JOBS FC 1.1
(JOBS and economic impacts of Fuel Cells)*

Marianne Mintz, Jerry Gillette and John Molburg,
Argonne National Laboratory
Eric Stewart and Catherine Mertes,
RCF Economic & Financial Consulting

December 11, 2012

Outline

- Welcome and Introductions
- Overview of JOBS FC – Marianne Mintz
  - Approach
  - Functionality
- Demo – Eric Stewart
- Acknowledgements & Next Steps – Marianne Mintz
- Questions

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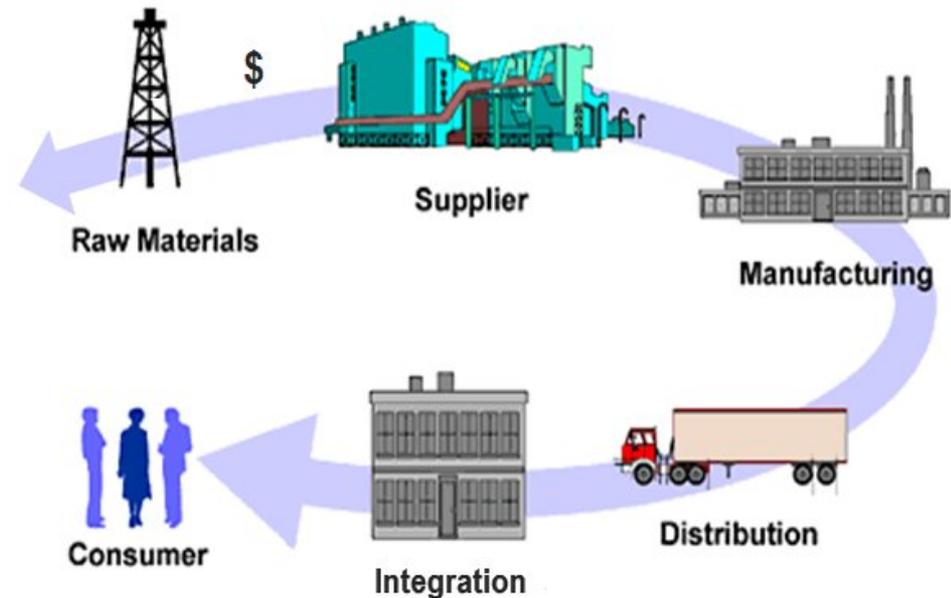
Jobs are created at each stage in FC production, fuel infrastructure, O&M and fuel supply chains (**direct + indirect**) plus from re-spending dollars in economy (**induced**)

JOBS FC models expenditure flows thru the supply chain

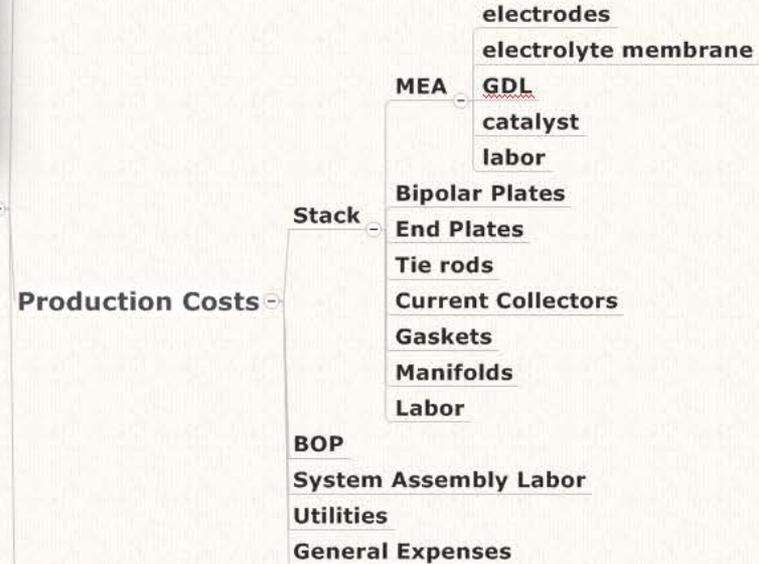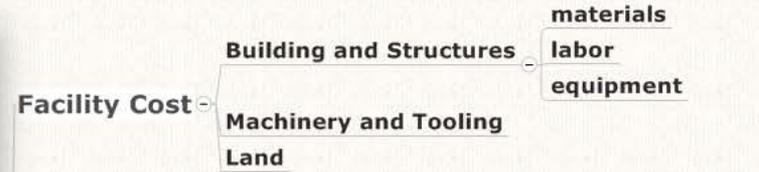King, J. 2011, *Fuel Cell-Powered Lift Truck FedEx Freight Fleet Deployment*, DOE Annual Merit Review, 2011.

