Green the Knowledge District
Status Report July 2011

Prepared by GKD Team

Contents

Introduction:

This Green the Knowledge District (GKD) document provides background on GKD initiatives, reports on the status of its six-month pilot activities, and proposes an action plan to carry the project forward. This report was produced by the GKD Team — an all-volunteer, cross-sector, cross-organization, and cross-discipline collaboration of dedicated talent in Rhode Island. The team encourages City and State support to enable continuation of GKD's work over the next 6-12 months, and provides recommendations for the types of support needed to accelerate sustainable strategies.

Green the Knowledge District (GKD) is a place-based analysis of the flow of resources and impacts on the environment associated with land development and building operations. Under the leadership of OSCAR, the initiative assesses conditions, recommends innovations, and pilots collaborations with the aim of furthering sustainability. Taking advantage of unique characteristics and a window of opportunity for new investments, GKD is generating findings relevant for application in other areas of the city and state.

The term "Knowledge District" (KD) derives from the nature of recent and targeted future development - both of which are related to "knowledge economy" activities. Such efforts include renovation of existing structures to house Rhode Island Center for Innovation and Entrepreneurship, Brown University's Medical School and its life sciences research labs, and the establishment of several small- to medium-sized life science businesses. The geographic location, proximate to downtown and the hub of hospital systems, research universities, an entrepreneurial cluster, and the 16 acres of developable land opened up by the relocation of I-195, make the district an opportune growth area for Providence and Rhode Island.

For the purposes of this place-based research project the KD is defined as the area of Providence Rhode Island bounded by Allens Avenue on the east, Public Street on the south, Prairie Street on the west, and Pine Street on the north. Of the approximately 18 million ft.² (413 acres), 8.3 million (190 acres) is covered by City Assessor parcel data. The balance is streets and highways and includes the land becoming available due to the Route I-195 relocation project. The major landholders include Rhode Island Hospital with about 20.5%, Dominion Energy with 11.4%, State of Rhode Island with 5.9%, Brown University with 3.1%, and Women and Infants Hospital with 2.6%. A map of the district with aerial image, parcel, building, and street tree layers is shown in ***Figure 1*****.**

The following characteristics of the Knowledge District (KD) uniquely qualify it for innovative approaches to physical and economic development and facilitate the study and testing of ideas in the near term:

- The availability of some 16 acres of developable land due to the relocation of Interstate 195;
- State and City involvement and collaboration in the planning and development processes for the 195 parcels;
- The presence of life and health science organizations and institutions (ie Hospitals, Medical and Nursing Schools, etc);
- Control of significant properties by several major institutional players;
- Recent and sizeable redevelopment investments;
- A rich history of entrepreneurship and manufacturing;
- Active private-public partnership that includes academic research institutions;
- An active community organization;
- Energy intensive uses, particularly the life sciences, with much to gain from innovative, energy-saving solutions; and,

- A large percentage of paved area, presenting significant heat island, energy use and stormwater drainage ramifications.

Many existing structures in the KD were not built with energy efficiency or materials conservation in mind; nor was site planning done, in most cases, with any real consideration for sustainability. These conditions, along with contamination from pre-existing jewelry and other manufacturing uses, may present constraints on the surface. However, when looked at opportunistically, the need to correct such conditions, the relative lack of density in the extant built environment and the "blank slate" that the 195 parcels offers, present a huge opportunity to collectively assess these conditions and provide a framework for green and innovative development. The potential for energy cost savings, business attraction and job creation is great if proper analysis and subsequent guidance for sustainable development are applied in the district.

Together these outlined characteristics and existing conditions support the collection of data, controlled interventions and interdisciplinary research that will become the basis for improved practices.

Resource use and sustainability are complex issues; therefore, an interdisciplinary and cross-sectoral approach has the highest likelihood of achieving progress. Technology and science-based innovation can support improvements, but it is also critical to understand the culture, attitudes, behavior patterns, and institutional structures that shape current practices and constrain responses. GKD provides a real world "laboratory" for applying theory and modifying praxis, in order to move towards more sustainable development and operations.

Background:

OSCAR is a movement of diverse RI stakeholders (refer to Appendix 1) contributing resources (subject matter experts, student labor, computing resources, real world knowledge) and innovative thinking to establish an economically sustainable statewide community. The OSCAR action teams cross organizations, disciplines and sectors to address RI's most challenging problems. OSCAR's social network of over fifty public and private partners leverages the state's collaborative culture, diverse expertise, and entrepreneurial spirit to support a data-driven decision making (D^3) process. Data is a key to building collaborations, generating and testing new ideas, and enabling good decision-making. The D^3 process delivers a platform for innovation, alternative policies, shared investments, and smart development.

In January 2011, OSCAR launched the GKD pilot project, to build and test a collaborative model and data strategy for benchmarking energy use in the Knowledge District. It was the first initiative to leverage this place-based approach to assess conditions, recommend innovations, and pilot collaborations with the aim of furthering sustainability in Rhode Island. The pilot team worked together in order to:

1) create a web-based portal for data collection and the visualization of energy use and distribution within the KD;
2) demonstrate a collaborative model for advancing a large-scale initiative;
3) provide student learning opportunities: and
4) translate community engagement of students into the retention of graduates through start-ups, industry research projects, and new hires for Providence-based industries.

In its first three months, the GKD energy pilot achieved the following:

- **Established a Collaborative Interdisciplinary and Cross Sectoral Model:** The GKD core team is all-volunteer and includes students, faculty and professionals drawn from Brown, URI, the City of Providence, and OSCAR. The team includes experts in engineering, economics, oceanography, social science, environmental science, city planning, and the humanities.
- **Engaged Students in Substantive Research and Data Gathering:** Brown undergraduate and graduate students, along with URI undergraduate students, became active members of the GKD Team. Student involvement took the form of independent study research and team projects within classes.
- **Built Informational Structures:** Following an exploratory meeting with the GKD Data Steering Group (*see Appendix 1*), the team identified EPA Energy Star Portfolio Manager as the preferred energy management tool for the building scale portion of this project. Beyond identifying the tool, students and faculty at URI and Brown built GIS maps, collected data that identifies large KD land holders to be recruited in the next phase, and developed conceptual data models to guide data collection
- **Clarified Scope:** The GKD Team conducted a literature review and surveyed what other cities and institutions are doing. This data gathering process informed the scope and future work proposed in this report. (*See Appendix 4.)* Through efforts to define the pilot project, GKD Team expanded the scope to ask, "What might be done to push change in the Knowledge District (KD) in a more sustainable direction?" which propagated a series of questions, such as,
  - What indicators of sustainability should we use? (*See Appendices 5 and 6.)*
  - Who are the stakeholders, and how can we engage them?
  - What data is accessible and valuable?
  - What limits of space, time, actors, and processes should be set?

These outcomes laid the foundation for and prioritized future activities of the GKD project, as outlined in the action plan.

Organization

GKD Team

The pilot project is facilitated by OSCAR, and managed by directors from the City of Providence, the University of Rhode Island and Brown University (*See below, bios in Appendix 2.)* Student teams were engaged throughout the process, attending meetings, gathering information from and providing information for stakeholders, and visiting sites. (*See Appendix 3)*

David Everett, Principal Planner	Department of Planning and Development, Providence
Marion Gold, PhD, Director	Outreach Center & Sustainable Energy Programs, URI
Rachel Sholly, Assistant Director	Outreach Center & Sustainable Energy, URI
Bradley Moran, Professor of Oceanography	Graduate School of Oceanography, URI

Kathleen Shannon, Pilot Coordinator	OSCAR
Christopher Bull, PhD, Senior Research Engineer/Senior Lecturer	School of Engineering, Brown University

