X.5 Green Communities

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Fiscal Year (FY) 2011 Objectives

NREL is fostering the integration of hydrogen and fuel cell technologies into communities to support the goals of energy efficiency, conservation, sustainability, renewable energy and reduced greenhouse gas (GHG) emissions. Our main tasks are to:

- Develop methods and techniques for identifying and evaluating candidate communities for suitable hydrogen and fuel cell technology projects.
- Assist communities in deploying and using hydrogen and fuel cell technologies in innovative integration projects with existing energy efficiency, conversation and renewable energy investments.
- Collect and report performance data, as well as lessons learned, on the hydrogen and fuel cell systems deployed into communities.
- Develop case studies that enable the replication of successful deployments to other similar communities.
- Develop and pursue community education and outreach opportunities for hydrogen and fuel cell systems.
- Build relationships with communities embracing hydrogen and fuel cell technologies. These relations will allow NREL to identify emerging community opportunities for the deployment of hydrogen and fuel cell systems in conjunction with renewable energy and energy efficiency projects.

Technical Barriers

This project addresses the following technical barriers relevant to the published sections of the Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Hydrogen from Renewable Resources
(B) Hydrogen and Electricity Co-Production
(C) Expanding Market Opportunities
(D) Technology Validation
(E) Education and Outreach

Technical Targets

The Market Transformation Activity does not develop new component technologies or sub-system configurations and, therefore, does not have technology targets. Instead, this subprogram assists in deploying technology systems developed within the other program elements.

FY 2011 Accomplishments

NREL has accomplished the following:

- Developed a decision matrix tool that highlights the most promising community types for hydrogen and fuel cell system deployment projects.
- Ranked 56 community types, using the decision matrix tool developed in this project, against a set of ranking criteria developed by DOE and NREL.
- Executed a Sources Sought effort that resulted in receiving responses from communities proposing to integrate hydrogen and fuel cell systems into their communities.
- Executed a request for proposals (RFP) effort that resulted in receiving formal proposals for community projects that integrate hydrogen and fuel cell systems with existing energy efficiency and renewable energy investments.

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Introduction

NREL and DOE are supporting community usage of fuel cell and hydrogen technologies as part of an overall energy efficiency, conservation and renewable energy portfolio. This support includes assisting communities that have existing energy efficiency plans, GHG reduction plans, sustainable energy plans and the like in place to incorporate hydrogen and fuel cell technologies as another option to achieve energy savings and GHG reduction goals. This support also includes identifying opportunities for education and outreach to increase the public's awareness of hydrogen and fuel cell technologies.

Green communities can be thought of as residential, mixed-use, light commercial, municipal or state sites, as examples, that have made a documented commitment to mitigating their environmental impact (reducing their carbon footprint, increasing their energy efficiency, decreasing their resource consumption rate, and installing renewable energy). This effort will help communities accomplish innovative projects that integrate hydrogen and fuel cell technologies with other complementary energy efficiency, conservation and renewable energy investments. DOE's Energy Efficiency and Conservation Block Grant (EECBG) Program included $3.2 billion in 2009 Recovery Act federal funds to deploy the least expensive, cleanest, and most reliable energy technologies available–energy efficiency and conservation–across the country. The goals of this investment were to: reduce fossil fuel emissions; reduce the total energy use of the eligible entities; improve energy efficiency in the transportation, building and other appropriate sectors; and create and retain jobs. This project complements this example investment and seeks to leverage the energy efficiency, conservation and renewable energy investments already made (by the EECBG program and others) in communities by identifying communities and potential projects for integrating hydrogen and fuel cell technologies into a community's existing energy efficiency and conservation plan. Integrating hydrogen and fuel cell technologies with energy efficiency, conservation and renewable energy technologies will contribute energy savings and environmental benefits to the community.

Approach

NREL applied the decision matrix tool developed in this project to assess the technical, environmental, economic and social benefits of integrating hydrogen and fuel cell systems into a community. NREL used a systems level approach to understand the project value to the community, as well as the potential for enabling the use of renewable energy. NREL used the following criteria in identifying and selecting candidate communities and deployment projects: innovation of project concept (40%), technical approach (35%) and ability to execute the project (25%).

