A Case Study of the Glen Acres University / Community Partnership to Reduce Energy Consumption in Existing Housing

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Existing building stock in the developed world is responsible for approximately 40% of all energy consumption. Replacement of the existing built environment with more efficient structures is not only impractical but also abandons much of the embodied energy already present in the extant materials. As a result, attempts to significantly reduce the operational energy consumption in existing buildings must be based on a combination of energy related retrofit of existing buildings and behavioural changes by the building's occupants.

Due to the common attributes of existing residential buildings, this sector offers large scale opportunity for energy related retrofit. Nevertheless, while the technologies for insulation, climate control, lighting, consumer appliances, and water consumption common to domestic structures are often similar within communities, many complicating factors exist which limit production scale energy retrofit. Unlike new housing construction which has, in many parts of the world, become uniform and systematized, energy related housing retrofit is done on a per house basis and continues to be restricted in scope. The limitations stem from a fragmentation of ownership, a dearth of construction organizations offering whole-house energy retrofit as a primary service, limited funds to advance the process, and housing valuation practices that fail to recognize the value created by energy related retrofits.

This paper is a detailed examination of a community-wide energy retrofit project which was financed using stimulus funds from the U.S. government and distributed to a small community adjacent to a major research university. The original concept of market transformation for energy retrofit expected from the program is presented along with the university's participation in program design, program management, related educational activities, student involvement, and resulting benefits to both the university and the community. In addition, some unexpected challenges which continue to constrain market transformation for energy retrofit are included.

Keywords: Energy Conservation, Community Partnership, Market Transformation, Retrofit, Housing, Stimulus Funds

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1. Introduction

Buildings are tremendous users of electricity, accounting for more than 72% of electricity use in the United States. This contributes 39% of the carbon dioxide (CO_2) emissions in the United States per year, more than either the industrial or transportation sector of the economy (The U.S. Green Building Council, 2009). Adopting energy conserving measures and alternative sources of energy production for use in buildings offers vast opportunity toward reaching the national goal of energy independence and reducing climate change.

An October 2008 report of the National Science and Technology Council titled *Federal Research and Development Agenda for Net-Zero Energy, High Performance Buildings* notes the general lack of informational guides and incentives, and the misinformation that exists about energy consumption in buildings. The report recommends effective technology transfer through improved tools and guides, education and training, and market-based building valuation metrics. The basis for this technology transfer would be research and demonstration coupled with private industry activity. This paper describes a program that provides a vehicle for the suggested education and technology transfer specifically targeting residential properties and the conditions encountered in the State of Indiana, USA.

The City of Lafayette, located in a small metropolitan area of less than 200,000 residents, was awarded grant funding from the U.S. federal government for approximately 80 energy conserving retrofits in the Glen Acres and Vinton communities through a retrofit ramp-up program. Lafayette administered these funds through the use of staff currently employed under a Comprehensive Neighborhood Revitalization Fund for Glen Acres. The fund for this Neighborhood Stabilization Program (NSP) financed the acquisition of foreclosed properties that are rehabilitated for sale to low income individuals. As the primary outreach vehicle for the retrofit ramp-up program, this NSP funding facilitated the acquisition of a home for a deep-energy retrofit demonstration.

The neighbourhoods of Glen Acres and Vinton are comprised of starter homes built from 1950 – 1970. A significant challenge for market transformation in these communities was the limited ability to communicate directly with homeowners. Because Glen Acres and Vinton are conventional post World War II first ring suburban communities, no community centre or other social meeting place is available for marketing outreach. As a result, no venue existed for the purpose of educating homeowners about the benefits of energy conserving retrofits or available opportunities for grant assistance to implement appropriate retrofits for low income homeowners.

As part of the Lafayette program, ultimately named the Lafayette Energy Assistance Program (LEAP), outreach opportunities and potential for homeowner education was provided by a high-profile, deep-energy retrofit demonstration home located within the Vinton community. The use of a deep-energy retrofit demonstration home within the community provided marketing outreach needed to encourage participation by community homeowners. Locating the home within the community helped to make grant implementation convenient for the community within a location appropriate for social interaction, and provided a path for bringing the retrofit program message to individuals who may not be exposed to it in the

mass media. The demonstration used established energy conservation retrofit strategies as well as alternative energy sources, some of which are beyond the current capability of participating homeowners to adopt, to draw as large an audience as possible. The program exposed homeowners in the target neighbourhoods and the larger Lafayette community to currently available retrofit technologies as well as the available grant incentives.

