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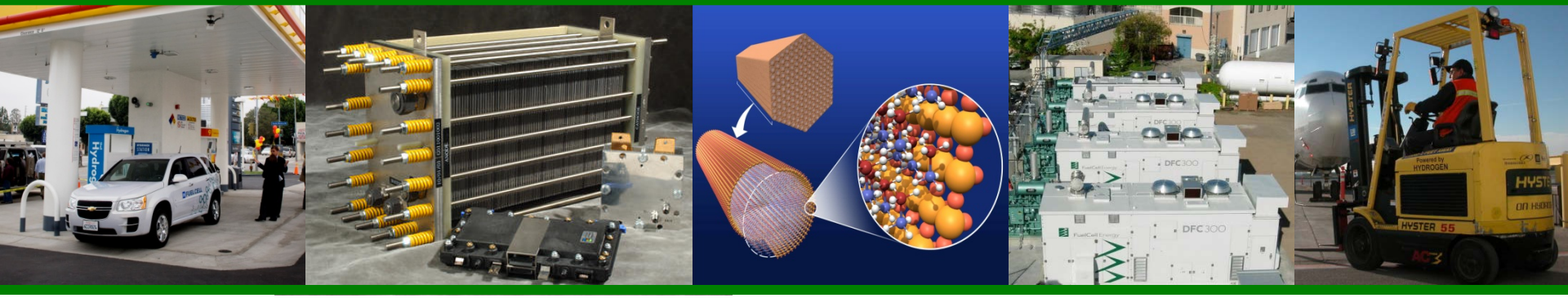

Systems Analysis

- Session Introduction -

Fred Joseck

2012 Annual Merit Review and Peer Evaluation Meeting

May 15, 2012

Goal & Objective

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***GOAL**: Provide system-level analysis to support infrastructure development and technology readiness by evaluating technologies and pathways, guiding the selection of RD&D technology approaches/options, and estimating the potential value of RD&D efforts.*

OBJECTIVES

- Assess the Life Cycle Analysis benefits of hydrogen and fuel cells for diverse applications
- Quantify the benefits of integrating hydrogen fuel production with stationary fuel cell power generation
  - Evaluate the potential for biogas, landfill gas, and stranded hydrogen streams
- Evaluate fueling station costs for early vehicle penetration
- Evaluate the use of hydrogen for energy storage and as an energy carrier
- Evaluate socio-economic benefits of the Program such as job creation

Challenges

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Market complexities and the need to ensure the availability, accuracy and consistency of data are key challenges

Future Market Behavior

- Understanding of drivers of fuel and vehicle markets needed for long-term projections.
- Models need to adequately address interactions - hydrogen/vehicle supply and demand.

Data availability, accuracy and consistency; Assumptions & Guidelines

- Analysis results depend on data sets and assumptions used.
- Large number of stakeholders and breadth of technologies - difficult to establish consistency.

Coordination of Analytical Capability

- Analytical capabilities segmented by Program element, organizationally by DOE office, and by performers/analysts.

Analysis Portfolio

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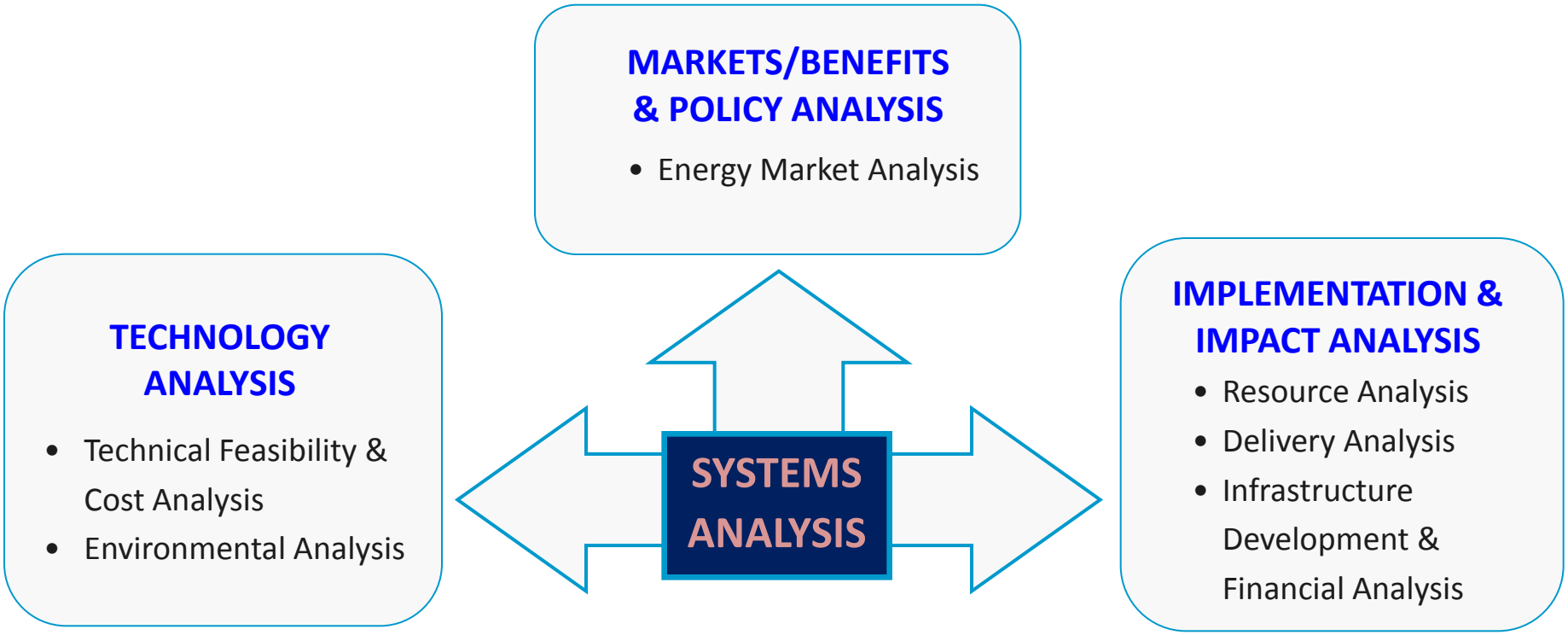
A variety of analysis methodologies are used in combination to provide a sound understanding of hydrogen and fuel cell systems and developing markets, as well as quantifying benefits, impacts, and risks of different hydrogen and fuel cell systems.



