SCC Comparative Systems Approaches for Community Planning and Development in the Olympic Region of NYS, Schenectady, and Beyond

Project Summary

Overview

A project executed through a partnership between Clarkson University, the US Green Building Council (USGBC), and two multi-party community groups: 1) The Olympic Region of NYS and 2) The City of Schenectady. This is a study to understand numerous community goals using smart and connected technologies, using LEED for Communities/Cities (LFC) as a leveling framework, to evaluate the impact of technology on communities by answering the following questions, using public information available from the City of New York as a comparator:

- What methods for collecting, organizing, sharing and using non-homogeneous data relevant to regional stakeholders and the community support their ability to assimilate disparate visions, plans, goals and projects?
- Do the ways in which LFC, Smart Cities, or other approaches, interconnect technology with community engagement, community knowledge, or community action lead to improved planning and engagement processes to meet community and regional goals?

Intellectual Merit

The underlying scholarly and scientific merit of this project has three significant facets. First, an important challenge for data collection is determining which data is useful (smart) and how to integrate it (connected). Our analysis will address this considerable multi-disciplinary systems-thinking problem for community development. Second, the implementation of smart city programs requires a single implementation system that is flexible and adaptive enough to be used with disparate kinds of communities and contexts. Our comparative approach (Olympic Region and Schenectady) provides the opportunity to test these important aspects of smart and connected systems. Finally, the use of the new USGBC LEED for Cities/Communities Program has been developed from a rigorous review of many smart cities programs. However, there has been a lack of a systematic science-based approach to these programs, both in implementation, and secondarily in assessment. This research program will address each aspect (execution and evaluation) through a thorough and methodical analytical lens.

Broader impacts

The broader impacts of this study are numerous. Communities across the country are struggling with how to manage opportunities to leverage data to drive outcomes for the benefit of their citizens and the betterment of their long-term vitality. The envisioned project will include the full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM). This study will provide an analysis of how sustainability frameworks can aid communities in engaging smart and connected technologies to answer social challenges.

SCC Comparative Systems Approaches for Community Planning and Development in the Olympic Region of NYS, Schenectady, and Beyond Project Description

Research Justification

What is Smart?

The concept of a Smart City has existed for over 20 years.[1] The number of smart city projects continue to grow as technology costs drop, the implementation of Internet of Things (IOT) solutions become easier, and urbanization increases. There are membership organizations such as the Smart Cities Council[2] and research partnerships like MetroLab[3] that support initiatives and continue to advance solutions. The concept has received substantial federal support, such as the launch of the Smart Cities Initiative[4] in 2015.

While the number of initiatives has continued to grow, the idea of what constitutes 'smart' has continued to evolve. The Smart City Wheel (figure 1) exemplifies the kind of comprehensive approach that many communities are adopting. The idea has broadened to not only include cities, but smaller communities as well. For the purposes of this proposal we define a smart community along three primary dimensions:

- Technological – IoT systems, data integration and management, security, and analytics
  (this could easily be the dimensions of the Smart City Council Readiness wheel)
- Social – Livable, Workable, Sustainable (Smart Cities Council)
- Operational – Increased efficiencies, lower costs, higher engagement

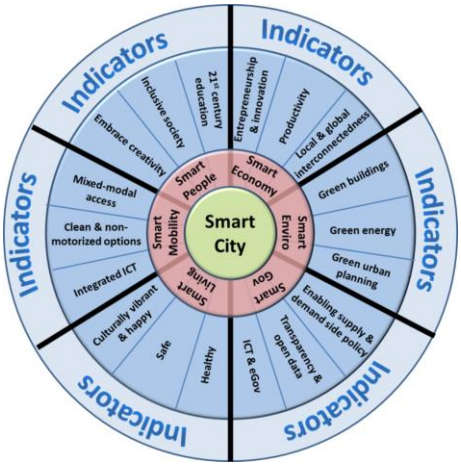

Figure 1 - Smart City Wheel[1]

There are many noteworthy smart city projects. The City of Chicago's Array of Things[5] project uses a sensor network to collect data on environmental quality and traffic. The largest municipal IoT lighting platform[6] in the world is being constructed in San Diego. Several recent initiatives have attempted projects on a larger scale. In 2016, Columbus Ohio won a $40 million smart city grant[7] from the Department of Energy. Google's sibling company Alphabet Labs recently announced a $50 million partnership with the city of Toronto to create an 800-acre smart waterfront district[8].

The proliferation in the number of smart city projects as well as the increasing scale of smart projects underscores the need for a framework to evaluate the success of projects and to meet the stated goals of the communities within which they operate. After all, a smart community is more than a couple of municipal technology projects. A smart community is one that leverages technology to respond quickly,

is resilient to change, and continually engages its constituents while adhering to and informing strategic policies that lead to a sustainable, livable, and workable community.

Sustainability Frameworks

This grant proposal will leverage the progress from frameworks, such as that from the National Institute of Standards and Technology (NIST)[9], the Networking and Information Technology Research and Development Program (NITRD), the Smart Cities Council, and the United States Green Building Council's (USGBC) LEED for Cities/Communities (LFC) program.

While there is not a widely accepted framework for evaluating smart community initiatives across a variety of municipal scales, the LFC program provides a common platform from which to start. As will be discussed below, this proposal will use LEED metrics as a framework and a trial means of evaluation of the success of smart city initiatives to achieve stated community goals.

LEED for Cities/Communities

LEED for Communities/LEED for Cities certification program (LEED for Comm. or LFC)[10] established by the U.S. Green Building Council (USGBC) interconnects city/community planning, development, operations and management with interactive feedback loops, with a primary emphasis on improving sustainability and quality of life of citizens around the world. LEED for Comm. provides cities a framework through the Arc performance platform[11], which measures and manages the city's water consumption, energy use, human experience, waste and transportation.

By looking at what LEED has done for buildings and neighborhood developments, USGBC utilized its experience with market transformation on sustainability to support cities and communities. LFC was developed with a vision that buildings and communities will regenerate and sustain the health and vitality of all life within a generation. And in order to realize this goal, the next generation of city building and management must focus on smart cities and resilient communities. Our communities must champion equitable, safe and healthy development policies, implement interoperable platforms and advanced technologies that improve the performance of their communities, in order to incorporate concepts like wellness and human experience into planning, development and management. Communities of all scales face many challenges in this day and age – citizens are demanding more transparency and information about the places where they live, work, learn and play.

LEED for Communities addresses these concerns on a global scale. Local governments, therefore, are becoming laboratories of innovation and are committing to novel ways for social problem solving. Leaders, especially in growing cities, have an enormous opportunity to initiate a dynamic dialogue with citizens and earn their trust in the process. LFC is an ideal framework to ensure high-performing communities at any scale. This is because LFC provides citizens and leadership with a detailed view of community-wide performance, accelerating the great leadership now being shown by communities and demonstrate value.

LEED for Communities/Cities innovatively works with cities and communities, of any size, based on a concise set of 14 performance metrics focusing on Energy, Water, Waste, Transportation, Education, Health, Safety, Prosperity and Equitability, and offers a very flexible mechanism for cities to track 250+ parameters for continuously measuring performance on numerous city specific priorities. LFC:

- provides cities and communities with a LEED based framework for measuring, managing and improving the performance of their economies, environment and quality of life,
- offers a robust platform for integrating plans, strategies and data interconnecting diverse aspects of community operations,
- makes reporting easier on various community needs,
- scores the performance, which offers a unique and easy way for communities and cities across the world to compare, benchmark and compete,
- enables a sharing and learning platform for cities, and
- recognizes and rewards leadership of cities and communities.

