Employment Impacts of Non-Automotive Fuel Cells and Natural Gas Vehicles

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Outline of presentation

- Background/purpose
- JOBS FC
  - Approach
  - Scope
  - Initial results
- JOBS NGV

Background/Purpose of Study

What are the macroeconomic effects of fuel substitution and market transformation?

- DOE OFCT: Early, non-automotive markets for fuel cell technology
  - Forklifts
  - Backup power
  - Distributed power
  - Light duty vehicles
- Clean Cities: Fuel substitution/petroleum reduction
  Local/regional economic development
  - Natural gas vehicles
  - NG fueling infrastructure

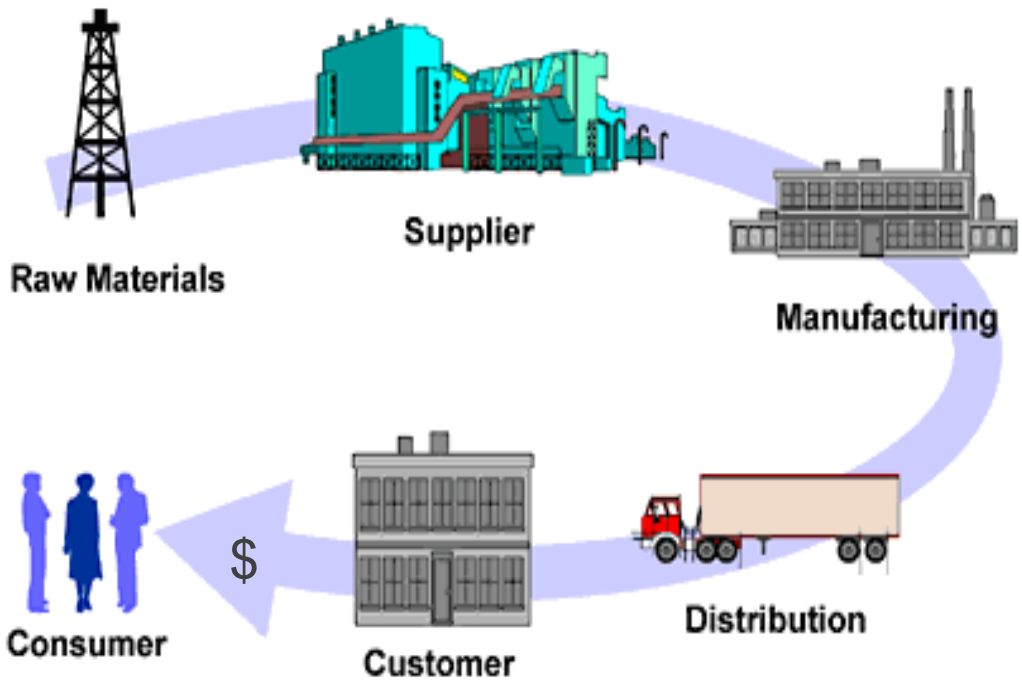
What are JOBS FC and JOBS NGV?

JOBS FC (Job and Output Benefits of Stationary Fuel Cells) and JOBS NGV (Job and Output Benefits from Supporting Natural Gas Vehicles) are user-friendly spreadsheet-based tools to calculate economic impacts of early market deployments of fuel cells and natural gas vehicles and fueling infrastructure

Geographic Regions	State Impacts	Regional Impacts	National Impacts
Modeled Activities	Construction of Component Manufacturing Facility	FC/NG Component Manufacturing	FC/NG Installation, Fueling, Operation & Maintenance
Results	Employment	Earnings	Economic Output

How do JOBS FC and JOBS NGV work?

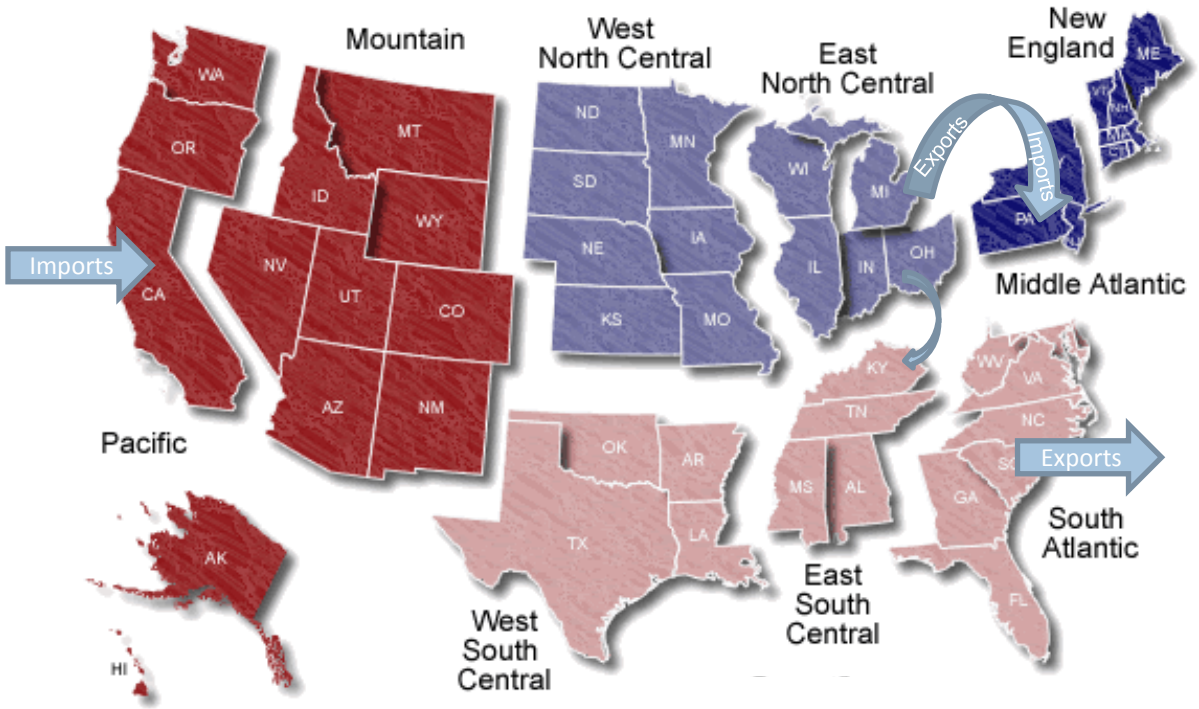
- User specifies an application (forklifts, backup power), a geography (state/region/US) and a target number of units to be produced, imported and exported.
- User can specify additional cost and operating parameters or use defaults
- JOBS models contain equations representing effect of expenditures along relevant supply chains on earnings, output and employment
- JOBS models capture induced changes from expenditures by workers and businesses throughout the economy
- JOBS models calculate direct, indirect and induced jobs created, wages and sales resulting from FC/NGV production, installation, operation and fueling.



