SA 035

EMPLOYMENT IMPACTS OF HYDROGEN AND FUEL CELL TECHNOLOGIES

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June 8, 2016

RCF ECONOMIC & FINANCIAL CONSULTING, INC.

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OVERVIEW

Timeline

Start date: FY 2016

End date: FY 2018

Budget

FY16 DOE Funds: $250k

Includes partners and model acquisition

Barriers

Future Market Behavior (A)

Stove-piped/Siloed Analytical Capability (B)

Inconsistent Data, Assumptions and Guidelines (C)

Insufficient Suite of Models and Tools (D)

Funded partners/collaborators

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RCF Economic & Financial Consulting

Valerie Taylor, consultant

Energetics

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RELEVANCE

Modeling & Analysis

- **Update** 2008 DOE Report to Congress, *Effects of a Transition to a Hydrogen Economy on Employment in the United States*
- Consider **additional applications** of fuel cells and model effects between industries and regions
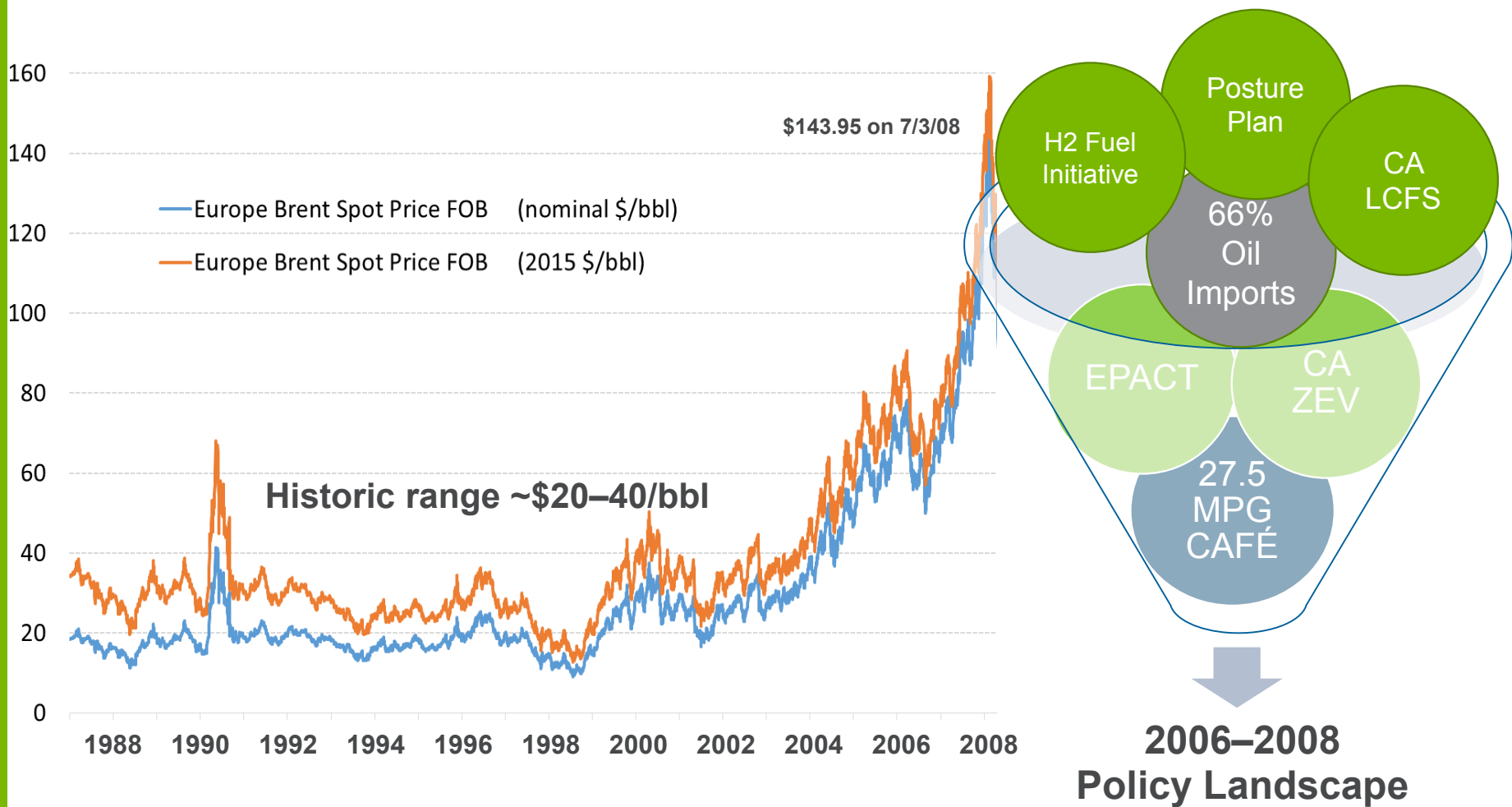
Stakeholder Support

- Work with stakeholders to determine consensus estimates of **current and future prospects** for H_2 and FC deployment
- Report analytical results to **demonstrate benefits** of hydrogen and fuel cells

Policy Implications

- Estimate net impacts on **national and regional employment** under alternative H_2 and FC scenarios
- Identify implications of scenario results on **work force development**

