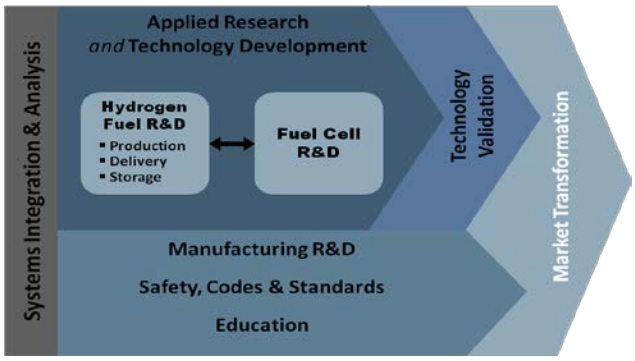
3.9 Market Transformation



The Market Transformation sub-program is conducting activities to help implement and promote commercial and pre-commercial hydrogen and fuel cell systems in real world operating environments. These activities also provide feedback to research programs, U.S. industry manufacturers, and potential technology users. Currently, the capital and installation costs of early market fuel cells (i.e., stationary, backup power, and specialty vehicle power) are between two to three times higher than incumbent technologies. [1,2] One of the sub-program's goals is to achieve fuel cell volumes in emerging commercial applications that will enable cost reductions through economies of scale and other market acceptance factors, resulting in further expansion of market opportunities. Efforts are primarily focused on identifying opportunities for operating and testing fuel cells in emerging markets including specialty vehicles, backup/remote power (including products targeted at displacing diesel-fueled products), hydrogen storage with renewables, auxiliary power for transportation (e.g., truck auxiliary power units [APUs]), continuous recharging for batteries, distributed stationary power generation (e.g., combined heat and power [CHP] and combined heat, hydrogen and power [CHHP]), energy storage renewable grid power, and renewable hydrogen applications. In addition to the positive impact on the hydrogen and fuel cell market, these operational tests will provide valuable information and data on the status of integrated systems and non-hardware barriers and challenges.

3.9.1 Goal and Objectives

Goal

The sub-program's goal is to enable and accelerate expansion of hydrogen and fuel cell system use by lowering the life cycle costs of hydrogen and fuel cell power and by identifying and reducing the barriers impeding full technology commercialization.

Objectives

- Conduct market transformation deployment projects to enable life cycle cost and performance of fuel-cell powered lift trucks and emergency backup power systems to be on a par with conventional technologies by 2020.
- Establish baseline energy efficiency and reliability performance metrics for commercially available emergency backup, material handling, and light commercial/residential power systems and provide feedback to component suppliers regarding cost reduction opportunities by 2013.

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[1] U.S. Environmental Protection Agency, "Catalog of CHP Technologies" (December 2008) (http://www.epa.gov/chp/documents/catalog_chptech_full.pdf)

[2] Oak Ridge National Laboratory, "Status and Outlook for the U.S. Non-Automotive Fuel Cell Industry: Impacts of Government Policies and Assessment of Future Opportunities" (May 2011) (http://www-cta.ornl.gov/cta/Publications/Reports/ORNL_TM2011_101_FINAL.pdf)

- Develop and launch energy efficiency and reliability certification programs. This can be achieved, for example, by including fuel cell stationary power systems in the Environmental Protection Agency's (EPA) Energy Star rating program by 2015.
    - Develop and publish a best practices procurement guide for Federal agencies by 2012.
- Test emerging approaches to grid management using renewable hydrogen storage and fuel cell systems in coordination with the U.S. Department of Energy (DOE) Office of Electricity Delivery and Energy Reliability by 2014.
- Advance the knowledge and expertise of waste-to-energy stationary fuel cells, shipboard auxiliary power unit applications, and aviation applications through targeted testing and evaluation efforts in coordination with the Technology Validation sub-program and in partnership with the U.S. Department of Defense (DOD), the U.S. Navy, the U.S. Army, and civilian agencies such as the U.S. Department of Agriculture (USDA) and the Federal Aviation Administration (FAA) by conducting design requirements planning for aircraft APUs by 2012, shipboard APUs by 2013, and waste-to-energy fuel cells by 2014.
- Identify lessons learned from promulgated policies and regulations and promote the development of the most effective and applicable incentives for hydrogen and fuel cell technologies by 2016.

