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The New Market Transformation Needed for Commercial Building Energy Efficiency

Valerie Patrick[1], Leslie A. Billhymer[2] & William Shephard[3]

[1] Fulcrum Connection LLC, Pittsburgh, USA

[2] University of Pennsylvania and Consortium for Building Energy Innovation, Philadelphia, USA

[3] Creative Problem Solving Group Inc. (CPSB), Buffalo, USA

Correspondence: Valerie Patrick, Fulcrum Connection LLC, 2416 Traci Drive, Pittsburgh, PA, 15237, USA. Tel: 1-412-742-9675. E-mail: valerie.patrick@fulcrumconnection.com.

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Abstract

The U.S. Department of Energy [DOE] established the Consortium for Building Energy Innovation [CBEI] to address commercial building energy efficiency as an innovation cluster, where the regional market context (Note 1) guides the research agenda for market transformation (Porter, 2001). CBEI develops content to support Advanced Energy Retrofits (AERs), a retrofit which results in 50% or greater reduction in building energy use, in small- and medium- sized commercial buildings (less than 250 000 ft^2). The challenge is collecting input for a market with many stakeholders so that a strategy emerges to implement AERs. This research applies systems and complexity theories to develop a strategy to promote the emergence of AERs in this market incorporating multiple stakeholder perspectives (Note 2).

Keywords: building retrofit, energy efficiency, facilitation , market transformation, stakeholder engagement, systems theory

1. Introduction

1.1 Motivation for the Work

Building energy consumption is an environmental sustainability issue, an economic issue, and a national security issue confirmed by multi-lateral public and private sector efforts. The environmental burden of anthropogenic greenhouse gas emissions is the most pressing challenge to a sustainable way of life. Anthropogenic greenhouse gas (GHG) emissions causing climate change by the burning of fossil fuels to supply energy to run and operate buildings were one-fifth of the global GHG emissions in 2010 according to the International Panel on Climate Change [IPCC] (2014). The U.S. inventory of greenhouse gases published by the Environmental Protection Agency [EPA] (2014) shows that in 2012, 78% of all greenhouse gas emissions in the U.S. were from the burning of fossil fuels. Of these fossil fuel emissions, 18% were from commercial buildings, 20% from residential buildings, 27% from industrial operations, and 34% from transportation. Climate change is gradually becoming more tangible to most of the world's population through its' broad ranging impacts that threaten existing civilization. In the U.S. political culture, we are beginning to comprehend the type of decisive action that will be needed to avoid catastrophic rises in global temperatures. Reducing greenhouse gas emissions attributable to building energy consumption is one clear track in these activities.

In 2005 the United States passed the Energy Policy Act, which required all Federal Buildings to achieve energy performance at least 30% below that specified in ASHRAE (American Society of Heating, Refrigeration and Air-Conditioning Engineers) Standard 90-1-2004, making it the first piece of national legislation to effect energy efficiency at the scale of the building stock. Additional actions have been taken by the federal government to reduce the energy consumption of buildings including, but not limited to, the EnergyStar rating system for buildings, Portfolio Manager for benchmarking the energy performance of buildings, the Better Buildings challenge, and the National Climate Action Plan.

The CBEI was formed in 2011 by the U.S. DOE to develop methods and means to catalyze a transformation of the building energy retrofit market for small- and medium-sized commercial buildings (SMSCB) to support the Obama administration's Climate Action Plan. The Plan sets a national goal to double energy productivity by

2030 over 2010 levels, and this goal makes energy efficiency a priority.

In 2012, CBEI formed retrofit stakeholder groups called Platforms to shape research work and results to grow the SMSCB energy efficiency market. Participating industry organizations such as Bayer MaterialScience, PPG, and United Technologies, understood the inherent challenges of introducing new products, services, and ideas into a market. These organizations have found that external drivers such as regulations, mega-trends, new market needs, and financial incentives are needed to overcome the inherent risk and extra work involved in introducing a new market or new product to existing customers. Consequently, to catalyze coordinated market transformation, an overarching plan is needed based on a holistic understanding of the market to determine the type and sequence of interventions needed.

This paper will cover work by the CBEI Stakeholder Engagement Platforms Project. A facilitative approach based on the techniques of creative problem solving has been used to identify and address market failures and barriers with retrofit market practitioners. A lens based on complex adaptive systems theory was used to evaluate the market failures and barriers. We propose a simple systems model to accomplish three goals. First gather the correct input to prepare a market-representative hypothesis about how to change the commercial building retrofit market. Second generate transformation insights from assessing the hypothesis with the lens of complex adaptive systems theory. Third develop a new approach for market transformation.

1.2 Review of Systems Theory and Complexity Science Applied to Change Initiatives

Strategies to improve the energy efficiency of buildings are supported at multiple scales through legislation, jurisdictional mandate, organizational, and sometimes even personal planning. Taking a systems approach to this work involves conceiving ways to intervene that apply to actions, decisions, projects, goals, strategies, and business practices of the market. Resulting impacts of the interventions include intended and sometimes unintended consequences to familiar infrastructure, economic, environmental, and social systems as well as to the interactions between these systems that are inherently connected through human and natural activities.

Thinking in terms of whole systems can lead to meaningful new associations, and this is the benefit the CBEI offers to the U.S. building retrofit industry. Scientists have applied the fields of systems theory and complexity science to develop frameworks to address problems in a way that includes examining specific systemic interactions. We draw on several precedents for this research in order to provide an approach specific for the U.S. building retrofit industry.