Clarkson Experience

Faculty at Clarkson University have been involved in research with relevance across a variety of contexts. Clarkson's Smart Housing Project focuses on extensive sensor implementation across two residential apartment buildings, with feedback screens, messaging components, and an educational and motivational program to reduce energy and resource use.[12] The University's Institute for a Sustainable Environment has focused extensively on the integration of data across multiple contexts for assessment and measurement purposes.[13] Known as CLICS (Cyber-Learning Infrastructure for Campus Sustainability), this effort addresses the challenges of normalizing data across contexts, and also across measurement, systems. The University also participates in the STARS (sustainability tracking and rating system), which, like LEED for Comm., requires a wealth of information from disparate sources to assess sustainability in a very broad context, which then provides a basis for goal setting and improvement. While a university campus is not a community per se, the challenges inherent in these analytical problems and research agenda are inherently similar and generalizable, providing expertise to this proposed research project's main research aims.

New York City Experience

Data availability was patchy for most the of energy system of New York City in 2004-05 timeframe, when Brookhaven National Laboratory embarked upon developing a comprehensive energy modeling for long-term energy planning for U.S. Environmental Energy Agency.[14] However, PlaNYC 2030 effort (now OneNYC) led by the Mayor's Office of Long-term Planning and Sustainability established a robust framework for detailed energy and emissions inventory in 2006-07.[15] Now, New York is considered unique in that Open Data is the law. New York City's vision is of Open Data for All — the idea that Open Data belongs to New Yorkers — naturally followed from the fact that elected officials, via the constituents they represent, were so committed to this idea that they added it to the administrative code.[16]

Overlap across LEED for Communities/Cities and the Smart Cities Framework

As discussed above, LEED for Cities/Communities provides a common framework for this study based on its ability to track numerous metrics and take in data from various sources[17]. To this end, numerous communities, including the City of Schenectady are attempting to track numerous metrics to measure their performance in a Smart Cities Dashboard[18]. These dashboards help to display information pertaining to the operations of a community municipal government using defined metrics. To that end, it is noted that "[f]ocus areas like energy, water, waste and public safety have common metrics in both systems and are a great starting point to understand how these two models can benefit from the other."[19] These common areas provide for an area of overlap that enable a study to evaluate how smart and connected approaches are influencing community planning and the drive to meet community aspirations generally.

Filling the Gap

The framework developed in this proposal is aimed to provide, in the simplest sense, a gap analysis. It is designed to uncover the fundamental differences between a community's current state and ideal end-state with respect to sustainability and identify opportunities and challenges in satisfying this end-state. These opportunities and challenges will be organized through the LEED for Comm. framework and understood and evaluated through a smart-community overlay to uncover the data, technology, and IoT strategies to drive city aspirations. Integrative research is at the heart of this investigation and using LFC is fundamental to that approach. This research will address both the technological and social dimensions of smart and connected communities as outlined in the program solicitation. Fundamentally, this effort aims to address the questions: "how can "smart" drive sustainability aspirations to develop better plans for communities?

Integrative Research

This proposal outlines a project that includes a partnership between Clarkson University (lead proposer), the US Green Building Council (USGBC), and two multi-party community groups: 1) The Olympic

Region of NYS (Village of Lake Placid, Town of North Elba, the New York State (NYS) Olympic Regional Development Authority (ORDA), Lake Placid Central School District), and 2) The City of Schenectady, in order to study and understand numerous community goals using smart and connected technologies.

Using LEED for Cities/Communities (LFC) as a leveling framework, the team proposes to evaluate the impact of technology on communities by answering the following questions in conjunction with the Olympic Region of New York State and the City of Schenectady, NY, using public information available from the City of New York as a comparator:

- What methods for collecting, organizing, sharing and using non-homogeneous data relevant to regional stakeholders and the community support their ability to assimilate disparate visions, plans, goals and projects?
- Do the ways in which LFC, Smart Cities, or other approaches, interconnect technology with community engagement, community knowledge, or community action lead to improved planning and engagement processes to meet community and regional goals?

Integrative Social Research Challenges

The communities in this study represent two different community types that mirror others from across the nation. Both communities want to realize economic growth while creating upward social mobility, equity and uplift within local, regional and natural resource constraints. Primary Integrative Social Research Challenge: How does technology support these goals? Specific to each community the following sub-questions are key:

- Olympic Region: How can the region develop a plan to grow economically as well as socially, without degrading the ecologic treasure that is the high peaks region of the Adirondack Park?
- Schenectady: How can technology be leveraged to promote social, economic and cultural growth?

Integrative Technological Research Challenges

The emerging field of Data Science provides a new set of tools to leverage disparate data sets to better inform decision making at the community scale. However, the decentralized nature of data acquisition and the volume of data collected pose technological challenges. Furthermore, it is not obvious how community leaders or those that assist them go about measuring and analyzing for social equity or other goals that occur in community context. It is even more complicated in that communities are open systems affected by technology deployed both locally but also outside of their context. Primary Integrative Technological Challenge: How best can data science be employed to provide information, knowledge and wisdom at the community scale? To that end, how does LFC as a framework and platform support a community's ability to use data in order to assimilate disparate visions, plans, goals and projects?

Research Methods

Figure 2 (next page) provides an overview of the research methodology proposed under this proposal. The numbered items define the five specific tasks that comprise the research work described below.

Task 1 - Understand the Current State/Existing Status

The first task of the research effort will be to work with both of the study communities (the Olympic Region of New York State and the City of Schenectady, see more below in the Community Engagement section) to ascertain their current state related to smart and connected communities. This will necessarily require the research team to execute several sub-tasks.

First the team will gather community-scale data and information from the community on current planning efforts. This will require an in depth evaluation of community comprehensive planning documents, allied sector plans and infrastructure development plans. The research team will search available public sites and request information that helps to better understand the community planning context. In this effort the team will outline current policies, documents and plans and categorize per community organization (as available).

In conjunction with this step, the team will begin the process of collecting and organizing data that can be derived by existing sources within the community. Following the Data Management Plan[20], the team will work to gain access to the applicable data sources that the community is using and bring them into a common platform (the Arc platform). This effort is significant in and of itself, as at the core this requires the ability to collect and manage disparate non-homogeneous data, and thus will be ongoing throughout all future tasks of the project.

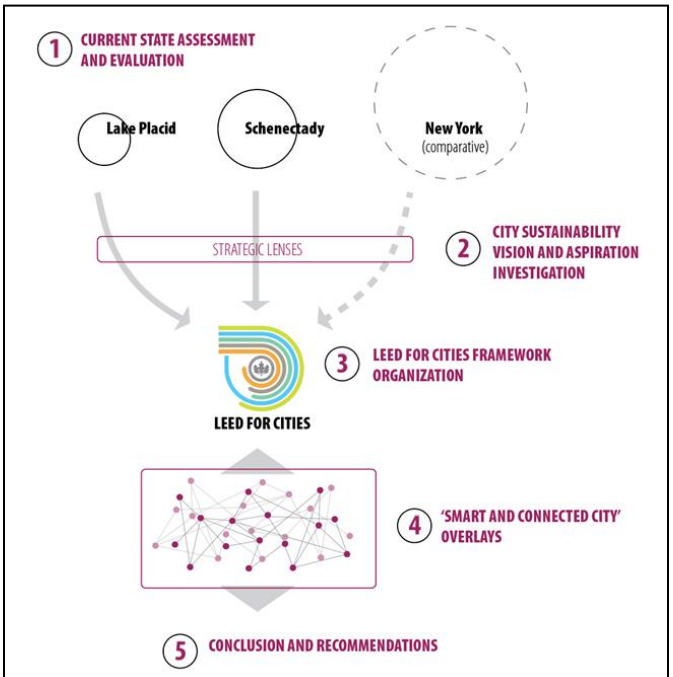

Figure 2 – Research Methodology Diagram

Next the research team will interview community officials and key stakeholders to gather information on current policies and procedures, meeting with both publicly elected officials (e.g. the Mayor, councilmen and women, etc.) as well as community staff, the staff of allied non-profit organizations, and potential corporate partners. These interviews will enable the research team to better understand the plans/strategies that have been developed and their current state of use/disuse in community efforts moving forward. In parallel, the team will work to understand organizational structures and governance models for sustainability-related activities. As a part of this effort, the team will seek to understand decision making frameworks or mechanisms as well as current prioritization mechanisms for community-scale investments. These will be mapped and diagramed so as to enable easy reference for both the research team as well as the community leaders, if not already clear.