In a December 2010 review of U.S. whole-home retrofit programs, the National Home Performance Council noted that utilities sponsored the majority (113) of the 126 whole-home retrofit programs identified in the study. Of this group, 38 met the home performance guidelines of the Energy Star program sponsored by the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA). To receive a Home Performance designation under the Energy Star program all of the following components must be included in the program. Similar components were used for the LEAP, specifically:

- An assessment of the home by a certified energy specialist using visual and diagnostic methods;
- A set of recommendations for improving the home based on the assessment;
- Assistance for homeowners in identifying contractors who can implement the recommendations;
- Verification that work was installed and that health and safety issues were addressed; and
- Quality assurance measures.

The following narrative presents a synopsis of the Lafayette Energy Assistance Program (LEAP), how it was conceived for funding by the U.S. Department of Energy (DOE), and the basic program implementation. The presentation of case study material introducing the program description and a narrative discussion of steps taken by local program administrators is intended to be instructive for those wishing to develop and implement similar community-scale retrofit programs. This case study is limited to the experiences of the author who has served in the role of technical advisor to the City of Lafayette during the initial funding request period and program administration.

2. Partnership Funding and University Participation

As part of the economic stimulus program in 2009 the U.S. government chose energy efficiency as an area where federal funds could be expended to achieve multiple goals. The funds appropriated by the American Recovery and Reinvestment Act of 2009 were primarily intended to stimulate the economy and create jobs. The Energy Efficiency and Conservation Block Grants (EECBG) Program, funded for the first time by the Recovery Act, supported a Presidential priority to promote energy efficiency and the use of renewable energy technologies. Using up to $453.72 million in Recovery Act EECBG funds for a funding opportunity announcement (FOA), the Retrofit Ramp-up Program was initiated.

Purdue University saw the Retrofit Ramp-up Program as an opportunity to utilize the skills and resources available in the College of Technology Department of Building Construction Management to assist the limited staff available in the City of Lafayette obtain support from this funding opportunity. The City of Lafayette’s close proximity to campus and recent

collaboration to seek funding from the State of Indiana for an energy related retrofit demonstration home, which generated interest but was not funded, led to a partnership to develop a Retrofit Ramp-up proposal. Although Lafayette was eligible to receive funding, it was necessary to team with the City of Indianapolis, the nearest major metropolitan area, to generate a funding request large enough to meet the program requirements.

The proposal was chosen as one of 25 awards throughout the US in April of 2010. Indianapolis received a grant totalling $10 million of which just over $1 million was allocated to the City of Lafayette. Although no grant funds could be expended beyond April of 2013, delays in final program guidelines from the Department of Energy prevented the agreement between Purdue University and the City of Lafayette from being drafted until late summer of 2010. Purdue University as a subcontractor to the City of Lafayette, a sub-grantee, was relieved from many of the reporting requirements of the program, but retained a substantial requirement to assist the city as the primary advisor to the program.

The City of Lafayette community development and redevelopment departments cooperated in choosing a neighbourhood for the retrofit ramp-up that would facilitate community-wide housing retrofit for improved energy performance. Retrofits would be funded through grants to low income homeowners with the deep-energy demonstration of housing retrofit serving as a highly visible example of possible outcomes in a typical neighbourhood home. The Glen Acres and Vinton communities are located in an area with a significant number of foreclosed post World War II homes that are appropriate for energy retrofit. Funds from a U.S. government Neighborhood Stabilization Program (NSP) grant to the City of Lafayette for a comprehensive redevelopment of the same communities was used to provide the necessary city planning staff to complete the project.

The NSP funding is intended to finance the acquisition of foreclosed properties that are then rehabilitated for sale to low income individuals. This financing provided the means for Lafayette to purchase a deeply discounted home in foreclosure that would serve as the basis for the deep-energy retrofit demonstration. The two programs utilized had different but compatible goals. The DOE Retrofit Ramp-up Program, later renamed Better Buildings, had the major goal "*to stimulate activities that move beyond traditional public awareness campaigns, program maintenance, demonstration projects, and other "one-time" strategies and projects … to stimulate activities and investments which can 1) Fundamentally and permanently transform energy markets in a way that make energy efficiency and renewable energy the options of first choice; and 2) Sustain themselves beyond the grant monies and the grant period by designing a viable strategy for program sustainability into the overall program plan*" (Department of Energy, 2009). Others have noted the urgency of energy market transformation that is outlined in the Retrofit Ramp-up funding opportunity because "*The full deployment of cost-effective, energy-efficient technologies in buildings alone could eliminate the need to add to U.S. electricity-generation capacity*" (National Academy of Sciences, 2010).