3.9.2 Approach

DOE addresses hydrogen and fuel cell market transformation challenges through the enhancement of government and industry technology adoption activities. DOE provides information and tools to federal, state, and local governments and industry fuel cell users and assists them in the development of application programs. The Fuel Cell Technologies Program is also promoting hydrogen and fuel cell showcase activities by providing technical assistance on synergistic and novel energy efficient and renewable energy systems that include crosscutting technology applications.

The sub-program supports key implementation projects and partnerships (with state and local governments and other stakeholders) to develop and assess policies, practices, and business models that accelerate adoption of fuel cell technologies. Another critical activity is the deployment of emerging applications at the late-stage prototype and early commercial levels, which will assist industry with improving the affordability and reliability of hydrogen and fuel cell systems, expand user and servicing expertise, and better define the business case for multiple applications. A key approach to increasing domestic market penetration is to develop standard institutional and financial market practices such as power purchase agreements (PPAs)[3], other third party financing methods, and installation guides. A suite of user tools, methodologies, and predictive analysis models including financial analyses for multiple applications (e.g., net payback period estimates) is being developed to support more early application deployments.

[3] A power purchase agreement is an agreement between a private entity and a site owner. The private entity purchases, installs, owns, operates, and maintains the site equipment. The site owner purchases electricity from the private entity.

The sub-program is developing strategies to mitigate commercial risks and to develop new approaches that will ensure high capacity utilization and improved reliability under initial and mass market penetration scenarios. Also, the Market Transformation sub-program collaborates with the Safety, Codes and Standards sub-program to provide lessons learned and best practices. These efforts should facilitate the development of standard operating procedures to provide high-quality, economic and environmental performance data and to help secure private sector financing for high volume fuel cell system deployments.

3.9.3 Programmatic Status

Current Activities

Market Transformation activities encourage higher-volume purchases of hydrogen and fuel cell systems, which, in turn, reduce barriers and support domestic industry growth. Ongoing and planned activities focus on the following:

1. Using data collected by the Technical Validation sub-program to 1) validate the business case for various early market fuel cell systems and 2) assess the performance of these integrated systems in real world operating environments. Example business cases developed using these data are made publicly available so that additional stakeholders become aware of the benefits of integrated hydrogen and fuel cell systems.

2. Collaborating with other Federal agencies to 1) increase market-ready application use, 2) increase awareness of the benefits of these deployments, 3) provide "models" for adoption by other Federal agencies and industry, and 4) help to meet important inter-agency cooperative agreements such as the DOE-DOD Memorandum of Understanding.[4]

3. Testing fuel, (e.g., gas clean up and compression, and power generation concepts) to co-produce hydrogen and electricity, including CHHP (tri-generation) approaches using natural gas and waste biogas. Successful, high-visibility applications, such as tri-generation using wastewater treatment gas as a feedstock, tend to foster other waste-to-energy projects using renewable biogas to co-produce hydrogen for market ready fuel cell systems and electricity in distributed generation applications.

4. Communicating the benefits of using hydrogen and fuel cells for grid storage of variable renewable energy. The goal is to introduce innovative new approaches that demonstrate the potential of utility-scale hydrogen generation to provide energy storage benefits to the electricity grid and fuel cell applications such as emergency backup power and specialty vehicles.

5. Facilitating distributed fuel cell power generation in congested grid locations and other opportune markets. The sub-program will provide information to potential technology users in the private and public sectors about the costs and financial benefits of deploying fuel cells,

[4] Memorandum of Understanding Between U.S. Department of Energy and U.S. Department of Defense, July 2010 (http://www.energy.gov/news/documents/Enhance-Energy-Security-MOU.pdf)

including information about government incentives like tax credits and financing methods such as power purchase agreements. Power purchase agreements will reduce reliance on power generation from the grid that is heavily dependent on the combustion of fossil fuels.

