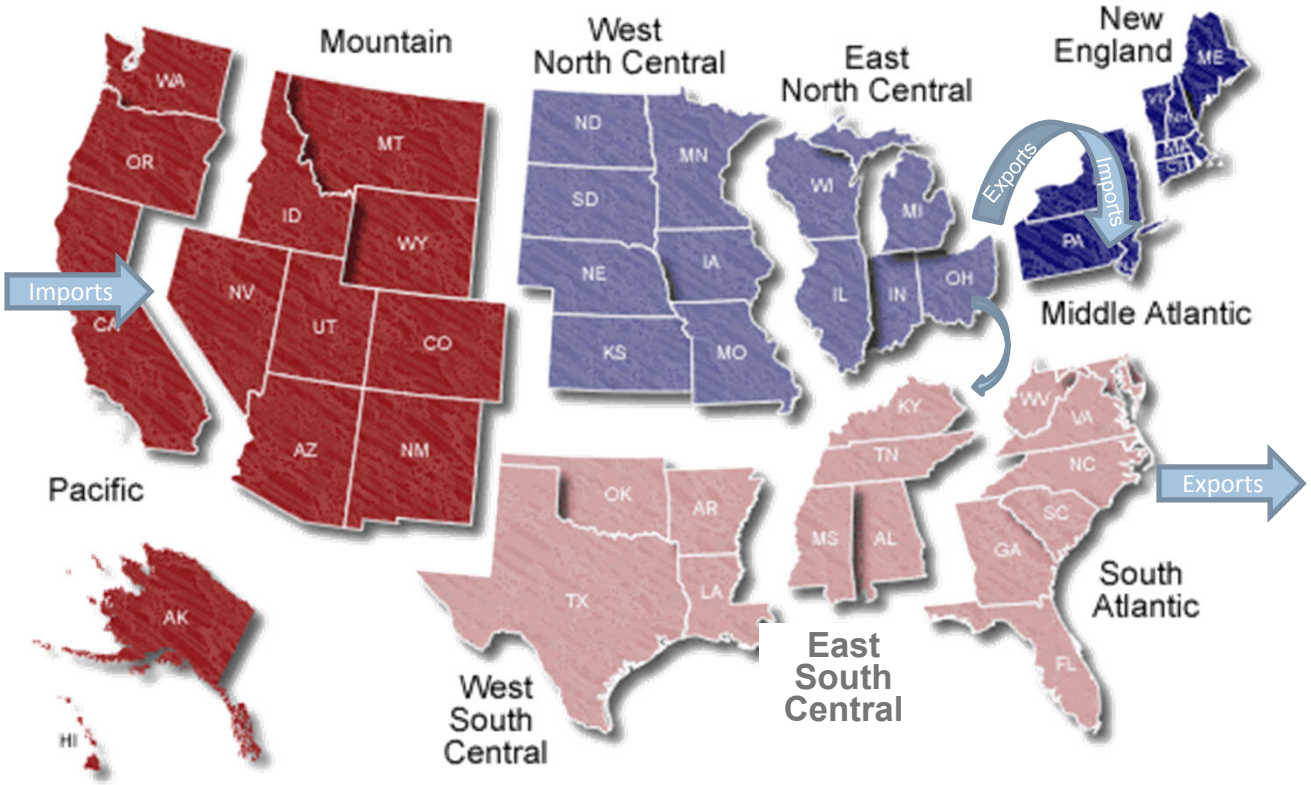
JOBS FC models expenditures for different geographies

Jobs occur where expenditures occur.
Domestic manufacturing, installation & use create the most jobs, but imports and exports also create jobs.



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

- JOBS FC uses **RIMS II multipliers** for 60 different geographies to account for geographic variation.
- Jobs are created from **imported** FCs installed and operated inside region (no manufacturing facility construction & FC production impacts occur).
- Jobs are created from **exported** FCs installed & operated outside region (no installation, O&M of FCs and fuel infrastructure & fuel purchase impacts occur).

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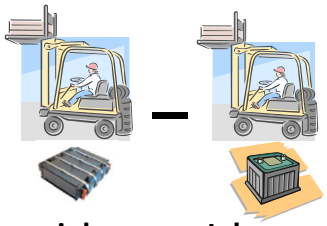
JOBS FC permits user to define scope of analysis & scenarios (with/without default assumptions)

Select Default Parameter	Forklifts		Backup Power	Prime Power	
	Class I/II	Class III		PAFC	MCFC
Capacity (kW)	10	2	5	400	1400
Fuel price (2010 $)	$8.50/kg		$30/kg	$9/mcf (NG)	
Operation	2496 hrs/yr		24 hrs/yr	90% CF	90% CF
Fuel use	0.25 kg H_2/op-hr	0.023 kg H_2/op-hr	0.065 kg H_2/op-hr	0.179 cfm NG/kW	0.13 cfm NG/kW
Displaced technology manufact'd. in US	65 % of batteries		42%, 65% (gensets, batteries)	Assume only electricity & heat (NG) displaced	

Scope of Analysis

- **Gross** or **net** effects
- **Net excludes jobs displaced** by FCs (unless FCs displace imports).
- Total net effects are sum of positive and negative values (gross jobs less displaced jobs).
- Metric = "**job year**" = one year of work for one person (e.g., 5 job years can be 5 years of work by 1 person, 1 year of work by 5 persons or any person year product equal to 5).