In contrast, the NSP funding goals sought to stabilize neighbourhoods experiencing significant foreclosure activity through community infrastructure improvements and elimination of vacant housing units. The NSP directly funded housing renovation, or in some

cases, demolition. Because NSP funds were available to improve both the physical condition as well as the current market viability of the home selected for the deep-energy retrofit, the demonstration home was able to showcase the cosmetic and lifestyle upgrades often chosen by homeowners along with the energy related retrofits being funded under the DOE program. Combining these two grants provided a showcase for a whole-house view of refurbishment services. Whole-house retrofits provide savings in cost and complexity by completing energy conserving measures at the same time that repair or cosmetic upgrades are implemented. A significant example of this was experienced in this case of the deep-energy demonstration home. Air sealing and insulation upgrades were completed with lower cost and complexity because the exterior siding for the home was already being replaced.

In parallel with technical research for selection of energy conserving measures (ECM) for the deep-energy retrofit demonstration by faculty and students at Purdue University, a weekly meeting was held with the builder and the NSP program manager. The ECM selection was based on the following guiding principles:

- ECMs should be appropriate for most homes in the communities
    - Easy for local building trades to understand and install
    - Materials available through traditional supply channels without delay
    - Performance was assessed from a whole-building viewpoint
    - With near term potential for positive payback but with no specific cut-off
    - Priority was given to retrofits that could be funded by program grants
    - Promote energy conservation first with introduction of alternative energy sources only when energy consumption has been minimized
- ECMs obvious to visitors and individuals that passed by the demonstration home were desirable for program visibility and ease of endorsement

The combined management of the NSP funding and the DOE funded grants for the Lafayette Energy Assistance Program created a positive synergy. Nevertheless, the local program manager initially involved with the NSP program possessed little knowledge of building technology or energy related construction and at times exercised poor financial management. Delays resulted that prevented the construction activity from progressing at a normal pace. Because of these delays, it was not possible to use the demonstration home as originally intended. A change in the program manager position by the City of Lafayette was made after approximately six months, but the LEAP was well behind schedule.

The intended use of the demonstration home was to provide the LEAP marketing outreach. Glen Acres and Vinton are communities with substantially more low-income and minority population than the overall Lafayette population and no venue exists within the communities for the purpose of educating homeowners about the benefits of energy conserving retrofit or available opportunities for assistance in financing and implementing appropriate retrofits for their home. The construction delays prompted the feeling that the demonstration home alone could not be counted on as a source of community outreach. To overcome this possible shortcoming, signage at the building site, frequent public service press and radio releases through Purdue University press outlets, meetings at a community school advertised by neighbourhood signage, and word of mouth from early grant recipients helped to keep the grant program on track.

3. The Deep-Energy Retrofit Demonstration Home

A detailed description of the ECMs chosen for the demonstration home is beyond the scope of this paper. The following list provides basic information about the ECMs.

Windows: R-5.56 triple glazed casement
Sun Tube: One in each bath with dimmer to provide daylight illumination
Exterior Doors: Insulated steel, thermal break frame, magnetic weather-strip, polyurethane core R-8.3
Crawl Space: Damp Proof w/ sealed 20 mil poly floor cover
Attic Access: R-40 insulated, weather-stripped attic closure system
Air Seal: Air seal all top plates and ceiling penetrations with closed cell foam
Expanding foam seal all exterior wall penetrations
Insulation: Attic – R-60 Loose Fill Cellulose
3" closed cell foam - 3' at roof edge (R-20+)
Crawl Space – 2" closed cell foam on interior of crawl wall and band joist (R-13+)
Exterior Walls – R-11 batts @ 2x3 wall cavity plus 4" (R-20) extruded polystyrene sheathing (2 layers of 2” foam with lapped and taped joints)
South Overhang: Extend to 16" for summer shading and add continuous vent
Hot Water: Heat Pump Water Heater min. COP rating of 2.0 or greater
Renewable Energy: Nominal 4 KW Solar PV System
Furnace & AC: multi-speed air handler, min. 25,000 BTU gas furnace, 1 ton AC
Mastic Seal All Ductwork
Energy Recovery Ventilator: min. 60% heat recovery, unit and ductwork installed in conditioned space
Thermostat: 7-Day Setback
Appliances:

Washer	Front Load	Energy Star Rated
Dryer		Energy Star Rated
Refrigerator	Top Freezer Model	Energy Star Rated
Dishwasher		Energy Star Rated

Lighting/Electrical: 44 circuit energy monitor, real-time internet energy use dashboard
All lighting CFL or T-8 florescent except LED kitchen task lighting
Window Coverings: Living Room Insulating Cellular Shades with air sealing tracks

Because the deep-energy retrofit home was also a NSP remodel project, the builder chosen to complete the work was a low bidder under the qualification rules of the NSP funding. They had a typical background in residential construction with no special expertise in energy related building. The weekly meetings used in the ECM selection process were an opportunity to provide the builder and some of his subcontractors with the technical requirements of the most unusual of the ECMs. A PhD student made weekly visits to the project site to meet with the builder, the program manager and any subcontractors or material suppliers involved that week. With the builder in charge of day to day work and quality control, occasional performance issues were anticipated.

While no serious quality control issues were apparent, several things did occur that are indicative of common oversights that can be experienced in energy related retrofit. To verify the energy performance of the demonstration house, an energy auditing firm was hired to complete a post-construction inspection using a blower door and duct blaster to confirm the success in air sealing the structure and ductwork. A preliminary use of the blower door was also utilized before completion of the interior wallboards. At this point the ceiling was complete and all air sealing measures were completed by the builder's subcontractors. Within a very short period of introducing negative air pressure to the structure, significant flows of cold exterior air were noted entering. Figures 1 and 2 are examples of a few of the many poorly sealed penetrations.

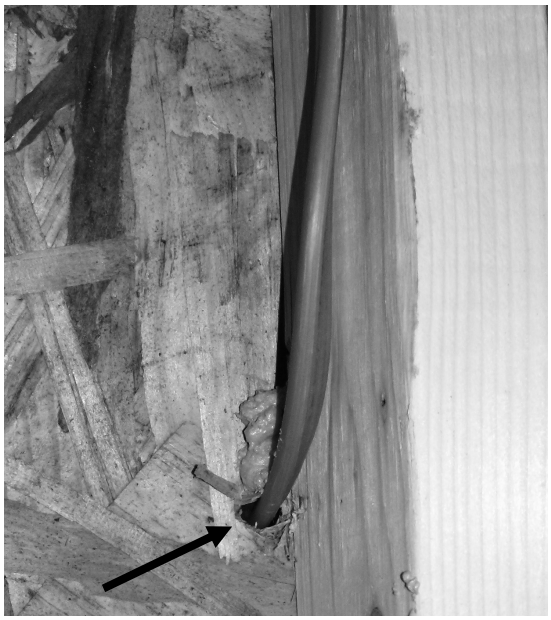

Figure 1: Poor Foam Air Sealing

Figure 2: No Foam Seal at Exterior Penetration

Failure to commission HVAC equipment is common in residential construction. It was no different in the demonstration home. The first time the air conditioning was turned on the air volume from the air handler was so high it caused significant noise within the home and caused papers to blow if located close to an air supply outlet. The multi-speed fan for the system was capable of servicing a range of capacities from 1.5 to 6 tons of cooling. Rather than setting the system for the design parameters, the HVAC installers left the factory preset values in place.

In addition to verifying the air infiltration and duct leakage of the completed demonstration home retrofit, the energy auditing firm completed a common U.S. home energy rating called the Home Energy Rating System (HERS). The HERS rating is an index using a score of 100 to represent the performance of homes based on a reference home built to meet the 2006 International Energy Conservation Code. A net-zero energy HERS home score is 0. The lower a home's HERS score, the more energy efficient it is in comparison to the HERS reference home. Figure 3 is the rating certificate with a score of 17 for the deep-energy demonstration home.