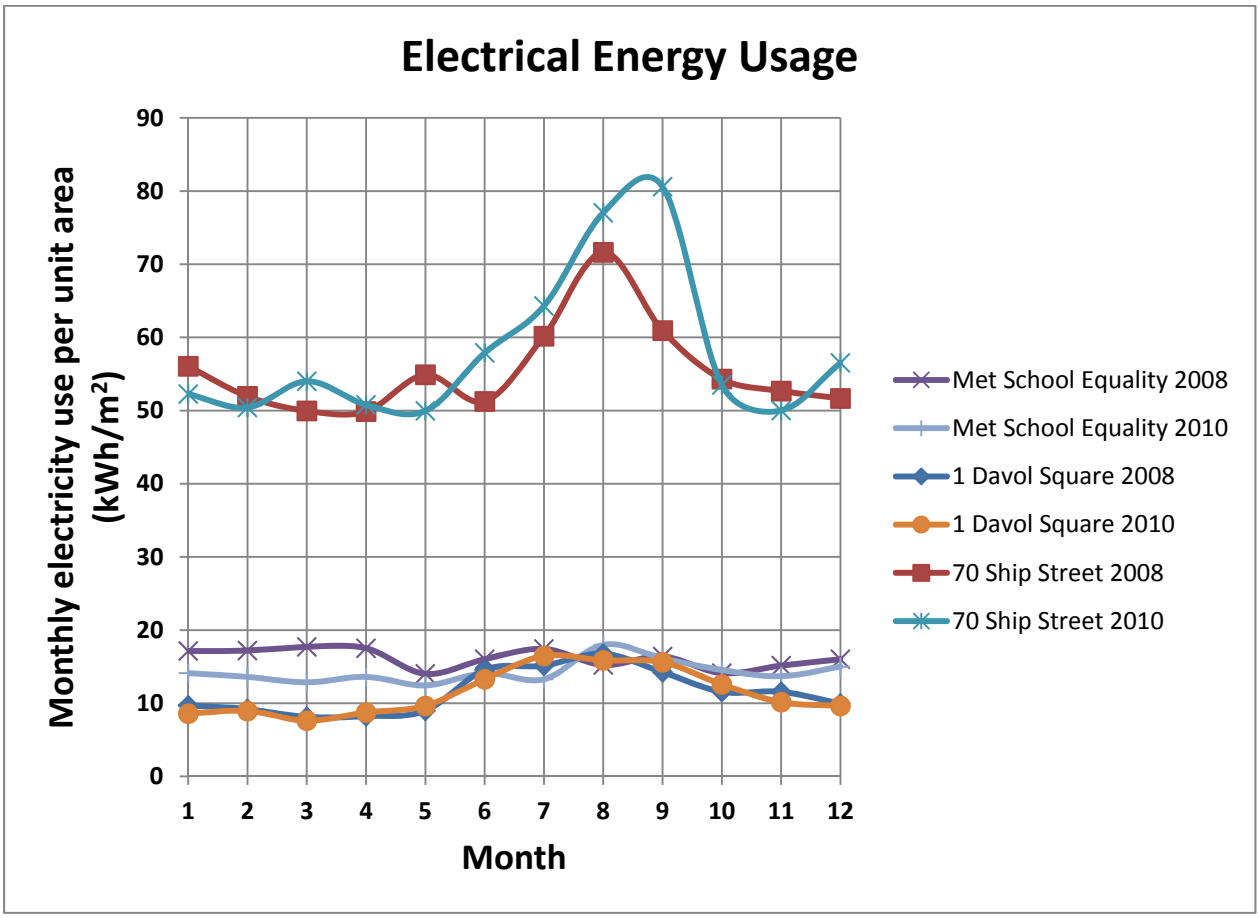
Research to Date

The efforts of the first six months have established a foundation for continued work and widening collaboration. The GKD Team has increased its understanding of the district and of data availability and gaps, and networked across sectors. It is has clarified its scope and lessons that inform the next phase. In the next 6-12 months it is critical that the project provides outcomes that can guide stakeholders' decisions.

Research Overview: Our research, as it should have, gave us a deeper understanding of the district and of the many issues that need to be addressed. It provided some outputs of immediate use to stakeholders. For instance, our study of 70 Ship St. showed that by updating the existing fume hoods and improving the seals around windows Brown University could significantly reduce the energy usage of that building.

Our investigation of sustainability indicators led to our adoption of the EPA's Energy Star model to capture building energy information in a way that allows easy comparison between buildings with similar uses. It also led to the recognition that, while much good work has been done on sustainability indicators, they need to be tailored to the specific context if they are to be useful. The use of these indicators to assess sustainability demands collecting and organizing data in many dimensions. The structure for that data needs to be carefully designed so that it admits census data, tax assessor data, geographic information, climate data, economic information, etc. while at the same time allowing easy access for the community. To be relevant, the data that populates the structure needs to be current. This points to the need to develop mechanisms that periodically update our records.

A portion of our research examined the feasibility of collecting and combining data from several sources. The chart below shows electrical energy use for three buildings in the KD; the Met School Equality building (secondary education), One Davol Square (commercial office space), and the Laboratory for Molecular Medicine (70 Ship Street, biomedical research). The gross electricity use has been divided by the area of the respective buildings to remove building area from the confounding issues. The data is in some ways mundane; it shows strong seasonal variation in electrical use for air conditioned buildings (70 Ship Street and One Davol Square) and much higher electrical use for life science labs (due to fume hoods requirement for conditioned makeup air). Both of these effects are predicted.



More remarkable is the joining of data from disparate sources – electrical energy usage from National Grid and Brown Facilities Management, building areas from the Providence Tax Assessor's office and ProvPlan. This hints at more questions to explore: "What happens if we normalize by building occupancy?", "Is there a relationship between energy use and economic activity?", "How many jobs or educations does that represent?", "What short and long term benefits are gained by the passage of that energy through the building?". To explore these questions will require more data, from other sources.

City tree counts obtained through the City Forester and analysis of canopy coverage in the Knowledge District provided a preliminary understanding of the urban forest's impact on the economics of redevelopment of the district and contemplated raising the environmental profile of the area. GIS and forestry computer programs provided a means of assessing direct economic benefits and comparing the tree canopy coverage to other areas of Providence, as well as to the City's stated tree canopy goals. Further research on the existing and potential impacts of the urban forest and other green space in mitigating the heat island effect is necessary, as are analyses of the natural systems and infrastructural interventions that constitute stormwater management - and the effects of climate change and sea level rise on these systems. Additional study might include research relating to water use and reuse (gray water), light and shadow studies relative to projected development and its impacts, and the potential impacts of green roofs.

The Bohrt and McPike study points out that the dialogues between “environmental sustainability” and “sustainable growth” in relation to dialogues about the “economic growth” of the district need to be aligned for the GKD and other growth coalitions to be effective in addressing city and statewide challenges. And, although GKD is a fluid and open model that provides a lot of entry points for diverse and interested parties, it is clear that the commonly used terms such as “Sustainable,” “Innovation,” “Knowledge” and “District” need to be defined and agreed upon between GKD and the City, GKD and the State, and between the City and State to provide understanding of value and to motivate change. If a common language is approved, GKD efforts will inform City and State decisions, and the City and State will jointly form regulations and interventions to support sustainable growth. This alignment will direct economic growth for the region. In our action plan, we propose ways to align these dialogues so that we can find common language to become more effective for region.

Below is a synopsis of the projects quoted above. The full reports can be found in appendices.

Student Efforts: The GKD mobilized critical human resources - faculty and students. They are a critical source of expertise for the City and State to leverage in challenging times. The following sketches of student work demonstrate the vital role of the academic enterprise, assisting stakeholders in the acquisition and interpretation of critical data. With the help of stakeholders we can place students in applied settings that provide valuable experience and much needed opportunities to practice and develop their skills.

Joshua Wurdeman (URI ‘12 Resource Economics and Commerce) led an effort to analyze an inventory of land use-based data for parcels in the Knowledge District. The inventory includes information on ownership, building size and current use. This data has established a profile of the holdings of primary institutional actors and identified other key stakeholders to bring into the project.

Stefanie Lynch (Brown ‘11, independent concentration in sustainable design) assessed green space in the district by combining data from the City’s forestry department with aerial analysis and ground-truthing. This analysis augmented available street tree information to establish a baseline for assessing improvements made towards sustainability goals. (*See Appendix 7.)*

As part of a Brown Engineering course on Sustainable Energy, Brown students Mike Caron (Brown ’12, Engineering), Courtney McCracken (Brown ’13, Engineering), Danielle Dahan (Brown ’11, Engineering), and Lingke Wang (Brown ’12, Engineering) investigated the availability and format of energy usage data. This work explored ways to structure and organize the data and began the process of identifying strategies for improving energy usage within the KD. Moving forward, student teams and research projects will build on this base, assessing total energy consumption patterns, building by building, in order to promote energy efficiency and assist stakeholders in making energy investment decisions. (*See Appendix 8.)*

In the same class, students Andrea Krukowski (Brown ’11, Engineering) and William Miller (Brown ’11, Engineering) investigated energy flows at one building, the Brown Laboratory for Molecular Medicine at 70 Ship Street. The objective of this project was to create a model of the energy flows associated with the building. This work also examined a particular practice (use of fume hoods) within the building and

how a behavioral change program in the building could reduce associated energy use. *(See Appendix 9.)*

Brown Sociology graduate students Marcelo Bohrt and Jamie L. McPike, as fieldwork for a class entitled "Political Ethnography," studied the organizations involved in the pilot project and similar efforts in New England. Their intent was to examine the operations of GKD itself in relation to the historical and contemporary development politics of the city. Using participant observation, qualitative research methodologies and interviews with key informants, these students critically reviewed the purpose of the project; how the group sustained itself; and how the GKD competes with other actors in Providence for power over the future direction of the District. *(See Appendix 10.)*

Challenges and Opportunities:

Stakeholder Recruitment: While collaboration is strong and growing, the engagement of all stakeholders remains a difficult and time-consuming process. Governance and the political will to engage partners are the most challenging aspects of this pilot. Research and model-building will provide beneficial outcomes, such as long-term savings, and prove to be a motivating force. The initial data gathering, however, has indicated that all relevant information is not publicly accessible, and strategies and partnerships are needed to expand voluntary participation.