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

JOBS FC and JOBS NGV have multiple geographies

What are "imports" and "exports"?



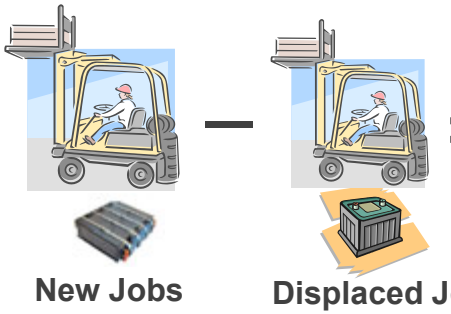
Map by the Indiana Business Research Center, Kelley School of Business, Indiana University

- **Imported** units are produced outside the region but installed and operated inside it (manufacturing facility construction & production impacts excluded).
- **Exported** units are produced inside region but installed & operated outside it (installation, maintenance of units and fuel infrastructure, & fuel purchase impacts excluded).
- To capture import and export impacts need to move to higher level of geography.
- If user does not enter imports or exports, models assume all impacts occur inside region.

JOBS FC

What is JOBS FC's scope and schedule?

2015–2020 timeframe
3 technologies, 3 applications



= Net Jobs

	Phase 1*	Phase 2**	
Unit Capacity (kW)	LT PEM	PAFC	MCFC
Class I/II Forklift	5-15		
Class III Forklift	1-3		
Backup Power	1-15		
Prime Power		400	1500

* Gross job additions.
** Gross & net job additions.

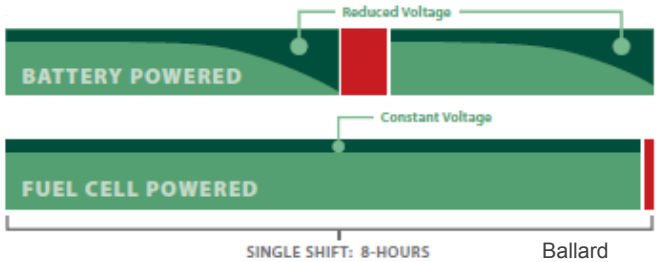
Beta 1.0 → Beta 2.0 → JOBS FC 1.0

1/31/12 3/30/12 5/30/12

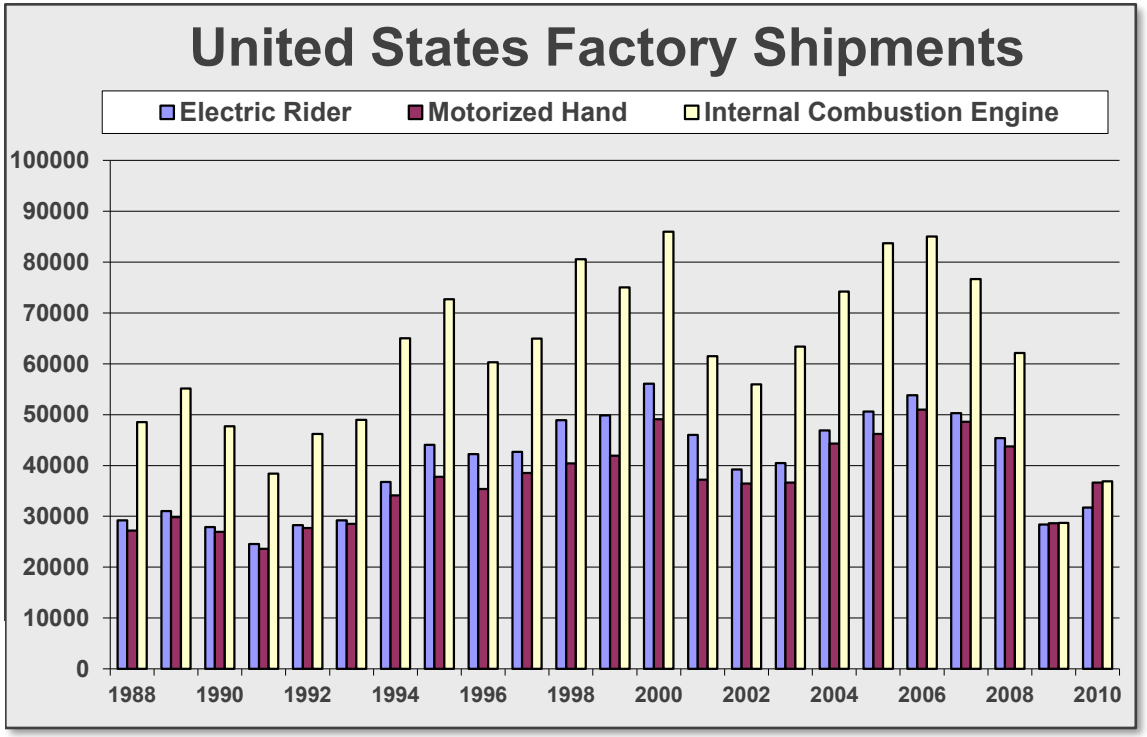
JOBS NGV initiated 10/1/2011. Beta 1.0 due 9/30/12.

Why are fuel cells attractive for forklifts?

- Lifecycle cost
  - FCs replace 2-3 batteries + chargers, charging room, etc.
  - BUT, FCs have higher 1st cost and require new fueling infrastructure (H_2 storage + compressors, dispensers, etc.)
- Productivity
  - FCs supply constant voltage throughout shift
  - FCs can be refueled in < 5 min vs. ~ 20 min. for battery exchange



- Emissions
  - Depend on source of H2 and electricity



https://www.indtrk.org/marketing.asp

Potential US market ~100,000 units/year
~ 60% of forklift shipments

Of ~ 3,000 FC forklifts, most are recent deployments with substantial infrastructure

Courtesy of BMW Manufacturing Co., LLC.