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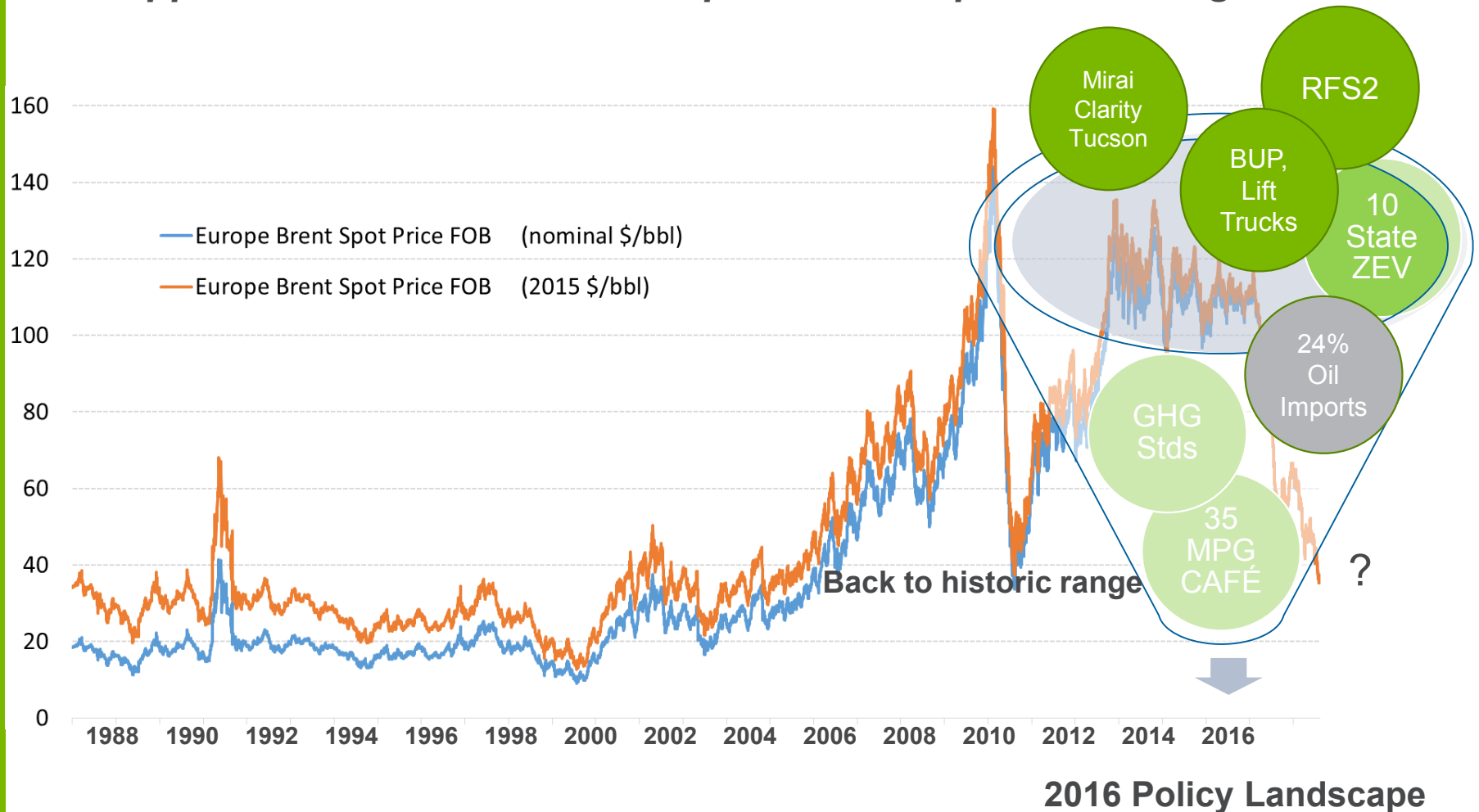
WHY UPDATE REPORT TO CONGRESS?

Oil price, production and policies looked very different in 2006–2008

$143.95 on 7/3/08

— Europe Brent Spot Price FOB (nominal $/bbl)
— Europe Brent Spot Price FOB (2015 $/bbl)

Historic range ~$20–40/bbl

H2 Fuel Initiative

Posture Plan

CA LCFS

66% Oil Imports

EPACT

CA ZEV

27.5 MPG CAFÉ

2006–2008 Policy Landscape

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MARKETS, TECHNOLOGIES & POLICIES HAVE EVOLVED

More applications, more market competition, less price advantage

— Europe Brent Spot Price FOB (nominal $/bbl)

— Europe Brent Spot Price FOB (2015 $/bbl)

Back to historic range

Mirai Clarity Tucson

RFS2

BUP, Lift Trucks

10 State ZEV

24% Oil Imports

GHG Stds

35 MPG CAFÉ

?

2016 Policy Landscape

"We can't have an energy strategy for the last century that traps us in the past. We need an energy strategy for the future – an all-of-the-above strategy for the 21st century that develops every source of American-made energy."

