

THE SOCIO-TECHNICAL TRANSITION INITIATIVE
at the
GEORGE PERKINS MARSH INSTITUTE
Clark University, Worcester, Massachusetts
in cooperation with the
INSTITUTE FOR ENERGY INNOVATION & SUSTAINABILITY
Worcester, Massachusetts

Prospectus for a Program of Action-Research,
Education, and Policy Engagement:

**AN URBAN TRANSITION TOWARD SUSTAINABILITY:
Worcester as a Model for Green-Energy
Innovation and Economic Renewal**

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Summary

The George Perkins Marsh Institute at Clark University has convened a diverse group of experts to work on the Socio-Technical Transition Initiative (STTI). Members of the group are from Clark, Worcester Polytechnic Institute (WPI) and other institutions. The group has developed a program of action-research, education, and policy engagement that is designed to help Worcester become a model city, demonstrating the potential for sustainability, green energy, and economic renewal. This program will be closely coordinated with the work of the Institute for Energy Innovation and Sustainability (IEIS), which has been jointly established by Clark and WPI. Under the umbrella of the program described here, teams will work on a portfolio of projects that share common principles, are mutually supportive, and are targeted at specific needs in Worcester. All projects will embody a principle that forms the basis of the STTI, as follows: Rapid transition of a city or other social unit toward sustainability is feasible and can yield multiple social benefits, but only if new technologies co-evolve with social, political and economic systems, business practices, and cultural norms. Guided by that principle, the program described here will catalyze and test a variety of innovations in green energy and other aspects of sustainability. That work will involve cutting-edge research and consistent engagement with local communities, in order to develop and learn from innovations that meet real needs, create new jobs and businesses, and can be widely replicated. The findings will help Worcester, Massachusetts and the United States address pressing challenges such as climate stabilization.

NARRATIVE

1. Needs, Opportunities, and Frameworks for Action

There is widespread recognition that continuing satisfaction of human needs, in a world of environmental and resource constraints, requires the adoption of new technologies and practices. That recognition is expressed through concepts such as sustainability and "green energy", where the latter term refers to efficient use and renewable supply of energy. In addition, there is growing awareness, highlighted by the present economic recession, that innovations in sustainability and green energy can be drivers of economic renewal. Public officials in Massachusetts and across the United States increasingly view environmental and resource challenges, such as stabilizing Earth's climate, not as economic burdens but as opportunities to build a sustainable economy that benefits all sectors of society. Their efforts are establishing policy frameworks that support appropriate actions. The Socio-Technical Transition Initiative will catalyze, test and evaluate such actions, and will formulate its findings in a manner that is helpful to policy makers, activists, community members, and governmental and non-governmental organizations.

Massachusetts enacted several major environmental laws in 2008, two of which are especially relevant to the research and action agenda of the STTI. The Global Warming Solutions Act aims to limit statewide emissions of greenhouse gases in 2050 to a level at least 80 percent below the 1990 level. State and regional institutions are working toward that objective. The Green Communities Act seeks to shift energy generation in Massachusetts toward renewable sources and to mobilize cities and towns to adopt programs for energy efficiency and renewable generation. The federal government has begun to move in the same direction. Economic stimulus funds are now available for various green initiatives, including improved energy performance of buildings and creation of "green collar" jobs.

Worcester has developed a Climate Action Plan and appointed a manager of energy efficiency and conservation. Also, Worcester has embraced a broad agenda of sustainability by joining ICLEI: Local Governments for Sustainability, which has members in 67 countries. Clark University and Worcester Polytechnic Institute have expanded upon their longstanding commitment to the city by jointly establishing a new Institute for Energy Innovation and Sustainability. IEIS will help Central Massachusetts become a regional hub for social and economic development and deep reduction in greenhouse gas emissions, through innovation in green-energy technologies, encouragement of entrepreneurship and job creation, and other actions.

The program described here will operate within the policy frameworks described above, and will contribute to strengthening policy processes in three areas – the making, evaluation, and implementation of policy.

2. The Socio-Technical Transition Initiative

Recent years have witnessed an explosion of activity in the development of technology for green energy and sustainability. However, the almost exclusive focus on technological development, rather than the use of technology, has limited the effectiveness of many initiatives. A conventional focus of this kind ignores the fact that technology is part of a complex system that also includes institutions, culture, physical infrastructure, and economic-structural underpinnings. Repeated experience shows that technological and policy developments often far outpace society's capacity to adapt its institutions, economy and culture. The fundamental challenge of transitioning toward sustainability entails harmonizing the pace and direction of change in two dimensions: the social, and the technical. Many initiatives during recent decades to improve sustainability have met with little interest among the public. Yet, despite this experience, public and private initiatives continue to overlook the integrated socio-technical advances and learning required for a successful transition. Experience also shows that a successful effort to create new, beneficial practices in one setting does not guarantee that the practices will be adopted elsewhere. Diffusion of knowledge is inhibited by various factors that can only be understood through systematic observation and analysis. Addressing the challenges of technology adoption and diffusion requires a thorough understanding of the complex interactions between social and technical systems, learning and change.