Default Cost/Site	
Site design & engineering	$40,000
Construction	$160,000
LH2 storage	$300,000
Fueling infrastructure	$900,000
Total	$1,400,000

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

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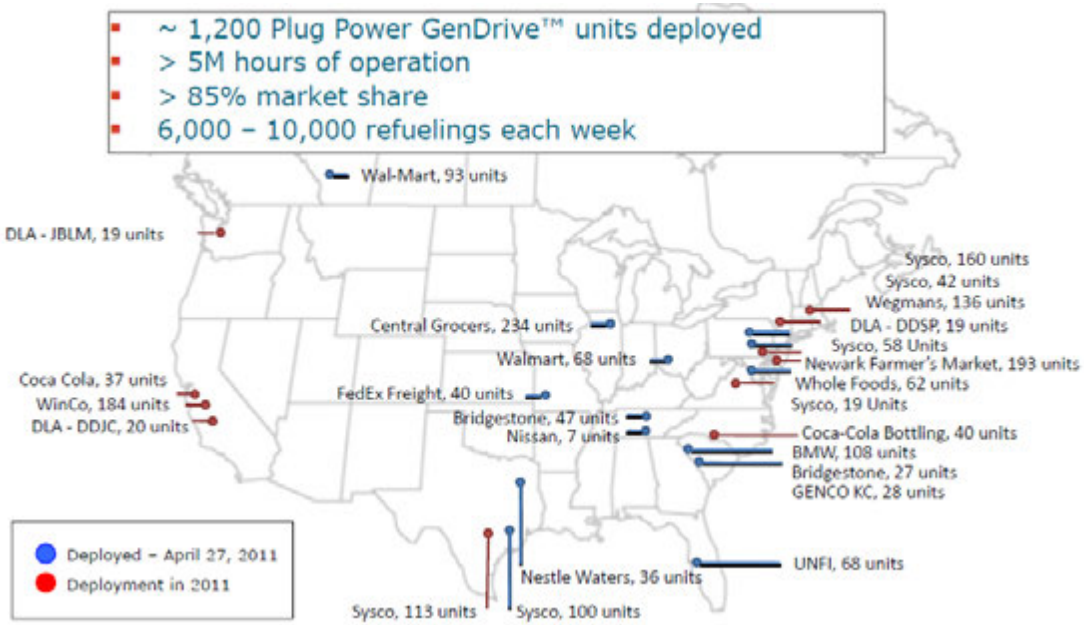
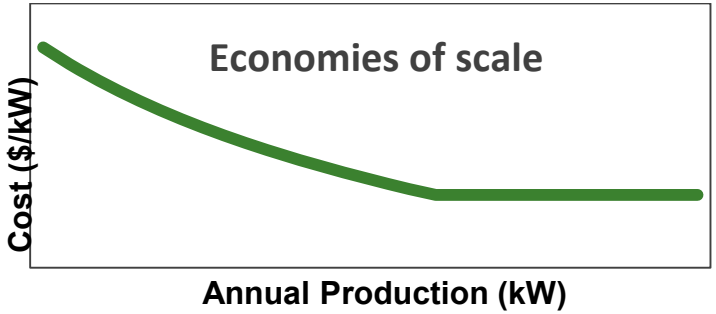
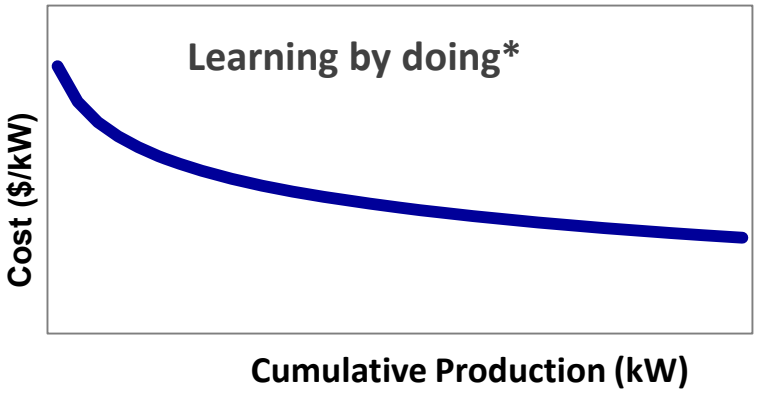
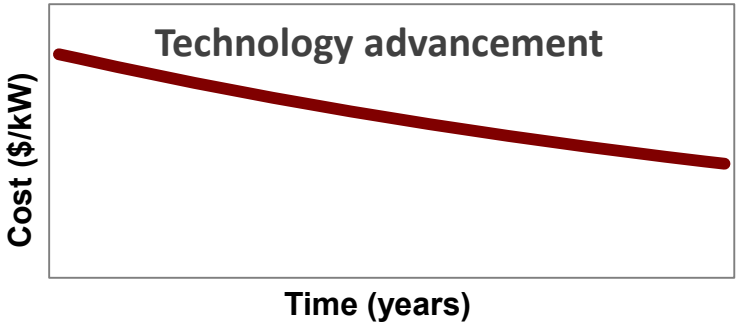


In JOBS FC manufacturing costs decline over time

Manufacturing cost model based on Greene, Duleep and Upreti (2011)