Courtesy of Ballard Power Systems.

Courtesy of BMW Manufacturing Co., LLC

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
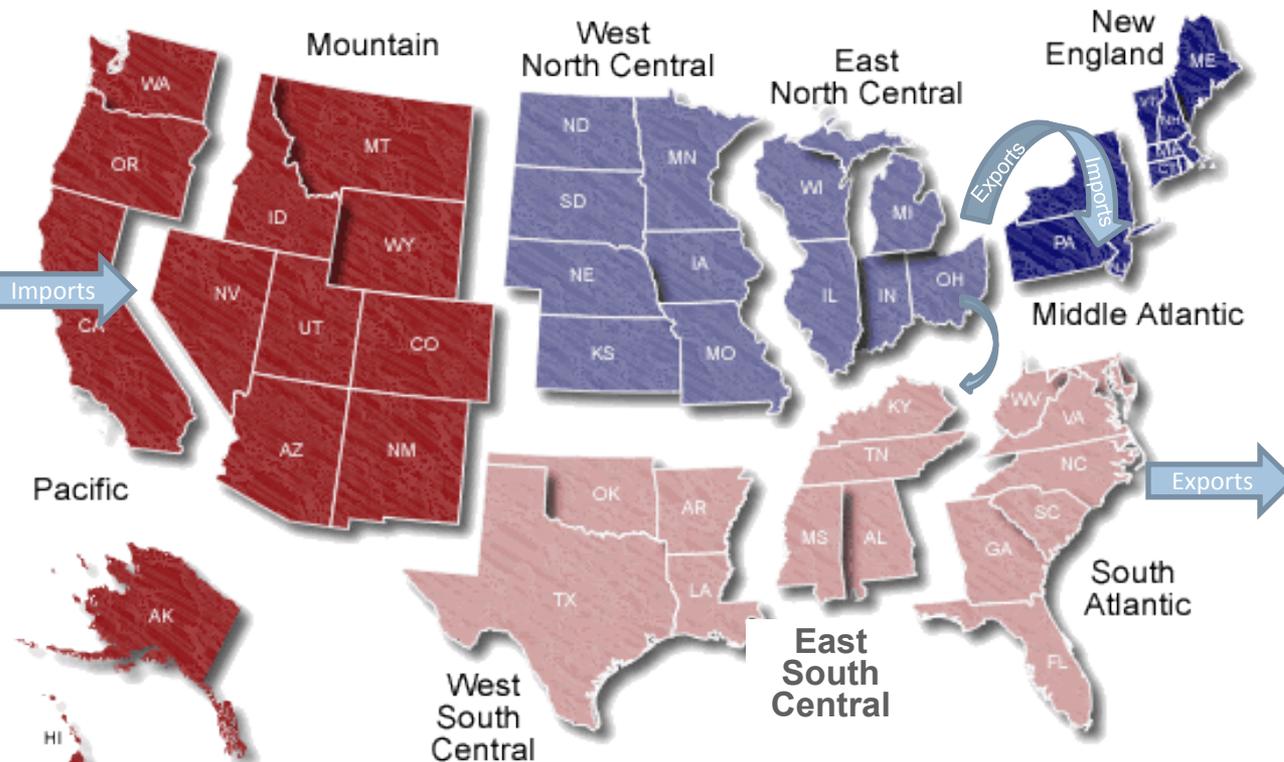
JOBS FC models expenditures for different geographies

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).

