Energy Planning for a Sustainable Neighborhood

An EnergyPlus Neighborhood in Seattle's South Downtown

Prepared by

International Sustainable Solutions
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Acknowledgements

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- Jayson Antonoff, May 2007

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ASRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers

BIWT – building integrated wind turbines

CBECS – U.S. Energy Information Agency's Commercial Buildings Energy Consumption Survey

CEP – community energy planning

CHP – combined heat and power

DPD – Department of Planning and Development

EFLH – equivalent full load hours

EIS – environmental impact statement

EU – European Union

GHG – greenhouse gas

IESNA – Illuminating Engineering Society of North America

kWh – kilowatt-hours (1,000 watt-hours)

LEC – Lonsdale Energy Corporation

LEED – The USGBC's Leadership in Energy and Environmental Design rating system

MSW – municipal solid waste

MWh – megawatt-hours (1,000,000 watt-hours)

PSE – Puget Sound Energy

PIN – King County Parcel ID Number

PSSD – Pioneer Square / South Downtown neighborhood

PV – solar photovoltaic

RPS – renewable portfolio standard

SCL – Seattle City Light

SODO – South of Downtown neighborhood

USGBC – U.S. Green Building Council

WBA – whole building approach

ZEH – Zero Energy Home

1. Executive Summary

The built environment consumes 40% of the energy in the United States[1], and in 2003 accounted for 39% of all greenhouse gas (GHG) emissions. When the embedded energy of constructing buildings is included as well, data from the U.S. Energy Information Administration shows that buildings are responsible for almost half (48%) of the GHG emissions in the U.S., exposing the built environment as the country's largest energy consuming sector and most significant source of GHGs. In order to prevent the potentially devastating impacts of global climate change it is imperative that we dramatically decrease the fossil fuel requirements, and associated GHG emissions, of the built environment. Many people are already looking at ways to make individual buildings more energy efficient, but few are elevating this discussion to the level of communities, where smart land use planning, taking advantage of the energy synergies between buildings, and developing community scale generation solutions can help make entire neighborhoods more energy self sufficient.

Based on international best case examples such as Västra Hamnen in Malmö, Sweden, and the Vauban development in Freiburg, Germany, this project evaluates the potential for creating urban neighborhoods that, on a net annualized basis, are capable of producing as much energy as they consume. The intent is to develop the vision and a technical assessment of how an existing neighborhood in a typical North American city could reduce or even eliminate its need to rely on distant sources of gas and electricity. The technical analysis is followed by a discussion of potential policy considerations needed to transform this vision into a reality.

Our work is based on the analysis of an existing urban neighborhood in Seattle, Washington, encompassing about 115 acres adjacent to the downtown core. This work has been done in conjunction with, and has provided input to, several other planning efforts now underway in this area. The analysis was led by the author and supported by an Advisory Group which included representatives from the City of Seattle, utilities, architects, engineers, developers and others.

The focus of this report is on community scale planning – the difficult and challenging space in which the efforts of private real estate developers and municipal planners must converge. Our approach to creating an energy self sufficient, or EnergyPlus neighborhood, considers three main opportunities:

- Energy efficiency at the building scale, including changes in siting, design and orientation, as well as high performance lighting and appliances, natural ventilation and daylighting;
- Opportunities for a district energy system or other means to more efficiently generate and distribute thermal energy for heating and cooling; and
- Development of renewable energy sources, both for individual buildings and at the neighborhood scale. This includes familiar sources such as wind and solar, as well as less commonly used urban resources such as municipal solid waste, wood waste and other biofuels.

In our analysis we found that implementing all of the proposed measures could reduce the projected energy footprint of this neighborhood from 221,000 MWh/yr to 57,900 MWh/yr, a 74% decrease. Major changes to public policy will be needed for this vision to be realized, but fortunately some of the preliminary policy recommendations discussed in this report are already being considered for adoption into local codes.

2. Introduction

By the year 2008, for the first time in human history over 50% of the world's population will be living in urban environments. In the U.S. this number is already at 80.9%.[2] This is a rapid and dramatic demographic shift from 100 years ago, when a mere 13% of the world's population lived in cites. Today's cities consume a tremendous amount of energy, with commercial and residential buildings together responsible for 40% of U.S. primary energy use (Figure 1), and over 72% of total U.S. electricity consumption.[3, 4]. Because this energy comes primarily from fossil fuel based power plants, the built environment also accounts for 39% of all greenhouse gas (GHG) emissions in the U.S.[5] When the embedded energy of constructing buildings is included as well, data from the U.S. Energy Information Administration shows that buildings are responsible for almost half (48%) of the GHG emissions in the U.S., exposing the built environment as the country's largest energy consuming sector and most significant source of GHGs.[6] In order to prevent the potentially devastating impacts of global climate change it is imperative that we dramatically decrease the fossil fuel requirements, and associated GHG emissions, of the built environment.

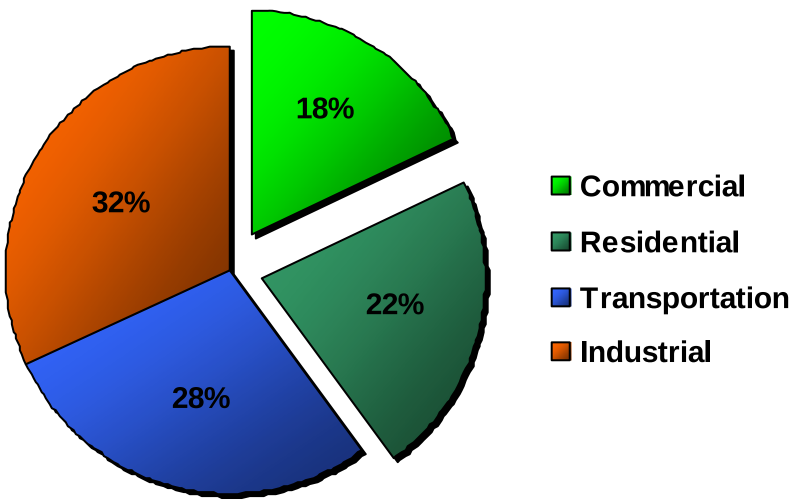

Figure 1 – End-Use Sector Shares of Total U.S. Energy Consumption, 2005

In addition, it is clear that the U.S. electric transmission system is in urgent need of modernization. Our current electric grid is dominated by large, centralized generating facilities, often located hundreds of miles away from the cities they are serving, and dependent upon a vast network of transmission and distribution lines to deliver their energy. The system has become congested because growth in electricity demand and investment in new generation facilities have not been matched by investment in new transmission facilities. Because the existing transmission system was not designed to meet present demands, daily transmission constraints or "bottlenecks" increase electricity costs to consumers and the risk of blackouts. Estimates of the grid investments needed over the next ten years in order to insure adequate system capacity and reliability have ranged as high as $100 billion[7], and the Edison Electric Institute projected that utilities would be investing $84 billion in improvements to transmission and distribution infrastructure just between 2006 and 2009.[8]

Distributed generation – producing electricity at or close to the source of consumption – can help alleviate some of these demands upon the grid, potentially at a much lower cost. In addition, it can decrease the vulnerability of critical energy supplies to disruption from terrorism or system failures. As access to scarce energy resources becomes an increasingly more critical consideration, it may be time to reevaluate some basic assumptions about the way energy is produced and delivered to our cities. We may find that relying solely on energy produced at large, remote, and generally fossil fueled power plants is no longer viable or desirable.

We must also find ways to reduce the energy consumption of the buildings and neighborhoods that make up the built environment. After years of advances in Europe and other parts of the world, energy neutral development is beginning to gain attention amongst a growing cadre of developers, design professionals, and government leaders throughout the U.S. Several hundred Zero Energy homes (ZEHs) have been constructed, primarily as demonstration projects in partnership with the U.S. Department of Energy's "Building America" home building program. A ZEH is connected to the utility grid, but at off-peak time periods, it generates more power than it uses by combining renewable energy technologies with advanced energy-efficient construction. As a result, a ZEH produces about as much energy as it consumes during a year, so is considered to achieve "net zero" energy consumption.[9]

Recently, this movement has begun to gain mainstream acceptance within the commercial sector as well. In 2006 the American Institute of Architects adopted the 2030 Challenge, which included targets for the reduction of fossil fuel use in all new buildings:[10]

60% in 2010

70% in 2015

80% in 2020

90% in 2025

Carbon-neutral by 2030 (using no fossil-fuel GHG-emitting energy to operate)

In June of that year the U.S. Conference of Mayors, a nonpartisan body whose membership includes the 1,139 Mayors of U.S. cities with a population of 30,000 or more,[11] unanimously adopted the 2030 Challenge for all new public construction.

Although technology is a critical element of this discussion, it will not be the only impediment; the solution depends on effective long range planning, and major changes to public policy. Therefore, in this report we are going to examine two crucial questions:

1. Is it technically possible, using currently available solutions, for urban neighborhoods to reduce their GHG footprint and become energy self sufficient, so that over time we can fundamentally change the way our cities are powered?
2. If so, what are some of the policies changes that might be needed to promote the necessary actions?

If this approach is viable, it would simultaneously help solve several major challenges that the U.S. is facing:

- Reducing our dependence on imported supplies of fossil fuels.
- Reducing GHG emissions and the associated climate change impacts of the built environment.
- Deferring some of the billions of dollars for investments needed to upgrade our aging electrical grid.
- Reducing the existing vulnerabilities of our energy supply systems.
- Constructing scalable generation capacity to meet new energy demands where and when it is needed.

To date, efforts to reduce energy consumption in the built environment have focused primarily on making individual buildings more energy efficient, with the assumption that the necessary energy supplies will be available and that existing infrastructure models will suffice. In fact, with the increasing market acceptance of the U.S. Green Building Council's LEED™ standards, high performance buildings are rapidly becoming "known territory", though the number of buildings actually achieving breakthrough energy performance is still small. The area that has yet to be adequately explored is how to broaden this discussion to the development of entire sustainable neighborhoods through Community Energy Planning (CEP).

The CEP process considers the use of energy within the context of the design and functionality of a community. It takes into account energy supply and demand in urban and neighborhood design and development, and involves land use planning, building design, infrastructure design, and alternative energy supply options.

CEP is inherently a much more complex undertaking than designing a single building. It requires a close partnership between private developers, who respond to market pressures when determining which features to include in their projects, and public authorities, who are largely responsible for defining the zoning and permitting requirements that guide developments to provide the greatest public good. It also recognizes the fact that municipalities have the ability to incorporate much more definitive energy goals into the community master planning process, so that buildings actually begin to provide some of the energy that cities depend on.

Our premise in this project is that in order to reduce the energy footprint of our cities we must not only design and construct buildings that are more efficient, but we must also shift to a greater reliance upon on-site or neighborhood scale sources of locally produced renewable energy. We begin this report by presenting a series of case studies of successfully implemented community scale energy solutions from around the world, and then we evaluate the potential for adopting similar strategies to transform an existing urban neighborhood in Seattle, Washington into an EnergyPlus neighborhood, which over the course of a year produces as much energy as it consumes.

In order to do this we calculated the overall energy budget of the entire neighborhood and then determined how much of the load could be fulfilled by each of three key strategies:

1. **High performance buildings:** Using aggressive building efficiency measures such as energy-efficient lighting and appliances, natural ventilation and daylighting to dramatically reduce energy consumption and peak demand.
2. **District energy systems:** Constructing a neighborhood-wide thermal distribution system, with hydronic heating within buildings. In a mixed-use area like this, with residential, commercial and industrial in close proximity, there are benefits to developing neighborhood-scale central plants. Opportunities could even be tapped for capturing the waste heat generated from some properties, using it to heat and perhaps cool other nearby buildings.
3. **Distributed generation, using sustainable energy sources:** Developing on-site or neighborhood-scale generation to produce power as close to the loads as possible. This could be based on the renewable sources that typically come to mind such as solar, wind or geothermal energy, or might rely on other locally produced fuels such as municipal solid waste (MSW), wood waste and other biofuels.

The purpose of this report is not to conduct a rigorous engineering analysis, but to describe the opportunity, assess the high level technical feasibility, and then examine some of the regulatory and planning aspects that would have to be considered to promote this approach. Many of the barriers to the approach outlined in this report are not technical; they are inherent within the way that energy planning is (or is not) done within the U.S. Energy planning and strategic decision making in the U.S. is more fragmented than in many parts of the world, making it difficult to initiate the changes in thinking and the substantial investments that could benefit a city or region as a whole. For example, our study area, the Pioneer Square / South Downtown (PSSD) neighborhood, is serviced by multiple utility companies: Seattle City Light (SCL) for electrical, Puget Sound Energy (PSE) for natural gas and Seattle Steam for heat. Having competing energy suppliers theoretically reduces energy costs for consumers. However, there is no formal venue for performing comprehensive energy planning across institutional lines, in order to determine which combination of energy strategies provide the most efficient solution from a regional perspective.

In addition, there is a tendency in the U.S. to think about energy only in its supply and demand dimensions. Other aspects, such as land use, building design and infrastructure, are generally not considered in an energy planning analysis.

As a result:

- Each utility is concerned only with the planning needed to serve its base of customers, and to maximize its own energy sales (within the limits of its available capacity). There is no overarching authority or planning body to evaluate which energy supply is best matched to the needs of a building or neighborhood.
- Because every building is separately financed and constructed, there is no mechanism to promote neighborhood-scale solutions that could more efficiently serve a small number of buildings or blocks.

Instead, we rely on market forces to determine whether a consumer’s load can best be met by electricity, gas or steam/hot water — without necessarily having sufficient mechanisms to fund and carry out the solutions that might, from a societal point of view rather than an individual consumer or producer’s perspective, be the most beneficial.

By comparison, in Malmö, Sweden, E.ON is an integrated energy provider, responsible for meeting all energy needs of its consumers – electrical, gas and heating. It has an inherent interest in determining how to best meet loads with the right combination of these resources, or by investing in conservation. As a result, the decision was made there, as in much of northern Europe, to invest in a network of hot water pipes and heat most homes and offices with a district energy system. E.ON also installed and owns solar hot water collectors on some of the newer buildings, further expanding its role as a “one stop shopping” energy provider.

Ultimately, our society’s ability to develop a more sustainable and resilient energy infrastructure will be predicated on our ability to look beyond the physical and institutional constraints that now dictate the development and delivery of today’s energy resources, and create completely new models for our energy systems. One of the greatest potential barriers to doing this is simply the resistance to doing something new and unfamiliar. By creating the vision and methodology for developing an EnergyPlus neighborhood in Seattle, we hope that communities throughout the country will begin to consider how to achieve greater energy efficiencies, and adopt distributed, renewable generation at the neighborhood level. If we are successful in this effort, we hope we will have created not only a key initial element to guide future development in Seattle, but also a model for a more reliable and sustainable energy future that will be studied by other communities throughout the world.

3. Scope and Definitions

The concept of an "EnergyPlus" neighborhood was initially inspired by the "plus energy" standard defined for some of the buildings in the Vauban development of Freiburg, Germany (see case study in Section 5.2). There, the term is used specifically to describe the houses constructed as early as the year 2000 which, on average, produce more energy than they need.[12] However, expanding this concept to an entire neighborhood introduces many subtleties that must be considered.

We are proposing the following definition for an EnergyPlus neighborhood:

> *An EnergyPlus neighborhood is one in which the ongoing operating energy needs of the buildings we live, work, shop and study in are met entirely by locally produced renewable energy resources.*

Specific aspects of this definition are further clarified below.

"Operating Energy"

Modern buildings consume energy in a number of ways. As described by Jones,[13] energy consumption in buildings occurs in five phases (Figure 2). These include:

1. Embodied energy – the energy consumed during the manufacturing of building materials and components;
2. Gray energy – the energy used to transport materials from production plants to the building site;
3. Induced energy – the energy used in the actual construction of the building;
4. Operations energy – the energy consumed to run the building while it is occupied; and
5. Demolition/recycling energy – the energy consumed in the demolition of the building and in the recycling of its components.

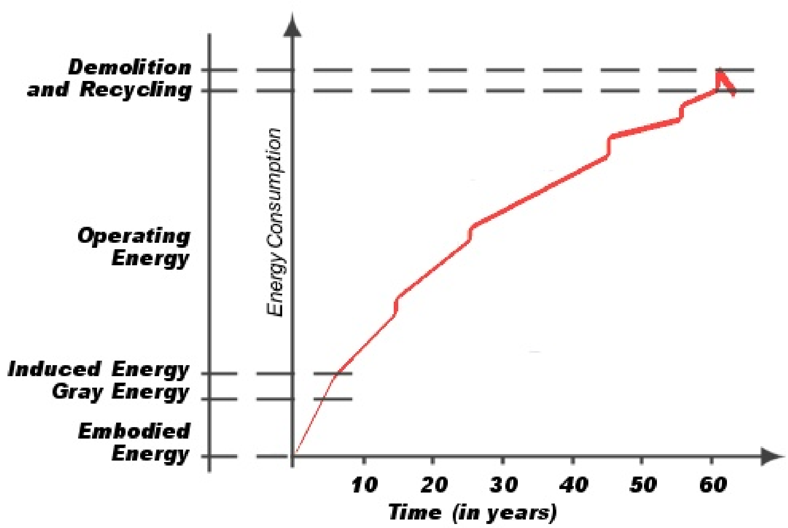

Figure 2 – Energy Consumed in the Life of a Building

It is estimated that in the United Kingdom the Operating Energy of buildings is responsible for about 50% of the nation's energy needs,[14] while in the U.S. the Energy Information Agency estimates that the building sector accounts for about 40% of the country's energy consumption. Mazria found that when the embodied, gray and induced energy of residential and commercial building construction is included, as well as the portion of the industry sector that goes to the operation and construction of industrial buildings, the architectural sector is responsible for 48% of total U.S. energy consumption, and 46% of the carbon dioxide production.[15]

Nevertheless, our analysis is looking exclusively at the Operating Energy consumed during the lifetime of the building. Although the other phases of a building's life have significant energy requirements, the most energy by far is consumed during this phase, which typically lasts from 60 to 100 years.

"Of the Buildings"

Although the built environment is the largest single consumer of energy in cities, the transportation sector is very significant as well, consuming 28% of the energy in the U.S. In fact, in an area like the Pacific Northwest, where much of the electricity is generated from carbon free hydropower, transportation is the single largest source of GHG emissions. Seattle's Green Ribbon Panel, organized to develop a local strategy for achieving the Kyoto accords, determined that the transportation sector was responsible for 42% of Seattle's GHG emissions in 1990.[16] The Panel's recommendations call for transportation improvements to account for 55% of the GHG reductions targeted for Seattle by the year 2012.

However, our analysis encompasses buildings and their internal loads only; the impacts of the transportation sector are not considered in our EnergyPlus analysis.

Similarly, manufacturing requirements were excluded from this definition. Where industrial or manufacturing activities take place in an EnergyPlus neighborhood, the energy budget should provide for the normal energy needs of the buildings that house these activities (heating, cooling, lighting, etc) but not for the industrial processes themselves.

"Met Entirely"

An urban EnergyPlus neighborhood should be capable of operating within the ongoing budget of the energy it can produce. This does not imply that it can independently meet its load at every instant, but that there is a balance between energy production and consumption on an annual basis, for zero net import. The neighborhood should be completely integrated into the electric grid and other energy distribution systems to take full advantage of the benefits this provides with regard to energy supply, storage, and reliability. For electric loads, this means that the central generating plants connected to the grid can continue to provide power to the neighborhood when needed, while the local distributed resources can sell excess energy to the grid when available.

"Locally Produced"

An EnergyPlus neighborhood should rely on distributed resources that produce energy at or near the point of consumption, unlike traditional "centralized" systems which generate electricity at remote, large-scale power plants and then transmit it through power lines to the consumer. This shift has the potential to mitigate congestion in transmission lines, strengthening energy security, and providing greater stability to the electricity grid. By reducing the demand on the grid electric utilities could defer or even eliminate some of the billions of dollars in investment that are being budgeted for strengthening and upgrading the U.S. transmission infrastructure.

Some methods for locally producing energy also have the advantage of generating heat and electricity simultaneously, in combined heat and power (CHP) plants. Thermal energy cannot be transported as far as electricity, because of the inherent temperature drop of the medium and the higher expense of installing underground pipes. By moving the generation facilities close to the loads any thermal energy created can be cost effectively captured and distributed, greatly increasing the overall efficiency of the energy generation and supply system.

Locally produced energy should be produced within the boundaries of the neighborhood, or within a reasonable (2 mile) distance from the perimeter. For example, the Western Harbor development of Malmö, Sweden (see case study, Section 5.1) is widely portrayed as being powered by "100% locally produced renewable energy," though over 99% of the electricity for the neighborhood is generated by a 2 MW wind turbine located in the North Harbor, 1.8 miles from the initial development in Western Harbor.[17, 18]

Even though this definition requires that energy be produced in or near the neighborhood, generation could still rely on fuel supplies that originate outside these geographic limits. Neighborhood-scale plants that produce energy by consuming biomass or MSW could become an important aspect of an EnergyPlus neighborhood, even though it is highly unlikely that the fuel supplies would be created entirely within the neighborhood. Experience with the wood chip fired CHP plant in Vauban has demonstrated that the technical and societal barriers to this approach can be overcome,[19] and Seattle Steam has already developed plans for converting its gas fired boiler, located in the heart of Seattle's downtown, to burn urban wood waste.[20] However, further analysis is needed to determine if the energy production benefits justify the additional cost and environmental impacts of transporting bulky biofuels to a plant located in an urban neighborhood.

"Renewable Energy"

Renewable energy is typically defined as energy that is supplied by sources that are naturally and continually replenished, such as wind, solar power, geothermal, hydropower, and various forms of biomass. Therefore, in order to reduce its carbon footprint to zero, an EnergyPlus neighborhood would ultimately have to rely exclusively on non-fossil-fuel based renewable energy sources. As this is admittedly an aggressive goal, there would be a transitional period during which offset credits could be purchased to compensate for the continuing near-term reliance on fossil fuel based energy supplies.

Because the EnergyPlus definition stipulates that the renewable energy be locally produced, large scale hydropower cannot be included. Otherwise, almost every neighborhood in Washington State could be considered to already meet the EnergyPlus standard, since hydropower is the dominant source of electrical power. In fact, the Pacific Northwest's hydro based energy system is ironically one of the strongest justifications for considering an EnergyPlus approach. No additional large-scale hydro projects will be constructed in this region, and there is actually considerable political pressure to remove some of the existing dams, in order to restore fish migration paths. When combined with the rapid population growth of the region, this leads to the realization that as new, non-hydro resources are built to increase regional capacity, the portfolio is in danger of becoming much more fossil fuel dependent, and actually increasing its GHG emission impacts.

4. Methodology

The goal of this study is to evaluate the technical viability of transforming Seattle's PSSD neighborhood into an energy self sufficient neighborhood. After the technical feasibility has been established the policy implications will be considered, and several alternative approaches presented. The intent is that this study would present the vision, and raise the public support for pursuing his concept more aggressively. Should resources be available, this will be followed up with an additional study to complete the detailed financial and engineering analysis needed to more rigorously evaluate the proof of concept.

Phase 1 – Case Study Review

The first phase of the project involved a review of several case studies from around the world, where the concept of an energy self-sufficient neighborhood has been implemented to varying degrees. These case studies provided the background for possible technologies that should be considered, as well as the policy roadmaps needed to achieve these results.

Phase 2 – Assemble Advisory Panel

We next assembled an advisory panel of professionals who are involved in sustainable energy issues, or have a particular interest in the development of this neighborhood. The panel included representatives from the City of Seattle's planning department, each of the three utilities serving the area, local developers who own property in the neighborhood, and engineers, architects and other consultants who were able to provide guidance and advice. The members of the Advisory Panel were selected to provide specific input into the following areas:

- High performance buildings
- Building mechanical/electrical systems
- District heating and cooling
- Renewable energy technologies
- Urban planning
- Climate change
- Economics
- Energy policy
- Gas and electric utility planning
- Legal

The advisory panel met periodically throughout this project to vet results and to provide input on the goals and approach for this effort. One of the first and most critical recommendations made by the Advisory Panel was that it would be impossible, in a Business as Usual approach based on our current market and policy realities, to create the framework for an EnergyPlus neighborhood. Although it could well be the best long term solution for the region from a both an environmental and a total life-cycle cost perspective, current prevailing energy prices and other economic barriers would preclude any significant investments in the infrastructure and other aspects needed to embark down this path. Therefore, we decided that our work would initially focus on the technical feasibility of reaching this goal, and then consider various policy measures necessary to achieve this vision. A thorough cost-benefit analysis will be delayed for a future study, after an assessment of the long term implications of technical innovation and strategic changes to the energy and climate change policy framework has been completed.

Phase 3 – Determine Current Energy Budget

In order to determine the potential for becoming an EnergyPlus neighborhood, it was first necessary to calculate the total current energy budget of the area. The initial task was to define the physical boundaries of the study region, and then perform a GIS analysis to characterize the existing buildings by floor area and by their predominant use. From this analysis we were able to generate a list of building addresses, which was then shared with each of the three energy utilities so that they could provide meter readings for a three year period. Before releasing the data each utility aggregated the billing records by month and by building use categories, in order to protect client confidentiality. This data was later disaggregated to produce an estimate of the distribution of internal loads within each building type.

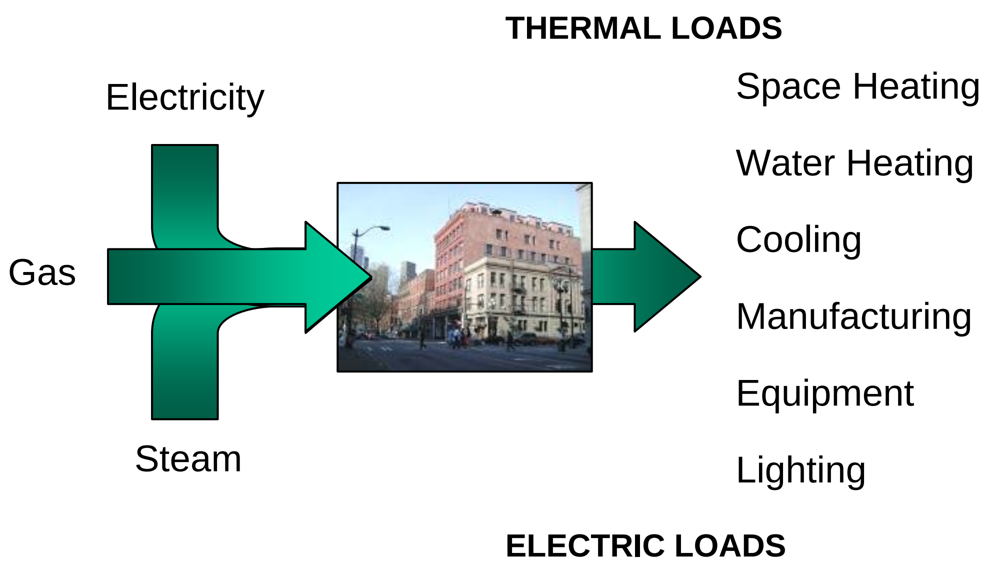

Figure 3 – Energy Flows

Since the goal was to look at all energy needs throughout the neighborhood, regardless of the physical form in which it was provided, all existing energy data was converted to a consistent kWh format, taking conversion losses into account.

Phase 4 – Evaluate New Development

The next phase demanded that we assess the impacts of new construction anticipated within the 10 year horizon of this study. It is very difficult to make accurate projections of new building construction, as these numbers are highly influenced by short term changes in the financial market, in the real estate market, and in the policies and permitting requirements affecting the area. However, we were able to work with the City of Seattle's DPD and with individual developers active in the area to compile reasonable estimates of new projects.

Phase 5 – Gap Analysis of Technology Alternatives

With an inventory of current and projected construction, and an understanding of how these buildings are being used, we were able to work with the Advisory Panel and others to build an energy vision for the neighborhood that would be an alternative to Business as Usual. We first calculated the projected future energy requirements, starting with the existing total energy budget and then applied the additions expected through new construction, under a Business as Usual scenario. Alternatives were then considered within each of the following three categories, to evaluate the potential for reducing the energy footprint to zero:

1. Consumption – how much can we reduce energy use in existing, new and to be renovated buildings?
2. Distribution – what savings can be gained by considering more efficient, distributed electric distribution (Smart Grid) or a thermally based, district energy system?
3. Generation – can renewable, locally produced energy resources, both building integrated and at the neighborhood scale, successfully fulfill the remaining energy gap?

Through this Gap Analysis we were able to consider some of the technologies that could play a role in creating an EnergyPlus neighborhood, and assess the technical potential for achieving a zero net energy goal

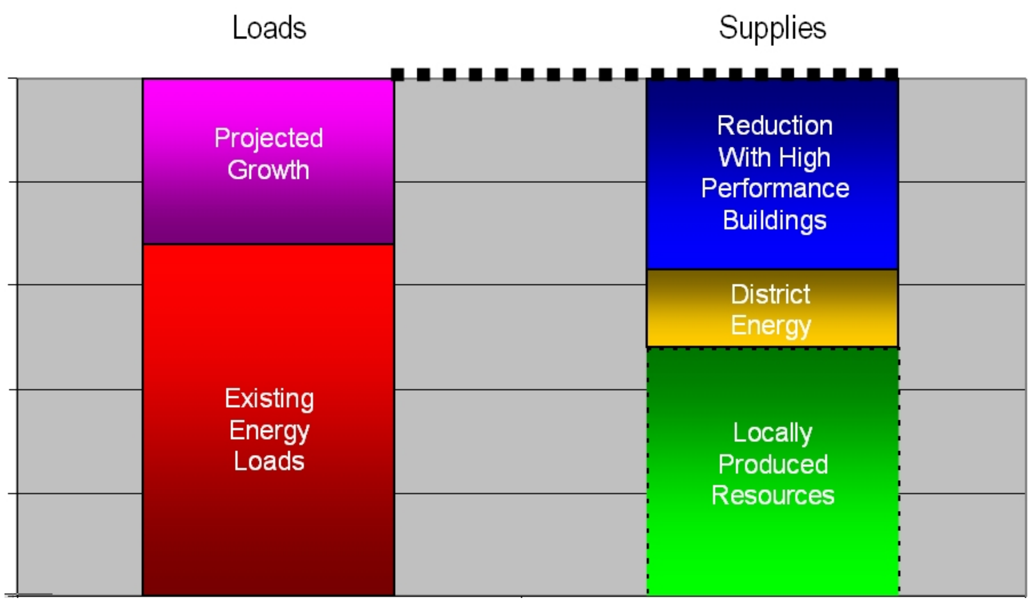

Figure 4 – Gap Analysis of the Energy Budget

Phase 6 – Review Policy Alternatives

An evaluation of the financial implications and the policy changes needed to incentivize the development model described in this report is beyond the scope of this project. However, by drawing on examples of policies throughout the world, we developed a set of possible strategies to consider for this region. Finally, some of these strategies were presented to planning groups within the City of Settle, where they are now being considered for possible inclusion into the City's planning and permitting procedures.