Results

In order to assess the ability of the candidate community to successfully integrate hydrogen and fuel cell systems into its existing infrastructure, the decision matrix tool evaluates the community in 18 ranking criteria grouped into four categories. The four categories are: 1) technical considerations, 2) market potential, 3) project financials, and 4) opportunities for public outreach and learning. Critical elements for a successful community deployment of a hydrogen or fuel cell system include:

- Community adoption of plans and strategies for GHG reduction, energy efficiency, conservation, clean energy and renewable energy.
- Ability to articulate a hydrogen or fuel cell project that leverages and integrates the existing energy efficiency, conservation and renewable energy investments in the community.
- Ability to describe the value and benefit of a project to the community.
- Knowledge of and connections with the proposed hydrogen and fuel cell technology.
- Ability to conduct high profile public outreach and education activities that increase the public's awareness of hydrogen and fuel cell technologies.

Based on this initial analysis, five community types were identified as high potential deployment sites for hydrogen and fuel cell systems. The community types cited here are example profiles. Once subcontracts are executed with the actual communities identified through the Sources Sought and RFP processes, NREL will collect and analyze the resulting deployment data to build case studies and validate the predictive nature of the decision matrix tool.

Community 1: An off-grid community has just completed extensive energy efficiency, time of use and conservation studies followed by an implementation program that has resulted in a 40% reduction in energy consumption by the community. Now the community has adopted a plan to generate 80% of its remaining energy needs from clean energy sources. The analysis conducted to baseline the community's energy usage profile has also identified opportunities for leveraging clean energy sources available in the community. The analysis indicates that biogas from an anaerobic digester located in the community could be used to used to operate a fuel cell system that generates electrical power and high quality heat needed by the community. The low quality heat and exhaust gas (rich in carbon dioxide and moisture) from the fuel cell system could also be integrated with a community greenhouse used to produce fresh vegetables for this off-grid community throughout the year. The value of this project to the community is measured in terms of contributing to the community's clean energy plan, reducing GHG emissions and increasing local food production with a decreased carbon footprint.

Community 2: A technology campus has an environmental mandate to improve energy efficiency and reduce GHG emissions by 50%. Retrofitting the existing buildings with energy saving measures has resulted in a 30% reduction in energy consumption; however, more improvements are still required to satisfy the mandate. Additionally, this environmental mandate must be balanced with the business mission of the community, which requires continuous, reliable, high quality power. A proposed fuel cell system could provide continuous back-up power to critical business operations and protect this community from power grid failures that would result in economic losses. Additionally, analysis shows that the fuel cell system would contribute to satisfying the community's base electrical load requirements during normal power grid operation with improved energy efficiency and decreased GHG emissions relative to the grid supplied power. The value of this project to the community is measured in terms of increased power security for the community's business mission, and contributing to the community's mandate for improved energy efficiency and reduced GHG emissions.

Community 3: A group of mixed-use buildings in an urban setting has banded together to form a community and implemented a district heating and cooling network based on an advanced hydronic loop system. This community has reduced their overall thermal energy requirements by 30% and reduced GHG emissions by 20% relative to their previous levels by implementing this technology. However, the community still has thermal and electrical energy needs that are not being met by on-site generators, and the community's sustainable energy plan calls for installing on-site generators that operate with greater energy efficiency and lower GHG emissions than power delivered via the grid from a coal-fired power plant. Analysis (supported in part by a DOE technical assistance program) indicates that a fuel cell cogeneration plant could provide sufficient electric power and heat to meet the community's requirements. The value of this project to the community is measured in terms of achieving energy efficiency and GHG emission goals adopted in the community's sustainable energy plan.

Community 4: A municipality has defined a plan for becoming a zero net energy community. The municipality has already leveraged federal funds and private foundation grants to greatly reduce community needs for vehicles, thermal and electrical energy. Renewable energy investments in the municipality are not capable of reliably meeting all of the community's energy requirements during peak consumption periods, even with the reduced demands resulting from the existing energy efficiency and conservation investments. The municipality has analyzed its energy consumption profile and identified a system capable of integrating with the existing renewable energy generators to produce hydrogen from renewable sources for use as an energy storage media. The community's plan for achieving net zero energy status includes the acquisition of a fleet of fuel cell-powered buses in the near future. In order to accommodate this future hydrogen demand, the system will be sized to produce sufficient hydrogen to fuel these buses. The value of this project to the community is measured in terms of achieving its goal of becoming a zero net energy community and reducing GHG/air emissions.

Community 5: A community with excess renewable energy production is forced to curtail production when the grid is saturated. Installation of an electrolyzer in the community would allow them to store and sell excess renewable energy production in the form of renewably produced hydrogen. The electrolyzer would generate a new revenue stream for the community by selling the excess hydrogen as fuel to a distribution warehouse located in the community with a fleet of fuel cell-powered material handling equipment. The value proposition for the community is justified by more fully utilizing existing renewable energy investments to shorten the financial payback period on these investments, and increasing revenue for the community. The use of renewable hydrogen by a local employer increases public awareness of hydrogen and fuel cell technologies, as well as providing a unique and valuable marketing tool for a business located within the community.

