MANAGING URBAN TRANSITIONS:

VISIONING AND STAKEHOLDER COLLABORATION. A CASE STUDY IN TRANSFORMING RESIDENTIAL HOUSING IN WORCESTER, MA

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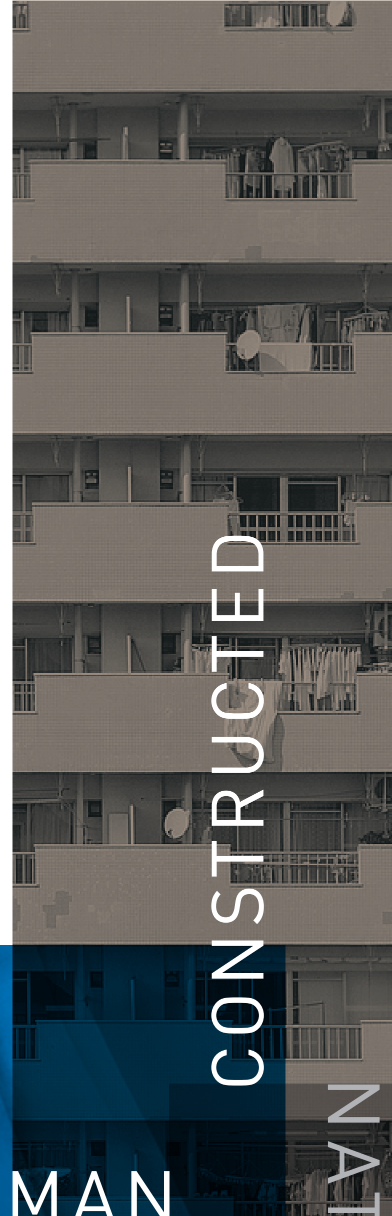

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Managing Urban Transitions: Visioning and Stakeholder Collaboration A Case Study in Transforming Residential Housing in Worcester, MA

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Abstract: Residential housing produces about 25% of greenhouse gas emissions in the US and many European countries. Deep energy retrofitting of existing residential buildings is an absolute necessity to mitigate climate change, but so far success has been elusive in that area. Traditional policy instruments that may be effective for new construction, such as subsidies, performance standards, or technology standards (e.g. building codes) have limited applicability for existing homes. This is for two reasons. First, from the energy performance perspective the housing stock is a complex socio-technical system that comprises technology, professional knowledge and know-how, private and public institutions (including formal and informal regulations and norms of behavior), markets, and consumers (with their priorities and cultural attitudes). We hypothesize that transforming such a complex system requires a mix of multiple coordinated top-down policies, bottom-up grass-roots initiatives, and long term strategies toward building institutional and technical capacity.

Second, in urban environments many agendas coexist that may appear to compete for attention and resources with the energy transition in the housing stock, such as security, job creation, economic development, education and others. A successful program needs to leverage these agendas and to create a shared vision capable of mobilizing diverse local and regional interests. There is little empirical experience or theory to guide the design of a program that addresses these varied requirements.

In this paper we present an ongoing case study in energy upgrading of the existing residential sector in Worcester, Massachusetts, and contrast it with the emerging Passiv House transition in Austria. Worcester, MA is a mid-size old industrial city burdened with a long legacy of environmental and social problems. The socio-technical experiment draws on national and state policies and funding sources (including the national stimulus package), and engages many local stakeholders, including city government, anti-poverty organizations, grass roots activists and local business and universities. The case study describes how a multi-stakeholder group emerges, that strives to develop not only a joint vision but also an effective action plan, combining top-down and bottom-up dynamics.

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1. Introduction

The economic and environmental transition to a low-carbon economy is now at the forefront of the technology, policy, and socio-economic development discussions in the US and internationally. A critical arena for this transformation is in buildings, which account for more than 70 percent of electricity use (USDOE 2007) and almost 40 percent of greenhouse gas emissions in the United States (EIA 2006). Together with transportation, buildings are among the major determinants of the environmental impacts of cities. In the US, with the right policies and instruments, the residential has an estimated potential to reduce its energy consumption by 28% relative to the business as usual projections for 2020 (McKinsey 2009).

Buildings are more than just physical artifacts; they are part of a socio-technical system, by which we mean a stable configuration of dominant technological artifacts and the knowledge of how to use them, embedded in institutions, professional practices, cultural meanings, and physical infrastructure. A large shift in that system is necessary for the sustainability transition of cities. But it is also very difficult because, in addition to technological innovation, it requires changes in existing institutions, infrastructures, established behaviors of multiple communities of practice, the knowledge networks, belief systems and lifestyles.

Among the "transition" community there has been a great deal of interest during the past decade in small scale (niche) experiments as possibly an effective way to facilitate large scale system-level transitions (Hoogma 2002; Geels 2005; Geels and Schot 2007). With regard to energy performance of residential homes, there have been some notable successes with high performing new buildings, on a scale of individual demonstration homes and small residential developments (Townsend development in Massachusetts, and the US Department of Energy demonstration homes in Michigan and Colorado, the BedZed project in London, SheaHomes in Southern California), and regional and national programs (Germany and Austria).