5. Case Studies

Although the neighborhood-scale approach to energy use described in this report is uncommon in the U.S., it has been considered and implemented in several communities throughout the world. By its very nature sustainable energy planning at the community scale demands a high level of involvement and commitment on the part of local municipalities, as well as a strong partnership with the local private developers. The impetus for our analysis of an EnergyPlus Neighborhood in Seattle was derived from the author's study of other communities where these concepts have been successfully implemented. This section will briefly describe several international case studies which exhibit some of the qualities of an EnergyPlus neighborhood.

Although these case studies all share in their innovative approaches to use of energy, some of them also extend much further into all aspects of sustainable community development. In these cases, an integrated approach to urban planning, transportation, and water and waste management has proven to be an important, though more indirect, aspect of their energy savings program.

All descriptions are based on site visits, on-site interviews and personal observations by the author, as well as a review of pertinent literature.

5.1. Västra Hamnen (Western Harbor) – Malmö, Sweden

Sources: The author visited Västra Hamnen on over a dozen occasions between 2002 and 2007, meeting with architects, developers and senior City officials involved in the development of the project. During that period the district has undergone a remarkable transformation, as it evolved from a bold but somewhat sterile and empty showcase of sustainable practices to a thriving and well used neighborhood that exudes a feeling of success.

Description: Western Harbor is a new neighborhood developed on the site of a former abandoned shipyard. The first phase of the project was completed in 2001 for the European Housing Expo, and was predominately residential in nature. Since then a new university and hundreds of small businesses have opened up. The area initially encompassed about 21 acres and when complete will provide for 30,000 people working, living and studying in a mixed use area with housing retail and educational facilities.

Figure 5 – Aerial View of Western Harbor

Objectives:

- Transform an industrial area into an attractive and diverse mixed use area.
- Develop a municipally mandated Quality Program in collaboration between the City of Malmö and the development community to establish meaningful and achievable sustainability goals. The Program includes binding requirements as well as recommendations for the environment, architecture and IT.
- Incorporate high building efficiency standards to reduce energy consumption to half the amount used in other residential properties in Malmö, and then rely on renewable energy resources to provide 100% of the neighborhood's remaining energy needs.
- Work with construction companies to develop new technologies, new materials and new types of construction in order to achieve sustainability and efficiency goals.
- Evaluate the viability of technologies such as solar PV which may not yet be commercially viable.

Technologies deployed:

- 2MW off-shore wind turbine adjacent to community provides almost 100% of the electrical needs for the initial 2,000 homes.
- Groundwater from 10 thermally isolated hot and cold water wells feeds a central heat pump plant, which delivers hot and chilled water to the City's district energy system. The system moves groundwater seasonally between the hot and cold portions of the aquifer, thereby taking advantage of the temperature differential maintained to increase the efficiency of the heat pumps. The system's contribution to the district energy network fulfils 85% of the neighborhood's heating and cooling load.
- 1,300 sf of solar PV and 15,000 sf of solar thermal panels are installed on 11 of the buildings, but owned and operated by the local energy utility. The flat plate and vacuum tube thermal solar panels feed hot water into the district heating network and fulfill 12% of the heat load.

Figure 6 – Tango Development in Western Harbor

- Performance based energy codes were enacted, limiting total energy consumption of Phase 1 projects to 9.75 kWh per sf (105 kWh/m2) – 3.25 kWh/sf for electric and 6.5 kWh/sf for heating.
- Biological wastes from 22 of the homes are captured and transported to a biogas digestion facility, where they are processed to produce natural gas for 3% of the neighborhood's heating load.
- Urban planning – the area was developed as a largely car-free zone, with frequent bus service to the center of the City. A "wall" of taller building around the perimeter of the neighborhood provides a more intimate interior setting that encourages walking, and protects the inner buildings from the impact of the cold winds blowing in from the sea.
- All storm water is conveyed through a network of surface channels, open gutters, fountains and wetlands, providing natural drainage and filtration before being returned to the sea.

Performance and benefits:

The Western Harbor redevelopment transformed a contaminated industrial area into a vibrant new neighborhood, which is attracting new residents back into the city from the surrounding suburban areas. In the process, the City has redefined its image from that of a blue-collar working class city to a highly sustainable, knowledge based center. Although connected to Malmö's electrical and district energy systems, 100% of the area's annualized energy requirement is now met by on-site, renewable energy sources. Through this process, developers, architects and engineers and have been encouraged to evaluate new building techniques and materials that can be applied to other communities.

5.2. Vauban – Freiburg, Germany

Sources: The author visited the Vauban District in May 2005 and September 2006, touring many of the buildings and facilities there. On the latter site visit he also spent a day and a half meeting with Wulf Daseking, the Director of Planning for City of Freiburg and the visionary behind many of Vauban's sustainability goals, in order to better understand some of the policies and approaches implemented there.

Description: Vauban is a new district being completed on the site of a former military base. It became available for urban development after the French occupation force left in 1992. The City of Freiburg purchased the area from the federal government, and has been responsible for its planning and development. The concept was developed by the municipality in conjunction with local NGOs and prospective buyers, relying on a process of extensive public participation and a principle of "Learning While Planning". Initial planning began in 1993, with completion of the 94 acre project scheduled for 2007. Vauban will have housing for 5,000 people, and provide about 600 jobs.

Objectives:

- Develop a new city district in a co-operative, participatory way which meets ecological, economical, social and cultural goals.
- Realize a sustainable model district, especially in the fields of traffic and energy.
- Balance working and living areas.
- Incorporate a co-generation plant and short-distance heating system.
- All buildings constructed to meet improved low energy standards, six years before these standards were adopted throughout the rest of Germany.
- Preference for building owners who reach passive house energy standard in special designed areas.
- Extensive use of ecological building materials and solar energy.

- Infiltration of rainwater into the ground, with ecologically based sanitary systems.

Figure 7 – Solar City in Vauban

Technologies deployed:

- All houses are built to meet a low energy standard of no more than 6 kWh/sf per year. In addition, more than 92 units planned or under construction meet the "passive house" standard of less than 1.4 kWh/sf per year. These houses do not have conventional heating systems, relying instead upon internal loads, passive-solar gains and a heat exchanger system. Ten of the homes meet the "plus energy" standard, whereby they produce more energy than they consume, with 100 to 200 more planned within the solar settlement which is part of Vauban.
- Over 4,800 sf of solar thermal panels and 13,000 sf of solar PV provide additional heat and electricity. The "plus energy" homes and other buildings incorporate PV panels as structural roof elements, replacing the traditional roofing materials.
- With the help of two funding incentives, many private households were enticed to use solar energy and energy-efficient household appliances in their building projects. The promotion of solar energy was run by FEW, Freiburg's public utility, while the program for energy-efficient household appliances was coordinated by the Forum Vauban.
- A bio-mass fired, neighborhood scale CHP is connected to the district's heating system. The plant consumes wood chips and serves domestic and hot water heating needs for about 2,000 households. In addition, this plant, together with solar PV panels installed throughout the neighborhood, provides 25% of the electricity for the area.

Figure 8 – Wood Chip Fired Neighborhood Scale CHP Plant in Vauban

- The Wohnen and Arbeiten condominium complex uses high insulation levels, heat recovery systems, and other features to reduce primary energy use by 79%. The remaining heating and electrical loads are met by solar thermal collectors and PV panels, and an on-site micro-CHP plant. The building also uses vacuum pipes to transfer sewage to a biogas plant, where it is anaerobically fermented together with organic household waste to generate biogas, which is used for cooking. The remaining gray-water is cleaned in biofilm plants and returned to the water cycle.
- Wind corridors were incorporated into the urban plan to take advantage of daily wind flow cycles. This draws in colder mountain air to reduce the cooling load during the summer, and helps flush out fog and air-borne pollutants during the winter.

Performance and benefits:

The Vauban development successfully implemented new concepts in the fields of energy, traffic / mobility, building and social interaction/public spaces. The transit oriented design, with a new trolley line passing through the heart of the district, has minimized the need for car ownership. Nearly 50% of Vauban's households are "car-free", relying on alternative mobility resources instead.

Vauban now contains one of the largest solar oriented developments in Europe. Compared to a traditional neighborhood in the same climate, Vauban has demonstrated annual energy savings of 7.8 MWh, reducing CO^2 output by 2,300 tons per year.

The Forum Vauban association was approved as the official coordinator of citizens' participation by the city in early 1995. The principle of "Learning while Planning" and the extended citizen participation within Forum Vauban set new standards of communication, interaction and integration.

5.3. Lonsdale – North Vancouver, B.C., Canada

Sources: The author visited the Lonsdale District in March 2007, and interviewed Bill Susak, general manager of the Lonsdale Energy Corporation (LEC), and other staff members of the City of North Vancouver by phone.

Description: Based on the model of European energy systems, The LEC is developing a new district energy system to provide competitively priced energy for heating while significantly reducing the demand for electricity. Major growth is expected in Lower Lonsdale as more people decide to live and work in one of the Lower Mainland's most vibrant neighborhoods. The city's Waterfront Project, Pier Development and proposed National Maritime Center are all expected to transform the former Shipyards site and bring new visitors and businesses to the area.

Figure 9 – Lonsdale District Energy System

To accommodate this anticipated growth the North Vancouver City Council insisted that energy planning be included along with other traditional urban planning issues such as land use, transportation, and infrastructure. This was an unusual consideration because in British Columbia energy planning is traditionally carried out by provincial-scale organizations such as BC Hydro for electricity and Terasen Gas for natural gas. However the City Council knew that status quo land development practices, where large buildings are often heated solely with electricity, would only contribute to a growing electrical energy supply and demand gap within British Columbia. The City decided that it had a responsibility to lead the way in ensuring that energy use was as sustainable as possible in its future.

By establishing a distributed district energy system, the City of North Vancouver can provide heating to several different types of buildings in a large area, as opposed to building a large, expensive central energy plant. LEC represents British Columbia's first major redevelopment project to be integrated with a community energy plan.

Objectives:

- Provide dependable. Clean and competitively priced energy while significantly reducing the demand for electricity.
- Improve on the European model of district energy by eliminating the need for a large central heating plant.

Features:

- Gas fired boiler mini-plants are being installed in the basements of several buildings and linked together via a new district energy system that distributes hot water through underground pipes, eliminating the need for each building to install its own boiler. Distributed energy production means that if one mini-plant fails the load can be easily shared with other mini-plants to avoid an energy outage.
- By installing a mini-plant in the basement of newly developing buildings, LEC is avoiding the need to build a new stand-alone facility. Instead, new mini-plants are being added

where and when they are needed as the system expands. Distributed production with mini-plants eliminated the capital investment needed for traditional energy plants, reduced the potential for land use conflicts with neighboring building owners, eliminated the visual impacts of the project, and minimized staffing and maintenance needs.

- The hot water based system is designed to be adaptable for alternative energy sources in the future, such as fuel cells.

Figure 10 – CHP Mini-Plant in Lonsdale

- LEC is a wholly owned city corporation working in partnership with Terasen Utility Services. As regulator of land use in the neighborhood, the City can place contractual requirements on builders who develop in the area, such as mandating that all buildings constructed on City lands use hydronic heating, compatible with a future connection to the system. Terasen provides all operations services as well as the design, construction, maintenance and operations of the boiler plants.
- The system's mini plants will contain more than 24 high-efficiency natural gas fired boilers, operating at overall efficiencies of 85 to 90%. The efficiency improvements resulting from the replacement of inefficient boilers with efficient ones, elimination of the heat to electricity process, and electricity transmission losses translate into direct economic and environmental benefits for the City and the entire Province.

Performance and Benefits:

The first plant is providing district energy services to five major buildings, with three mini-plants scheduled to provide heat for eight to ten buildings by 2008. Within 10 years more than three million square feet of residential and commercial properties will be connected to the system.

The district energy system is delivering hydronic heat three times more efficiently than electrical heat previously used. Since British Columbia imports electricity, often coal generated, to meet winter peak demands, the system is reducing nitrous oxide emissions by 64%, and carbon dioxide emissions by 21%.

5.4. Hammarby Sjöstad – Stockholm, Sweden

Sources: The author visited Hammarby Sjöstad in April 2006, followed by e-mail communication with staff from the City of Stockholm, and extensive literature surveys.

Description: Located on a former industrial-use Brownfield site and initially intended as a location for the 2004 Summer Olympics, Hammarby Sjöstad is being developed as one of Stockholm's largest urban development projects. Although Hammarby Sjöstad is located outside what is traditionally considered to be the perimeter of inner-city Stockholm, the design is intentionally urban rather than suburban, with boulevards, architecturally varied city blocks, and commercial spaces in the ground floor of the buildings. When completed in 2012 Hammarby Sjöstad will include 9,000 apartments for approximately 20,000 residents, with a total build-out for 30,000 living and working in the area.

Figure 11 – Hammarby Sjöstad
(Photo by Victoria Henriksson)

Objectives:

- Provide additional in-city housing for Stockholm residents by converting the industrialized waterfront into a mixed-use residential / commercial development.
- Make the Hammarby Sjöstad redevelopment project a leading showcase of urban sustainability by demonstrating the feasibility of improving efficiency in all areas of resource and energy use by a factor of two.
- Co-ordinate efforts of Stockholm's energy and water utilities in order to minimize externally supplied resources in the form of energy, nutritive substances and material.
- Reduce the economic cost of urban living by implementing a cyclical reuse model through intelligent lifestyle adjustments, policy and regulation, innovative and integrated technological systems, and the use of renewable energy sources and 'waste.'

Features:

- The Fortume thermal power plant supplies Hammarby Sjöstad with district heating and cooling from treated wastewater and biofuels. While all food waste is composted into soil, the remaining combustible wastes are incinerated to produce district heating and electricity. Additional heat for the system is recovered from the purified wastewater stream of the Henriksdal sewage plant.
- Hammarby Sjöstad has its own demonstration wastewater treatment plant that was built to test new technologies. Four different processes are currently being assessed, to evaluate how best to extract nutrients from sewage and wastewater for use on farmland.
- Four of the ten construction companies represented in the area are installing PV systems in their projects, producing an estimated total annual electrical output of 63 MWh. The NCC project alone contains 4,600 sf of PV panels integrated into the façade, balconies, and windows, producing about 32 MWh per year. The projects looked for double functions where PV has an added value - giving architectural benefits in additional to the energy produced – to demonstrate how PV can best be incorporated in an architecturally conventional building.
- Total annual building energy use is limited to 5.6 kWh per sf through the use of thick insulation, best available window technologies (including 4-glazed windows), heat recovery systems, controlled ventilation and the selection of Class A energy efficient appliances.
- A vacuum powered waste disposal system draws paper, organic waste and combustible waste through tubes to a central sorting office where materials are graded for recycling, including biomass for heating. Bringing all waste to a central processing room streamlines collection and reduces vehicle traffic in the area.
- The City of Stockholm and local utilities jointly developed the "Hammarby Model," a model for the integrated handling of energy, waste and water. This shows the interaction between sewage processing and energy production, and the added values that society gains from modern sewage and waste processing systems.

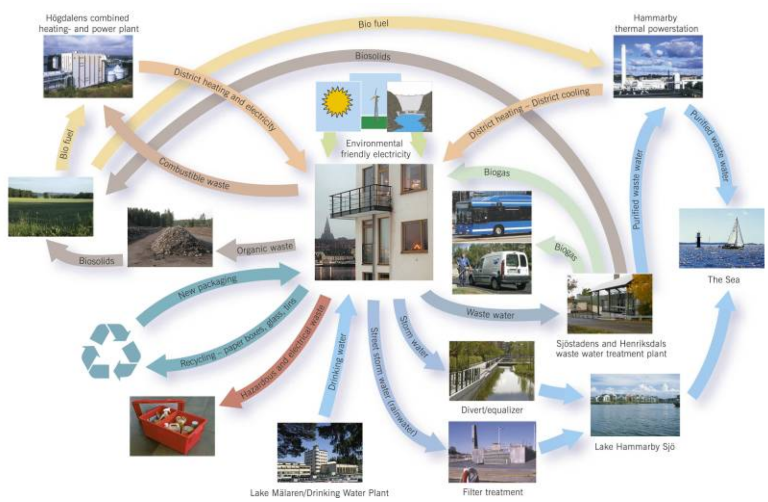

Figure 12 – Hammarby Model

- Biogas is produced in the wastewater treatment plant from the digestion of organic wastes. The wastewater from a single household produces sufficient biogas for the household's gas cooker, installed in approximately 1,000 apartments. The remainder of the gas produced is used as fuel in eco-friendly cars and buses, and in Hammarby Sjöstad's biogas-powered ferries.

- GlashusEtt, the environmental information center, disseminates knowledge via study trips, exhibitions and demonstrations of new environmental technology including fuel cells, green roofs and the building's double-glazed façade. GlashusEtt often plays host to overseas visitors as part of its cooperation with the City of Stockholm and Swedish Trade Council.
- Rainwater from surrounding buildings is led via open drains to an attractive channel. The water then runs through a series of basins and then out to the lake. By disposing of all storm water locally, the impact on the waste water treatment plant is minimized.

Performance and benefits:

Stockholm's overall effort to connect homes and other buildings to biofuel powered district heating has reduced per capita energy needs to less than 40% of the 2000 levels.[21]

The developers, promoters, constructors and sub-contractors that came to Hammarby Sjöstad have turned the site into a full-sized laboratory, finding new solutions for addressing energy, water, waste, transport, building design, and construction site logistics. Contractors have estimated that the additional requirements of construction added 3 to 5% to their total costs. In the process a consensus based model for cooperation was developed between the various city administrations, special interest groups, research institutions, and the private sector.

6. Study Area Background

6.1. The City of Seattle

Seattle, Washington is generally considered to be one of the country's most environmentally oriented communities, and has long been a leader in promoting energy efficiency as an alternative to constructing new power plants. SCL, the municipally owned electric utility serving the City of Seattle, has a policy of GHG neutrality. In December 2005 it became the first large electric utility in the nation to reach a net zero emissions goal.[22] The utility avoids emissions through using conservation and, when practical, renewable, non-GHG emitting energy. SCL also purchases offsets equal to its remaining GHG emissions from power generation and from operations such as vehicle use and airline travel.[23]

The Mayor of Seattle, Mayor Greg Nickels, has also been a leader in the national effort to address climate change. Through his leadership 522 U.S. mayors representing over 65 million Americans have now signed on to show their commitment for meeting the goals of the Kyoto Protocols at a municipal level,[24] despite the federal government's reluctance to adopt these principles at the national level.

The City also has a longstanding tradition of support for Green Building. In 2000 Seattle became the first city in the nation to formally adopt a Sustainable Building Policy,[25] and in 2006 the City established a dedicated Green Building Team within DPD to "…make green building standard practice in Seattle through education, technical assistance and incentives." [26]

These efforts are beginning to converge in the area south of the downtown core, known as the South of Downtown (SODO) neighborhood. The SODO neighborhood is a superset of the PSSD neighborhood being analyzed in this report. Since July 2005 DPD has been leading a public process to solicit input on proposed zoning changes to the South Downtown area, as part of Mayor Nickels' "Center City Seattle" strategy, which focuses on encouraging economic growth, transportation, new housing, and great urban neighborhoods in Seattle's downtown core and the nine centrally located neighborhoods immediately around it.[27] The South Downtown Advisors Group released a preliminary set of twelve sustainability recommendations for a Livable South Downtown, including several that could lead directly to support for innovative energy strategies.[28]

- Consider LEED™ Silver as a requirement for all new buildings or Built Green 4-Star or better for multi-family.
- Create and implement a new "Sustainable Infrastructure Policy" for all City Departments active in South Downtown.
- Evaluate a range of thermal and electrical strategies and efficiencies that could be appropriate in South Downtown.
- Develop a feasibility development analysis that explores the potential for a green business area that could incubate, co-locate, and encourage new and emerging sustainable businesses.
- Identify special sustainability demonstration zones to initiate implementation and experimentation of these policies.

This position was further solidified at the December 5, 2006 meeting of the Advisors Group, when a subgroup was established to look specifically at the opportunities for incorporating comprehensive sustainable energy strategies as one of the recommendations of the planning effort.

Figure 13 – Draft Sustainability Recommendations, Livable SODO Advisory Group

The SODO Draft Environmental Impact Statement (EIS) will be published in September 2007, with the final EIS scheduled to be published in early January 2008.[29] This EIS will eventually lead to significant zoning changes, so many potential projects in the PSSD neighborhood are awaiting the results of this rezoning. In the areas where the SODO Advisory Group is recommending higher densities there is a provision to encourage public amenities such as affordable housing, green spaces, etc. through "incentive zoning" criteria. This approach could potentially be expanded to provide incentives that encourage sustainability and energy efficiency as well.

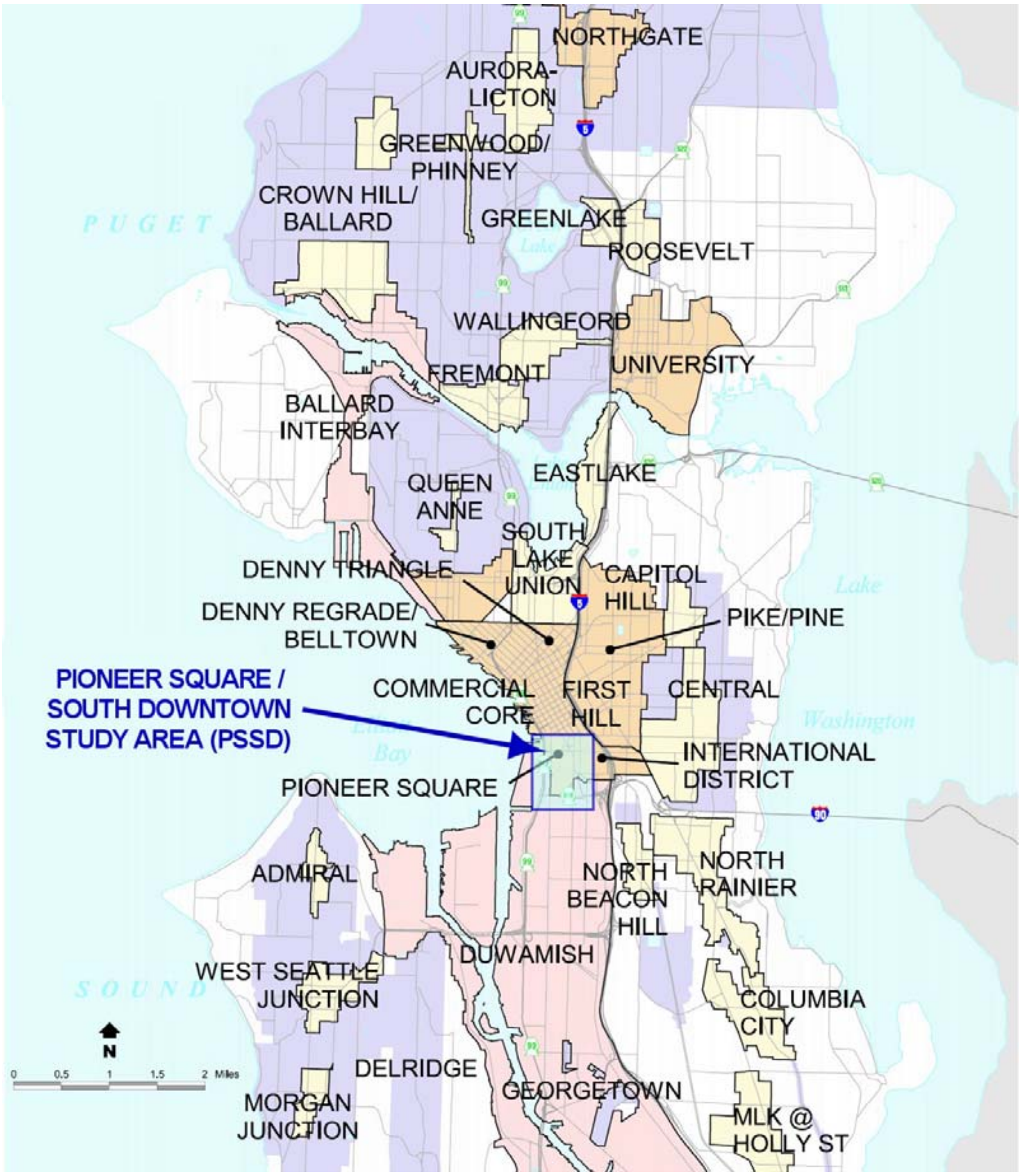

Figure 14 – Seattle Overview Map

6.2. Selection of Study Area

The PSSD area was selected for this study for a number of compelling reasons. One of the major goals of this study was to examine the possibility of taking a neighborhood and implementing major changes to building designs, infrastructure and policies. Since new developments each year represent only a tiny proportion of the total existing building stock, we felt that it was important to better understand the potential for renovating an existing neighborhood to EnergyPlus standards. For this reason it was decided early on to identify an established neighborhood in Seattle, rather than the much more straightforward alternative of planning for a new, greenfield development. In addition to meeting this baseline requirement, the PSSD neighborhood exhibited the following characteristics that made it a suitable study area:

- Mix of uses – our initial assessment of the neighborhood indicated that the neighborhood contained a wide variety of building uses, including residential, commercial, and light industrial. This combination not only allowed us to consider strategies that might be most suited for a specific type of building or use, but also created the possibility for examining the benefits of load diversity created by differences in timing and level of energy use between different building types.

- Urban setting – this neighborhood is located in a fairly dense neighborhood adjacent to the downtown core of America's 13th largest metropolitan area.[30] Since 58% of Americans now live in cities of 200,000 people or more[31] the lessons learned here will be highly relevant to planners throughout this country and abroad.

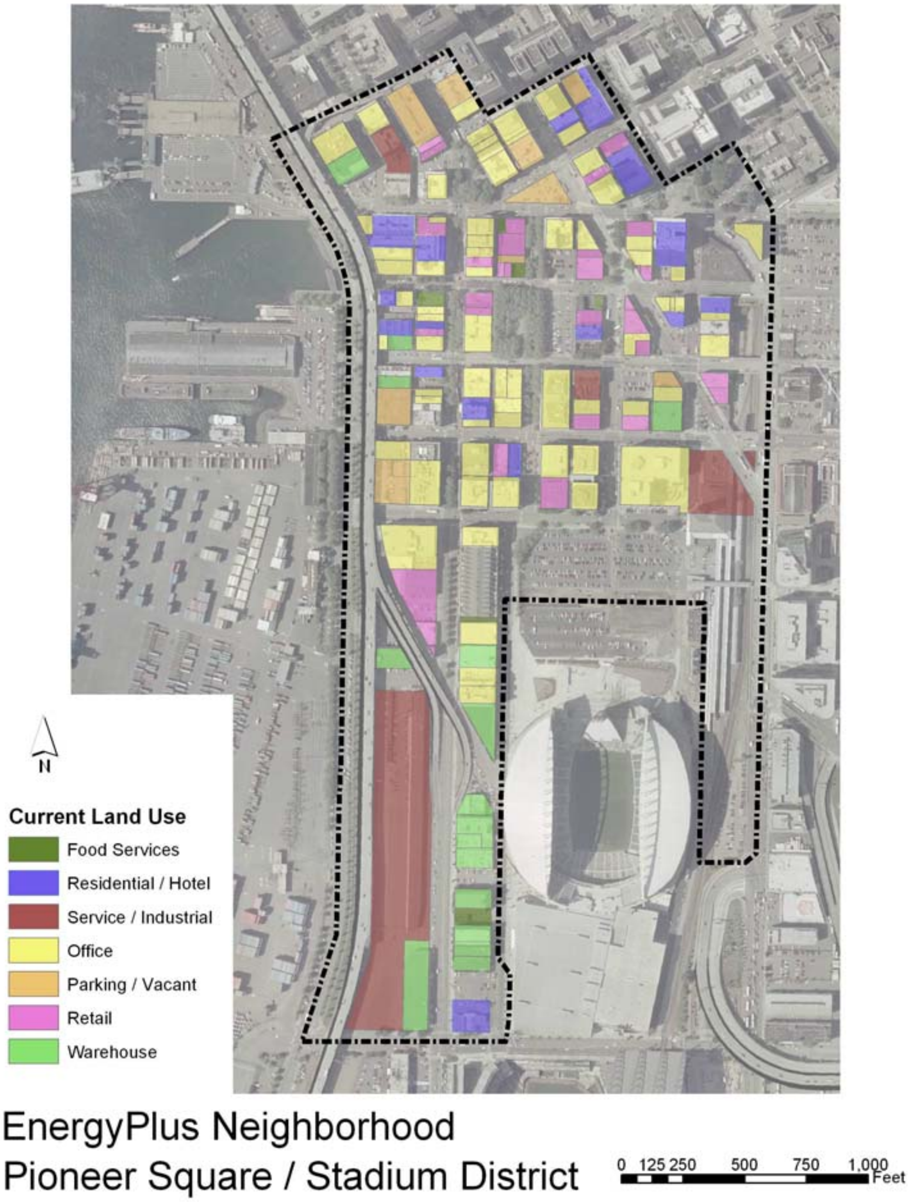

Figure 15 – Map of PSSD Study Zone

- Poised for change – the City of Seattle has designated this neighborhood as part of the Seattle Downtown Regional Growth Center, an urban center that is expected to undergo significant changes in its urban form as it accommodates major population growth.[32] As previously described, for the past 18 months the City has been conducting a planning effort, the Livable South Downtown, which is developing new zoning and land use regulations to stimulate housing and related development consistent with the Mayor's Center City strategy for great urban neighborhoods.[33] The lessons learned from this study therefore have the potential to help define the policies that will shape this evolving neighborhood during the next ten years.
- Public and private support – support of the public and private development community is critical for the results and recommendations of this report to have any impact. Not only have members of the City's staff expressed their willingness consider additional input for the SODO planning process, but several of the key developers who have land holdings in this neighborhood are already recognized as leaders in sustainability. Most have also participated in sustainable study tours organized by International Sustainable Solutions, where they have had a first hand opportunity to visit some of the sustainable neighborhoods profiled in the case studies of this report and gain familiarity with the concepts.