The definition of a complex adaptive system (CAS) and emergence that are used in this research is based on work to evaluate organizational change from the introduction of a health information system (Diment, Yu, & Garrety, 2009**)**. Specifically, a CAS is one in which the individual components self-organize by the system interacting with itself and with its environment so that the whole is greater than the sum of its parts. Emergence is a consequence of complexity in which interactions at one level of the system cause changes at another level.

This research identified three relevant approaches from existing literature that apply systems thinking and/or complexity science to change a system. A summary of this research is provided in Table 1.

Table 1. Summary of systems thinking and complexity science approaches to change systems

Process Framework	**Diffusion of Innovations Theory Applied to Market Transformation**	**Systems and Complexity Theories Applied to Organizations**	**Participatory Market System Development (PMSD)**
Reference:	York, 1999	Amagoh, F., 2008	Osorio-Cortes, 2012
Context:	Energy Center of Wisconsin incentivized use of energy-saving products to reduce energy consumption in buildings	Applying a process from systems and complexity theories to improve performance of a governance team in a non-profit organization.	Process developed by Practical Action to involve market actors in improving a market system to help eradicate poverty.
Key Process Steps:	1. Define markets in which to intervene. 2. Choose target products or services within the chosen market. 3. Measure market baselines against which intervention(s) will be evaluated. 4. Define program (intervention) goals. 5. Design strategies and measures for the intervention. 6. Implement measures. 7. Evaluate results of the program. 8. Develop and implement a transition (exit) strategy.	1. Gather data about how team members work together 2. Identify what is not working well for the team (themes) 3. For each theme, describe how it relates to containers (structures that provides teams spaces to operate), differences (style, background, experience, outlook), or transforming exchanges (interactions that create change) 4. For each theme, assess and explain the degree of constraint 5. Work with the team to identify corrective actions 6. Implement the corrective actions and monitor impact on team performance	1. Market system selection 2. Preliminary mapping and analysis 3. Strategic design and planning 4. Empower marginalized actors 5. Engaging key actors 6. Participatory market mapping 7. Participatory planning 8. Facilitating change 9. Monitoring, evaluating, and learning
Advantages	• Simple to implement • Simple to track	• Intervening on interconnections and purpose of a system is an effective way to change a system • The concept of an optimal level of constraint for functioning of a system provides new thinking on how to improve the system	• Intervening on interconnections and purpose of a system is an effective way to change a system • Viewing the market as a map provides a new perspective on how the market operates today and could operate in the future
Limitations	• Intervening on a system element (products) rather than on interconnections or purpose of a system which is an ineffective way to change a system • Identifying a single product that would lead to reduced energy consumption across the diversity of targeted commercial buildings in the Greater Philadelphia region and beyond would be very difficult	• The building energy retrofit market is not an organization • This approach is focused on improving a system while the need for building energy retrofits is to change the way retrofits are done in order to grow AERs	• The building energy retrofit market is very complex with both products and services as well as a multitude of stakeholders and market actors so applying a market map approach may be difficult • This approach is focused on engaging marginalized market actors to eradicate poverty while the focus for the building energy retrofit market is acceleration of AERs

1.3 The Applications of Relevant Systems Theory and Complexity Science Approaches

The Diffusion of Innovation (DOI) theory summarized in Table 1 was applied by the Energy Center of Wisconsin (York, 1999). This method of market transformation is centered around the penetration of products and services in a market, a stepped process which relies primarily on the DOI theory. In an example from the research, the selling and installing of natural gas furnaces for residential space-heating was incentivized. This market reached 90% but declined up to 20% within a year of the program ending. While this approach relies on macro-economic theory, the approach did not produce lasting change in the market's behavior because only one element of the market system was changed (York, 1999; and Eto, Prahl, & Schlegel, 1996). Systems possess four parts; purpose, elements, interconnections, and boundaries (Meadows, 2008). The DOI approach used by York only focuses on products and services in step 7, an element of the market system (Peach, Prahl, & Schlegel, 1993).

Systems theory predicts that changing elements is typically the least impactful way to change a system (Meadows, 2008). In Complex Adaptive Systems (CAS) theory, the focus is on creating the right minimalistic conditions and interventions for the market to self-organize towards the desired end-goal, or in other words, to demonstrate emergence. Understanding the market as a system helps to define the types of interventions that can have staying power. These will be those interventions which change behavior by changing not only single elements, but also system function, interconnections, and boundaries.

By direct contrast to York's DOI approach, Australia's construction market was transformed by changing the procurement rules for construction projects initiated by the government (Brown, Furneaux, & Gudmundsson, 2012). Specifically, contracts were required to include integrated approaches to design and construction work on buildings. Contracts are a system interconnection, or a way the market system members interact with each other.

CAS theory can also be important to the understanding of change in social, political, economic, and technical realms. The Organization for Economic Co-operation and Development produced a report on the application of complexity science to develop more effective public policy (2009). This report describes the new thinking required of policy makers as follows:

> "When analyses are done using complexity science methods, insights about the underlying mechanisms that lead to complex behaviour are revealed. Although deterministic quantitative prediction is not generally achieved, the elucidation of the reasons for complex behaviour are often more important for comprehending what might otherwise be puzzling real-world events."

And so even in spite of the inability to make quantified predictions of behavior change, there are those that seek to create change models that nonetheless appreciate system complexity. In support of this approach, the different theories for applying complexity science to organizations to address social challenges have been categorized as discovery of order, modeling emergent order, and intrinsic emergence (Lichtenstein, 2000). The category of most relevance to market transformation is intrinsic emergence which contains CAS theory according to this categorization (Lichtenstein, 2000).