The GKD Team spent the first 6 months meeting with large stakeholders, forming a collaboration and beginning the sharing of data. Results of this include:

- Brown University, through Facilities Management, agreed to fully participate, providing access, data, and general information about all buildings they own in the Knowledge District.
- The City of Providence committed personnel resources. Dave Everett, a Principal Planner, serves as a co-director of the GKD. This close connection is critical to gaining access and cooperative working relationships with other City departments.
- The City Forester provided data and served as a resource for the student project on greening the district. The street tree and green space data is now part of the district database.
- The Met School is an active participant, providing building and operations data, and integrating student learning. At the Met school, the team has installed data loggers, gotten access to electrical and gas data, and engaged a student to collect occupancy information and temperature, humidity and illumination data.
- National Grid is a partner, providing data and insight into their operational processes. Security concerns limit the sharing of detailed information.
- The Providence Plan (a.k.a. ProvPlan) has agreed to share both data and expertise.
- The Rhode Island School of Design has expressed interest in participation in the areas of materials, architecture, urban design, and natural systems. The team is engaging RISD in student opportunities in the upcoming phase.
- The GKD Team has begun initial conversations with Dominion Power and will continue to cultivate their partnership in the process.
- Stakeholders targeted for the next phase, as more faculty and students are involved, include the State of Rhode Island, Rhode Island Hospital and Women and Infants Hospital.

Data Sources and Collection: Data is central to the efforts of assessing resource use within the district, and of measuring improvements. Through the initial research projects the GKD Team has gathered base data and learned about some of the constraints and obstacles to developing a complete model—both at the district scale and for individual buildings within the district.

- District Profile Data: A spatial inventory of parcel land uses; green space types; building footprints; and impervious coverage. ProvPlan will provide additional GIS layers and 2010 Census data.
- Building Energy Use: Data for the past three years for all Brown University-owned buildings in the KD and for the Met School has been compiled.
- Real-time Data: For buildings with peak demand less than 200 kW (about 90% of the properties in the Knowledge District) only monthly totals are available; therefore, the temporal resolution is relatively low. These facts underscore the value of having "our own" data for which we can set the sampling frequency and collect by interrogating the equipment. At this point, we do not have the resources (people or equipment) to implement our own system.
- National Grid is an important partner. However, in the data retrieval process, the team learned that access to the current system is cumbersome. To release data National Grid requires authorization via an e-mail request from each building owner. Once those are in place, National Grid generates a spreadsheet, which is e-mailed to the requestor. Some buildings have renters and condominium ownership, which can also add complexity to the process.

Action Plan for 2011-12:

The research to date supports that further exploration and development is necessary, and this guides the proposed Action Plan. This Plan lays out recommendations for the next 6-12 months.

Stakeholder Agenda: The Action Plan proposes partnerships with the City and State to endorse GKD as a source of sustainability initiatives for the Jewelry District and other downtown development opportunities by supporting efforts when appropriate, inviting GKD faculty and student talent to participate in City projects related to sustainability, and partnering on City, State and federal opportunities to expand and accelerate GKD efforts. GKD should be a project within the City's economic, development, sustainability, and land management strategic plans.

Recommended actions:

a. *City of Providence:* Coordinate with City's Sustainability Director and appropriate city departments to identify areas of overlap and opportunities to work more efficiently and effectively in coming months.
b. *State of Rhode Island:*
    i. Engage the state on the GKD Team to encourage partnership and communication with ongoing efforts around development downtown.
    ii. Work closely with the newly appointed Rhode Island Climate Change Adaptation Commission to collect data to inform their efforts and encourage utilization of the place-based project as a mechanism or demonstration site for practices, surveys, focus groups, etc.
c. *195 Commission:* Coordinate and communication of ongoing efforts to align and support environmental sustainability and economic growth strategies.
d. *KD Stakeholders:* Engage remaining large-scale stakeholders in the data collection process and to initiate and implement a strategy for reaching out to small- and medium-sized stakeholders.
e. *Community-organized and residential Stakeholders:* Create a strategy for citizen communication and participation
    i. Engage Jewelry District Association and other local community organizations to advocate for sustainability strategies and to help educate public regarding efforts to innovate in the KD.

f. *GKD Partners:* Identify projects to be conducted with ProvPlan and Draper Labs for the 2011-12 action plan based on outcomes of this report, and to secure funding to explore these partnerships.

Research Agenda: The 6-12 month Action Plan proposes to continue to collect and analyze data for the GKD project. The GKD project also proposes to explore and identify new GKD projects and leaders/teams. These possible initiatives are outlined below and will require both human and monetary resources.

Recommended Actions:

a. Expand Energy Data Collection:
   i. determine relevant sustainability indicators
   ii. gather building construction type data
   iii. add selected building energy data
   iv. determine the potential to capture some of the solar and wind energy flowing into the district to offset fossil fuel-based energy sources.

b. Study Storm Water and Natural Systems:
   v. Review past efforts and engage research teams relevant to the issues that need to be addressed (Brown, Marine Biology Lab, URI, IBM).
   vi. Expand the efforts initiated by tree canopy report with City Forester's Office to include all green space.
   vii. Engage RISD city/state initiative and other appropriate partners.
   viii. Determine the potential to capture and infiltrate storm water flowing from, into and through the district to reduce the discharge of contaminated storm water into Narragansett Bay, mitigate flooding, reduce use of City water, and provide more green space.

c. Promote culture change around sustainability issues:
   ix. Assess commercial and residential mix and demographics within the district
   x. Study transportation choices in district

Student Agenda: The Action Plan calls for continued student engagement in the classroom and in the field. The Action Plan calls for the City and State to leverage the GKD Team as a source of talent to explore challenging questions identified in the development process.

d. Future class work will address designing software systems to interface with Energy Portfolio Manager and GIS, and demographic data platforms to produce valuable energy reports. (Brown Engineering, Sustainable Energy Technology, Spring 2012)
e. Impervious coverage and parking analysis by students—are parking areas oversized for current operations? (Review uses, document actual use of spaces, determine employee numbers, etc.) How do the City parking standards in zoning/existing parking amounts compare to ITE standards? Are there opportunities for shared parking arrangements? What alternatives to conventional impervious paving might be implemented and with what projected impacts? (Brown Sociology, Principles and Methods of Geographic Information Systems)
f. Explore how the confluence of design and technology might influence behavior related to sustainability targets. This is the topic of a joint RISD Industrial Design/Brown Engineering studio for the fall of 2011

Conclusion:

After six months, the GKD pilot has drawn to a successful conclusion. This report reflects the multiple accomplishments and establishes a foundation for future projects that are identified and recommended in the action plan. These recommendations will influence and introduce sustainability strategies as economic growth opportunities for the region, and they require support, advocacy and resources to continue to collect data, drive decisions and build solutions that will catalyze environmentally sustainable growth and development for the city, state and region.

The GKD Team has built a successful collaboration and gathered a significant amount of valuable data. We must continue data collection and nurture the network of talent created during the pilot phase. It is the outcome of this data-driven approach and collaborative team-based expertise that will drive consensus and produce “long-term” economic, environmental and social impact. The economic impact that demands more immediate solutions will include measurable improvements in energy consumption and cost efficiencies of investments; increased research support and commercialized activities; shared infrastructure and talent; enhanced public-private partnerships; and attraction and retention of new knowledge jobs, technologies and businesses based on a sustainable community. These economic outcomes have been proven in other projects in cities and states throughout the world and will continue to be tested to transform the current state of energy and environment around the world.

GKD will lead the transformation regionally, affording an opportunity for the Knowledge District to serve as a state, regional and national model for green design and development and promote human resource and capital investment. By encouraging and even requiring the use of green technologies such as solar, brown water, and green roofs, the GKD will demonstrate how urban communities can simultaneously foster economic development and improve energy efficiency, ecological health and sustainability, and quality of life.

The GKD Team is a trusted and collaborative community of aligned regional expertise that is committed to transforming the region in which they live and work. With this report, they look to expand and align talent and resources from both public and private sources to build a sustainability roadmap for the region that will be recommended to and utilized by the stakeholders for future development and growth of the city-state.

Resources used:

1. http://status-tool.iclei.org/content.php/demo.

2. http://www.siemens.com/press/pool/de/events/2011/corporate/2011-06-northamerican/northamerican-gci-report-e.pdf.

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8. Pereira, T. Sustainability: An integral engineering design approach. *Renewable and Sustainable Energy Reviews* **13**, 1133-1137 (2009).

9. Rice, A., Hay, S. & Ryder-Cook, D. *Proceedings of the 2nd ACM Workshop on Embedded Sensing Systems for Energy-Efficiency in Building - BuildSys '10; A limited-data model of building energy consumption* , 2010).

10. Ruth, M. *et al*. Sustainable prosperity and societal transitions: Long-term modeling for anticipatory management. *Environmental Innovation and Societal Transitions* **1**, 160-165 (2011).