Gross job-years – **Job-years displaced** = **Net Job-Years**

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* * * BACKUP POWER FUEL CELLS (PEM) INPUTS * * *

RESET - CLEAR ALL USER-SPECIFIED VALUES

REQUIRED USER INPUT FIELDS

Step 1 - Choose Region and Analysis Type

Step 1a - Select State or Region	USA-National	
Step 1b - Gross or Net Analysis	Gross	Gross analysis available for all regions. Net analysis available only for national analysis.

Step 2 - Backup Power Fuel Cell Size and Usage Requirements

Enter Fuel Cell Size and Usage Requirements	*User-specified value*	Default	Notes	Value used in model
Backup power fuel cell unit size (average kW/unit)		5	Please enter a value between 0.5 kW and 15 kW	5
Average power load during operation (average kW)		3	Please enter a value less than the backup fuel cell unit size.	3
Hours of required run-time from on-site storage (hours)		48	Determines default installation costs and amount of stored H2	48
Annual backup run-time (total hours/year)		20	Backup run-time includes all outage-related usage in one year.	20
Annual testing run-time (total hours/year)		4	Testing run-time includes all periodic testing-related usage.	4

Step 3 - Backup Power Fuel Cell Units Manufactured, Exported and Imported for USA-National (Step 3a is available only for national analysis)

If only analyzing installations, please skip to Step 6 and enter number of installed fuel cell units in the Imported section (column G). Then proceed to Step 6.

Step 3a - Units or Market Penetration Approach	Selection will impact entries in Step 3c	
For fuel cells entered in 3c, select…NUMBER of backup power fuel cell units manufactured in region or PERCENTAGE of annual backup power shipments.	NUMBER of backup power fuel cell units manufactured in region	Estimated maximum potential annual national backup power market for telecommunications applications - 15,000-20,000 units/year (5 kW unit equivalents). Please see Market Forecasts sheet for estimated US Backup power shipments for telecommunications applications.

Step 3b - Export Units or Percentage	Selection will impact entries in Step 3c	
For fuel cells entered in 3c, select . . . NUMBER of fuel cell units exported out of region or PERCENTAGE of fuel cell units manufactured in region exported out of region.	PERCENTAGE of fuel cell units manufactured in region exported out of region	Exports are units manufactured in the USA but installed in a region outside of the USA. Imports are units manufactured outside the USA but installed in the USA. Installed units = Manufactured units - Exported units + Imported Units (see Results sheets).

Step 3c - Enter Backup Power Fuel Cells		Manufactured in region (units)	Exported out of region (% of manufacturing)	Imported into region (units only)	Manufactured in region (units)	Exported out of region (units)	Imported into region (units)
Backup Power	Year	*User-specified value*	*User-specified value*	*User-specified value*	Units used in model calculations		
5 kW Fuel Cells	2015	2,000	50%		2,000	1,000	-
	2016	4,000	50%		4,000	2,000	-
	2017	6,000	50%		6,000	3,000	-
	2018	8,000	50%		8,000	4,000	-
Manufactured, Imported, and Exported for USA-National	2019	10,000	50%		10,000	5,000	-
	2020	12,000	50%		12,000	6,000	-

Example 1

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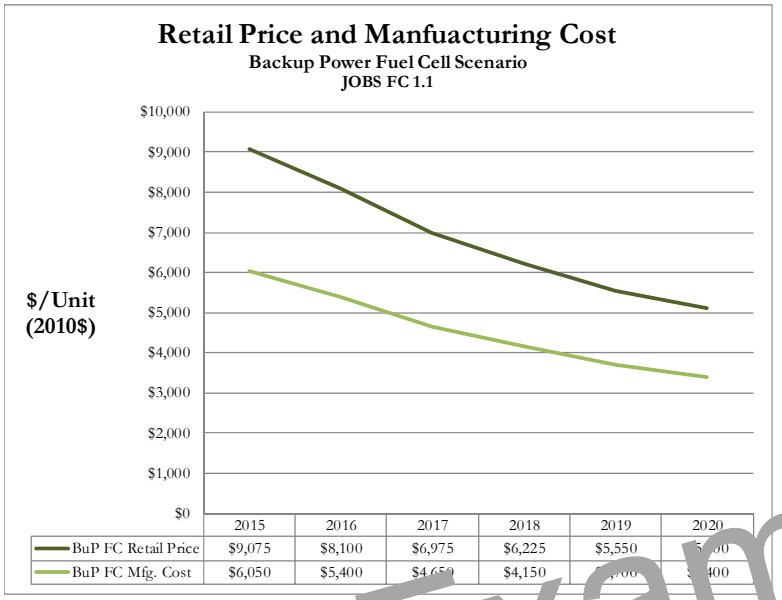