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 **ne**t effects
- **Net excludes jobs displaced** by FCs (unless FCs displace imports).
- Total net effects (shown by line overlaid on results charts in demo) are sum of positive and negative values (on stacked bar charts in demo).
- 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**
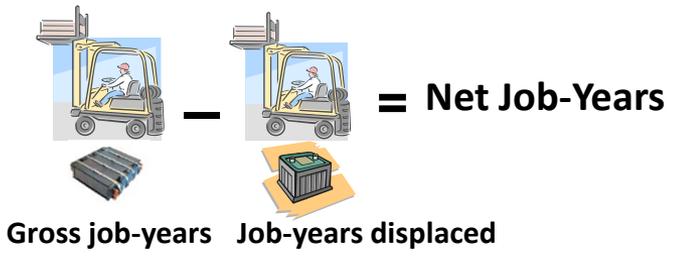
How might JOBS FC be used?

US Government

- Wants to know gross domestic employment impact from constructing and operating a new backup power FC manufacturing facility to be built by end of 2014.
- While forecasts indicate the 2020 FC market could absorb 12,000 units/year from the new facility, initial capacity will be 20,000 per year.
- Production forecast is 2,000 units in 2015, growing to 12,000 in 2020.
- 50% of production will be exported.

Example shown in demo

New City Development Corp.

- Wants to know regional gross employment impact from deploying phosphoric acid (PAFC) fuel cells.
- 5 new 400 kW PAFC units will be installed in Census Region 8-Mountain each year from 2015 to 2020.
- Results show economic impact from installation and operation; manufacturing occurs outside the user-specified region.

Example shown in demo

Warehouses R US Corp.

- Wants to compare net economic impact from powering their Class I/II forklifts with PEM fuel cells manufactured in the US instead of batteries (many of which are produced abroad).
- Could convert their existing fleet of forklifts to fuel cell power in 10 years, replacing batteries (and battery infrastructure) with fuel cells (and fueling infrastructure).
- Assumptions operations and location of manufactured units greatly impact the net analysis.

JOBS FC 1.1 Demo

(Screen shots of examples shown)

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

RESET - CLEAR ALL USER-SPECIFIED VALUES

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 the 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 3 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.

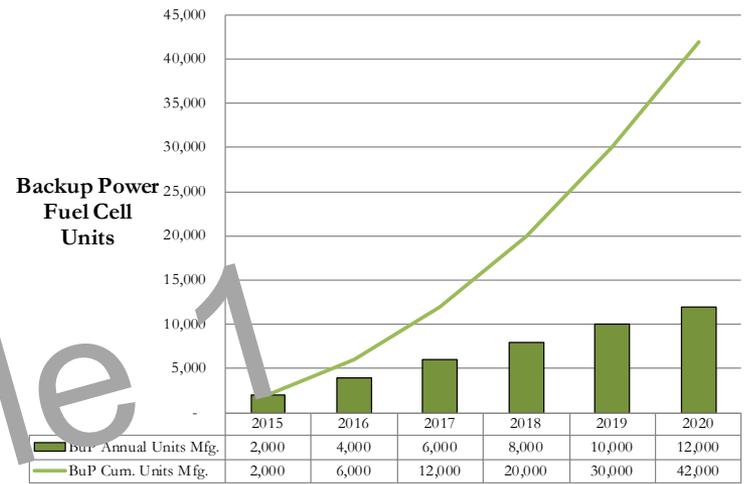| Step 3b - Export Units or Percentage	Selection will impact entries in Step 3c	
For fuel cells entered in 3c, select . . . NUMBER of fuel cell units exported out of region or PERCENTAGE of fuel cell units manufactured in region exported out of region.	PERCENTAGE of fuel cell units manufactured in region 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