6. Partnering with government and industry stakeholders to deploy pre-commercial applications by testing and evaluating new integrated fuel and power applications. Projects include innovative fuel cell applications such as fuel-cell-powered mobile lighting to displace diesel generator-based systems.

Current Market Transformation activities are summarized in Table 3.9.1.

Table 3.9.1 Current Activities for Market Transformation

Activity	Objective	Organizations
Interagency Coordination	Monthly coordination and collaboration meetings with federal agencies [5]	DOD, National Institute for Standards and Technology, Department of Commerce, U.S. Navy, U.S. Army, National Aeronautics and Space Administration (NASA), USDA, EPA, and FAA
Landfill and waste water biogas to power fuel cells	Cleanup and reforming of gas for fuel used in stationary and industrial truck fuel cells	Gas Technology Institute, South Carolina Research Authority
Shipboard APUs	DOE-DOD collaborative analysis and demonstration	U.S. Navy
Aircraft APUs and Airport Ground Support Vehicles	Conduct energy and cost evaluations for onboard APUs and Ground Support Equipment (GSEs)	U.S. Air Force, Pacific Northwest National Laboratory, Sandia National Laboratories (SNL)
Material Handling Deployments	Collect data and evaluate performance	DOD, Defense Logistics Agency, FedEx Freight, Sysco Houston, Nuvera Fuel Cells with deployment at H-E-B supermarket chain, GENCO with deployments at Coca Cola, Kimberly Clark, Sysco Philadelphia, Wegmans, and Whole Foods Market
Fuel Cell Federal Facilities Procurement Guidance	Develop methods and tools for stationary fuel cell deployment in federal buildings using third party financing	Oak Ridge National Laboratory (ORNL), SRA International, Inc.
Mobile Lighting	Conduct performance evaluations on mobile lighting using fuel cell power	SNL, Altergy Energy

[5] Energy Policy Act of 2005, Section 806

Table 3.9.1 Current Activities for Market Transformation (continued)		
Activity	**Objective**	**Organizations**
Fuel Cell power purchase agreements (PPAs)	Assist National Lab stationary power deployments through technical feasibility studies and third party financing support	Logan Energy
Hydrogen storage for grid management	Develop business cases using excess renewable energy from wind and geothermal power	Hawaii Natural Energy Institute, U.S. Navy
On Board Rechargers for Electric Vehicles	In collaborations with the EERE Vehicle Technologies Program and industry, evaluate the techno-economic and market feasibility of onboard fuel cell battery rechargers for medium class trucks and light duty vehicles	Argonne National Laboratory
Backup Power	To provide emergency power for critical loads such as telecommunications and to share lessons learned	Sprint, FAA, U.S. Army, NASA, National Park Service, Logan Energy, Idatech, ReliOn, Hydrogenics, Altergy

3.9.4 Challenges

While fuel cells are becoming competitive in a few markets, the range of these markets can be greatly expanded with improvements in durability and performance and reductions in manufacturing cost. Successful entry into emerging markets will also require overcoming certain institutional and economic barriers, such as the need for codes and standards, the lack of public awareness and understanding of the technologies, and the high initial costs and lack of a supply base that many new technologies face in their critical early stages.

Early market sales stimulate further market activity by supporting the growth of a domestic industry, overcoming some of the logistical and other non-technical challenges associated with adoption of a new technology, and establishing key elements of the infrastructure that will be essential for later market growth. In addition, these deployments will provide valuable data on the performance of the technologies in real-world operation, lessons-learned from early adopters, and information that will be used to benchmark the benefits of the technologies.

Sub-program Targets

Market Transformation activities increase domestic hydrogen and fuel cell market penetration by removing non-technical market barriers and reducing non-hardware system costs which are still a significant cost barrier.[6] Non-technical challenges include the high costs of insurance, permitting, installation, and project management. The sub-program assists in the challenge of lowering the cost by identifying and reducing the market barriers to full technology commercialization. Efforts under

[6] University of California, Irvine, National Fuel Cell Research Center, "Fuel Cell Explained" http://www.nfcrc.uci.edu/2/FUEL_CELL_INFORMATION/FCexplained/challenges.aspx

this sub-program complement the RD&D work of other sub-programs, as well as Systems Analysis work, by focusing on these non-hardware system costs and barriers.