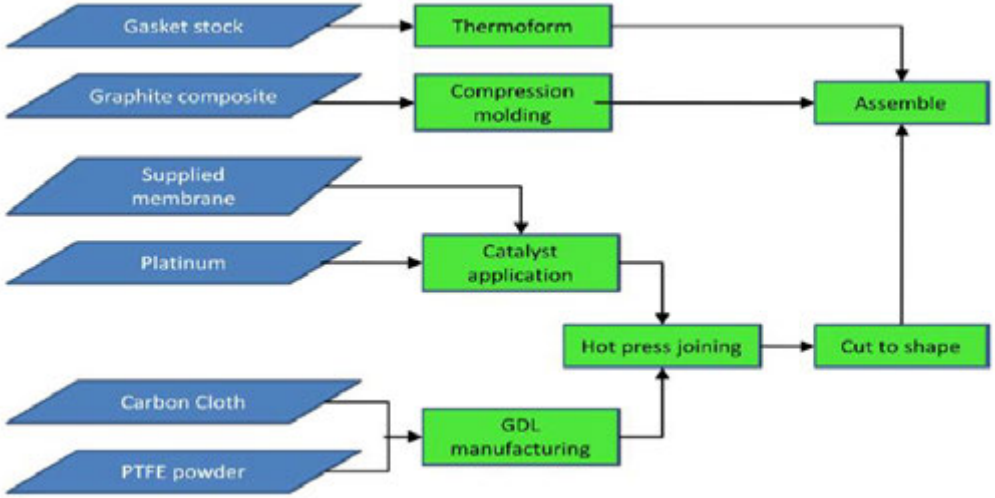


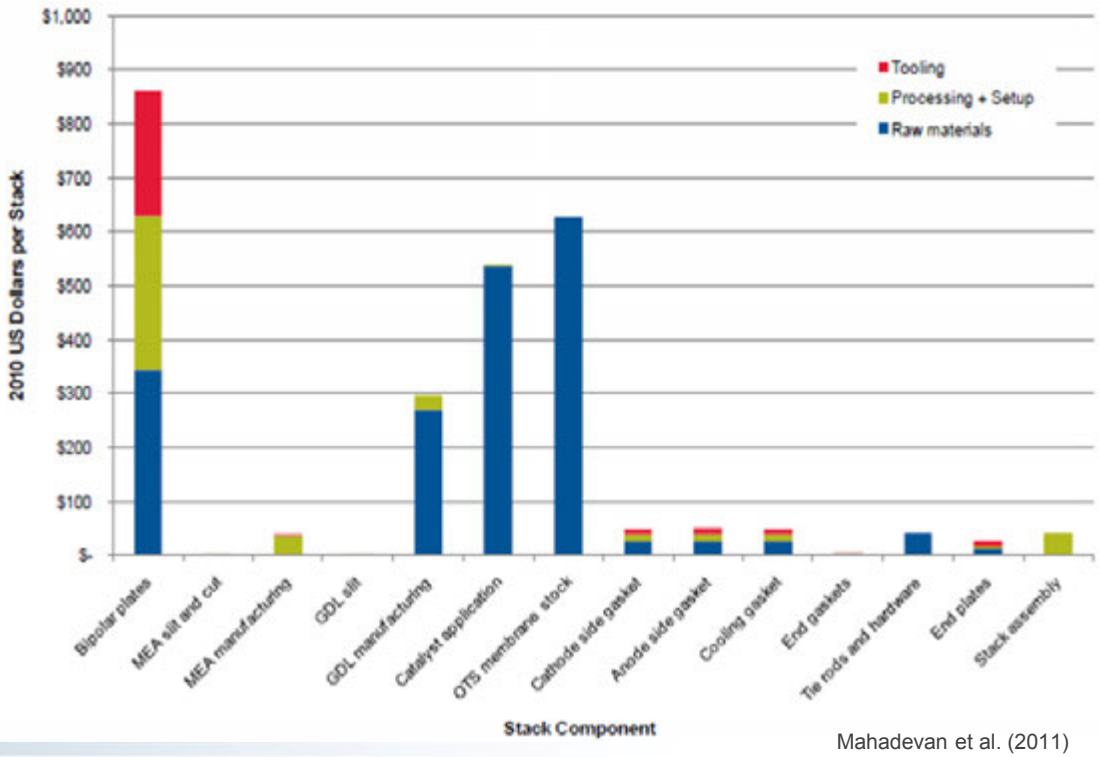


- Costs change due to cumulative production experience, scale effects & technology advancement
- Model output displays annual average $/kW resulting from dynamic factors & scenario inputs
- Scale economy affected by number of manufacturers in region
- User can override model defaults
- Price = manufacturing cost + non-manufacturing cost

Manufacturing cost includes labor, tooling and raw materials

Courtesy of Ballard Power Systems.





Mahadevan et al. (2011)

Supply chain breakdown:

- Direct = on-site or from delivery
  - Assembly
  - R&D, sales, G&A, etc.
- Indirect = upstream

Market success has a huge impact on results

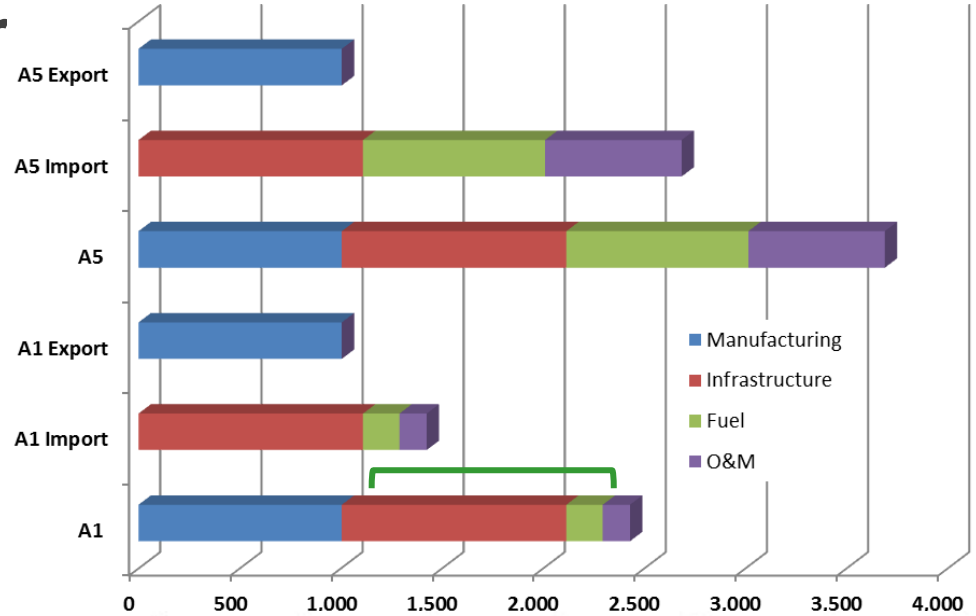
Gross Jobs Created under Two Deployment Scenarios