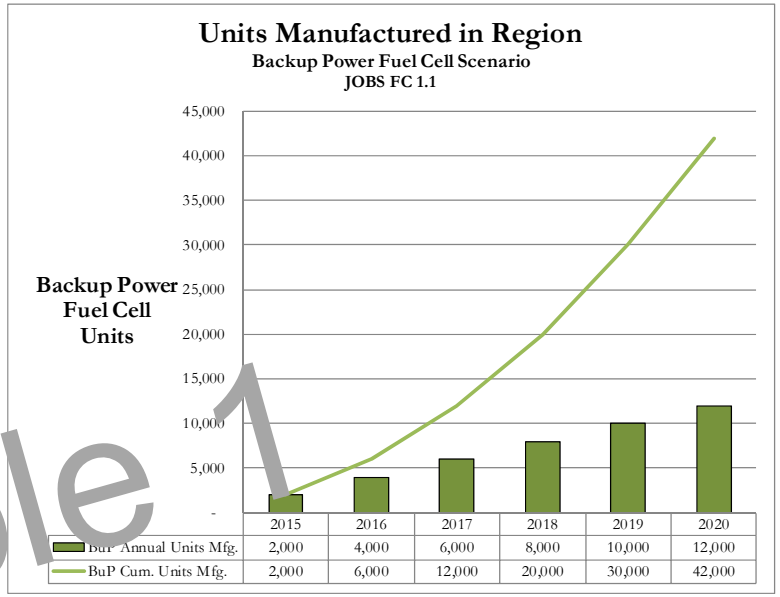

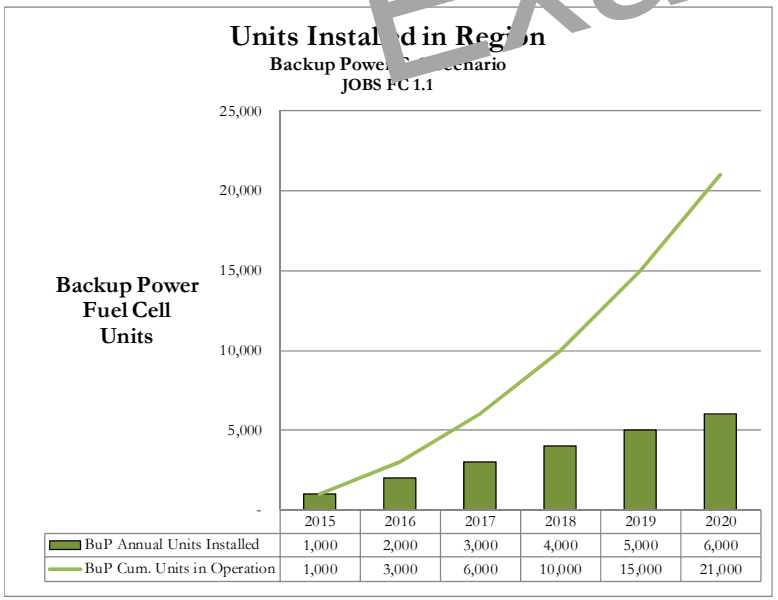

JOBS FC generates charts displaying scenario inputs

Example 1

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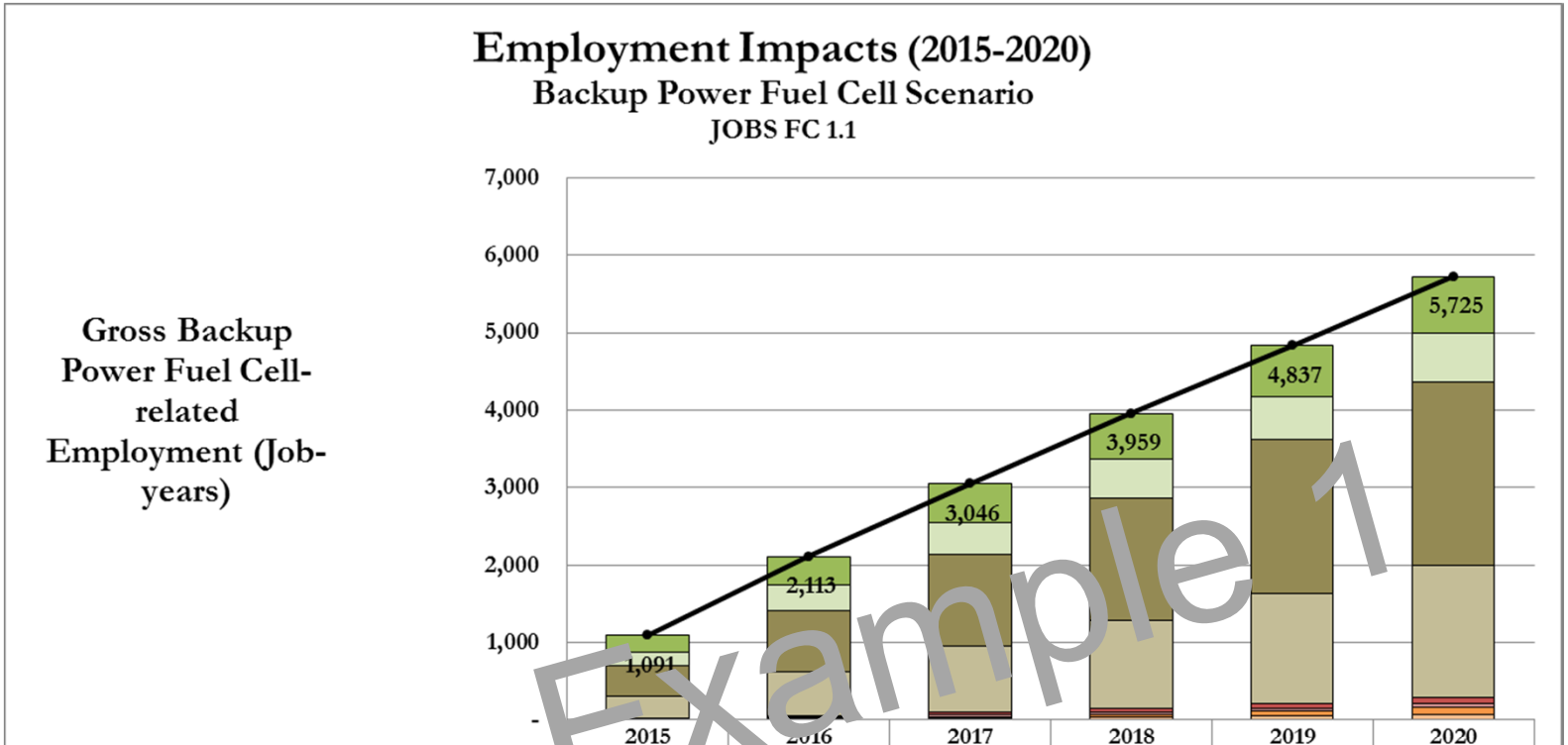
And charts displaying results



	2015	2016	2017	2018	2019	2020
Gross BuP Fuel Cell Supply Chain	[illegible]	377	491	588	660	733
Gross BuP Fuel Cell Induced	180	322	419	501	561	621
Gross BuP FC Installation Supply Chain	396	791	1,187	1,582	1,978	2,373
Gross BuP FC Installation Induced	285	570	855	1,140	1,425	1,710
Gross BuP FC Fuel Supply Chain	8	18	30	44	59	77
Gross BuP FC Fuel Induced	5	11	19	27	37	48
Gross BuP FC Maintenance Supply Chain	4	13	27	44	66	93
Gross BuP FC Maintenance Induced	3	10	20	33	49	69
Gross BuP FC-related Total	1,091	2,113	3,046	3,959	4,837	5,725

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To Use JOBS FC 1.1

- Register and download JOBS FC 1.1 (Excel 2010 file) and User's Guide at http://JOBSFC.es.anl.gov
- Open model and select application
  - Forklift INPUTS
  - Backup Power INPUTS
  - Prime Power INPUTS
  - PEM Facility Construction INPUTS
  - Prime Facility Construction INPUTS
- Select geography and scope of analysis
  - Gross or net analysis (net available for national geography only)
- Define scenario of interest
  - Required User Inputs (kW, number of units produced, imported, exported)
  - Optional User Inputs
  - Advanced User Inputs
- View results
  - Charts
  - Tables