The Austrian case has been especially interesting because of its duration (over 20 years), the success rate (approximately 4% of all new construction) and its capacity to make systemic changes (Ornetzeder and Rohracher 2009). In fact, it appears that the Austrian experience with the diffusion of the passive house technology into the mainstream practices and consumer markets may provide answers to the fundamental dilemma of a niche technology faltering when it tries to go mainstream. Smith's analysis of the organic food and eco-housing movements (Smith 2007) has shown that the dominant socio-technical system responds to this pressure for change by selectively adopting some elements of the niche activities (e.g. better performing windows and insulation), without however undergoing major changes in the prevailing practices and technologies that are necessary for a radically higher building performance. This has not been the case in Austria.

While the experience with radically more energy efficient new home construction is encouraging, focusing on new buildings alone assures that progress in reducing the overall environmental impacts of housing will be extremely slow. For example, during the most recent housing boom in the US, new construction represented less than 1% of all homes.

Attention must therefore focus on the *existing housing stock,* where the 28% potential for energy efficiency resides: on retrofitting and on microgeneration using solar and other non-carbon energy sources. In Massachusetts, this is particularly important for three reasons: with a flat population growth rate, Massachusetts does not expect a housing construction boom in the near future, even when we get the current financial crisis behind us; the characteristic charming New England style Massachusetts homes are old and leaky in all price categories, but also well-loved; the regional climate is characterized by extreme temperatures and humidity levels in the winter and summer, which makes high demands for space heating and air-conditioning.

In short, in Massachusetts we need a transition in the socio-technical system of the existing housing stock. As we discuss in this paper, a transition in that S-T system is far more difficult than with new construction. Our main argument for addressing this quandary is two-fold: To pay attention to the need for intermediating agents who can coordinate and harmonize the necessary changes in multiple elements of the S-T system; To proceed through small-scale socio-technical experiments that would have four essential characteristics: (1) they would be designed to replicate, on a small scale, the complexity of the established socio-technical system, and would attempt to affect change in that small complex system; (2) both niche and mainstream actors from widely ranging communities of practice would participate; (3) the effort would build on both bottom-up and top-down initiatives with regard to technology, policy, communications, and others; (4) and energy efficiency upgrade would be only one of several social objectives. With regard to the latter characteristic, the experiments would have to be framed much more broadly than typical experiments with high performance buildings: as economic development, job creation, and sustainable community development.

Drawing on the characteristics of the local context and on the experience from the passive house socio-technical transition in Austria, in this paper we outline the contours of one such experiment for the old industrial city of Worcester, Massachusetts, which is in great need of economic development and poverty reduction. The trigger for this experiment comes from several directions: new state-level policies aiming at providing financing and incentives for the so-called "weatherization" projects; a growing recognition by the city government of the importance of upgrading the housing stock; a vibrant network of grass roots organizations in the city; and the lure of the funding from the national economic stimulus package created by the President Obama's administration for weatherization, green technologies, and green jobs. The participants in the experiment would include: the local government, the business community, local universities, and community development organizations.

2. Lessons from the transition in the socio-technical system of new buildings in Austria.

A passive house is defined as one that uses about 80% less energy than a conventional equivalent house build to code. As reported by Ornetzeder and Rohracher (2009), since the late 1980s the concept of passive house as a technological innovation for consumers, and for institutional and commercial markets has been steadily taking hold in Austria, following its introduction in Germany. Starting with the first such construction in 1996, the number of passive houses has been increasing exponentially at more than 40% per year, and by 2006 about 4% of residential new houses built in Austria (about 14% in the province of Vorarlberg) met the "passive house" performance standard. In a country of 10 million people, at the end of 2008 Austria had 4150 passive houses (the highest density in the world).

Ornetzeder and Rohracher analyze this transition as a technical innovation system, TIS (see, for example, Hekkert at al. 2007) on a scale of a niche, focusing in particular on framing and the emergence of a shared vision, the role of experimentation, and the roles of specific actors and institutional changes. The two-decade process went through four distinct stages. During the "set-up" stage (in Germany) the technical concept was defined and developed through research and demonstration projects, championed (mostly in a bottom-up fashion) by innovators within the architectural and engineering professions. During the "regional niche growth" stage, a community of practice emerged within the geographic boundaries of the Vorarlberg province, driven and nurtured by Energy Institute Vorarlberg, an independent non-profit public-private entity, whose mission was to foster technological innovation, disseminate knowledge, and champion the growth of the passive house niche. This can be seen as institutionalization of a bottom-up process. The emergent community of practice comprised not only technical innovators but also mainstream actors, such as builders, developers, planners, manufacturers of building materials, and others. Also, because the emphasis was on building practical high quality houses for regular lifestyles, the feedback from the users of this technological innovation became part of that community of practice, sowing the seeds for future emergence of a market for passive houses.

The "outgrowing the niche" stage was characterized by strengthening of the passive house niche as well as its diffusion and mainstreaming through the top-down, nationally-funded program Building of Tomorrow. This stage essentially scaled up the role played by Energy Institute Vorarlberg: in technical problem solving, magnitude, geographic reach, and diversity of actors. This was an important stage for crossing the bridge between the niche and mainstream while maintaining a shared vision and innovative energy. The fourth, "institutionalization and stabilization", stage saw a parallel and harmonized top-down efforts from two key sectors: government regulations, subsidy and outreach programs for passive houses; emergence of a visible and influential national interest group to disseminate the passive house concept through lobbying and outreach campaigns, which comprised equally wide range of actors as during the earlier stages of the transition.

