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Energy District for South Lake Union/Denny Triangle

Phase 1 Feasibility Study
Final Report
Executive Summary

Prepared for Seattle City Light

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Phase 1 Feasibility Study Final Report

Introduction

This study was undertaken for Seattle City Light (SCL) by Washington State University. The work was funded by the U.S. Department of Energy, Seattle City Light, American Public Power Association and Vulcan, a major real estate development company in the study area. FVB Energy Inc. is the primary consultant on this project. Subconsultants include Kathleen Callison, Attorney on water permitting issues, Sonnichsen Engineering on air permitting and Energy Expert Services on electrical distribution issues.

An Advisory Committee was established to provide a sounding board and guidance for the preparation of this feasibility study. Early meetings of the committee took place in November 2002 and March 2003. A more extensive workshop session was held in April 2003. A preliminary Draft Report was discussed by the Advisory Committee in August. Based on the feedback received, additional investigation and analysis was undertaken to identify and develop additional technology options with stronger environmental benefits. A Final Report Review Draft, discussed by the Advisory Committee in December 2003, presented the results of that investigation, and provided: a full economic and environmental comparison of key technology configurations; 20-year pro forma economic analysis; and comparison of costs for Energy District service to costs for "self-generation" of heating and cooling by individual buildings.

This Final Report reflects a number of key changes in the economic and environmental analysis, including revision of:

- Electricity price projections to be more consistent with SCL's current forecasts;
- Assumed electricity generation resource mix (for emissions and economic comparisons) to reflect marginal capacity, based on discussion with SCL;
- Comparative analysis of technology options to reflect 20-year projected electricity and gas prices rather than static assumptions for these parameters; and
- Increased costs for environmental permitting for all technology options, especially options incorporating deep water cooling.

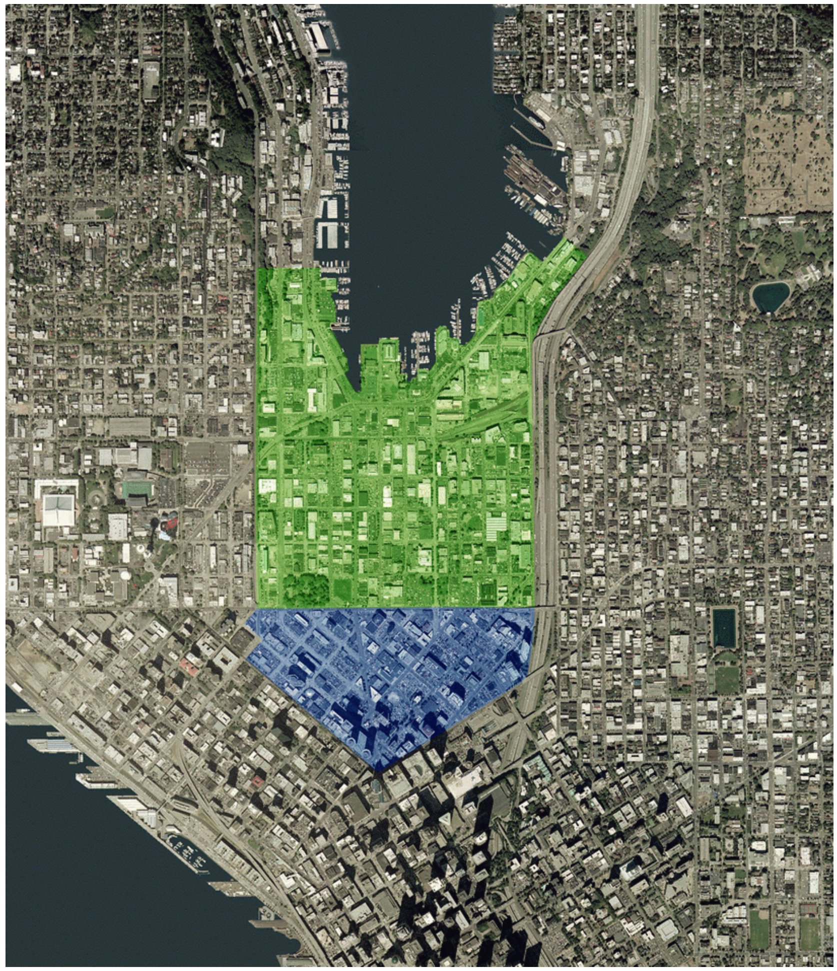
Rather than recommending a particular technology configuration, this Final Report concludes that:

- An Energy District in the study area offers significant opportunities for economic, energy and environmental benefits, and would open up many options for energy supply, some of which may not be currently anticipated;
- Significant questions regarding environmental impacts and permitting must be further addressed before a long-term technology configuration can be recommended; and
- An Energy District can be initiated with technologies that are relatively quickly implemented, enabling the Energy District to serve more of the near-term development.

Study Area

The South Lake Union and Denny Triangle areas immediately north of downtown Seattle will see substantial redevelopment over the next 15 years. The study consists of two sub-areas -- South Lake Union (SLU) and Denny Triangle (DT) – and is illustrated on the next page in Figure ES-1.

Figure ES-1. South Lake Union/Denny Triangle Study Area



Why an Energy District?

Redevelopment in the study area brings with it an opportunity to develop a sustainable energy infrastructure for the area that meets developer business objectives. This study was undertaken to evaluate the feasibility of establishing an "Energy District" that would meet the energy requirements of the buildings in the study area in a way that:

- Makes economic sense for developers and building owners;
- Supplies energy with better reliability than conventional approaches;
- Reduces reliance on fossil fuels through increased efficiency and/or use of renewable energy resources;
- Reduces environmental impact from meeting energy needs;
- *Potentially* improves water quality and salmon migration conditions as a byproduct of implementing deep water cooling; and
- "Future proofs" the buildings and the community by developing an infrastructure that provides flexibility to respond to challenges (e.g., increasing and/or volatile energy

prices) and opportunities (e.g., new technologies that are more sustainable and cost-effective) much more readily than individual building energy systems.