6.3. Study Area Description

The Pioneer Square / South Downtown neighborhood (PSSD) contains about 115 acres (5.0 million sf) immediately south of Seattle's downtown core. The area is bordered on the west by Alaskan Way South, and at its eastern extreme by 4th Avenue S. The northern boundary begins about two blocks north of Yesler Way, in the heart of the historic Pioneer Square neighborhood, and extends south just over 4,000 feet to Royal Brougham Way. The study area is U-shaped in its bottom half, wrapping around the east and west sides of the stadium district, which was excluded from our study.

PSSD includes one of the oldest portions of Seattle. The area around Pioneer Square was originally rebuilt after the 1889 fire, which destroyed almost all of Seattle's downtown. The majority of the buildings in this area are three to five story brick buildings, constructed more than one hundred years ago.[34] These buildings are some of the oldest structures in Seattle, and many are now protected by historical preservation regulations. Although a significant number of buildings have been renovated during the past 30 years, very few new buildings have been constructed. Because of recent and anticipated changes in zoning and maximum acceptable building heights, the area is attracting significant development interest, and will likely experience a dramatic increase in new construction in the near future.

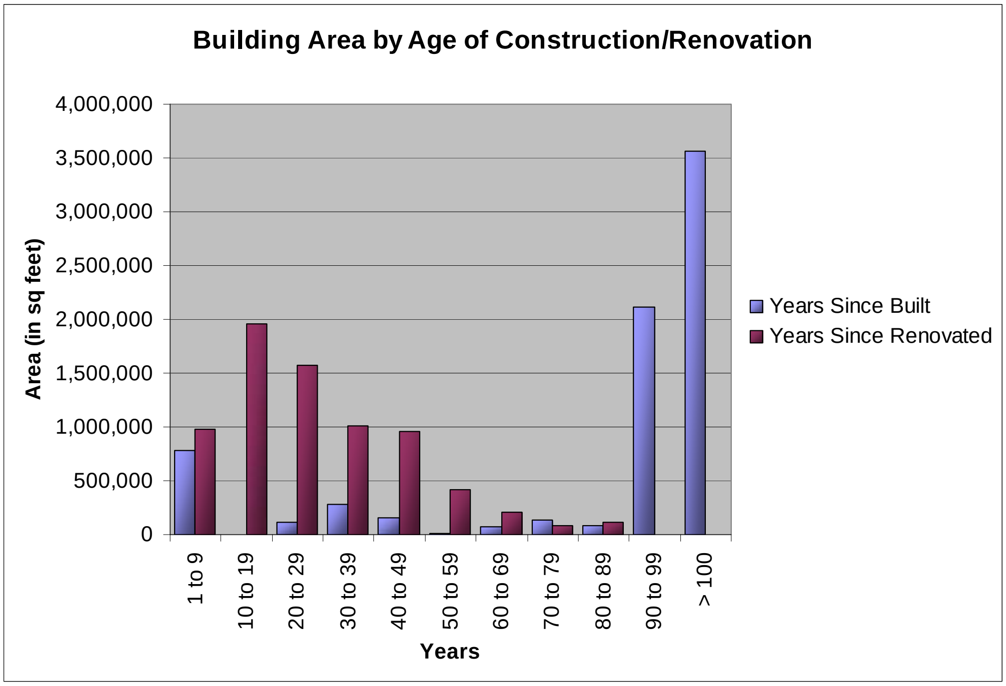

Figure 16 – Building Area by Age of Construction/Renovation

Most of the buildings in the neighborhood are used as commercial offices, with low income housing and residential hotels constituting the next largest grouping. Older warehouses dominate the southern portions of the study area. There are currently 7.3 million sf of developed real estate within the study boundaries, with just over 55% (4 million sf) being commercial office space.[35]

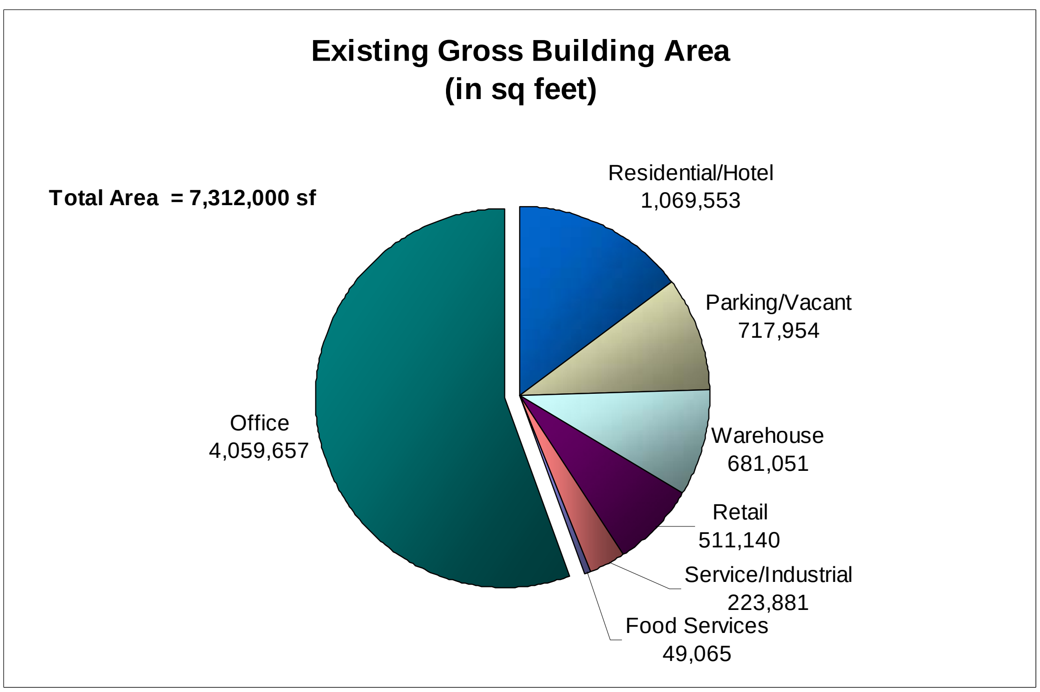

Figure 17 – Existing Gross Building Area

The King County Assessor's GIS Database was used as the foundational data source for analyzing the properties located within the study region. Several of the tables were combined to provide a single, consistent source for all relevant descriptive and quantitative information about each building, such as:

- General Building Use
- Detailed Building Use
- PIN (unique Parcel ID Number)
- Building Number (for multiple buildings sited on a single parcel)
- Property Description
- Address
- Lot Area
- Building Area (Gross and Net)
- Floors
- Heating System
- Construction Type
- Year Built
- Year Renovated

The tax assessor's parcel is the standard property unit used to define a building's use and address, and each parcel is defined by a unique PIN (Parcel ID Number). Although it is possible for a parcel to contain multiple buildings, the database will assign a common address and building use description to all buildings within a single parcel. A GIS analysis of our study area determined that after the vacant parcels, unimproved parcels and surface parking lots are removed, the PSSD region contains 159 unique buildings, located on 152 distinct parcels.

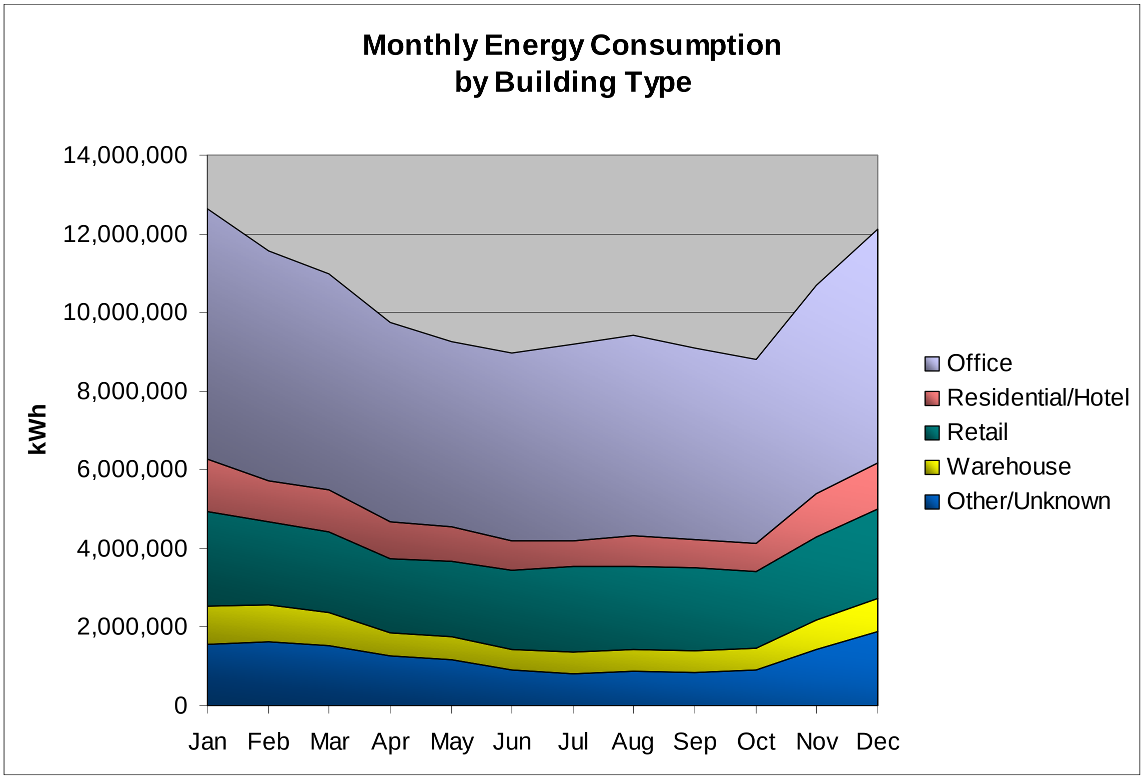

Figure 18 – Monthly Energy Consumption by Building Type

Initially Qwest Field and Safeco Field, the two large professional sports stadiums at the center of the study region, were included as a distinct use category. However, after our initial assessment of energy consumption patterns these were excluded, and the study area was redefined to its present configuration of a U-shaped region wrapping around the stadiums. The occupancy and use patterns of professional sports facilities are very different from those of most other commercial buildings. For example, Qwest Field is the home of the Seattle Seahawks professional football team. The stadium can seat up to 72,000 fans, and the adjacent Event Center is used primarily for trade and consumer shows. Although Qwest Field is also used for a small number of soccer matches and other outdoor events throughout the year, it is generally only filled to capacity on about ten days, when the Seahawks are playing home games. This produces very high energy peaks for lighting and other operations for a handful of hours, but loads are comparatively low at all other times. This is a very atypical load profile; it is representative of only a handful of similar facilities around the country, yet large enough on a small number of days to dominate the results for the remainder of the neighborhood. . Since one of the primary goals of this project was to develop a model for energy analysis on a neighborhood scale that would be representative of other typical urban neighborhoods, we excluded the sports stadiums from our study.

About 50 other buildings were removed from the study region at the same time, to maintain a more consistent and spatially connected area. The study size was reduced from 200 buildings, with an area of 11.2 million sf, to 158 buildings, with an area of 7.3 million sf. This was achieved primarily by eliminating all of the sports facilities (2.5 million sf) and 57% of the warehouses (reduction of 680,000 sf), which dominate the southern portion of the stadium district.

6.4. Unique Local Challenges

Seattle, Washington is internationally regarded as an environmentally progressive area and, as described above, the political leadership has taken a leading role in support of climate change initiatives. However, despite this attitude, there are several challenges that prevent the City from simply adopting some of the policies, practices and technologies that have worked successfully elsewhere:

- The area of our study was intentionally chosen to be an existing neighborhood, not a green-field development. Opportunities for significant changes are therefore much more limited, as existing buildings and infrastructure must be accommodated to the greatest extent feasible. Furthermore, making changes to major infrastructure systems, such as constructing new district energy piping or electrical distribution lines, is much more difficult and disruptive in an existing neighborhood.
- Seattle and the Pacific Northwest region have access to vast hydropower resources, and the projects operated by the Bonneville Power Authority and local utilities have historically provided the region with some of the lowest electric rates in the world. Because it depends on hydropower for over 90% of its resource base, and has actively sought other renewable energy sources, SCL, the municipally owned and operated electric utility, is one of the greenest electric utilities in the U.S. Therefore, Seattle's ratepayers already have access to energy that is both clean and inexpensive. SCL's 2006 Integrated Resource Plan shows that with the City's growth in energy needs, Seattle will outstrip the capacity of its existing resource base by 2010.[36] However, at present the utility's management feels that there is no compelling reason to be looking at fundamentally different strategies for meeting the City's energy needs.
- Because of its age and historical significance, almost all of our study area is designated as a historic district, so we are more limited in the energy efficiency measures that could be recommended for these buildings. Though nothing in the historic district requirements precludes constructing the infrastructure for a district energy system, any changes to the building envelope that impact facades and windows would be subject to historic preservation requirements.[37]
- In all of the case studies noted the local or national government was a major landholder, and thus had ultimate authority in defining the project goals for neighborhood redevelopment. These developments typically occurred on lands that were formerly under utilized, so that government authorities saw an opportunity to make a bold statement by developing a new type of community that incorporated sustainable values and goals. For example, Western Harbor was developed on the former site of a contaminated shipyard. The Mayor of Malmö, with the support of the national government, promoted the idea of hosting the BO01 National Building Exposition, in order to demonstrate to the world that Malmö was changing its identity from that of a working class, industrial city to that of a knowledge based community on its way to becoming a world leader in sustainability.

  Even in the Lonsdale District of North Vancouver, which as an existing urban neighborhood is not changing in character to the same degree as its European counterparts, the local government is a major landholder and party to the development. The City of North Vancouver not only actively voiced its goal of creating a more energy sustainable neighborhood, but was able to leverage its ownership position to provide the initial impetus needed to drive the desired changes.

  Seattle's PSSD neighborhood is an existing urban neighborhood that, though it is undergoing significant change, is not going to experience the same degree of fundamental change as the other communities in our case studies. Furthermore, with the exception of the 3.85 acre North Lot, which is currently owned by King County, all properties within the neighborhood are privately owned. When combined with the stronger role of private real estate developers in the U.S. market, this means that the City of Seattle is much less likely to mandate the measures that have been used to create this type of a sustainable neighborhood in other places. The implications of this political reality are discussed in more depth later in this report.

7. Existing Energy Budget

7.1. Data Sources

In order to determine the potential for living within an energy budget constrained by the amount that can be produced within the neighborhood, we first began by calculating existing energy needs. The area is served by three different utilities:

1. Seattle City Light (SCL) – the municipally owned electric utility for the City of Seattle serves 375,000 customers in the greater Seattle area, and provides all electric service for the PSSD neighborhood. SCL's portfolio is 86% hydro, 6% coal and natural gas, 4% nuclear, and 3% renewables. Because of its large portfolio of hydro assets SCL's retail commercial electric rates have long been among the lowest in the nation, averaging 3.7 cents per kWh from 1993 to 1997.[38] Although they have risen in recent years, SCL is still able to charge the lowest cost electricity in urban America – an average of 5.9 cents per kWh for non-residential service, as compared to the U.S. average of 7.3 cents.[39]
2. Puget Sound Energy (PSE) – PSE is an investor owned utility that provides electric and natural gas service to 1.3 million homes and businesses in the Puget Sound region. PSE's portfolio of electricity resources is 42% hydro, 36% coal, and 19% natural gas.[40] Within the City of Seattle, where PSE's territory overlaps that of SCL, PSE provides gas service only.
3. Seattle Steam – the Seattle Steam Company is a privately owned, thermal distribution utility that provides steam service to 191 hospitals, hotels and commercial customers in or adjacent to Seattle's downtown core. Seattle Steam was founded in 1893 as the Seattle Steam Heat and Power Co. and has 18 miles of pipes under the streets of Downtown.[41] The steam is produced at two natural gas fired boiler plants, on Western Avenue just west of the Pike Place Market, and on Post Avenue at Yesler Way, in Pioneer Square. Plans are currently in progress to convert one of the existing boilers to use recovered urban wood as its primary fuel source.

Older buildings, including many of those in the Pioneer Square neighborhood on the northern perimeter of PSSD use radiators for heating, and are serviced by Seattle Steam. Newer multi-story buildings throughout the city typically use gas heat in commercial spaces, with electric baseboard heating commonly used for residential construction.

Because of privacy issues with billing records, we were unable to gain access to energy consumption records on an individual building basis. Instead, each of the three utilities serving this area agreed to provide monthly billing records, aggregated by all buildings for a particular type of use. After a review of the land use records, the buildings were categorized into five primary use categories:

- Office
- Residential/hotel
- Retail
- Warehouse
- Other / Unknown (Food Services, Parking/Vacant and Service/Industrial

These use categories were aggregates based on the more detailed designations used in the King County Assessor's tax data tables. These tables identify every parcel in the county by its primary occupancy – mixed use facilities, with retail on the ground floors and commercial or residential above, are designated only by their primary use. Because of this simplification, retail and other ground floor uses are potentially under reported compared to actual conditions. However, after a visual inspection of the buildings in the neighborhood we determined that the impact on our analysis would not be significant.

The detailed results of this initial analysis are shown in Table 12 of Appendix Section 12.1, with results summarized below.

	Annual Consumption (in MW/h)	Annual Consumption (in aMW)
Office	63,121	7.2
Residential / Hotel	11,152	1.3
Retail	25,074	2.9
Warehouse	8,270	0.9
Other	14,838	1.7
Total	122,454	14.0

Table 1 – Existing Annual Loads in PSSD

The average monthly load profiles for all fuel sources are shown in Figure 19.

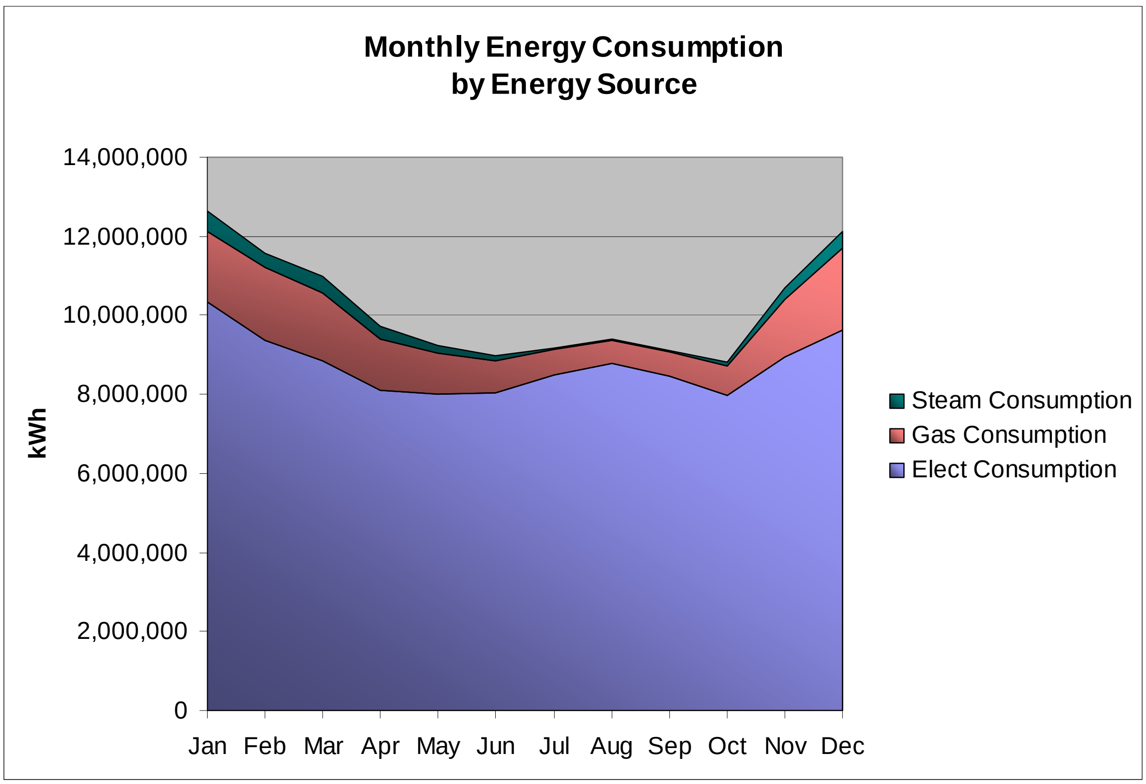

Figure 19 – Monthly Energy Consumption by Energy Source

The utilities provided only meter data that was associated with a requested physical address, as reflected in the King County Assessor's database. Although these numbers should represent all major, privately billed loads for the neighborhood they do not necessarily represent the complete energy profile for the neighborhood. For example, there may be additional loads for the City of Seattle, such as street lighting and services at parks and other public facilities that are not included in our analysis. In addition, undeveloped parcels and those without any permanent buildings were removed from our analysis during the initial screening. Therefore parking lot lights and other similar loads may have been ignored.

It was also difficult in some cases to match the physical addresses from the King County Assessor's database with the meter numbers which utilities use to track consumption. This was particularly true with natural gas records. PSE was able to retrieve, through GIS analysis, all loads generated within the boundaries of the PSSD neighborhood, but fully 52% of the loads could not be matched to an address. This means that, though the cumulative totals for energy delivered by PSE are reliable, the distribution between different building types had to be estimated.

The utility data we received allowed us to complete a detailed Bottom-Up Analysis; by aggregating hundreds of individual meter readings we were able to generate an overall energy budget for the existing PSSD neighborhood. However, because of concerns raised by the known errors in matching meter readings to physical addresses we also performed an independent Top-Down Analysis to validate the reliability of our results. For this Top-Down Analysis we examined regionally specific energy intensity data for each building type, based on an analysis of 14.7 billion square feet of floor-space in the Western U.S. compiled by the U.S. Energy Information Agency.[42]

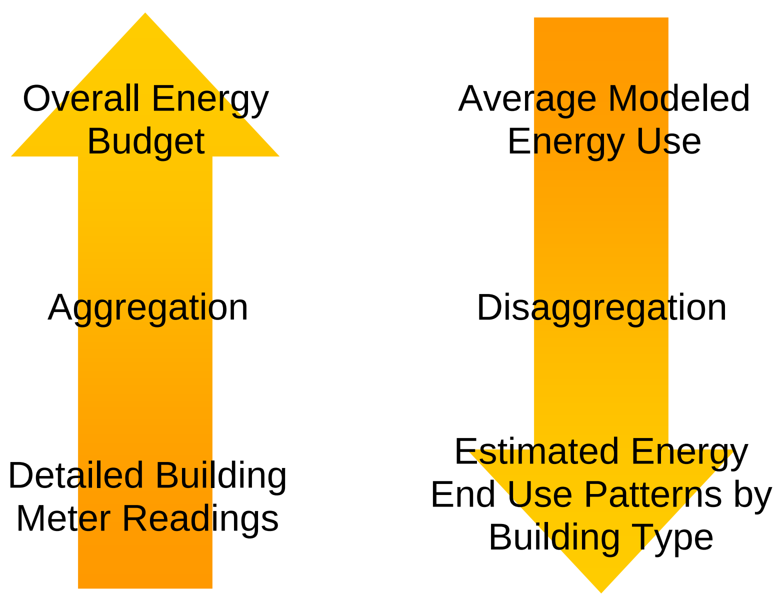

Figure 20 – Bottom-Up vs. Top-Down Analysis

These results, summarized in Table 2, show the there is a surprisingly large variation from the predicted values[a]. Energy consumption for offices was 59% lower than projected by regional averages, while that for retail spaces was 58% higher. Much of the variation could be due to the age and operating characteristics of the PSSD building stock, since it is considerably older than the average for the western U.S. These results indicate that additional validation of these numbers is needed, to better understand the reasons for this discrepancy, before a detailed cost estimate for the implementation of the recommendations in this report is attempted. However, as the total energy consumption of the neighborhood is within 27% of projected results, and the goal

[a] EIA value for Other / Unknown value is based on an weighted average of Food Services (59.5 kWh/sf), Parking/Vacant (7.7 kWh/sf) and Service/Industrial (22.0 kWh/sf).

of this project is to create a conceptual vision rather than a detailed engineering analysis, these values were considered to be within reasonable tolerances for the purposes of this study.

	Office	Residential / Lodging	Retail	Warehouse	Other / Unknown	Total
Typical Energy Intensity per EIA (kWh/sf)	24.7	24.4	20.7	7.7	13.5	
Net PSSD Area (1,000 sf)	4,060	1,070	511	681	991	7,312
Estimated Total Annual Energy Use per EIA (GWh)	100.3	26.0	10.6	5.2	13.3	155.5
Actual Annual Energy Use (GWh)	63.1	11.2	25.1	8.3	14.8	122.5
Variation From EIA Averages	-59%	-134%	58%	37%	10%	-27%

Table 2 – Measured PSSD Energy Consumption vs. Western U.S. Averages

The values shown in Table 1 were therefore accepted as the current baseline for the PSSD neighborhood – the existing average annual energy consumption is 122,500 MWh per year, or 14.0 aMW.

7.2. Internal Building Loads

In order to better characterize the existing energy needs of the neighborhood it was necessary to model the different internal loads contributing to the total. Individual utilities only track the loads they are serving, whereas our goal was to aggregate all loads together, regardless of form of energy delivered (electricity, natural gas or steam) or the utility providing it.

Figure 21 illustrates the energy flow serving the built environment;[43] in this diagram, fuel sources are shown on the left side, while end uses are shown on the right side. While some loads in a building rely, by their nature, on a specific type of energy, many can be met from a choice of energy sources. For example, computers and most other plug loads require a source of electricity, though even this can be supplied either from the utility grid or from on-site production. Many other loads are primarily thermal – they can be met by any appropriate combination of electricity or gas, as well as recovered heat or solar energy. Though not shown implicitly in this figure, thermal loads can also be met through a connection to a district energy system.

We were particularly interested in better understanding the proportion of loads that are of thermal nature (space heating, hot water and air conditioning) vs. those that can only be served by electricity. Since Seattle is in area with large hydroelectric capacity, and has historically had some of the lowest electric rates in the country, electricity has commonly been used to serve thermal loads that might best be handled in the future by other means. Thermal energy is inherently a “lower grade” of energy than electricity, making it easier and less expensive to produce. Substituting readily available sources of thermal energy for electric service where possible is one of the key strategies we will be assessing for reducing overall energy consumption.

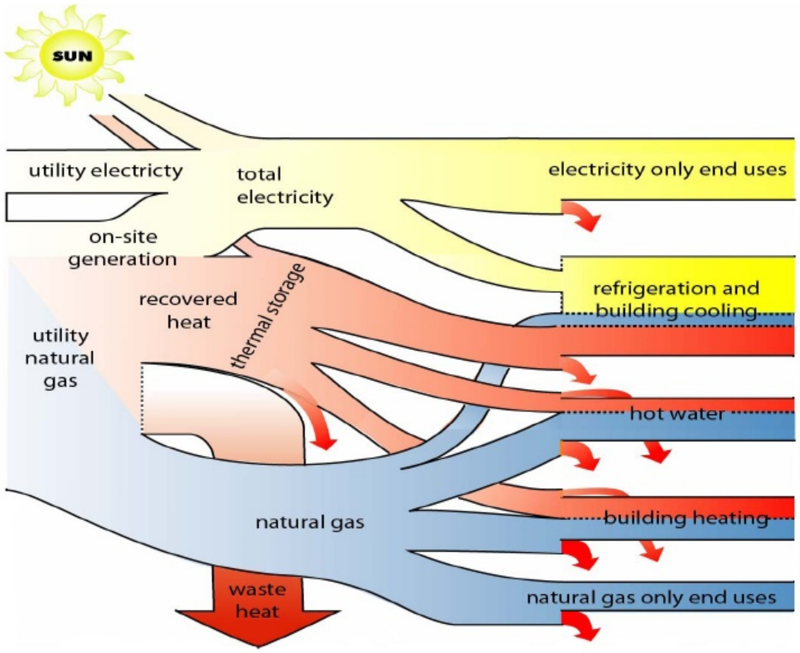

Figure 21 – Energy Sources and Uses in the Built Environment

Per the Energy Information Agency's Buildings Energy Data Book, the internal loads for a typical office building can be broken down as shown in Figure 22.[44] However, for our analysis we looked more closely at actual billing data in order to estimate the internal load characteristics.

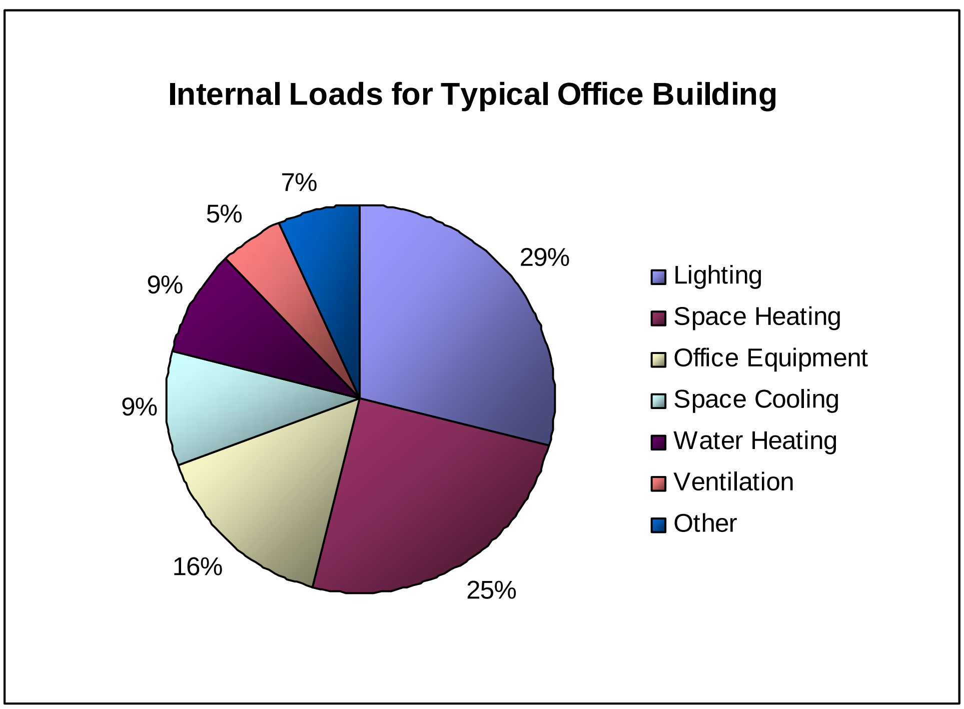

Figure 22 - Internal Loads for Typical Office Building

Figure 23 shows the combined energy consumption, by month for the 4.1 million sf of office space contained within PSSD, based on records for the years 2003, 2004 and 2005. Similar load data was obtained for each of the other building use categories (e.g., office, residential, retail). Each of the utilities submitted meter readings in an aggregated format which showed total monthly energy consumption for each building type, but gave no visibility into the internal loads associated with these values. Therefore, we examined the seasonal variations of the load data and derived a breakdown of existing internal loads based on the following assumptions:

1. All steam and natural gas consumption was assumed to be used for heating (space and hot water)
2. For each building type, the baseload of regulated and nonregulated electric loads was taken as equal to the total electric consumption for the month with the minimum electric consumption. This is generally the month during the shoulder season (May or June) when heating and cooling requirements are at their lowest, at or near zero, so that remaining electric loads can be assumed to be attributed almost entirely to non HVAC requirements.
3. The electric heating load was calculated as the electric load above the baseload value during the heating season. This is generally November to May, but varied somewhat between building types, as could be seen by a visual inspection of consumption patterns. The total heating load was calculated as the combination of the electric, gas and steam heating consumption, on a monthly basis.
4. Since all cooling is from electric chillers, rooftop units and portable window units, the total cooling load was calculated as the electric load above the baseload value during the cooling season. This is generally July to October, but varied somewhat between building types, as could be seen by a visual inspection of consumption patterns.