The second identified approach that applies systems thinking and complexity science in order to develop interventions to change a system comes from Organizational Science. In this approach, CAS theory is applied to improve the performance of a governance team in a non-profit organization (Amagoh, 2008). The approach in this study applies three characteristics of CAS to the governance team; differences, transforming engagements, and containers. The study uses a premise that there is an optimum level of constraint that needs to result from the differences, transforming engagements, and containers in order for the desired organizational change to intrinsically emerge. Interestingly, in related research, it is stipulated that a key to valuable creativity is the right kind of constraints (Amabile & Kramer, 2011 and May, 2013). Market actors will be the ones to conceive and implement a CAS model for change, therefore, their creativity must be enlisted early. This approach impacts system interconnections and purpose, a more effective way to change a system than just changing elements.

The third identified approach is the Participatory Market System Development (PMSD) approach which uses systems theory to develop markets in developing regions (Osorio-Cortes, 2012). It's been tested by the Practical Action organization in several contexts to help serve as interveners, particularly in crisis management situations. The market map and identification of systemic blockages, opportunities, and risks engages market actors to develop approaches that can improve a given market system. The market map from PMSD can be used to process and validate approaches derived from applying CAS theory to transform the building energy retrofit market. In PMSD, the intervention is also on the level of the interconnections and purpose of the system at the market scale, where it operates between organizations, in contrast to the single organization intervention of the

second approach. Creating and viewing the market as a map provides a new perspective for the users of this process on how to improve a market, a feature that further distinguishes this approach.

These approaches provided important insights that informed the CBEI team's facilitative program to prioritize work in the SMSCB retrofit market. The models sharpened the focus of our research with stakeholders to identify the purposes and interconnections in the existing market that need to change first to enable more and deeper 50% or greater energy efficiency. While these approaches do offer valuable direction for the building industry, they are insufficient to address the operational energy efficiency of SMSCB. This is because the specific contexts in which these approaches were used differ substantially from the SMSCB retrofit market.

2. Methods: Building a Collaborative Approach

Because SMSCB retrofit market actors will be the ones to conceive and implement a CAS model for change, their creativity was enlisted early by collaboratively engaging them. Part of the challenge in establishing this collaboration was the many diverse and sometimes competing functions and roles that the market actors play. Two elements proved to be essential to overcome this challenge and enable productive collaboration.

First, CBEI established the Platforms project to bring together committed and diverse regional actors who play a similar role in the energy retrofit market. The diversity of perspectives includes size of firms and adoption propensity among other factors to gain a true understanding of market receptivity to changed practices. Participants in Platforms are engaged to be co-producers of CBEI content (for example contracting protocols, technology solutions, training for building operators, etc.) so that content is responsive to and supported by the regional market. CBEI currently has 6 Platforms as follows:

- Architecture, Engineering, and Construction Firms
- Building Owners, Operators, and Occupants
- Suppliers to the Building Retrofit Market
- Workforce Education for the Building Retrofit Market
- Financing Providers for Building Retrofits
- Utilities and Public Policy Makers

CBEI designed an initial convening of these groups to examine the current state of the SMSCB energy retrofit market from their integrated perspective. This examination included the identification of the strengths and advantages as well as of the perceived barriers and challenges to the growth of this market. 125 retrofit market stakeholders committed to participate in one of two scheduled workshops. Participant interviews gathered information about their expertise in the energy retrofit market, innovation style preference, and people interaction preference. This information was used to form four diverse cross-platform groups each to focus on one of the four different segments of the value chain for the energy retrofit market as depicted in Figure 1. Each of these breakout groups benefitted from a professional facilitation program.

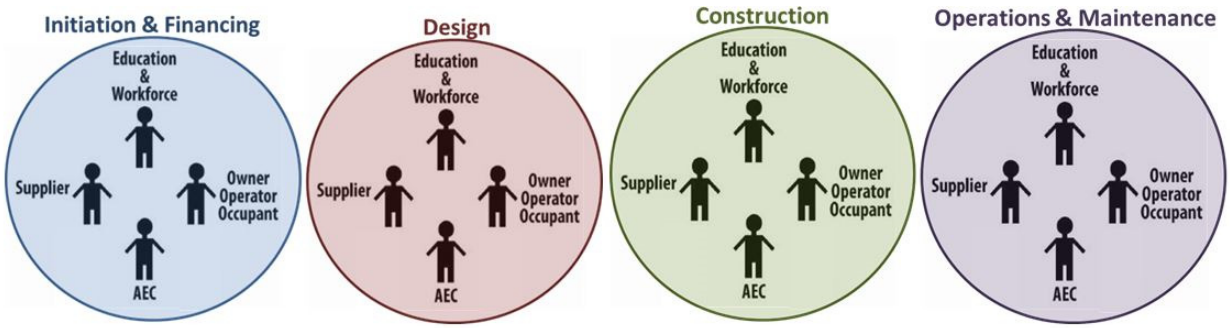

Figure 1. Cross-platform groups by value chain segment for building retrofits

The facilitation design prepared participants to contribute their individual opinions and experiences in an organized way so that the body of findings could reflect the "market", insofar as it was represented by the participants. Each break-out group was provided with a one-page document containing as-is context-setting statements for the market segment and a working statement to serve as a starting point for generating ideas for the most effective ways for the retrofit market to adopt a greater number of energy retrofits.

A technique called "ALUo" (Isaksen, Dorval, & Treffinger, 2000) was used to provide a structured approach to collect input on the SMSCB retrofit market across the groups. "ALUo" is a process approach that stands for Advantages, Limitations, Unique Attributes, and Overcoming Limitations. Participants were instructed to offer their perspectives including everything from actual participation in the market to what has been heard and read about the market. Each break-out group had representatives from across the building retrofit supply chain so the interconnections between the different market players would be included. The break-out groups started with identifying advantages and then moved on to growth barriers (limitations). Finally, the break-out groups were asked to identify those limitations that they felt could be most impactful if addressed. These limitations were presented to the entire group and additional limitations were identified by the big group.