— President Barack Obama, March 15, 2012

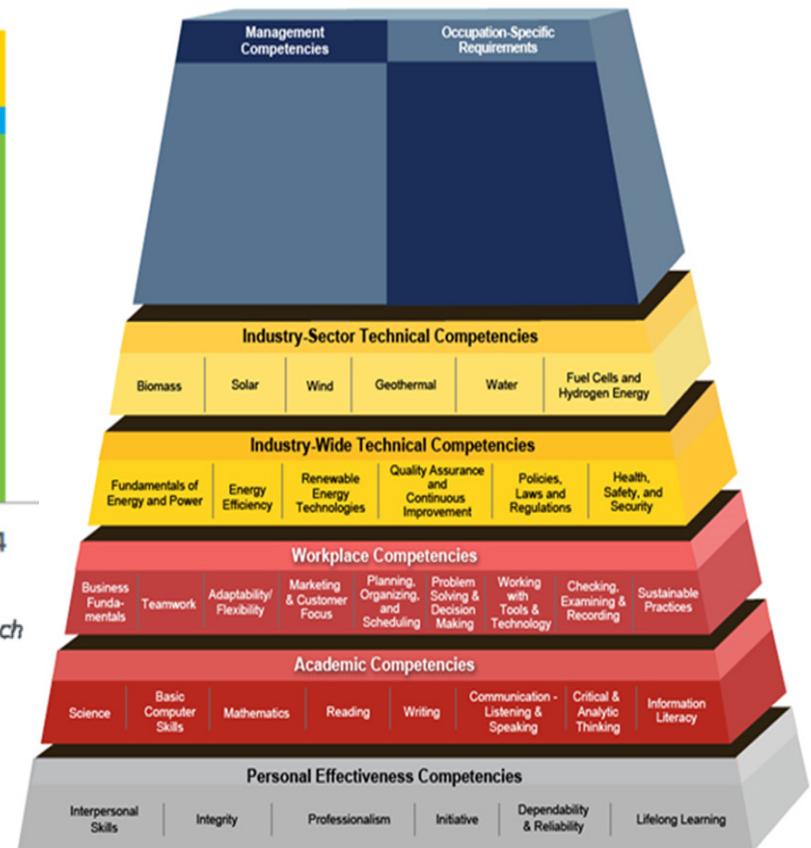# *MORE EMPHASIS ON NON-HIGHWAY APPLICATIONS AND OCCUPATION ANALYSIS*

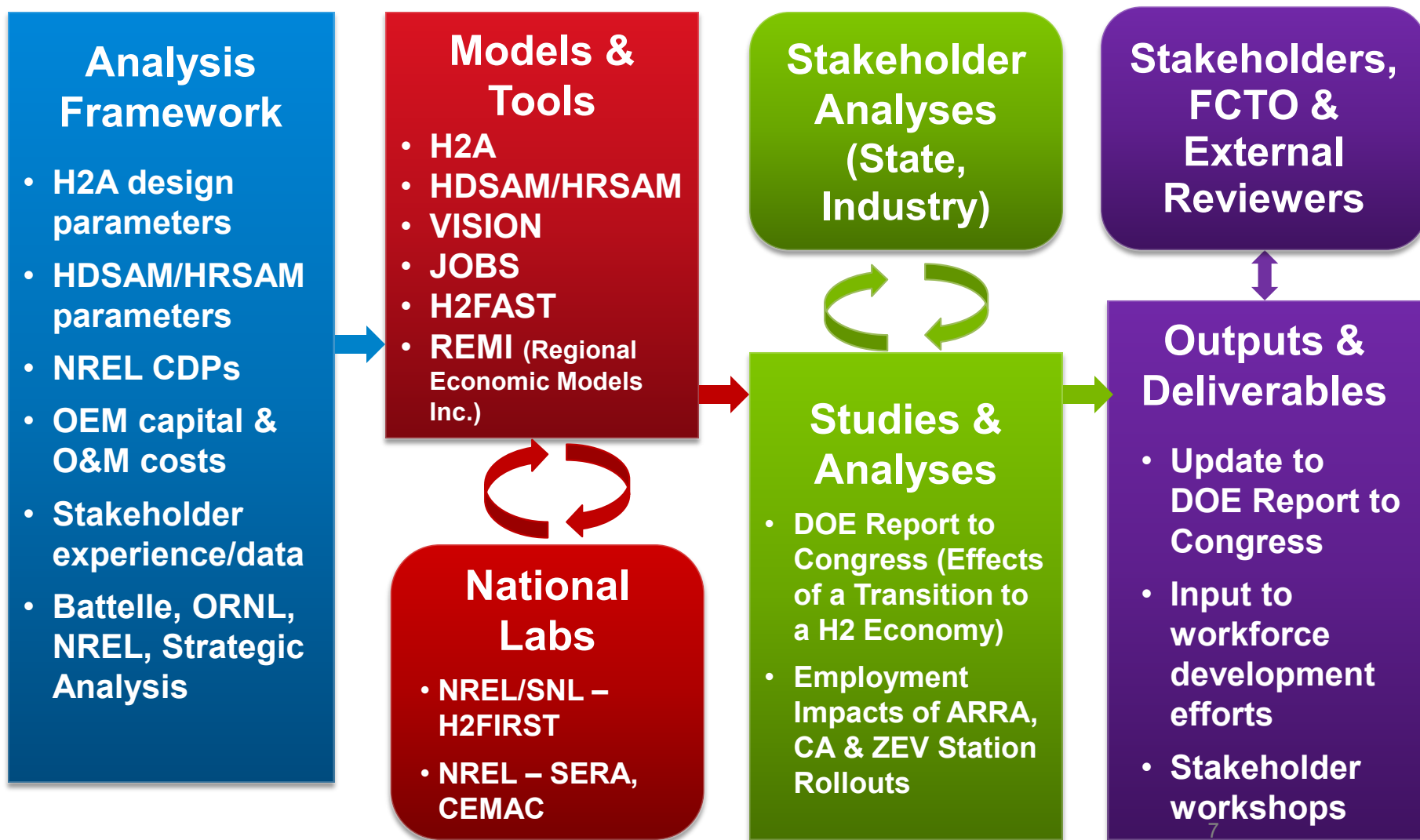## Fuel Cell Systems Shipped Worldwide by Application

>50,000 Fuel Cells Shipped in 2014

Legend: Stationary, Transportation, Portable
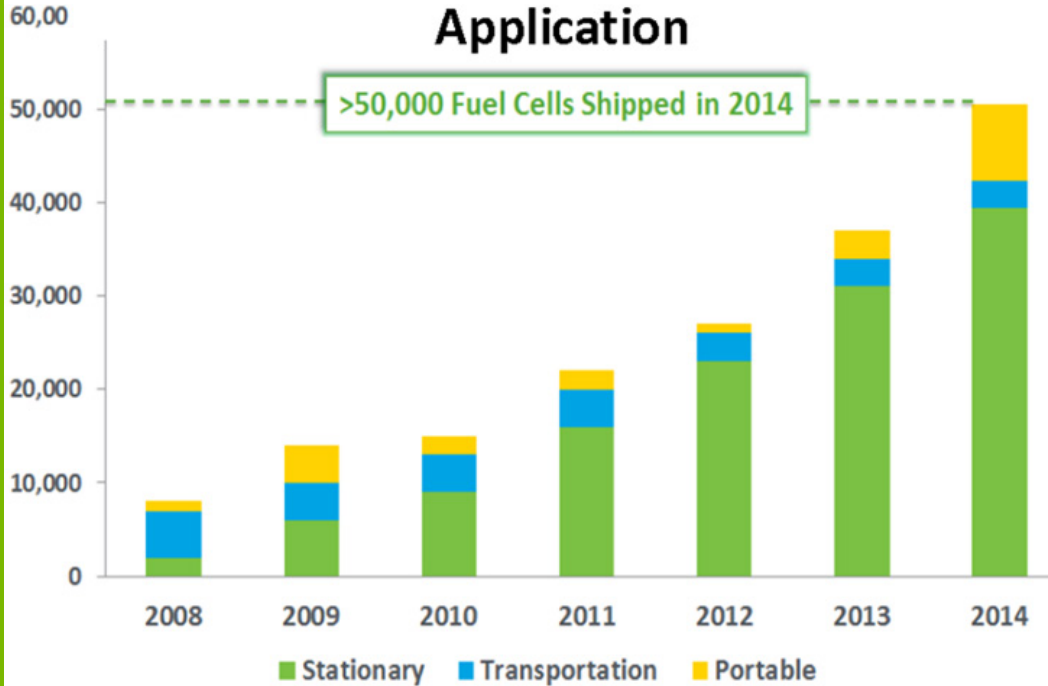
Source: Navigant & E4tech