For the developer, sustainable energy approaches like an Energy District have the potential to provide a "triple bottom line" of economic, environmental and social payback.

What is an Energy District?

The fundamental idea of an Energy District is to distribute heating (in the form of hot water or steam) and cooling (in the form of chilled water) from a highly efficient central plant or multiple plants to individual buildings through a network of pipes. Energy Districts provide space heating, air conditioning, domestic hot water and/or industrial process energy, and often also cogenerate electricity in Combined Heat and Power (CHP) systems. There are three major elements in an Energy District:

- Plants – equipment to produce hot water and chilled water, located at one or more locations. These plants can be designed to be attractive parts of the building landscape.
- Distribution -- buried pipes to distribute hot water and chilled water. There would be four pipes (hot water supply and return, and chilled water supply and return).
- Building connections – the interface between the distribution systems and the building heating and cooling systems. To use Energy District service, buildings must use hydronic heating, i.e. hot water and chilled water are distributed within the building to heat or cool the space.

It is important to understand that Energy Districts can use a diversity of energy resources, ranging from fossil fuels to renewable energy to waste heat. They are sometimes called "community energy systems" because, by linking a community's energy users together, Energy Districts maximize efficiency and provide opportunities to connect generators of waste energy (e.g., electric power plants or industrial facilities) with consumers who can use that energy. The recovered heat can be used for heating or can be converted to cooling using absorption chillers or steam turbine drive chillers.

Broader Context

This feasibility study was prepared in a broader, dynamic context of community debate concerning redevelopment in the study area, particularly SLU. A variety of issues face the City Council regarding how to guide, control and provide infrastructure for redevelopment, including: the character and density of development; impacts on current residents; transportation infrastructure; and electricity distribution infrastructure.

Several potentially positive factors for an Energy District in this broader context were not accounted for in this study. In late 2003 the City approved a new zoning ordinance that will allow higher density development than assumed in this study. This will improve the economics of an Energy District. In addition, changes to streets and construction of a streetcar system are being planned, which could provide potential opportunities to coordinate energy infrastructure with other construction. However, given the uncertainties surrounding the timing of construction of this infrastructure compared to Energy District development, no economic synergies were assumed in this study.

The substantial new development will bring significantly increased electricity demand, which will require Seattle City Light (SCL) to invest substantial capital into reinforcing the electrical distribution system in SLU. At a time of fiscal difficulty for SCL, it is useful to determine if an Energy District can delay or eliminate some of the capital investment required for electricity distribution infrastructure.

Finally, there is a broader community context of policy relating to sustainability and environmental impact. The City and SCL are committed to green energy and reduction in emissions of greenhouse gases (GHG). While SCL has historically been fortunate to have ample access to hydroelectric power, the future will not be like the past. With changes occurring in the structure of the electricity industry, and with regional electricity requirements growing, it will become more challenging to access resources for electricity supply that are both sustainable and economical. This study evaluates how an Energy District can help meet the City's green energy and GHG goals as part of an economical and diversified sustainability strategy.

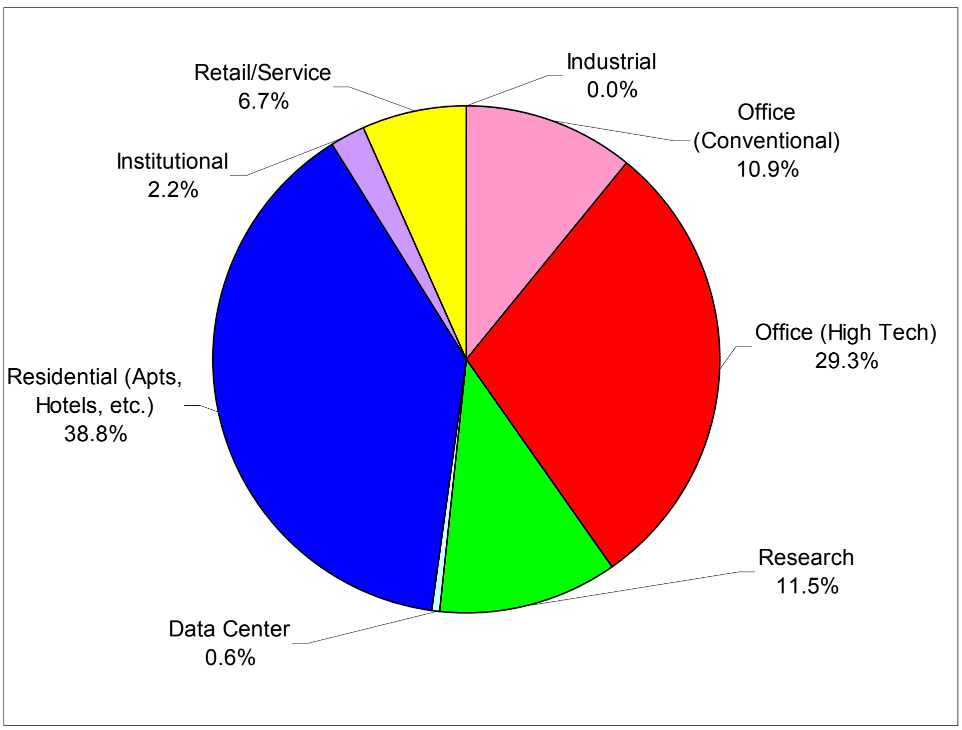
Market Assessment

Building Space

Over thirty million square feet of new development is anticipated in the study area through 2020, including biotechnology research facilities, commercial buildings and residential development. After years of community discussion of plans for redevelopment of these areas, the pace of development is rapidly picking up. There are two main regions of future load density, based on near and intermediate-term plans of developers. One of these regions of load concentration is in the middle of the SLU study area, toward Lake Union. The other region of load concentration is in the middle of the Denny Triangle area, to the east of Westlake Ave.

Projections of future building space in the study area were developed using a combination of specific planning information from developers and the growth forecasts of the SLU Capacity Model in the Heartland study (updated October 4, 2002) and the Downtown Environmental Impact Statement (for Denny Triangle). The breakdown of the total projected building space by type is summarized in Figure ES-2.