Once the limitations were generated and shared, two different approaches were used to select limitations. The first approach was "Selecting Hits" (Isaksen, et al., 2000) in which each participant was asked to review all the limitations and identify those, based on their perspective, they felt best addressed the task statement. Participants indicated their choices by placing a color-coded dot that identified their professional category on that limitation. The second approach was to sort the limitations to collectively identify the most important ones. Within a matrix comparing marketplace impact to marketplace capability, participants sorted the limitations and then selected the most important ones for CBEI to address.

3. Results

3.1 Stakeholder Input

In total, 577 limitations were identified, and the 221 determined to be high-priority limitations for CBEI to address first with the help of the platforms are summarized in Table 2.

Table 2. High-priority limitations by value chain segment and platform for building retrofits

Value Segment	Owners, Operators, Occupants ●	Architecture, Engineering, Construction Firms ●	Suppliers ●	Workforce Education ●
Project Initiation and Financing	Improving the return on investment for shorter-term energy-efficiency investments. ●●●●●●●●●	Hold energy users accountable for their energy consumption.●●●	Measure cost savings and value ●●●●●	Better package and promote an incremental approach to energy retrofits. ●
	Change the culture to evaluate energy savings in light of lifecycle costing and IEQ (indoor environmental quality). ●●●	Create modeling that is faster, more accurate, and less expensive.	Educate energy retrofit service providers to insure integrated solutions are selected. ●●●●	Change the culture to value energy efficiency. ●
	Create a winning value proposition when energy prices are low. ●●●	Call for creativity and innovation to surmount the challenges.	Quantify the intangible benefits of energy retrofits.	Make the permit and approval processes for energy retrofits easier.●
	Create national, state, and local level energy policies that value energy efficiency. ●●●			Help building owners compete for the most energy efficient buildings.●

Value Segment	Owners, Operators, Occupants	Architecture, Engineering, Construction Firms	Suppliers	Workforce Education
Design	Reach and educate building owners with the clear benefits of retrofits.	Base design decisions on accurate building energy performance data	Appropriate new union job cooperation for energy retrofit market.	Overcome inertia to move away from the "same old" towards innovation.
	Avoid incorrect assumptions in energy modeling leading to compromised results.	Overcoming the over-emphasis on initial cost at the expense of life cycle cost	Provide adequate training so decision-makers can make informed decisions about technology and material decisions to improve energy efficiency.	Creating market pull for energy efficiency retrofits through education.
	Improve communication of integrated design results including a view of individual contributions to energy savings to accommodate busy decision-makers.	Ensure that building codes and behavior support integrated strategies for achieving energy efficiency performance.		
Construction	Increase the conditions such as risk mitigation, experience base, and knowledge base in order to enable more new products and new technologies to be used in energy retrofit building projects.	Reduce the complexity of retrofit financing from a construction standpoint.	Build confidence in the construction outcomes and future building energy performance.	Compete against the "do nothing" option.
	Understand the return on investment in terms of intangibles that impact building performance.	Transition the market into true integrated design, project and delivery and demonstrating the correlation between occupant performance and a high performance building.	Complete low-cost, standardized audits for uniform results and project costs.	Identify and prioritize which building components create the most energy efficiency.
		Avoid cost-cutting of critical energy conservation measures.	Convincing owners to investing energy retrofit projects when tenants pay the bills, and introducing cutting-edge technologies and designs to a conservative building design community.	
		Followed by obtaining money to underwrite retrofit projects.		
		Train building operators to use and optimize sophisticated technologies for energy efficiency.		

Value Segment	Owners, Operators, Occupants ●	Architecture, Engineering, Construction Firms ●	Suppliers ●	Workforce Education ●
Operations and Maintenance	Media to have as much vigor covering stories about improved energy efficiency in buildings as they do for use of renewable energy. Fund and incentive opportunities from the government. ●●●●●● Sharing risks and benefits between owners and tenants. ●●●●●	Allowing individuals to control their workspace without adversely impacting energy performance. ●●●●● Implementing incremental and continuous improvements in energy performance without having to wait for the big retrofit. ●●●●● Including operating cost impacts into decision-making and not just first costs. ●●●●● Use energy performance diagnostics to drive operations & maintenance decisions. ●●	Ensure proper installation of equipment, providing operations. ●●●●●● Maintenance information to optimize energy efficiency, and giving maintenance staff better incentives to increase energy efficiency and reduce risk. ●●●●●● Train operations and maintenance personnel in the latest technologies for energy efficiency. ● Educate about the dynamic nature of building energy efficiency. ●	Educate building operators on building science to optimize energy performance. ●●●●●● Developing clear, concise, and accessible ways to communicate this energy retrofit work. ●●●●●● Get continuous commissioning to be routinely practiced in existing commercial buildings. ● Making the business case to invest in effective energy metering of buildings. ●

3.2 Analysis

Table 3 provides a color-coded map of our proposed process for market transformation as a modified composite of the three process models found in the literature. The starting and ending steps of our proposed process have been informed by the starting and ending steps from the DOI Theory applied to market transformation (coded in dark red in Table 3). The processing of data collected from our first engagement with market actors (steps 4 to 6) was informed by the steps identified by the orange color in Amagoh's approach to organizational transformation. The next step (step 7) was informed by the market mapping process from PMSD (coded purple in Table 3). Our second engagement with market actors (step 8) was informed by both the participatory market mapping from PMSD and the identification of corrective actions with the non-profit governance board (coded green in Table 3). Finally, our monitoring step was informed by all three of the process models (coded light blue in Table 3).