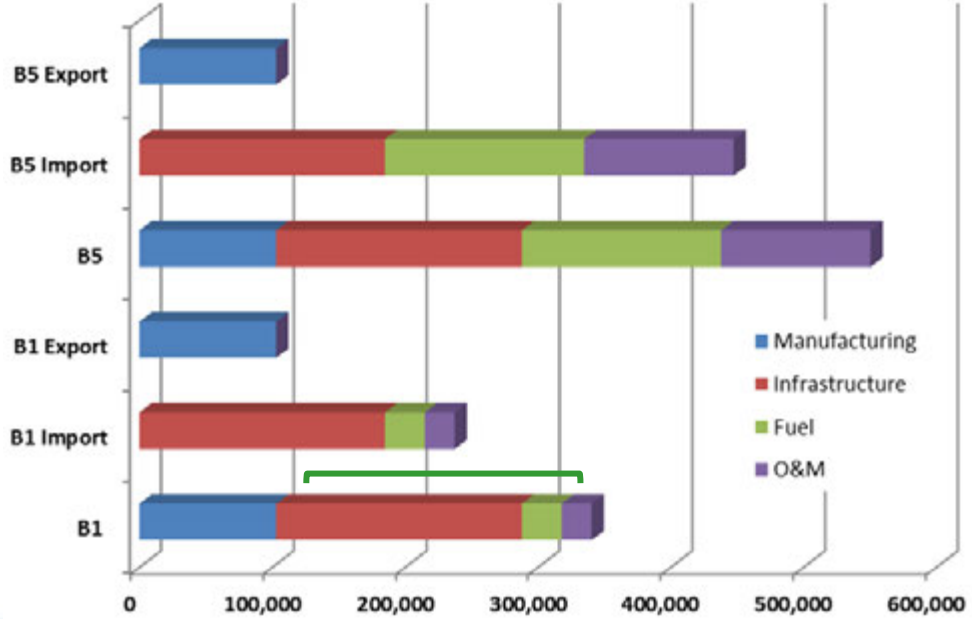
Fuel Cell Forklifts	Scenario A1 (3,000)	Scenario B1 (500,000)
FC manufacturing (1-time)	1,000	103,000
Fueling infrastructure installation/construction (1-time)	1,100	185,000
Fueling (recurring, per yr)	180	30,000
O&M of fuel cell & fueling infrastructure (recurring, per yr)	135	22,500

… but how should we combine recurring (continuing) with non-recurring (1-time) jobs?

Assumptions for import/export split and reporting of recurring jobs matter

- If all units are imported, gross job creation drops by 1000 in Scenario A (103,000 in Scenario B – blue bar)
- If all units are exported, gross jobs drop by 1425 in Scenario A (237,000 in Scenario B – green bracket)
- Over 5 years, recurring jobs (i.e., fueling, O&M) account for nearly half of total (Scenarios A5, B5)
- Over 10 yrs, assuming no change in operating cost or performance, recurring jobs grow to 65% of total

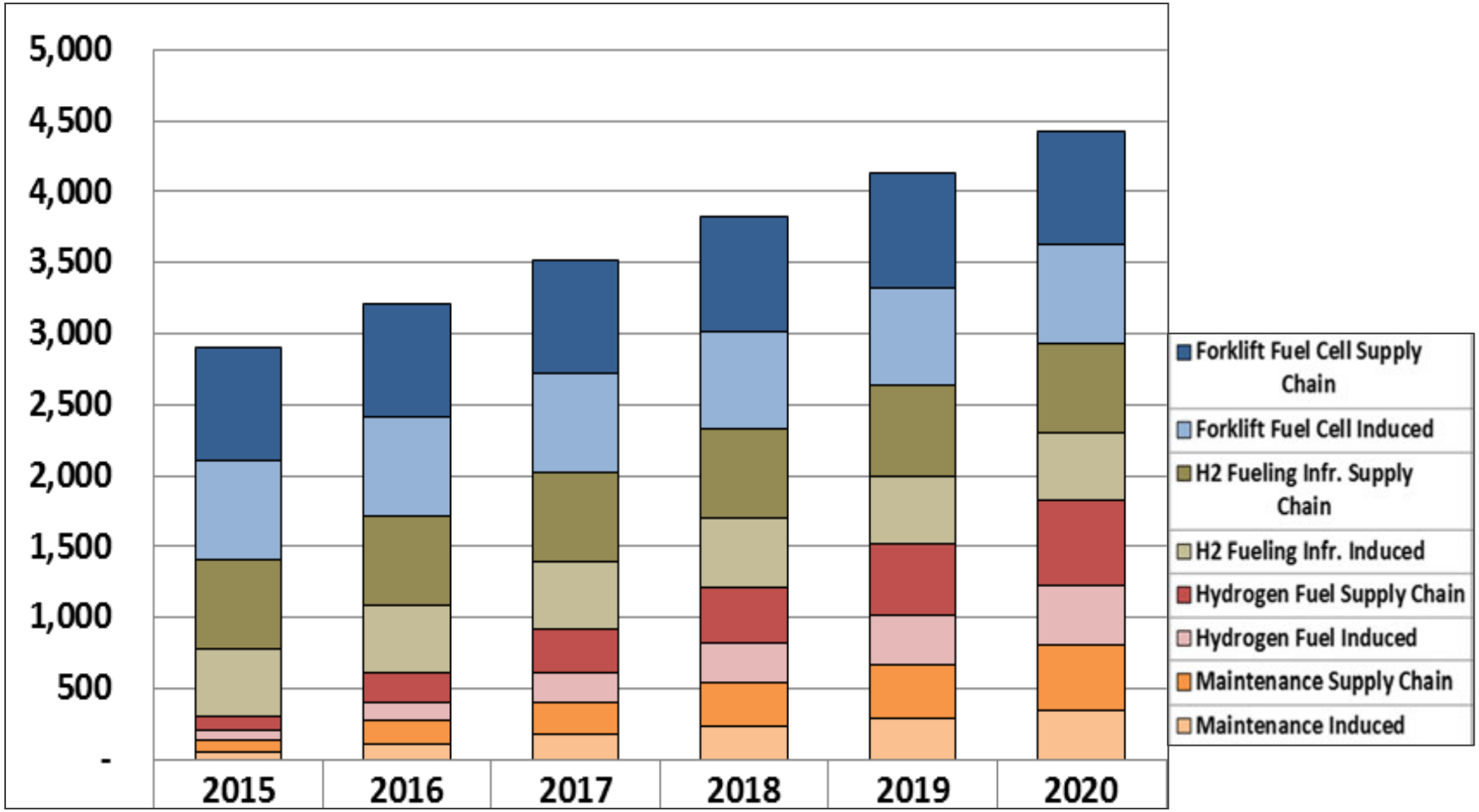




A1 = Gross jobs, Scenario A, year 1
A5 = Gross jobs, Scenario A, years 1-5
A Import = Gross jobs, FC infrastructure, fuel, O&M
A Export = Gross jobs, FC manufacturing