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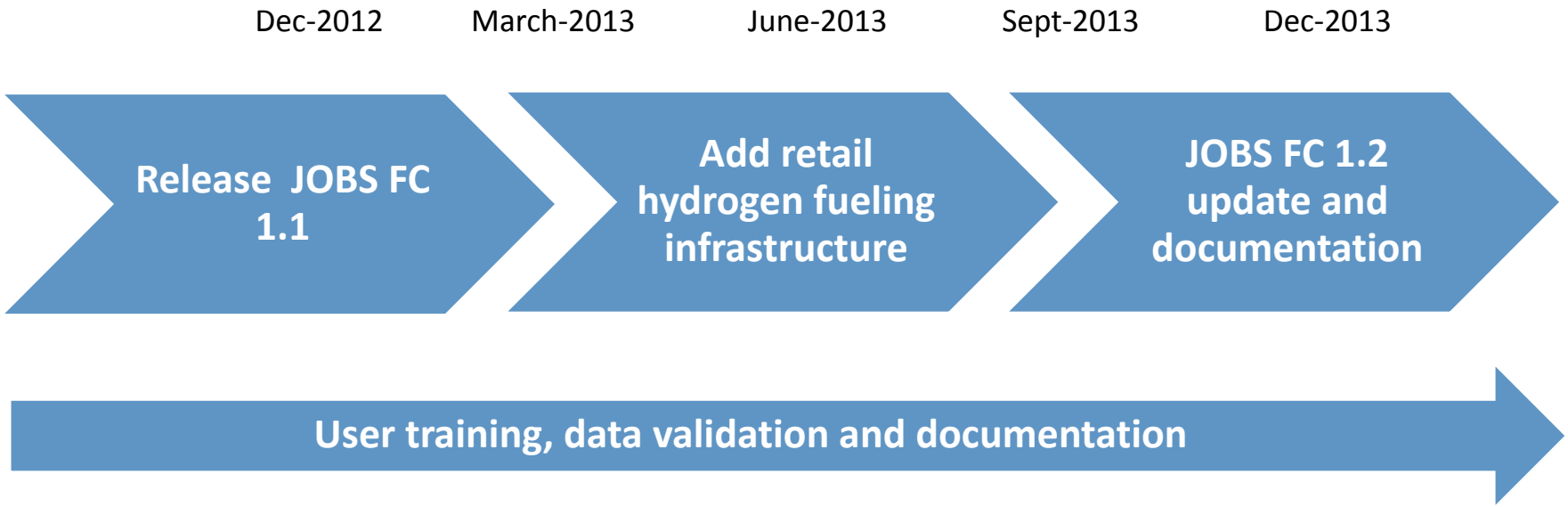
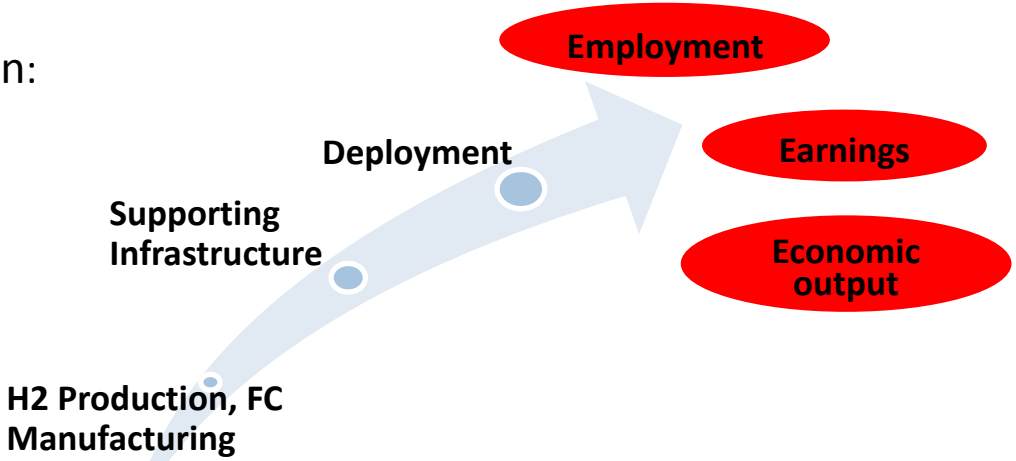
Where do we go from here?



Potential future model expansion:

- High temperature PEMFC
- SOFC
- CHHP
- Transportation APU
- Debt or other financing



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Stakeholders have been key collaborators for peer review, data collection/validation & beta testing

Beta tester/Peer reviewer

Public Agencies:

South Carolina Hydrogen and Fuel Cell Alliance

California Stationary Fuel Cell Consortium

Connecticut Center for Advanced Technology

Ohio Fuel Cell Coalition

NYSERDA

Clean Energy States Alliance

California Fuel Cell Partnership

Virginia Clean Cities

Trade Associations:

FCHEA

Fuel Cells 2000

Manufacturers:

PlugPower

ReliOn

Idatech

UTC Power

Fuel Cell Energy

Ballard

Customers:

Sprint-Nextel

Metro PCS

Whole Foods

Sierra Nevada

Researchers:

ORNL

NREL

PNNL

Battelle

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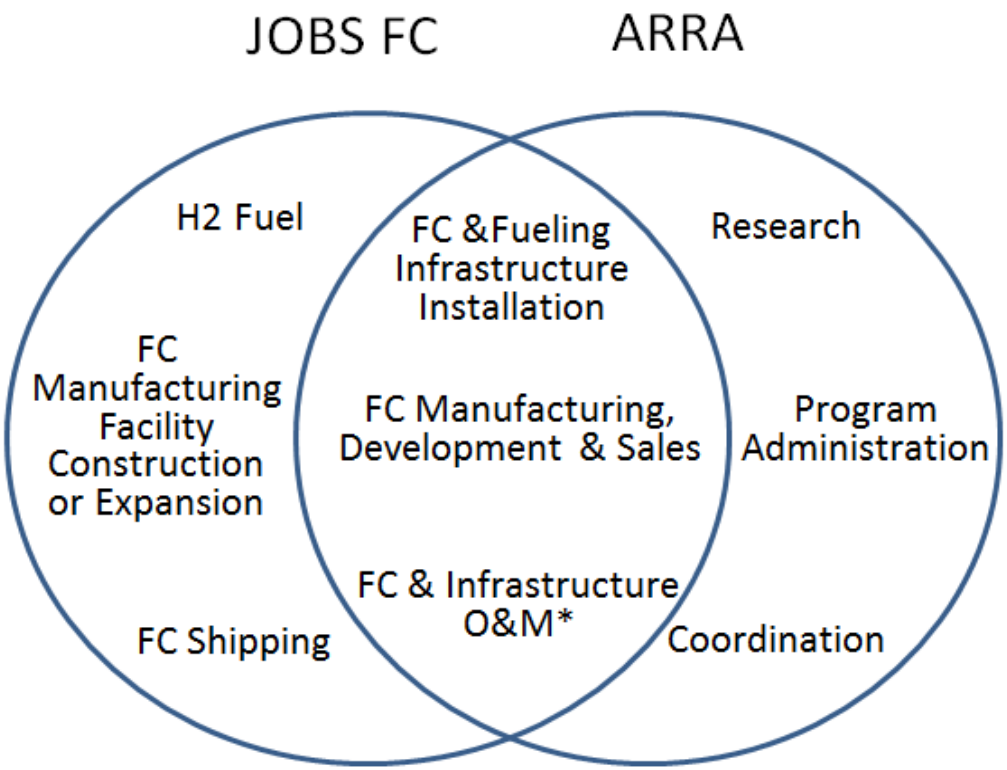
Employment impacts of ARRA fuel cell deployments were estimated by JOBS FC and offline analyses



* JOBS FC allows for ongoing maintenance expenditures while the ARRA analysis modeled only reported maintenance expenditures associated with ARRA-specific funding.

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Key assumptions and data sources in ARRA analysis

- Expenditures = DOE + industry cost shares. (*DOE Hydrogen and Fuel Cells Program Records,* http://www.hydrogen.energy.gov/pdfs/11017_industry_lift_truck_deploys.pdf, and http://www.hydrogen.energy.gov/pdfs/12013_industry_bup_deploys.pdf)
- All economic impacts occur in the year of fuel cell deployment (Kurtz, J. *DOE ARRA Funded Early Fuel Cell Markets: Units in Operation*, cdparra_em_02_numdetails)
- Net effects exclude:
  - Equipment and fueling infrastructure of displaced technology (sunk costs)
  - Program administration, research, and coordination of displaced technology
- FC & infrastructure maintenance expenses offset those of displaced technology
- FC backup power displaces diesel gensets (42% of gensets are US produced)
- FC forklifts displace batteries (65% of batteries are US produced).