Table 3. Building a new process for market transformation

Diffusion of Innovations Theory Applied to Market Transformation	Systems and Complexity Theories Applied to Organizations	Participatory Market System Development (PMSD)	Systems and Complexity Theories Applied to Market Transformation
York, 1999	Amagoh, 2008	Osorio-Cortes, 2012	This research paper
1. Establish infrastructure to lead and manage the market transformation initiative. This could take the form of an organization such as NEEA or NEEP, or it could be an existing organization that takes on this responsibility. **2. Establish funding to cover costs of the intervention(s) (program costs).** **3. Identify market participants (manufacturers, retailers, consumers) and stakeholders (such as public energy offices, advocacy groups, trade organizations).** 4. Form collaboratives among key market participants and stakeholders. 5. Define roles of participants in the collaborative. 6. Define markets in which to intervene. 7. Choose target products or services within the chosen market. 8. Measure market baselines against which	1. Gather data about how team members work together **2. Identify what is not working well for the team (themes)** **3. For each theme, determine and describe how it relates to containers (structures that provides teams spaces to operate, either physical or organizational), differences (style, background, experience, outlook), or transforming exchanges (interactions between entities, people, systems that create change)** **4. For each theme, assess and explain the degree of constraint** **5. Work with the team to identify corrective actions** **6. Implement the corrective actions and monitor impact on team performance**	1. Market system selection **2. Preliminary mapping and analysis** **3. Strategic design and planning** 4. Empower marginalized actors 5. Engaging key actors **6. Participatory market mapping** **7. Participatory planning** 8. Facilitating change **9. Monitoring, evaluating, and learning** **10. Communicating evidence for uptake**	**1. Identify organization to catalyze market transformation.** **2. Establish funding to complete steps 3 to 10.** **3. Identify market actors, market influencers & other stakeholders.** **4. Collaborate with market actors & key stakeholders to understand barriers.** **5. Evaluate barriers with Maya's conditions for self-organizing to focus on methods and means for emergence.** **6. Project the likely impacts of the methods and means (step 5) and identify accelerants and decelerants to predict desirable & undesirable impact.** **7. Generate a draft market map and evaluate the output from steps 5 and 6 relative to this map to articulate the top market inefficiencies.** **8. Collaborate with market actors and stakeholders to validate the market map, generate market inefficiencies, and identify ways to**

Diffusion of Innovations Theory Applied to Market Transformation	Systems and Complexity Theories Applied to Organizations	Participatory Market System Development (PMSD)	Systems and Complexity Theories Applied to Market Transformation
York, 1999	Amagoh, 2008	Osorio-Cortes, 2012	This research paper
intervention(s) will be evaluated. 9. Define program (intervention) goals. 10. Design strategies and measures for the intervention. 11. Implement measures. 12. Evaluate results of the program. 13. Develop and implement a transition (exit) strategy. **14. Continue to monitor and evaluate market developments.** **15. Continue intervention as indicated by monitoring and evaluation results**			**overcome the top market inefficiencies.** **9. Process all stakeholder input into proposed emergence scenarios for market transformation.** **10. Monitor market impacts and evidence for emergence as methods and means are released to the market.** **11. Revise the key accelerants and decelerants and the emergence scenario as needed to catalyze transformation.**

Following our first engagement with market actors, the Amagoh characteristics needed for emergence were applied to the high-priority barriers by value chain segment to draw insights on what was missing. The insights were drawn using interpretational qualitative analysis by first identifying categories and then the relationships between the categories (Tesch, 1990 and Kawulich, 2004). These insights were used to generate methods and means to address the gaps identified for emergence to be able to occur. For each method or mean, ways to accelerate or decelerate the emergence of that method or mean in the market were considered. This work taken together will be referenced as the insights from the first stakeholder engagement.

Second, the PMSD approach was used to create a market map. The insights from the first stakeholder engagement were used to identify systemic blockages, opportunities, and risks for the market system as depicted in the market map. The systemic blockages, opportunities, and risks were used to identify the following market issues:

- Market Fragmentation. Retrofit product and service providers are fragmented but the business case depends on a holistic view of the building.
- Complexity. There are many variables to account for in measuring building energy performance over time and comparing building energy performance across different buildings but no method to incorporate this into justifying and measuring the results of a building energy retrofit.
- Uncertainty. There are many variables impacting building energy performance with different levels of uncertainty and with different levels of impact on the building energy performance but no tool to quantify this uncertainty as input into creating and validating the business case.
- Operation Isolation. The way a building is operated and maintained can significantly impact its building energy performance before and after a building energy retrofit but this function is typically not included in the retrofit process.

- Procurement. The procurement (e.g., RFP/RFQ) process comes from a building component mentality rather from a whole building mentality on the part of building owners and operators.
- Labeling. Current industry best practices (e.g., LEED and EnergyStar certifications) do not require an integrated approach to design and delivery and costing which would yield the best business case.