5 kW Fuel Cells

Manufactured, Imported, and Exported for USA-National | Year | User-specified value | User-specified value | User-specified value | Units used in model calculations | | |
	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	-
	2019	10,000	50%		10,000	5,000	-
	2020	12,000	50%		12,000	6,000	-

Retail Price and Manfuacturing Cost
Backup Power Fuel Cell Scenario
JOBS FC 1.1

$/Unit (2010$)

	2015	2016	2017	2018	2019	2020
BuP FC Retail Price	$9,075	$8,100	$6,975	$6,225	$5,550	5,100
BuP FC Mfg. Cost	$6,050	$5,400	$4,650	$4,150	3,700	3,400

Units Manufactured in Region
Backup Power Fuel Cell Scenario
JOBS FC 1.1

Backup Power Fuel Cell Units

	2015	2016	2017	2018	2019	2020
BuP Annual Units Mfg.	2,000	4,000	6,000	8,000	10,000	12,000
BuP Cum. Units Mfg.	2,000	6,000	12,000	20,000	30,000	42,000

Units Installed in Region
Backup Power Fuel Cell Scenario
JOBS FC 1.1

Backup Power Fuel Cell Units

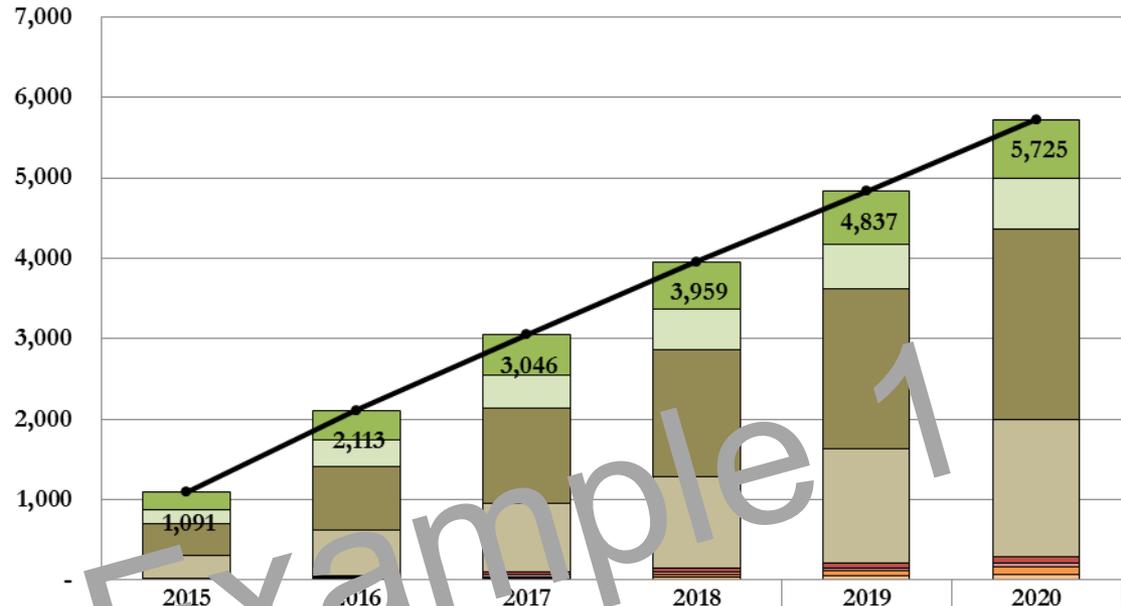|	2015	2016	2017	2018	2019	2020
BuP Annual Units Installed	1,000	2,000	3,000	4,000	5,000	6,000
BuP Cum. Units in Operation	1,000	3,000	6,000	10,000	15,000	21,000
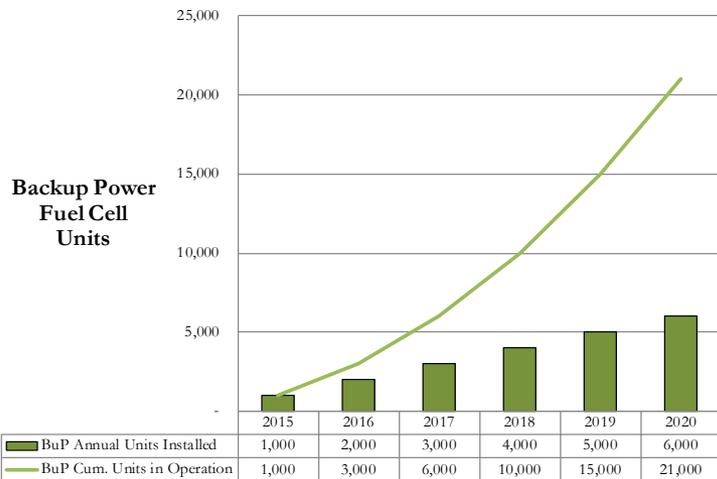
Example 1