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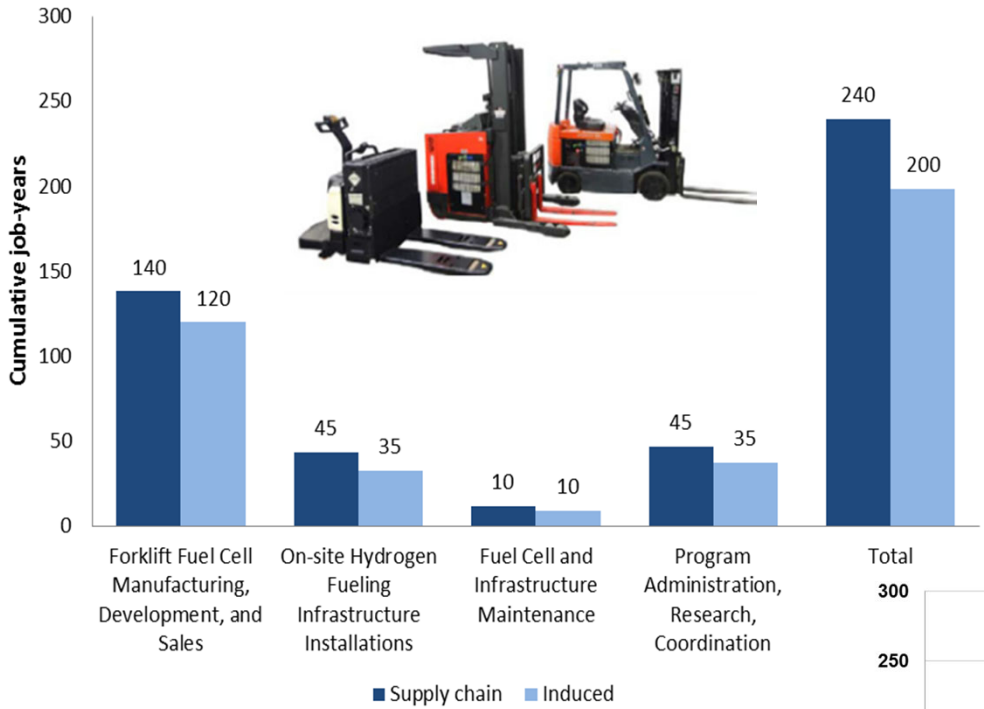
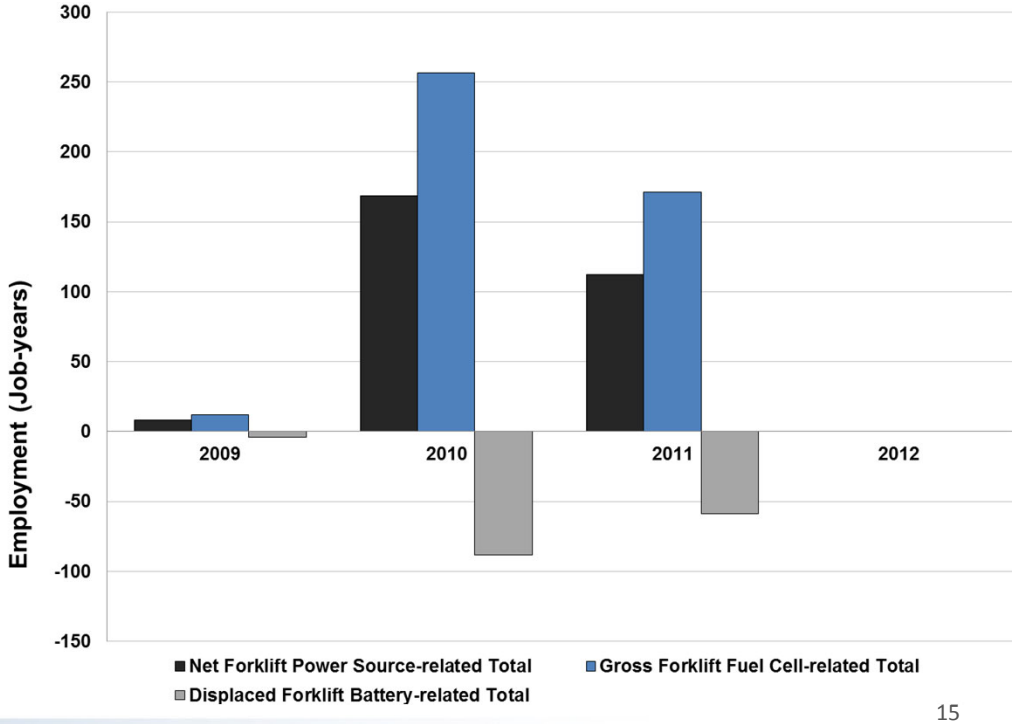


Mintz, M., C. Mertes and E.. Stewart, *Economic Impacts of the American Recovery and Reinvestment Act's (ARRA) Investments in Hydrogen Fuel Cells for Forklifts and Backup Power*, draft report, Sept. 30, 2012.

ARRA Deployments, 2009-2011	Forklifts		Cell Tower Backup Power
	Class I/II	Class III	
Units: 2009	14	0	0
2010	122	172	190
2011	124	72	416
Total	260	244	692
Ave. capacity (kW)	8	2	2.1
Annual operating hrs.	2500	2500	24
Fuel type	LH2/GH2	LH2/GH2	GH2
Operating hrs./refuel	4	4	72

For 2009–2012, ARRA-funded fuel cells deployed in forklifts resulted in employment of ~440 gross (~290 net) job-years