While the above is ongoing, and following from the discussions had with the community leadership, the research team will chart a set of externalities (economic, environmental and social) for the community. By understanding these externalities, the team will be able to account for those items that are having effect on the studied communities that arise from influences beyond the direct influence of the community itself. In that regard, the team will then also document commonalities and differences between the two study communities in regards to the externalities that may exist.

Following these efforts, the team will begin to compare data and information quality of the communities in question. This will remain an ongoing task throughout the project, however, this initial review will seek to create a baseline understanding of the current data quality and what may need to be corrected, altered, or abandoned as a data source using acknowledged methods of data science. Throughout the project, there will be periodic data quality evaluations that occur to validate that the sources of data have not degraded in a manner inconsistent with data science methods.

It is likely that the team will discover, at this point or in the previous steps, a number of additional data sources (for instance those that are not currently recognized/leveraged) that require direct data collection on the part of the research team. As part of this effort, given the large amount of available public information, the team will use the outcomes of the City of New York efforts as a comparator to discover other data sources and or the need for data to be gathered. Therefore, the team will begin, during these sub-tasks, to execute direct data collection. Additionally, with the above data evaluation, the team will also analyze the extent to which internet of things (IoT) systems are currently being used by government, institutions, businesses, and citizens.

The outcome of this task will be a narrative that describes the initial status of data within the studied communities. This narrative will include a narrative on the level of data, mapping and information in each community to build a current-state of physical and operational and create the mechanisms to establish business as usual project calculations for a variety of data sets: ex: greenhouse gas emissions, mobility data (modal splits), and socio-economic bin data.

Task 2 - Identify Common/Diverging Aspirations

Building up on Task 1, this task will distinctly outline gaps and additional efforts needed to comprehensively address data, social and technological research challenges outlined above. Task 2 will address the following:

- In what ways can a systems approach (policy systems, engineering and systems thinking) facilitate the Olympic region and the City of Schenectady in connecting infrastructure availability with the community needs, to improve sustainability and quality of life for people, through LEED for Comm. program (LFC)?
- Involve regional stakeholders and the community in assimilating disparate vision, plans, goals and projects into a unified implementation plan for continuously monitoring data in achieving optimal progress for the region, including Lake Placid Village, Town of North Alba, Essex County, ORDA, ROOST, and others as well as the City of Schenectady and its partners.
- Evaluate the readiness and data availability in the Lake Placid region for improving performance, including energy, water, waste, transportation, education, health, safety, prosperity and equitability.
- Assess ways in which LFC interconnects technology with community engagement, community knowledge, or community action for improving sustainability and quality of life (pre / post surveys; other assessment tools)?
    - Examine the results of past Smart City initiatives within this framework.
    - Create a link of the data that currently exist to drive the vision of the community through these strategic lenses.
- Compare these outcomes in each community to identify consistencies and differences. Utilize NYC as an anecdotal layer to highlight or challenge these consistencies and differences.

This task will result in a qualitative understanding of the vision, aspirations and goals of the community and research of current state layering of the quantifiable data and the aspirations of the community, including clear demarcation of data availability and gaps and establish exact needs for additional data required.

Task 3 - Translate the Current Efforts to LEED for Communities/Cities - Level with a Consistent Framework

A significant challenge is to develop consistent frameworks for sustainability metrics and implementation. This has important implications both for municipalities adopting sustainability frameworks, and for researchers and stakeholders to improve, assess, and develop frameworks in a variety of contexts. The research effort will focus on several efforts to improve the state of knowledge in this area, and to help assess and develop an "optimal" approach for the LEED for Comm. framework.

LEED for Comm. was developed by the US Green Building Council (USGBC) in part by implementing a comprehensive review of many other community approaches to sustainability development (USGBC evaluated numerous rating/indicator systems and guidelines as a precursor to developing LEED for Cities/Communities[21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45]) and as a result, there is already a significant knowledge base present. Despite this, there is additional work needed to assess the approach empirically, to develop many of the conceptual ideas into fully conceived, and operationalize programmatic elements.

In this task, the team will build sustainability rating and tracking tools for each community utilizing LFC. This will include the identification of gaps in knowledge that are needed to accurately assess points in communities. The research program will help to organize credits against the strategic lenses identified in Task 2 to create a direct relationship between the LEED for Comm. framework and the community

visions. The team will measure community metrics and generate a performance score in the Arc platform as a pathway to LEED for Comm. certification under the pilot rating system (the team could consider formal certification to build upon this effort, but it is not intended as a core outcome of this effort).

In terms of operationalizing this approach, the research team will establish policies and initiatives within the LFC framework that each community adopts to improve the credits. This will include the establishment of an ideal end-state definition of the framework. Once this is done, this will allow the researchers to assess the gap between the current versus the idealized end-state. It may be that these gaps will ultimately be addressed by efforts the communities are implementing, or alternately, it may be that this "gap analysis" will inform the next stage of the LFC framework. A specific outcome of this analytical process will be a resulting "Arc Performance Score," the identification of gaps within the framework and description of interdependencies and linkages of LEED Communities and the Community's Sustainability Vision.

Task 4 - Utilize LEED for Communities as Sustainability Framework in which to activate through Smart Strategy - Establish "Smart-Community" Overlays and Ideal End-State

In many of the "smart" technology initiatives planned for large cities, the primary technology component aspect is a large, real-time, networked data collection system. An underlying assumption in implementing such projects is that the data collected can be used to actually improve some aspect of community operations, connecting to quality of life. However, such technologies don't necessarily scale to smaller settings. The locations considered under this grant represent a very different scale of population density. The problems to be addressed emerge on very different time scales. As such, the "smart" solutions will almost certainly be very different.

The intended sustainability programs provide a mechanism for significant data collection, with a desired outcome improving quality-of-life, economic benefit, and other priorities established by the strategic vision of each community. Critical needs are the methods by which the communities connect "collected data" to "desired outcome." For these settings, the smart technology element that may provide the most relevant gains, both in short and long term, are methodologies that support improved operations, management, and strategic planning. Data Analytics - effective use of collected data for improved decision making - provide the tools that allow a community to *use*, rather than simply *collect* the framework data.

The solutions required by these studied communities (with regards to an analytic toolkit) are likely to be similar to other communities. The data dashboards, metrics, mechanisms of analysis, when applied against the common framework, may actually admit scalable approaches that could be more broadly implement as other communities adopt similar frameworks. The goal with task four is that the project develop such an analytic toolkit that is not simply a one-off tailored solution to the community at hand. Rather, it would produce an adaptable analytic approach that allows other communities to connect their data with their decision making needs.

To that end, in this task we expect to accomplish the following:

- Categorize smart and connected community strategies (by category, credit or as needed to communicate a link to smart and connected opportunities for the community).
- Begin to map and prioritize strategies that would advance the community sustainability vision and aspirations through gap analysis. Uncover which strategies link to the strategic aspirations and vision of the community.
- Understand the levels of technological infrastructure necessary to support a variety of smart and connected scenarios.
- Identify the resource pathways and intensity of investment for smart and connected community investments.
- Layer in qualitative and value-add propositions to other quantifiable benefits of smart and connected community strategies.
- Utilize LEED for Comm. as an organizational tool to identify current smart-city physical and operational strategies to advance city aspirations

- Build visualization tools of the intersections between LEED for Comm. and smart and connected community strategies.

The resulting outcome from the accomplishment of the above sub-tasks will be a LFC and smart and connected communities relationship matrix with categorized and prioritized strategies depicted and further explained in an accompanying report/description of the matrix. Additionally, we will provide an initial set of visualization tools that will enable to iteration and investigation of various scenarios of investment to move the studied community's sustainability visions.