11. Sailor, D. J. Relating residential and commercial sector electricity loads to climate—evaluating state level sensitivities and vulnerabilities. *Energy* **26**, 645-657 (2001).

12. Valentin, A. & Spangenberg, J. H. A guide to community sustainability indicators. *Environ. Impact Assess. Rev.* **20**, 381-392 (2000).

13. Yau, Y. H. The use of a double heat pipe heat exchanger system for reducing energy consumption of treating ventilation air in an operating theatre—A full year energy consumption model simulation. *Energy Build.* **40**, 917-925 (2008).

Figures:

Figure 1: Map of the Knowledge District (KD).

Overlaid on a 2003 aerial (before the I-195 relocation) are parcels (green); building footprints (blue), street trees (yellow); and residual land (purple). Created by C. Bull. Data Layers: 2003-04 Aerial, RIGIS; Parcel and Buildings, City Planning Department (March 2011); Street Trees, City Forester (February 2011).

Figure 2: Network of Stakeholders

This figure illustrates the range of stakeholders, particular interests, goals, and data sources involved in this project. Green highlights items in process (connections made, data collected, data integrated across dimensions)

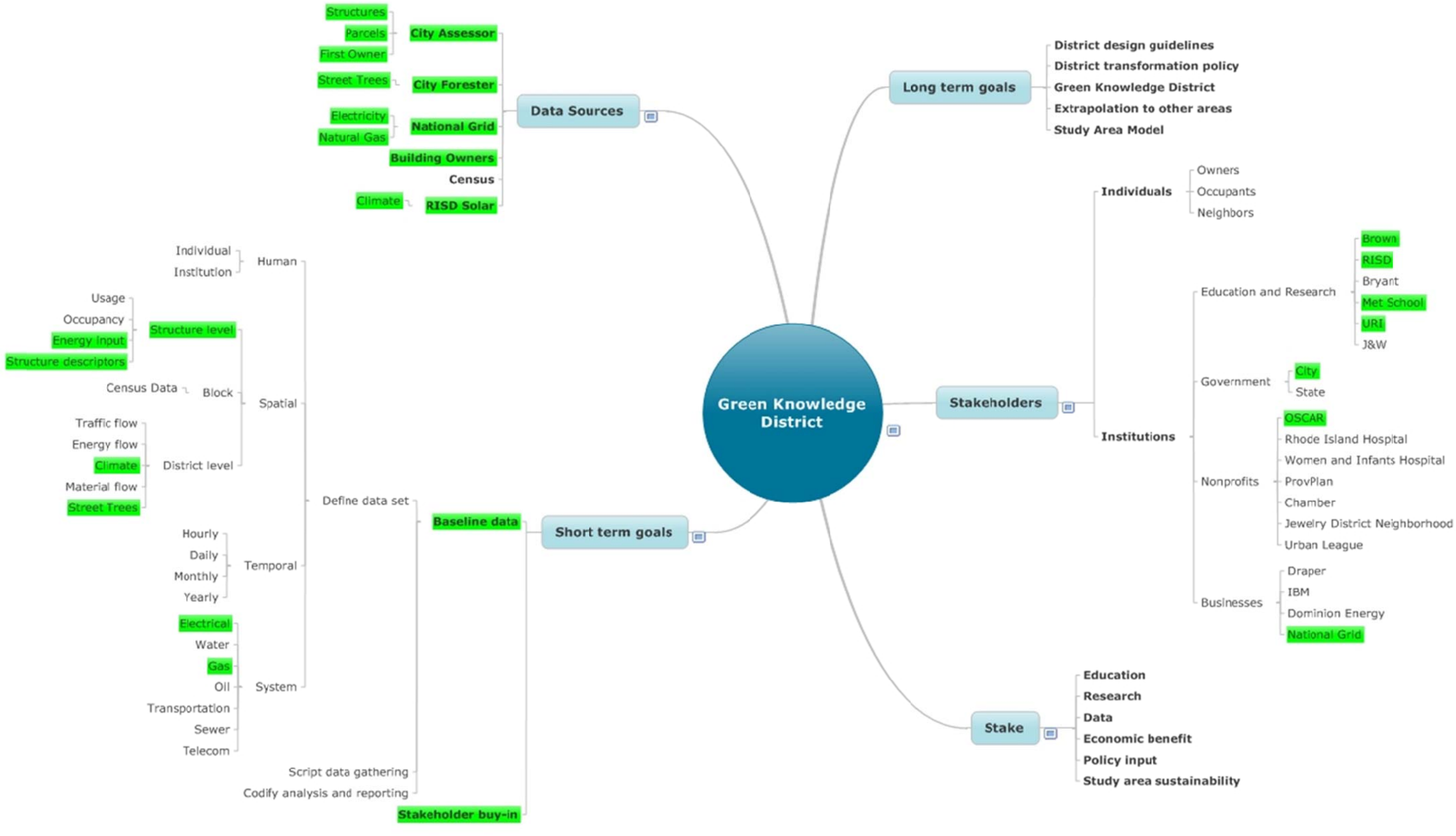
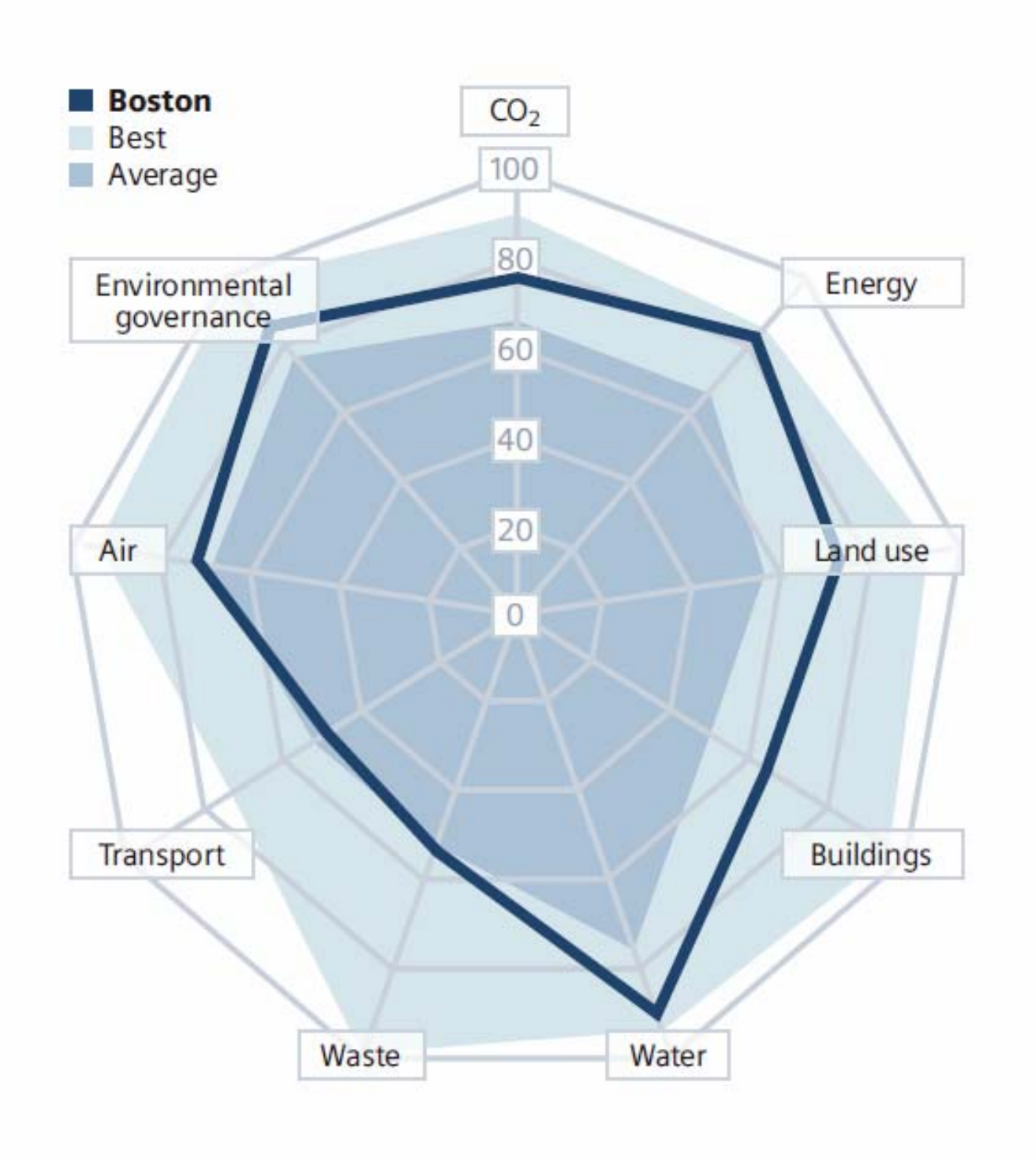


Figure 3: Sustainability Indicators

This figure shows a graphical representation of sustainability indicators for Boston from the North American Green Cities Report (permission to publish pending)