The draft market map and market issues described above were used in the second market actor engagement to validate a market map and trigger input on market inefficiencies. The validated market map is shown in Figure 2. The top market inefficiencies identified by market actors in the second market engagement were as follows:

- Reliance on ROI is heavily dependent on energy cost - low cost of energy drives ROI (9 points)
- Market fragmentation on owner's side limits ability to implement retrofits - many small owners with a single building (7 points)
- Need regulation/law to drive energy efficiency rather than only ROI calculations (7 points)
- Lack of understanding of the cost of doing nothing (6 points)
- Market does not account for indicators of extraction, waste, pollution, and future scarcity (4 points)
- Order-of-magnitude economy-of-scale serves the 10% of large building owners but not the 75% of small and non-profit building owners as well as disadvantaged neighborhoods (4 points)
- Lack of consistent policy (4 points)

Interpretational qualitative analysis was again used to process all the market efficiencies identified by market actors in the second market engagement to develop the following categories:

- Information Failure: Markets may not provide enough information because, during a market transaction, it may not be in the interests of one party to provide full information to the other party (17 points)
- Ineffective Legislation and Law (15 points)
- Unstable Markets (12 points)
- Inequality: Market transactions reward consumers and producers with incomes and profits, but these rewards may be concentrated in the hands of a few (12 points)
- Negative Externalities: Consumers and producers may fail to take into account the effects of their actions on third-parties, individuals, organizations, or communities indirectly benefiting or suffering as a result of the actions of consumers and producers attempting to pursue their own self interest (4 points)
- Ineffective Price Mechanisms: Policies that change the behavior of consumers and producers by using the price mechanism and financial incentives (4 points)
- Productive and Allocation Inefficiency: Markets may fail to produce and allocate scarce resources in the most efficient way. (4 points)
- De-merit Goods and Services: Markets may also fail to control the manufacture and sale of goods and services which have less merit than consumers perceive (1 point)

4. Discussion: Emergence Scenarios

The systems model shown in Figure 3 was created as a tool to help formulate and evaluate emergence scenarios to address the top market inefficiencies identified in the second market engagement.

Interpretational qualitative analysis was again used to process the top market inefficiencies and approaches to address the top market inefficiencies identified by market actors in the second engagement together with the above top categories of market inefficiencies, to develop the following three proposed emergence scenarios:

A. Disclosure with an Integrated Purpose Scenario:

A building energy disclosure and benchmarking requirement could help fuel an integrated approach to building energy retrofits if the right information and tools could get to the right people in an environment of the right legislation and laws for incentive to take action. The interventions proposed are as follows:

- Develop and apply protocols to insure good quality of building energy disclosure data, to determine the highest and lowest energy performers by comparable category from benchmarking data, and to supply publicly the minimum data needed by architecture, engineering, and construction (AEC) providers and others to target buildings that could most benefit from an AER.

- Implement a building energy disclosure and benchmarking law that takes into account the needed protocols and data fields
- Provide educational and instructive guidance to AEC providers on how to use disclosure data with available tools and methods to identify integrated solutions for building owners to improve their energy performance and to building owners on how to interpret the disclosure data and determine ways to improve their benchmarking performance (e.g., through integrated ECM packages)
- Develop a matrix of integrated energy-conservation-measure (ECM) packages and potential range of building energy performance improvement by category and size of building (include assumptions)
- Impose consequences (e.g., business tax penalties) on building owners for poor quality of reported data and poor building energy performance per the benchmarking protocol

Evidence for emergence in this scenario: AEC providers change the way they approach owners for building retrofits and/or building owners change their approach to working with AEC providers for building retrofits.

B. Create the Money Trail Scenario:

Financing has been a battle cry from SMSCB owners so creating loans and other incentives contingent on using the integrated design and delivery approach combined with a supportive legislative and regulatory environment would catalyze growth of the SMSCB energy retrofit market. The interventions proposed for this scenario are as follows:

- Establish federal minimum standards for building energy performance to serve as a basis for local policy development (i.e. fuel standards for vehicles) and a federal standard to regulate building energy performance (perhaps predicated on ASHRAE standards) with a schedule to increase building energy performance of existing buildings that incentivizes an integrated design and delivery approach (similar to what has been done via CAFÉ fuel standards for vehicles)
- Establish and enforce penalties for not meeting the building energy performance standards and mandate building energy performance evaluation (retro-commissioning, energy audit) at a specified minimum interval
- Work with the DOE and ASHRAE to develop both simple guidelines that help educate building owners on approaches to meet federal regulations for building energy performance and a list of resources and tools that span the project initiation, design, construction, and operations & maintenance phases (and support an integrated design and delivery approach)
- Work with banks, utilities, and other financial institutions to create loans and incentives for AERs that comply with the new federal regulations and to educate building owners, operators, and tenants about these loan and incentive programs emphasizing more strategic investment (e.g., balance sheet) thinking over more tactical profit-and-loss thinking
- Partner with an independent third party to offer education and training to recipients of loans and other incentives on the integrated design and delivery approach and to validate the design, construction contract, and M&V plan incorporates integrated design principles and is sufficient to deliver on the projected energy savings for the funded AER
- Track actual versus predicted energy savings and modify the approach as needed to keep the funding/incentive program viable.

Evidence for emergence in this scenario: Building owners and operators applications for the new incentives increases over time and the programs are modified as market needs change.