Figure ES-2. Breakdown of Total Projected Building Space by Type



Energy Requirements

Based on analysis of timing, location and characteristics of projected development, the customer base for the Energy District is conservatively projected to total 18 million square feet (MSF) of building space, or about 55% of the projected building space. The coincident peak energy requirements of the Energy District at full build-out are estimated to be:

- peak cooling demand of 32,700 tons of refrigeration;
- peak heating demand of 210 million Btu per hour of heat; and
- peak power demand of 123 MegaWatts to meet power requirements other than production of heating or cooling.

Why Customers Choose Energy District Service

Building owners choose Energy District service for a variety of reasons. First, it *makes building management easier and more effective*:

- Heating and cooling is available 24/7, so it's convenient and doesn't require management attention. This frees up time to focus on building manager's primary business.
- Energy Districts provide flexibility to increase the amount of capacity available to the building without an additional capital expenditure.
- Buildings are quieter because there is no heavy equipment generating vibration and noise, making tenants happier and more productive.

The Energy District concept fits very well with the general trend toward *outsourcing* of operations that are not central to a company's core business. By outsourcing heating and cooling, building managers can focus on their core business—whether it is biotech research, headquarters office operations, residential housing, attracting hotel, motel or condo renters, attracting and retaining tenants in a merchant office building, providing municipal services, etc.

Energy District service *reduces capital and operating risks*:

- No capital is tied up in the building for cooling and heating equipment.
- Risks associated with operation and maintenance of building heating and cooling equipment are eliminated.
- Energy Districts provide more flexibility to respond to changing energy prices, and to take advantage of new technologies.
- Costs are more predictable because more of the costs are fixed and less is spent on fuel and electricity, which can be volatile in price.

Energy District service also *reduces competitive risks*:

- Buildings that consistently provide reliable, high-quality energy services will attract and keep tenants.
- Energy District service increases the attractiveness of buildings in a competitive real estate market, thereby increasing the building's market value.

Energy Districts can deliver *better reliability* than typical individual building systems. The building owner and/or manager have a critical interest in reliability because they want to keep the occupants happy and want to avoid dealing with problems relating to maintaining comfort. Reliability takes on a critical importance for some buyers, such as biotech research facilities. Energy Districts can provide a level of equipment redundancy and round-the-clock expert management that individual buildings generally can't match. It is critical that customers be justifiably convinced that the Energy District utility can reliably deliver building comfort whenever it is needed. And it is essential the utility deliver on this promise through sound design, construction, operation and maintenance.

There are fundamental *cost advantages* that Energy Districts can provide:

- Better equipment loading, leading to better energy efficiency.
- Economies of scale to implement advanced technologies such as deep water cooling or CHP.
- Better staff economies.
- Reduced overall costs due to diversity in building loads.

Energy Districts also tend to have the disadvantage of capital-intensiveness. This approach typically requires more capital than individual building systems, and that capital tends to be "front-loaded" – it must be invested early, before growth of the system enables fully beneficial use of the technologies installed. A phased development approach can help mitigate, but not eliminate, this challenge.

In addition to capital-intensiveness, Energy Districts share other characteristics with real estate investments. It's a long-term investment, with real payoff as the system is built out, analogous to a building being fully leased. And like real estate, an Energy District needs contract commitments from initial anchor customers to support financing, analogous to pre-leasing a building.

Typically, Energy Districts charge for service through a fixed charge tied to peak demand ("demand charge" or "capacity charge"); and a variable charge for energy consumed ("energy charge"). The relationship between an Energy District and its customers is a lot like the relationship between building owners and tenants. The structure of an Energy District service agreement is analogous to a triple net lease: demand charges are like base rent; and operating costs are passed through.

Technology Analysis and Conceptual Design

An Energy District provides flexibility to use a wide variety of energy sources, some of which are difficult to tap with individual building systems. These energy sources include:

- Waste heat from gas-fired power generation (combined heat and power), providing heating, cooling (using absorption chillers) and power production;
- Lake or sea water, which can be used for heating and cooling;
- Groundwater, which can be used for heating and cooling; or
- Industrial waste heat.

Energy District Scenarios

Based on analysis of these innovative options as well as conventional heating and cooling technologies such as natural gas boilers and electric chillers, the following four technology scenarios were determined to be most viable for full concept design evaluation:

Scenario 1. Natural gas boilers for heating and electric centrifugal chillers for cooling. This conventional technology scenario is most conducive to a modular implementation approach, with equipment installed as load grows, and provides the lowest capital and total costs.

Scenario 2. Natural gas-fired combined heat and power (CHP) for production of power and by-product heat. The heat is used for a majority of the Energy District heating requirements (with gas boilers for peaking) and a significant portion of the cooling requirements (using absorption chillers that convert heat to cooling). Both gas turbines and gas engines were evaluated. A modular approach to implementing gas turbine CHP was selected, with 5 MW gas turbines installed consistent with load growth. Nitrogen oxide and carbon monoxide would be controlled with Selective Catalytic Reduction (SCR) with an oxidation catalyst. About 10% of the electricity generated would be used by Energy District plant facilities, with the remainder sold as wholesale electricity.

Scenario 3. Deep water cooling for the majority of cooling energy, with natural gas boilers for heating. Lake Washington can provide a renewable source of air conditioning energy from 60 meter (M) deep water that is 45-47 F year-round. The cold 60 M deep water can be used directly for over 75% of total annual cooling energy requirements. At peak demand conditions during the hottest weather, direct cooling from the water source must be supplemented with electrical chilling, using lake water for condenser cooling. Fortunately, there are very few annual hours when significant "tempering" with electrical chilling is required.

Scenario 4. Deep water cooling integrated with heat pumps for heating. Consistently cold 60 M temperatures can supply a natural source of cooling for building air conditioning, while shallower Lake Washington water can provide a renewable source of heat for space heating and domestic hot water using "heat pumps." This technology extracts the heat contained in relatively low temperature water (45-70 F) to produce Energy District hot water for building heating. There is ample experience with use of heat pumps with low-temperature sources in Sweden and other locations. Heat pumps fed by Lake Washington water could provide over 80% of the annual heating energy requirements. At peak demand conditions, during the coldest part of the year, the temperature of the district heating water must be increased using a boiler. However, because the Seattle climate is relatively mild, there are relatively few annual hours when substantial "tempering" with boilers will be required.