The process of the passive house socio-technical transition described by Ornetzeder and Rohracher is consistent with Bijker's Social Construction of Technology perspective on technological innovation, in which the cultural meaning of technology and its technical design evolve together through interaction between innovators and users. It is also consistent with the historical cases of socio-technical transitions described by Geels and others (Geels, 2005). In particular, this case highlights the importance of such factors as: coordination of widely ranging bottom-up activities and diverse actors, harmonizing bottom-up and top-down initiatives at different stages of the process, the emergence of a shared vision, the framing of the new technology for different actors (e.g.as cutting edge innovation for early professional movers, as statement of progress and environmental action for early adopters, and a statement of progress for later adopters, and so on), the role of users' feedback in creating the market, and the institutionalization of innovations by emerging interest groups and through strategic public policies. What is especially interesting in the passive house case is the importance *of intermediation* in this coordination process, in creating the knowledge network, and ultimately in building a bridge between the niche and mainstream. The intermediation *needs* changed over time during the two-decades-long process of transition, and were met by various institutions with different missions: from public to commercial to private non-profit organizations.

What lessons can we draw from the passive house case for the case of the existing residential socio-technical system? Our attention is drawn to such concepts as: intermediating needs that change over time and different institutions that can fulfill those, the relative contribution of bottom-up and top down-activities to the systemic change, small scale experimentation, harmonization of top-down and bottom up activities, emergence of communities of practice, and institutionalization of emerging practices and codes. We explore these questions more specifically in the next section by describing that socio-technical system in the U.S., and by highlighting the differences between the two systems: of new and existing buildings.

3. The Socio-Technical System of Residential Housing

3.1 The US Context

In the US context, the socio-technical housing system has a specific meaning. The system is very much left to the free market. The initiative to build comes almost exclusively from private developers acting in their own economic interests; municipalities act as regulators and gatekeepers, through zoning laws and various requirements. The government does not build housing developments, and only rarely participates in their co-financing, and when it does so, it often proceeds through private-public partnerships to create incentives and to broker private financing for so-called “affordable housing”.

Another characteristic of the US system is that the activities at the level of municipalities, states and feds are very distinct and must be all accounted for. Thus, municipalities have a strong role in zoning decisions and permits for developers, while states influence building codes, impose policies regarding energy efficiency, and provide financial incentives for energy-related initiatives. The federal government acts from a greater distance: its role is to provide leadership, to support research and demonstration into new technologies, to offer financial incentives for energy-related project through the tax code, and to provide more general “block grants” for cities and towns. The current stimulus package, which offers direct funding for green projects, including building upgrades, is a relatively unusual role for the federal government, especially on this scale.

In the next sub-section we describe in general terms the elements of the socio-technical system of the housing stock. For the most part, the Massachusetts, and more specifically, the Worcester system, mirrors that broader picture, with some specific characteristics. Where appropriate, we highlight these place-specific characteristics.

3.2 Elements of the system

Technology.

During the past several years there has been an explosion of trade shows, conferences and fairs featuring new technologies for retrofitting of buildings for energy performance and for measuring that performance. In 2009 Massachusetts hosted more than half a dozen conferences and trade shows about energy efficient buildings that collectively attracted tens of thousands participants. In particular, new insulation materials for walls and attics, efficient heating and cooling technologies, and new windows have been heavily promoted. What is striking about these energy conservation innovations is that, while there have been gradual improvements in their performance over the years, the underlying scientific principles as well as technical and design concepts have not significantly changed. These technologies have been available and "shelf-ready" for a decade or two. It is their use that has been lagging behind.

On that count, the existing S-T system differs from the passive house system, where technological innovation was a central event during the early stages of the transition, and was driven by the science and technology community within the fields of architecture and engineering. The innovations around the new concept of "passive house" had a cache and the promise of professional advancement. It is hard to envision such an attraction of young and creative professionals to the concept of "retrofitted house". The innovations for retrofits are generally introduced by manufacturers, and do not carry a signature of the inventor. This is an important difference because it means that the movement toward retrofitted homes, if it were to emerge, would need other foci.

On the other hand, significant progress has been made with regard to microgeneration of heat and electricity by way of wind and passive and active solar, and increasingly by way of geothermal technologies. For these technologies, costs have declined while performance efficiency has increased. There are signs of a growing market demand for these technologies. In January 2009, a local Catholic high school (hardly perceived as an environmental advocate) installed a 600 kW, 262 feet tall wind turbine, and a local Community Development Corporation equipped new homes for low income residents with photovoltaic roof panels. PV panels are becoming an increasingly frequent feature on single and multiple-unit residences in Massachusetts, and the recent pilot programs with smart metering by a leading utility company will increase the attractiveness of electricity microgeneration.

Professional knowledge and know-how.

One of the notable elements of the passive house S-T transition was the early emergence of a cross-professional/cross-disciplinary community of practice of innovators, visionaries, and leaders around the vision of the passive house. Initially a research and technology institute provided a platform for this community to evolve and grow, but over time, as the community grew in size and diversity (to include the more mainstream actors as well as consumers and policy makers), other organizations took on that role. This community of practice performed crucial functions in the system transition by creating knowledge, facilitating collective and individual learning, creating a shared vision, and disseminating the knowledge and mainstreaming the passive house concept.