Systems Analysis url: http://www.hydrogen.energy.gov/systems_analysis.html

Analysis Project Overview

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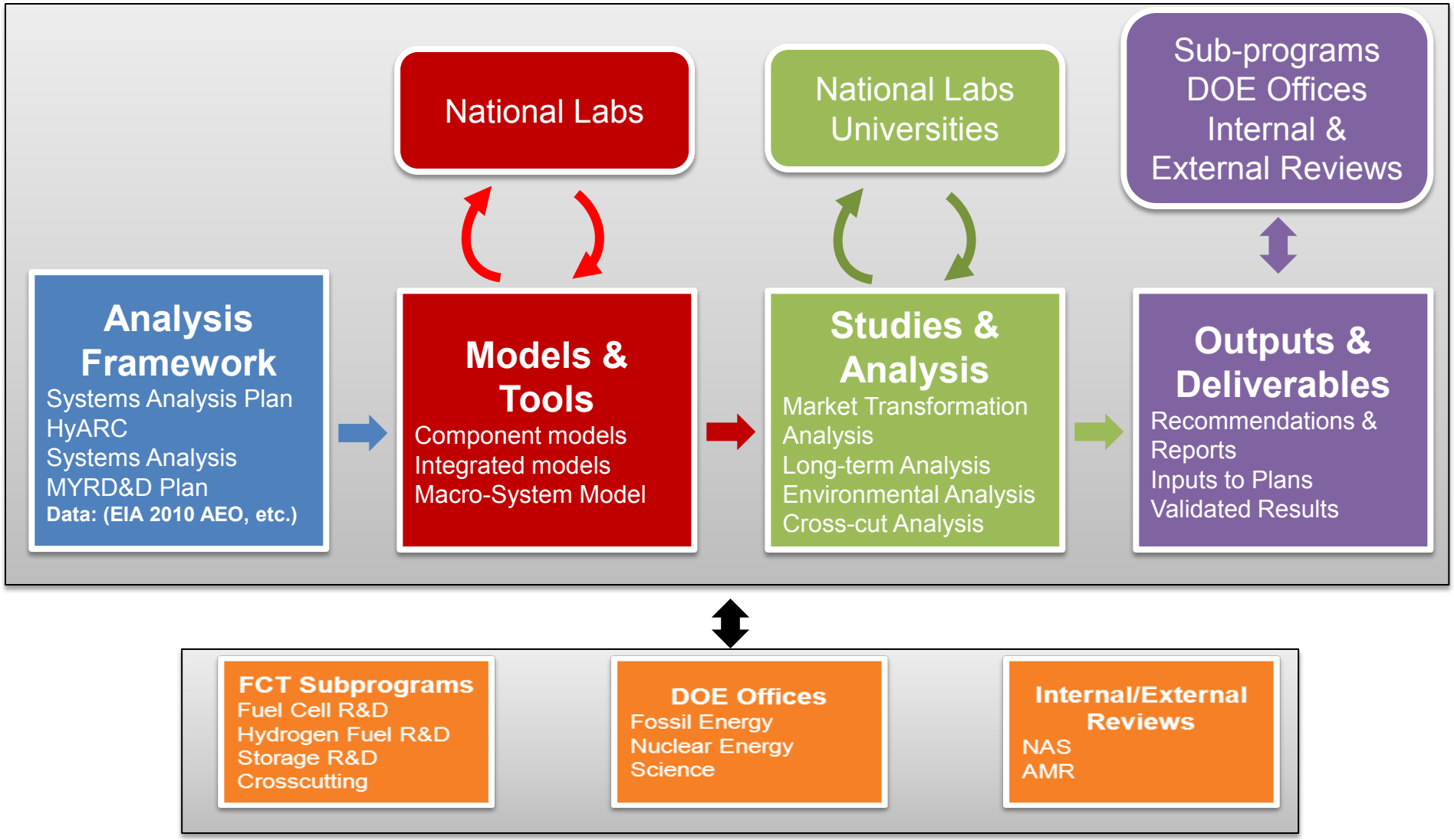
Systems Analysis process achieves consistent and transparent results.



Model/Analysis Application Matrix

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The FCT model and tool portfolio is well-equipped to tackle all the analysis tasks.

Analysis Category	Technology Analysis					Implementation & Impact Analysis					
Models \ Analysis Type	Stationary Power Generation	Pathway & Components Cost	H2 Quality Impact	WTW Energy & GHG Emissions	Vehicle Technology	Infrastructure & Resource Anal.	Consumer Choice	Vehicle Penetration	National Econ. Impacts	Policy Options	Employment
H_2A Production Cost Model[1]		✓									
H_2A Delivery Cost Model[1]		✓									
DTI/SA HyPRO[1]						✓					
Jobs Model (ANL)[1]											✓
SERA (NREL Infrastructure)[1]						✓					
HyDRA[1]						✓					
Autonomie					✓						
HyTrans[1]							✓	✓			
MA3T (ORNL)[1]							✓	✓			
GREET[1]				✓							
Macro-System Model (MSM) [1]	✓	✓	✓	✓		✓					
RCF Agent Based Model[1]						✓					
NEMS									✓	✓	
MARKAL									✓	✓	
FC Power Model	✓										

Notes:

1. The models/projects funded by Systems Analysis are referenced with a "1".
2. A hydrogen module is being added to the NEMS model in 2006.
3. Risk analysis is being incorporated in the models. The GREET Model has risk analysis capabilities.
4. The primary analysis focus of the models are illustrated in the matrix. However, the models are multi-functional and can be applied for other analyses in the matrix.