With flat penetration, recurring jobs increase share

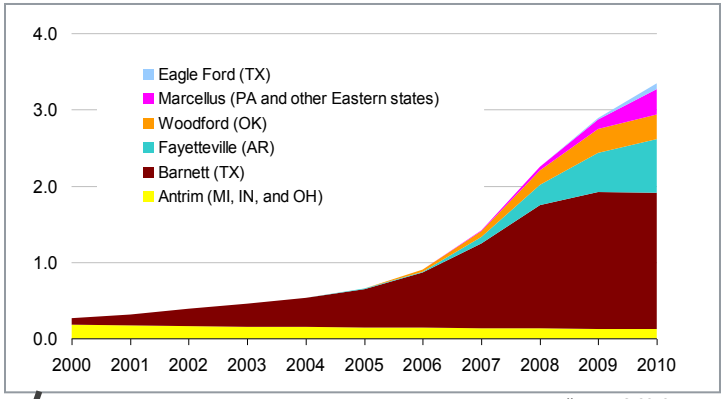
(from ~10% to 40%)



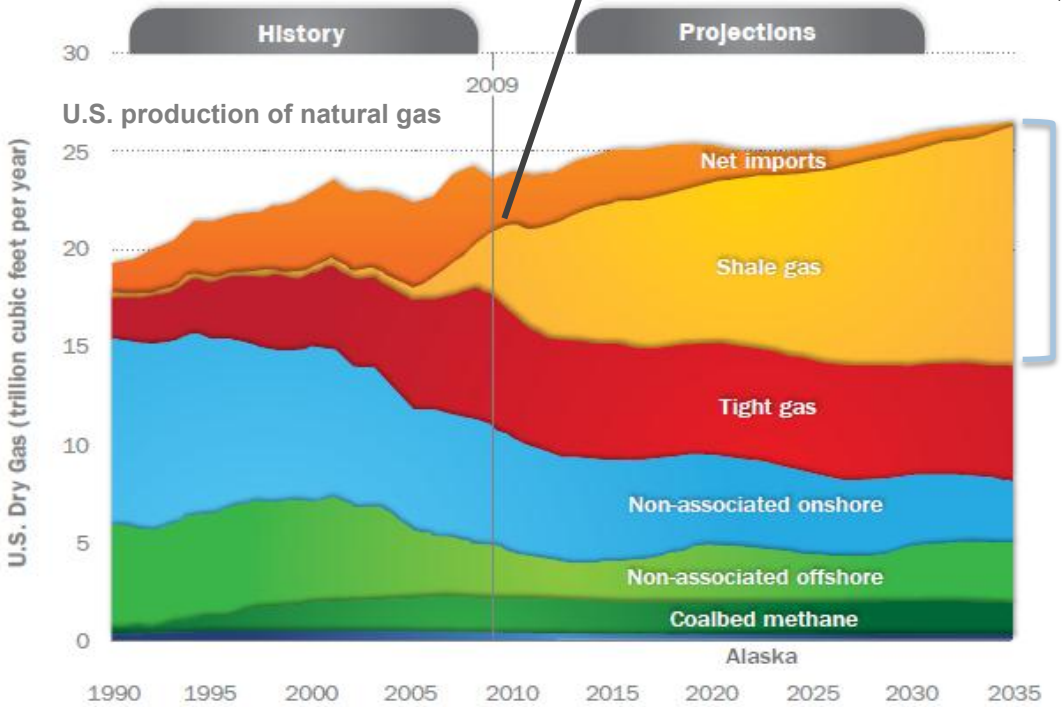
JOBS NGV

The US is awash in natural gas

- NG production grew 17%/year, 2000–2006; 48%/year, 2006–2010
- Production expected to triple, 2009–2035 (EIA), but technically recoverable resource base is uncertain
- Uncertain energy and environmental implications of new technologies
- Shale gas offsetting declines in imports and conventional gas production
- Employment in shale gas production may differ from conventional NG and oil production



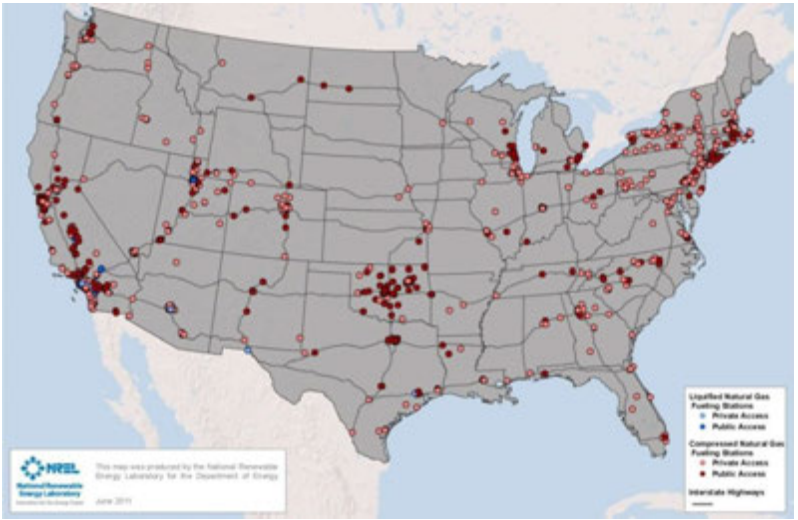
R. Newell, Dec. 16, 2010.