Creating such a community of practice and a wider knowledge network is more difficult in the case of existing housing S-T system. The home improvement sector is already very large and diffuse, comprising various generalists with claims to all kinds of knowledge. The traditional method of acquiring professional skills often consists of apprenticeships and informal knowledge networks, including marketers of products. These are often small, fiercely independent and politically and socially conservative businesses for which radical innovation, cutting edge problem solving, and pursuing a vision has little appeal.

In this environment, analysis of millions of energy upgrade projects for existing buildings around the country shows that performance improvements are generally modest, ranging from 9 to 27%, with a national average of 11% (Blasnik 2009), and that misconceptions about what works and what does not in such projects abound (for example, window and door replacements or heating system tune-ups have low effectiveness). These data are in contrast with the performance potential and specifications of the available technologies (e.g. insulation materials), and with the best practice cases (of about 50% improvement), and suggest that people who work on retrofitting homes, and who usually claim expertise for their clients, urgently need to upgrade their knowledge and skills. There is also a need to create a cadre of trained inspectors and performance evaluators of homes. The current shortage of knowledge and lack of standardized methods of conferring and certifying knowledge was one of the major themes at the recent conference of New England Sustainable Energy Association in Boston in March 2009 (NESEA, 2009).

Creating a shared understanding of the appropriate body of knowledge and a well-trained workforce is especially important now, given the hopes we are placing on green jobs as a way out of the economic recession and as a way of enlarging those employment sectors that do not outsource jobs abroad. For example, a recent analysis (Polin et al., 2008) estimates that home improvements can create twice as many jobs as oil production and processing while salaries are comparable. The New England Green Economy Council predicts many new jobs in the building sector, such as design and engineering, building and construction, technical support and training, and social marketing (to consumers) (Doyle 2009).

This is slowly changing. Training courses and certificate programs have been proliferating in Massachusetts and elsewhere. The majority of these are non-standardized initiatives by the private sector, from small businesses to large utility companies. But state-funded community colleges (in Massachusetts) have also begun to develop a standardized curriculum, apprenticeships and certificates for energy home improvements (including the Worcester-based Quinsigamond College). A small group of leading contractors has emerged who offer training courses, and lobby for performance standards and certificates of competency. In Massachusetts, the major gas utility runs a small pilot program for deep energy retrofits for residential and institutional buildings (80% reduction in energy use), aiming for knowledge development and training.

These promising developments with would be greatly strengthened by the existence of intermediary agents to provide a platform for information exchange, knowledge building, networking of leaders and mainstreamers and across professions and occupations, and lobbying and outreaching. A system of performance standards and certifications, discussed in the next section, would also advance the emergence of a knowledge network. Ultimately, the system will need to draw on a collective accumulated knowledge about how to design a retrofit project: what actions are most effective and economically efficient in a specific house, what works and what does not work, and what tradeoffs make sense.

Institutions: formal and informal regulations and standards.

In the passive house S-T transition, defining a passive house by way of a performance standard (80% below the norm) was instrumental in stimulating early research and development as well as the emergence of the community of practice. During the stabilization stage, government regulations for building and professional standards played a key role in institutionalizing the emerging norms and practices in the form of both performance and technology standards (the latter including materials and design specifications).

Such a definition of a retrofit by way of a universally applied numerical performance standard is difficult to contemplate for existing buildings. But efforts in that direction are being made by governments and professional associations. For example, the deep retrofit pilot project mentioned in the preceding section uses a numerical performance standard (of 80% reduction in energy use). In 2009 Massachusetts adopted a more demanding, so-called Stretch building code for new construction and major renovations (for voluntary adoption by municipalities). The stretch code is a prescriptive technology standard, but it requires energy performance rating. Among performance standards, HERS (Home Energy Rating System) is the best known in the US (for new buildings), but several others are being considered or have been adopted (on a voluntary or mandated basis) by states and municipalities. Similarly, the requirement for disclosing an energy performance index of homes during real estate transactions is hotly debated across the US. Europe is generally ahead of the US in the above initiatives, but there too many uncertainties and implementation problems remain.

But standards alone cannot do the job of pushing the housing stock toward a transformation. Performance standards are bounded by the implementation reality: they must be sensitive to the cost and feasibility of performing the measurement and implementing the upgrades necessary to meet it. Here, the issues of the professional knowledge and know-how, and of mobilizing consumers (discussed in the next section) become central. Furthermore, technology-based standards are a double-edge sword: by institutionalizing certain practices they become, sooner or later, a barrier to more radical changes. And finally, all formal standards, by being a product of widely-based consultation -- either through professional networks or the political process of rule-making -- are rarely reaching for radical change. For that reason, other approaches to mobilizing the markets for retrofitting homes need to play a central role in the socio-technical system change.

Markets and consumers: creating a market pull.