Task 5 - Understand how "Smart-Community" Overlays Drive City/Community Aspirations

In early tasks, the effort identifies current state. In this task, the effort will focus on ongoing and future operations, tying any smart and connected technologies and current policy to the future direction of the community. The team will forecast the current state through future external forces, such as climate change and technology advancements. This is not unlike a 'business as usual' projection, which will encompass the data to be captured and understood within the LEED for Comm. framework, but also the operational, policy and critical to this proposal, the smart and connected city opportunities available within the constraints of the community.

The team will identify city sustainability aspirations and understand the pathway to achieving these aspirations through innovative smart city strategies. The intent is to identify these opportunities, to understand their impacts and to link the value of these technologies directly back to people, place and prosperity. Cities and communities vary dramatically in their operations and resources. The project aims to not only place the term 'smart and connected' in the context of advancing real city challenges of Schenectady and the Olympic Region, but to identify the commonalities and differences between these two cities and draw conclusions as to how demographics, size, aspirations can alter the right smart and connected strategy.

We propose the following efforts within this task of work:

- Understand through inventories and explorations how "smart and connected" strategies can drive community aspirations.
- Establish conclusions on the data investments (capture and analytics) needed to drive community-scale aspirations for various community scales
- Understand how smart strategies can inform process and engagement with community communities
- Recommend LEED for Comm. investment to advance community sustainability performance score.
- Create a direct set of community-specific outcomes to inform the future dialogue of the community when investing in strategies to meet their community sustainability vision with smart and connected strategies.
- Build recommendations for short, medium and long-term smart and connected investments for community.

The outcomes of this task will be numerous. First, the research team will produce high quality presentation materials that share the process the team underwent as well as the resulting outcomes for both the community and the research effort. More significantly, the team will produce a refined visualization tool that enables iterative use as communities engage in their ongoing efforts to improve along their various lines of effort. This same tool will also be refined to enable further investigations in to the results and the data from which they are drawing to enable better information, knowledge and wisdom to develop. Finally the team will produce a conclusions narrative (report) with study outcomes and recommendations for further study, development and engagement with these community partners as well as others nationally.

Community Engagement

Community Descriptions

Olympic Region of New York State

The Olympic region of NYS is located in the heart of the Adirondack Park, a state constitutionally protected preserve that is sensitive to ecological concerns about development. The region seeks to obtain increased events and activities to spur economic growth and increase social mobility among its citizens.

Village of Lake Placid/Town of North Elba:

The Village of Lake Placid was incorporated in 1900 and is located in the Town of North Elba in the heart of the Adirondack Mountains/Adirondack Park in the northwestern corner of Essex County, New York. The Village is internationally known having proudly hosted the Winter Olympics twice in 1932 and 1980 when the famed "Miracle on Ice" occurred in the win of the USA men's hockey team over the USSR team. Lake Placid is also home to one of only three year-round United States Olympic Training Centers and periodically hosts world-class competitions in downhill and Nordic skiing, biathlon, ski jumping, luge, bobsledding, skeleton, speed skating and figure skating. The Village of Lake Placid annually hosts the Empire State Winter Games, and the Lake Placid and I Love New York Horse-shows, and the Lake Placid Ironman in summer. The Village is surrounded by the Town of North Elba, which strives to preserve its Olympic heritage and remains committed to offering a quality lifestyle and enjoyable family experience. This renowned mountain community is truly a beautiful, historical and magical place to live, offering incredible views of the Adirondack Mountains including New York State's highest peak at Mt. Marcy. The diversity and heritage of this small town brings thousands of visitors each year to explore, relax and enjoy this very special place.

NYS Olympic Regional Development Authority (ORDA):

The New York State Olympic Regional Development Authority (ORDA) was originally created by the State of New York to manage the facilities used during the 1980 Olympic Winter Games at Lake Placid. Today, ORDA operates Whiteface Mountain ski area located in the Town of Wilmington, just 15 minutes outside the Village of Lake Placid as well as the Olympic Center, the Olympic Jumping Complex and Olympic Sports Complex – all located in Lake Placid. As host to international and national championships, the Authority has brought millions of athletes and spectators to the regions it serves. ORDA has seen unparalleled assistance and support of its operation from many quarters, including New York State, the Department of Economic Development as well as local elected officials through an alliance allowing all involved to remain at the forefront of winter and summer sports training, competition, recreation, and tourism.

Lake Placid Central School District:

Lake Placid Central School has been offering students great experiences since the first "little red schoolhouse" was built in 1848. Today, students enjoy small class sizes, state of the art technology, college preparatory/AP classes and an abundance of extra-curricular opportunities.

Other Community Partners:

ROOST: Regional Office of Sustainable Tourism - The Regional Office of Sustainable Tourism/Lake Placid CVB is a 501c6 not-for-profit corporation. ROOST is the accredited Destination Marketing Organization (DMO) for Lake Placid and Essex County, Franklin County and Hamilton County in New York.

Schenectady, NY

Schenectady was first settled in 1661 when the area was part of the Dutch colony of New Netherland. In 1765, Schenectady was incorporated as a borough. It was chartered as a city in 1798. In 1887, Thomas Edison moved his Edison Machine Works to Schenectady. In 1892, Schenectady became the headquarters of the General Electric Company. The city was once known as "The City that Lights and Hauls the World"-a dual reference to two prominent businesses located in the city, the Edison Electric Company (now known as General Electric), and the American Locomotive Company (ALCO).

The City of Schenectady is a typical community in the historic industrial heartland of the US (aka the "rust belt") that is anchored by several legacy industry partners including General Electric. In the early 21st century, the city is experiencing difficult financial times, as are many upstate New York cities. The profound loss of employment opportunities has led to Schenectady's population decline by nearly a third since 1950. As a part of the NYS capital region, this is a typical "blue collar" town that is in the process of revitalizing. As indicated by their recent 2017 Smart Cities Report[46], Schenectady is moving ahead with a number of smart innovations, including improved street lighting and traffic improvements.

Other Community Partners:

The City of Schenectady has assembled a number of partners that are assisting their smart and connected efforts. Industries partnering with the city include National Grid, CIMCON Lighting, Cisco, Ellis Medicine, and AT&T. As can be seen by several letters of collaboration these partners are willing to aid in the efforts of this proposal as technology assistors going forward with the City leadership.

Community Engagement Strategy

As the living laboratories for this research project, the Olympic Region of NYS and the City of Schenectady will be full partners, as demonstrated by the letters of collaboration included with this proposal. The communities will be engaged through a primary municipality government: Village of Lake Placid for the Olympic Region and the City of Schenectady itself. Because of their unique characteristics, the make-up of other parties involved in this effort varies from community to community. In order to holistically evaluate community development, the data required will come from varied groups in each context. The following illustrations help to identify the partners and their relationships in each community:

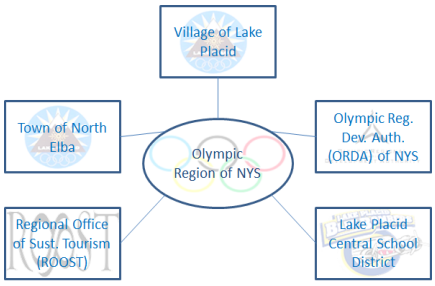

Figure 3 - Olympic Region Partners

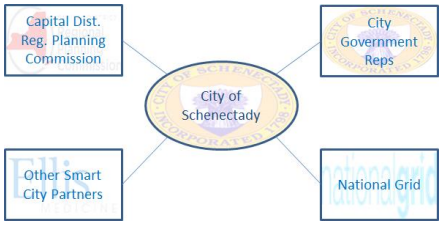

Figure 4 - City of Schenectady Partners

The communities will be asked to provide staff support assistance, as indicated in their letters of collaboration, to enable data collection on many levels. To that end, they've committed to grant access to various systems that provide a primary data source for across the spectrum which LEED for Comm. evaluates. Further, communities will engage in information sharing as to their plans and priorities with the research group. At this juncture, we are not asking for the community partners to provide funding support for the research effort itself. Nor are the funds provided through this proposal intended to fund specific technology employments that a community may opt to implement. This research effort, however, will study any such technology employments that a community may opt to implement, using its own resources, which happened to occur during the time of this study. It is our intent to provide for meaningful community engagement by virtue of the participation of community leadership (staff and/or elected officials) through participation with the research team as indicated in the Integrated Research section, as well as through a liaison with the project PI throughout. The communities, in addition to being the primary laboratory for this study are also "co-investigators" with the research team in order to better understand their own community.