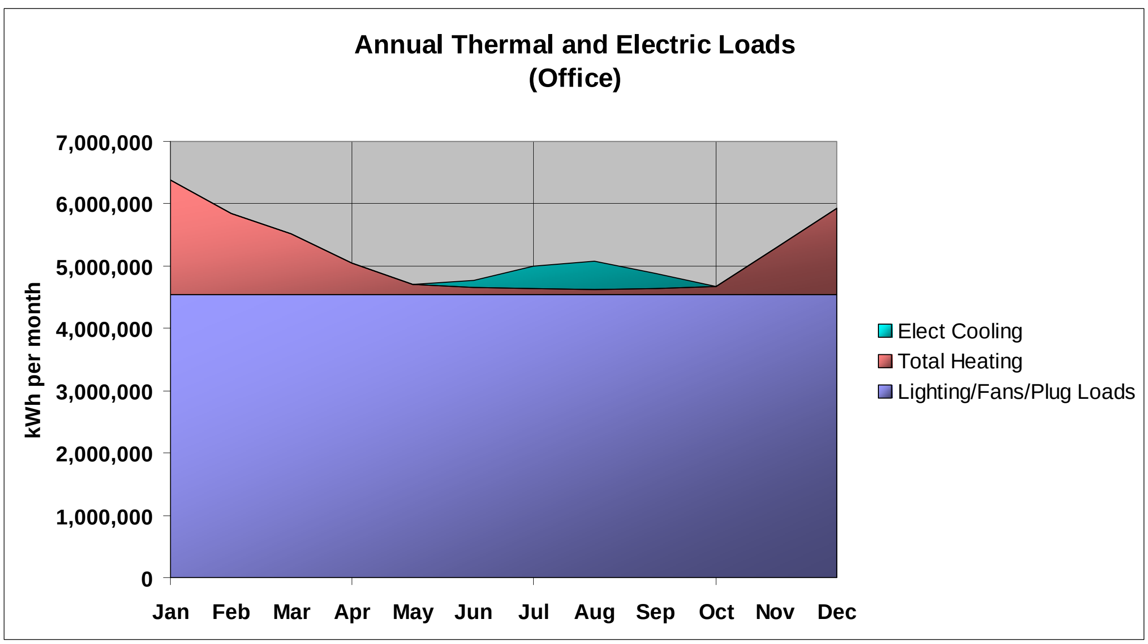

Figure 23 – Annual Thermal and Electric Loads (Office Buildings)

From this analysis we were able to calculate the values shown in Table 3, with total monthly internal loads as shown in Figure 24. These results show that thermal loads (heating and cooling) constitute less than 18% of the total energy load – a much lower ratio of thermal to electric loads than would normally be expected. Per the U.S. Energy Information Agency a more typical distribution is 43% heating and cooling, 29% lighting, 28% plug loads, and 12% other. The consensus of the Advisory Group was that buildings in the Seattle area generally have 1/3 plug loads, 1/3 lighting, and 1/3 HVAC, though because the buildings in the PSSD neighborhood are older with little or no air conditioning the HVAC energy needs should be lower than usual.[45] This low thermal to electric ratio uncovered by our analysis has a significant impact later in our analysis, as it is generally easiest to substitute alternative sources for low exergy loads such as space heating.

	Office	Residential / Lodging	Retail	Warehouse	Other / Unknown	Total
Lighting / Fans/Plug Loads	54,536	5,727	21,471	5,963	5,360	93,056
Cooling	1,174	218	1,103	159	216	2,870
Total Heating	7,411	5,207	2,500	2,148	9,261	26,528
Electric Heating	4,960	774	1,564	936	786	9,020
Gas Heating	1,728	2,686	702	1,078	8,475	14,668
Steam Heating	724	1,747	235	134	0	2,839
Total Loads	63,121	11,152	25,074	8,270	14,838	122,454

Table 3 – Estimated Existing Internal Loads for PSSD Buildings (in MWh per year)

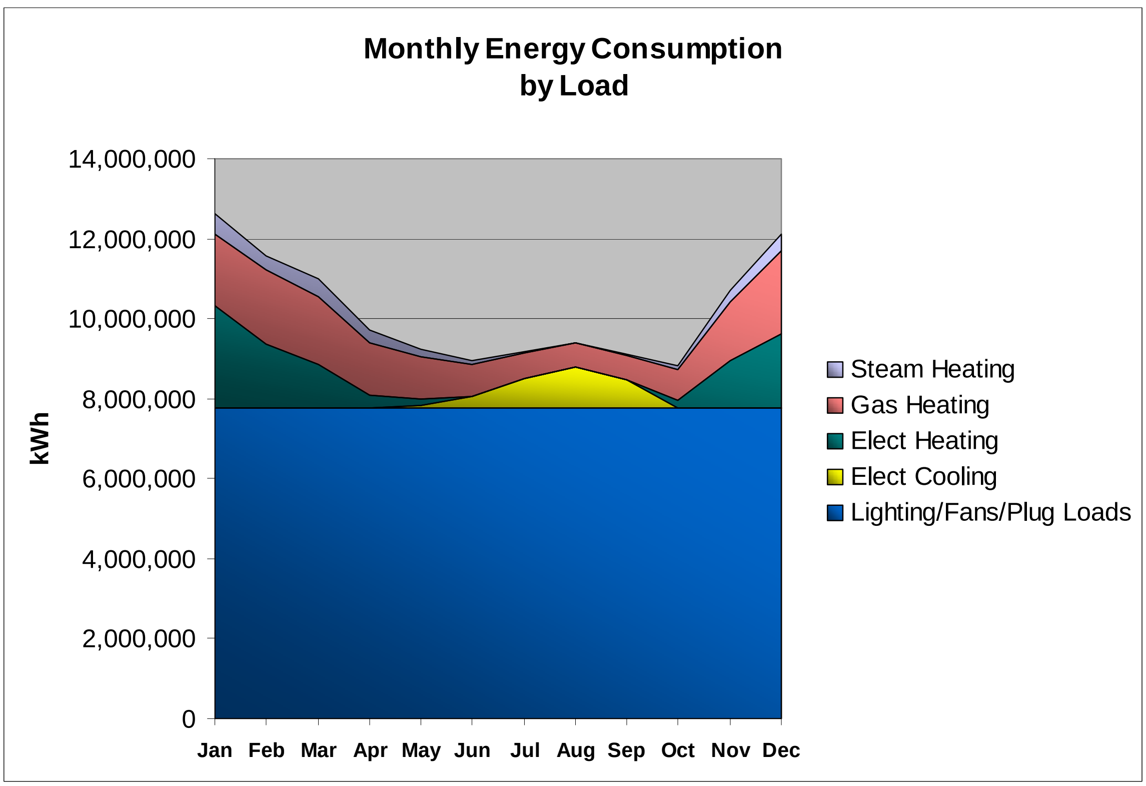

Figure 24 – Total Monthly Energy Consumption by Load

Because of the concerns raised by Advisory Group members, the load distributions were validated by comparing them to a breakdown of internal electrical loads that SCL had previously completed for its entire service territory.[46] Table 4 shows the results of this analysis. The critical values of concern are the percentage of electrical loads represented by heating requirements (space heat and hot water) as compared to lighting, fans and plug loads. Using office buildings as an example, SCL has calculated that, throughout its entire service territory 65% of the electrical load in office buildings is attributed to lights, fans, and plug loads; 6% for hot water and space heating; and 28% for cooling. The buildings in the PSSD area are much older than those that SCL typically serves, and have minimal cooling loads. In order to accurately correlate the load characteristics of these buildings to those throughout the remainder of SCL's territory we reduced the cooling loads in the SCL report to match our projected values and pro rata distributed the excess amounts to the remaining load categories. After this adjustment, the electrical load for all office buildings served by SCL is 89% for lights, fans, and plug loads; 9% for hot water and space heating; and 2% for cooling. This closely matches the expected load distribution of 89% for lights, fans, and plug loads; 9% for hot water and space heating; and 2% for cooling for the office buildings within the PSSD neighborhood. Therefore, we are confident that the internal load characteristics summarized in Figure 24 accurately represent the buildings in the study neighborhood.

		Office	Hotel / Residential	Retail	Warehouse
SCL ELECT LOADS FOR					
ENTIRE SERVICE TERRITORY					
(in aMW)					
	Cooling	74.2	2.4	6.8	1.0
	Lights	98.2	25.6	34.0	5.0
	Plug Loads	32.6	47.5	0.9	0.3
	Space Heat	11.3	39.3	2.2	0.5
	Ventilation	39.4	1.1	3.5	2.3
	Water Heat	5.4	31.1	1.5	0.6
(as Percent of Total Elect Load)					
	Lights/Fans/Plug Loads	65%	50%	79%	79%
	Heat (space and water)	6%	44%	8%	11%
	Cooling	28%	7%	14%	10%
	Total	100%	100%	100%	100%
With Cooling Adjustment					
	Cooling adj factor	-26%	-4%	-9%	-8%
	Lights/Fans/Plug Loads	89%	52%	87%	86%
	Heat (space and water)	9%	46%	8%	12%
	Cooling	2%	3%	5%	2%
	Total	100%	100%	100%	100%

		Office	Hotel / Residential	Retail	Warehouse
SCL ELECT LOADS FOR					
PSSD ONLY					
	Lights/Fans/Plug Loads	90%	85%	89%	84%
	Heat (space and water)	8%	12%	6%	13%
	Cooling	2%	3%	5%	2%
	Total	100%	100%	100%	100%

Table 4 – Validation of Internal Building Loads

Based on this validated data, Figure 25 summarizes the complete existing energy profile of the PSSD neighborhood, with annual consumption values shown by source, by load, and by building type.

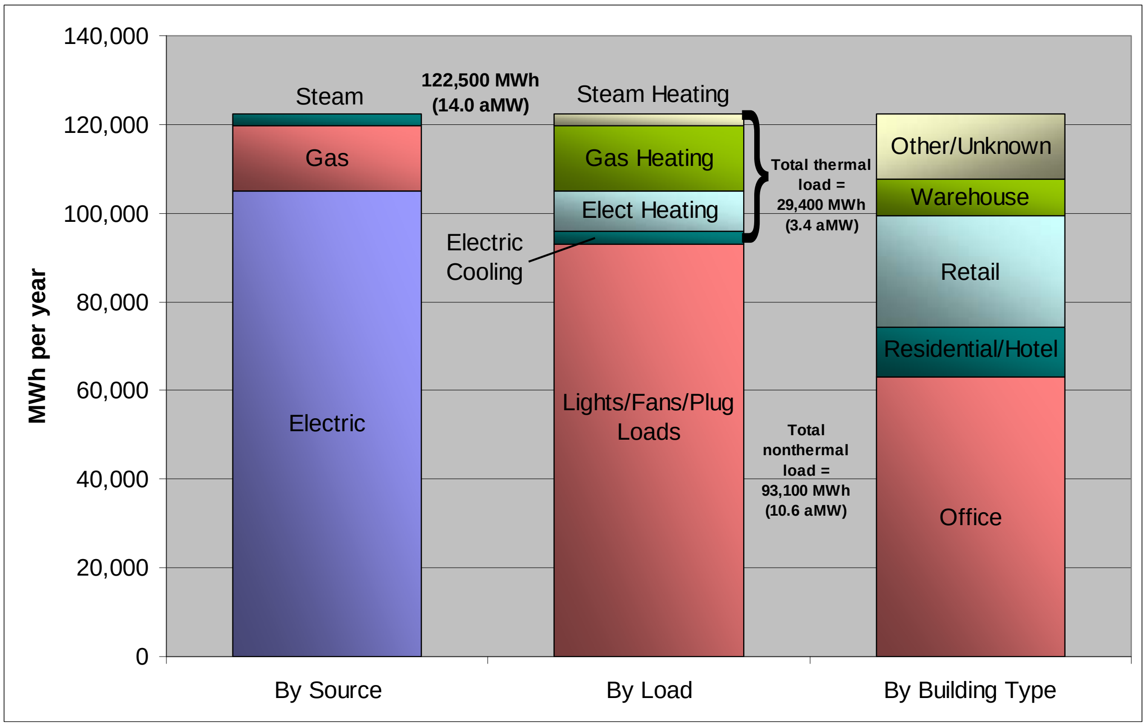

Figure 25 – Average PSSD Annual Energy Consumption, 2003 to 2005

7.3. Energy Intensity

An assessment of the energy performance of the neighborhood showed that the there was considerable variation in the energy intensity, or consumption per square foot of building area, based on building type. All energy calculations are referenced to the gross building area, per industry norms. We also considered presenting data on a per capita or per employee basis – bigger buildings can distort the data by appearing to have lower energy intensities, when in fact they are less energy efficient if they have a low occupancy level. However, it would be difficult to gather accurate occupancy levels for the buildings in this study, so this was not evaluated. This would be an important metric to investigate in future studies.

As shown in Figure 26, the energy intensity of all existing buildings other than retail ranged between 10 and 20 kWh/sf-yr throughout the year. Since the median value of commercial office buildings in our region is 15 kWh/sf-yr,[47] this compares favorably with expected results. However, the energy performance of these older buildings, constructed during the era of inexpensive energy and poor energy codes, is actually significantly better than that of recently built, "high-performance" buildings in our region. This realization presents some major questions: 1) is our data accurate; 2) if so, why is the performance of older buildings so much better than expected; and 3) how does this impact our expectations for improvements in the energy performance of the existing building stock?

After carefully reassessing our data sources and comparing the results to other reports issued by local utilities, we determined that our figures do provide an accurate representation of the area's energy performance. Based on the professional input of the Advisory Group, the low energy intensity figures can be attributed to a variety of factors:

1. Because of high vacancy rates in some buildings they are being under utilized
2. Older masonry buildings typically have high thermal mass throughout, and require less energy than would be otherwise needed for heating.
3. Existing buildings all have operable windows for summer cooling; air conditioning loads are essentially non-existent.
4. Large amounts of glazing provide daylighting, minimizing the electrical lighting load.
5. Because of the types of business that locate there, older buildings typically experience much lower plug loads for computers and other appliances.
6. In general, occupants in older buildings have lower expectations of being in a "perfectly controlled" environment, and have a greater tolerance for variations in temperature, humidity and lighting.

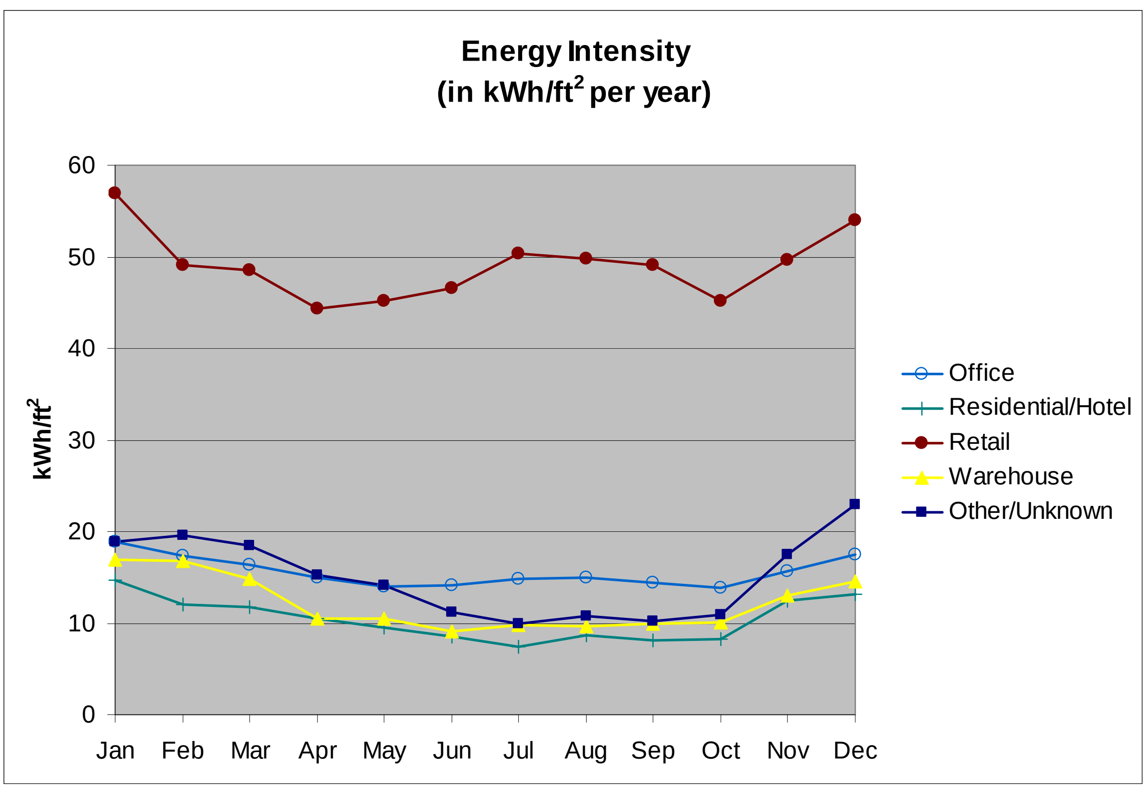

Figure 26 – Energy Intensity for Existing Buildings

Retail buildings exhibited energy consumptions statistically higher than all other categories. Energy intensity for retail spaces averaged 49.1 kWh/sf-yr, as compared to an annual weighted average of 14.3 kWh/sf-yr for all other building types. We initially suspected that the higher energy consumption in retail can be attributed largely to higher lighting levels – retailers typically highlight their merchandise by maintaining lighting levels of 75 to 100 foot-candles, with feature displays as high as 300 foot-candles.[48] However, the American Council for an Energy-Efficient Economy calculates that the lighting energy intensity for retail spaces should average only about 1.3 kWh/sf-yr higher than for commercial office space.[49] Therefore, we were unable to determine the cause for the abnormally high retail energy consumption figures.

We had originally anticipated that the poor performance of older buildings would provide ample opportunities for reducing the energy consumption of the neighborhood, through a variety of energy conservation means or, in some cases, more radical modifications to the building façade or electrical and mechanical systems. Furthermore, we had planned to model the load characteristics of future buildings by starting with the load distributions for existing buildings and then reducing each of the internal loads by an appropriate value. The unexpectedly low energy intensities for existing buildings had two important consequences: 1) we reduced our expectations for the energy savings achievable within the existing buildings, and 2) we determined that energy consumptions figures by load type could not simply be extrapolated forward to predict the load characteristics of new construction.

8. Vision for the Future PSSD Neighborhood

8.1. New Projects

The South Downtown region has been targeted by the City of Seattle as a prime location for new development. The City is hoping to attract 17,500 new households and 70,000 new jobs into the downtown core between 2000 and 2020,[50] and in 2006 the City Council passed sweeping land use reforms to raise building height limits and attract new development. Based on current projections by the Seattle DPD, up to 3.7M square feet of new construction will be completed in the PSSD area within the next 10 years. This would represent a 50% increase in the current real estate stock. Clearly, this neighborhood is about to undergo profound changes.

This amount of intensive, new construction provides the opportunity for implementing new and innovative approaches to the way in which energy is viewed and used at a neighborhood scale. Conversely, if development proceeds along a Business as Usual path, there will be a dramatic increase in the energy needs of this neighborhood, which will impact the energy delivery infrastructures of the utilities that serve the area.

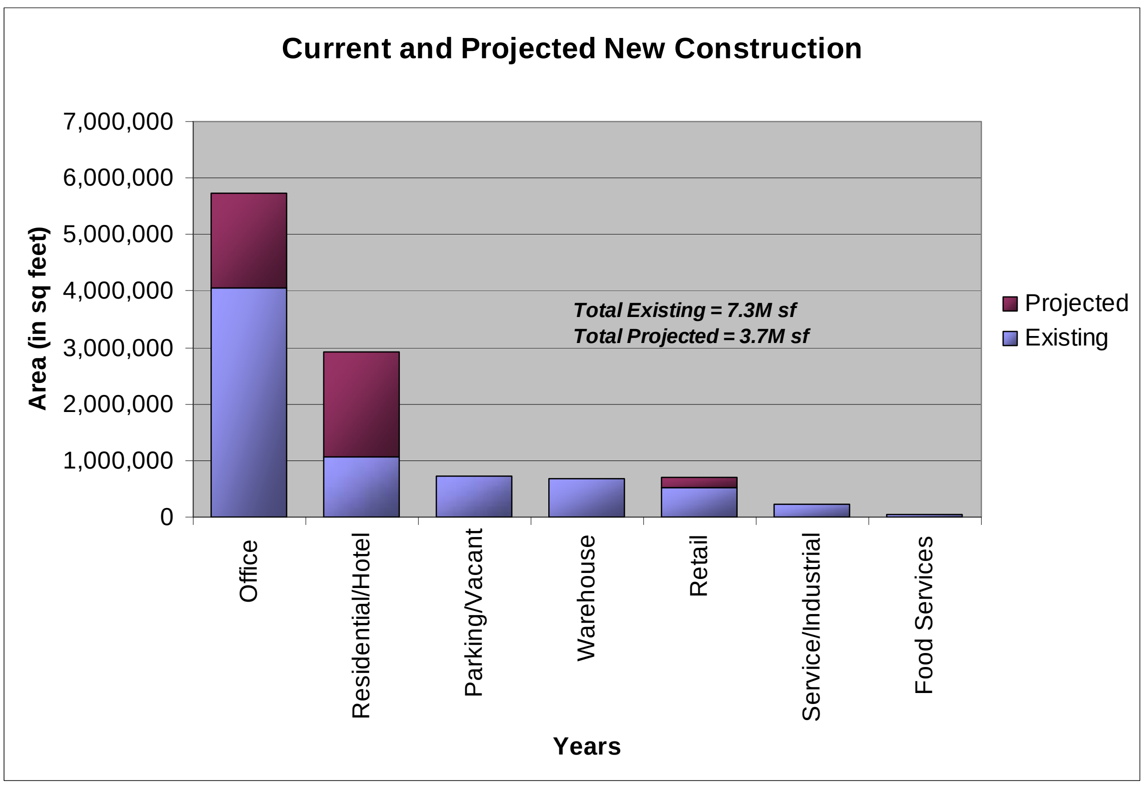

Figure 27 – Size of Current and Projected New Construction

There are ten major properties on DPD's list of potential upcoming projects for the neighborhood, as summarized in Table 5 below.

Description	Residential	Office	Retail	Total
WOSCA Terminal	560,000	1,000,000	150,000	1,710,000
North Lot	782,000		25,000	807,000
505 1st Ave South		202,000	19,000	221,000
Over the Tracks		205,200		205,200
Trolley Barn	193,100			193,100
Alaska Way and King Street		176,500		176,500
Stadium Silver Cloud	169,000			169,000
Reedo Building		94,200		94,200
NE Corner Occidental and Washington	89,300			89,300
Main and 2nd Ave South	67,000			67,000
Total	1,860,400	1,677,900	194,000	3,732,300

Table 5 – Table of Projected New Developments (Area in sf)

The three largest ones form a contiguous U-shaped border that wraps around the west, north and eastern sides of Qwest Field, the existing football stadium.[51] These projects are of particular significance, because of their size and their potential impact upon the energy needs of the PSSD neighborhood. Because of their physical proximity, they could provide an excellent opportunity to link different privately owned projects together to a single neighborhood scale generating facility or thermal distribution network. All of the developers responsible for these projects have been involved in the Advisory Panel for this study, or made presentations to the group.

The North Lot – this project, located on the north half of the surface parking lot on the north side of Qwest Field, is being planned for development by Nitze-Stagen and Opus. The 3.85 acre site will include 807,000 sf of mixed use space, with 782,000 sf of residential and 25,000 sf of retail, including a neighborhood grocer. As currently envisioned the project would include 394 condos and row houses, 562 apartments, and 1,035 parking spaces. All housing will meet LEED or Built Green Certification. King County, which owns the land for the project, has been a leader in sustainable building design, and selected the development team partially for their commitment to achieving sustainable/green building criteria.

Over the Tracks – Nitze-Stagen is also considering a proposal to build a lid over the Burlington Northern railroad tracks, south of King Street Station, and develop over 200,000 sf of office, retail and hotel towers on the property between Fourth Avenue and Qwest Field. No additional details are publicly available about the project at this time.

WOSCA Terminal – these existing warehouse facilities are scheduled to be redeveloped by Urban Green, who has a pending $750 million proposal for redeveloping this 8-acre site just west of Seattle's sports stadiums. The site is the largest unused property adjacent to Seattle's downtown core. Since the capacity of the WOSCA property is twice that of the North Lot, it could be a great catalyst site that would contribute to Pioneer Square's character and economy as well as provide areas and uses attractive to the stadium users.

Urban Green envisions six office buildings, four residential buildings, scores of shops and restaurants, as well as a series of public parks, all on a long strip of aging industrial property west of Qwest Field. If the project is approved it would bring hundreds of new residents and thousands of office workers to the stadium district, and boost the economy of that neighborhood and nearby Pioneer Square. City planning staff has preliminarily proposed raising the height limit to 160 feet in the northern portion for residentially-oriented uses and then possibly 120 to 125 feet in the remainder, in order to facilitate development of this site.[52] Greg Smith, principal in Urban Green, has indicated that he wants the project to meet the highest green building standards.[53]

Some of the new developments in Table 5 will occur on lots that are currently vacant or used for surface parking, while others will replace existing structures. In total, the new projects will result in the demolition of 593,000 sf of existing buildings – 307,000 sf of office, 168,000 sf residential/hotel, and 118,000 sf other – reducing PSSD's current annual energy load by 8,287 MWh/year.

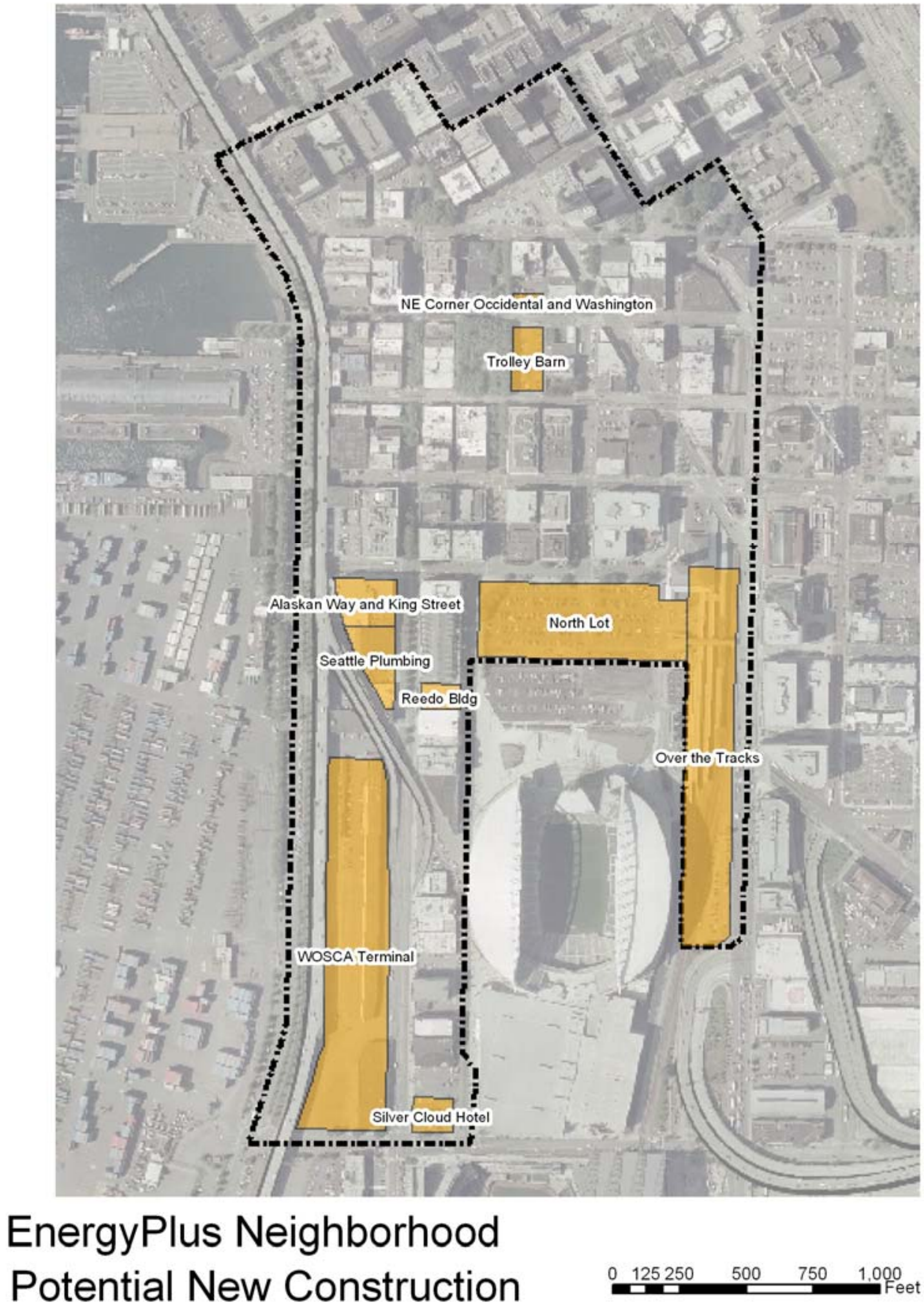

Figure 28 – Map of Proposed New Projects

8.2. Energy Performance Targets

The properties in the PSSD neighborhood can be broken down into three categories, depending on the changes anticipated over the next ten years. Each of these provides different opportunities and economically viable potential for building level energy reductions, and will be evaluated separately:

- Existing construction – existing buildings that will not undergo significant improvements over the next ten years. Energy efficiency measures in these buildings will be largely limited to changes in plug loads and lighting only, or recommissioning of existing systems, providing limited opportunities for reductions in energy consumption.
- Renovations – existing buildings that will undergo significant physical improvements to the building envelope or mechanical / electrical systems over the next ten years, providing opportunities for substantial reductions in energy consumption.
- New construction – new buildings that will replace existing buildings with new structures that could, if designed properly, exhibit dramatically lower energy intensities. However, because new construction will almost always be larger than the buildings they replace, the total energy consumption on the lot will often increase.