The bottom line is that owners of the buildings – the consumers of the technology – must want to improve their energy performance and to pay for it. The passive house case as well as various smaller developments in the US and Europe demonstrate that there is a potentially large market for passive houses, at least in some cultural and socio-economic contexts. But buying a passive house, even if it costs more than a comparable conventional house, is a very different experience than retrofitting an existing home. With a passive house, the cost of higher energy performance is folded into the purchase price and thus can be part of mortgage financing spread over three decades; the purchaser knows more or less what they are getting for their money; and the energy considerations are but a small part of the overall excitement of buying a new home. With retrofits, the decision to retrofit competes directly with other, more attractive and visible potential upgrades; the size of the benefits is uncertain, and the relatively large upfront "invisible" investment with long payback times into the already existing home feels psychologically like a loss. These disincentives to invest are magnified in the rental market in Massachusetts because landlords can simply pass onto the renters the costs of heating, but not the capital investments for energy upgrades.

During the past few years efforts have been made to break the financial barrier for retrofits. These include direct and indirect government subsidies, rebates provided by utility companies through public-private partnerships, government incentives for mortgage lenders to create "green mortgages" (Harney 2009), municipal revolving funds (www.thebabylonproject.org), bundling a large number of projects and financing by local banks though an ESCO company (CEA 2009), and others. Another relatively recent idea is a scheme whereby the municipality finances an approved project through issuing municipal bonds, and recoups the money over a long period of time (commonly 20 years) through increased property taxes. This program, known as PACE, requires enabling legislation at a state level. There is a growing grass root movement to pass the legislation (15 states have done so during the past two years) and to mobilize municipalities to adopt it (Fuller at al. 2009).

Generally, the implementation experience for most of these programs has been disappointing: despite the strong outreach, easy access to energy audits, and the availability of financing, home owners have been slow to implement the energy- and money-saving upgrades. This outcome is consistent with the national statistics: among the 10,000 motivated homeowners who took the initiative to have free energy audits performed in their homes, only about 25% followed up with implementation, even when the majority of the costs would be covered by various tax breaks and other subsidies (Doyle 2009). Clearly, the availability of financing is a necessary but insufficient condition for progress in this area.

Indeed, at least three other factors seem to be at play. One of those is the availability of skilled and readily identified trustworthy and experienced contractors. Here, institutionalization of such elements as an agreed-upon body of knowledge, professional licensing expertise, and creating appropriate standards of performance, would be immensely helpful. Secondly, the opportunity costs in terms of a limited attention and personal time has been obviously too high for homeowners, despite the potential financial rewards. The common experience among even highly motivated homeowners has been that they do not know how to arrange for financing and take advantage of subsidies, nor whom to hire and trust. Third, energy is not a high priority for most people, and is unlikely to become that. It is not clear how high the energy prices need to be to overcome this barrier.

But there is no guarantee that overcoming the above barriers will suffice to mobilize homeowners. It is quite possible that champions of large scale retrofitting of homes need to dig deeper into the *cultural meanings* of energy upgrading of homes, and to re-frame the problem accordingly. In the S-T transition in Austria, framing the passive house as an issue of quality, trend-setting and environment was effective with consumers and other mainstream home building actors. But that was in Austria and with regard to new construction. In the Massachusetts retrofitting context other framings may be more effective: as an issue of high quality of life, or thriftiness, or improving the house's market value, or product quality, or as increased community cohesion by joining others who have taken the initiative. Most likely, different frames will speak to different people, depending on their socio-economic status (especially in the heterogeneous city such as Worcester, as discussed below) and other values. In fact, multiple frames may work for the same people. Drawing on the work of Schön and Rein (1994) and Nisbet (2009) on the role of framing, we hypothesize that the Cambridge and Berkeley framings have not been adequately aligned with the core values of the homeowners or that multiple framings need to be used in these programs.

The passive house case highlights the need for an effective intermediary to coordinate the variety of approaches that are needed to create a market for retrofits: to facilitate the emergence of such effective framings, mobilize various actors (including real estate agents), push for enabling legislations, promote promising financial schemes, give consumers a focal point for getting information and identifying appropriate contractors, lobby and outreach, and others. So far, no such intermediating agent has emerged.

3.3 Conclusions

Mapping out the socio-technical system of the housing stock allows us to identify interdependencies between its elements and the drags in the system. Thus, market pull does not work in the absence of professional knowledge and know-how; and standards do not work in the absence of a market pull. It is clear from some of the cited examples that a change in one element, or one component of an element, is not sufficient to affect the system. Mapping out the socio-technical system also highlights various actors, and their current and potential roles as change agents. The multiple changes that are necessary to shift the system will require collaboration among various actors and intermediating agents, all changing over time.

The analysis of the system also highlights some important difference between the new construction and the existing housing S-T systems as well as the additional challenges the latter faces. For one thing, the housing stock system does not provide the conditions for an emergence of a community of practice of early innovators, united by a shared concept of a passive house (with its specific technical definition) and driven by an impulse to find solutions to a challenging technical problem. Such a community of practice, if it existed, would provide a starting point for the growth of a larger community of interest: first in a niche and then in the mainstream. Second, the homeowners present an essential and very difficult to mobilize agent of change in this system, in contrast to the new construction system, where they played a lesser role in the systemic change. For these reasons, creating a shared vision that would drive a socio-technical change may not be possible. Instead, multiple framings for different actors in this complex system may be a more promising approach. Third, the knowledge about what to do in a retrofitting project, how to do it, how to judge progress (both in individual projects and on a scale of society), how best to finance it, and how to facilitate it through public policies is uncertain, underdeveloped, and highly diffused. From the consumer's perspective, it is largely inaccessible in an easily absorbable form.