Appendices:

Appendix 1: OSCAR and GKD Stakeholders

OSCAR Participating Member Organizations

Universities and Research Labs

- Association of Independent Colleges and Universities of Rhode Island
- Brown University
- Bryant College
- Draper Labs
- Johnson and Wales University
- Marine Biological Laboratory
- Naval Undersea Warfare Center
- Rensselaer Polytechnic Institute
- Rhode Island School of Design
- United States Naval War College
- University of Rhode Island

Industry

- Aspen Aerogels
- Alteris
- APC
- Deepwater Wind
- Greater Providence Chamber of Commerce
- Helicos BioSciences
- IBM Corporation
- ICF International
- Raytheon
- Social Venture Partners Rhode Island
- Thought Cap

Public

- Office of the Lieutenant Governor
- Providence Department of Planning
- Providence Mayor's Office
- Rhode Island Economic Development Corporation
- Rhode Island State Office of Energy Resources
- Science and Technology Advisory Council

Non-Profits

- Apeiron Institute for Sustainable Living
- AS220
- Care New England
- Cleanwater Action
- Grow Smart RI
- Institute for the Study and Practice of Nonviolence
- Lifespan
- Northeast Sustainable Energy Association
- OSHEAN
- People, Power and Light
- Providence Plan
- Quality Partners
- Revolution by Design

- Rhode Island Quality Institute
- Rhode Island Center for Entrepreneurship and Innovation
- Save the Bay
- Slater Technology Fun
- U.S. Green Building Council, Rhode Island Chapter

OSCAR Green Hub

Purpose: To help advance energy and environment discussions, build a shared agenda, and come to consensus around potential pilot projects.

Co-Chair: **Bradley Moran, University of Rhode Island**
Co-Chair: **Len Polizzotto, Draper Labs**
Facilitator: **Betsy Loucks, OSCAR pilot coordinator**
Babette Allina, RISD
Matt Auten, Lt Governor's Office
Bob Azar, Department of City Planning
Kipp Bradford, Rev by Design/Make/Brown University
Chris Bull, Brown University
Charlie Cannon, Rhode Island School of Design
Dwight Coleman, URI GSO
Al Dahlberg, Brown University/Project Get Ready
Lou DiPalma, Raytheon
Tom Dziki, United Natural Foods
Dave Everett, Department of City Planning
David Farmer, former URI Dean of GSO
Peter Fox, RPI
Mark Higgins, URI Dean of the CBA
Anne Jackson, IBM
Jonathan Knowles, RISD
Mark Kravatz, Apeiron-Sustainable Business Group
Larry Kunkel, Governor's Office
Beth Leinberry, US Naval War College
George Loftus, OSHEAN
Angelo Lucia, URI, Engineering
Karina Lutz, People, Power and Light
Paul Matthews, US Naval War College
Michael Mernick, ICF Intl.
Jim Miller, URI-GSO
Paul Nahass, Aspen Aerogels
Ken Payne, Office of Energy Resources
Paul Raducha, formerly Alteris
Janet Raymond, Greater Providence Chamber of Commerce
Rick Rhodes, URI- Associate Dean of CELS
Paul Rich, Deepwater Wind
Timmons Roberts, Brown University
Cathy Roheim, URI

Kathleen Shannon, Brown University-OVPR
Steven Smith, NWC
Christine Smith, Science and Technology Advisory Council
Jonathan Stone, Save the Bay
John Tuccillo, APC and Green Grid
Frank Tweedie, Dean, School of Technology, JWU
Joe Vallino, Marine Biological Laboratory
Ken Wavell, US Naval War College

GKD Data Steering Committee:
Purpose: To identify and recommend regional resources available to enable green initiatives and solutions.

Chris Bull, Brown University
Chris Powell, Brown University
Ginger Gritzo, Brown University
Marcelo Bohrt, Brown University graduate student
Stefanie Lynch, Brown University undergraduate student
Jamie McPike, Brown University graduate student
David Dos Reis, City Department of Planning
Dave Everett, City Department of Planning
Bonnie Nickerson, City Department of Planning
Raanan Miller, Draper Labs
Len Polizzotto, Draper Labs
Cynthia Green, EPA New England
Mark DiPetrillo, National Grid
Lori Spangler, National Grid
Jim Lucht, Providence Plan
Bradley Moran, URI-GSO
Marion Gold, URI Energy Center
Rachel Sholly, URI Energy Center
Josh Wurdman, URI Energy Center Fellow
Kim Lundgren, VHB

Appendix 2: GKD Team Bios

Christopher Bull, Ph.D., Brown University School of Engineering
Chris Bull combines research and teaching the areas of renewable/sustainable energy and engineering design. His research focuses on smart grid issues of grid integrated distributed storage, solar thermal energy for industrial processes, and the role of design in changing people's attitude and behavior concerning energy usage. The grid related works brings together grid operators (ISO-NE), transmission and distribution utilities (National Grid), and colleagues in computer science to develop practical systems for energy storage. The design work is done in collaboration with colleagues in industrial design and architecture at RISD. Dr. Bull is a strong proponent of engaging students in the community by integrated community driven projects with course material so that course outcomes include products that benefit student learning and the larger community.

David Everett, Principal Planner, Providence Department of Planning and Development
Dave Everett is DPD's planner for environmental and sustainability issues and has been actively involved in local institutional plan review, comprehensive and neighborhood planning, harbor management, and flood and hazard mitigation planning over the past several years. He currently serves on a number of local boards and committees including the Providence Urban Agriculture Task Force and the Healthy Corner Store Initiative leadership team. Dave has past experience in Rhode Island, Massachusetts, New York City, and Florida as environmental advocate, small town planning director, regional planner. planning consultant, speechwriter, and researcher. He holds a Master of City Planning from MIT with a concentration in Environmental Design and Development. Dave is also a painter, inspired primarily by the natural world.

Marion S. Gold Ph.D., URI Outreach Center & Sustainable Energy Programs
Marion Gold is director of the Outreach Center at URI's College of the Environment and Life Sciences and Director of URI's Sustainable Energy Programs. In her energy role, she coordinates an interdisciplinary team of researchers, students and outreach specialists to work in collaboration with national, state and local governments, energy providers and the business community to develop locally based solutions to energy issues. In her Outreach Center role, she directs Cooperative Extension programs through which individuals and stakeholders can access research-generated knowledge and obtain assistance to address a broad range of socioeconomic and environmental issues. Dr. Gold is an Adjunct Assistant Professor in the URI Department of Environmental and Natural Resource Economics. She serves on the URI President's Council for Sustainability, the Rhode Island Energy Efficiency and Resource Management Council, as well as the state's Renewable Energy Task Force. She earned a B.S. in natural resource science from the University of Michigan, a M.S. in environmental economics from Michigan State University and a Ph.D. in environmental sciences from the University of Rhode Island.

Betsy Loucks, Ocean State Consortium of Advanced Resources (OSCAR)
Betsy is a public health and environmental professional seeking to address social inequalities and promote environmental sustainability by facilitating the collaboration of public and private organizations. She has worked on a wide array of projects in community development and public health, include HIV/AIDS education for prison-based healthcare providers, urban environmental renewal, and elementary school education in ecology. Betsy is the chief strategist and facilitator

behind GKD efforts. She also shares GKD project and relationship manager role with Kathleen Shannon.

S. Bradley Moran, PhD, University of Rhode Island
S. Bradley Moran, Ph.D., is Professor of Oceanography at the Graduate School of Oceanography and oversees an active research program in ocean carbon dynamics, Arctic oceanography, coastal groundwater transport, and environmental radioactivity. He evaluated URI's greenhouse gas emissions and energy costs, co-chaired the Environment and Alternative Energy Hot Team for the Greater Providence Chamber of Commerce Knowledge Economy Initiative, and is co-chair of the Energy and Envionment Collaborative for OSCAR, for which he proposed the GKD pilot project. At URI, he initiated the development of the Master of Business Administration-Master of Oceanography "Blue MBA" dual degree. Dr. Moran received a bachelor of science degree in Chemistry from Concordia University and a Ph.D. in Oceanography from Dalhousie University.

Kathleen Shannon, Brown University and OSCAR
In her role as Director of Research Initiatives at Brown University, Kathleen advances and coordinates strategies to align Brown's core expertise and strengths with public and private partners to enhance grant opportunities, long-term strategic partnerships, and solutions to grand challenge science questions. In this capacity, Kathleen was one of the founders of OSCAR over three years ago, and she continues her role as a key stakeholder in developing statewide research initiatives and shared infrastructure to address Rhode Island challenges. Kathleen shares GKD project and relationship management roles with Betsy Loucks. She is also the key liaison to other OSCAR teams.