The sub-program focuses on achieving life cycle cost parity with incumbent technologies by deploying new high volume applications such as airport ground support vehicles and addressing non-hardware related costs such as delays in permitting, siting, and installation as well as performing key analyses of finance and technology options. For example, a fuel cell stack is manufactured using similar processes regardless of the equipment application. As a result, combining the market penetration of various fuel cells such as stationary power, specialty vehicles and other vehicle uses, and backup or auxiliary power results in a rapid reduction in capital costs. By 2016 – 2017, the markets are expected to reach a combined manufacturing volume of around 4 million kilowatts annually and trigger a rapid commercialization and the related reduction in fuel cell system costs. [7]

3.9.5 Barriers

The following section outlines barriers to achieving the Market Transformation sub-program's goal and objectives.

A. Inadequate standards and complex and expensive permitting procedures

- Hydrogen and fuel cell system's installation costs are too high[8]
- Hydrogen and fuel cell system's insurance costs are too high
- Hydrogen and fuel cell system's energy efficiency standards do not exist
- Permitting approval by local officials takes too long and is expensive
- Sufficient life cycle performance data to enable standards development is lacking

B. High hydrogen fuel infrastructure capital costs for Polymer Electrolyte Membrane (PEM) fuel cell applications

C. Inadequate private sector resources available for infrastructure development

D. Market uncertainty around the need for hydrogen infrastructure versus timeframe and volume of commercial fuel cell applications

E. A lack of flexible, simple, and proven financing mechanisms

- Inadequate private funds available for new projects
- Lack of sufficient financing instruments for large projects
- High cost of fuel cells using current low production volumes
- Shorter product warranty periods than for other commercial new or renewable energy technology products

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[7] U.S. Department of Energy Hydrogen and Fuel Cells Program Records, http://www.hydrogen.energy.gov/program_records.html, record currently in process as of April 2012

[8] ORNL/ TM-2011/ 101, table 5 (BUP PEM), page 67, May 2011 http://cta.ornl.gov/cta/Publications/Reports/ORNL_TM2011_101_FINAL.pdf

- Lack of government energy acquisition processes to facilitate large scale fuel cell deployments
- Lack of life cycle cost and performance data to demonstrate low investor risks
- Inadequate federal and state-level incentives relative to other clean or renewable energy technologies

F. Inadequate user experience for many hydrogen and fuel cell applications

G. Lack of knowledge regarding the use of hydrogen inhibits siting (e.g., indoor refueling)

H. Utility and other key industry stakeholders lack awareness of potential renewable hydrogen storage application

I. Lack of cross cutting information on how to use hydrogen and fuel cell systems in combination with energy efficiency and renewable energy technologies with existing projects

J. Insufficient numbers of trained and experienced servicing personnel

K. Inadequate installation expertise

L. Lack of qualified technicians for maintenance

M. Lack of certified service providing organizations for installation and maintenance

N. Policies and incentives (e.g., Investment Tax Credit) are not available to government or other non-profit entities - impeding early market adoption in the public sector

O. Lack of standard recycling/disposal processes

3.9.6 Task Descriptions

The technical task descriptions are presented in Table 3.9.2. The barriers associated with each task appear after the task title.