Implementation of water-based cooling and heating may also be possible using groundwater, which may be particularly appropriate for early-stage development because permitting of such an approach is expected to be quicker than with deep water cooling.

System implementation was assumed to take place in four phases, with start-up occurring in fall of 2006:

- Phase 1 – 2006-2007
- Phase 2 – 2008-2010
- Phase 3 – 2011-2015
- Phase 4 – 2016-2020

Note that the development of the Energy District is analyzed in terms of four *phases*. In addition, as discussed below, four technology *scenarios* were evaluated.

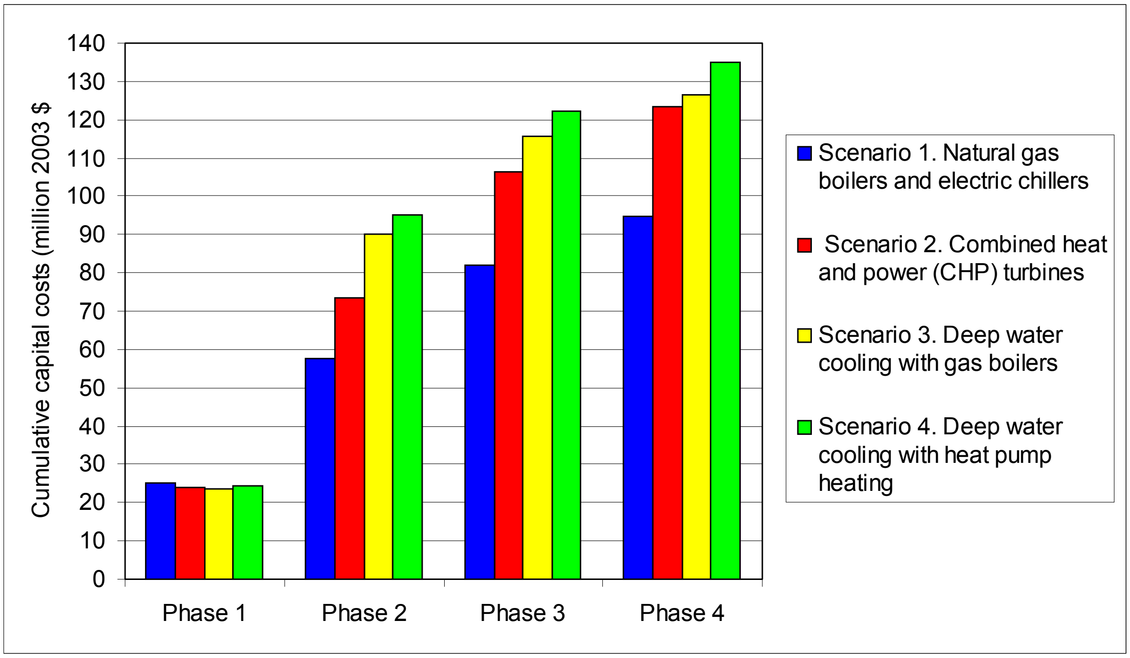
Evaluation of Technology Scenarios

Conceptual designs for implementing each scenario were developed, including the capacities and characteristics of the equipment and facilities installed in each of four phases of system development at two plant locations. A two-plant approach was taken to minimize distribution piping cost. Each of the four scenarios starts with the same basic technologies: natural gas boilers and electric centrifugal chillers. This was done to facilitate an early start to the system – the other technologies involve more time for permitting.

Economic Comparison

The capital and operating costs of each scenario (2003 $) were then estimated, and the total annual heating and cooling cost per Square Foot (SF) of building space at full build-out (year 2020) was calculated. Cumulative capital costs for each scenario are summarized in Figure ES-3. Scenario 1 (gas boilers and electric chillers) has the lowest total capital cost ($95 million), with Scenario 4 (deep water cooling and heat pumps) having the highest cumulative capital costs ($135 million) and the other two scenarios reaching cumulative costs of between $123 and $126 million.

Figure ES-3. Cumulative Capital Costs (2003 $) for Energy District Scenarios



The phasing of the Energy District infrastructure can to an extent track along with the actual pace of development and the success in marketing Energy District service. To the extent that development does not proceed at the pace envisioned, and/or market penetration is not the level projected, construction of later stages of the Energy District could be scaled back or eliminated. This would affect the higher-capital-cost approaches more than Scenario 1. This study did not include analysis of sensitivity to higher or lower levels of building space served. However, this study has conservatively assumed that only 55% of the projected building space in the study area would be served by the Energy District. It is important that follow-up studies undertake sensitivity analysis on this point.

For this screening economic analysis, total annual costs were calculated assuming amortization of capital costs at 5% interest over 20 years, plus all operating costs including fuel, purchased electricity, maintenance, labor and carbon dioxide emissions mitigation. Total annual costs per SF of customer building space at full build-out (Phase 4) are compared in Figure ES-4. Scenario 1 (gas boilers and electric chillers) has the lowest annual costs, and Scenario 4 (deep water cooling and heat pumps) has the highest annual costs under the base case projections for natural gas prices and wholesale electricity value. The Phase 4 total annual costs for Scenario 2 (CHP), Scenario 3 (deep water cooling) and Scenario 4 (deep water cooling and heat pumps) are 10%, 16% and 22%, respectively, higher than for Scenario 1 (natural gas boilers and electric chillers).

Projected total natural gas prices for the Energy District are illustrated in Figure ES-5. The price calculation is based on interruptible gas with 30% firming, and includes franchise fees. The technology scenarios include back-up fuel oil storage sufficient to meet peak requirements for 3 days. The base case projection is derived from third party forecasts incorporated into Puget Sound Energy's latest rate filing. The other scenarios are based on the same annual changes but start at a 2006 value that is $1.00 less or $1.00 to $2.00 more per million Btu.