Legend

✓ **Models and Tools available for analysis**

Analysis Process Flow

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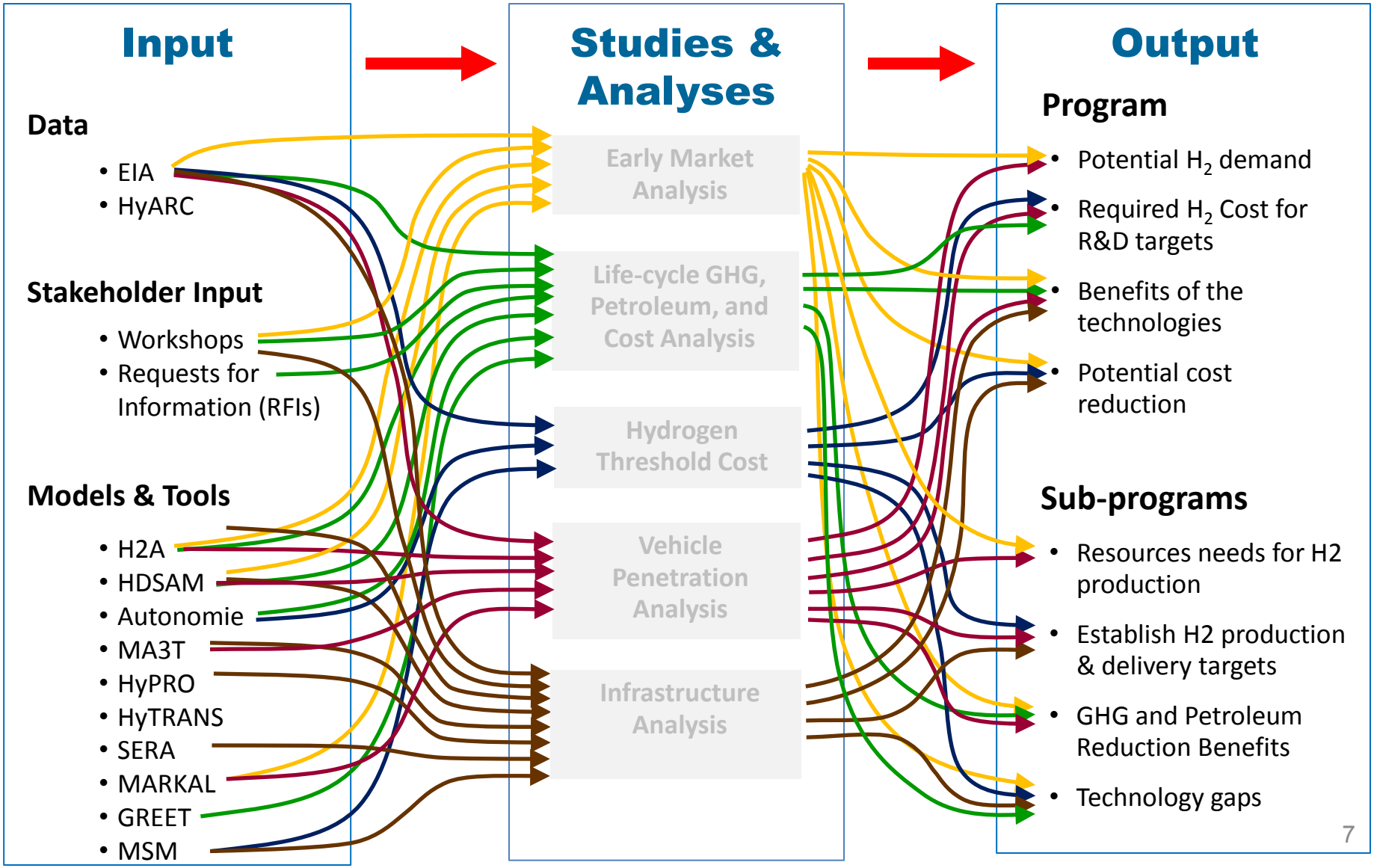
A portfolio of models and tools with transparent data for studies is used to influence Program direction and input.



Systems Analysis Budget

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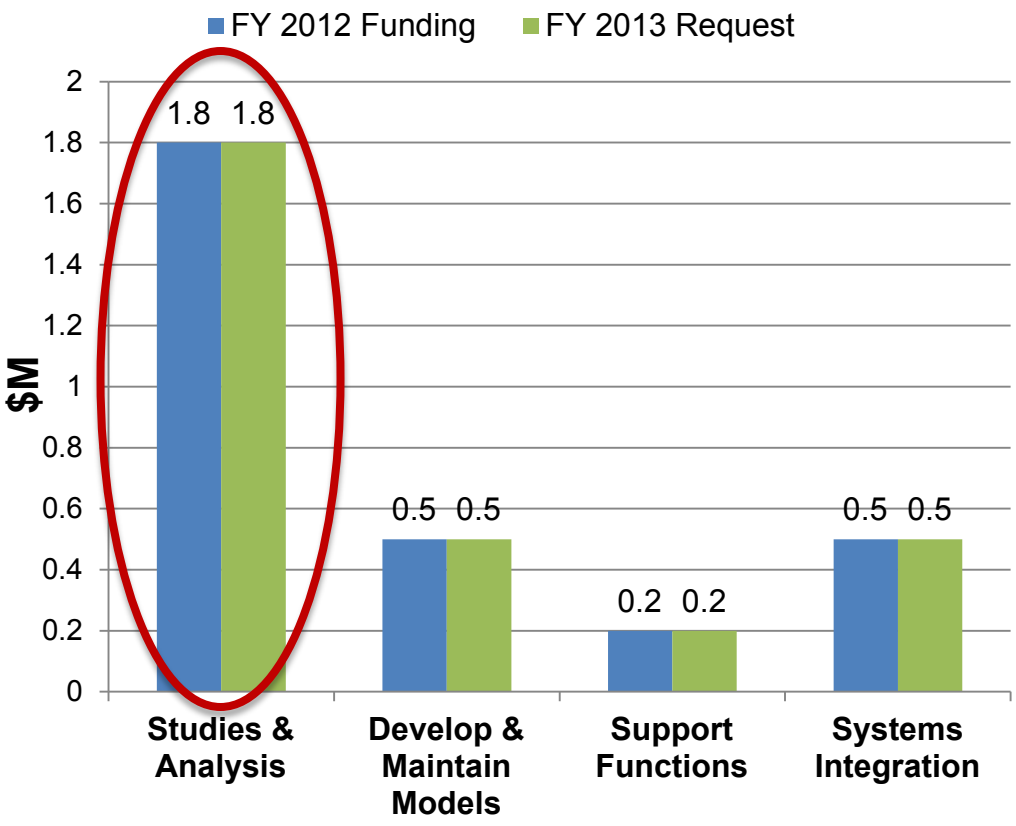
Determine technology gaps, environmental benefits, economic/jobs potential, and quantify technology advancement impacts

FY 2013 Request = $3.00 M

FY 2012 Appropriation = $3.00 M



EMPHASIS

- Update models for program analysis, using cost performance and environmental information.
- Assess market penetration, job creation, and opportunities for fuel cell applications in the near term.
- Assess gaps and drivers for early market infrastructure cost for transportation and power generation applications
- Assess business cases of biogas applications, infrastructure applications and integration in a domestic fueling network, and fuel cell Combined Heat and Power (CHP) applications.
- Assess synergies with other fuels and fueling systems.
- Validate analysis with input from subject matter experts, industry and peer review process.