Table 3.9.2 Technical Task Descriptions

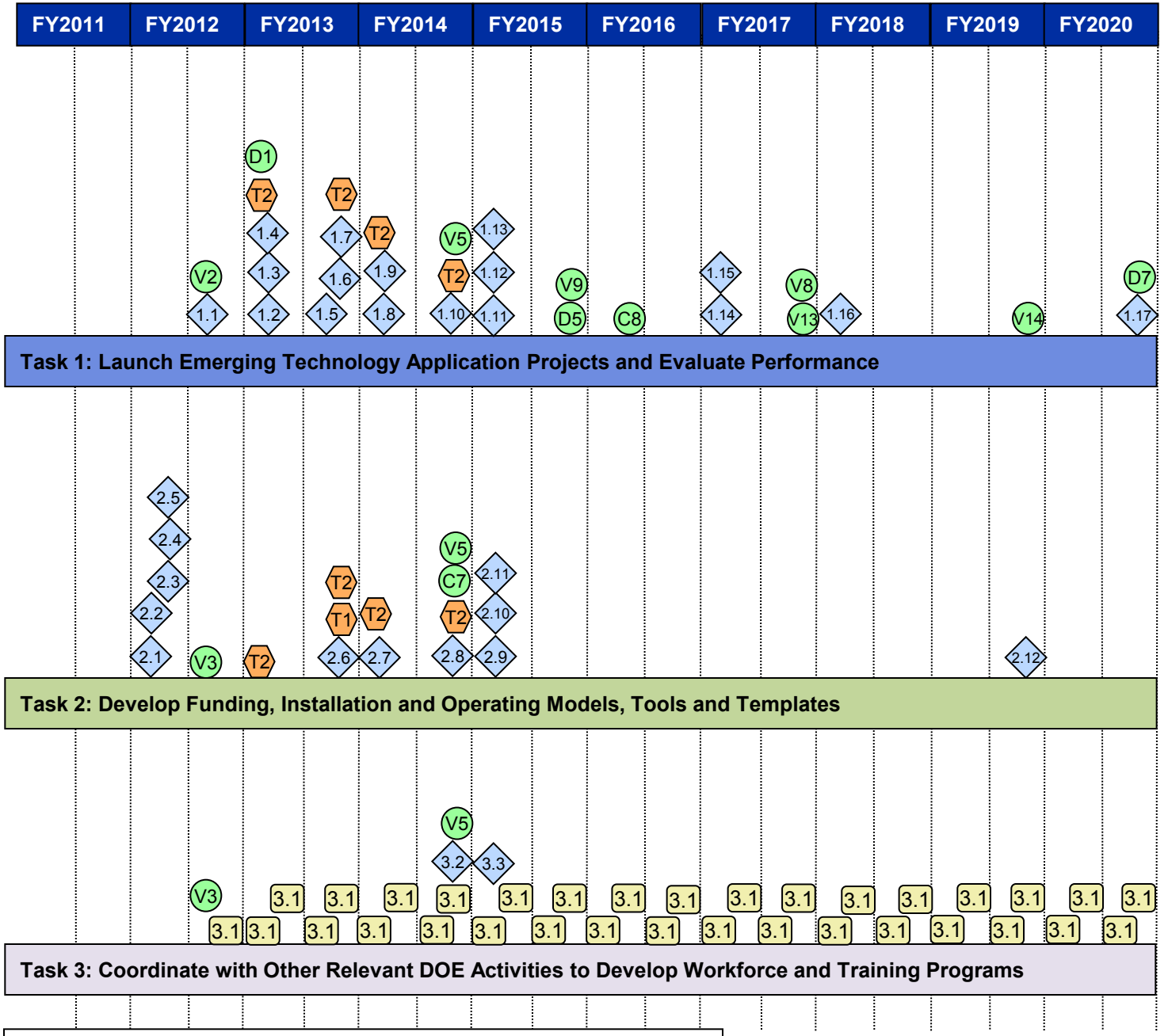
Task	Description	Barriers
1	**Launch emerging technology application projects and evaluate performance** • Demonstrate the value proposition and business case for freight support equipment and vehicles, emergency backup power systems, and small stationary power. • Test and evaluate port support equipment applications including motive (e.g., baggage tractors or drayage trucks) and non-motive (e.g., ground lighting and onboard APUs). • Test and evaluate onboard fuel cell rechargers and prime power for medium duty trucks and light duty battery electric vehicles. • Evaluate air emissions and energy effects of fuel cells in commercial passenger aircraft for APUs. • Conduct renewable hydrogen generation and energy storage performance and business case testing activities. Demonstrate at utility or near-utility scale. • Conduct user forums and adoption analysis for emerging commercial applications including power for lift trucks, airport ground support equipment, and small buildings. • Identify specific opportunities to increase deployments by aggregating demand for hydrogen and fuel cells to lower cost of both technologies. • Work with Recovery Act award winners to complete deployment of fuel cell-powered lift trucks and emergency backup installations. Support press events and media outreach. • Track energy benefits of completed installations in order to supply real-world results with potential end users and media. Develop case studies and outreach materials highlighting project results. • Evaluate business case studies for various low-cost hydrogen infrastructure pathways over near-, mid-, and long-term market time frames.	A through M
2	**Develop funding, installation and operating models, tools, and templates** • Develop installation and permitting procedure templates. • Develop best-practices for financing fuel cell projects. • Develop financial planning analysis tools and identify new, innovative finance methods (e.g., power purchase agreements for fuel cell micro-CHP residential power; project bundling). • Develop guidance detailing best practices for funding mechanisms such as power purchase agreements, third party financing, project bundling methods, and procurement guides. • Develop business cases. • Develop case studies of customer economic and environmental benefits of deploying fuel cells for emerging applications (e.g., stationary power for grocery stores). Disseminate these case studies widely across the public domain. • Develop near- and mid-term hydrogen infrastructure market case studies in collaboration with the Hydrogen Production, Delivery, and Technology Validation sub-programs.	A, E, I, N, O