In order to sustain the engagement levels, Clarkson is in the process of developing a memorandum of agreement between the various Olympic Region Partners and another agreement with the City of Schenectady. In order to facilitate these agreements, Clarkson has already engaged with the senior leadership in each of the communities, especially Mayor Craig Randall of Lake Placid and Mayor Gary McCarthy of Schenectady who are fully in support of this proposal. These memorandums of agreement

serve as principle based documents that define how Clarkson will serve as a resource to support their broader objectives and provide a framework for how these partners access those same resources on an episodic basis.

Expected Outcomes from Community Engagement

The specific research outcomes, as described in the Integrated Research section will serve as foundational documents and resources for ongoing community planning for both community groups. The outcomes of the research will be incorporated, therefore, in to community comprehensive plans, sector planning, development objective statements, and infrastructure planning, as well as economic/business development efforts.

Management Plan

Team Roles and Responsibility

Figure 5 depicts the interactions between the various parties within this proposal.

Project Leadership

As Primary Investigator (PI), Professor Erik Backus will provide overall leadership for the research team along with maintaining a key liaison role with the leadership of the two studied communities. Backus has extensive leadership experience in the development of community scale planning efforts from his prior role as Engineering Planner for George Mason University, where he was a part eight specific infrastructure planning efforts throughout the metropolitan Washington, DC area. As part of the community liaison role, the PI will facilitate monthly meetings with the self-identified primary civic/commercial leadership group for the studied communities.

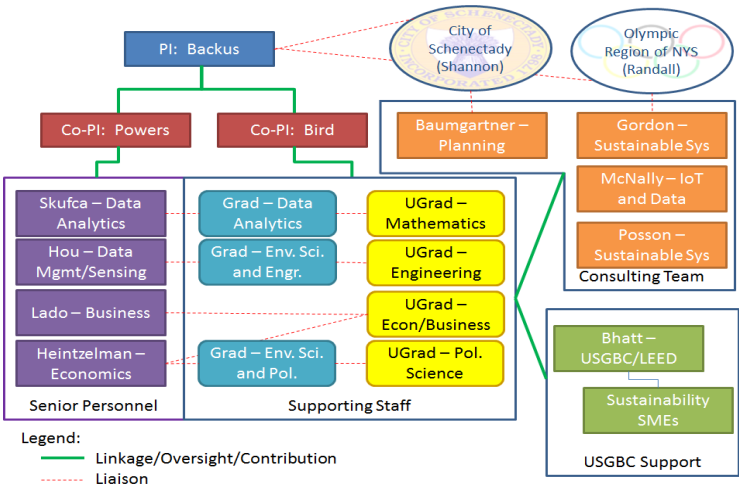

Figure 5 - Project Organization Chart

The two co-PIs (Susan Powers, Stephen Bird) will oversee the primary research team and aid in the coordination of the support staff to accomplish the outlined tasks in this proposal. Both Powers and Bird are primary leaders on the Clarkson University Smart Housing research effort, wherein smart technologies were used to monitor and understand the effects of behavioral messaging on energy and water usage within a multi-tenant, split incentive housing environment. Dr. Powers will oversee the technology and data teams and Dr. Bird will oversee the business, policy, and economics teams.

Primary Research Team

The senior personnel (Dr. Joseph Skufca, Dr. Daqing Hou, Dr. Augustine Lado, and Dr. Martin Heintzelman), graduate and undergraduate students will comprise the primary research team. The group will be managed along discipline/area of expertise lines with each senior personnel researcher having support of various graduate students and undergraduate students. Each of the proposed project tasks will require efforts on the part of one or more functional areas at various times as outlined in the project schedule. To coordinate the support for each task, the research team will meet with the PI/Co-PIs and select consultant support on a regular basis (e.g. weekly/bi-weekly/monthly meetings). As it is appropriate, community partners will be invited to join these meetings.

Consulting Team and USGBC Support

The consulting team will consist of three groups: (1) SmithGroupJJR, (2) G2 | Gordon + Gordon Architecture, LLC, and the (3) US Green Building Council (USGBC). For SmithGroupJJR and G2 | Gordon + Gordon Architecture, LLC, specific individuals (Mr. Steven Baumgartner, Mr. Peter McNally, and Mr. Don Posson for Smith and Mr. Harry Gordon for G2) will be assisting the research team. USGBC, however, will be providing organizational support as indicated below. These consultants will have particular roles and interact with the primary research team as their expertise is required. Given the nature of the proposed project, there will be periods where this support will be fairly extensive. Working with the Co-PIs and particular consultants, the consultants will join in on periodic meetings held by the primary research team as the project progresses.

SmithGroupJJR:

SmithGroupJJR is one of the largest architecture, engineering and planning firms in the U.S. With a staff of 1,300, this firm specializes in the healthcare, higher education, science & technology, and workplace sectors. Their integrated practice offers depth in all disciplines serving the built and natural environment, including architecture, engineering (civil, structural, mechanical, electrical and plumbing), landscape architecture, urban design and environmental science.

SmithGroupJJR will be supporting the project through the expertise of Mr. Steven Baumgartner, Mr. Peter McNally, and Mr. Don Posson. Steven Baumgartner is a leading energy and infrastructure strategist and planner. Peter McNally is a data scientist for the firm. Don Posson is SmithGroupJJR's co-director of sustainable design. Steven will be the primary contact with this firm and provide a wealth of expertise with regards to how cities and communities plan for a more sustainable, smart and connected future, most especially from his previous work with New York City.

G2 | Gordon + Gordon Architecture, LLC:

Harry Gordon is the founding principal of this firm that specializes in the research and design of high performance sustainable buildings and communities. He has led research projects sponsored by the US Department of Energy and national laboratories including NREL, LBNL and PNNL, as well as private industry. He has particular expertise in community engagement of diverse groups of stakeholders. He is a resident of neighboring Saranac Lake and will assist with the liaison relationship with the Olympic Region of NYS partners.

US Green Building Council:

The vision at the U.S. Green Building Council (USGBC) is that buildings and communities will regenerate and sustain the health and vitality of all life within a generation. The USGBC mission is to transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life. Through their community network, continuous collaboration with industry experts, market research publications and Leadership in Energy and Environmental Design (LEED) professional credentials, its global staff is working every day to help advance spaces that are brighter and healthier for us to live, work and play in.

USGBC is the program developer for LEED for Communities/Cities certification as a mechanism for measuring performance at a community scale. It is currently available as a pilot program, with 25 registered projects and following already certified:

- Certified Cities: Washington DC, and Phoenix/AZ
- Certified Community: Arlington County/VA
- Pre-Certified City: Savona/Italy
- Pre-Certified Community: Songdo International Business District/South Korea and Atlanta International Airport

USGBC will support the research team throughout the project with technical assistance on the Arc platform[47], data, documentation, training and capacity building on LEED for Communities/Cities. Dr. Vatsal Bhatt will be the primary contact at the USGBC for the research team and will contribute his expertise in data informed planning for communities throughout the project.

Project Schedule and Reporting

Figure 6 lays out the overall project schedule for each task as discussed in the Integrated Research section above. To summarize, this proposal envisions a three (3) year term to accomplish tasks 1 through 5. Tasks 1 and 2 will begin immediately upon notice the project may begin, with task 2 completing at the end of the first year. Task 1 will continue throughout as data collection will likely be ongoing. Task 3 will begin once ample information is gathered about community aspirations to begin the development of applicable tracking tools. This task will complete midway through the second year, when task 4 will begin. Task 4 will complete at the end of year two, with task 5 working through the balance of the proposed time-frame.