Employment Impacts (2015-2020)
Backup Power Fuel Cell Scenario
JOBS FC 1.1

Gross Backup Power Fuel Cell-related Employment (Job-years)

	2015	2016	2017	2018	2019	2020
Gross BuP Fuel Cell Supply Chain	210	377	491	588	660	733
Gross BuP Fuel Cell Induced		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

* * * PRIME POWER FUEL CELLS INPUTS * * *

RESET - CLEAR ALL USER-SPECIFIED VALUES

REQUIRED USER INPUT FIELDS

Step 1 - Choose Region and Fuel Cell Type

Step 1a - Select State or Region	Census Division 8-Mountain	
Step 1b - Gross or Net Analysis	Gross	Gross analysis available for all regions. Net analysis available only for national analysis.
Step 1c - Fuel Cell Type	PAFC	MCFC=Molten carbonate fuel cell; PAFC = Phosphoric acid fuel cell

Step 2 - Fuel Cell Unit Size and Operations Variables (entries should be made on a per fuel cell unit basis)

Step 2a - Enter Fuel Cell Unit Size	*User-specified value*	**Default**	**Notes**	**Value used in model**
Fuel cell unit size (kW/unit)		400	Please enter a value between 100 kW and 3000 kW.	400
Step 2b - Select Operations Input Option	Use default operations variables		Must select option from drop-down menu if entering capacity factor or annual kWh.	
Capacity factor (kWh generated/potential kWh)		90.0%	Average annual kWh generated divided by potential annual kWh.	90.0%
Annual kWh generated per fuel cell (kWh/year)		3,155,760		3,155,760

Step 3 - PAFC Units Manufactured, Exported, and Imported for Census Division 8-Mountain

If only analyzing installations, please skip to Step 3b and enter number of installed fuel cell units in the Imported section (column G). Then proceed to Step 6.

Step 3a - Select Exports Value Type	**Selection will impact entries in Step 3b**	
For fuel cells entered in 3b, select . . . NUMBER of fuel cell units exported out of region or PERCENTAGE of fuel cell units manufactured in region exported out of region.	<Please select>	Exports are units manufactured in Census Division 8-Mountain, but installed in another region or country. Imported units are manufactured outside Census Division 8-Mountain, but installed in Census Division 8-Mountain. Installed units = Manufactured units - Exported units + Imported Units (see Results sheets).

Step 3b - Enter Regional PAFC units

PAFC	Year	Manufactured in region (units) *User-specified value*	Exported out of region (units) *User-specified value*	Imported into region (units) *User-specified value*	Manufactured in region (units)	Exported out of region (units)	Imported into region (units)
					Units used in model calculations		
400 kW Fuel Cell Units Manufactured, Imported, and Exported for Census Division 8-Mountain	2015			5	-	-	5
	2016			5	-	-	5
	2017			5	-	-	5
	2018			5	-	-	5
	2019			5	-	-	5
	2020			5	-	-	5