45%

Fueling is unavailable in many locations

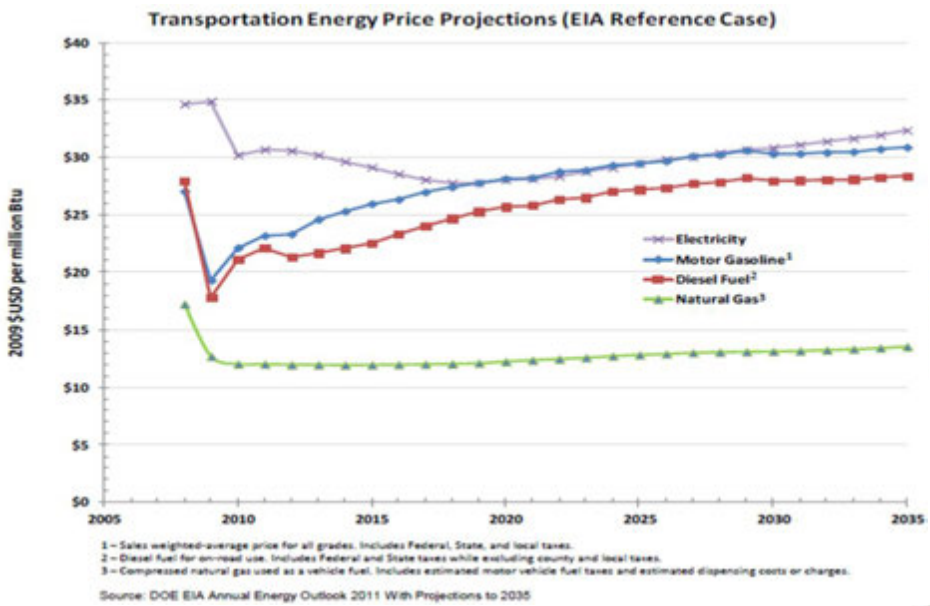
…but a step change may be underway

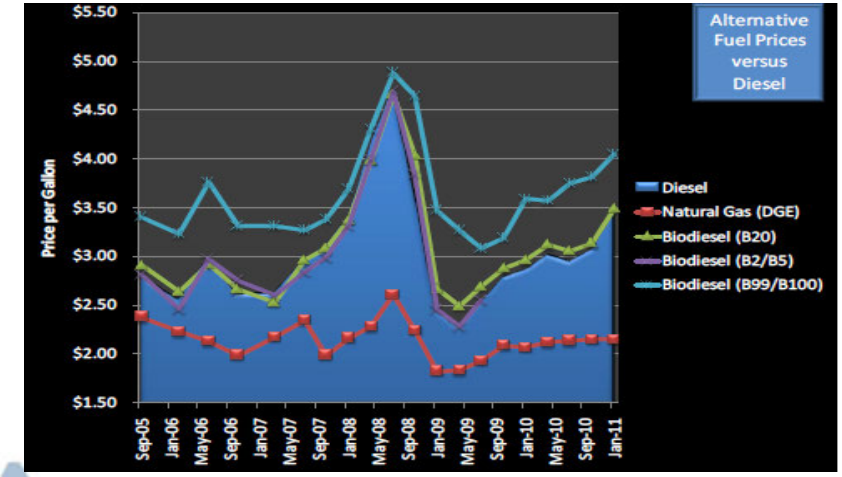


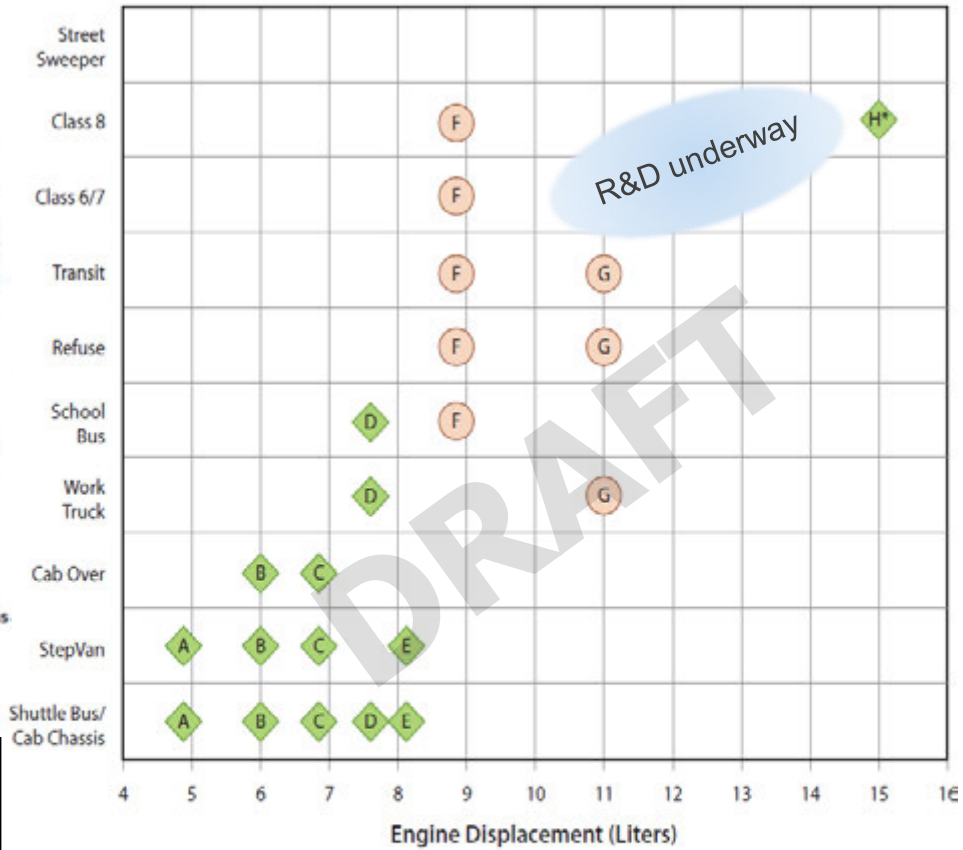
Melendez, M. and M. Mintz, *Natural Gas Alley*, Clean Cities Stakeholder Summit, Indianapolis, June 28, 2011.

- As of May 2011, 885 CNG and 44 LNG stations were in operation in the US
- Less than half (386 CNG and 17 LNG) were open to the public
- Clean Energy has announced plans for "America's Natural Gas Highway", with 150 LNG stations at Pilot Flying J Travel Centers within 2 years
- $150 million obtained from Chesapeake Energy plus another $300 million from Asian investment funds & other sources
- CNG stations also coming on line with assistance from Clean Cities, ARRA (~130 alone) and other sources.
- Encana, Chesapeake and other shale developers converting their own fleets and building stations
- Many Clean Cities involved in local efforts to encourage fleet conversions and station development

Fuel cost savings raise attractiveness of NG OEM & conversion offerings







Melendez, M. and M. Mintz, *Natural Gas Alley*, Clean Cities Stakeholder Summit, Indianapolis, June 28, 2011.