The sensitivity of the annual cost per SF to natural gas cost is illustrated in Figure ES-6. As would be expected, CHP (Scenario 2) is highly sensitive to gas price, with gas boilers (Scenarios 2 and 3) less so, and the heat pump/boiler combination (Scenario 4) hardly at all.

Figure ES-4. Annual Costs per Square Foot at Full Build-out (Year 2020)

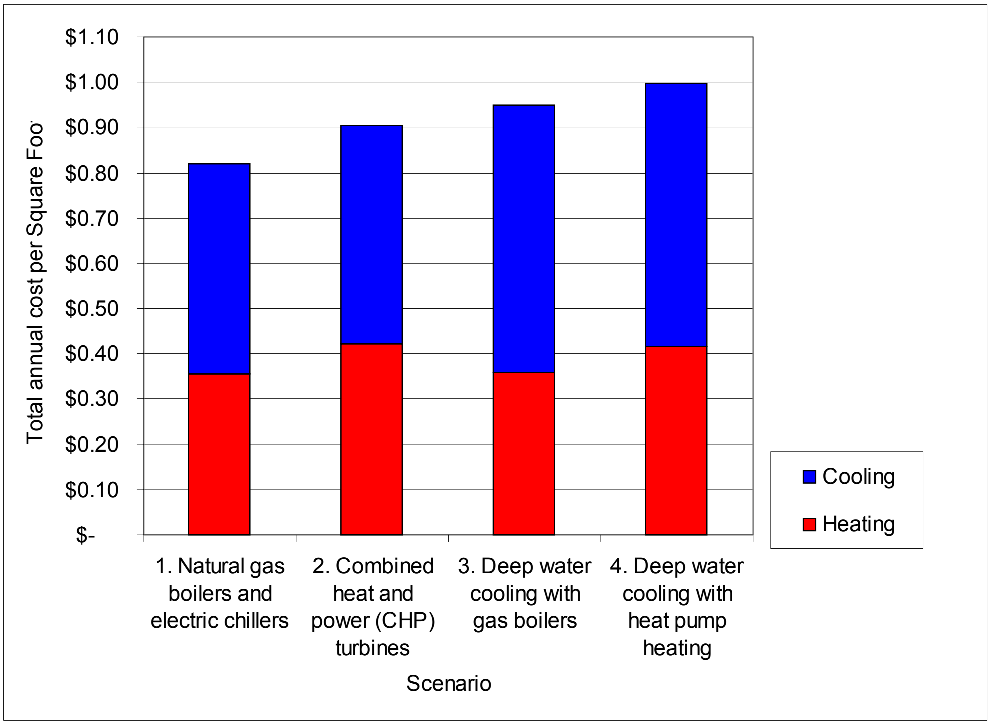


Figure ES-5. Natural Gas Price Projections

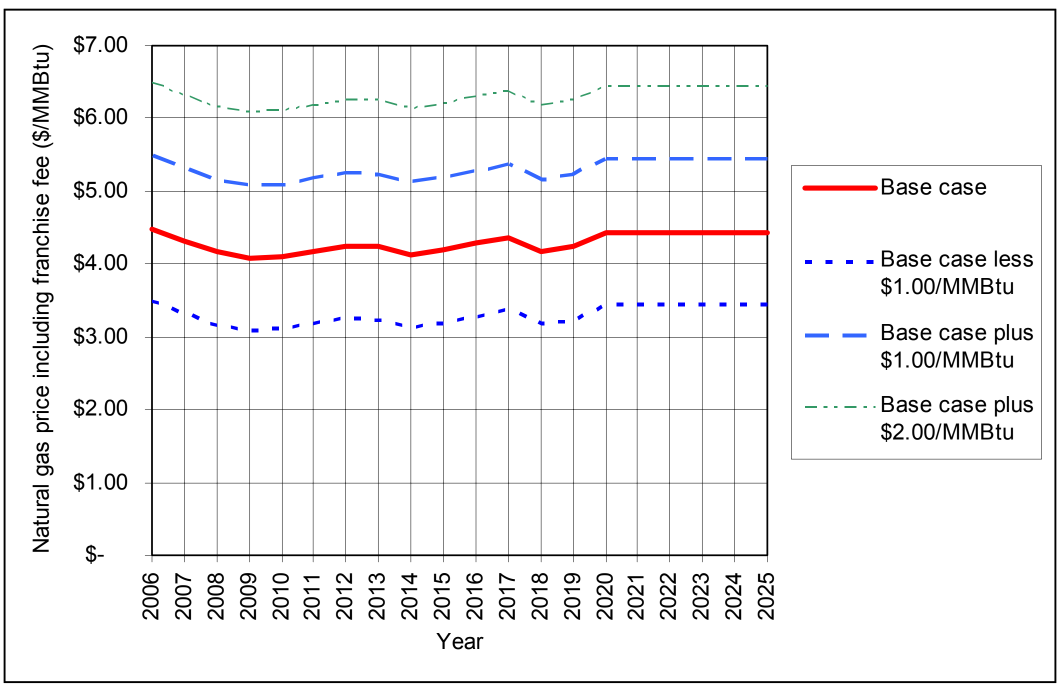
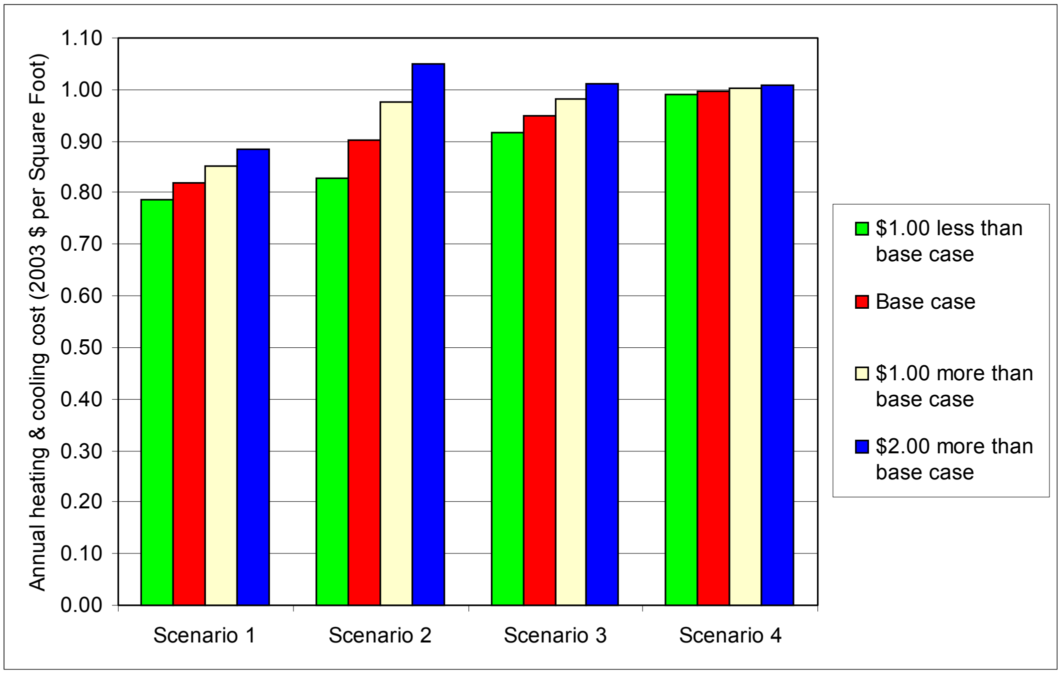