Resource Analysis

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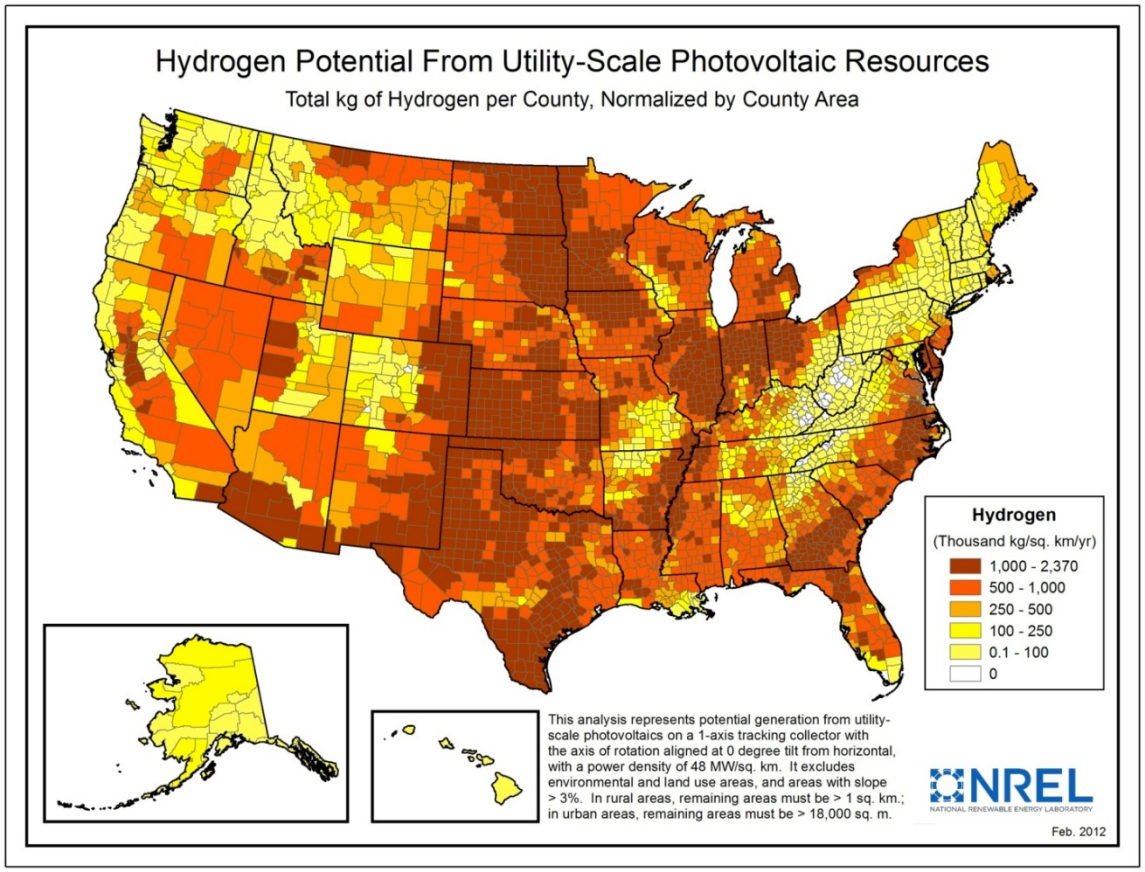
U.S. has an abundance of regionally distributed domestic resources to produce renewable hydrogen.



- **Renewable hydrogen can be produced from a variety of domestic resources including solar, wind and biomass.**
- **Abundance of resources for hydrogen production quantified below:**

Solar > Wind > Biomass

Source: NREL

- **Renewable resources are regionally concentrated which limit the distribution of the resultant hydrogen production to urban demand centers.**
- **Each resource faced with barriers such ecological, physical and environmental restrictions.**

Early Market Analysis: Station Cost Reduction

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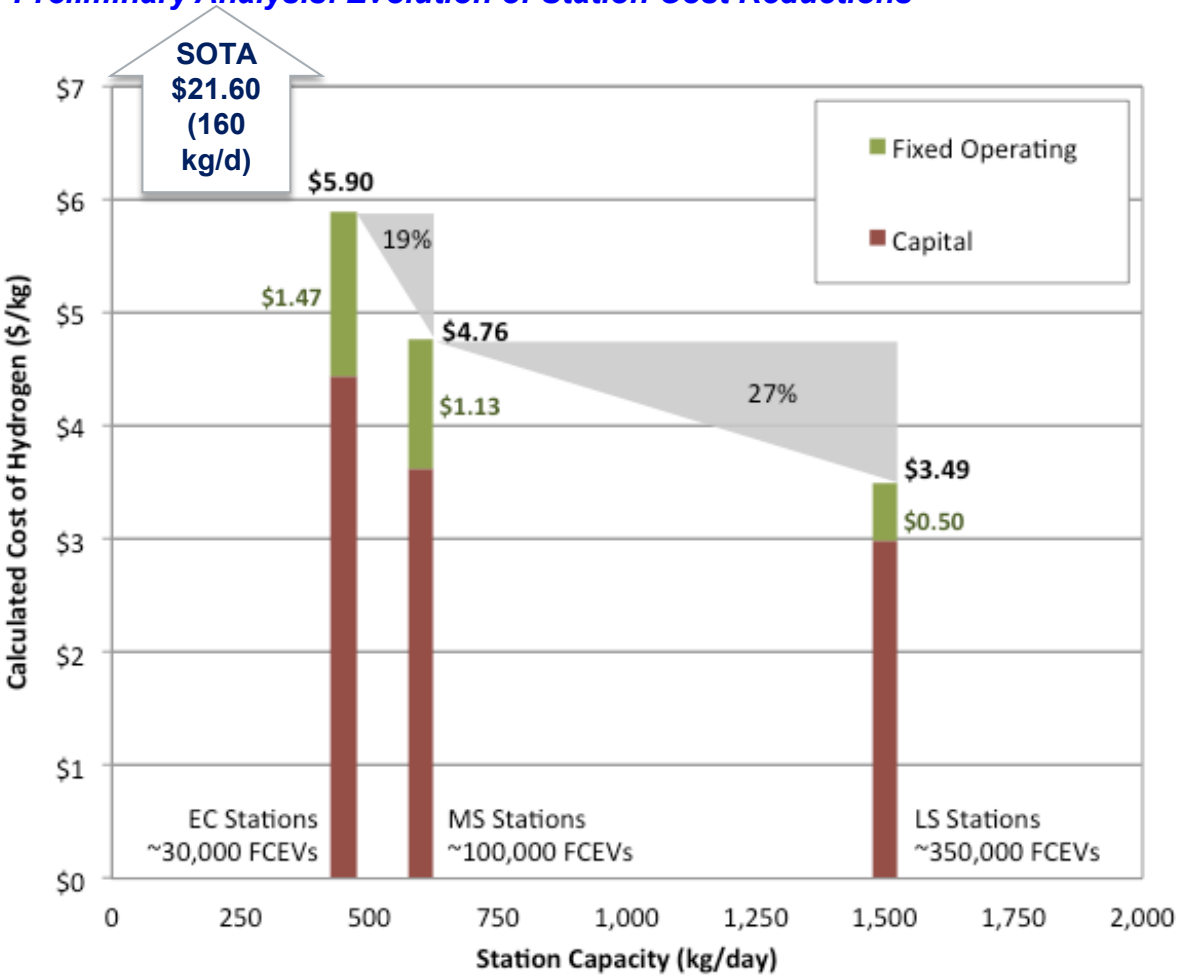
Stakeholders' input identified >80% reduction in hydrogen fueling station cost