In order to determine the technical feasibility of reaching a zero energy target, our point of departure was the assumption that a financial analyses based on Business as Usual would not drive the strategic changes we wished to explore. In order for the community to gain future benefits of a new energy paradigm there will have to be public investments and/or policy changes, that encourage appropriate private investments.

The overall approach in this study is therefore to evaluate the “technical potential” for new energy strategies rather than the “achievable potential.” Technical potential assumes that all measures may be implemented regardless of their costs or market barriers. Achievable potential, on the other hand, represents that portion of technical potential that is likely to be implemented over our planning horizon, given prevailing market barriers that may limit the adoption of desired measures.[54]

8.3. Energy Efficiency Potential – Existing Construction

As a reference point, we examined the potential energy savings projected in PSE’s 2005 Least Cost Plan, which analyzed the potential energy efficiency savings over the next 20 years for 127 unique electric measures and 62 unique gas measures.[55]

Sector	Projected 2025 Total Load (aMW)	Technical Potential (aMW)	Technical Potential (Percent of Total Load)	Achievable (aMW)	Achievable (Percent of Total Load)
Electric					
Residential	1,450	375.8	26%	133.4	9%
Commercial	1,578	503.7	32%	147.6	9%
Gas					
Residential	2,518	928.0	37%	211.9	8%
Commercial	1,426	340.2	24%	129.3	9%
Total					
Residential	3,968	1,303.8	33%	345.3	9%
Commercial	3,004	843.9	28%	276.9	9%

Table 6 – Energy Efficiency Potential, Existing Construction

These values were compiled from data compiled by PSE's 2004 residential appliance saturation survey, the Commercial Building Stock Assessment (a study of the Northwest's commercial building characteristics sponsored jointly by the Bonneville Power Administration, the Northwest Energy Efficiency Alliance, and PSE), the Northwest Power Planning Council and the Regional Technical Forum, the California Energy Commission's Database for Energy Efficiency Resources, and other conservation potential studies and conservation program evaluation reports on energy efficiency programs in the Northwest and California.

Nearly 45% of potential electricity savings in the commercial sector are attributable to the application of energy-efficient lighting. Retrofit, upgrade, and better operation and maintenance of HVAC equipment are also effective energy efficiency measures, accounting for more than 38% of the total electricity savings potential in this sector. High efficiency plug loads account for 14% of the savings potential, while water heating measures account for 3% of total commercial-sector electricity savings. On the gas side, space heating, water heating, and appliance energy efficiency measures provide the largest potentials for savings in the commercial sector. These measures represent 52% (space heating), 37% (water heating), and 10% (appliances – primarily cooking) of the total achievable gas energy efficiency potential in the sector.[56]

In Table 6 "achievable" energy-efficiency and fuel conversion potentials are defined as that portion of technical savings potentials that can be acquired under prevailing barriers that prevent a full market penetration at a levelized per-unit cost of less than 11.5 cents per kWh for electricity and less than $1.05 per therm for gas. As summarized in Table 7, achievable energy efficiency potential averaged 8% to 9% across all sectors and fuel sources, and was in total only 29% of the technical potential.

Sector	Projected 2025 Total Load (aMW)	Technical Potential (aMW)	Technical Potential (Percent of Total Load)	Achievable (aMW)	Achievable as Percent of Technical Potential	Achievable (Percent of Total Load)
PSE Totals						
Residential	3,968	1,303.8	33%	345.3	26.5%	9%
Commercial	3,004	843.9	28%	276.9	32.8%	9%
Total	6,972	2,147.7	31%	622.2	29.0%	9%
EnergyPlus Target	6,972	2,147.7	31%	1,075.0	50.0%	15%

Table 7 – Achievable Energy Efficiency Potential vs. Technical Potential

Our study assumes that for an EnergyPlus concept to develop successfully the regional policy framework will be changed to incentivize additional energy efficiency opportunities. Therefore, our target is for 50% of the technical potential in energy efficiency improvements to be realizable, rather than 29% as determined by the PSE analysis. This results in a projection of 15% achievable reduction in consumption through energy efficiency measures. Even this value of 15% may be low, as the hundreds of potential efficiency measures evaluated in the PSE plan are based strictly on existing technologies. Although it is difficult to quantify their impact, new energy efficiency solutions for existing buildings will no doubt be developed before the 2016 target date of our report. The potential savings from these not yet developed technologies were not included in our analysis.

Note that in the last line of Table 7 the projected loads, and all other related values, are for PSE's entire service territory, not just for the PSSD study area. Based on the current PSSD neighborhood load of 114,000 MWh per year (after taking into account projected demolition of existing buildings), a 15% reduction in existing consumption through energy efficiency would save 17,100 MWh annually.

8.4. Energy Efficiency Potential – New Construction

The City of Seattle is generally recognized as having an aggressive energy code, and was recently described by the Building Codes Assistance Project as exceeding the ASHRAE/IESNA 90.1-1999 standard by 20%.[57] However, in order to create an energy neutral neighborhood all new buildings will have to achieve energy performance far beyond that required by the codes currently in place. We considered a variety of benchmarks to determine reasonable energy targets for new construction. Some of the possible standards were:

LEEDTM case studies: The U.S. Green Building Council (USGBC) has achieved tremendous recognition over the past few years, and its Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ has become a benchmark for the design, construction, and operation of high performance green buildings. LEED promotes a whole-building approach to sustainability by recognizing performance in five key areas: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality. Buildings are evaluated against a checklist of criteria, and are rated as Certified (26 to 32 points), Silver (33 to 38 points), Gold (39 to 51 points), or Platinum (52 to 69 points).[58]

The Energy and Atmosphere portion of the LEED checklist includes 17 of the 69 total possible points, for goals such as optimizing energy performance and using on-site renewable energy. The bulk of the LEED energy points are earned by demonstrating a percentage improvement in the proposed building performance rating compared to the baseline building performance rating per ASHRAE/IESNA Standard 90.1-2004 by a whole building energy modeling simulation. The minimum energy cost savings percentage for each point threshold for new construction is as follows:

- 1 point: 10.5% reduction
- 2 points: 14.0% reduction
- 3 points: 17.5% reduction
- 4 points: 21.0% reduction
- 5 points: 24.5% reduction
- 6 points: 28.0% reduction
- 7 points: 31.5% reduction
- 8 points: 35.0% reduction
- 9 points: 38.5% reduction
- 10 points: 42.0% reduction

LEED has become the defacto sustainability standard for buildings within Seattle and Washington State, and has strong political support and acceptance among the design community. Since 2000, all public buildings within the City of Seattle over 5,000 sf must achieve a minimum LEED silver rating,[59] and the City of Seattle now has 38 projects – either completed, under construction, or planned – that are targeted for LEED certification.[60] However, although LEED is an excellent tool for evaluating the whole building sustainable performance of a project, it is not the ideal system for promoting better energy performance:

- Because the LEED system is a whole building rating, it is difficult but still possible to achieve a gold rating without earning any points for energy measures.
- The majority of LEED points are based on modeled energy performance improvements as compared to a building that meets national energy standards. There is no

requirement for follow-up, nor repercussions if the building falls short of the modeled performance expectations.

- The energy improvement requirements for LEED are referenced to national standards, which are in some areas less demanding than the existing Seattle energy code. This means that a project begins to earn energy points simply by conforming to existing codes, whereas the intent of the standard is to promote design that is superior to code compliant.

The USGBC is aware of these criticisms and is taking actions to correct them. For example, in May 2007 the Council issued its intent to increase LEED's impact on reducing building energy-related GHG emissions, by requiring that all LEED certified projects achieve at least two "Optimize Energy Performance" points, representing a 14% reduction in energy consumption. Pending member approval, the proposed change will go into effect June 26, 2007.[61]

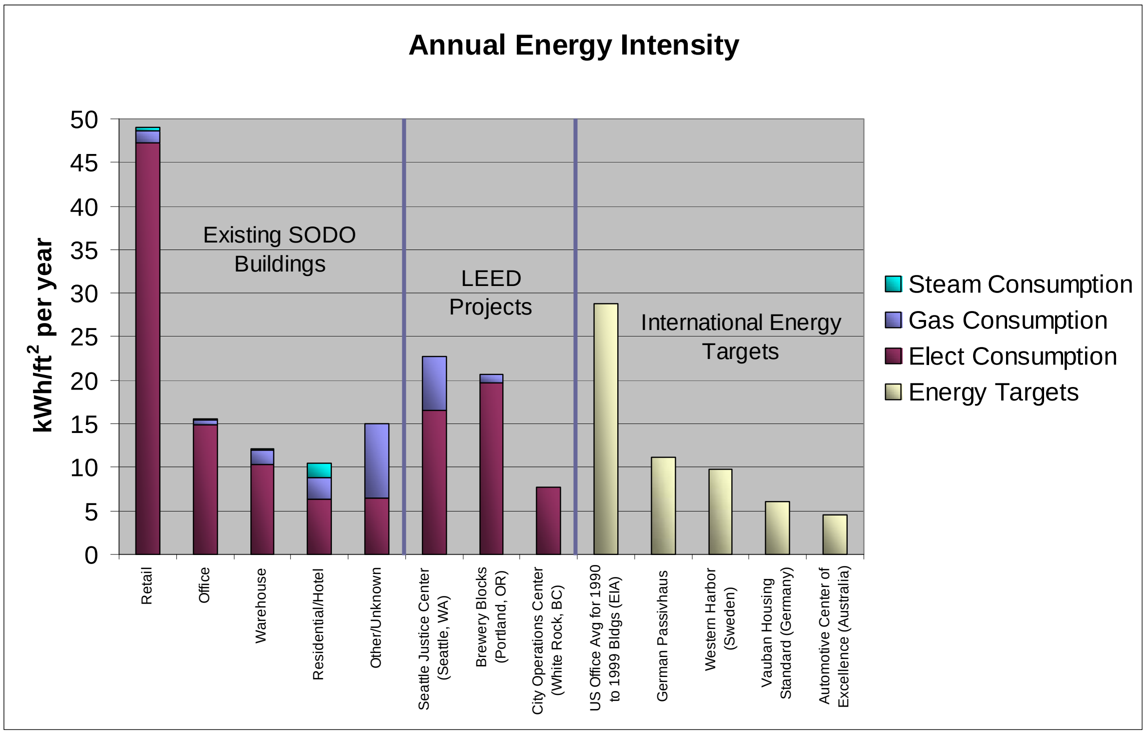

Figure 29 – Comparison of Annual Energy Intensities for Different Projects/Standards

International benchmarks: Many projects throughout the world have already demonstrated their ability to operate within energy consumption limits far below those still considered acceptable for a typical American building. For example, the German Passivhaus standard refers to ultra-low energy buildings that consume less than 11.2 kWh/sf per year for heating, hot water and electricity. This is between 75 to 95% less energy for space heating and cooling than current new buildings that meet today's U.S. energy efficiency codes.[62] In Europe more than 6,000 homes, office buildings and schools have been constructed to this standard. Figure 29 compares the energy consumption of some projects built to these international energy standards to the energy performance of existing U.S. buildings in PSSD and elsewhere.

U.S. Department of Energy's EnergyStar Target Finder: Target Finder[63] is an on-line tool developed by the U.S. Department of Energy and the Environmental Protection Agency to compare the estimated energy performance of a commercial building to that of hundreds of similar buildings in the Energy Information Agency's Commercial Buildings Energy Consumption

Survey (CBECS). The energy ratings have geographic specificity, as determined by the zip code of the building's location. The zip code is used to determine the climate conditions that the building would experience in a normal year (based on a 30-year climate average). The total annual energy use intensity for the target is based on the energy fuel mix typical in the region specified by the zip code. Site and Source energy calculations are provided for both energy use intensity and total annual energy.

2030 Challenge: In January of 2006 Architecture 2030 issued the 2030 Challenge, which calls for dramatic, staged reductions in the fossil fuel needs for constructing and operating buildings, with the target of carbon neutrality by 2030. The 2030 Challenge was precipitated by the realization that in order to avoid dangerous climate change we must keep global warming under 2°C above pre-industrial levels. Since the built environment is one of the largest producers of GHGs, the 2030 Challenge requires that starting today all new buildings, developments and major renovation projects be designed to use 1/2 the fossil fuel energy to construct and operate that they would typically consume. The fossil fuel reduction standard for the operation of all new buildings will be increased to:

- 60% in 2010
- 70% in 2015
- 80% in 2020
- 90% in 2025
- carbon-neutral by 2030 (meaning they will use no fossil fuel energy to operate).

The American Institute of Architects adopted the 2030 Challenge targets in January 2006, and in June 2006 the U.S. Conference of Mayors passed a provision, introduced by Seattle Mayor Greg Nickels and three other mayors, mandating that all new city buildings meet these standards as well.[64] Although this is a publicly stated goal, there appears to be little awareness of this program or its implications. Our project could be an important step in demonstrating how to achieve these goals.

The 2030 Challenge performance targets are referenced to the CBECS database, and can be calculated by using the EnergyStar Target Finder. For example, a typical 10,000 sf office building designed to meet the 2015 standard, reducing its energy consumption by 70%, would consume no more than 9.1 kWh/sf per year.[65] One of the concerns raised with using the 2030 Challenge as a benchmark is that the database of existing buildings has geographic specificity. For a building to meet the 60% reduction target it has to perform 60% better than the mean for all existing buildings within the same postal zip code. Since the energy code in Seattle is already more demanding than ASHRAE 90.1-2004 and other national standards, buildings would face a more stringent performance standard in Seattle than in most other jurisdictions. For example, the same office building constructed in Chicago, Illinois would only have to meet a target of 10.6 kWh/sf per year.

We projected the future energy needs of the PSSD neighborhood under two scenarios: The High Load Scenario and the Low Load Scenario. According to the U.S. Energy Information Agency the average energy intensity for all commercial office space constructed in the U.S. between 1990 and 1999 was 28.7 kWh/sf per year. This represents a Business as Usual value for new construction, and was used to model the High Scenario in Figure 30. If all the potential projects listed in Table 5 were built to this standard the total energy consumption of the PSSD would increase by 107,100 MWh per year. Our analysis for the Low Scenario is based on all PSSD buildings constructed in the next ten years meeting the 2015 standard for the 2030 Challenge, limiting their energy consumption to no more than 9.1 kWh/sf per year. With this target, completing all the potential projects would only increase the PSSD load by 34,000 MWh/year, a net savings of 73,200 MWh per year over the High Scenario. These values correspond to bookend values for total energy load for the PSSD neighborhood, including both existing and projected construction, of between 148,000 MWh and 221,000 MWh.

Although new construction theoretically provides the greatest opportunity for energy performance improvements, economic realities of developing a building, particularly a "spec" building that must be adaptable to a variety of future tenant needs, limit the design measures that can be incorporated. One of the newest buildings to be completed in the PSSD neighborhood, the Reedo Building, was recently completed by Urban Visions, a developer committed to high performance, sustainable building designs. However, even in this project many of the features that were originally considered for their energy savings potential (chilled beams, radiant floors, open atrium with natural thermal chimney) were ultimately eliminated or minimized. Because it is not an owner occupied building leaseable space had to be maximized, and the building and mechanical systems had to be very flexible, so that they could be easily modified to meet the unknown needs of future tenants.[66]

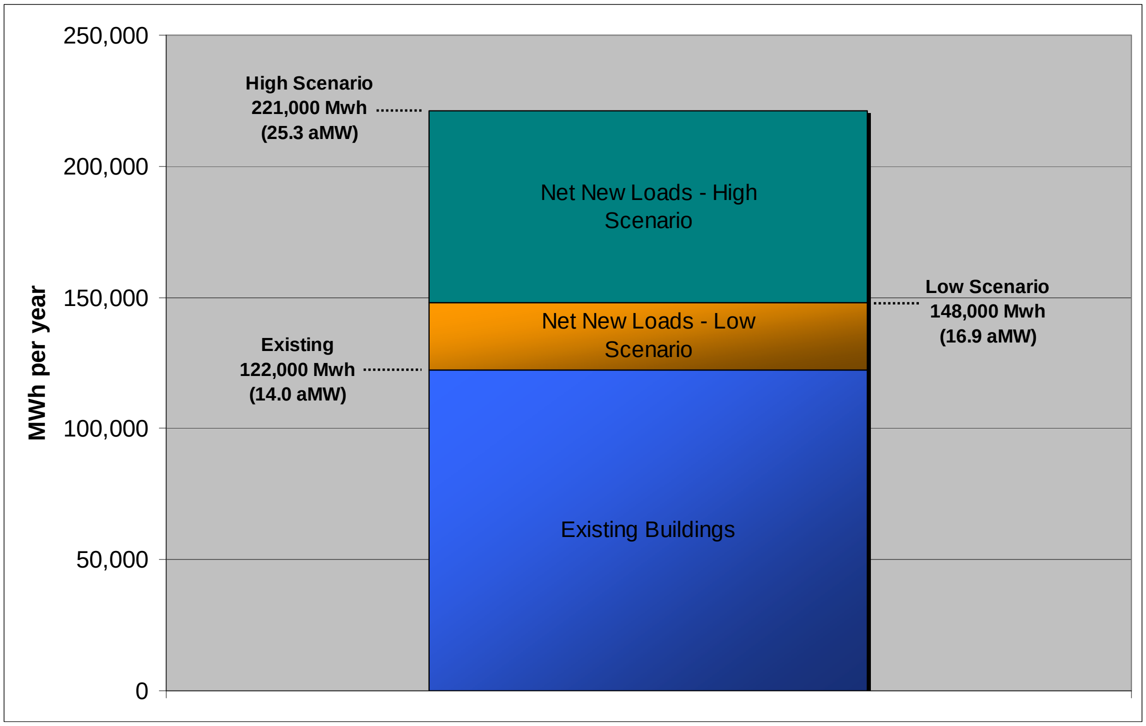

Figure 30 – Projected Average Annual Energy Consumption

It is important to note though, that as the industry matures and more design professionals become proficient in sustainable design concepts, the additional incremental cost for an energy efficient building design will continue to drop. The true benefits of sustainable design are achieved not by applying new technologies, but by following an integrated design process whereby opportunities for energy efficiency are considered at every stage of the design, not as an afterthought when the building concept is largely complete. Based on work by Mazria and Frankel,

Table 8 outlines some of the strategies that could be used to help new buildings achieve a net zero energy and GHG footprint.[67, 68]

Phase	Strategies
Phase 1 – Site Strategies	▪ Siting

	▪ Building shape, color and orientation ▪ Shading ▪ District energy
Phase 2 – Passive Strategies	▪ Passive solar heating ▪ Passive cooling ▪ Daylighting ▪ Natural ventilation ▪ Thermal mass ▪ Night venting ▪ Evaporative cooling ▪ Economizers ▪ Ground coupling
Phase 3 – Load Reduction Strategies	▪ Lighting ▪ Equipment and plug loads ▪ Envelope improvements ▪ Fenestration location, size and shape ▪ Infiltration ▪ Expand comfort zone
Phase 4 – Active Strategies	▪ Lighting controls ▪ Demand control ventilation ▪ Moveable insulation ▪ Mechanized shading ▪ Solar hot water ▪ Radiant heating / cooling ▪ Underfloor heating / cooling ▪ High efficiency pumps and motors
Phase 5 – Generation Strategies	▪ Solar photovoltaics ▪ Wind microturbines ▪ Geothermal ▪ Biomass
Phase 6 – Operational Strategies	▪ Commissioning ▪ Monitoring ▪ Peak shedding ▪ Operations guide ▪ Equipment maintenance / replacement ▪ Occupant behavior
Phase 7 – Mitigation Strategies	▪ Purchase green renewable energy - Wind - Solar -Geothermal - Biomass

Table 8 – Strategies for Designing Zero Energy Buildings

8.5. Thermal Distribution

Benefits

As Stan Gent, a member of our Advisory Group noted,[69] "Sustainability can only be achieved when we can move thermal energy as efficiently as electrical energy." Therefore, in order to meet the remaining load of the PSSD neighborhood with new energy resources, we next considered the potential for using a district energy system to fulfill the thermal needs. A quick survey of existing industrial processes or other potential heat sources in or near the neighborhood turned up no significant opportunities. There is potentially some diversity in the thermal load characteristics of nearby buildings within the neighborhood (some requiring heating while others, at the same time, require cooling) so that excess heat could be captured and transported to where it is needed. However, the aggregated meter data provided by the utilities did not permit the detailed building by building energy analysis needed to identify these opportunities. Therefore, for now we assumed that dedicated, neighborhood scale heat plants would be necessary to power a district energy system. Ideally, any thermal distribution system would be designed as a distributed system, with multiple sources of heat supply (central plant, roof top solar panels, heat generating building or industrial processes) delivering heat to a loop that each consumer draws from as needed. With this type of system in place the neighborhood could attract heat producing industries, such as an ethanol production plant.

Although not as efficient as capturing “free” waste heat, a neighborhood scale CHP plant would provide significant efficiency gains over separate heat and electricity production. Generating electricity in a thermal power plant is a highly inefficient process. The left side of Figure 31 shows the primary energy sources for the commercial sector in the U.S., while the right side shows end uses. Renewable resources, including hydro, account for only 5% of the electrical generation in the U.S. for this sector. The remaining 95% is generated at centralized thermal power plants fueled by coal, natural gas or nuclear. Only 4.19 Quads of retail electricity was delivered to the commercial sector from an input of 10.4 Quads of fuel and renewables; 60% of the primary energy content was lost due to conversion inefficiencies (waste heat), plant use, and transmission and distribution losses. A CHP plant intentionally produces heat and electricity simultaneously, and captures the waste heat for low grade thermal uses. With efficiency rates of 70 to 90%, a distributed CHP system can effectively double the central electric system's average delivered fuel-use efficiency.[70]

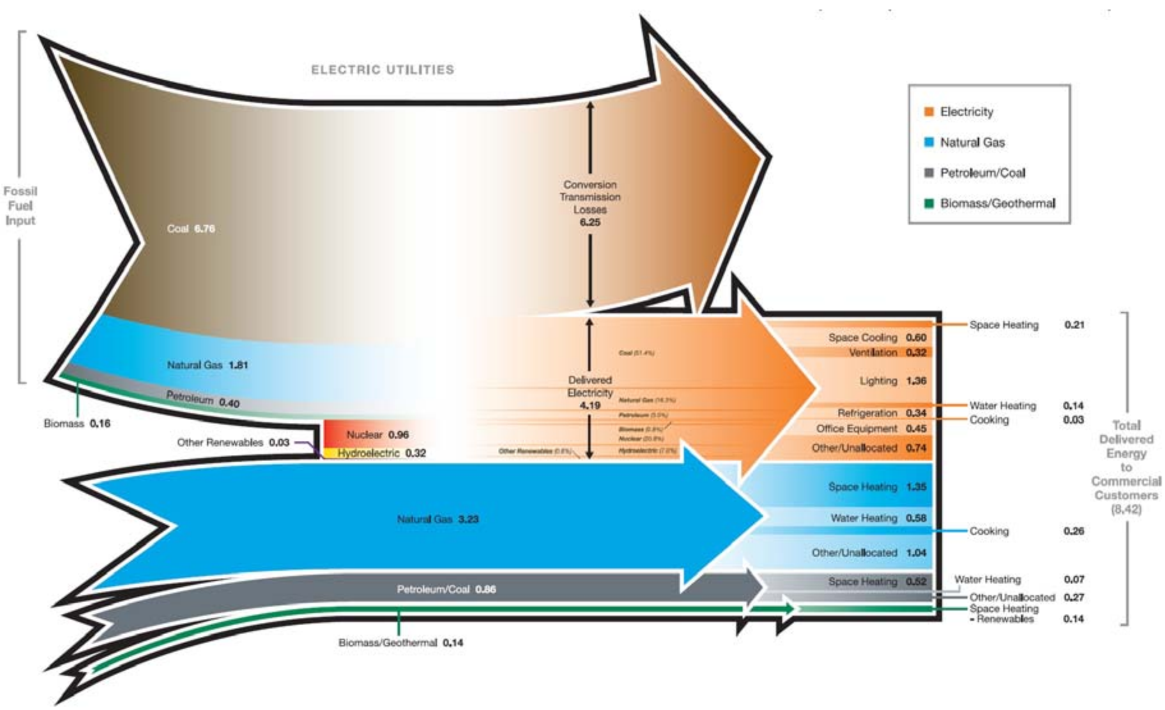

Figure 31 – Energy Flows for U.S. Commercial Sector, 2004
(All units expressed in quadrillion Btu)[71]

Thermal System Analysis

Two different models were considered for the study area:

1. A single neighborhood scale plant, based on the wood chip fired CHP plant in the Vauban District of Frieburg, Germany could be sized to fulfill the thermal needs of the entire PSSD neighborhood. This would require a larger, one time capital expense, but would be able to handle non traditional fuel sources such as wood chips or other bio-fuels. (See technical specifications, Section 12.2)
2. A number of smaller distributed CHP plants could be built within new buildings, based on the model demonstrated in the Lonsdale District Energy System of North Vancouver, British Columbia. This model would be less capital expensive, and could be built in phases as need to service load growth, but would likely depend on natural gas for fuel. Using solid biofuels for multiple, small-scale plants introduces extra costs for the scrubbing equipment needed to meet local air quality standards, and creates additional challenges in transporting and delivering the fuel.

Since one of the goals of the EnergyPlus concept is to reduce the carbon footprint, thermal production was based on the single, neighborhood-scale plant of the Vauban model, with the following characteristics:

- CHP plant burns biomass (recovered wood, straw etc.) to generate baseload heat and electricity;
- Peaking energy for heat is produces from gas fired boilers;
- Energy is recovered from waste and recovered energy, when available; and
- System harvests solar thermal energy, when available.

As shown in Figure 25 the existing annual thermal load (heating and cooling) for the PSSD is 29,400 MWh. The peak demand occurs in January, with a total monthly load of 4,880 MWh.

Existing Buildings	MWh/yr
Thermal Loads	29,400
Electric Loads	93,100
Total	122,500
New Projects (Low Load Scenario)	
Thermal Loads (at 35% of net new loads)	9,000
Electric Loads (at 65% of net new loads)	16,700
Total	25,700
Total Load (Low Load Scenario)	
Thermal Loads	38,400
Electric Loads	110,000
Total	148,000

Table 9 – Thermal vs. Electric Loads for Existing and New Projects

Under the Low Energy Scenario for new construction the neighborhood will experience a net annual energy increase of 25,700 MWh, of which 9,000 MWh/yr is estimated to be thermal loads.[72] Therefore, PSSD will have a total annual thermal load of 38,400 MWh (4.4 aMW) and an electric load of 110,000 MWh (12.5 aMW). Current load duration curves provided by Seattle Steam show that for the local climate the plant heating capacity should be sized to serve about 1,850 equivalent full load hours (EFLH), or 20.8 MW.[73] By producing 38,400 MWh of thermal energy per year, as well as 18,800 MWh of electricity,[74] this plant would reduce the remaining future energy needs of PSSD to 73,800 MWh.

8.6. Renewable Energy Resources

A variety of renewable energy resources were considered to fulfill the remaining energy load of the PSSD neighborhood. Since the district energy system and biofuels powered CHP plant described in Section 8.5 meets all thermal demands, the remaining loads are electrical, greatly restricting the technology options to consider. The potential renewable sources of electricity include geothermal, biomass, municipal solid waste (MSW), wind and solar. Each of these is discussed below.

Geothermal

With geothermal energy, hot water or steam naturally occurring near the earth's surface is used for heating and cooling, or for electricity generation. Much of Washington State east of the Cascade Range has good low-temperature (less than 212°F) geothermal resources. This is especially true in the southern portion of the state throughout the Columbia River basin, where there are more than 900 thermal wells. Such low-temperature geothermal resources have the potential for direct-use applications, where hot water may be used directly to heat buildings, grow plants in greenhouses, heat water for aquaculture, and other applications. The volcanic fields of the Cascade Range itself offer good high-temperature resources (greater than 300°F). Three areas have thus far been identified as having particularly good potential for development of geothermal electric power: the Mount Adams area in the southern Cascades, the Wind River area east of Vancouver, Washington, and the Mt. Baker area in the northern Cascades.[75] However, in Seattle and the greater Puget Sound region there are no known geothermal resources that could be used to generate electricity.

Biomass

With its expanse of forests and its 8th place ranking in national crop production, Washington State has a vast supply of biomass. The Washington Department of Ecology estimates that each year the state produces over 16.9 million tons of underutilized dry equivalent biomass from field residues, animal manures, forestry residues, and food processing, which is capable of generating, via combustion and anaerobic digestion, over 15.5 million MWh of electrical energy. 88.5% of this potential is from the combustion of woody, lignocellulosic materials. Much of this woody biomass is forestry and field residues that are dispersed, and therefore difficult to collect and process. However, some forms of the woody biomass, such as mill residues and municipal yard and wood debris, are more concentrated.[76]

Woody biomass is already being suggested as the fuel supply for the CHP plant described in Section 8.5 of this report. In order to maintain a broader portfolio of fuel options, we elected to examine other sources of energy to supplement the wood supply.

One fuel source that has not yet been exploited for electric production in the U.S. is biodiesel. Washington State is home to a small but rapidly growing biodiesel industry. In 2006, the state was the first in the country to pass legislation requiring that all diesel fuel sold in the state contain a minimum of 2% biodiesel by volume when the production of biodiesel is sufficient to support this.[77] Biodiesel production in Washington has been targeted exclusively at the transportation sector. However, it could be used in stationary applications as well, for generating heat or electricity. The Reischstag building, in Berlin, Germany, uses bio-diesel in an onsite 1.6 MW CHP system to produce clean heat and electricity, reducing annual carbon dioxide output by 94%. The biodiesel is burned in a modified diesel engine, with an electrical capacity of 400 kW and a total efficiency as high as 90%.[78]

Since there are very few other examples of liquid biofuels being used for generation of electricity this option was not evaluated any further in this study, but it does warrant additional investigation in the future.