Figure ES-6. Sensitivity of Annual Cost per Square Foot to Natural Gas Price

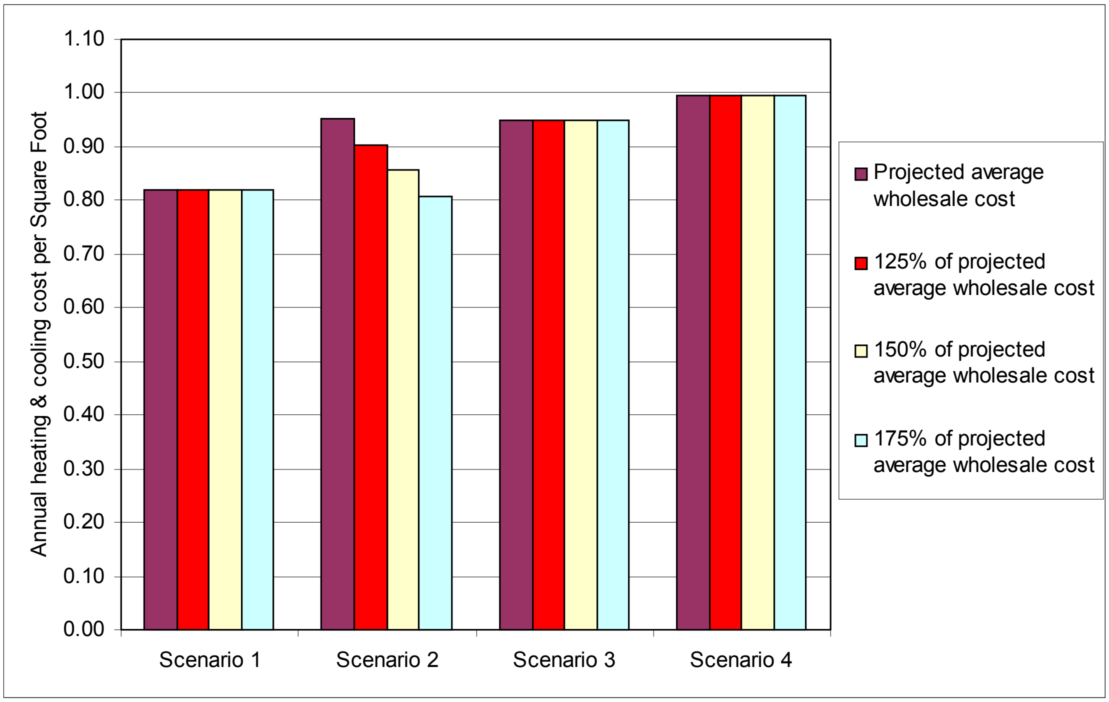


The sensitivity of the annual cost per SF to wholesale value of electricity is illustrated in Figure ES-7. CHP (Scenario 2) is the only technology sensitive to electricity value. In the base case projections, it is assumed that the value of net power production from CHP facilities was equal to 125% of the projected average summer and winter wholesale values of electricity as currently projected in a SCL working paper. Those projected wholesale values range from about $27/MWH (summer 2006) to about $38/MWH (winter 2020). The base case assumption that the value of CHP power is 125% of the average wholesale prices was made in an attempt to recognize that:

- marginal resource costs will be higher than average resource costs;
- a CHP facility can provide dispatchable power, which has a higher value than some types of renewable resources; and
- generation near load reduces transmission and distribution losses.

In a sensitivity analysis, the value of electricity was assumed to be 100%, 150% and 175% pf the projected average wholesale value. With the 175% assumption, the total costs of the CHP approach (Scenario 2) are equal to the costs of gas boilers and electric chillers (Scenario 1).

Figure ES-7. Sensitivity of Annual Cost per Square Foot to Electricity Value



The sensitivity of total Energy District costs to other variables was tested. For example, if the financing term for all capital is 30 years rather than 20 years, Phase 4 costs drop by $0.08-0.11 per SF. As described below, the Energy District will result in reductions in total carbon dioxide emissions, but no economic credit is given in the analyses described above. If the CO2 reductions are valued at $40 per metric ton (a value used by SCL in resource planning), the Phase 4 net costs of the Energy District decrease by $0.04-0.06 per SF.

Emissions Comparison

The emissions associated with each Energy District scenario were estimated, including the regulated air pollutants nitrogen oxides (NOx) and carbon monoxide (CO) as well as the greenhouse gas carbon dioxide (CO2). This analysis included direct emissions (e.g. emissions from an Energy District boiler stack) as well as indirect emissions, i.e. emissions resulting from generation of electricity obtained from Seattle City Light (SCL). Energy District emissions were then compared with the estimated emissions if no Energy District was implemented.