Natural gas industry (excluding vehicle conversion) accounts for 2.1% of US employment

- Industry includes significant portions of:
  - NGL extraction (100%)
  - NG distribution (100%)
  - NG pipeline transport (including storage, 100%)
  - Extraction (72%)
  - Drilling & support (61%)
  - Pipeline construction (68%)
  - Manufacture of field machinery/equipment (65%)
  - Geophysical services, site preparation services
  - Compressor, pump, off-shore platform manufacturing
- Some states are particularly dependent on NG

WY	20.9%	62,000
LA	13.7%	267,000
TX	12.0%	1,270,000
OK	10.9%	175,000
CO	5.9%	138,000
NM	5.4%	46,000
UT	3.1%	39,000

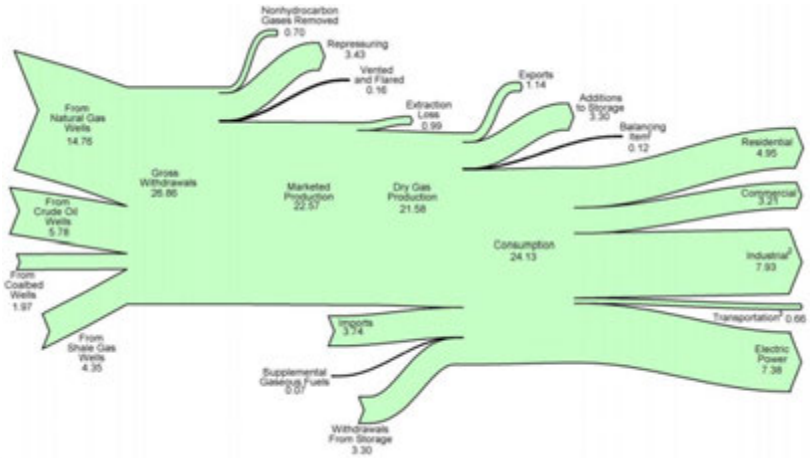
- Others have significant NG employment

CA	1.7%	255,000

Natural Gas Impact on the U.S. Economy

	Direct	Indirect & Induced	Total
Employment (Thousands)			
2006	517	1,902	2,420
2007	587	2,106	2,693
2008	622	2,206	2,828
Value Added (Billions of dollars)			
2006	147	184	331
2007	162	202	364
2008	172	213	385
Labor Income (Billions of dollars)			
2006	60	97	157
2007	66	107	173
2008	70	111	181

IHS/Global Insight, *The Contribution s of the Natural Gas Industry to the U.S. National and State Economies,* Sept 2009.



JOBS NGV is being built off JOBS FC platform

* * * FORKLIFT FUEL CELLS (PEM) INPUTS * * *

CLEAR ALL USER-SPECIFIED

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 only at this time.

Step 2 - Forklift Fuel Cell System Sizes

Choose system size(s)	***User-specified value***	**Default**	**Notes**	**Value used in mode**
Class I/II: forklift fuel cell size (average kW/unit)	5	10	Range of 5-15; Average of 10	**5**
Class III: forklift fuel cell size (average kW/unit)		2	Range of 1-3; Average of 2	**2**

Step 3 - Forklift Fuel Cell Units Manufactured, Exported, and Imported

Step 3a - Select Manufacturing Value Type	**Selection will impact entries in Step 3c**	An estimated 5,000-15,000 forklift units (for each Class) may be shipped each year (2015-2020) which are intended for multi-shift operations. Please see Reference sheet for estimated potential Forklift shipments by class and year (National).
Enter mfg. values in 3c as...Units manufactured in region or Percentage of est. potential annual forklift	Units manufactured in region	
Step 3b - Select Exports Value Type	**Selection will impact entries in Step 3c**	Exports are those systems which are manufactured in the United States but shipped out of the United States. Exported units will not impact Infrastructure, Fuel, or Maintenance results.
Enter Exports in 3c as . . . Units exported out of region or Percentage exported out of region ?	<Please select>	

Step 3c - Enter Regional Class I/II units		**Manufactured in region (units)**	**Exported out of region (units)**	**Imported into region (units only)**	**Manufactured in region (units)**	**Exported out of region (units)**	**Imported into region (units)**
Class I/II	**Year**	***User-specifed value***	***User-specifed value***	***User-specifed value***	**Units used in model calculations**		
5kW Forklift Fuel Cell Units Manufactured, Exported and Imported for USA-National	**2015**	3,000			**3,000**	**-**	-
	2016	3,000			**3,000**	**-**	-
	2017	3,000			**3,000**	**-**	-
	2018	3,000			**3,000**	**-**	-
	2019	3,000			**3,000**	**-**	-
	2020	3,000			**3,000**	**-**	-

Step 3c - Enter Regional Class III units		**Manufactured in region (units)**	**Exported out of region (units)**	**Imported into region (units only)**	**Manufactured in region (units)**	**Exported out of region (units)**	**Imported into region (units)**
Class III	**Year**	***User-specifed value***	***User-specifed value***	***User-specifed value***	**Units used in model calculations**		
2kW Forklift Fuel Cell Units Manufactured, Exported and Imported for USA-National	**2015**				**-**	**-**	-
	2016				**-**	**-**	-
	2017				**-**	**-**	-
	2018				**-**	**-**	-
	2019				**-**	**-**	-
	2020				**-**	**-**	-

OPTIONAL USER INPUT FIELDS

Summary

JOBS FC

- 1.0 beta test (gross jobs)
  - Forklifts
  - Cell tower backup power
- 2.0 beta test (net jobs)
  - Forklifts
  - Cell tower backup power
  - PAFC prime power
  - MCFC prime power

JOBS NGV

- Economic sector analysis
- Platform modification, data collection
  - OEM LDVs, HDVs
  - Conversions
  - Fueling infrastructure
  - CNG & LNG

Thank you!

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