Municipal Solid Waste

One of the most underutilized potential energy sources in the U.S. is MSW. As in most metropolitan areas all over the world, Seattle is facing the problem of disposing of increasing amounts of waste, despite the best intentions of reversing this trend. The solution is to close the resource management loop by reusing and recycling both the materials and the energy in the waste stream, rather than disposing MSW in landfills. As shown by the waste management strategies being adopted throughout the European Union (EU), extracting the imbedded energy content of waste materials is an important aspect of waste management. According to the EU Directive 2006/12/EC on waste Member States should take appropriate measures to encourage "(i) the recovery of waste by means of recycling, reuse or reclamation or any other process with a view to extracting secondary raw materials; or (ii) the use of waste as a source of energy." [79]

The technology is already well established in the EU. In 2003 Europe's waste to energy plants had an annual capacity of 27 million MWh of electricity and 63 million MWh of heat,[80] and in 2005 MSW was used to produce 3.9% of the electricity, and 14.4% of the heating in Denmark.[81] The district energy system of Copenhagen is supplied by four waste to energy facilities, which together cover more than 25% of the total heat demand in the metropolitan area.[82]

The most significant barrier to using MSW as an energy source within an EnergyPlus environment is that, because of the economies of scale that dominate the design of modern plants, facilities that use MSW as a fuel source may simply be too large to be appropriate as a neighborhood-scale solution. Most waste to energy plants in Europe are located in more industrialized urban areas, where they can easily tie into the thermal energy distribution loop to deliver heat but will have minimal impact upon residential or commercial developments. For these reasons, MSW was not considered to be a viable energy source for the PSSD neighborhood.

Wind

Wind energy is currently the most cost effective renewable source of electricity generation, as evidenced by the fact that the U.S. installed capacity has been growing by an average of 30% per year since 2000.[83] Washington State's wind resources are estimated to be sufficient to generate 62 million MWh of electricity per year, or more than 400 times the total future energy needs of the PSSD neighborhood. Unfortunately, prime wind locations are dictated by the combination of adequate wind resources and access to transmission and distribution infrastructure. In Washington State these are located in the Columbia Gorge area and in the central portion of the state, near Ellensburg, both of which are hundreds of miles from Seattle. Wind resources in the greater Puget Sound region are insufficient to support development of wind farms.

One issue that should be examined further is the concentrating effect that the urban built form has upon naturally occurring wind resources. The built environment of cities can create much higher wind velocities than would normally occur, because of wind tunneling effects. Although architects generally try to minimize these impacts, they can also design structures that intentionally channel wind flow around and through buildings that have building integrated wind turbines (BIWTs). The first known commercial application of BIWTs is the Bahrain World Trade Center, where three massive turbines, measuring 95 feet in diameter, are supported by bridges spanning between the complex's two towers. Through its positioning and the unique aerodynamic design of the towers, the prevailing on-shore Gulf breeze is funneled into the path of the turbines, helping to increase power generation efficiency. When they begin operating at full capacity in 2008 the turbines will be capable of producing 1,100 to 1,300 MWh of electricity per year.[84, 85]

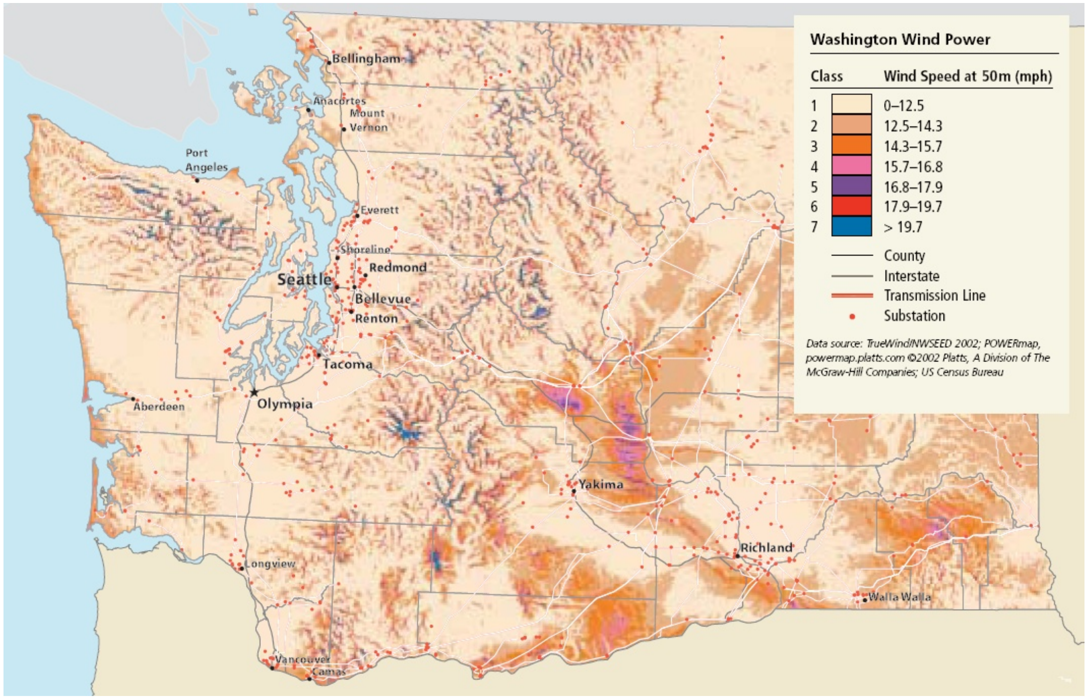

Figure 32 – Washington Wind Resources

Solar

Solar energy is one of the most abundant forms of renewable energy. The sun's energy can be utilized in passive building design, or captured through thermal solar or photovoltaic (PV) collectors. PVs convert light directly into electricity without moving parts, noise, or pollution. They also have a lifetime expectancy of 30 plus years, are readily adaptable to a variety of applications.

Because they are very scalable and can be installed in many different configurations (on rooftops, wall-mounted, or in ground based arrays) photovoltaic systems arguably have more potential to transform the energy landscape of our communities than any technology under development. The cost is steadily dropping, and Washington State has recently passed aggressive solar legislation to accelerate market adoption.

The challenge with solar electric generation is the disperse nature of the resource; given the low conversion efficiencies of the solar panels currently available solar arrays require a large surface area relative to the power produced. The National Renewable Energy Labs has determined that in Seattle the average direct solar radiation level on a south facing, flat plate collector fixed at an angle of 32 degrees is 0.35 kWh/sf per day. The total solar radiation is a combination of direct beam radiation, diffuse (sky) radiation, and radiation reflected from the surface in front of the collector.[86] To calculate the maximum solar electric potential for the PSSD neighborhood we worked with the following assumptions:

1. The average building footprint is equal to 85% of the gross lot size.
   - Existing total developed lot area = 2,446,000 sf
   - Projected new developed lot area = 376,000 sf (211,000 sf for North Lot and 165.000 for Over the Tracks project – other new projects will be on lots that are already developed)
   - Total gross developed lot area = 2,823,000 sf
   - Total building footprint = 2,399,000 sf

2. 20% of the roof surfaces are unavailable for solar PV systems due to physical conflicts (architectural and physical integration issues such as multiple roof levels or angles, setbacks for gutters), incompatibilities with roofing materials, and obstructions on the roof such as chimneys, antennas, etc.

   - Available roof area = 1,919,000 sf

3. 50% of available roof surfaces are unsuitable for PV installation due to shading from nearby buildings.

   - Net unshaded roof area available = 960,000 sf
   - Net solar energy that can be captured = 336 MWh/day, or 123,000 MWh/yr.

4. Approximately 13% maximum for overall system conversion efficiency.[87]

   - Net solar electrical production = 15,900 MWh/yr.

5. In western Washington, a 1 kW solar system will generate approximately 1,000 kWh/yr.[88]

   - System capacity factor = 1,000 / 8,760 = 11.4%
   - Installed capacity = 15.9 MW

With current technologies and solar conversion efficiencies, the PSSD neighborhood could theoretically produce 15,900 MWh of electricity annually. However, at a capacity factor of 11.4%, 15.9 MW of solar capacity would be needed. This would require solar investment at a massive scale – at current installed prices of about $8/watt the capital investment would be $127 million.

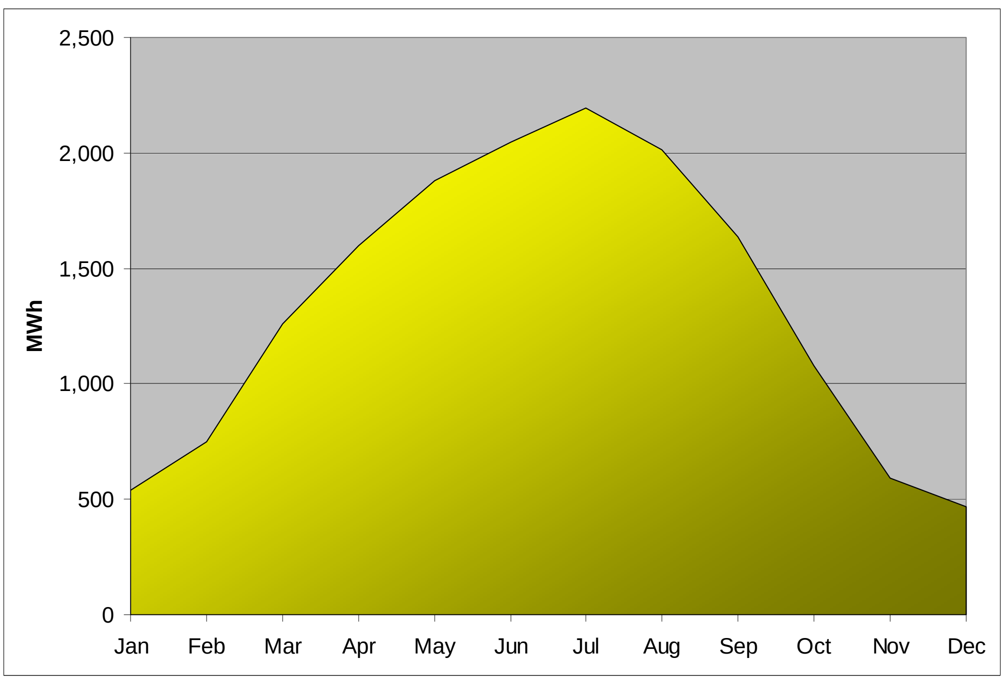

Figure 33 – Monthly Electric Energy Available From Solar PV

Clearly a detailed economic analysis is needed to determine if there is an adequate business case to justify this level of investment. This analysis would have to consider factors such as the anticipated per unit decrease in costs of solar systems as the technology continues to mature, as well as the avoided cost to local utilities for substations and transmission/generation facilities that this investment would replace. Another important consideration with solar generation is that the peak power production coincides with periods of peak summer demand for cooling. If time of day or other rate structures are implemented by local utilities to reduce peak demand, solar systems would be generating much of their electricity at marginal rates far above the average rate, which could provide a much more reasonable return on the investment.

8.7. Summary of Technical Gap Analysis

When all of the technical solutions suggested in this chapter are taken together, the total load of the PSSD neighborhood is reduced by 74% compared to the Business as Usual projections (see Table 10). Although this has not reached the level of a true EnergyPlus neighborhood, it does demonstrate that the external energy generation requirements of an existing urban neighborhood can be dramatically reduced. The largest contributors to achieving this performance are the high performance building requirements for new construction, and the thermal output of the CHP system. These two strategies combined for a 50% reduction in the energy needs.

Energy Loads	**Energy (MWh per year)**	**Percent of Total Load**
Existing construction	123,000	55%
New construction (Business as Usual)	107,000	48%
Less demolition of existing buildings	(8,290)	(4%)
Total for Business as Usual Scenario	221,000	100%
Load Reductions	**Energy (MWh per year)**	
High performance building requirements	73,200	33%
Conservation in existing buildings	17,100	8%
CHP (thermal)	38,400	17%
CHP (electricity)	18,800	8%
Solar PV	15,900	7%
Total Load Reduction	172,000	74%
The Gap	***57,900***	***26%***

Table 10 – Summary of PSSD Energy Opportunities

Figure 34 illustrates the full impact these strategies would have upon the energy budget for the PSSD neighborhood.

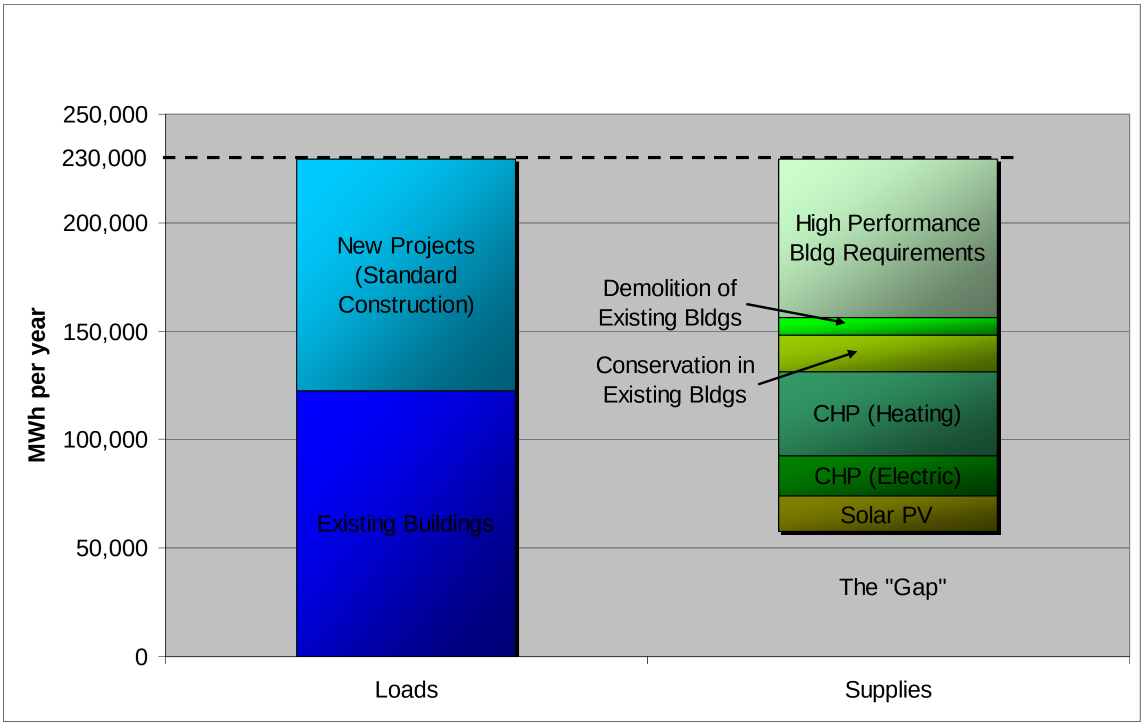

Figure 34 – Projected PSSD Energy Budget

9. Policy and Planning Needs

9.1. Technology / Planning and Development Enablers

Implementing the technical alternatives portrayed in the previous sections would create a neighborhood with an energy profile unlike that of any other large, urban U.S. neighborhood. There are clearly many economic and institutional barriers that must be addressed for this vision to become a reality. One of the roles of government should be to determine the types of responses which would benefit society as a whole, and then institute public policy measures that reward “good” behavior and penalize “bad” behavior. If properly designed and executed, this provides the framework so that market forces can stimulate the most efficient means of achieving the desired end results.

The policies needed to promote community energy planning can be broken into two broad categories: Technology Enablers (see Table 14) and Planning and Development Enablers (see Table 15). These can be summarized as:

- Technology enablers
    - Market transformation
    - Carbon Mitigation
    - Project financing
    - Production incentives
    - Other
- Planning and development enablers
    - Municipal zoning and permitting
    - Development process incentives
    - Municipal planning process

Technology enablers provide incentives for developing and implementing specific energy technologies such as renewables or district energy. Although these technologies are not necessarily “new” they are not yet widely adopted, and may need additional assistance to overcome the barriers to widespread market adoption created by factors such as:

- Higher near term costs due to lower production levels (no economies of scale yet)
- Existing subsidies which artificially reduce costs for competing energy technologies
- Immature business models and organizational structures
- Lack of familiarity and confidence amongst utilities and other traditional energy providers
- Different demands on existing infrastructure (e.g., impacts of integrating intermittent and distributed resources)

These enabling policies are designed primarily to modify competitive market forces by providing higher financial returns for sustainable energy technologies, or by transforming the market to demand more of these types of solutions.

Planning and development enablers are designed to change the way that the built environment is conceived, and in particular to provide incentives for buildings and neighborhoods that are more sustainable and energy efficient. These policies tend to impact the built form and energy infrastructure of urban environments, rather than directly promoting specific technologies.

In the U.S. technology enablers are traditionally handled by the bodies that have a direct impact on energy policy – federal or state government, or sometimes more indirectly by energy utilities. Because they address local land use issues, site planning and development enablers are the responsibility of local municipalities, or are local implementations of general state policies. Both types of enabling policies are needed for an EnergyPlus neighborhood concept to succeed. For example, there are a variety of programs (feed-in tariffs, renewable portfolio standards, retail tax rebates, etc) that can be adopted to encourage the wider adoption of solar PV systems. However, without solar access laws to provide unencumbered access to sunlight, as well as zoning and permitting regulations that make it easy to install systems in a variety of locations, the technology will never achieve widespread penetration in urban environments.

9.2. General Policy Recommendations

Many of the successful implementations of highly sustainable neighborhoods have been in European countries, as evidenced by the case studies in this report. In these countries, particularly within the social democracies of Scandinavia, government often plays a much stronger role in mandating policy reforms that might be considered harsh and unacceptable in the U.S. Public policy must always be sensitive to the culture and political realities of the area in which it will be enforced. In the U.S. the “carrot” approach is generally considered to be more politically palatable than the “stick” approach. Even in an environmentally and socially progressive area like the Pacific Northwest, this means that public policy generally takes the form of tax incentives, rebates and bonuses rather than penalties, or laws that simply make a current practice illegal.

This is even more evident with public policy at the municipal level; cities fear that imposing penalties or other land use regulations that are onerous could drive real estate developers and business owners to relocate their projects to nearby communities that are less restrictive. The potential loss of jobs, housing and economic benefits this could lead to is not looked upon kindly by the electorate! Therefore, public policy intended to promote fundamental changes in well entrenched systems such as energy generation and consumption must walk a fine line – the legislation must be aggressive enough to make a bold statement about a new approach, but cannot create any significant barriers to continued long term economic health (though the policy may create negative shorter term economic consequences, until new business models mature).

In the following sections we will review examples of some policies that have been successful in promoting community energy solutions in other areas, consider their applicability to the political and social climate of the Pacific Northwest, and provide recommendations on modifications to make existing policies more relevant and applicable. Many of these examples are drawn from Denmark which, by promoting renewable energy and the widespread adoption of thermal distribution systems, was an early global leader in achieving efficient utilization of energy resources at the national level. The majority of the policies discussed are Planning and Development Enablers, as these tend to be most effective at the local level.

9.3. Energy Taxes

Scandinavian Energy Taxes

By Pacific Northwest standards electricity prices in Denmark are very high – in 2003 residential retail rates in Aalborg, Denmark averaged 23.7¢ per kWh, more than three times the 6.6¢ per kWh rate for residential customers in Seattle.[89] This wide price spread is attributable to two primary factors: 1) the Pacific Northwest, unlike Denmark, has access to bountiful hydropower resources, which were largely developed and capitalized over 50 years ago; and 2) Danish energy policy has for many years used the leverage of taxation to shift the reliance of energy supplies away from fossil fuels such as oil and coal to renewables such as wind and biomass. As shown in Figure 35, the costs in Aalborg which are directly comparable to the utility business model in Seattle were only 6.81 ¢/kWh (wholesale power purchases at 4.32 ¢/kWh, local distribution costs of 1.83 ¢/kWh, and transmission costs of 0.66 ¢/kWh). The other 71% of retail energy costs covers a variety of taxes and rebate programs:

- Priority energy (31% of retail energy rate) – energy surcharge to cover the feed-in tariff rates that utilities were required to pay to purchase energy from small-scale CHP plants and wind power projects. The triple rate subsidy for small-scale CHP varied based upon time of day and the network level the plant is connected to, but averaged 1.8 ¢/kWh of electricity sold to the grid, with an additional 3.1 ¢/kWh given to CHP plants using biofuels.[90] (This priority pricing program is being phased out for plants of greater than 5 Mew capacity as Denmark, like the EU, moves to greater liberalization and competition within energy markets.[91])

- CO^2 tax / energy tax– since 1992 Denmark has imposed CO^2 taxes and energy taxes upon energy producers, based on the fuel supply used and its GHG impacts. Renewable energy was exempt from this tax.
- State VAT tax – a standard 25% VAT tax is added to the cost of goods and services sold in Denmark, in lieu of a sales tax or use tax.

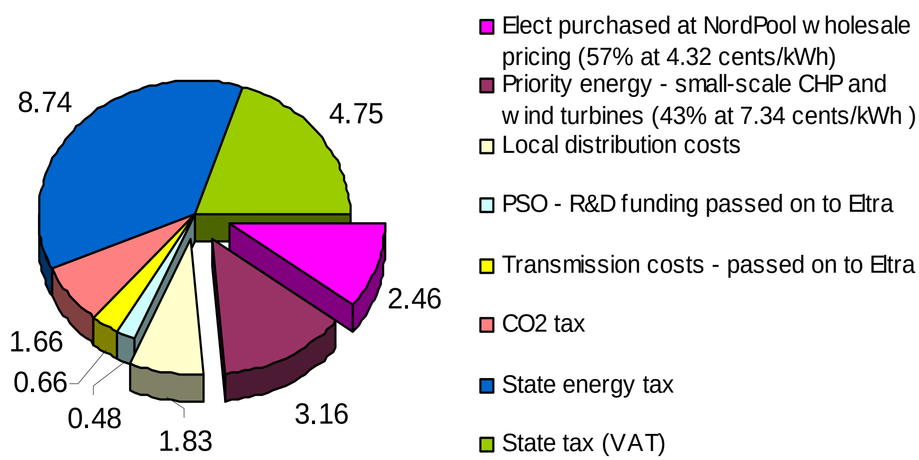

Figure 35 – Components of End Use Energy Costs in Aalborg, Denmark (2003)

Although these taxes created higher near term energy costs for Danish consumers, they have been used successfully to subsidize the development and market growth of alternative sources of energy and to reduce the country's reliance on imports. These energy taxation policies prove that properly constructed taxes can help make markets work effectively by incorporating more of the indirect costs of goods and services into their prices, and by changing consumer and producer behavior accordingly. In Denmark, this has ultimately had the effect of:

- Greater reliability and security in energy supplies – since the 1970's Denmark transformed itself from 98% dependence on imported oil to being a net energy exporter, with 56% excess capacity.
- Decreased GHG emissions – non fossil fuel production of electricity grew from 6% in 1994 to 28% today. Denmark leads the world in the use of renewable energy.
- Greater reliance on locally produced resources, with associated economic benefits in fuel production and local employment.
- There has been no net increase in overall energy use over past 30 years (see Figure 36). Energy intensity (amount of energy consumed per dollar of GDP produced) in Denmark is now only 55% that of the U.S. [92]

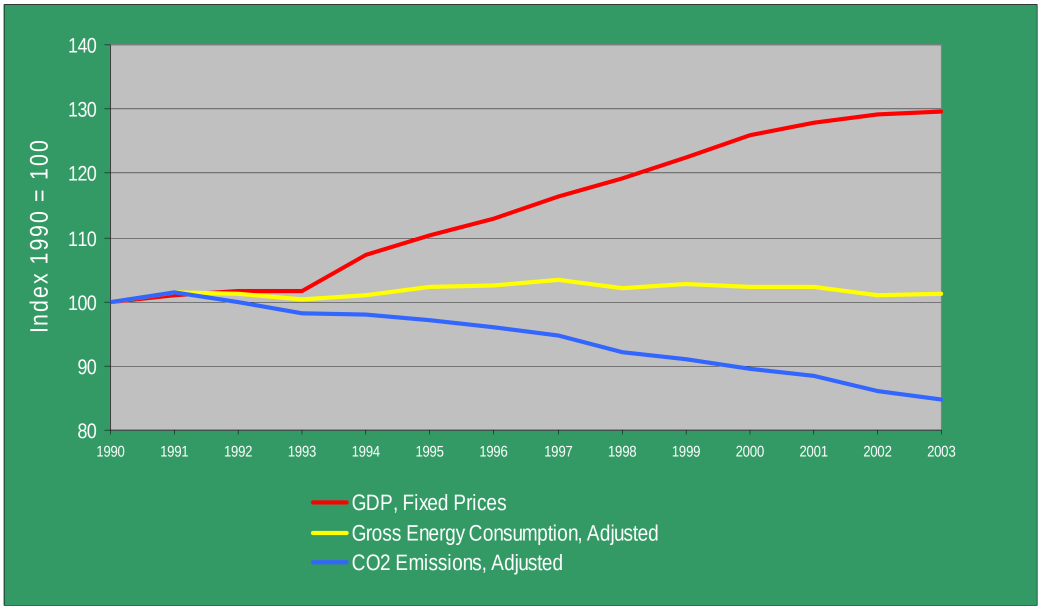

Figure 36 – Trends in Key Danish Energy Indicators

Energy Tax / Carbon Cap and Trade in the U.S.

Proposals for both an energy tax and a carbon cap and trade system are currently being debated at the U.S. Federal level. A carbon tax offers certainty about the price of polluting, which appeals to many economists and businesses, while a cap and trade system appeals to conservative lawmakers who like the idea of letting the market determine the price of carbon, while keeping revenue out of the hands of government. House Democrat, Rep. Pete Stark plans to introduce a bill in April that would levy a tax of $25 per ton of carbon released for five years, and there are at least five cap and trade plans already proposed in the Senate.[93] Though Democrats have vowed to push through some sort of carbon dioxide control in this Congress, Bush has consistently opposed mandatory limits, so it remains unclear whether the U.S. will adopt any system before the 2008 elections.

Either form of legislation would be a significant technology enabler; both a national carbon tax or a cap and trade system would have an immediate, positive effect upon promoting the renewable and efficiency technologies that are crucial to the development of an EnergyPlus neighborhood. However, in this study we wish to focus more on the policies that are implementable at the local or state level. Fortunately, the precedent for a municipal carbon tax was already established in November 2006 when Boulder, Colorado passed Initiative 202, the Climate Action Plan Tax, making it the first city in the country to impose an energy tax to directly combat global warming.[94] The tax will be used to fund the city's own Climate Action Plan, which was approved by City Council in June 2006.

Seattle released its own Climate Action Plan in September 2006, based on the recommendations of the Mayor's Green Ribbon Commission on Climate Protection. One of the elements of the Action Plan (Action #10) is to reduce GHG emissions by increasing natural gas conservation. This will be done primarily through soft measures such as "conservation program promotional materials and messages" and "by offering targeted technical assistance, incentives, promotion of utility conservation programs, and making case studies available." Progress will be measured by monitoring per capita residential energy use, and by completing regular updates to the city's GHG inventory.[95]

The City of Seattle should closely monitor its progress in natural gas conservation. It is quite possible that the current approach will not be able to sufficiently impact gas consumption, in which case more direct measures such as an energy tax or a carbon tax will be needed.

Recommendation

1. Create Climate Action Plan Tax (carbon tax) at the state or municipal level.

9.4. Market Support for Renewable Energy Generation

State Level Implementation of Feed-in Tariffs and RPS

Two general approaches are used throughout the world to promote the market adoption of renewable energy technologies:

1. Feed-in tariff – utilities are required to purchase renewable energy at a predefined price. The guaranteed price often varies based on the type of generation, and the quantity produced is determined by the market.
2. Renewable portfolio standard (RPS) – utilities are required to purchase or generate a predefined percentage of their electricity from renewable resources. The quantity is politically fixed as a quota (often rising in incremental stages over time), and the price of the resource is determined by the market.

Hvelplund argues that the RPS system, with its politically set quotas, has persistently but inaccurately been portrayed as more market-oriented than a feed-in tariff system with politically fixed prices, and quantities determined on a market. This delusion has been so successful that it is now an almost undisputed 'fact' that a program based on quota regulation should be 'the genuine market' system. [96]

Feed-in tariffs are a popular mechanism in Europe, and Germany's solar feed-in tariffs are widely acknowledged as being the impetus for the rapid growth of the solar market there. At the individual state level within the U.S. the RPS has become the preferred energy policy mechanism for promoting renewable energy, both because it is viewed by policy-makers as being "market-friendly" and because it typically does not require an explicit allocation of governmental funding. Figure 37 shows the states that have enacted an RPS and their associated renewable energy targets.[97]

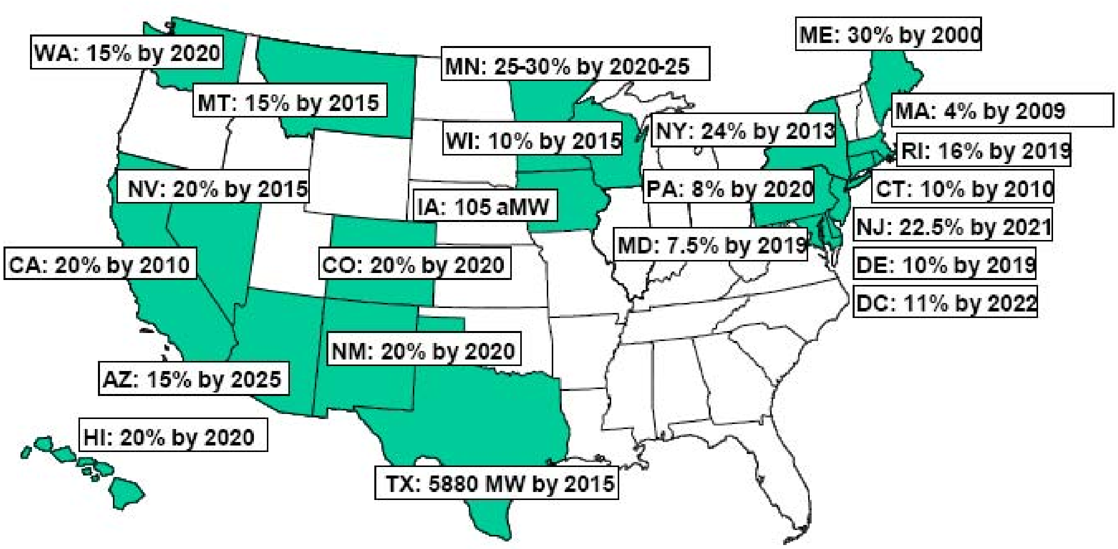

Figure 37 – State RPS Policies as of April 2007

Legislation in Washington State

Washington State is in the somewhat enviable position of having legislation for both an RPS and feed-in tariffs. On May 5, 2006 the state legislature passed SB5101, establishing a renewable energy "feed-in" production incentive, modeled after the successful German program. With this first state-wide program of its kind in the U.S., homes and businesses with solar photovoltaics, wind power systems and anaerobic digesters earn 15 cents per kWh of electricity generated by their renewable energy systems. This figure is increased to as much as 54 cents per kWh if the project's components are manufactured in Washington, up to an annual limit of $2,000 per installation.[98]

Customer Generated Power	Base Rate	Factor	Price per kWh
Anaerobic digester or solar equipment without components manufactured in Washington state	$0.15	1.0	$0.15
Solar or wind generating equipment with an inverter manufactured in Washington state	$0.15	1.2	$0.18
Solar modules manufactured in Washington state	$0.15	2.4	$0.36
Solar modules and inverter manufactured in Washington state	$0.15	3.6	$0.54

Table 11 – Payment Structure for Solar Rebates

Residents and businesses receive the per kWh credit from their local utilities but those utilities are not required to take part in the program. The legislation is a case of offering a carrot rather than a stick; since utilities are allowed to write-off the cost of providing the credits against their state taxes, they see an inherent value in participating.