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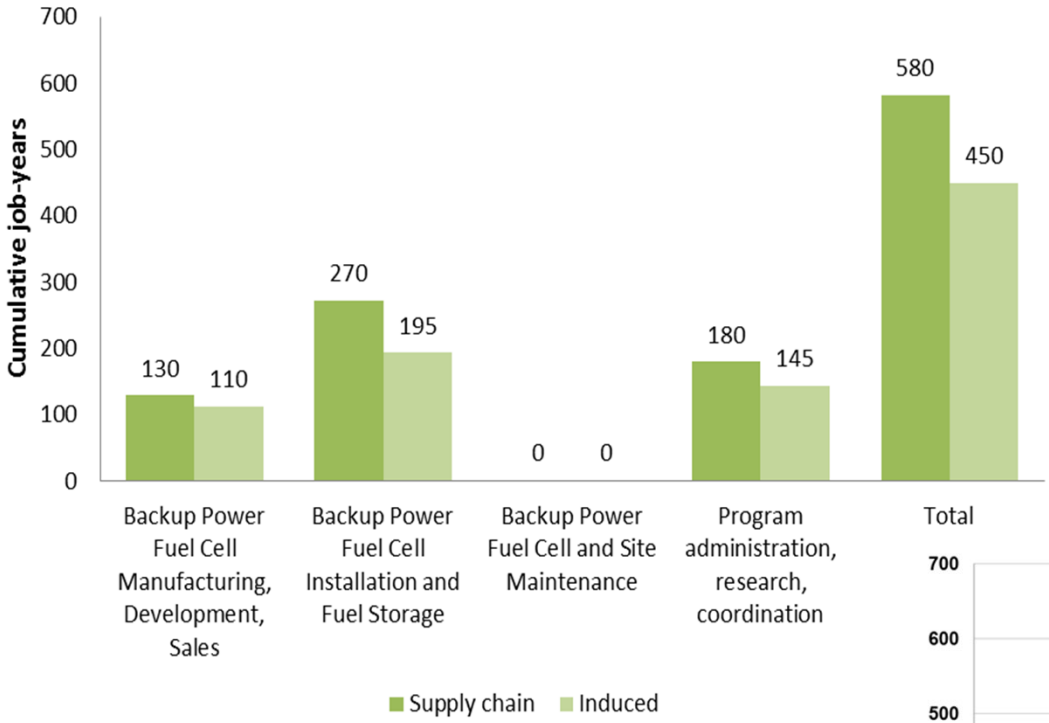

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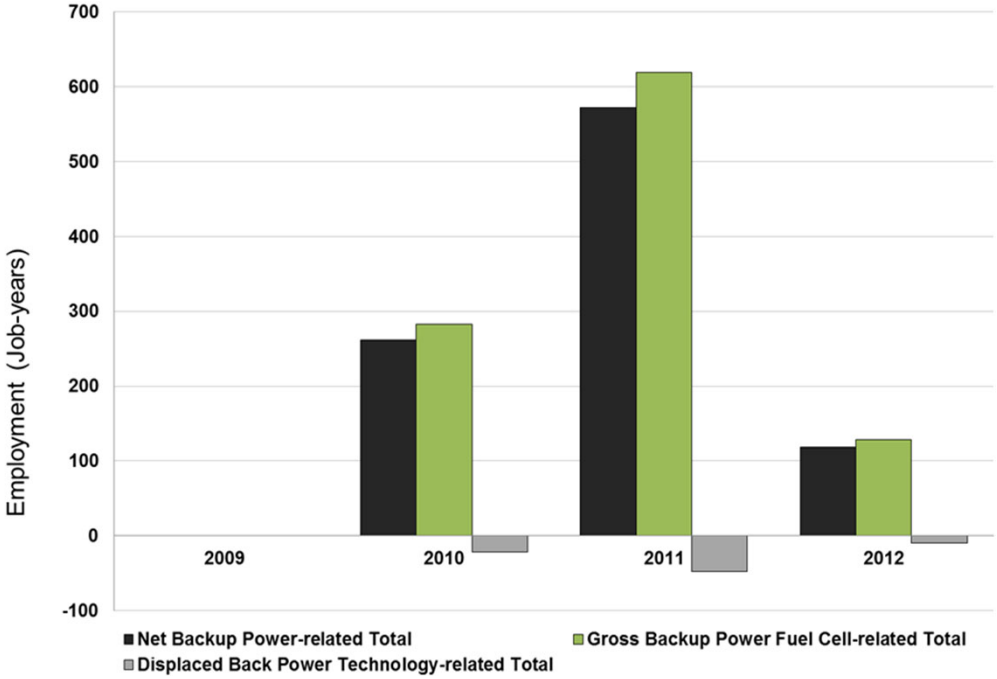
For 2009–2012, ARRA-funded fuel cells in backup power resulted in employment of ~1030 gross (~950 net) job-years



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Conclusions and observations

- ARRA awards generated employment of ~1500 gross job years
- 2/3 employment impact in backup power (692 FCs deployed)
- 40% employment impact in induced jobs
- For forklifts, largest employment gain occurred in FC production
- For backup power, largest employment gain occurred in installation of FC & fuel storage
- ARRA “out-of-scope” expenditures (H2 fuel, FC shipping) would have increased gross job estimates

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Thank you!

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