- Consistent ~**30% annual growth** since 2010
- **Global Market Potential in 10- 20 year** → $14B – $31B/yr for stationary power
$11B /yr for portable power
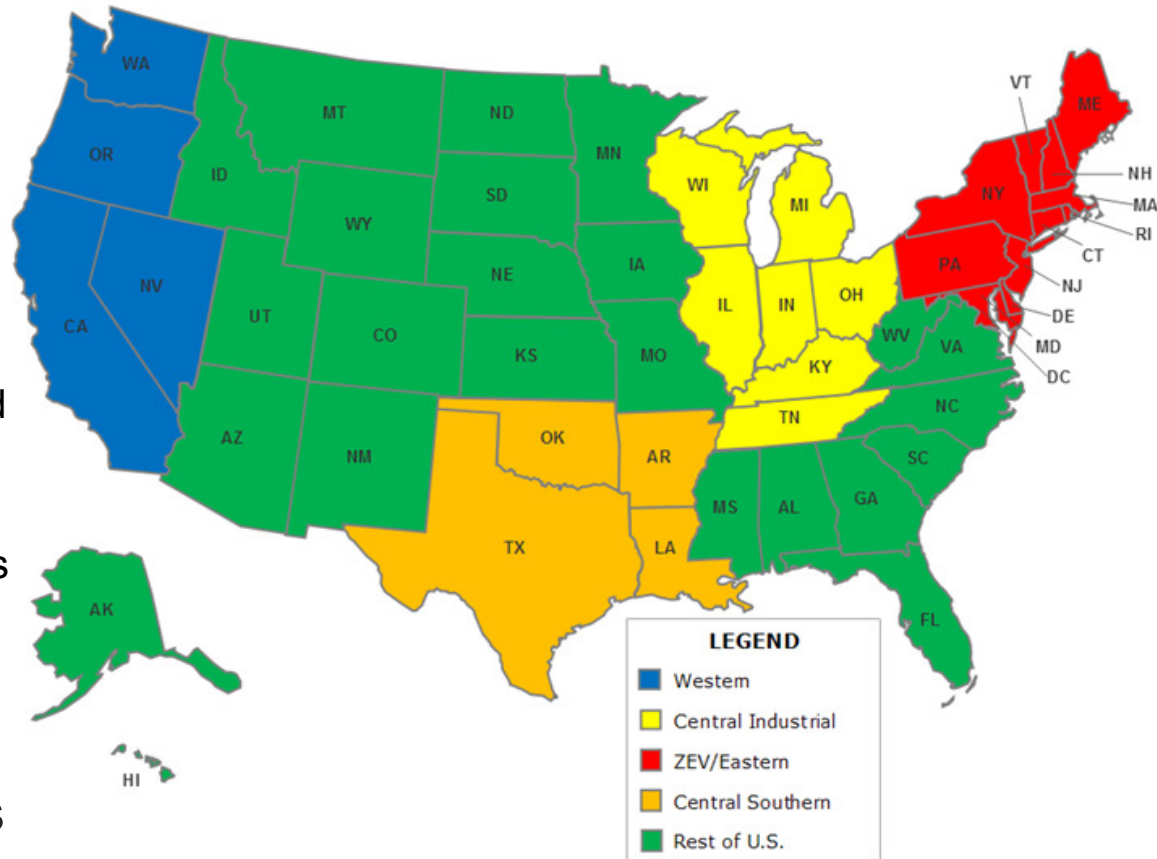$18B – $97B/yr for transportation

Industry and Occupational Analyses

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Employment Impacts of Hydrogen and Fuel Cell Technologies

Analysis Framework

- **H2A design parameters**
- **HDSAM/HRSAM parameters**
- **NREL CDPs**
- **OEM capital & O&M costs**
- **Stakeholder experience/data**
- **Battelle, ORNL, NREL, Strategic Analysis**

Models & Tools

- **H2A**
- **HDSAM/HRSAM**
- **VISION**
- **JOBS**
- **H2FAST**
- **REMI** (Regional Economic Models Inc.)

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- **NREL/SNL – H2FIRST**
- **NREL – SERA, CEMAC**

Stakeholder Analyses (State, Industry)

Studies & Analyses

- **DOE Report to Congress (Effects of a Transition to a H2 Economy)**
- **Employment Impacts of ARRA, CA & ZEV Station Rollouts**

Stakeholders, FCTO & External Reviewers

Outputs & Deliverables

- **Update to DOE Report to Congress**
- **Input to workforce development efforts**
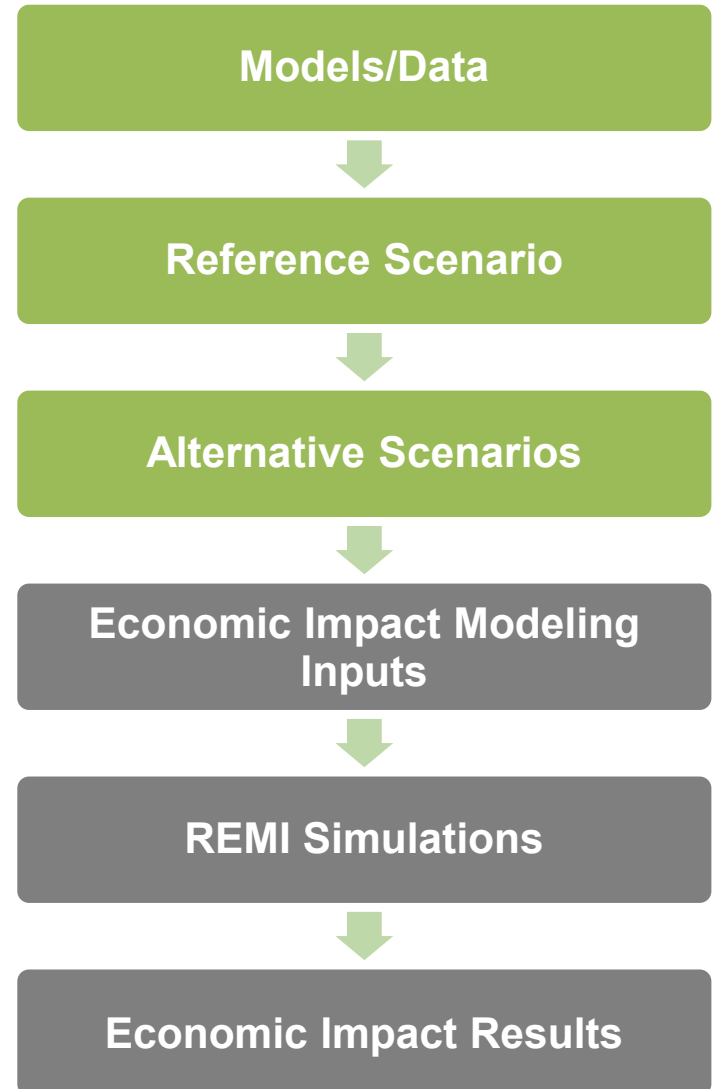- **Stakeholder workshops**