On November 7, 2006, six months after enacting SB5101, Washington state voters passed Initiative I-937, which imposes interim and long term targets for energy conservation and use of eligible renewable resources on the 17 electric utilities in the state that serve more than 25,000 customers. These utilities, which account for 80% of the state's load, must secure 3% of their energy from renewable resources by 2012, 9% by 2015, and 15% by 2020. They must also set and meet energy conservation targets starting in 2010. Electricity must be generated from a renewable resource, other than fresh water, that commences operations after March 31, 1999. Existing hydro resources do not qualify under the initiative.[99, 100]

Critique of Washington State's RPS

Although Washington's RPS and feed-in tariffs could do much to promote both energy efficiency and renewable energy solutions in the state, neither one is particularly effective for supporting the vision outlined in this report. They currently target opposite ends of the market – the RPS tends to support mature renewable industries such as large-scale wind projects, which are able to deliver electricity at rates competitive with wholesale prices, while the feed-in tariffs support small-scale residential systems.

Competition for wind resources in Washington State will be fierce as a result of state requirements and regional competition for resources. Accordingly, the utilities will have to adopt an aggressive acquisition model to secure them. This competition could bode well for raising the profile of other forms of generation that fulfill the requirements of the RPS, such as neighborhood scale biomass and CHP plants. However, the RPS would be more effective in building markets, encouraging investment, and forcing the price curve down on emerging technologies if it included quotas for different technologies or types of installation environments. For example, the RPS legislation enacted in Arizona not only mandates a 15% renewables target by 2025, but also stipulates that after 2011 30% of the standard must be derived from distributed renewable energy.[101] A similar modification to Washington's RPS would do much to promote the solutions needed for an EnergyPlus neighborhood.

The Washington RPS could also be improved by embracing a broader view of energy, which includes both thermal and electrical resources. Although the initiative was subtitled as the "Energy Independence Act" in reality it applies only to electric utilities. Neither thermal conservation measures nor the expansion of a biofuels powered district energy system will be credited, unless they lead directly to a reduction in electrical consumption.[102] The exception to this is cogeneration, which is allowed as a conservation measure. However, the much more efficient alternative of capturing waste heat from an existing building or process, rather than constructing a new co-generation facility, does not qualify.

Critique of Washington State's Renewables Production Rebates

The biggest shortcoming of the solar feed-in tariff legislation is that it was designed for domestic systems; the $2,000 annual limit on payments is roughly tailored to the output of a 3.5 kW PV system.[103] In addition, the payments are structured as a state tax credit to the utility, which in turn passes these savings on to the producer in the form of guaranteed payments. In order to limit economic impacts on the state treasury, the total annual tax credits a utility can receive is limited to 0.25% of the businesses' taxable power sales, or twenty-five thousand dollars, whichever is greater.

PSE is Washington State's oldest and largest power utility, with electricity sales of $1,780 billion and gas sales of $1,120 billion in 2005.[104] At these revenue levels the utility is limited to paying a maximum of $7.23M per year in guaranteed production payments. Should building owners choose to install solar systems manufactured entirely in Washington, and be eligible for a 54 cents/kWh payment, PSE would be able to purchase no more than 13,400 MWh per year, less than the 15,800 MWh per year solar PV target for the PSSD neighborhood.

Clearly, in order for this legislation to have a significant impact in urban, mixed use neighborhoods these limits must be eliminated. The $2,000 limit per owner is the most problematic, as it makes this program largely irrelevant for commercial scale applications. The 0.25% limit per utility company will be a barrier to large scale deployments of renewables at a neighborhood scale, but it will likely be many years before this point is reached. By removing the $2,000 limit per owner first the state could promote development of both residential and commercial scale distributed solutions, without increasing its exposure to higher lost tax revenues.

In addition, utility participation in this program is purely voluntary. Most utilities have chosen to participate, because it allows them to promote renewable energy with minimal direct company expense. However, there are no long term assurances for potential developers of renewable energy solutions, as there is nothing preventing a utility from terminating its participation in the program. Lenders are often reluctant to loan money against a project with an uncertain revenue stream. This is a situation where a mandatory, long term commitment on the part of the utilities is necessary to successfully expand the market for new energy solutions.

Recommendations

1. Revise Washington's RPS legislation to include targets for distributed generation and emerging technologies.
2. Expand goals of Washington RPS to include both thermal and electric resources.
3. Eliminate the $2,000 annual cap on renewable energy production rebates available to each customer.
4. Raise the 0.25% limit on annual tax credits available to each utility participating in Washington's renewable energy production rebate program.

5. Make utility participation in the renewable energy production rebate program mandatory.

9.5. Performance Based Energy Targets

Building energy codes typically take one of two forms: 1) prescriptive codes define specific acceptable building techniques and materials such as building envelope requirements, thermal resistance of the insulation used, and quality and quantity of the glazing; 2) performance codes specify the maximum acceptable energy consumption for a building, as compared to a baseline such as comparable buildings, or the same building had it been constructed to meet the corresponding prescriptive requirements.

Denmark's national energy codes have been predominately performance based for many years, giving designers and engineers wide latitude in designing non-traditional spaces and using innovative materials and construction techniques to meet the energy goals. The targets are based on a standard per sf consumption level, specific for the intended use of the building. For example for Danish offices and schools the annual energy limit to cover space heating, hot water heating, ventilation, cooling and lighting is:[105]

> $95 + 2200/A$ (in kWh/m^2 per year)
>
> For buildings larger than 2,200 m^2 (23,700 sf) this energy consumption limit becomes 95 kWh/m^2, or 8.82 kWh/sf

For a low energy, Class 1 building in Denmark the limit is reduced to:

> $35 + 1100/A$ (in kWh/m^2 per year)
>
> For larger buildings this limit becomes 35 kWh/m^2, or 3.25kWh/sf

In order to compare these limits to the complete energy consumption values for U.S. buildings the additional non-regulated plug loads have to be included as well. Nevertheless, these targets, for the buildings being built today in Denmark, are aggressive compared to U.S. standards. For example, plug loads and other non-regulated loads are typically about 23% of the total load in an office building (see Figure 22). Adding this into account for all internal loads in a building brings the equivalent current annual Danish energy target to 11.5 kWh/sf for general buildings, and 4.22 kWh/sf for low energy buildings, corresponding to a U.S. EnergyStar rating (on a scale of 1 to 100) of 66 or 100 respectively.[106]

Energy codes in the U.S. have traditionally been prescriptive, with many pages dedicated to specific details of acceptable materials and construction techniques. The City of Seattle Energy Code does provide an equivalent option for a whole building, systems analysis approach for compliance, by modeling the entire building and its energy-using sub-systems. However, this performance based alternative to the prescriptive energy code requirements is seldom exercised. This is apparently due to the additional cost of energy modeling, the additional time needed for both modeling and subsequent permit review and approval, and the uncertainty in actually receiving code approval for a more complex design approach.[107]

Ironically, the LEED certification process, which is being undertaken by many of the buildings now planned or under construction in the Seattle area, already requires the use of a computer simulation model to assess energy performance. LEED 2.2 requirements state that documentation must be provided to verify that the building complies with ASHRAE/IESNA Standard 90.1-2004, which is not the same as the Seattle Energy Code. However, "If a local code has demonstrated quantitative and textual equivalence following, at a minimum, the U.S. Department of Energy standard process for commercial energy code determination, then it may be used to satisfy this prerequisite in lieu of ASHRAE 90.1-2004."[108] To date this equivalency has not been adequately demonstrated, with the result that a project's energy performance must be modeled twice – once compared to a ASHRAE 90.1-2004 baseline to meet LEED certification requirements, and a second time against a Seattle Energy Code baseline to demonstrate code compliance. This duplication of efforts is too expensive and time consuming for most building owners, who choose instead to forgo more innovative designs and simply meet the prescriptive requirements of the energy code. Thus, a one-time effort on the part of the City to adequately compare the Seattle Energy Code to ASHRAE 90.1-2004, combined with greater training of permit examiners so that they could interpret and approve building energy models in a timely manner, would greatly promote the adoption of energy modeling as a standard means of local energy code compliance.

Lot Based Energy Targets

Instead of simply having an energy target based on gross building area, the target could consider the height limits of current zoning designations, as well as the intended building use, and establish a total energy target for the lot. The City of Seattle currently has an ordinance that provides for height bonuses in designated areas if a developer provides funding for low income housing, or if the building is certified as LEED silver or better. Height and density are extremely valuable assets to a developer, as they are needed to maximize the saleable or leaseable space for a given lot.

Lot based energy targets would provide a mechanism to bonus a developer with additional height and/or density, as long as they continue to adhere to the energy budget for their lot. For example, assume that a 20,000 sf lot is zoned to accommodate a maximum 5 story building. With 90% utilization of the lot, a building of 90,000 sf could be constructed. Using the 9.1 kWh/sf target proposed earlier, this building would consume 819,000 kWh/sf annually. Alternatively, the target could be defined as 819,000 kWh per year total for the lot, with a maximum building height of six stories. A developer could then make the decision to construct a five story building with an energy intensity of 9.1 kWh/sf, or introduce additional energy efficiency measures and on-site renewables to propose a six story building of an equal footprint with an average energy intensity of 7.6 kWh/sf. This framework provides a market incentive for owners to build better buildings, and enforces an absolute energy cap which gives utilities the ability to reliably predict maximum future energy needs of the neighborhood (and associated distribution and other infrastructure requirements). However, this approach would obviously have to be balanced with other design and quality of life provisions, to prevent construction of massive, blocky structures designed to maximize every available foot of developable rights.

Reference Source Energy Rather Than Site Energy

Energy code standards are generally written in terms of site energy – the energy actually consumed within a building (less any energy generated on-site). Source energy includes the energy consumed at the building itself *plus* the energy used to generate, transmit, and distribute the site energy. Thus, if codes are referenced to source energy targets building owners would have to consider not only how much energy they consume but also how that energy was generated and supplied.

The difference between site and source energy is most pronounced for electric energy. Electricity is not itself a fuel, but rather a "secondary" source of energy which must be produced through the combustion of "primary" fuels, such as coal or gas. The typical process of converting primary fuels into electricity is about 30% efficient; each unit of energy purchased from the power grid (i.e., site energy) represents the consumption and associated environmental impacts of roughly three units of energy (i.e., source energy). Therefore, source energy is a better measure for comparing building energy use and the associated environmental and economic impacts.[109]

This distinction is also important when considering the benefits of district heating. A thermal distribution system that captures heat from solar panels, or waste heat from industrial processes or other heat sources, is acting very much like a large scale heat pump – by taking advantage of free thermal energy the system is able to move heat rather than generating heat, providing much higher efficiencies. Although its site energy needs would not change, a building that is connected to a district energy system would have much lower source energy needs than one producing heat with an on-site boiler or furnace.

Source energy calculations are relatively easy to perform, as long as each utility is responsible for determining and disclosing its overall system efficiency, describing how much primary energy is consumed for each unit of energy delivered to the customer. Highlighting the importance of source energy could motivate building owners to switch their mix of services to those utilities or fuel supplies that are most efficient to generate and distribute, and thus grow market demand for these more efficient solutions. Since the current electric supplies in Seattle are predominantly hydro based, incorporating source energy references would have negligible near term effect. In the longer term, however, it would help influence the mix of new marginal resources being added to the portfolio. In addition, distributed, renewable resources would have a competitive advantage for serving building loads, as they have no fuel conversion losses, and little or no transmission and distribution system losses.

CO^2 Targets

As a further refinement, a performance energy code should consider not only energy consumption but also GHG impacts, with a corresponding per square foot carbon target. Inclusion of carbon targets, particularly when combined with a carbon tax or cap and trade system as described above, would apply pressure on reducing the use of carbon intensive fuel supplies from both the supplier and the consumer ends of the value chain. For example, even though natural gas is among the cleanest fossil fuels with regard to GHG emissions, a CO^2 tax could encourage a natural gas supplier such as PSE to consider how to best fulfill the end users need for heat with district heating rather than delivering gas.

Recommendations

1. Streamline the permitting and review process for buildings using energy modeling to demonstrate performance based compliance to the Seattle Energy Code.
2. Develop equivalency guidelines comparing Seattle Energy Code to ASHRAE 90.1-2004 so that a single baseline can be used to validate compliance with requirements of both LEED and the Seattle Energy Code.
3. Consider more aggressive performance based energy targets such as those now being implemented throughout the EU.
4. Examine potential impact of implementing lot based performance energy targets.
5. Reword energy code targets to reference Source Energy rather than Site Energy.
6. Incorporate CO^2 targets into the Energy Code.

9.6. Energy Scorecard

Greater use of energy modeling opens up opportunities for more innovative designs and materials. However, energy modeling, whether for LEED certification or energy code compliance, merely looks at designed intent, not actual performance. Many buildings have failed to perform up to their projected energy expectations, due to changes in building use, unexpected changes in the behavior of the building's occupants, or errors/inaccuracies in the energy modeling. Follow-up auditing of actual energy performance is necessary to provide accountability for the energy modeling, and to provide feed-back to refine that process.

In Denmark this has been addressed by the use of an Energy Scorecard, as shown in Figure 38. The Danish labeling system for public buildings was started in 1993, and later extended to large and small private buildings. The current mandatory labeling system takes different forms for small buildings and for large buildings. The energy rating for small buildings contains information about the calculated consumption of energy and water, and CO^2 emissions of the building.

Energy Labeling of Smaller Buildings

The Energy Label for small buildings (less than 16,145 sf) is one page and includes a standardized energy rating or labeling of the building, containing information about heating, electricity and water consumption and subsequent CO^2 emission impacts. The energy audit results are compared with other buildings with a similar use, and the calculated consumption is placed on a scale from A1 to C5 (A1 is best). The energy label also contains information on the expected total energy and water consumption for the building in a reference year (average of 25 years) and the anticipated energy costs.

Another part of the audit is an energy plan, identifying which measures could be worthwhile carrying out, in the short or long run, to save energy. All small buildings and all owner-occupied homes must be energy rated and an energy plan for them must be drawn up *when they are sold*. To be valid, the energy rating and energy plan must be completed no more than three years prior to a sale.

Energy Labeling of Larger Buildings

The mandatory annual audit of larger buildings (more than 16,145 sf) is carried out by specially-trained, government-approved consultants. About 25,000 buildings are involved. Every month, all buildings, except industrial buildings, larger than 16,145 sf must register their actual consumption of heat, electricity and water.[110]

Once a year, a consultant conducts an audit and compiles an "Energy Label" and an "Energy Plan". The Energy Label evaluates the consumption of heat, electricity and water, while the Energy Plan informs the building owner about relevant measures for energy-savings.

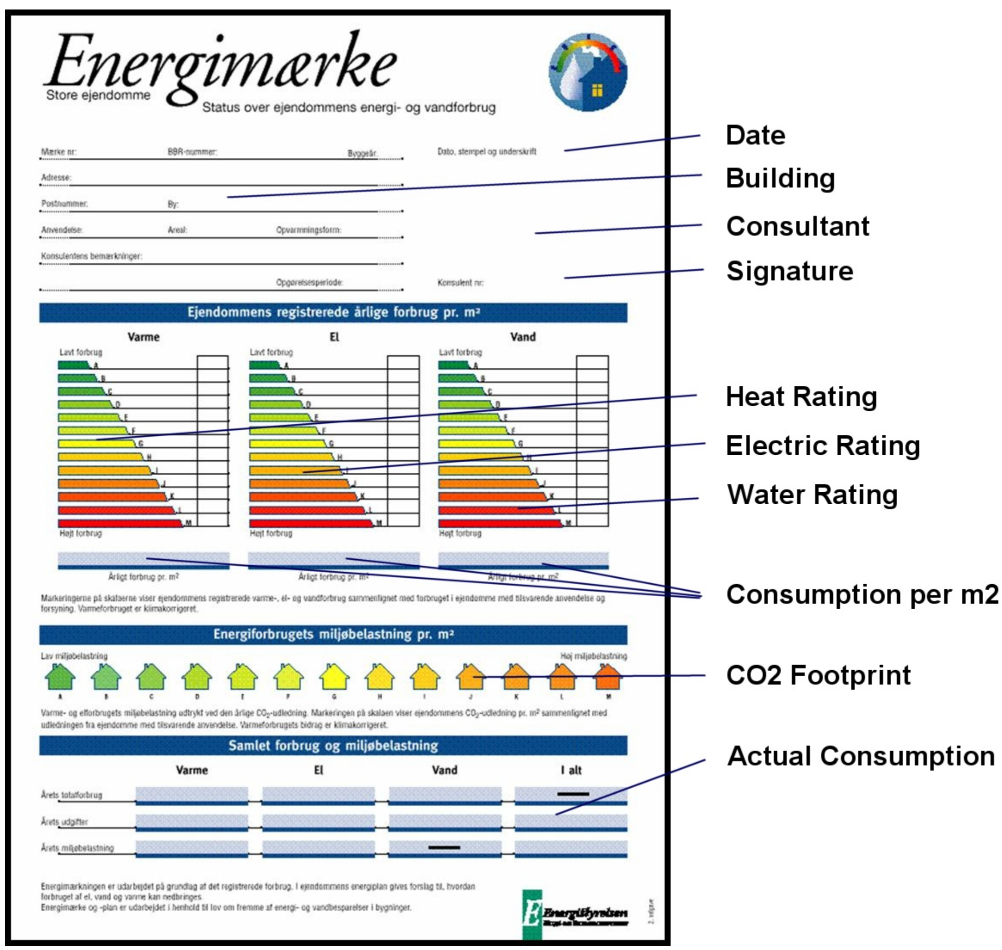

Figure 38 – Energy Scorecard

The Energy Label is based on the building's actual energy consumption, water use and CO^2 emissions over the last three years, compared with figures from similar buildings (based on best practices under the applicable codes). Finally, the energy performance and total environmental impact are calculated and rated (A to M) on an easy to interpret, color coded scale.

The Energy Plan includes proposals for reducing all types of energy and water use in the building, an estimate of investments and annual savings involved in the individual proposals, and the projected cost-benefit analysis during the lifetime of the proposed measures. It contains information on improvements in general maintenance as well as recommendations for investments in insulation, the heating system, and electric or water using appliances. Proposals for savings are prioritized based on payback time, investment cost, lifetime, and other aspects.

Market Transformation

Energy labeling is considered to be an important tool for market transformation. Labeling the energy use of buildings helps bring market pressures to bear on building owners, encouraging them to make energy efficiency investments. Applied to existing buildings, it can encourage owners and renters to invest in energy efficiency retrofits.[111]

In Denmark real estate agents must provide information on the mandatory energy labeling whenever they sell a building, and the buyer has the right to request the label on the account of the seller if it is not presented. Prospective buyers and tenants prefer energy efficient buildings, which influences the sale or rental value of buildings. Sellers and those offering buildings for rent thus make those investments that are cost-effective, and these investments are reflected in the value of the buildings, when they are sold.

SCL does have a free Facility Assessment Audit program for large and medium size commercial and industrial customers, but the program is small in scope. From 1998 to 2005 only 225 facility audits were completed, or about 28 per year[112]. There are literally thousands of large buildings in SCL's service territory that have never had an energy audit, with building owners who have never had the opportunity to learn how they could improve their energy performance. In addition, if the energy audit was contracted from an outside party, rather than SCL, the auditor would be able to make a more independent assessment of all energy savings opportunities, including potentially moving loads from one energy supplier to another.

Recommendation

1. Implement a building energy scorecard system with periodic independent energy auditing requirements.

9.7. Whole Building Incentives

Traditional utility conservation programs have emphasized equipment changes such as installing more efficient lighting or motors. For example, SCL offers financial incentives as high as 60% for lighting fixtures, controls, HVAC equipment, efficient transformers, and motors. These programs provide no incentives for changes made to the siting, orientation, or envelope of the building early in the schematic design process, nor to fundamental change in the comfort strategy such as a commitment to natural ventilation.

To address these opportunities SCL also has an Energy Analysis program, which provides customers with in-depth analysis of proposed electrical energy conservation measures not covered by standard incentives. SCL pays 100% of the cost of the consultant analysis contract for new construction applications, and provides incentive funding per kWh for projects that go beyond code; the funding is a linear function of how far the project exceeds code requirements.[113] Though this program can help inform developers of whole building energy efficiency opportunities beyond the scope of normal equipment upgrades, it has not yet been promoted successfully. In 2004/2005 only 21 new and existing commercial projects participated in SCL's Energy Analysis program, while 445 applied for the standard incentives for lighting and HVAC upgrades.[114]

PSE has three levels of conservation programming:

1. Rebates – Standardized incentives available for various technologies and end uses.
2. Component Approach – Incentives are provided for individual energy efficiency measures. The grant is determined using energy savings estimates and incremental measure cost data. Grant funding can be up to:
   - 50% of the incremental cost for improvements in electric energy efficiency
   - 70% of the incremental cost for improved natural gas efficiency
3. Whole Building Approach (WBA) - Owners must utilize energy simulation tools to compare the energy performance of the proposed building to an energy code baseline model, and the facility must be served by PSE electricity to qualify for WBA incentives. The incentives are:
   - $0.40/squre foot for energy efficiency of 10% above the code baseline.
   - $1.20/square foot for energy efficiency of 30% or greater above the code baseline.
   - Buildings between 11% and 29% above the code baseline will receive a prorated incentive.

PSE's rebate program specifically states that contractors are expected to consider building orientation to optimize HVAC equipment size and selection and increased day lighting to allow for high quality, energy-efficient lighting and improved productivity in the space.[115] Because the per square foot value of the WBA incentives increases the more the building exceeds code requirements, the PSE program is also much more effective at encouraging aggressive energy efficiency measures.

Reduce Service Requirements

A utility has a legal obligation to serve its customers, which means it must maintain sufficient system capacity to be able to meet peak demands. In turn, this means that the utility must size substations and the distribution infrastructure for these peaks. The solutions discussed in this report – higher building efficiencies, increased reliance on thermal energy solutions, and access to distributed generation resources – not only decrease average annual energy consumption, but also reduce peak loads. However, building owners must have confidence that these strategies will work as predicted, and must be willing to specify a lower maximum service rating for their electrical connection to the utility. Otherwise, the utility loses the potential financial benefit of deferring or eliminating capital investments in distribution systems, and thus has less financial interest in supporting these energy reduction strategies.

Recommendations

1. Provide whole building energy efficiency incentives for new and existing construction. The rebate value should increase the more a building exceeds the energy code baseline, to encourage adoption of more aggressive energy efficiency practices, including those that affect the siting and architectural design of the building.
2. Provide incentives for building owners to reduce the rating of their utility service connection.

9.8. Municipal Planning

In North America there is very little precedent for energy planning at the municipal level; traditional urban planning focuses on issues such as land use, transportation, water/wastewater, and infrastructure. Energy planning is typically carried out by the individual utilities, and looks primarily at supply and conservation measures. Energy distribution alternatives, and the interaction between energy and land use planning are rarely considered by any organization.

In order for cohesive and integrated community scale energy planning to occur, there must be a regulatory framework that encompasses issues beyond the typical boundaries of an individual energy utility. For example, municipal planning guidelines should consider the impact of issues such as building siting, density, and orientation. In general, Master Use codes in the U.S. give little attention to energy related issues – these are addressed only in the building energy codes which define insulation, envelope, and mechanical system requirements, but do not consider the relationship of a building to its site, available energy resources, or the utility infrastructure. This is beginning to change in some jurisdictions, where a dedicated energy element is sometimes being added municipal comprehensive planning documents.

Comprehensive Planning

The Washington State legislation added energy conservation and solar access protection to the list of permitted optional elements in local comprehensive plans in 1979. However, few communities have taken advantage of this to mandate energy strategies at the municipal level. On March 16, 2004, the City Council of Olympia, Washington passed Resolution M-1550 reaffirming the City's commitment to energy policies in Chapter 8 of the City's Comprehensive Plan. The passage of this resolution required some changes to policies dealing with reducing energy use, fuel consumption, and GHG emissions.[116] Some of the specific goals of this measure were:

- To ensure that new growth in the City services are accommodated with zero net increase in GHG emissions;
- To establish an active, comprehensive citywide program to measure energy consumption levels per capita and report on them and use these targets as performance measures; and
- To develop a long term energy management action plan for the City that will lead to a reduction in GHG emissions by 2% per year, until all available, cost-effective technology and strategy options are exhausted, or they reach the 1990 emissions levels throughout City operations or shall be consistent with international treaties targets.

Municipal Energy Planning

In Scandinavia municipal planning requirements have been particularly effective in mandating the construction of district energy systems, with the goal of increasing overall energy efficiency at the regional level. By providing a means to capture and transport waste heat naturally produced through industrial or other processes, a district energy system can greatly reduce the need to consume gas or electricity in order to generate heat on-site. District energy systems have now been widely adopted throughout Scandinavia, where they typically provide the majority of heating supplies for entire cities.

However, though they provide great potential for increasing the ongoing energy efficiency, they require a significant initial capital investment for the insulated piping and other infrastructure. A utility can cover all operating costs if they know there will be sufficient long term connected load to justify the distribution system. But in order to have the new infrastructure available for new developments, it must be built and sized for future growth before the development occurs, which raises tremendous financing challenges – how is the capital raised and paid for in the early years, before the rate paying loads are connected?

In Copenhagen this dilemma was addressed with public sector based Least Cost Planning. Unlike traditional utility Least Cost Planning, this effort transcended the normal boundaries of geography, technologies, and fuel sources to determine the most energy efficient means of providing heat to urban neighborhoods. Where the density and energy use was high enough to justify it, all buildings were required to connect to the district energy system, providing a captive market to underwrite the capital investment for system expansion. Where the density was lower, the buildings are heated with gas lines and on-site boilers. Figure 39 shows the distribution pattern generated by this analysis; gas lines run to single family homes (green) while multi-family housing (red) is heated by district energy.[117] Neighborhoods with sufficient density could have both a district energy system for heating and gas lines for cooking.

A typical U.S. objection to this publicly mandated connection scheme is that it eliminates market forces. However, this need not be true. On the contrary, neighborhood-scale heat planning can be regarded as coordinated competition between the district heating company and the gas company. The company able to offer the alternative that best meets the objectives of the municipality's energy strategy, such as lowest long term costs, high security of supply, low environmental impact, use of local resources etc., will win the competition.

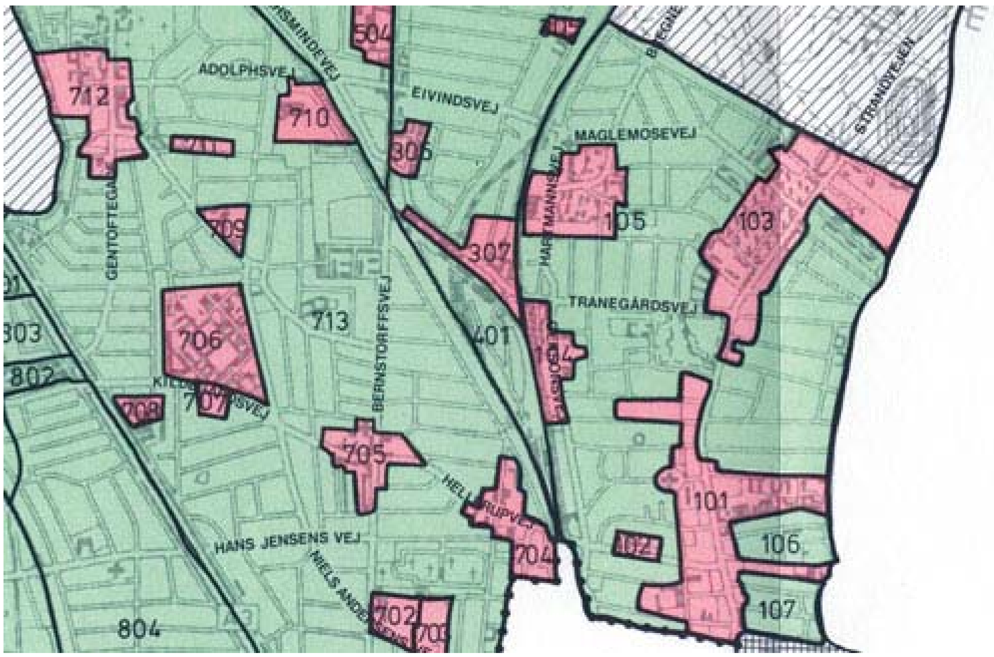

Figure 39 – Least Cost Planning for District Energy Systems

Still, in most U.S. communities there would be strong resistance to the energy planning approach used in Copenhagen, as it would likely be viewed as an inappropriate level of government intervention. However, the Lonsdale Energy Corporation (LEC) example profiled in the case study of Section 5.3 illustrates a model that could more easily be adapted for the U.S. As previously described, the LEC is a new public/private energy utility owned by the City of North Vancouver, which is providing district heating for a rapidly expanding neighborhood. The LEC cannot directly control the design, building or operation of the buildings connected to its system – these are the responsibilities of the initial developer – but the City, as regulator of land use, is able to place requirements upon developers that are in the best interests of the public. North Vancouver has placed contractual requirements on builders who develop in the area, such as mandating that all buildings constructed on public lands use hydronic heating, compatible with a future connection to the system. These building code requirements, combined with the City's ability to access municipal financing mechanisms, have allowed the LEC to fund the construction of the upfront infrastructure, with guarantees of a future connected customer base sufficient to service the projected debt load. It is the tight relationship between the utility and the municipal planning requirements that has provided this foundation for success.