Units Installed in Region
Prime Power Fuel Cell Scenario
JOBS FC 1.1
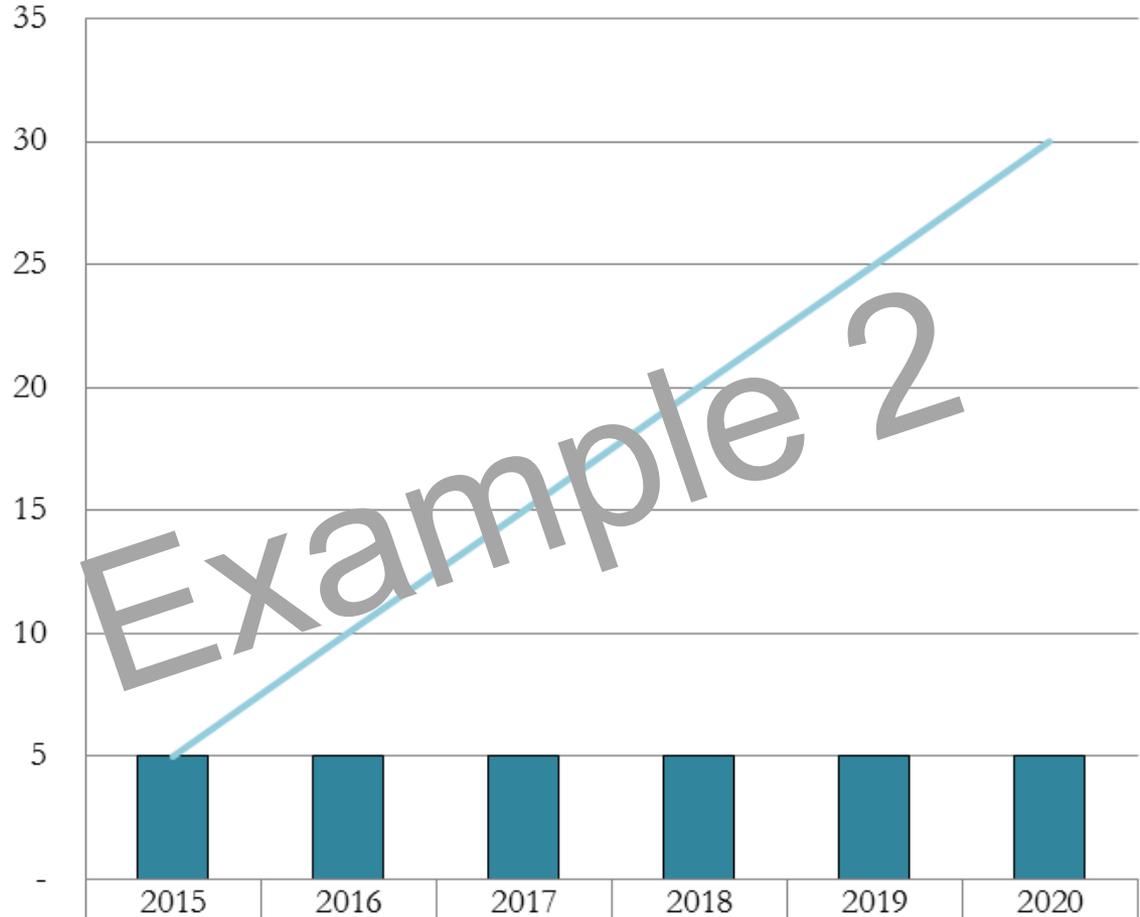
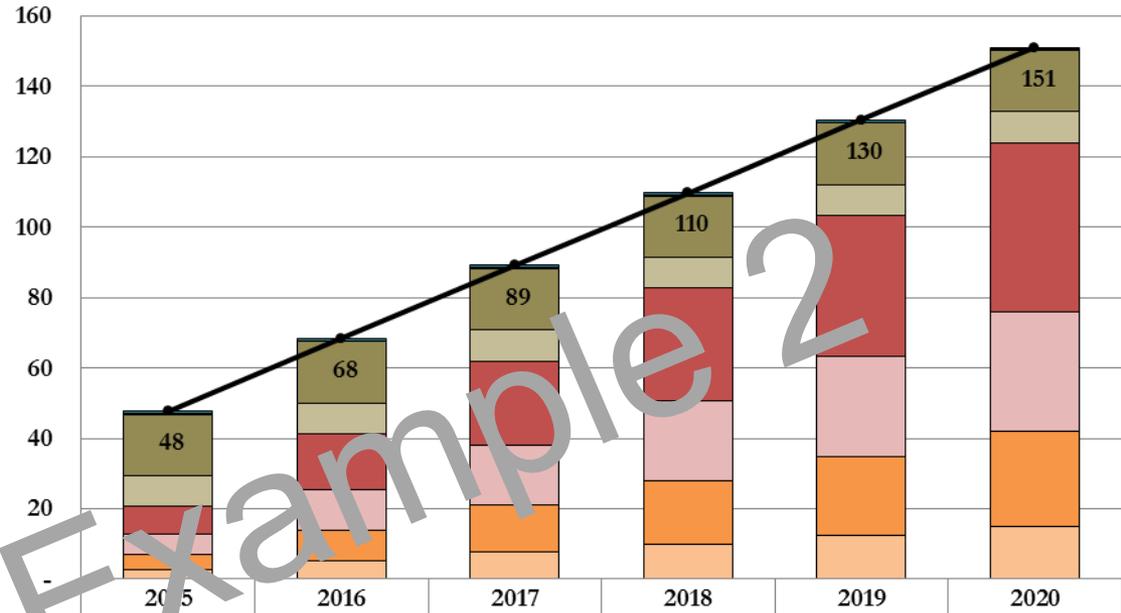|	2015	2016	2017	2018	2019	2020
Annual Units Installed (PAFC)	5	5	5	5	5	5
Cum. Units in Operation (PAFC)	5	10	15	20	25	30