Taken together, it seems to us that setting in motion a change in the socio-technical system of the existing residential housing will require much experimentation on a small scale. Social, rather than technological, entrepreneurs are likely to play a key role in these experiments and in the early transition of the socio-technical system. Some of the small scale experimentation with social entrepreneurship may transition to the role of an intermediary. Such intermediaries will be essential payers in the systemic transition of the residential housing system.

Later in this paper we describe an emerging intermediary in residential housing in a medium-size city in the USA. This intermediary emerged facilitated by the researchers; we will reflect on the process and indicate first results.

4. Theoretical framework for small scale experiments.

Experimentation in niches has featured prominently in the literature on transition management, with the argument that changes in a socio-technical system (regime) would be facilitated by both pressures from the landscape (top-down) and by opportunities created by experimentation on alternatives in niches (bottom-up). The concept of Strategic Niche Management has figured prominently in the discussions of socio-technical transitions during the past decade. Embraced by some and criticized by others, the concept means experimenting with an innovative technology in a protected space (a niche), where social actors learn about both the technology itself, its intended and unintended consequences, and about the social embedding of that innovative technology. The protected space could be provided by government subsidies, public-private financing, relaxing existing regulations, and other mechanisms, all intended to create space for experimentation and learning and to reduce the market pressures on the experiment for a limited period of time. The challenge is then to proliferate such an experiment into new experiments and eventually into the mainstream, removing the protective mechanisms that constituted the niche.

While Strategic Niche Management (SNM) is mainly built around an innovative technology, Social Niche Management (Verheul et al, 1995, Hegger et al 2007) denotes a social experiment initiated by citizens' groups and/or NGOs operating outside the institutional structures of firms and governments. Such a social experiment may be built on new technologies or on existing or even traditional technologies, and is motivated more by creating new social arrangements and environmental benefits rather than furthering a specific technology.

Recently, Hegger et al (2007) also suggested, based on their work on innovation on sanitation, that the 'niche' concept should become more 'social' in order to better contribute to sustainable transformation of socio-technical systems. They argue that the focus of the niche experiments should be redirected more to concepts and guiding principles rather than technologies, which they call Conceptual Niche Management. They develop guidelines how to pay more attention to the social embedding of new concepts, thus, as they claim, making it more likely that such concepts make a significant contributions to regime change and that broad as well as deep learning is enhanced.

Along the same lines, we developed in our previous work (Brown et al. 2003; Brown and Vergragt 2008) the concept of small scale experiments and learning (emphasizing higher order learning) by introducing the concept of Bounded Socio-technical Experiment (BSTE). A BSTE has been defined as a "collective endeavor, carried out by a coalition of diverse actors, including business, government, technical experts, educational and research institutions, NGOs and others. Cognitively, at least some of the participants explicitly recognize the effort to be an *experiment*, in which learning by doing, trying out new strategies and new technological solutions, and continuous course correction, are standard features. The experiment is driven by a long term and large-scale vision of advancing the society's sustainability agenda, though the vision needs not to be equally shared by its participants. Its goal is to try out innovative approaches for solving larger societal problems of unsustainable technologies and services. This latter characteristic distinguishes BSTE from, for example, solving a particular environmental problem in a community, or from a strictly market-driven introduction of a new mode of transportation".

Our empirical work in the area of transportation (Brown et al, 2003) and high performance buildings (Brown and Vergragt 2008) has shown that BSTEs facilitate higher order learning, by which we mean changes in problem definitions or interpretive frames among the participants. The conceptual support for these empirical observations derives from several bodies of literature -- from cognitive psychology, to sociology, to organizational sciences -- which can be distilled down to this: learning takes place when actors representing a range of interpretive frames, problem definitions and core competences engage in intense interactions around a technological innovation, an issue, a problem or an idea. Higher order learning manifests itself as changes in problem definitions and interpretive frames, the latter denoting mental models that help us identify the most salient features of situations, make sense of our observations, and ultimately lead to create problem definitions.

The issue of higher order learning is central to socio-technical system transitions. This is because the inherent stability of such systems is partly grounded in the resistance to change among the dominant communities of practice and institutions that, along with other elements, collectively comprise the system. Part of the systemic change must involve changes in the interpretive frames and problem definitions shared within communities of practice. Magnant's recent study of an experiment with zero energy building in a suburban development in Townsend, Massachusetts, has shown that the builder and the home occupants changed their interpretive frames (Magnant 2009): both began to see a zero performance building not as a separate technological category but rather as a better performing version of a "regular" building that can be created with existing technology. In addition, the owners shifted their self perception from being average citizens with no particular interest in the issues of energy, technology, and environment to becoming innovators and trend-setters. In another study in the small Massachusetts town of Hull that hosts two of the largest wind turbines in Massachusetts, Rand showed that living in close proximity to that technology led some local actors (such as city government, environmentalists) to change their interpretive frames. However, the frame changed only when the new frame was congruent with the values and worldviews of the actors (Rand 2009). These observations are consistent with other studies on the impact of technology on individual framings (Martiskainen 2007; The Hub Research Consultants 2005).