Facilitate Construction of District Energy Systems

Although district energy solutions are recognized as being an effective way to reduce energy consumption and GHG impacts, they are inherently expensive to construct, particularly in existing neighborhoods where the existing streets, buildings and utility lines must be navigated. There are several considerations that could either facilitate construction in these environments or provide the more predictable load growth needed to secure financing.

1. Allow special dispensation to place piping at less than 36 inch depth – all new utility infrastructure in the City of Seattle must be placed 36 inches below grade, creating a web of potentially poorly documented pipes and raceways. If district energy piping were permitted to be buried only 24 inches deep, above all other utility lines, long unobstructed runs could be made, reducing construction costs considerably.

2. Whenever new utilities are placed in a roadway right of way, the contractor is required to repair and resurface the "zone of influence" affected by the trenching. The zone of influence extends out from the edge of the opening a horizontal distance equal to 25% of the depth of the trench.[118] If an 8 inch trench is dug 36 inches deep, the contractor is responsible for restoring 26 inches of roadway (8 inch wide trench, plus 9 inches on either side), more than tripling the cost of road restoration. Newer trenching equipment and techniques may be able to eliminate or greatly reduce the impact on soil surrounding the trench, making this requirement to restore an area larger than the trench width unwarranted..

3. Once a district energy infrastructure is available in a neighborhood such as PSSD, potential customers should be able to decrease their energy costs by connecting to the system, but only if their existing mechanical systems are compatible. For example, an existing building with electric baseboard heating would need a complete internal renovation to tap into the district energy system. New construction in areas likely to be served by a district energy system should be heated with hydronic systems, making it simple and inexpensive to connect to a district energy system when it becomes available.

4. The city should require that all existing buildings connect to a district energy system if it runs near the building, but should also underwrite loan funding to pay for mechanical system improvements. A grandfather clause would permit a phased in connection schedule for existing buildings.

Global Warming Mitigation

Another area of municipal planning that is just beginning to gain attention is the city's responsibility to mitigate the effects of global warming. California's adoption of statewide emission-reduction targets in 2006 supplied the basis for the *State of California v. San Bernardino County* law suit. After San Bernardino County issued its analysis for a comprehensive planning update that would guide future development in the County, both the State and environmental groups sued, claiming that the County failed to assess how the substantial development anticipated by the plan would contribute to climate change, and failed to adopt measures to mitigate the climate change impacts of these future developments. The legal petition specifically identified feasible GHG mitigation measures that should have been considered, such as solar energy, passive heating and cooling, and high density development.[119]

Washington State has enacted similar legislation defining GHG emissions reduction goals. Although no legal challenges have been filed in Washington to date, the precedent in California shows that a state can take the position that local municipalities must comply with, and help the state comply with, legislatively mandated emission reduction goals. Therefore, updates of municipal planning and permitting documents in Washington State may now need to account for the GHG emissions associated with growth and new developments.

Ironically, municipalities such as the City of Seattle that have imposed impact assessment or adaptation measures on themselves (e.g., Seattle's internal GHG inventory, or the requirement that all new city owned buildings be LEED certified) which are more stringent than those imposed on the private sector may be exposing themselves to greater risk of litigation. An environmental group or someone opposed to a large development could point to this inequity as an indication that the municipality is not taking the impacts of GHG emissions upon the entire community into account. A far safer approach is for municipalities to adopt zoning and comprehensive plan regulations that are effective upon the entire development community.[120]

Recommendations

1. Add energy and GHG mitigation elements to local Comprehensive Master Plans.
2. Perform comprehensive, regional Least Cost Planning for energy across all utility fuel supplies and distribution systems.
3. Enact building code requirements that will facilitate future connection to a thermal energy distribution system.
4. Develop construction permitting requirements that reduce costs of burying thermal energy distribution piping.
5. Adopt zoning and permitting requirements for energy conservation and GHG mitigation that are consistent across both the public and private sectors.

10. Future Needs

This study should be viewed as the first step in the work that is needed to produce an implementable plan for an EnergyPlus neighborhood. It is obvious that a much more detailed technical analysis of options will be needed in the next phase, as well as an accompanying financial assessment that thoroughly evaluates how the cost of efficiency improvements compares to the marginal cost of new generation.

Following are some of the other issues that were identified during the course of this project, but were considered outside of the scope of the current effort.

Demand Profiles

Utility investments are driven largely by demand; they must assess infrastructure needs not by the average loads, but by their ability to fulfill peak demand. All of the measures considered for increasing energy efficiency – increased daylighting, more efficient equipment, greater use of natural ventilation, etc. – will reduce both energy consumption and peak loads. However, this study did not attempt to quantify the impact the suggested plan will have on peak demand.

Capacity Limits

The electrical, gas and steam infrastructure serving the PSSD neighborhood has a finite capacity. If load growth continues to increase, at some point substantial infrastructure investments will be needed for additional piping and wiring, and a new substation. Because these investments occur in large, discrete steps, it is important to understand these limits and their affect on each utility's willingness to subsidize the neighborhood-scale improvements that could prevent or delay these major capital investments.

Load Diversity

Similarly, because we did not have access to detailed hourly records for individual buildings, this study did not attempt to evaluate the potential positive impacts of load diversity. There will be times when some buildings or processes are producing excess thermal or electric energy that could be used to service nearby loads. This could be consciously managed, by encouraging heat producing process to take place when that heat can be best utilized by other buildings or processes. However, there will inevitably be times when excess energy must be sold to the grid or, in the case of excess thermal energy, either stored in thermal storage tanks or wasted.

Energy Intensity Discrepancies

There was insufficient data to validate our hypotheses explaining why the energy intensities of the existing PSSD buildings were so much lower than many well respected, high performance buildings. We were also unable to determine the reason for retail buildings being so much more energy intensive than other building types. Much more detailed, building specific meter readings on an hourly basis will be needed to better understand these patterns.

Characterization of Building Use

Since the majority of buildings in the PSSD neighborhood are older, they have one primary use, and the designations provided by the County Assessors Office can be taken with high degree of confidence. However, mixed use development is becoming the norm in newer neighborhoods, and will become dominant in this neighborhood as well. Any future analysis must take this into account, which could require a floor by floor depiction of the primary use rather than relying on a single definition for the entire building.

Benefits of Investing in New vs. Existing Buildings

Although the rapid projected growth in the PSSD neighborhood creates an anomaly, in general the amount of new construction in an established neighborhood is very small relative to the amount of existing building stock. Therefore, the energy efficiencies of existing buildings must be improved in order for a neighborhood to ever approach EnergyPlus status. It is still unclear how to compare the incremental per unit cost of efficiency improvements in an existing building vs.

new construction. A relatively small increase in the efficiency of existing buildings could provide more energy savings than an extreme reduction in the energy consumption of new buildings. Further analysis is needed to determine how quickly energy standards for new buildings should be ramped up, as the resources needed to meet aggressive energy codes for new buildings may be better spent renovating existing buildings. However, innovative new buildings can also have great value as an inspiration and as a demonstration of new techniques.

Community Outreach

The primary goal of this report was to evaluate the technical challenge of creating an EnergyPlus neighborhood and creating a vision of how it could be achieved. Before beginning any further analytical work this vision should be shared with building owners, neighborhood groups, city planning officials, and other key stakeholders to solicit their input and comments and engage their support for any subsequent planning work.

11. Conclusions

Through this project we have shown that it is technically possible to dramatically reduce the energy requirements of an existing urban neighborhood using proven, readily available solutions. This charts a potential course that can be taken by cities and neighborhoods of the future to reduce their dependence on fossil fuel resources. Since the built environment of our cities is the largest single consumer of energy in the U.S., as well as the largest source of GHG emissions, this change would have great significance in our efforts to both reduce our dependence on energy imports and combat climate change.

The strategies we have outlined would transform a neighborhood that, under a Business as Usual scenario, is expected to see annual energy consumption grow to as much as 221,000 MWh per year within the next ten to fifteen years, an 87% increase over present levels. Our plan would reduce the future energy needs to 57,900 MWh, a 74% reduction from the energy loads that would otherwise be reached, and only 47% of the current level. These savings would be generated by:

High performance building requirements	73,200 MWh (33% reduction)
Conservation in existing buildings	17,100 MWh (8% reduction)
CHP (thermal)	38,400 MWh (17% reduction)
CHP (electricity)	18,800 MWh (8% reduction)
Solar PV	15,900 MWh (7% reduction)
Total Load Reduction	172,000 MWh (74% reduction)
Load Remaining	***49,900 MWh (26% of BAU load)***

This plan demonstrates the potential benefits of fundamentally rethinking the relationship between cities and energy. The projected load growth for our region over the next twenty years provides an excellent opportunity for change. Considerable new investment will have to be made in energy capacity, from both private and public sources. This challenge provides an opportunity to do things differently – moving from a centralized, grid-based system to a more flexible model where cities and neighborhoods are responsible for producing much of the energy they consume, and thereby freeing up the billions of dollars now budgeted for improvements to our grid infrastructure, providing the country with greater energy security, and creating local economic development opportunities.

Getting there will require an array of public policy changes that venture into unfamiliar territory for this country. The feasibility of financing the measures suggested will depend on creating a framework that brings the public and private sector together in a partnership – the public sector can provide incentives and underwrite infrastructure investments whose financial returns are longer than those expected by private developers; the private sector can bring additional funding and innovation in design, to transform neighborhoods into a vibrant new communities. Creating buildings and neighborhoods that are more sustainable and energy efficient will also require a careful combination of policies, including technology enabling policies, to provide incentives for developing and implementing specific energy technologies such as renewables or district energy, and planning and development enabling policies, to change the way that the built environment is conceived.

The neighborhood we selected as our case study in Seattle, Washington proved to present some unique challenges. We began this process over two years ago with the hope that, because of Seattle's global leadership in environmental awareness and global climate change initiatives, this neighborhood, even with the restrictions of historic zoning status and other hurdles, could become an EnergyPlus neighborhood. We ultimately discovered that because of the region's vast hydroelectric resources, the neighborhood is served by such "green" and inexpensive energy supplies that local government and businesses are not yet experiencing the pain that energy supplies are creating in other communities – big changes require everyone to feel the same pain, so there is not yet a compelling call for change here.

Though we determined that it is unlikely that this particular neighborhood will achieve a zero energy footprint, the effort spent in establishing a process and creating a vision has not been wasted, as the methodology we have developed can now be applied in identifying and analyzing other candidate neighborhoods. There are many other communities in the U.S. who are not as fortunate as Seattle, and are already faced with high energy costs, high levels of GHG emissions from fossil fuel based power plants, and an overtaxed electric grid. We hope that, as a result of this report, the leadership and general public of these municipalities can better understand the political, technical, and institutional barriers to achieving an EnergyPlus future, and that the vision we have created can serve as an roadmap to those in both the public and private sectors who must work together to create communities that follow the energy planning path we have portrayed.

12. Appendices

12.1. Monthly Energy Consumption by Building Type

ENERGY CONSUMPTION (in MWh)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Office														
By Source	**Elect Consumption**	6,006	5,532	5,201	4,806	4,545	4,658	4,898	4,998	4,787	4,557	5,075	5,608	**60,669**
	Gas Consumption	213	209	198	163	124	106	93	85	90	103	138	205	**1,728**
	Steam Consumption	155	110	115	83	42	9	2	1	2	17	74	113	**724**
	Total Energy (MWh)	**6,374**	**5,850**	**5,514**	**5,051**	**4,711**	**4,773**	**4,993**	**5,084**	**4,878**	**4,678**	**5,287**	**5,927**	**63,121**
By Load	**Ltg/Fans/Plug Loads**	4,545	4,545	4,545	4,545	4,545	4,545	4,545	4,545	4,545	4,545	4,545	4,545	**54,536**
	Elect Cooling	0	0	0	0	0	113	353	453	242	13	0	0	**1,174**
	Elect Heating	1,461	987	656	261	0	0	0	0	0	0	530	1,064	**4,960**
	Gas Heating	213	209	198	163	124	106	93	85	90	103	138	205	**1,728**
	Steam Heating	155	110	115	83	42	9	2	1	2	17	74	113	**724**
	Total Heating	1,829	1,306	969	507	167	115	95	86	92	120	742	1,382	**7,411**
	Total Energy (MWh)	**6,374**	**5,850**	**5,514**	**5,051**	**4,711**	**4,773**	**4,993**	**5,084**	**4,878**	**4,678**	**5,287**	**5,927**	**63,121**

ENERGY CONSUMPTION (in MWh)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Residential/Hotel														
By Source	**Elect Consumption**	718	573	533	493	477	488	478	606	555	492	686	620	**6,719**
	Gas Consumption	313	290	271	247	224	175	144	137	135	180	253	319	**2,686**
	Steam Consumption	285	203	244	198	151	101	36	30	30	69	171	229	**1,747**
	Total Energy (MWh)	**1,315**	**1,066**	**1,047**	**939**	**853**	**764**	**657**	**773**	**720**	**741**	**1,110**	**1,168**	**11,152**
By Load	**Ltg/Fans/Plug Loads**	477	477	477	477	477	477	477	477	477	477	477	477	**5,727**
	Elect Cooling	0	0	0	0	0	11	1	129	78	0	0	0	**218**
	Elect Heating	240	96	56	16	0	0	0	0	0	15	208	143	**774**
	Gas Heating	313	290	271	247	224	175	144	137	135	180	253	319	**2,686**
	Steam Heating	285	203	244	198	151	101	36	30	30	69	171	229	**1,747**
	Total Heating	838	589	570	461	375	276	179	167	165	264	633	691	**5,207**
	Total Energy (MWh)	**1,315**	**1,066**	**1,047**	**939**	**853**	**764**	**657**	**773**	**720**	**741**	**1,110**	**1,168**	**11,152**

ENERGY CONSUMPTION (in MWh)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Retail														
By Source	**Elect Consumption**	2,296	1,975	1,939	1,789	1,862	1,949	2,103	2,083	2,053	1,888	2,048	2,153	**24,137**
	Gas Consumption	78	82	80	60	54	35	43	37	38	37	52	104	**702**
	Steam Consumption	51	36	46	36	10	0	0	0	0	0	16	41	**235**
	Total Energy (MWh)	**2,425**	**2,093**	**2,065**	**1,886**	**1,926**	**1,984**	**2,147**	**2,120**	**2,090**	**1,925**	**2,116**	**2,299**	**25,074**
By Load	**Ltg/Fans/Plug Loads**	1,789	1,789	1,789	1,789	1,789	1,789	1,789	1,789	1,789	1,789	1,789	1,789	**21,471**
	Elect Cooling	0	0	0	0	72	159	314	293	264	0	0	0	**1,103**
	Elect Heating	507	186	150	0	0	0	0	0	0	99	259	364	**1,564**
	Gas Heating	78	82	80	60	54	35	43	37	38	37	52	104	**702**
	Steam Heating	51	36	46	36	10	0	0	0	0	0	16	41	**235**
	Total Heating	635	303	276	96	64	35	43	37	38	136	327	509	**2,500**
	Total Energy (MWh)	**2,425**	**2,093**	**2,065**	**1,886**	**1,926**	**1,984**	**2,147**	**2,120**	**2,090**	**1,925**	**2,116**	**2,299**	**25,074**

ENERGY CONSUMPTION (in MWh)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Warehouse														
By Source	**Elect Consumption**	691	718	653	519	521	497	547	545	558	547	632	630	**7,058**
	Gas Consumption	236	209	166	67	69	22	11	3	6	25	91	173	**1,078**
	Steam Consumption	35	27	20	8	2	0	0	0	0	2	14	26	**134**
	Total Energy (MWh)	**962**	**954**	**838**	**594**	**592**	**519**	**557**	**548**	**563**	**574**	**738**	**829**	**8,270**
By Load	**Ltg/Fans/Plug Loads**	497	497	497	497	497	497	497	497	497	497	497	497	**5,963**
	Elect Cooling	0	0	0	0	0	0	50	48	61	0	0	0	**159**
	Elect Heating	194	221	156	22	24	0	0	0	0	50	135	133	**936**
	Gas Heating	236	209	166	67	69	22	11	3	6	25	91	173	**1,078**
	Steam Heating	35	27	20	8	2	0	0	0	0	2	14	26	**134**
	Total Heating	465	458	342	97	95	22	11	3	6	77	241	332	**2,148**
	Total Energy (MWh)	**962**	**954**	**838**	**594**	**592**	**519**	**557**	**548**	**563**	**574**	**738**	**829**	**8,270**

ENERGY CONSUMPTION (in MWh)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Other/Unknown														
By Source	Elect Consumption	617	579	525	480	586	460	472	555	505	475	513	598	**6,363**
	Gas Consumption	942	1,037	998	780	577	464	351	333	342	426	931	1,293	**8,475**
	Steam Consumption	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	Total Energy (MWh)	**1,559**	**1,616**	**1,523**	**1,260**	**1,163**	**924**	**823**	**887**	**847**	**901**	**1,444**	**1,891**	**14,838**
By Load	Ltg/Fans/Plug Loads	447	447	447	447	447	447	447	447	447	447	447	447	**5,360**
	Elect Cooling	0	0	0	0	7	13	25	108	58	5	0	0	**216**
	Elect Heating	170	132	78	34	132	0	0	0	0	23	66	151	**786**
	Gas Heating	942	1,037	998	780	577	464	351	333	342	426	931	1,293	**8,475**
	Steam Heating	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	Total Heating	1,112	1,170	1,076	814	709	464	351	333	342	449	997	1,444	**9,261**
	Total Energy (MWh)	**1,559**	**1,616**	**1,523**	**1,260**	**1,163**	**924**	**823**	**887**	**847**	**901**	**1,444**	**1,891**	**14,838**

ENERGY CONSUMPTION (in MWh)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
TOTAL														
By Source	**Elect Consumption**	10,328	9,377	8,850	8,087	7,990	8,051	8,498	8,786	8,457	7,960	8,953	9,609	**104,946**
	Gas Consumption	1,781	1,827	1,713	1,317	1,049	802	642	595	610	771	1,465	2,095	**14,668**
	Steam Consumption	525	376	424	325	206	111	38	31	32	88	275	409	**2,839**
	Total Energy (MWh)	**12,635**	**11,580**	**10,987**	**9,730**	**9,244**	**8,964**	**9,177**	**9,413**	**9,098**	**8,819**	**10,694**	**12,113**	**122,454**
By Load	**Ltg/Fans/Plug Loads**	7,755	7,755	7,755	7,755	7,755	7,755	7,755	7,755	7,755	7,755	7,755	7,755	**93,056**
	Elect Cooling	0	0	0	0	80	296	743	1,032	702	17	0	0	**2,870**
	Elect Heating	2,573	1,622	1,096	333	156	0	0	0	0	187	1,199	1,854	**9,020**
	Gas Heating	1,781	1,827	1,713	1,317	1,049	802	642	595	610	771	1,465	2,095	**14,668**
	Steam Heating	525	376	424	325	206	111	38	31	32	88	275	409	**2,839**
	Total Heating	4,880	3,825	3,233	1,975	1,410	913	680	627	641	1,047	2,939	4,358	**26,528**
	Total Energy (MWh)	**12,635**	**11,580**	**10,987**	**9,730**	**9,244**	**8,964**	**9,177**	**9,413**	**9,098**	**8,819**	**10,694**	**12,113**	**122,454**

Table 12 – Monthly PSSD Energy Consumption by Building Type

12.2. Vauban CHP Plant Specifications

Supplied households:	2,000	
Total connected thermal load:	6,150	kW
Wood Boiler		
Thermal output	2,300	kW
Natural gas Boilers		
Thermal output (2 x 2500)	5,000	kW
Total thermal output (68% of heat from wood, 32% from natural gas)	7,000	kW
Total elect output	345	kW
Annual Production		
Heat from wood boilers	8,780	MWh/yr
Heat from gas boilers	4,220	MWh/yr
Total Heat Production	13,000	MWh/yr
Total Elect Production	1,700	MWh/yr
Other		
Wood consumption	325	trucks/yr
Natural gas consumption	470,000	m3/yr
Construction Cost		
Long distance heating pipelines for the entire construction site	1.5M	Euro
Building construction (excluding property)	3.2M	Euro

Table 13 – Vauban CHP Plant Specifications

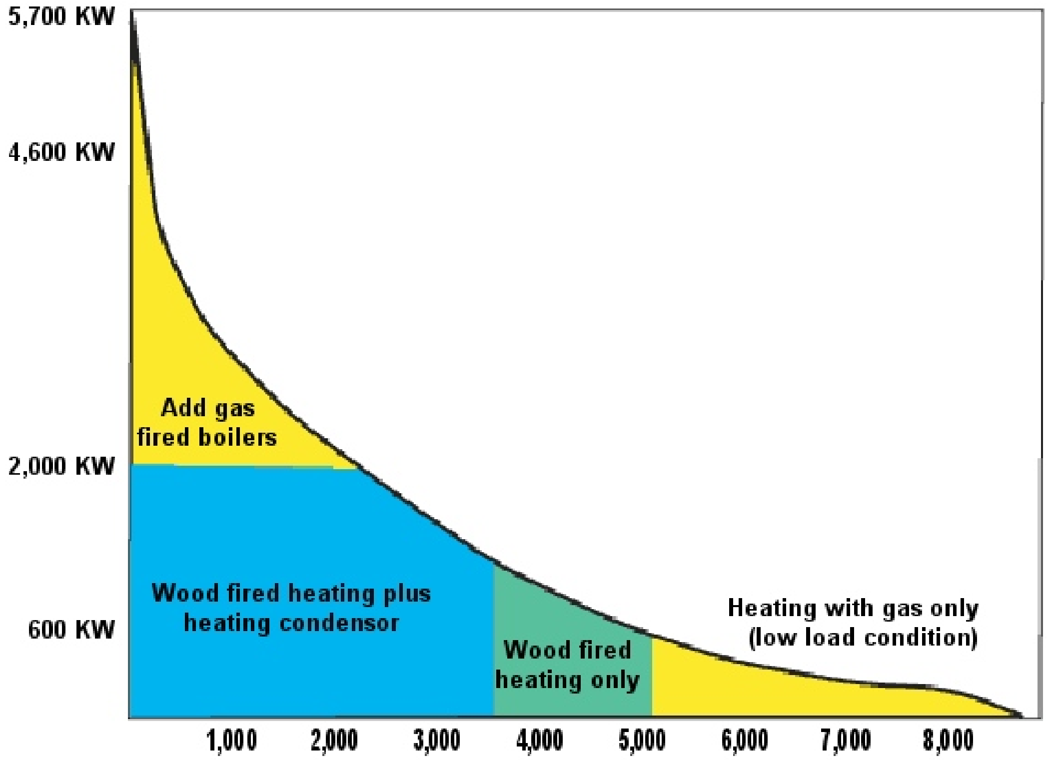

Figure 40 – Vauban CHP Load Duration Curve

12.3. Technology Enablers

TECHNOLOGY ENABLERS			
		DESCRIPTION	EXAMPLES
MARKET TRANSFORMATION	**Appliance Standards**	▪ Efficiency standards for new appliances are applied to equipment such as washing machines, lighting, water heaters, air conditioners and boilers.	
	Building Codes / Energy Codes	▪ Local codes can be used to achieve energy efficiency by requiring that building projects surpass requirements for resource conservation or incorporate renewables ▪ For both new construction and renovations ▪ Performance based codes are being widely adopted in the EU	▪ UK ▪ Denmark
	Energy and Sustainability Rating Programs	▪ Provide quantifiable and comparable metrics on the performance of appliances, buildings, or entire neighborhoods ▪ Can be incorporated into planning and permitting requirements.	▪ Seattle, WA ▪ Santa Monica, CA ▪ LEED ▪ EnergyStar
	Green Marketing Program	▪ Allows customers to support utility company investment in renewable energy technologies by paying a surcharge for energy produced by "green" sources	▪ Austin Energy ▪ Puget Sound Energy ▪ Portland General Electric
	Green Power Purchasing / Aggregation	▪ Non-residential customers (municipalities, state governments, and businesses) can buy electricity from renewable resources for municipal facilities ▪ Local governments can aggregate the electricity loads of the entire community (or even other communities) to purchase larger blocks of green power.	▪ Cape Cod Light Compact (CLC)
	Renewable Energy Certificates / Green Tags	▪ Allows consumers to purchase the environmental attributes of the power produced from renewable energy projects separately from the physical electricity.	▪ Western Renewable Energy Generation Information System (WREGIS) ▪ Sweden ▪ Italy

TECHNOLOGY ENABLERS			
		DESCRIPTION	**EXAMPLES**
	Renewable Portfolio Standard	▪ Mandates that a defined percentage of energy sold in a region is produced from defined sources or technologies ▪ Can include renewable and conservation	▪ California ▪ Colorado ▪ Texas ▪ Washington
CARBON MITIGATION	**Carbon Cap and Trade**	▪ Caps total CO2 emissions on an entire region ▪ A market for trading emissions permits is developed ▪ Encourages conservation and the development of carbon neutral energy sources ▪ Quantity based approach	▪ EU
	Carbon Tax	▪ Taxes energy sources which emit carbon dioxide into the atmosphere ▪ Based on the carbon content of the fuel being consumed ▪ Price based approach	▪ U.K. ▪ Denmark
PROJECT FINANCING	**Clean Energy Fund / System Benefits Charges**	▪ Typically financed by a surcharge on retail electricity rates ▪ Provides subsidies to promote development and commercialization of sustainable energy projects	▪ Oregon ▪ Minnesota ▪ Wisconsin ▪ Illinois ▪ Vermont
	Corporate Tax Incentives	▪ Corporations receive credits or deductions against the cost of renewable energy equipment.	▪ Washington
	Energy Efficient Mortgages	▪ Owners of energy efficient homes qualify for larger loans because of lower utility bills ▪ Mortgage loans can pay for additional energy improvements	▪ FHA ▪ Fannie Mae
	Government Loan Program	▪ Low-interest or no-interest loan programs ▪ Provide financing for the purchase of renewable energy equipment or conservation improvements.	▪ Iowa
	Government Loan Guarantees	▪ Government guarantees shield lenders from project risks ▪ Reduces debt interest rates and Increases availability of loans	
	Personal Income Tax Incentives	▪ Governments provide personal income tax credits or deductions ▪ Covers the expense of purchasing and installing renewable energy equipment	
	Public Grants	▪ Supports use and development of sustainable energy solutions ▪ Provided to municipalities or organizations	▪ New York

TECHNOLOGY ENABLERS			
		DESCRIPTION	**EXAMPLES**
PRODUCTION INCENTIVES	**Rebate Programs**	▪ Utilities or public agencies provide rebates ▪ Promotes installation of sustainable energy equipment	
	Sales Tax Incentive	▪ Exemption from the state or local sales tax for the cost of renewable energy equipment	
	Feed-in Tariff	▪ Guaranteed rate (generally well above retail rates) paid by the utility for all qualified renewable energy produced	▪ Germany ▪ Spain ▪ Washington
	Net Metering	▪ Power generated on-site can spin back the electrical meter ▪ Offsets the avoided electricity purchases at retail rates.	▪ Iowa ▪ Washington
	Production Incentive	▪ A surcharge is paid for each kWh of qualified energy produced, in addition to the rate received by selling to the purchasing utility	▪ Minnesota ▪ U.K.
	Production Tax Credit	▪ Tax credits provided based on the amount of renewable energy produced	▪ U.S.
OTHER	**Education / Training**	▪ Increases the awareness on the benefits of sustainable energy solutions.	
	Simplified Interconnection Procedures	▪ Facilitate connecting distributed power systems to the grid.	
	Utility Planning	▪ Requires utilities to complete an IRP ▪ Highlights externalities such as hidden environmental costs and long term fuel supply risks ▪ Can reveal opportunities that may not be otherwise considered	
	Energy Tax	▪ Taxes imposed at differing levels for different primary fuel sources ▪ Reflects embedded environmental costs ▪ Promotes more efficient solutions.	

Table 14 – Technology Enablers

12.4. Planning and Development Enablers

PLANNING AND DEVELOPMENT ENABLERS			
		DESCRIPTION	EXAMPLES
MUNICIPAL ZONING AND PERMITTING	**Building Rating and Labeling**	▪ Ongoing measurement and labeling of building energy performance ▪ Provides easily comparable data on the cost and impact of operations ▪ Can require implementation of cost effective conservation recommendations as a prerequisite for the permitting of building improvements	▪ Denmark
	Covenants on Municipally Owned Lands	▪ Additional requirements placed on the sale of municipally owned lands ▪ Can require use of predefined energy sources or efficiency options	▪ North Vancouver, B.C.
	District Energy Zoning	▪ Special standards for density, diversity, rate of growth, and connections to utility infrastructure ▪ Preserves options for district energy for areas identified as having appropriate characteristics	▪ Copenhagen, Denmark
	Mixed Use Zoning	▪ Encourages complimentary land uses to coexist ▪ Increases diversity of use ▪ Minimizes spread between peak and baseload power demands	
	Narrower Streets / Restricted Parking	▪ Encourages use of smaller cars or alternatives such as electric cars and plug-in hybrids for short trips	
	Performance Targets	▪ Encourages creativity in incorporating innovative, energy efficient design elements ▪ Generally based on a points system or energy target	▪ LEED ▪ Danish Energy Code ▪ California Title 24 Energy Code
	Permitting	▪ Issuance of building permits can be predicated on meeting energy requirements such as mandatory hookup to district energy system or meeting LEED standards	▪ Vancouver
	Solar Energy Zoning	▪ Standards re roof pitch, solar access, street orientations, and/or insulation upgrades	
	Solar and Wind Access Laws	▪ Provide solar or wind easements or access rights ▪ Building owner is guaranteed continued future access to a renewable resource	

PLANNING AND DEVELOPMENT ENABLERS			
		DESCRIPTION	**EXAMPLES**
DEVELOPMENT PROCESS INCENTIVES	**Density or Height Bonuses**	▪ Developers receive additional value in return for using renewables, or meeting energy supply or efficiency targets	
	Streamlined Approval Process	▪ Fast track permitting process available for projects that use renewables, or meet defined energy supply or efficiency targets	
	Property Tax Incentives	▪ Tax exemptions, exclusions, or credits are provided so that added value of energy improvements is not included in the valuation of the property for taxation purposes	▪ Connecticut ▪ Iowa ▪ Maryland ▪ Vermont ▪ Virginia
MUNICIPAL PLANNING PROCESS	**Community Scale Energy Planning**	▪ Incorporates an energy element in the master planning process ▪ Community energy planning strategies can be incorporated at the earliest stages of new community developments	

Table 15 – Planning and Development Enablers

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