The emissions modeling required assumptions regarding the types of heating and cooling systems that would otherwise be installed, as well as estimation of the emissions associated with electricity obtained from SCL.

Without an Energy District, a mix of conventional heating, ventilation and air conditioning (HVAC) technologies will be implemented on an individual building scale, including: natural gas boilers; water loop heat pumps; electric resistance heat; and a variety of types of electric-driven cooling systems. Electric HVAC has been dominant in Seattle in the past, and is likely to continue to be a major element in building design. However, with recent increases in the price of electricity, its use for heating can reasonably be expected to decline somewhat. Based on consultation with Seattle City Light staff familiar with local practices, assumptions were developed for "default" (no Energy District) HVAC for each category of building space. The total shares of default HVAC are as summarized in Table ES-1.

Table ES-1. Aggregated Shares of Default HVAC at full Build-out

Heating		Cooling	
Electric resistance heating	32%	DX cooling	28%
Heat pump heating	19%	Heat pump cooling	19%
Gas heating	49%	Centrifugal chiller cooling	53%

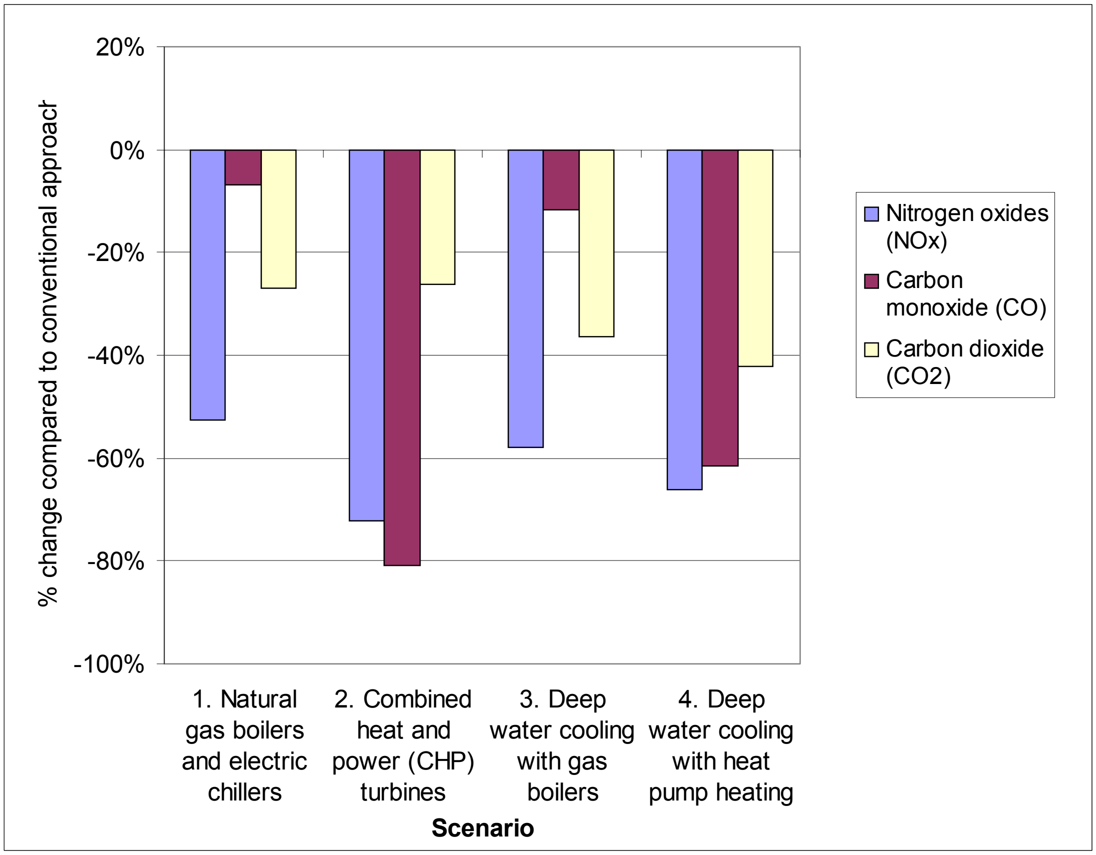
SCL's resource mix is currently 90.2 % hydro, 5.3% natural gas, 2.6% nuclear and the remainder wind, coal, waste and biomass (per the SCL website). However, since the peak capacity provided or avoided by the Energy District can be compared to SCL's alternatives for meeting new demand, the emissions characteristics of the Energy District should be compared with SCL's marginal resource (future increments of new capacity). Based on discussion with SCL, the marginal resource is assumed to be combined cycle gas turbines in the near term with a small amount of fluidized bed coal capacity in the longer term. Based on input from SCL, emissions factors for offset SCL resources were projected based on the estimated 2003 factors and the projected 2020 factors summarized in Table ES-2.

Table ES-2 . Assumed Emission Factors for SCL Resources

	Emission rates in lbs/MWH			Metric tons	Heat rate
	NOx	CO	CO2	CO2/MWH	(Btu/kWh)
New gas turbine combined cycle inc. 5% transmission losses	0.105	0.044	848	0.385	7,185
Estimated 2003 factor	0.149	0.062	1,201	0.545	10,179
Projected 2020 (90/10 combined cycle/coal mix)	0.238	0.267	1,009	0.458	7,661

The resulting total net emissions comparison for the year 2020 is shown in Figure ES-9. This graph shows percentage savings with an Energy District compared to no Energy District. In 2020, the Energy District would reduce annual carbon dioxide (CO2) emissions by 26 to 42 percent, and nitrogen oxides emissions by 52 to 72 percent (depending on technologies used) compared to conventional energy approaches.