Analyzing the responses to the Sources Sought notice revealed the trends shown graphically in Figures 1 and 2. Figure 1 shows that slightly less than half (45%) of the responses were submitted by teams led by traditional communities (e.g. cities, municipalities, counties). Interestingly, this indicates some community awareness of hydrogen and fuel cell systems, and a willingness by community members to take ownership of these systems in their communities. The remaining responses (55%) were led by non-community entities. These non-community led responses were typically championed by commercial entities motivated by the opportunity for the sale of commercial product.

Figure 2 shows the breakdown of technology types proposed in the Sources Sought responses. Some of the responses incorporated multiple technologies, so each of the proposed technologies was accounted for separately in this analysis. The most common type of proposed technology in the Sources Sought responses was a stationary fuel cell for

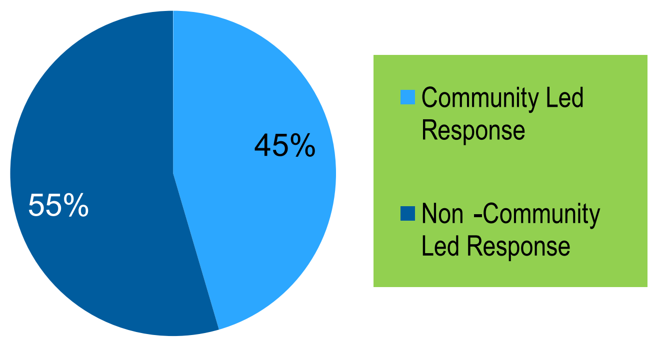

FIGURE 1. Of the Sources Sought responses received, 45% were community led responses while 55% were non-community led responses.

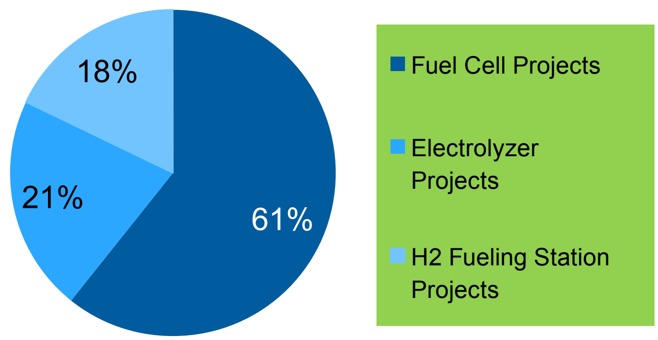

FIGURE 2. The breakdown of technology types proposed in the Sources Sought responses. Fuel cell projects were identified in 61% of the responses, followed by electrolyzer projects in 21% of the responses and hydrogen fueling station projects in 18% of the responses.

generation of electricity and heat, which was identified in 61% of the responses. The second most common proposed technology was an electrolyzer for splitting water into hydrogen and oxygen gases, typically utilizing electricity from a renewable energy source such as wind or solar. The third most common technology found in the Sources Sought responses was a hydrogen fueling station for dispensing hydrogen for transportation applications.

Future Direction

- Complete subcontract negotiations which will result in NREL awarding subcontracts to communities to assist them in achieving innovative integrations of hydrogen and fuel cell systems.
- Monitor the awarded subcontracts.
- Analyze operational data collected by the subcontracted communities. This analysis will include hydrogen and fuel cell system performance data, and will quantify how the project helped the community in progressing towards its sustainability and conservation goals.
- Build case studies from the successful deployment projects that will serve as precedence for similar communities to execute their own hydrogen and fuel cell projects.

FY 2011 Publications/Presentations

1. "A Methodology for Identifying and Modeling Candidate Communities for Distributed and Community Hydrogen," John Lewis, International Energy Agency – Hydrogen Implementation Agreement Task 29 Meeting, February 2011, Istanbul, Turkey.

2. "Hydrogen and Fuel Cell Systems for Agricultural Applications and Rural Communities," John Lewis, USDA Natural Resources Conservation Service Meeting, March, 2011, Denver, CO.

3. "Green Communities: A Methodology," John Lewis, 2011 Alliance for Sustainable Colorado Meeting, April, 2011, Denver, CO.

4. "Green Communities," John Lewis, 2011 Hydrogen and Fuel Cells and Vehicle Technologies Programs Annual Merit Review and Peer Evaluation Meeting, May, 2011, Washington, D.C.

5. "Green Communities: A Methodology," John Lewis, 2011 Colorado Renewable Energy Conference, June, 2011, Ft. Collins, CO.