Preliminary Analysis: Evolution of Station Cost Reductions



Source: NREL

- Preliminary results of Infrastructure analysis aggregated from 11 stakeholders' input
- Results show high current station costs can be reduced through
  - Economies of scale
  - Standardized station design
  - Multiple station installations
  - Continued R&D of manufacturing station components, compressors and hydrogen storage
  - Increase the number of station installers and component suppliers
- NREL developed station cost calculator tool for analysis.

Station Description

SOTA: "State of the art" first of a kind station at 100-200 kg/d

EC: "Early Commercial" station sized at 200-600 kg/d

MS: "More stations" sized at ~600 kg/d

LS: Larger stations sized at 1,500-2,000 kg/d

Infrastructure Analysis in conjunction with Vehicle Technologies Program

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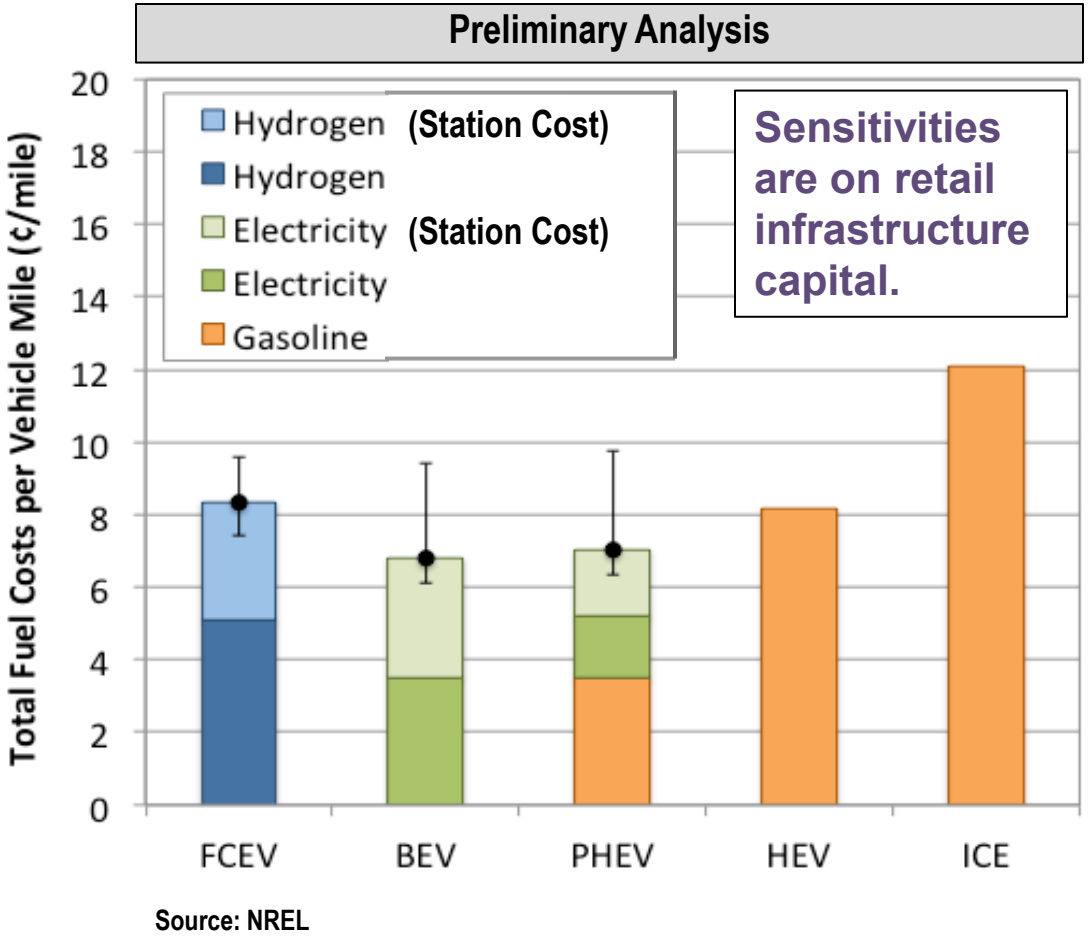
NREL has estimated infrastructure cost for various technologies.



Source: NREL

Key Assumptions for 2025

- Cost of hydrogen delivered to the retail station: $3.00/kg [B]
- Cost of electricity:
  - $0.11/kWh Resid. (Home)
  - $0.095/kWh Comm. (Public)
  - AEO 2012 Early Release
- Cost of gasoline: $4.02/gal (AEO)
- Fuel Economies
  - FCEV: 59 mpgge
  - BEV: 113 mpgge
  - PHEV: 141/45 mpgge (e/g)
  - HEV: 49 mpg
  - ICE: 33 mpg

Early Market Analysis: Integration of Natural Gas and Hydrogen

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Natural Gas workshop with multiple stakeholders provided valuable insight for potential synergies with hydrogen.