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REMI PI+ (POLICY INSIGHT) ECONOMIC IMPACT MODEL

- Integrated approach:
  - Input-Output: transactions between industries
  - General Equilibrium: supply-demand balance (long-run changes in prices, production, consumption, etc.
  - Econometric Analysis: advanced statistical techniques
  - Economic Geography: industry clustering & labor market access affect inter-regional trade, productivity, competitiveness

- 160 industries
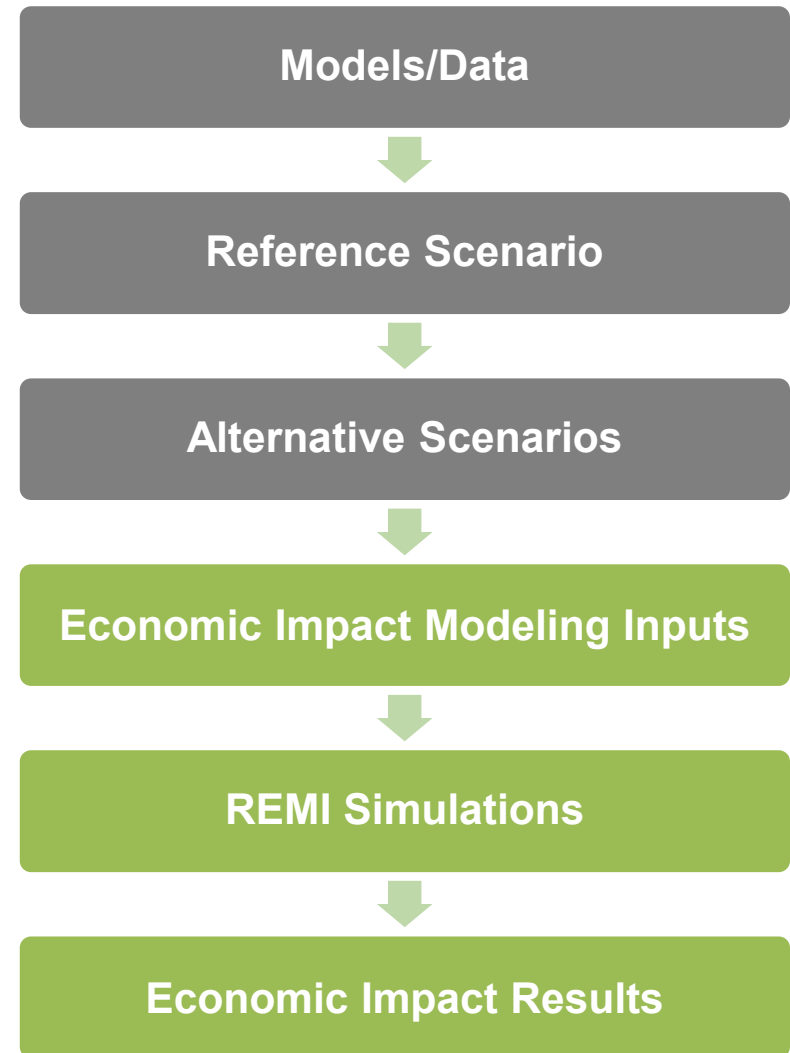- 95 occupational categories
- 4 regions plus U.S.

LEGEND

- ■ Western
- ■ Central Industrial
- ■ ZEV/Eastern
- ■ Central Southern
- ■ Rest of U.S.

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MODELS/DATA & SCENARIOS

- Review/compare models and data sources

- Estimate market penetration for each technology modeled

- Define needed infrastructure

- Create custom industries when appropriate

- Determine changes by region for each scenario

- Outreach to stakeholders (webshop)

Models/Data

↓

Reference Scenario

↓

Alternative Scenarios

↓

Economic Impact Modeling Inputs

↓

REMI Simulations

↓

Economic Impact Results

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ECONOMIC IMPACT MODELING

- Plus (+) examples
  - Transportation FCs and related components
  - Stationary FCs and related components
  - H_2 production and facility construction

- Minus (-) examples
  - Conventional powertrain and components
  - Displaced gasoline, other fuels and electricity

- Results
  - Differences in economic metrics relative to reference scenario
  - Employment, output, earnings, etc.
  - By industry, occupation, region

Models/Data

↓

Reference Scenario

↓

Alternative Scenarios

↓

Economic Impact Modeling Inputs

↓

REMI Simulations

↓

Economic Impact Results

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FY 2016 MILESTONES

Milestone	Quarter	Status
Contract and workscope development	1	✔
Reference scenario development, stakeholder outreach & workshop	2	✔
Model acquisition, sector and occupational analysis (SMART)	**3**	✔
Review and modification of industry cost vectors	4	9/30/16

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WEBSHOP FACILITATED STAKEHOLDER INPUT TO REFINE ASSUMPTIONS AND SCENARIOS

- 30 web-enabled attendees:
  - Study benefit: inform federal R&D investment, state & local workforce development, industry planning
  - Webshop process very useful tool
- Overview presentations:
  - 2008 Report to Congress
  - Rationale for revisiting study
  - Economic modeling
  - Scenario options
- Interactive discussions:
  - Benefits and key issues
  - Data and assumptions
- Condensed from 1-day onsite to 3-hr facilitated discussion
- Followup survey + future webshops

Economic Impact of Hydrogen and Fuel Cell Deployment Workshop

Join us for a workshop to help guide economic analyses of hydrogen and fuel cell deployment.

Invited participants will convene to review the U.S. Department of Energy's *Report to Congress on Effects of a Transition to a Hydrogen Economy on Employment in the United States* and current plans for updating and expanding this work. Breakout groups will provide feedback on enhancing the proposed analytic framework, incorporating consensus data and assumptions, and identifying issues and opportunities that should be addressed in the analysis.