The PI will facilitate the required standard reports to the NSF. Additionally, as outcomes provide distinct deliverables these will be shared with the NSF program manager for use by the sponsoring agency.

			Year One				Year Two				Year Three			
		Quarters	1	2	3	4	5	6	7	8	9	10	11	12
	Start-up		X											
Task 1	Understand the Current State/Existing Status													
		Data Collection	X	X	X	X	X	X	X	X	X	X	X	X
		Community Leader Interviews	X	X										
		Organization/Policy/Decision Making		X										
		Externality Exploration		X										
		IoT Evaluation/Other Data Sources		X										
		Data Quality Evaluation		X	X	X	X	X	X	X	X	X	X	X
		Outcome: Initial Data Narrative			X									
Task 2	Identify Common/Diverging Aspirations													
		Aspiration Documentation	X	X										
		Establish/Understand Overlapping "Lenses"		X	X									
		Examine Past Smart City Initiatives		X	X									
		Link Data to "Lenses"		X	X									
		Compare/Contrast Communities			X	X								
		Outcome: Aspirations Understanding				X	X							
Task 3	Translate the Current Efforts to LEED for Communities/Cities													
		Tracking Tool Development			X	X			X	X	X	X	X	X
		Assessment Gap Analysis				X								X
		LEED for Communities/Cities Credit Analysis/Scoring					X							
		End-State Definition/Sustainability Vision					X	X						
		Present/End-State Gap Analysis						X						
		ID Smart and Connected Tools to Fill Gaps						X	X					
		Outcome: Arc LEED Performance Score					X							
		Outcome: Gap Analysis Report						X						
		Outcome: Narrative Linkage between LEED for Comm/Cities and Comm Sus. Vision							X					
Task 4	Utilize LEED for Communities/Cities as Sustainability Framework													
		Categorize & map Smart Strategies							X					
		Gain technology implementation understanding							X	X				
		ID resource pathways							X	X				
		Qualitative Input							X	X				
		Create Visualizations								X				
		Outcome: LEED for Comm/Cities and Smart Connection Matrix								X				
		Outcome: Visualization tools for iterations								X				
Task 5	Understand how "Smart-Community" Overlays Drive Aspirations													
		Investigate and understand how SCC drives aspirations									X			
		Conclusion on Data Investments									X			
		Understand how SCC informs process									X			
		LEED for Comm/Cities Investment Value Analysis									X	X		
		Future Dialogue Best Practices for Smart										X		
		Recommend short, medium, long-term smart investments										X	X	
		Outcome: High-quality presentation material											X	X
		Outcome: Improved Visualization tools for iterations											X	X
		Outcome: Report on study outcomes and recommendations												X

Figure 6 - Research Schedule

Data Collection and Evaluation

As discussed in the Integrated Research section of this proposal, data will be collected from multiple non-homogenous sources. Data will be collected out of existing systems as identified and utilized by the communities that will be studied. An initial review of the community's data sources reveals a mixture of digital live feed, analog recordings, spreadsheets, and online password protected files. There are also areas where there are noted data collection gaps and there will likely be additional gaps discovered. The research team will execute direct data collection as described above to mitigate gaps that are known or

emerge. Further, data will be evaluated throughout the project. As described in the research approach and in the schedule, there will be specific steps for data evaluation to occur to ensure it has the proposer rigor and accounts for sampling error, among other factors. See also the provided Data Management Plan.

Evaluation Plan

Outcome Based Evaluation

This proposal will be evaluated based on its ability to deliver the proposed outcomes as detailed in the above Integrated Research section. The project PI will share deliverables as outlined in the project schedule to the NSF as well as others. Success in this proposal will be defined by a clearer understanding of how data affects communities as they plan and develop in time. Table 1 is a summary of the expected outcomes from each task in this study with annotations on the planned evaluation points.

Task	Outcome	Evaluation Points
Task 1 - Understand the Current State/Existing Status	● Initial Data Narrative	● Year 1, Month 8; Provide understanding of data point available, data quality, and collection plan.
Task 2 - Identify Common/Diverging Aspirations	● Aspirations Understandings	● Year 2, Month 2; Provide a clear set of goals and objectives for each community across a spectrum of metrics
Task 3 - Translate the Current Efforts to LEED for Communities/Cities - Level with a Consistent Framework	● Arc LEED Performance Score ● Gap Analysis Report ● Narrative Linkage between LEED for Comm/Cities and Community Sustainability Vision	● Year 2, Month 1; Score as per LEED Criteria[48] ● Year 2, Month 6; A report on data gaps, and performance gaps and potential smart and connected mechanisms to address gaps ● Depiction of linkages of community goals/objectives (Task 2 report) and LEED for Communities/Cities
Task 4 - Utilize LEED for Communities/Cities as Sustainability Framework in which to activate through Smart Strategy - Establish "Smart-Community" Overlays and Ideal End-State	● LEED for Comm/Cities and Smart Connection Matrix ● Visualization Tools for Iterations	● Year 2, Month 12; Clear mapping of metrics between LEED for Communities/Cities and smart and connected strategies ● Year 2, Month 12; Tools that illustrate performance along chosen metrics and utilized by community partners
Task 5 - Understand how "Smart-Community" Overlays Drive City/Community Aspirations	● High-quality presentation material ● Improved Visualization tools for iterations ● Report on study outcomes and recommendations	● Year 3, Month 10; Provide presentation materials to be used to explain the research efforts and results for the studied communities ● Year 3, Month 12; Improved tools from Task 4, that are in regular use by the communities ● Year 3, Month 12; Publication of a report that is distributed through numerous venues

Table 1. Expected outcomes and evaluation

Publications Plan

It is the intent of the research team to report its findings through publication in juried publications, through presentations at conferences and similar allied activities. Articles will be co-authored by the applicable partners, and it will be our intent that the information be made available to the public to the greatest extent possible.

Intellectual Merit

The underlying scholarly and scientific merit of this project has three significant facets. First, an important challenge for data collection is determining which data is useful (smart) and how to integrate it (connected). Our analysis will address this considerable multi-disciplinary systems-thinking problem for community development. Second, the implementation of smart city programs requires a single

implementation system that is flexible and adaptive enough to be used with disparate kinds of communities and contexts. Our comparative approach (Olympic Region and Schenectady) provides the opportunity to test these important aspects of smart and connected systems. Finally, the use of the new USGBC LEED for Cities/Communities Program has been developed from a rigorous review of many smart cities programs. However, there has been a lack of a systematic science-based approach to these programs, both in implementation, and secondarily in assessment. This research program will address each aspect (execution and evaluation) through a thorough and methodical analytical lens.

Broader Impacts

The broader impacts of this study are numerous. Communities across the country are struggling with how to manage opportunities to leverage data to drive outcomes for the benefit of their citizens and the betterment of their long-term vitality. The envisioned project will include the full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM). This study will provide an analysis of how sustainability frameworks can aid communities in engaging smart and connected technologies to answer social challenges.

Results from Prior NSF Efforts

Developing Advanced Resilient Microgrid Technology to Improve Disaster Response Capability.[49] This is a Partnership for Innovation: Building Innovation Capacity Award 1534035 (PI, Tom Ortmeyer; Bird, co-PI, $1 million, 2015-2018). This project is focused on the development of a newer, broader form of microgrid with unique characteristics, the development of a microgrid with multiple generation owners, and multiple demand loads, as well as a role for the utility as a service provider. It's innovative technical aspects relate to design and the use of a Smart Controller to manage generation and load. It is also ground-breaking as a pilot project for the development of policy, implementation, regulatory concerns, and business model of multi-stakeholder microgrids. If successful, it will help to pave the way for larger implementation of higher scale microgrids across a variety of contexts and circumstances. The research is still primarily in development, with one paper published[50] but many others forthcoming, with final stage implementation to begin in 2019.