To help in addressing the challenges of sustainability transitions, the George Perkins Marsh Institute has convened an interdisciplinary group of experts to work on the Socio-Technical Transition Initiative. STTI builds on expertise at Clark, WPI and other institutions in several areas, including technological and social innovation, policy analysis, and action-research on community development, environmental health, and sustainability. The mission of STTI is to develop the knowledge and partnerships necessary to overcome the social barriers that slow the development and deployment of a more sustainable infrastructure, with particular attention to understanding the co-evolution of new technologies with social, political and economic systems. STTI seeks to ensure that technological advances in energy and other areas related to sustainability are paired with the socio-technical knowledge and tools needed to accelerate transitions that yield multiple benefits to society.

STTI will conduct and adapt research on socio-technical learning and transitions, yielding findings that can be used by policy makers, entrepreneurs, and other stakeholders. Work done through STTI will combine science with outreach to promote environmental, economic, and social benefits. In STTI we view energy sustainability as not only important intrinsically, but also as an anchor for a broader set of structural benefits including economic development, job creation, poverty reduction, and the movement of local economies toward green technologies and services. Coordinated, bottom-up and top-down interactions with public and private partners will promote these and other synergistic benefits. STTI will provide businesses with access to technical, intellectual

and entrepreneurial resources, while fostering, monitoring and evaluating socio-technical projects on local and regional scales.

The initial focus of STTI's attention will be on Worcester's transition to sustainability. This focus reflects longstanding commitments by Clark and WPI to the city, embraces the potential to accelerate socio-technical learning by concentrating efforts in one city, and incorporates the mission of IEIS to help Central Massachusetts become a regional hub for green-energy innovation with accompanying social and economic benefits.

3. The Program – Worcester as a Model of Urban Transition Toward Sustainability

In this program, the capabilities and principles of STTI will be applied to help Worcester become a model for green-energy innovation and economic renewal. The program will involve action-research, education, and policy engagement, as described below. Under the umbrella of this program, separate teams will work on a portfolio of projects that share common principles, are mutually supportive, and are targeted at specific needs in Worcester. Through these projects, we will catalyze, test, evaluate, and analyze a variety of innovations related to green energy and sustainability. Those activities will involve a variety of relationships with partners and stakeholders. The word "innovation" is used here to distinguish practical actions by partners and stakeholders – such as enhancing the energy performance of a building, or introducing a new financing mechanism or business model – from our portfolio of projects.

Our focus on an urban transition to sustainability reflects the prominent placement of urban sustainability on political and social agendas around the world, and acknowledges that cities are complex socio-technical systems. The transition of a city toward sustainability involves long-term processes of structural transformation that affect numerous domains, including the energy performance of buildings, systems for personal mobility and transport of goods, energy generation, management of solid and liquid wastes, social and economic development, equity, community cohesion, public health, and others.

Urban transitions toward sustainability require large, systemic changes in society, on various scales and timeframes. The concept of "transition management", developed in the early 2000s in the Netherlands, provides a useful framework for analysis, intervention and monitoring. At a May 2009 workshop on urban transitions, Derk Loorbach from Erasmus University in Rotterdam, a leading node of scholarship on transitions, noted (based on experience from the Rotterdam Climate Initiative) that:

“Key elements in the transition management approach are: frontrunner networks that develop an integrated understanding of their common transition challenge and a desirable future perspective; a shared transition agenda as roadmap for social innovation; transition experiments as innovation icons to implement parts of the future agenda; and monitoring, evaluation and adaptation” (emphasis added).

Our program will contribute to the sustainability transition in Worcester by supporting existing and emerging frontrunner networks, by facilitating the emergence of a shared

agenda, by catalyzing (and, where appropriate, co-designing) local socio-technical experiments, and by monitoring and evaluating such experiments from the technical, social, economic and policy perspectives.