Event Details

April 28, 2016
8:30 a.m. – 5:00 p.m. CDT
Argonne National Laboratory
Bldg. 240, TCS Conference Center
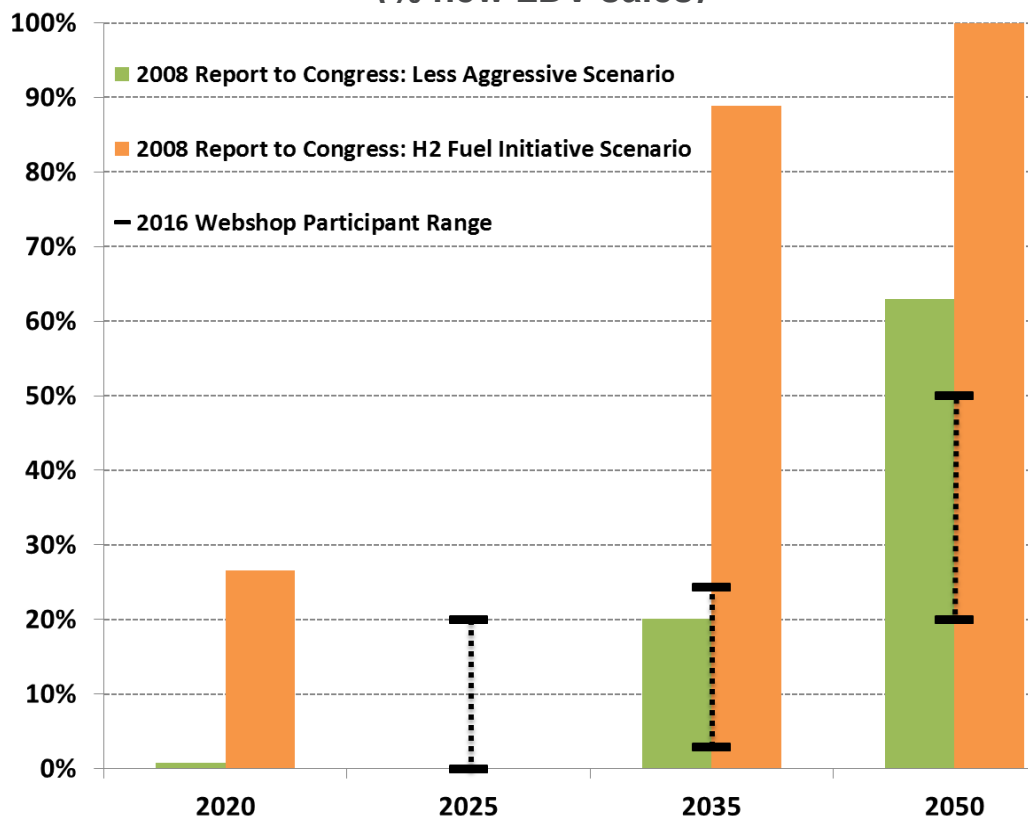9700 S. Cass Ave.
Lemont, IL 60439

If you have any questions or require additional details, please contact Marianne Mintz at 630-252-5627.

Register by April 8

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WEBSHOP: SCENARIO ASSUMPTIONS & TAKEAWAYS

- **Energy price** most important macro issue, followed by climate change/GHG emissions & pollutant regulations. EIA/AEO best source.

- **Playing field relatively level** in current emerging market. With deployment, market entry/growth become more difficult & foreign competition increases.

- Hydrogen will be produced from **lowest cost option** (not technology preferred), NG unless policies drive nuclear or coal. State policies/ cultures may favor different options.

- Viability of FCEVs greatest where **state/ regional incentives** exist, but **fueling infrastructure** critical for OEMs to supply vehicles. Cost, utility support & public education/familiarity also key.

FCEV Market Share, 2020–2050
(% new LDV sales)

- 2008 Report to Congress: Less Aggressive Scenario
- 2008 Report to Congress: H2 Fuel Initiative Scenario
- 2016 Webshop Participant Range

- FCEV penetration depends on **oil & electricity price** + **government infrastructure investment**. In near- to mid-term, regulations are driving force (with regional/cultural influence) followed by OEM & foreign strategies.

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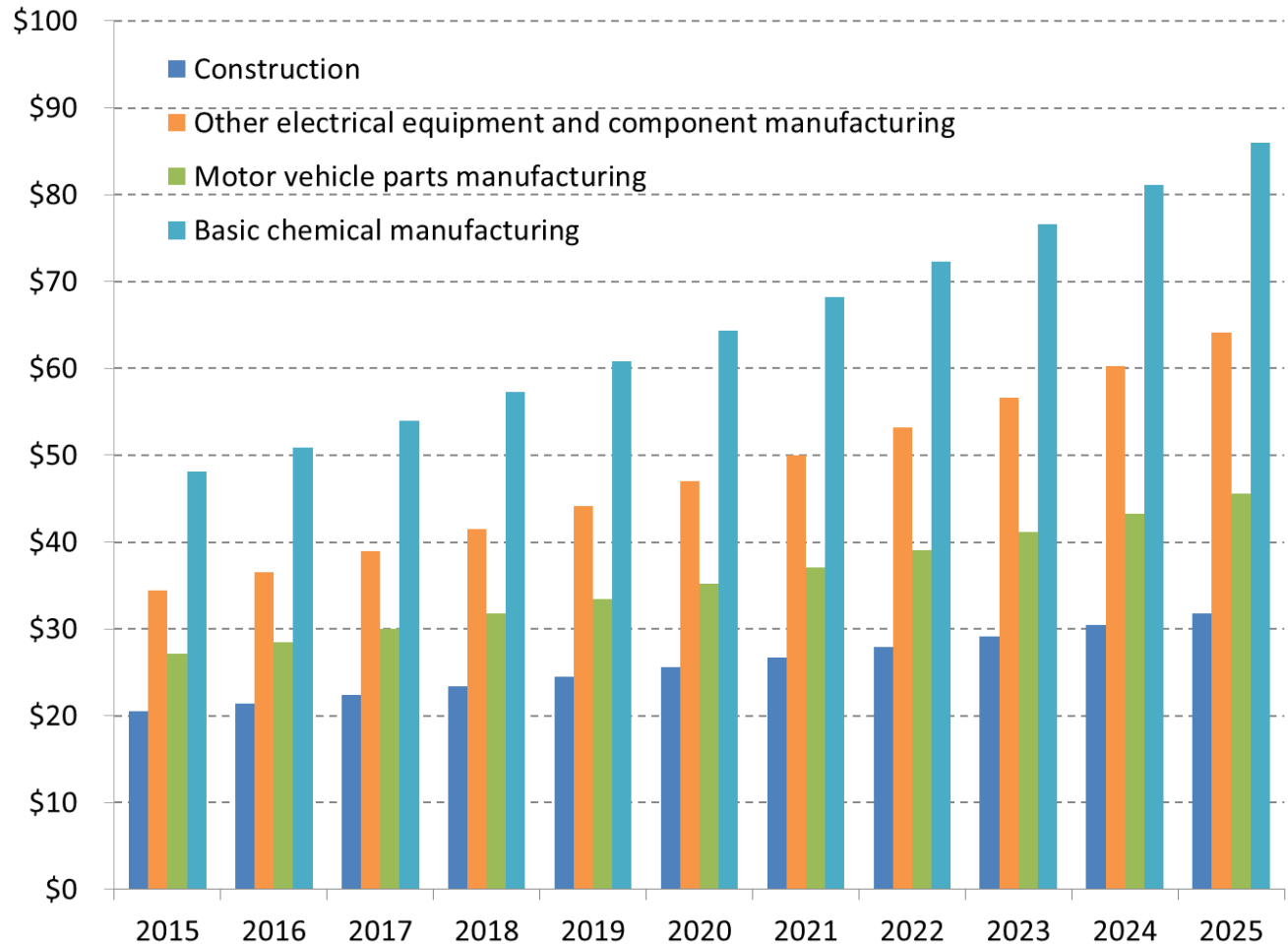# REGIONS DIFFER IN MIX & GROWTH OF JOBS IN SELECT OCCUPATIONS