Table 3.9.2 Technical Task Descriptions (continued)		
Task	**Description**	**Barriers**
3	**Coordinate with other relevant DOE activities to develop workforce and training programs** • Develop workforce training for fuel cell installation and maintenance with industry stakeholders. • Provide workforce development plan for fuel cell maintenance and installation. • Conduct outreach to energy service contractors, utilities, and venture capitalists. • In coordination with the Education sub-program conduct local public and community outreach events. • Conduct outreach actions for insurance and underwriter industries.	C, D, G, H, I , J, K, L, M

3.9.7 Milestones

The following chart shows the interrelationship of milestones, tasks, supporting inputs from sub-programs, and outputs for the Market Transformation sub-program. The input/output information is also summarized in Appendix B.

Market Transformation Milestone Chart



Task 1: Launch Emerging Technology Application Projects and Evaluate Performance	
1.1	Complete initial aircraft APU systems analysis. (3Q, 2012)
1.2	Implement cross-cutting interagency project for hydrogen infrastructure integrated with renewable energy generation. (1Q, 2013)
1.3	Complete data collection and assessment of deployed Direct Methanol Fuel Cell lift trucks. (1Q, 2013)
1.4	Deploy fuel cells and evaluate business cases for micro-CHP in light commercial applications. (1Q, 2013)
1.5	Deploy and test potential benefits of distributed generation fuel cells as a strategic tool to help mitigate grid congestion. Create users forums for backup fuel cells deployed with U.S. Army CERL and TARDEC. (3Q, 2013)
1.6	Deploy and test backup power at military installations in coordination with DOD and publish results and benefits analysis. (4Q, 2013)
1.7	As part of the Recovery Act, install approximately 1,000 backup and lift truck power fuel cell units at industry partners' sites. (4Q, 2013)
1.8	Complete deployment and evaluation of short haul/drayage trucks and range extenders. (1Q, 2014)
1.9	Deploy fuel cells and evaluate business cases for micro-CHP in residential applications. (1Q, 2014)
1.10	Enable >8 MW of fuel cell deployments in emerging markets. (4Q, 2014)
1.11	Complete design and test deployment of airport ground support vehicles using hydrogen from renewables. (1Q, 2015)
1.12	Complete test and business case analysis for onboard fuel cell rechargers for battery electric vehicles. (1Q, 2015)
1.13	Deploy, test, and develop business cases for renewable hydrogen energy systems for power, building, and transportation sectors. (1Q, 2015)
1.14	In collaboration with other Federal agencies and industry partners, begin deployment of fleets incorporating validated fuel cell vehicles (available on the GSA schedule) that have achieved 5,000-hour durability (service life of vehicle) and a driving range of 300 miles between fueling. (1Q, 2017)
1.15	In collaboration with DOD and industry partners, begin deployment of truck fleets incorporating validated APU fuel cell systems having 15,000-hour durability. (1Q, 2017)
1.16	In collaboration with State and Federal agencies, begin deployment of validated technology to produce hydrogen through distributed reforming of renewable liquid fuels at refueling stations for a cost of <$3.80/gge at the pump. (1Q, 2018)
1.17	Enable economies of scale to achieve cost-competitiveness. (4Q, 2020)