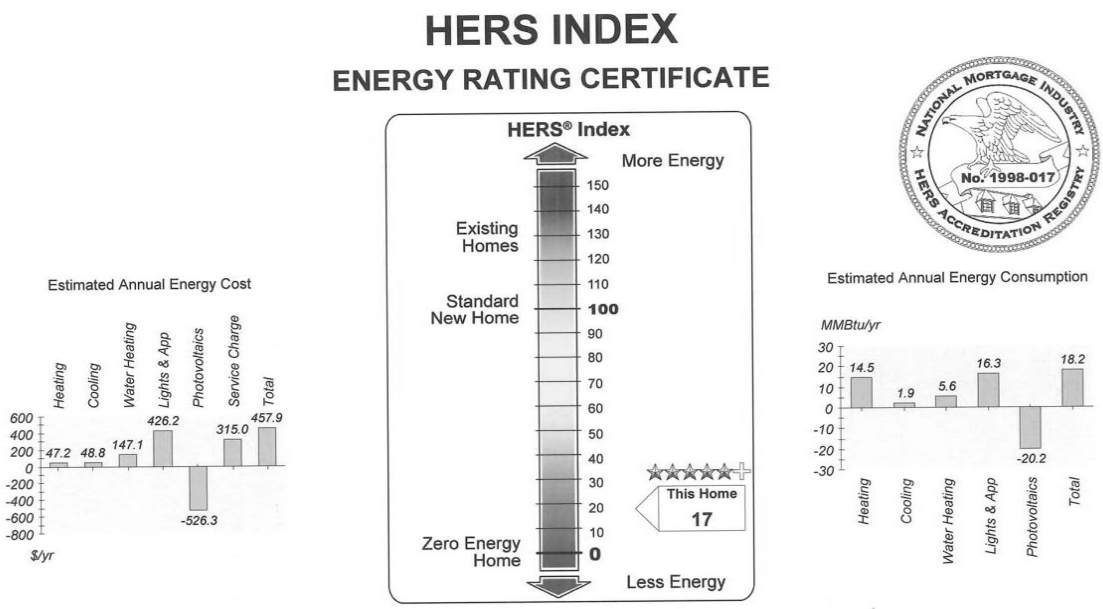

Figure 3: Demonstration Home HERS Rating Certificate

While it is not possible to separate all costs related to the energy related retrofits from the major modifications to fully rehabilitate the demonstration home, the final energy retrofit costs were 18% less than original budget for the deep-energy retrofit. Some saving came from carful selection and purchasing of ECMs, but the bulk of the savings resulted from the significant reduction of installed cost for solar PV systems that took place between 2009 when the initial budgeting was completed and the actual installation in 2012. The budget savings allowed three additional grants to be made from program funds for low income homeowners.

4. Program Educational Activities

Community outreaches were extensive for the deep-energy retrofit home and retrofit grants. A combination of press coverage, community meetings, open houses, printed handouts, displays, as well as educational seminars for homeowners, contractors and the academic community were utilized. Press coverage began as soon as the funding award was announced, generating interest almost immediately. This was followed by press releases from the City of Lafayette, Purdue University, and the media group in the College of Technology. Press releases were strategically timed to coincide with phases of the project and opportunities for community interaction throughout the grant period.

The most significant evidence of community interest came during the open house period in the summer of 2012. The deep-energy retrofit home was staffed by students every weekend. Newspaper and radio advertisement, as well as street signage and word of mouth contact throughout the community supplied a steady attendance. Weekly attendance ranged from 20 to 35, with visitors coming from the entire Lafayette metropolitan area rather than just the targeted neighbourhoods. The consistent attendance prompted the decision to extend the open house period several weeks beyond the original plan.

To extend the outreach penetration, the demonstration home was included in several activities not directly related to the LEAP. The first was inclusion as part of the International High Performance Building Conference at Purdue University in July of 2012. This conference included a short course on net-zero homes conducted by the author and several others from the College of Technology and a tour of the demonstration home open to all conference attendees. The researchers who attended the tour included individuals with interest in high performance buildings, HVAC performance, and compressor design. Several weeks later the home was included as part of the Parade of Homes conducted each year by the Builders Association of Greater Lafayette.

At each of the open houses and special events contact information was collected from individuals interested in more in-depth energy related retrofit education. Over 40% of the visitors provided contact information. This strong response is an indication of the keen interest the visiting homeowners had in learning more about how they can reduce the energy consumption in their homes. To accommodate this interest, a half-day educational seminar was offered for homeowners. Presentations were given on the following topic areas by the author and the PhD student who was involved with supervision of the deep-energy retrofit.