Jobs by Occupation, Western & Central Industrial Regions, 2015–2025
(million jobs, all industries and compound annual growth rate)
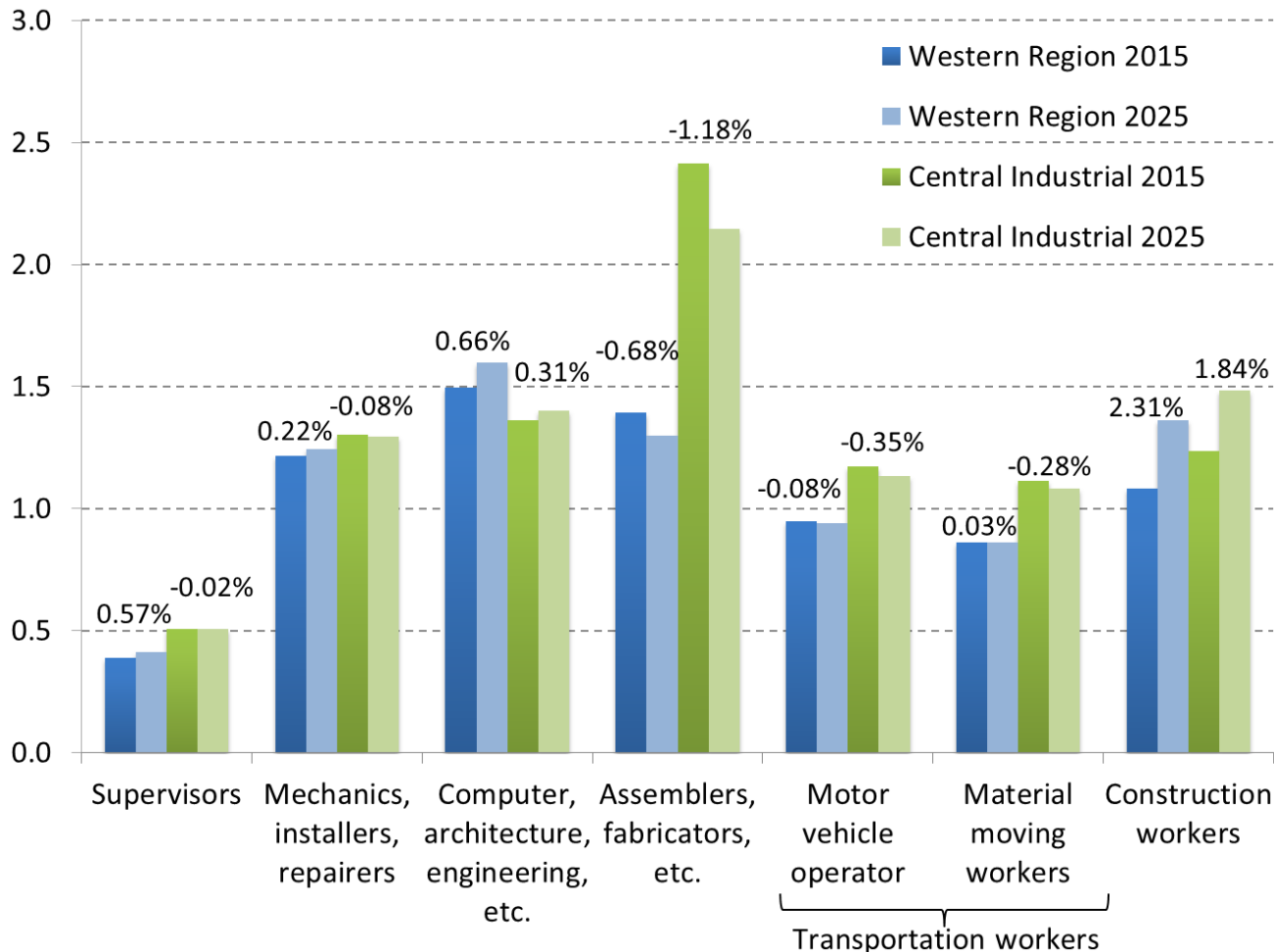
- Initial conditions based on Bureau of Labor Statistics, University of Michigan forecasts

- Western region has more uniform occupational mix

- Most impacts likely in 7 occupational categories (shown) comprising ~ 25% of jobs in each region

- Transportation workers: near even split between motor vehicle operation & material handling

- Largest growth in construction, especially Western Region

Source: REMI PI+ v1.7.11

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INDUSTRIES DIFFER IN WAGES & WAGE GROWTH

- Chemical manufacturing most highly paid of industries shown

- Wages expected to grow nominally in next decade for all industries shown

- Wages for electrical equipment & component manufacturing grow most (86%)

- Wages for construction grow least (55%)

**Average Hourly Wage in Four Industries
Western Region (initial conditions, current dollars)**

Legend:
- Construction
- Other electrical equipment and component manufacturing
- Motor vehicle parts manufacturing
- Basic chemical manufacturing