C. Do-it-Yourself Building Energy Retrofit to Support Single Building Owners

Making the financial benefits enjoyed by building portfolio owners as well as tools like energy modeling, energy auditing and uncertainty quantification accessible to single SMSCB owners to provide the foundation for a smart approach to AERs. The interventions proposed for this scenario are as follows:

- Implement a carbon tax as either a regulatory approach to support the Clean Air Act or as the result of federal legislation
- Develop and implement a business model for a third party to provide the purchasing power, access to capital and economies of scale that building portfolio owners enjoy as well as providing the

centralized expertise, analysis, and management to a collection of small single-building owners to enable a cost-effective approach to AERs

- Develop web tools that are easy-to-use and accessible to different stakeholders across a range of expertise (e.g., provide intelligent default data) for energy auditing that can suggest integrated ECM packages to consider for improved energy performance, for energy modeling, and for uncertainty quantification to identify the most common sources of energy use uncertainty depending on building type, building systems, and geographic location
- Develop a tool or guide to simplify the process and understand all the available options for financing a building energy retrofit and to streamline M&V strategies based on the building data with the most uncertainty and the most significant impact on building energy use
- Education to building owners (perhaps through BOMA) to get them motivated to pursue an integrated approach to building retrofits including media attention as an added incentive (e.g., develop tips to get media attention based on study of building energy efficiency stories that made it into the news)
- Develop and deliver training and guides to building owners (and to AEC providers on how to work with SMSCB owners) on how to use the energy audit, energy modeling, uncertainty quantification, and financing tools to build an attractive business case for an AER and on how to use a simplified M&V approach to validate savings post-retrofit

5. Conclusion

In the first comprehensive engagement of a wide representation of market actors and influencers from the building energy retrofit space, we got a market systems perspective and prioritization of barriers to building energy retrofits. The input collected was analyzed by applying different systems lenses and interpretative qualitative analysis in order to produce a map of the market and initial thoughts on market inefficiencies. A second more focused engagement of market actors was conducted to produce a validated market map and identify approaches to address a more refined systems view of market inefficiencies.

In the second market engagement, the participants emphasized that the natural market forces (consumer demand and economic feasibility) do not uniformly exist for building energy retrofits to implement the type of change CBEI is tasked to catalyze in the market. Therefore, policy, regulation and incentives are needed to generate demand for this market. Further, the participants highlighted how a holistic approach to policy, regulation and incentives is needed to generate demand in a way that avoids unintended consequences to the building energy retrofit market. We also learned that the lack of consumer demand coupled with the fragmentation of service providers in the building energy retrofit market leads to unreliable and biased (untrustworthy) service and advice (e.g., self-serving rather than holistic). Finally, it was clear that building owners do not view energy performance as a critical success factor for their business (e.g., critical to effective marketing, sales, compliance, operations, and so on) or they would have energy managers on staff. The participants also concluded that the use of a traditional ROI (a calculation of time to payback of the cost of the retrofit services and supplies) applied to a building energy retrofit is heavily dependent on energy cost which does not adequately capture the full business benefits. A systems thinking approach is needed for energy efficiency investment to account for the broad array of positive business impacts not captured by simple payback calculations.

Prioritization of market inefficiencies by participants in the second market engagement identified information failures, especially not viewing an investment in energy efficiency holistically in terms of impact on the owner's business, as the most important. A close second was ineffective legislation and law qualified by a systems perspective approach. The next two most important were unstable markets (i.e., energy price) and inequality (between single building owners and portfolio building owners). Participants affirmed these market inefficiencies and the need for effective legislation and law intervention.

The market transformation process developed for this research (see Table 3) was effective at catalyzing new insights by market actors on how to transform the SMSCB energy retrofit market. It is recommended that the transformation scenarios presented be tested to see if they catalyze lasting growth of the AER market.