The catalyzing, testing and evaluation of innovations constitute the action-research aspect of this program. Our work in this area will emphasize the importance of empirical evidence. In some instances, we will evaluate innovations that are initiated and designed by others, while in the remaining instances we will play a catalytic and perhaps a co-designing role in the innovation. Our evaluation in the latter instances will give careful attention to potential conflicts of interest. Throughout, we will encourage entrepreneurs (social, technical, business, nonprofit, etc.) to propose and test new approaches. Facilitating entrepreneurial initiatives will expand the range of actors in the green-energy arena, will encourage creativity, and will help to spin off new businesses.

The education aspect of this program will occur at the undergraduate, graduate, and community levels. Students will be involved with the program's action-research through curricular inclusion in courses taught by STTI faculty, and through extra-curricular experience that includes engagement in community-based, action-research projects. Education at the community level will be integrated with facilitated processes of dialogue and shared visioning, which STTI will help to convene. These processes will contribute to the emergence of a widely-shared agenda for Worcester's transition.

The policy-engagement aspect of this program will bring the findings of our action-research to relevant policy arenas. Those findings will be compiled and presented with a view to their usefulness to policy makers. Tools such as modeling, simulation and visualization will be used in linking the observed properties of green-energy innovations with related policy questions.

This program will establish and maintain connections with relevant centers of research, practice, and education worldwide. Several of the key researchers will integrate this work into their existing international collaborations.

4. The Project Portfolio

An evolving portfolio of projects to be implemented through this program is described below. The listed projects are in various stages of development, and span a spectrum of sustainability issues. Themes addressed by these projects reflect environmental and social needs, governmental policy commitments, and expertise within our group.

No. 1: Deep Reduction in Energy Use by Existing Residential Buildings (Contact Persons: Halina Brown, Philip Vergragt)

Radical improvement in energy performance of existing residential buildings has great potential to reduce greenhouse gas emissions, because the residential sector accounts for about one fifth of all emissions in the United States, and one quarter in Worcester. Yet, we as a society do not know how to implement a successful program of deep reduction in

housing energy use on the scale of a neighborhood, community, or city. Much has to be learned on the technical and business side of building retrofits, as well as on the social, institutional and cultural side. Open questions include: How to mobilize homeowners, create a knowledge network, develop sustainable financing mechanisms, set goals, monitor progress, and adapt and coordinate the existing institutions? Also, what should be the roles of state and local governments, NGOs and grass-roots activists? Small-scale prototypes and experiments, ranging from a few to hundreds of homes in a community context, can answer these and other questions. Experiments of this type provide the most promising settings for socio-technical learning, and many communities around the country are currently initiating such experiments.

Through the initiative of STTI researchers as conveners and catalysts, the frontrunner network for small-scale experiments has already emerged in Worcester, including prominent political figures, city officials (e.g., the manager of energy efficiency and conservation), Worcester Community Action Council, Worcester Roots, Summer of Solutions, Stone Soup, the local Community Development Corporation, and others. Collectively, this network has a high level of enthusiasm, knowledge, and institutional and political resources. With leadership, coordination, technical resources, entrepreneurship, and business participation, a housing retrofit experiment can become an entry point to a long-term transition within Worcester.

In comparison with energy retrofits in the residential sector elsewhere, initiatives being implemented in Worcester are especially innovative on three counts. First, they regard improvements in the energy performance of houses as not only important intrinsically, but also as an anchor for a broader set of structural changes. Those changes include economic development, creation of jobs at all salary ranges, job training, vocational and professional education, poverty reduction, and shifting the city's economic base toward advanced green technologies and services. Second, the Worcester initiatives simultaneously build on top-down state policies, bottom-up activities by numerous local stakeholders, and the City's initiatives, and seek to harmonize those in a coordinated fashion. Third, they seek to create a model that can be replicated and learned from across Worcester, Massachusetts, and the United States.

STTI researchers will play two roles in this project. First, they will be a source of technical and scientific knowledge and conceptual framing, drawing on international research networks and empirical experience. Second, they will monitor, evaluate and analyze energy retrofits in Worcester. Evaluation of retrofit initiatives will address such indicators as: the employment opportunities created; energy use reductions; diffusion of advanced technologies; changes in homeowners' attitudes toward energy consumption; emergence of effective institutional and coordination mechanisms; and others. The overall goals of the research are to create new knowledge on how an urban transition can be designed and implemented, centered around the task of upgrading energy performance of the residential housing stock, and to identify factors that are central to a successful diffusion of that knowledge across different locales and contexts.