Source: REMI PI+ v1.7.11

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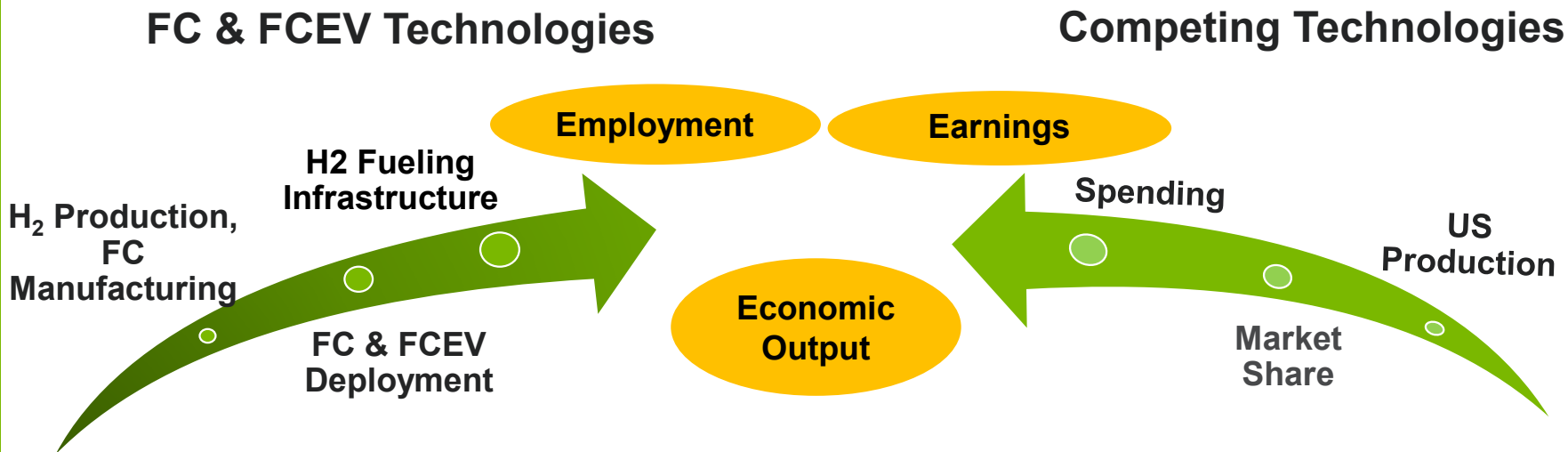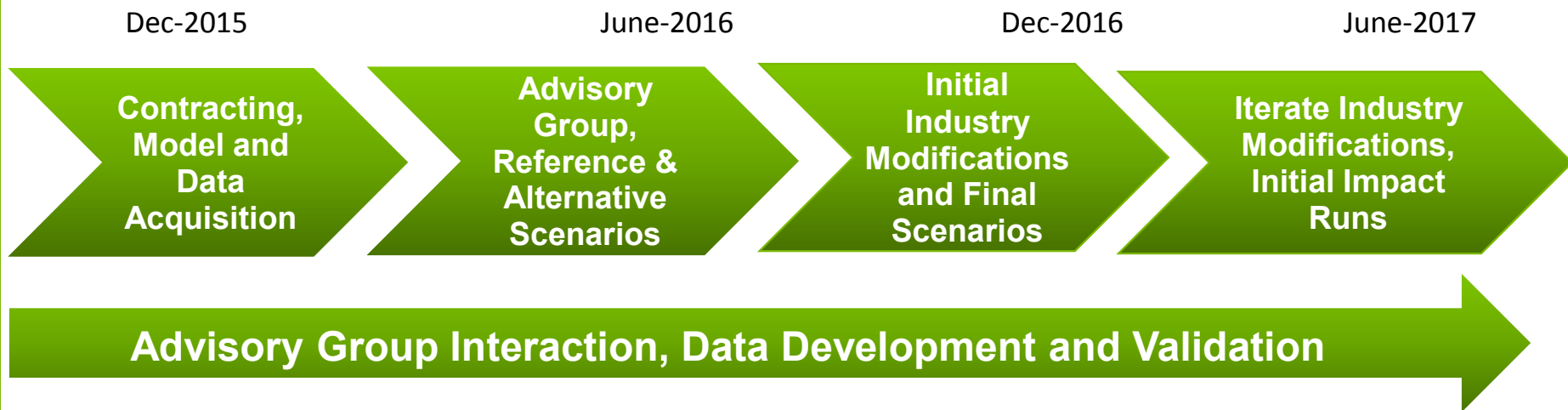# *COLLABORATORS PROVIDE KEY ADVICE/EXPERTISE*

Advisory Group

- Public agencies (CARB, CaFCP, CCAT, OFCC)
- Fuel cell and hydrogen suppliers
- Researchers

Assistance/role

- Defaults (data/analyses)
- Scenarios
- Future directions/needs
- Review

Collaborator	FY 2016 Role
Argonne	Management and coordination; engineering data collection and analysis; quality assurance; outreach; documentation
RCF	Economic data collection and analysis; quality assurance; code development and application; documentation
NREL	Scenario development
Valerie Taylor	Career pathways and workforce development
Energetics	Webshop planning, facilitation and documentation

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WORK FLOW FY 2016 – FY 2017

Dec-2015	June-2016	Dec-2016	June-2017
Contracting, Model and Data Acquisition	**Advisory Group, Reference & Alternative Scenarios**	**Initial Industry Modifications and Final Scenarios**	**Iterate Industry Modifications, Initial Impact Runs**

Advisory Group Interaction, Data Development and Validation

FC & FCEV Technologies

Competing Technologies

Employment

Earnings

H2 Fueling Infrastructure

Spending

H_2 **Production, FC Manufacturing**

US Production

Economic Output

FC & FCEV Deployment

Market Share

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SUMMARY

- **Relevance:** Update DOE 2008 Report to Congress. Fills gap/barrier in analysis portfolio.

- **Approach:** Input-output and general equilibrium modeling to capture long-run changes in employment, earnings, and other economic metrics from H2 and FC deployment.

- **Accomplishments and progress:**
  – April webshop with stakeholders addressed key issues/assumptions. Will guide scenario development.
  – Initial investigations of REMI reference forecasts.

- **Collaborations**: Active partnership between ANL & RCF with assistance from Energetics and Valerie Taylor. Extensive stakeholder interaction.

- **Future work**:
  – Develop scenarios and translate assumptions into economic impact modeling inputs
  – Select and modify industries in REMI
  – Continue validating and refining input data and assumptions.
  – Continue interaction with advisory group.

July 2008

Effects of a Transition to a Hydrogen Economy on Employment in the United States Report to Congress

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