Rachel Sholly, URI, URI Outreach Center & Sustainable Energy Programs
As Assistant Director, Rachel coordinates sustainable energy programs and projects while assisting the director with general management of the URI Outreach Center. Specifically, she manages the URI Energy Fellows program and oversees the Fellows' work on Energy Center projects. Projects of note include assisting Rhode Island's four "EPA Climate Showcase Communities" with development and implementation of comprehensive energy management plans, piloting a diesel emissions reduction program for RIDOT construction projects, and developing a Climate Action Plan for URI. Rachel also coordinates energy education programs such as the Master Energy Program and organizes energy events hosted by the URI Outreach Center.

Rachel holds a Master's of Environmental Science and Management, specializing in Environmental Policy and Management. Her Master's work involved surveying URI commuters to estimate greenhouse gas emissions, assess knowledge and attitudes toward alternative transportation and identify potential transportation policies that could reduce emissions from commuting. Rachel also served on the URI President's Council on Sustainability, which is charged with reducing the university's energy use and greenhouse gas emissions and making campus operations more sustainable.

Appendix 3: GKD Student Team and Contributions

Sustainable Energy Technology (Brown School of Engineering, spring 2011)
Two teams of students from this class are working on building the data base of current activity in the KD. One is looking specifically at the Brown Laboratory for Molecular Medicine (70 Ship Street) to create an in depth picture of the flow of energy through the structure and to identify opportunities to reduce electrical and heat usage through building modifications, policy changes, and behavior change. The other team is collecting energy data from several buildings and integrating it with data from the city (parcel and building), climate data, and use/occupancy data to create a unified resource that is compatible with the EPA's Portfolio Manager program and provides data clients with a rich data source.

Marcelo Bohrt Seeghers, Doctoral Student Department of Sociology, Brown University
In this project, *Politics of Sustainable Economic Development in the Knowledge District*, Marcelo explores the politics of local, sustainable economic development. More specifically, he is interested in uncovering the mechanisms by which the meaning of sustainable development is negotiated by actors from the private and public sectors as well as the production of knowledge around contested definitions. This is an ethnographic project based entirely on participant observation, semi-structured interviews, and informal conversations with members of the Greek the Knowledge District Project in Providence, RI.

Stephanie Lynch, Senior, Brown University
Stephanie is conducting an analysis of green space in the Knowledge District, showing how inclusion of urban forest in the redevelopment can be economically viable and enhance the environmental profile of the area. Using GIS technology as well as forestry programs, she is assessing direct economic benefits of existing urban forest, and comparing the tree density (measured by urban tree canopy coverage) to other areas of Providence, as well as development goals stated by the city. Her final product will be a landscape proposal with visual and written components that takes into account findings, current development, recommendations of city planners, and brownfield remediation potential.

Jamie McPike, Doctoral Student Department of Sociology, Brown University
Jamie is interested in broader questions related to urban and political sociology. Specifically, she is interested in learning more about how urban planning and urban development projects impacts the local community and how various community members and other groups (i.e. city government, businesses, non-profits, universities, neighborhood associations, etc.) participate in the development process. She is participating in the GKD project because she would like to see how plans to improve cities are designed and implemented and how various actors engage in the development process. She is also particularly interested in how these actors negotiate their interests and work collectively to achieve a common vision for the urban settings.

Josh Wurdeman, URI Senior, Resource Economics and Commerce/minor Political Science
Josh has led an effort to identify five target stakeholders using Knowledge District parcel data provided by the Providence Planning Department. Sorting the data by zoning code and then by building square footage, he identified the largest buildings in each sector (commercial, industrial, residential and public), which are also likely to be the largest energy users. Using the parcel addresses, he then identified the specific entities that occupy the buildings. This is the first step in establishing the necessary lines of

communication to obtain commitments of participation and authorization for from the five stakeholders.

Appendix 4: Examples and Models:

Gateway Park at WPI, Worcester, MA

Located at the intersection of routes 190 and 290 in downtown Worcester, Gateway is a master-planned, 12-acre park that envisions five buildings totaling 500,000 square feet of flexible laboratory and office space for research and commercial activities. Gateway has a 660-space parking garage and more than 200 surface parking spots to accommodate the needs of further development.

Gateway Park has been recognized as a national model of environmental stewardship and urban redevelopment. In 2007, the park won the Phoenix Award for its successful redevelopment of an old industrial site and the U.S. Department of Commerce gave Gateway Park the Excellence in Economic Development Award for Urban or Suburban Economic Development. In 2008, the Commonwealth of Massachusetts designated Gateway as the anchor of the state's first Growth District, a new initiative to accelerate job creation in locations primed and ready for development.
http://www.gatewayparkworcester.com/index.html

Eco-Districts, Portland, OR (Portland Sustainability initiative)

EcoDistricts are districts or neighborhoods that commit to ambitious sustainability performance goals to guide investment and community action, and to track the results over time. The EcoDistricts Initiative, with the goal of "accelerating environmental performance at a district scale," was launched in 2009 by the Portland Sustainability Institute (PoSI), in partnership with the City of Portland. The EcoDistricts Initiative is a comprehensive strategy to accelerate sustainable neighborhood development.

EcoDistrict Pilot: The Lloyd Green District Project concept focuses on two primary solutions efforts: establishment of finance and management tools (the "how") to implement joint sustainability projects and programs in the District; and the development of implementation agreements for sustainability projects and programs (the"what") that require district-wide public/private agreement, management and financing, categorized into four components: Energy and Carbon; Water and District Scape; Tourism and Education, and Other.

info@pdxinstitute.org

Vancouver Neighborhood Energy Utility

"Neighbourhood Energy Utility" is described as "leading the way with adaptability, renewable energy and innovation." See link below. The Southeast False Creek Neighbourhood Utility is an environmentally-friendly community energy system that provides space heating and domestic hot water to all new buildings in Southeast False Creek, which includes the Olympic Village.
Neighbourhood Energy Utility (NEU) - Southeast False Creek:

- Environmental Benefits: economies of scale and flexible infrastructure make NEU adaptable to a wide range of renewable "waste energy" options that would otherwise not be available to an individual building heating system. Using system efficiencies and sewage heat recovery to supply approximately 70% of the annual energy demand, the NEU eliminates over 60% of the carbon emissions associated with the heating of buildings. LEED™ buildings connected to the NEU further minimize energy demand and greenhouse gas emissions using high quality building envelope design and hot water radiant heating systems. Furthermore, the NEU utilizes surplus energy generated by solar thermal modules located on the rooftops of three Olympic Village buildings.
- Social Benefits: Through the NEU's use of renewable energy sources and flexibility to adapt to future energy technologies, it is anticipated that NEU customers will enjoy rate stability that outperforms conventional options. Also, the NEU supports the use of radiant hot water heating systems in

buildings that provide customers with a higher level of comfort at a lower energy use, as compared to conventional space heating options. In addition, the NEU eliminates heat production equipment from SEFC buildings, creating more space for green roofs and reducing maintenance for building owners.
- Economic Benefits: The NEU is a self-funded utility that will provide return on investment to the City's tax payers, while at the same time providing competitive rates to NEU customers. The NEU helps building developers meet the energy efficiency and green building requirements for SEFC more cost effectively as compared to the use of distributed stand-alone green energy options, such as geo-exchange.

c o r t e x

"cortex" = Center of Research Technology & Entrepreneurial Exchange

It is self-described as a "non-profit organization that buys and develops real estate to attract biotech start-up companies" in St. Louis. c o r t e x is a collaboration of:

- BJC HealthCare (prominent healthcare org. with ties to two prominent hospitals, including Barnes-Jewish Hospital))
- Missouri Botanical Garden (biodiversity research, world's largest database of plant info)
- Saint Louis University (top research university, virus research, is developing $67 million research building in Cortex district)
- University of Missouri-St Louis (Centers of Excellence in life science R & D, Center for Tropical Ecology, founding sponsor of Center for Emerging Technologies – tech incubator)
- Washington University (top research med school, recipient of many NIH grants, host of Human Genome Project and BioMed 21)

Funding:

- In 2003 the five entities (above) invested $29 million to form Cortex, a legal partnership.
- This leveraged much more from: State of Missouri, City of St Louis, Missouri Development Finance Board, Missouri Dept of Econ Dev, federal EDA, the Coalition of Plant and Life Sciences, the Regional Chamber and Growth Association, Civic Progress, Harris Stowe University, the Regional Business Council, and numerous locally-based corporations and foundations.

http://www.cortexstl.com/

MASCO, Boston

MASCO is a non-profit organization dedicated to enhancing Boston's Longwood Medical and Academic area (LMA) for the benefit of those who live, work, study, or receive care there.

MASCO's 24 members and associate members include several of the nation's top medical institutions, a prominent museum, Harvard Medical School, Dental School and School of Public Health, the six "Colleges of the Fenway," the largest Reform temple in New England, cutting-edge medical research organizations, a leading health maintenance organization, a distinguished private high school, and a major health insurer.

Overall, MASCO members employ more than 43,600 people and generate an average of 1,200 new jobs and 8,800 job openings each year. More than a third of those who work in the LMA are Boston residents.