No. 2: Modeling and Tracking Improvements in the Energy Performance of Buildings
(Contact Persons: Brian Meacham, Gordon Thompson)

Innovations in the design, construction, and operation of buildings could allow existing and new buildings to perform their functions while using much less fuel and electricity than at present. With appropriate attention to socio-technical factors, these innovations could become reliable and affordable enough to become widely used. The resulting benefits could include deep reductions in greenhouse gas emissions, together with cost savings, creation of green-collar jobs, and other social and economic benefits. For a variety of planning and policy purposes, it would be very useful to estimate the future diffusion of building innovations, and the resulting benefits, across a given geographic setting (e.g., a city, or a state) and sector (e.g., commercial buildings). Such an estimate could, for example, guide the development of policy measures that promote low-energy buildings. The value of an estimate would be further enhanced if the findings were continuously updated, based on measurement of relevant indicators. Comparing estimated and actual outcomes would allow policies and plans to be adjusted appropriately.

This project will develop a model (a software package) for estimating the future use of building energy innovations and the resulting benefits, and for subsequent tracking of the actual outcomes. The estimated and measured indicators will address the energy performance and functional performance of buildings, costs over a building's life cycle, employment effects, and other social and economic variables. Selection of indicators will involve extensive stakeholder engagement. The model will be tested in Worcester. It will, however, be written with generic applicability to a wide range of geographic settings, building types, and innovations. It will have a user-friendly interface. When fully developed, this model will be useful in many public and private contexts, to guide policy choices, planning and investment decisions, and the innovation process.

No. 3: Cyber Systems for Urban Sustainability
(Contact Persons: Gordon Thompson, Jing Zhang)

Much effort is currently being devoted to developing electronic systems that can speed the transition to urban sustainability by capturing, creating and sharing information. For example, Oberlin College has a successful system of monitoring energy and water use in dormitories, providing real-time feedback to student residents, who have responded by altering their behavior. Cisco and San Francisco are piloting an analogous system, known as Urban EcoMap, at the citywide level. Purdue University's Vulcan system maps CO₂ emissions at a range of scales. The follow-on Hestia system, being piloted in Indianapolis, has the ultimate aim of providing stakeholders worldwide with a common framework of models, data sets, visualizations, and decision-support functions that facilitate the management of emissions.

In our project, we will establish a library of cyber systems that are relevant to urban sustainability, and will test selected systems in Worcester across a range of scales from

the household to the city. The objective is to assess the performance of these systems in representative, practical settings. That process will expedite the refinement of systems and their integration across functions and scales. As experience develops, we may work with partners to develop new cyber systems. The project will build on Clark's expertise in geographic information systems (GIS). Use of GIS to map indicators of urban sustainability has exciting potential. Such graphical, spatially explicit information can be an effective way to represent baseline conditions and monitor changes over time. GIS also has the advantage of being able to communicate information in visually compelling ways that facilitate stakeholder engagement and social learning through dialogue.

While addressing specific needs in an urban context, this project will also contribute to general understanding of the ways in which GIS and other information, communication, and education technologies can serve sustainable-development goals. Many observers see a large potential in this area. For example, the vice-chairman of Fujitsu has suggested that these technologies could reduce greenhouse gas emissions by 15% by 2020.

No. 4: Grid Integration of Distributed and Renewable Electricity Sources
(Contact Persons: Scott Jiusto, Philip Vergragt)

The sustainability transition will involve increased use of distributed and renewable modes of electricity generation. These modes will include wind turbines, photovoltaic arrays, and microgeneration units serving a combined heat and power role. Such devices will typically be grid-connected, often with two-way metering. Integrating these devices with the grid will be a major, socio-technical challenge. Loads must be managed and storage must be introduced, to account for the intermittence of supply and the variability of load. For example, plug-in hybrid cars could provide a substantial electrical storage capacity. A so-called "smart grid" could provide the information flows needed to integrate intermittent supply with load management and storage. However, developing a smart grid that is reliable, cost-effective, and user-friendly will require the solution of numerous socio-technical problems. This project will address those problems by working with a range of partners to test smart-grid arrangements through incremental, modular steps. Partners will include equipment and software vendors, utilities, and various electricity users.

No. 5: Sustainable Urban Neighborhoods with Multiple Sustainability Objectives
(Contact Persons: Timothy Downs, Gordon Thompson)

An urban transition toward sustainability involves a variety of domains, including the supply and use of energy, public health, modes of personal mobility and transportation of goods, food security, management of wastes, social and economic development, equity, community cohesion, exercise and recreation, crime prevention, and many others. There are numerous interconnections among these domains, and pursuit of sustainability will involve multiple objectives across the domains. In some instances, objectives can be satisfied simultaneously through synergies, while in other instances there must be tradeoffs among objectives. Moreover, stakeholders will differ in the weights they assign to particular objectives. Also, pursuit of sustainability objectives can demand substantial

changes in institutions, business models, cultural norms, etc. From a citywide perspective, the roadmap is unclear – pursuing such a diverse set of objectives is daunting in its complexity.