Workshop Summary

Objectives

Identify:

- Current status of natural gas (NG) and hydrogen (H_2) infrastructure
- Key challenges preventing or delaying wide spread deployment of natural gas and hydrogen infrastructure
- Opportunities for addressing challenges and for government and industry stakeholders

50 Participants attended:

- Natural gas and hydrogen producers
- Vehicle manufacturers
- Alternative vehicle agencies
- Fuel cell developers
- National laboratories
- Academia
- Government agencies

Preliminary Summary of Workshop Results

- **NG and H_2 have similar storage and regulatory concerns.**
- **Build clusters of refueling centers to support a critical mass of both vehicles.**
- **Develop NG and H_2 infrastructure along major commercial corridors.**
- **Develop consistent , long-term energy policies for NG and hydrogen fuel applications.**
- **Workshop summary report is available at: http://www.transportation.anl.gov/pdfs/AF/812.PDF**

Next Steps:

- **Develop low-cost, conformable lower pressure (sorbent-based) on-board storage for NG and hydrogen fuels.**
- **Harmonize codes and regulations for permitting NG and hydrogen fuel.**
- **Involve business and community leaders in developing NG and H_2 infrastructure.**
- **Involve investment community in financing options.**

Programmatic Analysis: Life-Cycle Analysis Updates

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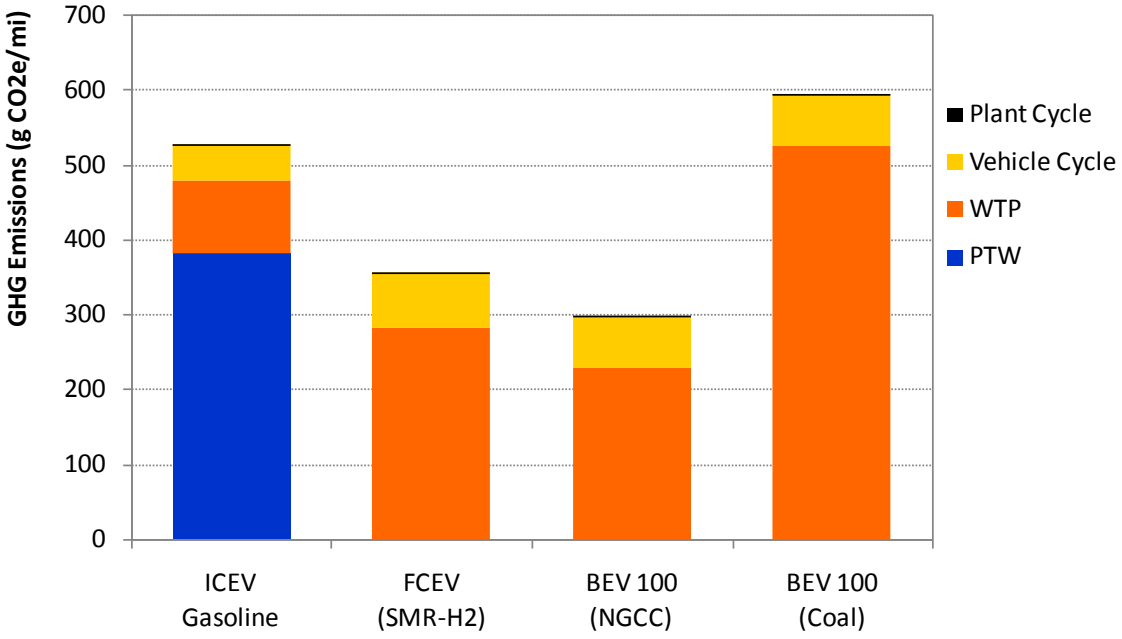
On a Lifecycle analysis basis, emissions from plant construction are negligible compared to fuel- and vehicle-cycle emissions.

GREET = the Greenhouse gases, Regulated Emissions, and Energy use in Transportation Model



Source: ANL

- Expanding analysis of greenhouse gas and criteria emissions and petroleum/energy use to full lifecycle analysis for multiple pathways.
- Multi- Program analysis with consistent assumptions and transparent approach
- Current GREET Lifecycle Analysis (LCA) includes the Fuel Cycle plus the Vehicle Cycle
- Through the USDRIVE partnership (DOE, OEMs, energy, and electric companies), gaps in the LCA of full pathways are being assessed.

GREET LCA Analysis = Fuel Cycle + Vehicle Cycle

Impact of Infrastructure Availability and Program Objectives on FCEV Penetration

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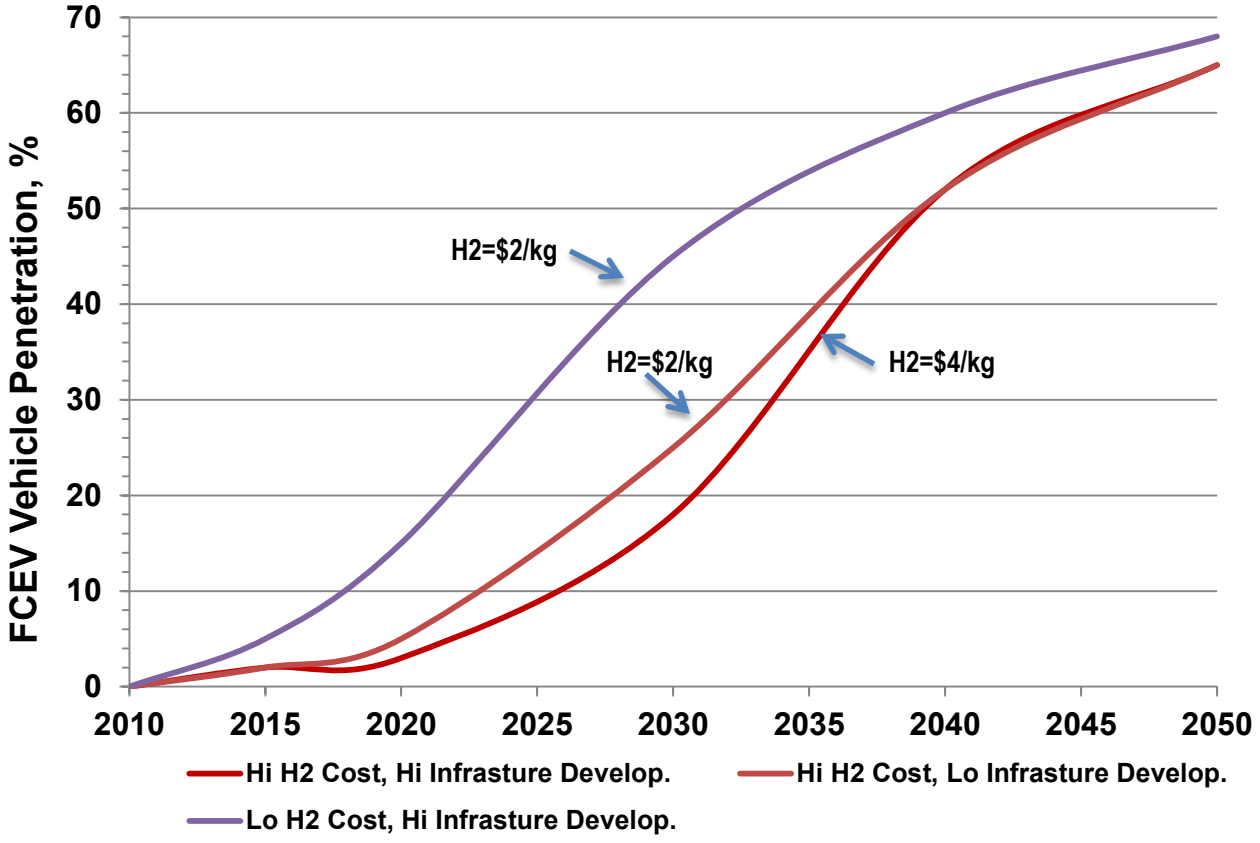
Analysis by Oak Ridge National Lab shows infrastructure buildout and success in meeting Program targets are critical to achieving FCEV penetration.