Task 2: Develop Funding, Installation and Operating Models, Tools, and Templates	
2.1	Develop and publish a fuel cell user's guide (e.g., third party financial planning guide) for use by energy managers or facility managers who are considering the deployment of stationary fuel cell systems. (1Q, 2012)
2.2	Develop installation and permitting templates for stationary and backup power. (1Q, 2012)
2.3	Develop case studies for deployed lift trucks and emergency backup power. (2Q, 2012)
2.4	Develop outreach materials for grocery retail and food distributors. (2Q, 2012)
2.5	Develop third party financing model for Federal users to aggregate and multiply power needs. (2Q, 2012)
2.6	As a result of Recovery Act deployments, publish fuel cell backup and lift truck power business cases. (4Q, 2013)
2.7	Begin to conduct information seminars to insurance underwriters and venture capitalists. (1Q, 2014)
2.8	Develop a case study for hydrogen infrastructure that services the MHE and other emerging fuel cell application markets. (4Q, 2014)
2.9	Complete peer-reviewed, on-line financial planning tool for emerging applications. (1Q, 2015)
2.10	Develop Best Practices Database as a web tool for permitting and installing fuel cell stationary power. (1Q, 2015)
2.11	Develop installation and permitting templates for airport ground support equipment. (1Q, 2015)
2.12	Develop a case study for hydrogen infrastructure that services mid-term (renewable) fuel applications markets. (4Q, 2019)

Task 3: Coordinate With Other Relevant DOE Activities to Develop Workforce and Training Programs	
3.1	Conduct seminars at customer end-users' forums to inform earlier adopters of economic and environmental benefits of fuel cells. (one per quarter - 1,000 attendees per year). (on-going starting in Q4, 2012)
3.2	In collaboration with other Federal and State agencies, develop training modules that can be used in implementing stationary fuel cell projects. (Q4, 2014)
3.3	Identify installation workforce needs for emerging applications. (1Q, 2015)

Outputs

T1 Output to Technology Validation: Aircraft auxiliary power unit final analysis. (4Q, 2013)

T2 Output to Education: Report on the status of early market deployments and industry needs. (1Q & 4Q, 2013 – 2014)

Inputs

C7 Input from Safety, Codes and Standards: Materials reference guide and properties database. (4Q, 2014)

C8 Input from Safety, Codes and Standards: National indoor fueling standard. (2Q, 2016)

D1 Input from Delivery: Delivery options that can meet an as-dispensed hydrogen cost of <$4/gge ($1/100ft^3) for emerging fuel cell powered early markets. (1Q, 2013)

D5 Input from Delivery: Provide options that meet <$4/gge for hydrogen delivery from the point of production to the point of use for emerging regional consumer and fleet vehicle markets. (4Q, 2015)

D7 Input from Delivery: Provide options that meet <$2/gge for hydrogen delivery from the point of production to the point of use in consumer vehicles. (4Q, 2020)

V2 Input from Technology Validation: Validate achievement of a refueling time of 3 minutes or less for 5 kg of hydrogen at 5,000 psi using advanced communication technology. (3Q, 2012)

V3 Input from Technology Validation: Updated composite data products for material handling and backup power published. (3Q, 2012)

V5 Input from Technology Validation: Report on validation of stationary fuel cell system that co-produces hydrogen and electricity with 40,000-hour durability while maintaining a minimum of 40% overall efficiency. (4Q, 2014)

V8 Input from Technology Validation: Complete validation of commercial fuel cell combined heat and power systems that demonstrate 45% efficiency and 50,000 hour durability. (4Q, 2017)

V9 Input from Technology Validation: Report on the validation of residential fuel cell micro combined heat and power systems that demonstrate 40% efficiency and 25,000 hour durability. (4Q, 2015)

V13 Input from Technology Validation: Report on the status of validation of 15,000 hour truck auxiliary power unit durability target. (4Q, 2017)

V14 Input from Technology Validation: Report on the status of validation of 5,000 hour durability target. (4Q, 2019)