The small scale experiment we initiated in Worcester draws together the concepts of higher order learning through BSTEs, as well as the idea of a BSTE being designed as a mirror of the large socio-technical system that we seek to change.

5. WoHEC as a Socio-Technical Experiment in Worcester

5.1 **Context: The City of Worcester**

With 175,000 inhabitants, Worcester is the second largest city in Massachusetts (after Boston), located in the central part of the state. First incorporated in 1684 under the name Quinsigamond (after a local Indian tribe), Worcester reached its peak size of 200,000 in 1950, and has been declining both economically and in population ever since.
Worcester and the nearby Blackstone valley claim to be the "birthplace of the American Industrial Revolution". The original industries were textiles, clothing and shoes, which were replaced by, first, metal industry, and later, envelope folding and corsetry industry, both of which employed large numbers of women. In the 19th century the classic New England three-decker house was invented here as a form of affordable housing, which was generally occupied by the owner and two tenant families. The construction of a waterway (the Blackstone Canal, which connects Worcester to Providence, Rhode Island) and railroads boosted Worcester's economic development. In the 18th and 19th centuries Worcester was an important center for the temperance and abolitionist movements, as well as for the 19th and 20th century suffrage and labor movements: Lucy Stone and Emma Goldman lived here.

Today, Worcester is a highly diverse city in terms of income, ethnicity and culture. While is has a well established white middle and upper middle class with long family pedigrees, its median household income is $35,000 (30% lower than Massachusetts), with 18% of households below the official poverty line (twice that of the state); 15% of residents are foreign-born and 28% report the language spoken at home being other than English. The economy in Worcester is quite diversified, including thriving biotechnology and medical centers, construction and insurance, and higher education: eight colleges and universities, including Clark University, are located in Worcester.

The area immediately surrounding Clark University, known as the "Main South" neighborhood is generally poor, rich in immigrants, known for petty crimes, and dependent on various social programs. Since the 1980s Clark University has deeply, and successfully, invested in developing that community through educational programs, infrastructure development, and other initiatives. Despite its current problems, the Main South area has made great strides since its slum-like atmosphere 20-30 year ago.

5.2 **WoHEC as an emerging Socio-Technical Experiment**

The Worcester Housing, Energy, and Community group (WoHEC) came together through the initiative of researchers at Clark as a way to engage diverse local stakeholders in a community project. By "community project" we mean one with multiple framings and objectives. In this case, the objectives were: to design and facilitate a large scale energy-retrofitting of residential houses to a level that would significantly reduces energy use for heating and cooling; create a wide range of jobs; employ local at-risk unemployed youths; enhance vocational training programs; improve the quality of life in the community; improve the market value of houses; and improve indoor air quality (including eliminating lead where necessary). In short, it would be a sustainable community development. The underlying idea was that framing the project as energy conservation and climate change would not mobilize that community, which was faced with a plethora of more urgent social and economic problems. The researchers also saw it as a challenging socio-technical experiment, as discussed in Section 3 of this paper.

The group was convened for the first time May 2009 at Clark University. Several of the participants had been active in the Worcester Main South area for years or decades; they knew each other very well from previous projects and activities and there was a high and rather unusual level of trust among them. Participants collectively represented NGOs, the City, grassroots activists, builders, and academics: Clark researchers, students, the Vice President for community outreach, and the sustainability coordinator; researchers from two other nearby educational institutions: Worcester Polytechnic Institute and Worcester State College; the City of Worcester Energy coordinator, whose responsibility it is to implement Worcester's Climate action Plan; the Worcester Green Jobs Coalition; Worcester Roots, a grassroots organization dedicated to contaminated soil remediation; Stone Soup, a community building housing a number of grassroots organizations; Worcester Community Action Council (WCAC), an organization that is mandated to implement fuel assistance to poor residents, and which increasingly focuses on "weatherization" (the term used by these programs that is equivalent to "retrofits") of poorly insulated housing to reduce residents' heating and cooling bills; Summer of Solutions, a student volunteer group engaged in mostly summer projects and who organized community "barn raisers" where a group of volunteers jointly weatherized a community building; the Massachusetts Alliance Against Predatory Lending, which seeks to prevent home foreclosure; and a facilitator.

The issues identified at the first meeting collectively represented many dimensions of community life and the missions of the organizations present at the table: Some the most salient issues included: funding sources for weatherization (many participants were in different forms involved in raising money for all kind of different projects, ranging from weatherization and deep- energy retrofits to creating a revolving loan fund); the need for measuring the effects of energy retrofits; the need to create jobs, especially among unemployed youths at high risk to engage in criminal activities and street gangs (WCAC described at the meeting their small scale summer program, funded through multiple sources, to train and employ local youths in weatherization projects); vocational and jobs training generally (an issue that is being addressed by community colleges in the city and elsewhere in the State); opportunities for energy retrofits at foreclosed properties; and the need to motivate middle income home owners to retrofit their homes.