- Why save energy?
- Energy audit & testing
- Specific technologies to reduce home energy consumption
- Renewable energy systems for the home
- Energy use impact of landscaping, overhangs, site plans
- What to watch out for when contracting for a home energy retrofit
- Choosing appropriate energy conserving upgrades
- Energy Monitoring

The handouts and curriculum developed will be used for one additional wintertime open house and homeowner seminar. In the future these materials will serve as a template for anticipated educational outreach for other programs.

An additional half-day educational seminar was offered for contractors and suppliers using topics similar to the homeowner seminar. Greater technical depth was offered and the discussion was oriented to the concerns contracting organizations have as they consider business opportunities in energy related retrofit. Attendance at this seminar was built through the contacts that the Purdue University Department of Building Construction Management has developed by working on a number of projects with the Builders Association of Greater Lafayette.

5. Discussion

University and student involvement in the project provided benefits to the program outcomes, university community relations, future university research, and student growth. Without the participation of Purdue University, the City of Lafayette would not have initiated a proposal to obtain funds from the DOE retrofit ramp-up. The resulting grants allowed low-income individuals to reduce monthly costs to help them maintain homeownership in the two foreclosure prone communities. Purdue University received significant notice in the mass media for their participation, emphasizing positive public relations with the City of Lafayette.

Homeowner education provided detailed information for numerous individuals who did not obtain retrofit grants but were prompted to investigate energy efficient retrofits for their homes. These benefits to the community will continue to accrue for years to come.

Two graduate students and six undergraduate students were funded by the program to participate in planning, supervision or community outreach activities. In all cases these students learned a great deal about home energy conservation. In addition, many improved their skills in public interaction. One graduate student is completing his Master of Science thesis on measurements of success in energy use reduction from retrofit work supported by the homeowner grants. Additional research will be conducted on the deep-energy retrofit home performance and on long-term energy use of the homes retrofit through grants.

Despite all of the very positive outcomes of the LEAP partnership, not all of the goals of the original retrofit ramp-up concept have been realized. One of the original objectives of the Lafayette program was to reduce the risks that a single construction organization must undertake when they choose to provide energy retrofit services for smaller-scale projects. Most small construction organizations choose not to initiate whole-house energy services activity. They typically lack skills to assess, sell, and complete affordable residential building energy improvements that maximize energy savings for individual homeowners.

The need for market transformation based on contractor competency was emphasized in the conclusions of a 2008 report to the State of Vermont reviewing existing programs in the United States that attempt to eliminate first cost barriers for energy efficiency improvements in the residential sector. The report by Merrian Fuller makes six recommendations to the state. The only recommendation not directly related to financing energy related improvements was to expand the network of energy improvement contractors. The report's author felt that support and action was needed to train more contractors and their crews in a way that will increase the capacity of businesses to serve more customers. They also noted that the programs with the highest volume of energy related loans had a strong contractor network and included regular communication with the contractor network.

Within the Lafayette metropolitan area the number of contractors qualified to undertake whole-house energy related retrofits is very limited. In the two years prior to implementing the LEAP, the City of Lafayette had undertaken home renovations which included substantial energy upgrades under the NSP. Only three qualified construction organizations responded to the call for bids even though during this period an economic recession limited participation in other construction activity. The LEAP initially intended to attract small scale residential renovation contractors who would like to expand into energy services contracting. The potential for up to 80 government funded home retrofits in two contiguous communities provided strong market potential. If successful, at the end of the three year program a qualified group of whole-house energy services contractors would be operating in the Lafayette metropolitan area.

Subsequent to the final funding document preparation for the Lafayette award, the DOE administrators released guidance about applicability of Davis Bacon wage rules for retrofit activities. Davis Bacon is a series of related acts of the U.S. Congress administered by the

U.S. Department of Labor (DOL) which require all contractors and subcontractors performing work on federally funded contracts in excess of $2,000 to pay wages and fringe benefits equal or greater than the prevailing wages in the area of the project. In some geographic areas the prevailing rates are established wage rates paid to unionized labour. For small residential projects, the prevailing wage rates may not be heavily influenced by union negotiations. Nevertheless, the current Davis Bacon rules require substantial recordkeeping and reporting. These reporting requirements typically prevent small contractors from participation in federally funded work. As a result, all LEAP retrofit work for homeowners receiving grants were completed under the management of a large general contractor. This conflict of priorities constrained the growth of a viable small contractor base for energy retrofits. Market transformation through growth of a qualified group of whole-house energy services contractors in the Lafayette market did not take place.