Engage and Excel: A framework for promoting 21st century skills by integrating campus sustainability initiatives and data into instructional practices (NSF DUE-1245622, 2/13-1/16; $200,000; Powers PI, Hou, co-PI). The development of a cyber-learning tool to enable the integration of campus sustainability projects into a wide variety of classes as relevant experiential learning sites. The goal of this Type 1 grant was to develop, pilot, and assess a framework used at Clarkson University as a step towards future use at other universities. Intellectual merit: The framework includes the cyber-learning infrastructure for campus sustainability (CLICS), as well as examples of how these data can be used in project-based learning experiences. Assessment and evaluation provide preliminary evidence that the approach engages students and helps them excel in 21st century skills. Broader impacts: Fourteen faculty members at Clarkson University have been trained to use CLICS in their classrooms, impacting over 800 students. Our classes that address sustainability issues have a relatively high percentage of female students. Relation to proposed work: Sustainability as part of standard course projects will be extended. Products: Two peer-reviewed conference papers have been published.[51],[52]

Collaborative Research - I/UCRC for Identification Technology Research (NSF #IIP-1068055 entitled "I/UCRC CGI: Collaborative Research - I/UCRC for Identification Technology Research" Schuckers (PI) with J. Skufca, 3/15/2011-2/29/2017. CITeR is a NSF Industry/University Cooperative Research Center focusing on biometrics[53]. Over 20 affiliates, including the FBI, DOD, DHS, and industrial partners cooperatively define, fund, and execute work to meet common needs. Datasets have been created and shared[54] and publications[55]. Clarkson is lead University Site with three additional sites: West Virginia University, The University of Arizona, University at Buffalo.

References

[1] Cocchia, Annalisa. "Smart and digital city: A systematic literature review." In *Smart city*, pp. 13-43. Springer, Cham, 2014

[2] Smart Cities Council, https://smartcitiescouncil.com/, accessed on 15 February 2018

[3] MetroLab Network, About, https://metrolabnetwork.org/about/, accessed on 15 February 2018

[4] The White House, "FACT SHEET: Administration Announces New "Smart Cities" Initiative to Help Communities Tackle Local Challenges and Improve City Services" https://obamawhitehouse.archives.gov/the-press-office/2015/09/14/fact-sheet-administration-announces-new-smart-cities-initiative-help, 14 September 2015

[5] Array of Things, Introduction, University of Chicago, https://arrayofthings.github.io/, accessed on 15 February 2018

[6] Watson, Bruce,From Light To Bright: San Diego Is Building The World's Largest Municipal Internet Of Things, GE Reports, https://www.ge.com/reports/light-bright-san-diego-leads-way-future-smart-cities/, 10 October 2017

[7] City of Columbus, Smart Columbus Projects, https://www.columbus.gov/smartcolumbus/projects/, accessed on 15 February 2018

[8] Sidewalk Toronto, About,. https://sidewalktoronto.ca/, accessed on 15 February 2018

[9] NIST, "International Technical Working Group on IoT-Enabled Smart City Framework", https://pages.nist.gov/smartcitiesarchitecture/, accessed on 15 February 2018

[10] Further information on LEED for Cities Program is available at: https://www.usgbc.org/cityperformance. See also USGBC, "New certification now available: LEED for Cities and LEED for Communities", https://www.usgbc.org/articles/new-certification-now-available-leed-cities-and-leed-communities, 1 December 2016

[11] Further information on Arc Skoru is available at: https://www.arcskoru.com/.

[12] Bird, Stephen, Daqing Hou, Kerop Janoyan, Lisa Legault, Susan E. Powers, Lydia Fox, Alex Rowe, Alan Schay, and Amanda K. Sherman. 2016. "Clean Energy and Smart Student Housing: Motivational Interventions for Improved Energy Efficiency in University Housing." Final Report, #32013. Albany, NY: New York State Energy Research and Development Authority.; Hou, Daqing, Stephen Bird, Kerop Janoyan, Lisa Legault, and Susan E. Powers. 2016. "Predictive Building Energy Modeling for Efficiency Improvements in HVAC and DHW." Albany, NY: New York State Energy Research and Development Authority.

[13] Powers, S.E., J. DeWaters, M.M. Small, S. Grimberg, D. Hou, *CLICS – Integrating Data from Campus Sustainability Projects across Disciplines*. In: Proceedings ASEE Annual Conference, paper #12529, pp. 26.351.1 - 26.351.15 Seattle WA June 2015.

[14] Bhatt, V.; Friley, P.; Lee, J. (2010) Integrated Energy and Environment Systems Analysis Methodology for Achieving Low Carbon Cities, Journal of Renewable and Sustainable Energy, of the American Institute of Physics, Vol. 2, 031012 (2010).

[15] Further information is available at: http://www1.nyc.gov/site/orr/index.page.

[16] Further information is available at: https://opendata.cityofnewyork.us/.

[17] See the provided Data Management Plan

[18] Shannon, Eric and Bhatt, Vatsal, "Envisioning a Smart City Dashboard", February 2018, available at http://www.cityofschenectady.com/505/Schenectady-Smart-City

[19] Shannon, Eric and Bhatt, Vatsal, "Envisioning a Smart City Dashboard", February 2018, available at http://www.cityofschenectady.com/505/Schenectady-Smart-City

[20] See the supplemental information.

[21] Siemens US and Canada Green City Index, "Economist Intelligence Unit, US and Canada Green City Index, 2011, Retrieved from http://www.siemens.com/entry/cc/features/greencityindex_international/all/en/pdf/report_northamerica_en.pdf","Economist Intelligence Unit, sponsored by Siemens", http://www.usa.siemens.com/entry/en/greencityindex.htm

[22] Urban Indicators Guidelines, "UN-HABITAT, Urban Indicators Guidelines, August 2004, Retrieved from http://ww2.unhabitat.org/programmes/guo/documents/urban_indicators_guidelines.pdf",UN-HABITAT, http://ww2.unhabitat.org/programmes/guo/guo_guide.asp#b1

[23] Indicators of Sustainable Development: Guidelines and Methodologie,"United Nations, Indicators of Sustainable Development: Guidelines and Methodologies, October 2007, Retrieved from http://www.un.org/esa/sustdev/natlinfo/ indicators/guidelines.pdf",United Nation,http://www.un.org/esa/sustdev/natlinfo/indicators/guidelines.pdf

[24] SPeAR? (Sustainable Project Appraisal Routine) Framework,"ARUP, SPeAR? (Sustainable Project Appraisal Routine) framework, 2011, Retrieved from http://www.oasys-software.com/media/Manuals/Latest_Manuals/SPeAR_Manual.pdf",ARUP,http://www.arup.com/Projects/SPeAR.aspx

[25] "Global City Indicator Initiative: helping cities measure, report, and improve performance","Global Citiy Indicators Facility, Global City Indicator Initiative: helping cities measure, report, and improve performance, 2008, Retrieved from http://www.cityindicators.org/Deliverables/Final%20Indicators%20Report%203_21_08_4-23-2008-924597.pdf",Global City Indicators Facility,http://www.cityindicators.org/Deliverables/Final%20Indicators%20Report%203_21_08_4-23-2008-924597.pdf

[26] Sustainability Reporting Guidelines version 3.1,"Global Reporting Initiative, Sustainability Reporting Guidelines v3.1, 2011, Retrieved from https://www.globalreporting.org/resourcelibrary/G3.1-Guidelines-Incl-Technical-Protocol.pdf",Global Reporting Initiave,https://www.globalreporting.org/resourcelibrary/G3.1-Guidelines-Incl-Technical-Protocol.pdf

[27] CASBEE (Comprehensive Assessment System for Built Environment Efficiency),"Japan Sustainable Building Consortium, CASBEE (Comprehensive Assessment System for Built Environment Efficiency)(for Cities, 2012, Retrieved from http://www.ibec.or.jp/CASBEE/english/download/CASBEE_City_manual_2012(E).pdf",Japan GreenBuild Council (JaGBC) / Japan Sustainable Building Consortium (JSBC),http://www.ibec.or.jp/CASBEE/english/index.htm