The participants at this first meeting decided to continue their gatherings. They became a self-organized group (with no chair person) under the name Worcester Housing, Energy and Community project, WoHEC, and were supported by the efforts of Clark researchers, who served as conveners, facilitators, idea entrepreneurs, and monitors of the learning processes. WoHEC defined is mission as "*a shared interest in community development built around upgrading existing housing stock; through retrofits pursue multiple agendas; drawing on bottom-up developments and new funding opportunities and policy developments.*"

Over the next eight months WoHEC continued its monthly meetings, keeping open boundaries which allowed new individuals and organizations to enter. Several did, including an influential City Councilor and a manager of a vocational training program for housing retrofits at the nearby community college. Mostly, the meetings consisted of information exchange, coordination, building bridges, and leveraging the new links and knowledge to seek federal and state funding for energy and community development projects. In some cases, the information exchange led to new collaborative activities. The scope of the discussions was broadened through invited speakers on such topics as deep housing retrofit program by one of the major utilities, financing by a local bank, revolving loan funds, new developments in vocational training. Visiting developers and contractors presented their perspectives.

WoHEC has become a learning group. During discussions, participants increasingly evoked systemic nature of the challenge of retrofitting houses, and use multiple framings to discuss strategies for pursuing it. Outside the meetings, WoHEC members have become involved in functions that cross over to what can be considered different elements of the socio-technical system than the one "hosting" their organization. For example, the head of Worcester Community Action Council became a board member of the newly created Institute for Energy and Sustainability (connected with Clark and Worcester Polytechnic Institute), and in that position she put home retrofits and community development to the Institute's emerging agenda. Through interviews with its individual members we learned that they see WoHEC as a place "for information exchange, creating collaborative projects, 'keeping everyone in the same direction', building trust, and finding inspiration and learning." Most recently, WoHEC has entered the next stage: it identified a need for creating a long term vision (2020), a medium term strategy (2015), and a short (1-2 years) action plan, and to engage in a collective project of house retrofits: a showcase project on a scale of a large residential building, a street, or a neighborhood in the Main South area, to illustrate, draw attention, and test ideas. Following two effective visioning sessions, at the time of this writing (mid February, 2010), these ideas are being implemented.

WoHEC is a heterogeneous group whose members represent several (but not all) elements of the socio-technical residential housing system in Worcester, with all its complexity, but it also extends beyond that system, bringing into deliberations sustainable community development. WoHEC thus wrestles with the issues of house retrofits from a wider perspective, as illustrated by its shared vision. WoHEC would be strengthened by additional participation of the representatives of additional elements of the socio-technical system, such as innovators in the technology, financing, marketing and consumers of retrofits. Having both the innovators and mainstream actors from these interest groups represented at WoHEC would greatly enhance the learning processes. WoHEC could easily accommodate these additional members, with its porous boundaries, learning mission, and self-organization (not rules for participation). WoHEC's ability to accommodate various framings of retrofits is a great strength.

At this stage, a specific large scale retrofitting project would become, with WoHEC's presence, a bounded socio-technical experiments as envisioned in Section 3 of this paper. Through it, WoHEC could emerge as an effective Intermediary with multiple functions: bridging bottom-up social innovation, local governance, knowledge centers, and top-down policies on energy technology, social development and green economy. Some of this is already happening: WoHEC has linked with the newly formed Institute for Energy and Sustainability, and with the City Task Force on Climate Change Action Plan, and by doing so it has developed a greater potential as a resource, a think tank, a political player, and an advocate for linking energy conservation projects with community development.

6. Conclusions

Examination of the transition in the Passiv House (PH) socio-technical system, and comparison with the system of existing residential housing stock, illuminates the important role of early innovators as drivers of transitions. It also points to social (rather than technical) innovators as the most important players in affecting change in the residential housing stock. In the US, the field of social innovation with regard to housing retrofits is very much alive, and growing, largely as bottom up community-based actions but also effectively supported by various state-level policies.

Intermediaries (like WoHEC) can play a key role in channeling this energy effectively and synergistically to produce some movement in the resistant socio-technical system. Potential intermediaries emerge at all stages of systemic change, as shown by the Austrian PH case, and originate in different elements of the system. More research is needed to understand why some intermediaries become influential and some not. It surely depends on the challenge at hand at various stages. In the PH case, the early challenge was a technical one, so both the early innovators and the early intermediary (the Energy Institute Vorarlberg) were strongly grounded in the technical issues. But its success very much drew on its ability to bring to its agenda other, non-technical, issues, which interconnect all the elements of the system, including the innovators and mainstream actors. This way, though initially driven by the technology element, the change was taking place on a systemic scale from the beginning.

In the case of residential housing retrofits, where social innovation is the most visible early driver, effective intermediaries must be able to make similar interconnections among the system elements, including technologic knowledge and know-how, the fringe actors and mainstream actors. We have shown in the case study that WoHEC might fulfill that role at this stage in Worcester.

This case study could be compared to the 'Transition Arena' concept, as described by Loorbach (2010). In this work, a transition arena also consists of frontrunners, and is described as an open, evolving process of innovation (p 174) that implies variation and selection: some people drop out others join in. This arena produces visions, but, contrary to the WoHEC case, "transition visions will oppose expectations and visions of regime actors, and in that sense transition visions are explicitly seeking conflict with vested interest and powers to establish a fundamental debate upon future development (p 175). It is very interesting that a) WoHEC does want to move quickly from vision and action; and b) WoHEC does not want conflict, but wants to help transform the present socio-technical regime (on the scale of Worcester) with help of the incumbent players. In this sense WoHEC cannot be seen as a transition arena.

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