Mission and Services

"MASCO's mission is to pursue programs that promote a sense of community among its members and to deliver services that are more efficiently developed collaboratively."

MASCO offers a wide range of services including planning and development, parking and

transportation, collaborative purchasing, a call center, and child care.
Open Space: MASCO conceives and coordinates initiatives to preserve and protect open spaces and public areas. **"**Working with members and neighbors, MASCO has restored Evan's Way Park, part of the "Emerald Necklace" of Parks designed by Frederick Law Olmsted; planted trees along Huntington Avenue and preserved trees on Avenue Louis Pasteur; and placed and maintained directional signs, planters, banners and benches throughout the LMA.
Access: MASCO improves access to the LMA through advocacy, area planning and direct service**.** This includes working with city and state agencies to enhance public transportation to the area, redesign major roads, improve signals and establish bicycle routes. MASCO also developed a comprehensive area signage program, and coordinates construction and utility work. A consolidated LMA shuttle reduces traffic, carbon emissions and costs, and the CommuteWorks program helps commuters find alternate transportation to the area."
Collective Planning, Programming and Services: "MASCO designs and delivers programs that are more efficiently provided jointly – improving services and lowering costs to members. Examples include LMA emergency preparedness and disaster planning, security coordination and management of off-site parking facilities and transportation to and from parking areas. MASCO Services, Inc., a taxable subsidiary of MASCO, provides an array of other collaborative services to members. These include a state-of-the-art Call Center and telecommunications services as well as cost-savings joint contracts on travel, elevator and fire alarm maintenance, waste management and recycling, child care and office supplies and services.
The Longwood Medical Area Child Care Center (LMACCC) was established in 1982 to meet the needs of employees of Longwood area institutions. The LMACCC provides full and part-time care for 96 children from ages 2 months to 5 years."
The Colleges of the Fenway was incubated by MASCO and is now a separate consortium of six colleges in the LMA. It expands academic, social and cost-savings opportunities for more than 12,000 students and 700 faculty members.
www.**masco**.com/

Moscone Center, San Francisco

The Moscone Center is the largest convention and exhibition complex in San Francisco

The Moscone Center Recycling Program 1998-2007
The recycling program today targets materials from all areas and sources, ranging from foam core signage and vinyl banners to cardboard, broken wooden pallets and scrap metal. Donations route reusable excess product to local agencies for reuse.
• Nearly 2 million pounds is diverted annually from the city's landfill.
• Nearly 20% of that total is comprised of donations to local area nonprofits.
Winner of Governor's Environmental and Economic Leadership Award, State of California, Special Congressional Recognition, U.S. House of Representatives, Environmental Leadership Award of Excellence, U.S. E.P.A.
The Moscone Center's Composting Program 2007
The newest and most ambitious phase is a food composting program that captures all organic material from food service operations. While a kitchen-based program has been in place for some time, this newest phase includes capturing all food material as well as compostable serveware and utensils from all concession and catering locations throughout Moscone North, South, and West.
• Over 25,000 meals served in look-alike compostable containers instead of plastic
• Over 12 tons of food scraps composted to date
The Moscone Center's Energy Efficiency 2003-2007
Installed and launched in March 2004 by Mayor Gavin Newsom and officials from the San Francisco Public Utilities Commission, the photovoltaic system atop Moscone South's

Esplanade Ballroom and South lobby roof consists of the 675kW rooftop solar system and the extensive exhibit hall lighting system retrofit which converted 5,000 light bulbs from incandescent T12 fluorescent and mercury vapor to compact fluorescent lamps, T8 fluorescents and metal halide fixtures. Together the building's lighting retrofit and the solar system displace 1,933 tons of carbon dioxide annually.

Other Measures at The Moscone Center

• 2007 restroom retrofit installing high efficiency flush valves.
• 2006 installation of variable speed drives on cooling tower fans.

Purchasing and Contract Compliance at The Moscone Center

Policies and procedures place emphasis on sustainability in all purchasing activities.
http://www.moscone.com/community/sustain.html

Appendix 5: US and Canada Green City Index

List of categories, indicators and their weighting in the US and Canada Green City Index

Category	Indicator	Type	Weighting	Description	Normalization technique
CO_2	CO_2 emissions per unit of GDP	Quantitative	33%	Total CO_2 emissions, in metric tons per US$m of GDP.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	CO_2 emissions per person	Quantitative	33%	Total CO_2 emissions, in metric tons per person.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	CO_2 reduction strategy	Qualitative	33%	Assessment of the ambitiousness of greenhouse gas emissions reduction strategy as well as of the rigor of the city's CO_2 reduction target and emissions measurements.	Scored by EIU analysts on a scale of 0 to 10.
Energy	Electricity consumption per unit of GDP	Quantitative	33%	Total electricity consumption, in GJ per US$m of GDP.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	Electricity consumption per person	Quantitative	33%	Total electricity consumption, in GJ per person.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	Clean and efficient energy policies	Qualitative	33%	Measure of a city's commitment to promoting green energies, developing green energy projects and increasing the amount of locally produced energy.	Scored by EIU analysts on a scale of 0 to 10.
Land use	Green spaces	Quantitative	25%	Sum of all public parks, recreation areas, greenways, waterways and other protected areas accessible to the public, as a percentage of total city area.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	Population density	Quantitative	25%	Number of inhabitants per square mile.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	Green land use policies	Qualitative	25%	Assessment of a city's efforts to sustain and improve the quantity and quality (for example, proximity and usability) of green spaces, and its tree planting policy.	Scored by EIU analysts on a scale of 0 to 10.
	Urban sprawl	Qualitative	25%	Assessment of how rigorously a city promotes containment of urban sprawl and reuse of brownfield areas.	Scored by EIU analysts on a scale of 0 to 10.
Buildings	Number of LEED-certified buildings	Quantitative	33%	Number of LEED-certified buildings (silver, gold or platinum) per 100,000 persons.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	Energy efficient building standards	Qualitative	33%	Assessment of whether a city requires energy audits and whether energy consumption regulations require that new buildings satisfy energy efficiency standards.	Scored by EIU analysts on a scale of 0 to 10.
	Energy efficient building incentives	Qualitative	33%	Assessment of a city's incentives for retrofitting buildings to improve energy efficiency and how widely it promotes energy efficiency in homes and offices.	Scored by EIU analysts on a scale of 0 to 10.
Transport	Share of workers travelling by public transit, bicycle, or foot	Quantitative	20%	Percent of workers travelling to work by public transit, bicycle, or foot.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	Public transport supply	Quantitative	20%	Evaluation of availability of public transport, including length of public transport network.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	Average commute time from residence to work	Quantitative	20%	Average commute time from residence to work, in minutes.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	Green transport promotion	Qualitative	20%	Assessment of how extensively the city promotes public transport and offers incentives for less carbon-intensive travel.	Scored by EIU analysts on a scale of 0 to 10.
	Congestion reduction policies	Qualitative	20%	Assessment of a city's efforts to reduce congestion.	Scored by EIU analysts on a scale of 0 to 10.
Water	Water consumption per capita	Quantitative	25%	Total water consumption, in gallons per person per day.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	Water system leakages	Quantitative	25%	Share of non-revenue public water leakages.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	Water quality policy	Qualitative	25%	Assessment of the level and quality of a city's main water sources.	Scored by EIU analysts on a scale of 0 to 10.
	Stormwater management policy	Qualitative	25%	Indication of whether a city has a stormwater management plan.	Scored by EIU analysts on a scale of 0 to 10.
Waste	Percent of municipal solid waste recycled	Quantitative	50%	Percentage of municipal solid waste recycled.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	Waste reduction policies	Qualitative	50%	Assessment of measures to reduce waste and make waste disposal more sustainable.	Scored by EIU analysts on a scale of 0 to 10.
Air	Nitrogen oxides emissions	Quantitative	25%	NO_X emissions per annum, in lb per person.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	Sulphur dioxide emissions	Quantitative	25%	SO_2 emissions per annum, in lb per person.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	PM_{10} emissions	Quantitative	25%	PM_{10} emissions per annum, in lb per person.	Scored on a scale of 0 to 10 based on min/max of data for all cities.
	Clean air policy	Qualitative	25%	Measure of a city's efforts to reduce air pollution.	Scored by EIU analysts on a scale of 0 to 10.
Environmental governance	Green action plan	Qualitative	33%	Measure of the rigor of a city's green action plan.	Scored by EIU analysts on a scale of 0 to 10.
	Green management	Qualitative	33%	Measure of the extensiveness of environmental management undertaken by the city.	Scored by EIU analysts on a scale of 0 to 10.
	Public participation in green policy	Qualitative	33%	Measure of the city's efforts to involve the public in monitoring its environmental performance.	Scored by EIU analysts on a scale of 0 to 10.