Source: Oak Ridge National Laboratory

- ORNL explored a portfolio of conventional and alternative vehicles including BEVs and FCEVs.
- Study results show infrastructure availability and development is critical to FCEV penetration.
- Reduction of the hydrogen cost accelerates the FCEV penetration.

Programmatic Analysis: Socio-Economic Benefits of Fuel Cell Industry Impact on Employment

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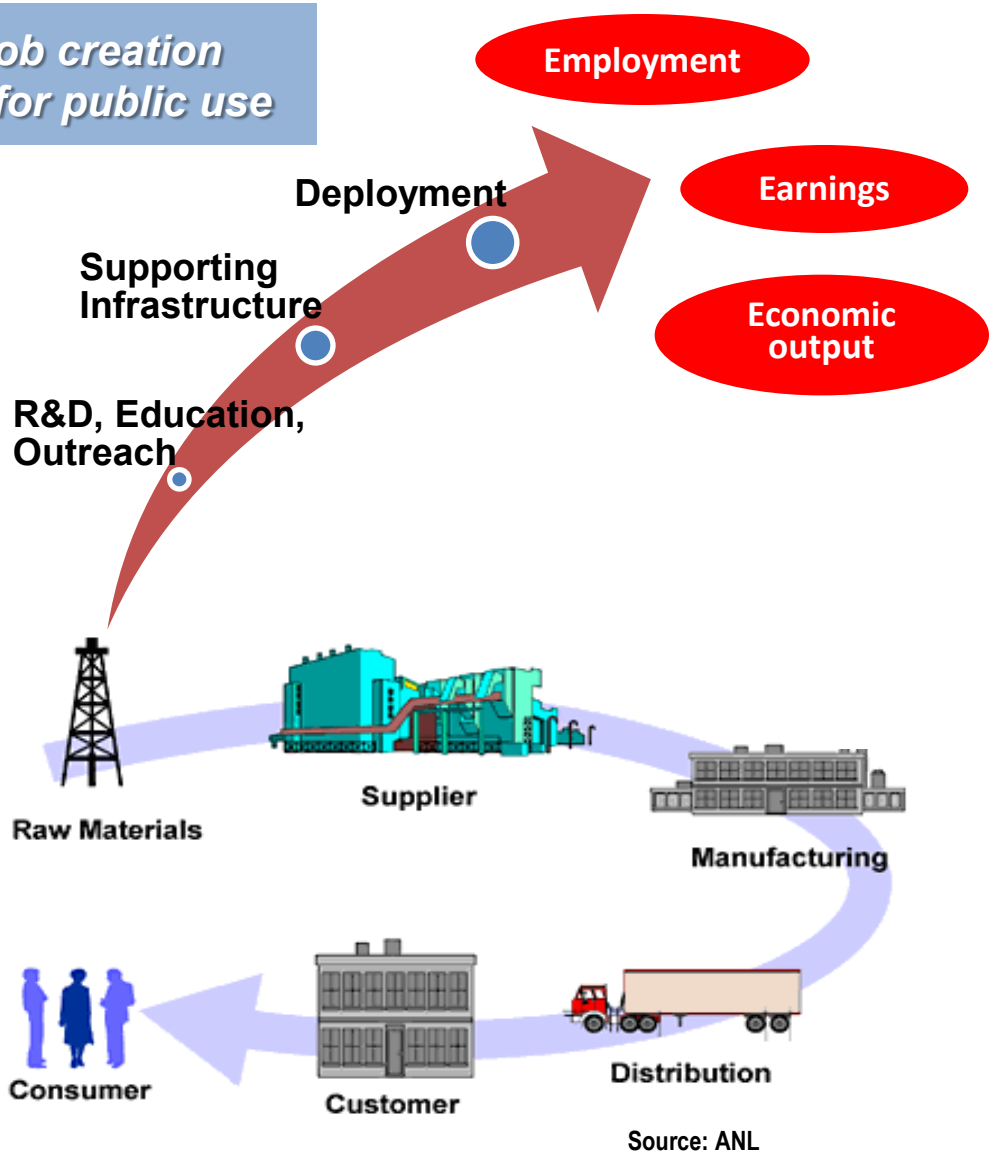
Peer-reviewed employment model for job creation potential for states and regions released for public use

- ANL-RCF developed an employment and economic impact tool to estimate stationary FC industry impacts:
  - Production (PEMFC, PAFC and MCFC) in target applications
  - Installation of FCs and required infrastructure
  - O&M including fuel
  - Construction/expansion of manufacturing capacity
- Model was peer reviewed and beta tested prior to model launch.
- State, regional and national level analyses including supply chain impacts
- Applications included forklifts, back-up power, specialty vehicles, etc.
- Jobs model will enable analysis of gross and net jobs, and revenues generated from fuel cell installation and investment.



Model NOW available from ANL website: JOBSFC.es.anl.gov

Key Systems Analysis Milestones & Future Plans

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- Diverse portfolio and expanded capability of models developed by the Systems Analysis sub-program are enabling analysts to address barriers to technology development and commercialization.
- Emphasis on *early market and infrastructure analysis* :
  - Focus on utilizing biogas as a resource for an alternative fuel.
  - Comprehensive approach to evaluate a portfolio of fuel cell applications for light duty transportation, stationary generation, backup power and material handling equipment, and the electric sector to realize economic, environmental and societal benefits.
- Plans continue to enhance existing models and expand analyses.