6. Conclusion

This case study introduces one approach to the world-wide residential energy use challenge presented by the large number of individually owned and operated homes that were constructed when the energy consumed to operate these structures was not a consideration in design and construction. By combining multiple government programs, cosmetic and lifestyle upgrades were completed along with energy efficiency upgrades. This showcase for a whole-house view of refurbishment services where savings in cost and complexity can result from completion of energy conserving measures while completing other housing repairs or cosmetic upgrades is an example for both subsidized and market-rate retrofit.

The author's experiences with this case demonstrate the need for program managers that understands the complexity of energy related retrofit. The case also demonstrated that quality control is a major challenge to successful energy retrofit programs. Over the upcoming years both the demonstration home and the subsidized retrofit homes will be monitored for research to confirm the actual energy reduction benefits of the program.

Major benefits accrued to the Glen Acres and Vinton Communities but questions remain about how well the program achieved the originally intended goals. No market transformation took place to increase the supply of contractors pursuing energy services work. Contractor knowledge was improved somewhat, but for the overall city a skills gap persists. In the U.S., natural gas prices are falling, which offers little financial incentive for energy conserving retrofit. Homeowners continue to show a personal preference for visible upgrades. In addition, financing and valuation norms support visible upgrades while at the same time ignoring energy related upgrades. Contractors have no compelling reason to close the skills gap and sell energy related upgrades unless government programs finance the work and promote the energy related investment. In this case conflicting priorities from government wage rate support essentially nullified any incentives for contractors to participate.

Thirteen jobs were created by the program in the most recent quarterly report for the DOE grant (Department of Energy 2012), but job creation reporting was not required by small sub-recipients of funding such as the City of Lafayette. As a result, it is not clear if any

Indianapolis or Lafayette jobs were included in the report. Job growth was probably negatively impacted by the Davis Bacon wage rate recordkeeping and reporting requirements as well. These observations serve to demonstrate the potential for failure when competing regulatory interests are not considered in program design. The sharing of additional case study experiences as new energy conserving programs are developed and put into action is encouraged so that others can learn from the experiences and outcomes of each new program. Above all future programs need greater engagement of small contractors typically employed for residential retrofit in program activities. Engaging students in similar programs as part of their normal coursework is also advisable.

References

1. Department of Energy (DOE) (2009) *Competitive Solicitation: Retrofit Ramp-up and General Innovation Fund Programs, Funding Opportunity Announcement Number: DE-FOA-0000148*, Office of Energy Efficiency and Renewable Energy, (available online https://www.fedconnect.net/fedconnect/?doc=DE-FOA-0000148&agency=DOE, accessed on 10/10/2011)

2. Department of Energy (DOE) (2012) *Grants – Award Project DE-EE0003577 Summary for April 1 – June 30, 2012*, (available online http://www.recovery.gov/Transparency/RecoveryData/Pages/RecipientProjectSummary508.aspx?AwardIDSUR=106076&qtr=2012Q2, accessed on 15/10/2012)

3. Department of Labor (DOL) (2011) *The Davis-Bacon and Related Acts*, (available online http://www.dol.gov/compliance/laws/comp-dbra.htm, accessed on 10/11/2011)

4. Fuller M (2008) *Enabling Investments in Energy Efficiency: A study of programs that eliminate first cost barriers for the residential sector, Efficiency Vermont*, (available online http://www.greenforall.org/what-we-do/building-a-movement/community-of-practice/enabling-investments-in-energy-efficiency, accessed on 10/10/2011)

5. National Academy of Sciences (NAS) (2010) *Real Prospects for Energy Efficiency in the U.S.*, (available online http://www.nap.edu/openbook.php?record_id=12621&page=263, accessed on 17/5/2011)

6. National Home Performance Council (2010) *Residential Energy Efficiency Retrofit Programs in the U.S.: Financing, audits, and other program characteristics*, (available online http://www.nhpci.org/images/NHPC_WHRetrofitReport_201012.pdf, accessed on 10/10/2011)

7. National Science and Technology Council (2008) *Federal Research and Development Agenda for Net-Zero Energy, High Performance Buildings*, (available online http://www.ostp.gov/cs/nstc/documents_reports, accessed on 10/2/2008)

8. U.S. Green Building Council (2009) *Buildings and Climate Change*. (available online http://www.usgbc.org/ShowFile.aspx?DocumentID=5033, accessed on 16/3/2009)