Quantitative indicators

Category	Indicator	Average	Boston	Year	Basis	Source	Comments
CO_2	CO_2 emissions per unit of GDP (metric tons/US$m)	296.4	**198.6**	2002	MSA	Purdue University – The Vulcan Project; US Bureau of Economic Analysis	Using MSA GDP
	CO_2 emissions per person (metric tons)	14.5	**12.2**	2002	MSA	Purdue University – The Vulcan Project; US Census Bureau	Using MSA population
Energy	Electricity consumption per unit of US$ GDP (TJ/US$m)	0.33	**0.10**	2009	City	City of Boston; US Census Bureau	Using MSA GDP
	Electricity consumption per person (GJ)	52.2	**40.6**	2009	City	City of Boston; US Census Bureau	Using MSA population
Land use	Green spaces as % of total area (%)	11.9	**16.3**	2008	City	Trust for Public Land; US Census Bureau	Using city population
	Population density (persons/miles^2)	8,106.8	**13,441.0**	2009	City	US Census Bureau	Using area of city in 2000
Buildings	Number of LEED certified buildings (silver, gold or platinum) (buildings/100,000 persons)	6.4	**6.5**	2010	City	US Green Building Council; US Census Bureau	Using city population
Transport	Share of workers traveling by public transport, bicycle, or foot (%)	13.0	**18.3**	2009	MSA	US Census Bureau American Community Survey	
	Length of public transport (miles/miles^2)	1.1	**0.3**	2009	Metro-area	National Transit Database	Using service area square miles
	Annual vehicle revenue miles (miles/person)	24.4	**20.8**	2009	Metro-area	National Transit Database	Using service area population
	Maximum public transport vehicles available per square mile (vehicles/miles^2)	9.0	**0.8**	2009	Metro-area	National Transit Database	Using service area square miles
	Average commute time from residence to work (minutes)	28.9	**28.4**	2009	MSA	US Census Bureau American Community Survey	
Waste	Recycled municipal waste (%)	25.8	**20.0**	2009	City	City of Boston Department of Public Works	
Water	Total water consumption per person per day (gallons)	155.1	**73.5**	2005	MSA	USGS	Using USGS publicly supplied population
	Water leakages in water distribution system (%)	12.8	**9.0**	2009	City	Mayor's Office of Sustainability	
Air	Nitrogen oxides emissions per annum (pounds/person)	66	**50**	2005	County	EPA; US Census Bureau	Using county population
	Particulate matter (PM10) emissions per annum (pounds/person)	25	**16**	2005	County	EPA; US Census Bureau	Using county population
	Sulfur dioxide emissions per annum (pounds/person)	22	**14**	2005	County	EPA; US Census Bureau	Using county population

Appendix 6: Sustainability Tools and Targets for the Urban Thematic Strategy

From: http://status-tool.iclei.org/content.php/demo

1. Governance
   - 1.1. Capacity building
     - 1.1.1. Share of all Local Authority (municipal) employees to complete sustainability training
     - 1.1.2. Existence of a regular program of awareness raising in schools on sustainable development issues
     - 1.1.3. Existence of a cross departmental working group on sustainable development
   - 1.2. Participation
     - 1.2.1. Percentage of statutory planning processes involving stakeholders before a draft plan is developed.
     - 1.2.2. Existence of a strategy and related activities to involve difficult to reach groups in local decision making
   - 1.3. Transparency
     - 1.3.1. Share of publicly available municipal documents published on Internet
     - 1.3.2. Share of population regularly informed on Local Government Environmental activities
2. Sustainable Local Management
   - 2.1. Integration of environment in other plans
     - 2.1.1. Adoption of an Environmental Management Plan
     - 2.1.2. Percentage of all statutory plans subject to a environmental assessment
   - 2.2. Adoption of environmental management systems
     - 2.2.1. Number of Local Authority departments with certified Environmental Management Systems (IS014001/EMAS or other national system)
     - 2.2.2. Number of private companies located in the municipality with certified Environmental Management Systems (ISO14001/EMAS or other national system)
3. Natural Environment
   - 3.1. Water quality
     - 3.1.1. Proportion of rivers classified at least as of 'good' status (according to EU classification)
     - 3.1.2. Compliance with EU standards on wastewater treatment
     - 3.1.3. Proportion of population connected to a wastewater treatment plant
   - 3.2. Biodiversity
     - 3.2.1. Local trend in EU threatened/protected species
     - 3.2.2. Trend in locally relevant species and/or habitats (birds/ trees/other species)
   - 3.3. Air quality
     - 3.3.1. Number of days per year EC limit value was exceeded for PM10 (daily mean)
     - 3.3.2. Number of days per year EC target value/long-term objective was exceeded for Ozone (8h mean)
     - 3.3.3. Annual mean concentration of NO2
     - 3.3.4. Annual mean concentration of PM10
4. Sustainable Consumption
   - 4.1. Waste
     - 4.1.1. Per capita amount of waste
     - 4.1.2. Proportion of total/biodegradable waste production sent to landfill
     - 4.1.3. Share of Municipal waste collected separately
   - 4.2. Sustainable Procurement
     - 4.2.1. Percentage of the food purchased by the local authority which is EC certified as organic production
   - 4.3. Water Consumption
     - 4.3.1. Proportion of urban water supplies subject to water metering
     - 4.3.2. Domestic consumption
     - 4.3.3. Water loss in pipelines
5. Planning and Design
   - 5.1. Re-use of land
     - 5.1.1. Proportion of new developments on brownfield sites
   - 5.2. Accessibility to basic public services
     - 5.2.1. Population living within 300 meters to basic public services

- 5.3. Sustainable Urban Design
  - 5.3.1. Population density for new developments
- 5.4. Sustainable Urban Construction
  - 5.4.1. New buildings and renovations assessed in terms of environmental sustainability
  - 5.4.2. Energy consumption of municipal buildings per square meter.

6. Sustainable Transport
   - 6.1. Transport infrastructure
     - 6.1.1. Length of dedicated cycle lanes
     - 6.1.2. Share of population living within 300 m from an hourly (or more frequent) public transport service
   - 6.2. Transport Use
     - 6.2.1. Proportion of all journeys under 5 km by private car use
   - 6.3. Low Emission Vehicles
     - 6.3.1. Proportion of public transportation classed as low emission
7. Health
   - 7.1. Decent Housing
     - 7.1.1. Proportion of dwellings classed as being of adequate or decent standard
   - 7.2. Access to Green Areas
     - 7.2.1. Proportion of population able to access public open areas within 300 m
   - 7.3. Quietness
     - 7.3.1. Share of population exposed to noise values of L (den) above 55 dB (A)
     - 7.3.2. Share of population exposed to noise values of L(night) above 45 dB(A)
   - 7.4. Traffic Safety
     - 7.4.1. Number of pedestrian and cyclist fatalities as a result of road traffic accidents/year/10000 inhabitants
     - 7.4.2. Number of car driver or passenger fatalities/year/10000 cars
8. Vibrant and Sustainable Local Economy
   - 8.1. Support and develop local employment
     - 8.1.1. Percentage of early school leavers within the municipality
     - 8.1.2. The percentage of the working-age population employed in the locality.
     - 8.1.3. Proportion of children under the mandatory school age for whom childcare is provided by the local authority
     - 8.1.4. Existence of a social and community enterprise strategy
     - 8.1.5. Percentage of new business start-ups in the locality each year
     - 8.1.6. Existence of regular forums between local government and local business representatives on issues of local concern.
   - 8.2. Support markets for high quality local and regional produce
     - 8.2.1. Existence of a farmer's market coordinator in a local authority
   - 8.3. Promote sustainable local tourism
     - 8.3.1. Existence of a Sustainable Tourism strategy for the locality
9. Social Equity and Justice
   - 9.1. Poverty
     - 9.1.1. Local Unemployment rate in %
     - 9.1.2. Share of households reliant upon social security
     - 9.1.3. Ratio of first to fifth quintile earning
   - 9.2. Social Inclusion and Gender Equality
     - 9.2.1. Share of Women in local leading positions
     - 9.2.2. Female unemployment compared to male unemployment
     - 9.2.3. Number of homeless people
     - 9.2.4. Literacy rate (%) in population aged 15+
   - 9.3. Safety/Security
     - 9.3.1. Total number of recorded crimes per 1000 population per year
     - 9.3.2. Percentage of residents who feel safe whilst outside during the day / after dark
     - 9.3.3. Children's journeys to and from school (ECI)
10. Global Responsibility
    - 10.1. Greenhouse gas emissions
      - 10.1.1. Total CO_2 equivalent emissions per capita
      - 10.1.2. Total electricity consumption per capita

10.2. Renewable Energy
- 10.2.1. Share of energy consumption produced by renewable sources
- 10.2.2. Capacity installed for renewable energy production

Appendix 7: Greener City: Assessing Benefits Of Urban Forest In The Knowledge District

Appendix 8: Green the Knowledge District (GKD): Catalyzing environmentally sustainable and economically powerful development

Appendix 9: 70 Ship Street: Laboratories for Molecular Medicine: Energy and Fume Hood Use

Appendix 10: Unpacking the Growth Machine: Exploring Urban Development Politics in Providence through the Greening of the Knowledge District Project