FY 2012	FY 2013	FY 2014	FY 2015	FY 2016-2020
Update well-to-wheels analysis and quantify reductions in petroleum use, greenhouse gas emissions and criteria pollutant emissions.	Complete analysis of job growth for MHE	Complete analysis of resources/ feedstock, production/ delivery and existing infrastructure for technology readiness	Provide analysis of Program milestones and technology readiness goals-including risk analysis, independent reviews, financial evaluations, and environmental analysis-to identify technology and risk mitigation strategies.	Complete analysis of program technology performance and cost status and potential to enable use of fuel cells for a portfolio of commercial applications.
Complete jobs model development	Complete analysis of biogas resources for H_2 production and stationary power generation	Complete analysis of job growth for distributed power generation		Complete analysis of H_2 quality impact on H_2 production cost and FC cost for long range techs and tech readiness.
				Complete environmental analysis of tech env impacts for H_2 scenarios and tech readiness.

Systems Analysis Collaborations

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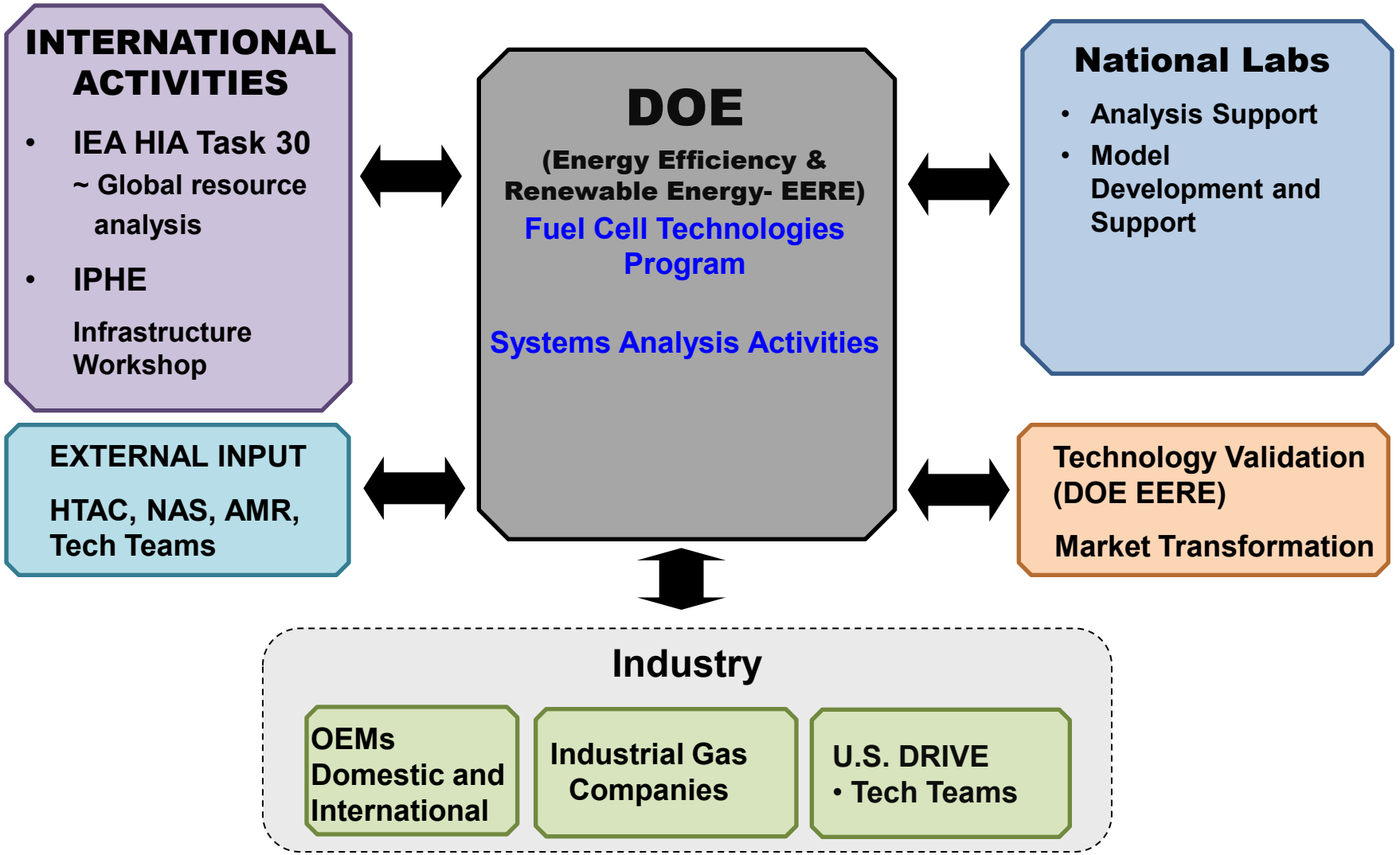
Analysis and peer review input are coordinated among national and international organizations.



Summary

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Systems Analysis is an integral component of EERE and the Fuel Cell Technologies Program.

The Systems Analysis sub-program will:

- Identify the synergies of hydrogen and fuel cells with other fuels and technologies to minimize barriers to market entry
- Confirm the technology advances needed to reduce infrastructure cost and show the cost similarity of hydrogen fueling infrastructure to conventional and other alternative fueling infrastructure costs
- Assess impact of domestic and international growth in hydrogen demand on renewable resource availability and cost
- Show the socio-economic benefits of fuel cell applications for transportation, stationary and distribution applications

Reviewer Reminders

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- Deadline to submit your reviews is **May 25th at 5:00 pm EDT.**
- ORISE personnel are available on-site for assistance.
  - **Reviewer Lab Hours:** Tuesday – Thursday, 7:30 am – 8:30 pm; Friday 7:30 am – 1:00 pm.
  - **Reviewer Lab Locations:**
    - Crystal Gateway Hotel—Rosslyn Room (downstairs, on Lobby level)
    - Crystal City Hotel—the Roosevelt Boardroom (next to Salon A)
- Reviewers are invited to a brief feedback session – at 4:45 pm today, in this room.

Session Instructions

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- This is a review, not a conference.
- Presentations will begin precisely at scheduled times.
- Talks will be 20 minutes and Q&A 10 minutes.
- Reviewers have priority for questions over the general audience.
- Reviewers should be seated in front of the room for convenient access by the microphone attendants during the Q&A.
- Please mute all cell phones and other portable devices.
- Photography and audio and video recording are not permitted.

For More Information

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