Gross Employment Impacts (2015-2020)
Prime Power Fuel Cell Scenario
JOBS FC 1.1

Gross PAFC-related Employment (Job-years)

	2015	2016	2017	2018	2019	2020
Gross PAFC Unit Supply Chain	1	1	1	1	1	1
Gross PAFC Unit Induced	0	0	0	0	0	0
Gross PAFC Installation Supply Chain	17	17	17	17	17	17
Gross PAFC Installation Induced	9	9	9	9	9	9
Gross PAFC Fuel Supply Chain	8	16	24	32	40	48
Gross PAFC Fuel Induced	6	11	17	23	28	34
Gross PAFC Maintenance Supply Chain	4	9	13	18	22	27
Gross PAFC Maintenance Induced	3	5	8	10	13	15
Gross PAFC-related Total	48	68	89	110	130	151

Example 2

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

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

RCF ECONOMIC & FINANCIAL CONSULTING, INC.

Where do we go from here?

Dec-2012	March-2013	June-2013	Sept-2013	Dec-2013

Release JOBS FC 1.1 → **Add retail hydrogen fueling infrastructure** → **JOBS FC 1.2 update and documentation**

User training, data validation and documentation →

Potential future model expansion:

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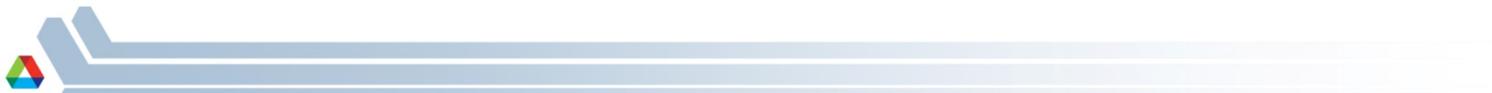- Debt or other financing

H2 Production, FC Manufacturing → **Supporting Infrastructure** → **Deployment** →

Employment

Earnings

Economic output

Questions?

Thank you!

mmintz@anl.gov
estewart@rcfecon.com
cmertes@rcfecon.com