[28] Sustainable Jersey Certification program, "Sustianable Communities Working Group, Sustainable Jersey Certification, 2009, Retrieved from http://www.sustainablejersey.com/actions-certification/actions/",Sustaniable Communities Working Group,http://www.sustainablejersey.com/actions-certification/actions/

[29] City Energy Efficiency Scorecard, "Eric Mackres, et al. ""2013 City Energy Efficiency Scorecard"", American Council for an Energy-Efficient Economy, September 2013",ACEEE (American Council for an Energy-Efficient Economy),http://www.aceee.org/local-policy/city-scorecard

[30] LEED ND,"US Green Building Council, LEED v4 for Neighborhood Development rating system, July 2014. Retrieved from http://www.usgbc.org/sites/default/files/LEED%20v4%20ND_07.01.14_current.pdf",USGBC (U.S. Green Building Council),http://www.usgbc.org/sites/default/files/LEED%20v4%20ND_07.01.14_current.pdf

[31] ELITE Cities (Eco and Low-carbon Indicator Tool for Evaluating Cities),"He, G, Zhou N, Williams C, Fridley D. ""ELITE Cities: A low-carbon eco-city evaluation tool for China"". Lawrence Berkeley

National Laboratory, ECEEE 2013 Summer Study. Retrieved from file:///Users/linghaohe/Downloads/3-399-13_He.pdf","China Energy Group, Lawrence Berkeley, National Laboratory",http://proceedings.eceee.org/visabstrakt.php?event=3&doc=3-399-13

[32] EAPI (Energy Architecture Performance Index) 2014,"The World Economic Forum and Accenture, The Global Energy Architecture Performance Index Report 2014. Retrieved from http://nstore.accenture.com/acn_com/Accenture-Global-Energy-Architecture-Performance-Index-Report-2014.pdf",The World Economic Forum/Accenture,http://nstore.accenture.com/acn_com/Accenture-Global-Energy-Architecture-Performance-Index-Report-2014.pdf

[33] Energy Efficiency Indicators, "International Energy Agency. ""Energy Efficiency Indicators: Essentials for Policy Making"" IEA Publications (2014). Retrieved from http://www.iea.org/publications/freepublications/publication/IEA_EnergyEfficiencyIndicators_EssentialsforPolicyMaking.pdf",International Energy Agency,http://www.iea.org/topics/energyefficiency/subtopics/energyefficiencyindicators/

[34] Eco-city(MEP) indicators, "Ministry of Environmental Protection (2007). Notice on the insurance of indicators for ecological county, ecological city, and ecological province. Retrieved from Chinese website http://sts.mep.gov.cn/stsfcj/",China's Ministry of Environmental Protection (MEP),http://eaei.lbl.gov/sites/all/files/china_eco-cities_indicator_systems.pdf

[35] National Eco-Garden City(MoHURD) indicators, "Ministry of Housing and Urban-Rural Development (2004). Notice on implementation of creating ""eco-garden city."" Retrieved from Chinese website http://www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjcsjs/200611/t20061101_157113.html",MOHURD,http://www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjcsjs/200611/t20061101_157113.html (in Chinese)

[36] Tianjin Eco-city KPIs, "Ministerial-level Eco-city Joint Working Committee, Tianjin Eco-City Key Performance Indicators (KPIs),Retrieved from http://www.tianjinecocity.gov.sg/bg_kpis.htm",Ministerial-level Eco-city jointly formulated Committee between China and Singapore,http://www.tianjinecocity.gov.sg/bg_kpis.htm

[37] Indicators for sustainability, “Sustainable Cities International. ""Indicators for Sustainability : How cities are monitoring and evaluating their success"", November 2012. Retrieved from http://sustainablecities.net/our-resources/document-library/doc_download/232-indicators-for-sustainability",Sustainable Cities International,http://sustainablecities.net/our-resources/document-library/doc_download/232-indicators-for-sustainability

[38] WHO Healthy Cities indicators, "World Health Organization, Healthy Cities indicators, Retrieved from http://cms.unige.ch/isdd/IMG/pdf/ehcpquest.pdf",WHO Healthy Cities Technical Working Group on Health and Indicators,http://decipherproject.com/project/who-healthy-cities-indicators

[39] One Planet Communities,"BioRegional Development Group, ""One Planet Action Plan Report 2012"" . Retrieved from http://www.bioregional.com/files/media/image/publications/BioRegional%20OPAP%20Report%20for%202012-13.pdf",BioRegional Development Group,http://www.oneplanetcommunities.org/about-2/approach/the-10-principles/

[40] Bloomberg Sustainability,"Bloomber L.P. ""Bloomberg BCAUSE IMPACT Report 2013"". Retrieved from http://www.bloomberg.com/bcause/content/themes/sustainability-2014/report/BloombergSustReport2013.pdf",Bloomberg L.P,http://www.bloomberg.com/bcause/content/themes/sustainability-2014/report/BloombergSustReport2013.pdf

[41] GHG Protocol Policy and Action Standard, "World Resource Institute. ""GHG Protocol Mitigation Goals Standard for public comment"", July 2014. Retrieved from http://www.ghgprotocol.org/files/ghgp/Mitigation%20Goals%20Standard%20-%20Final%20Draft%20for%20Public%20Comment_0.pdf",World Resource Institute, http://www.ghgprotocol.org/mitigation-accounting

[42] ISO 37120 Sustainable development of communities - Indicators for city services and quality of life, "International Standard Organization, ISO 37120: Sustainable development of communities - Indicators for city services and quality of life, 2014. Retrieved from http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=62436",International Standard Organization,http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=62436

[43] Green star-communities PILOT rating, "Green Building Council of Australia, Green star-communities PILOT rating, July 2012. Retrieved from http://www.gbca.org.au/green-star/green-star-communities/rating-tool/",Green Building Council of Austrilia,http://www.gbca.org.au/green-star/green-star-communities/rating-tool/

[44] OECD Green Cities Programme,"OECD, ""Towards Green Growth: Monitoring Progress"" (2011). Retrieved from http://www.oecd.org/greengrowth/48224574.pdf",OECD,http://www.oecd.org/greengrowth/48224574.pdf

[45] Green Communities, "EPA, Green Communities Indicators. Retrieved from http://www.epa.gov/greenkit/indicator.htm",EPA (US Environment Protection Agency), http://www.epa.gov/greenkit/indicator.htm

[46] 2017 Schenectady Smart City Report, found at https://www.cityofschenectady.com/DocumentCenter/View/1656

[47] The Arc platform is the online platform in which LEED for Communities/Cities is managed; https://www.arcskoru.com/

[48] See the following for the performance scoring under LEED for Communities/Cities: https://www.usgbc.org/cityperformance

[49] More information at http://www.nsf.gov/awardsearch/showAward?AWD_ID=1534035

[50] Bird, Stephen, and Chelsea Hotaling. 2017. "Multi-Stakeholder Microgrids for Resilience and Sustainability." *Environmental Hazards*, Special issue on Sustainability and Environmental Hazards, Peter Walker, Guest Editor. http://dx.doi.org/10.1080/17477891.2016.1263181.

[51] Powers, S.E., S.J. Grimberg. Cold-climate Greenhouse and Food Waste Digester Provide Education and Research Opportunities While Greening the Campus. in 120th Annual ASEE Conference & Exposition. 2013. Atlanta, GA: ASEE.

[52] Powers, S.E., J. DeWaters, M.M. Small, S. Grimberg, D. Hou. CLICS – Integrating Data from Campus Sustainability Projects across Disciplines. in ASEE Annual Conference. 2015. Seattle, WA: ASEE.

[53] More on this center at www.clarkson.edu/citer

[54] Shared at this location: https://citer.clarkson.edu/biometric-dataset-collections/

[55] Publications at this location: https://citer.clarkson.edu/publications/