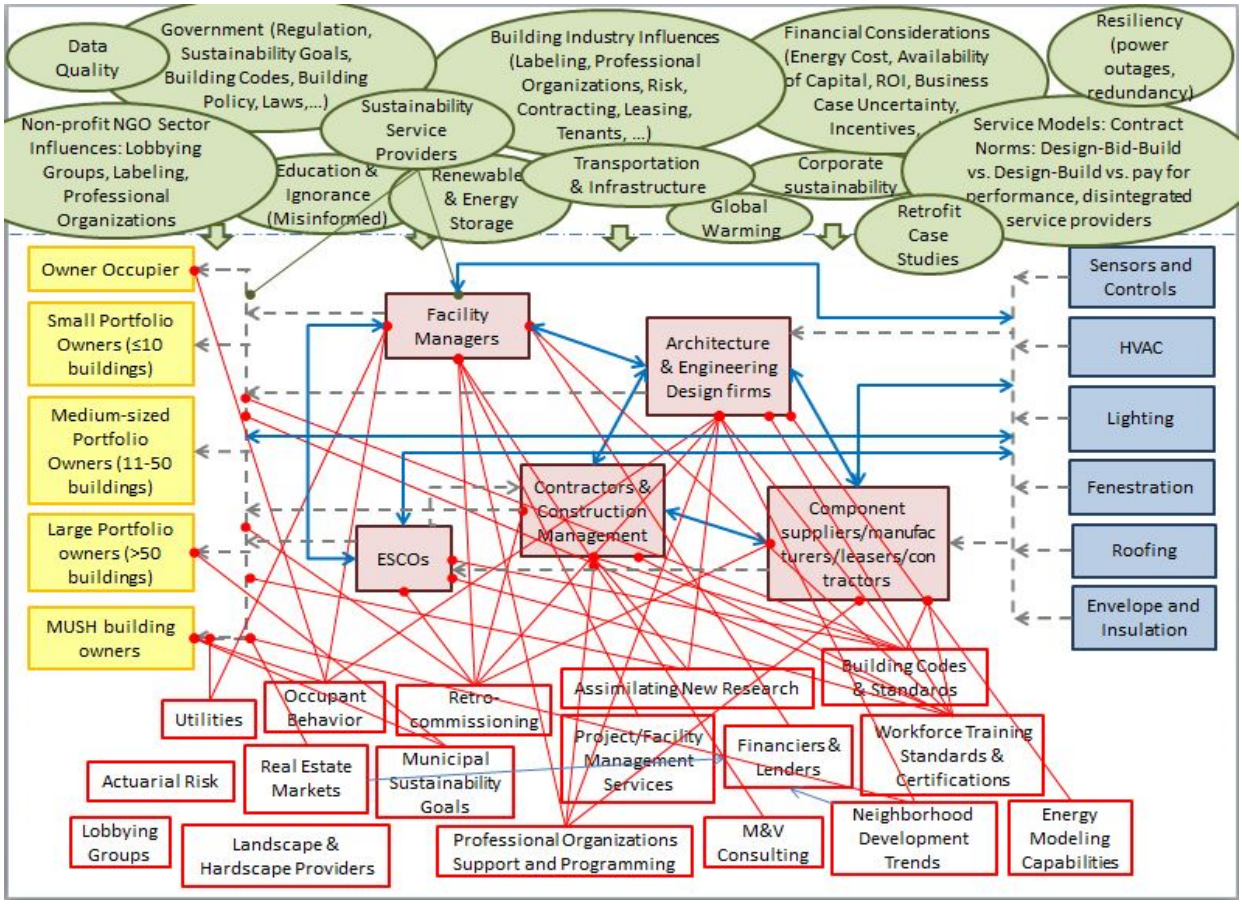

Figure 2. Validated market map for building energy retrofits in greater Philadelphia region

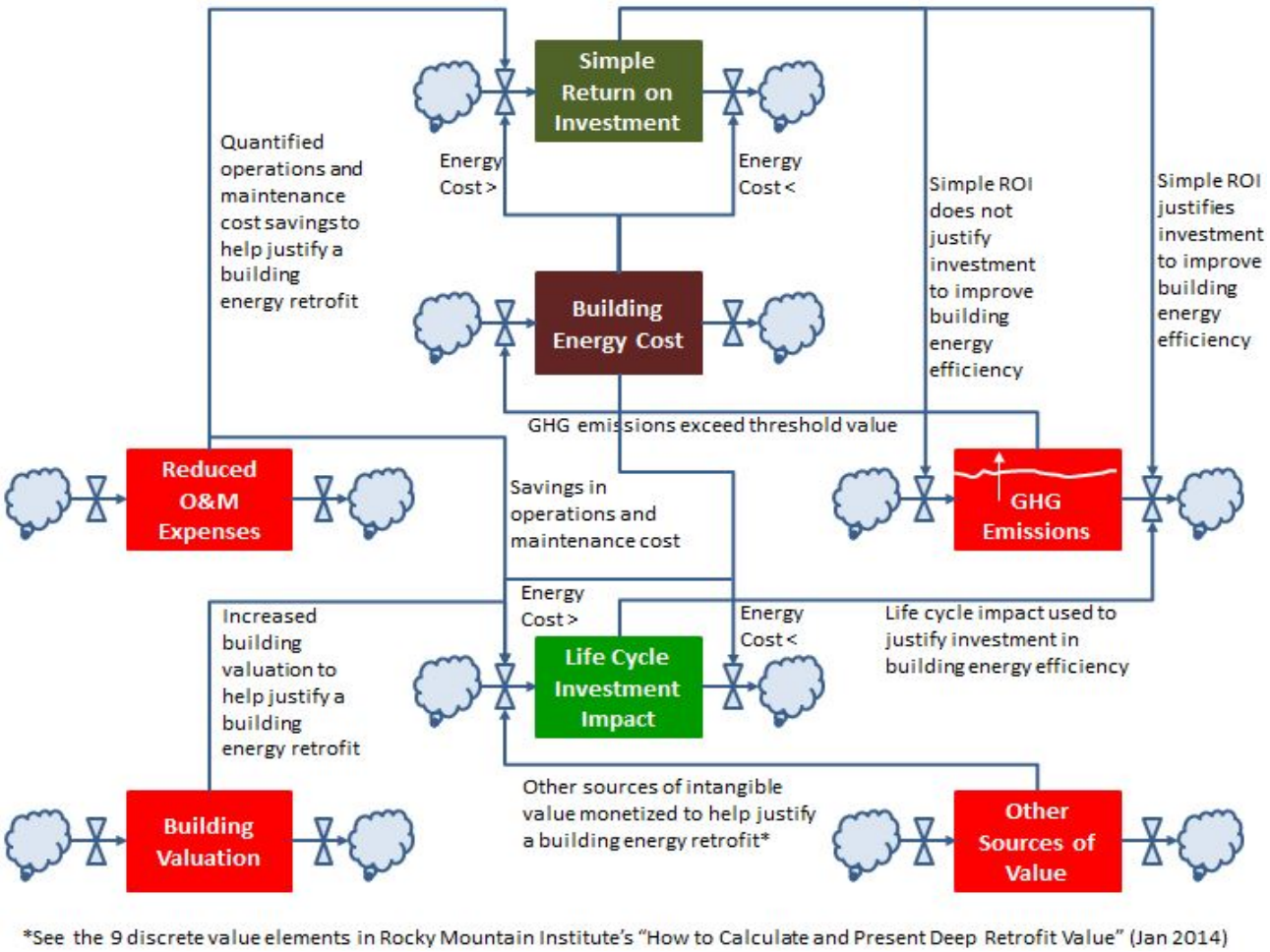

Figure 3. Simple systems model for building energy retrofits based on stock and flow diagrams: life cycle investment impact approach offers more robustness than simple return on investment approach for more building energy retrofits (the clouds capture additional influences such as information, legislation, regulation, incentives, tools, education, and so on)

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Notes

Note 1. The greater Philadelphia region includes the following 10 counties: Philadelphia PA, Montgomery PA, Chester PA, Delaware Valley PA, Bucks PA, Burlington NJ, Camden NJ, Mercer NJ, Gloucester NJ, and Salem NJ.

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