The concept of a sustainable urban neighborhood (SUN) offers a way forward. At the neighborhood scale, socio-technical systems are less complex than at the city scale, and there are fewer stakeholder interests. There is greater potential to develop a shared transition agenda as a roadmap for innovation. (Experience in Rotterdam identifies such an agenda as a key element of a successful transition.) Thus, a SUN initiative can be a prototype that tests new options for the sustainability transition. This project will pursue that opportunity by selecting an appropriate neighborhood and engaging with local stakeholders to develop and implement a shared SUN transition plan over time. Lessons from this experience will help to guide transitions at larger scales. Worcester's Main South neighborhood may be an appropriate location for this project. The success of such a holistic, community-based project will depend on crafting stakeholder partnerships that build collective capacity and distribute benefits equitably. There will be a need to bring together key partners committed to compatible ready-to-go activities, creating synergy to achieve diverse sustainability goals.

No. 6: Universities, Community Engagement, and Sustainable Technology
(Contact Persons: Mary-Ellen Boyle, Jennie Stephens)

Acknowledging the importance of social learning in sustainability, together with a movement in higher education toward more civic engagement, this project focuses on improving understanding of opportunities and challenges for university-community engagement in promoting a sustainability transition. The project integrates analysis, theory, and practice related to technology diffusion, transition management, university civic engagement, organizational change, and experiential learning. It conducts cross-disciplinary research in two major areas: (i) exploring, monitoring, evaluating, and reporting on several specific examples of university-community engagement for sustainable technology, including the IEIS and STTI; and (ii) categorizing and comparing university-community initiatives to create an online network/database designed to facilitate and support implementation of new university-community initiatives and foster collaborations and comparisons among different approaches. A web-based portal will be developed to catalogue, connect, and disseminate knowledge about different types of university-community initiatives related to sustainable technology. This project will provide a critical, self-reflective component of the IEIS and STTI endeavors, and will also contribute valuable resources and insights to the growing international movement for more civic engagement in higher education.

5. Venturing Beyond the Business Incubator Model: A New Role for Universities in Research and Education for Sustainability

The "business incubator model" is a traditional approach to economic development. In that model, a university can make an important contribution as a place where basic scientific research and education occur. The success of that model in facilitating

technological innovation has been well documented. Yet, the increasing complexity of societal problems (e.g., climate stabilization, poverty alleviation), and the need for socio-technical innovation in addition to technological breakthroughs, are obliging universities to consider a wider range of models for business development, and for the production and dissemination of knowledge.

STTI exemplifies a new model. While drawing on key elements of the business incubator model – spatial proximity of intellectual and institutional resources and actor networks, access to capital, and supportive government policies – the STTI approach also accounts for social embedding of technology and the local context in which the technology is used. It engages the university in so-called "mode two" research that is context-driven, problem-focused, and interdisciplinary, a form of action-research that involves a range of local stakeholders. Ultimately, the goal is to co-produce, with the stakeholders, the knowledge on how to foster systemic transition towards a sustainable society.

6. Clark University's Capabilities

Clark provides an ideal host institution for this program, because Clark has a long history of, and has become a recognized national leader in, integrating community engagement into its research and educational endeavors. Within Worcester, Clark has played a leadership role in the community for decades. Clark's commitment to community engagement is integrated into learning and research in multiple ways. Clark's motto of "making a difference" manifests itself in: opportunities coordinated through the Community Engagement and Learning Center; use-inspired research conducted at the new Mosakowski Center for Public Enterprise; the University Park Partnership, a national model for neighborhood revitalization; and the Jacob Hiatt center for Urban Education, a partnership between Clark and the Worcester Public Schools that researches innovative ways to address the challenges and possibilities of urban education. Several members of the STTI group are faculty in Clark's unique, interdisciplinary department of International Development, Community, and Environment – a community of scholars and practitioners dedicated to environmental sustainability, social justice, and economic well-being.

The George Perkins Marsh Institute at Clark will coordinate the STTI and the program described here. Building on a Clark tradition of basic and applied research on environmental hazards and international development, the Marsh Institute addresses a wide range of research themes, including environmental assessment and management, risk and hazards, the human dimensions of global environmental change, and the development and application of GIS for environmental, resource and development issues. The Marsh Institute fosters interdisciplinary, team-based research that engages graduate students and faculty in problem formulation and resolution.