Figure ES-8. Percentage Emissions Reduction with Energy District Scenarios Compared to No Energy District



Cumulative 20-year energy (fuel), electricity and CO_2 savings, and annual savings in 2020, are estimated in Table ES-3, with the range depending on Energy District technologies. Annual 2020 savings can be compared as follows:

- Fossil fuel savings could provide space and water heating for 6,800 to 11,200 multi-family residential units.
- Electricity savings could power 1,800 to 13,800 Seattle homes.
- CO_2 reductions are equal to 4.5 to 7.4 percent of annual emissions from Seattle City Light's generation portfolio in 2003.

Table ES-3. Summary of Energy, Electricity and Carbon Dioxide Savings Compared to No Energy District

	Cumulative	Year 2020
Energy savings (trillion Btu)	3.6 - 5.6	0.2 - 0.4
Electricity savings (million MWH)	0.3 - 2.8	0.02 - 0.17
CO2 savings (million lbs.)	495 - 820	33 - 54

Environmental and Sustainability Policy and Permitting Issues

Based on the preliminary assessment performed for this study, there do not appear to be "showstopper" air quality permitting issues associated with any of the Energy District alternatives. In addition to regulated pollutants, carbon dioxide is a key policy issue. The City of Seattle has established a long-range goal of meeting the electric energy needs of Seattle with no net greenhouse gas (GHG) emissions. Per a resolution passed on Earth Day 2000, the City has committed SCL to meet growing demand with no net increases in GHG emissions by "using cost-effective energy efficiency and renewable resources to meet as much load growth as possible," and "mitigating or offsetting GHG emissions associated with any fossil fuels used to meet load growth." In addition to the City GHG policy, it is clear that key stakeholders in the study area have a strong interest in reducing the environmental impacts associated with meeting energy needs and the environmental benefits that may be realized.

As summarized above, all Energy District concepts would provide a net reduction in GHG emissions, and sensitivity analyses were performed to calculate the economic impact of including economic credit for these reductions using an SCL planning value of $40 per metric ton.

Scenario 3 (deep water cooling) and Scenario 4 (deep water cooling and heat pumps) raise a number of environmental issues associated with construction of deep water piping in water bodies and the withdrawal and return of water. Key concerns regarding the environmental impacts of deep water cooling relate to impacts from: laying of the pipeline; impact on aquatic life at the intake; and impact on aquatic life from discharge of water at elevated temperature and heating of water surrounding the pipeline. The impacts involved would have to be identified and addressed in a thorough environmental assessment of a heat pump and/or deep water cooling project.

There may be potential environmental benefits relative to improvement of water quality and enhancement of conditions for salmon migration. Water quality in Lake Union is poor, with a key indicator, dissolved oxygen, at zero in the lower depths of this shallow lake. This condition is related to lack of mixing between the stratified layers in the lake, biological oxygen demands within the sediments, relatively high water temperatures and a saline layer at the bottom of the lake during the July-September period. In addition, salmon migration is inhibited by a "thermal barrier," i.e. high water temperatures in the Ship Canal and the Montlake Cut.

Scenarios 3 and 4 may provide an opportunity to supply cooler, oxygenated water to Lake Union, the Ship Canal and the Montlake Cut, potentially facilitating salmon migration to Lake Washington, and improving water quality:

- Cold Lake Washington water, once used for air conditioning, would be pumped into Lake Union. Although heat would be added to the water (through its use for air conditioning), the system would discharge cleaner, cooler Lake Washington water to Lake Union, potentially providing an improvement to Lake Union water quality and a net cooling of Lake Union and the salmon migration route.
- Shallower Lake Washington water used for heating would be cooled in the process, also providing a net cooling of the water before discharge to Lake Union.
- The heat exchangers used in both the heating and cooling processes could be designed to introduce oxygen into the water, thereby further improving water quality.

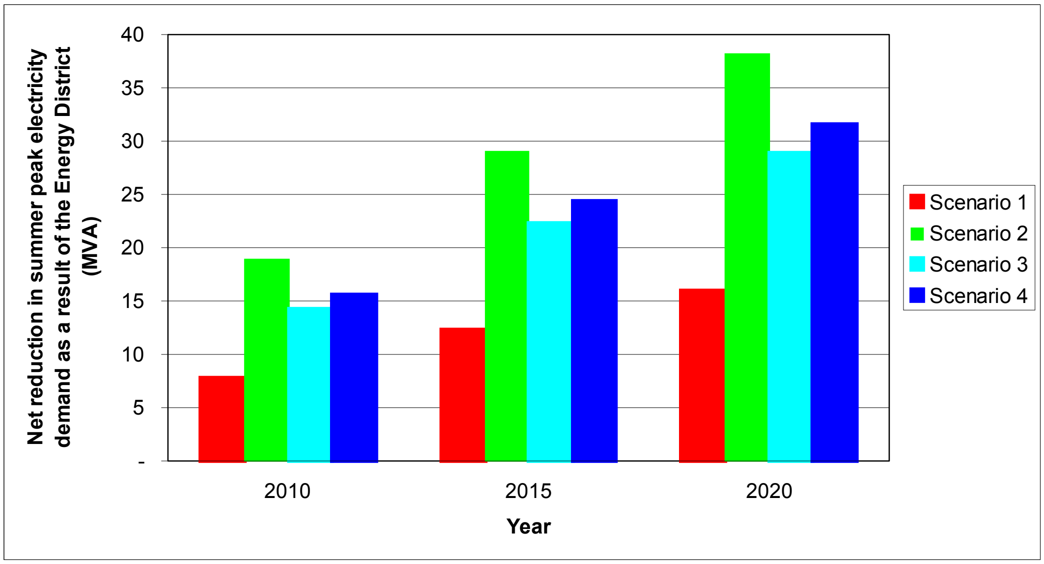
It is not clear to what extent these potential benefits are realizable. Assessment of the positive and negative impacts of a heat pump and/or deep water cooling Energy District on fisheries and water quality will require an extensive, complex and lengthy analysis.

Scenario 2 (CHP) also raises a number of policy and contractual issues relative to integration of CHP facilities into the SCL grid, relating to both technical requirements for grid interconnection as well as valuation of the power exported from the CHP facility to the wholesale markets.

Seattle City Light Infrastructure

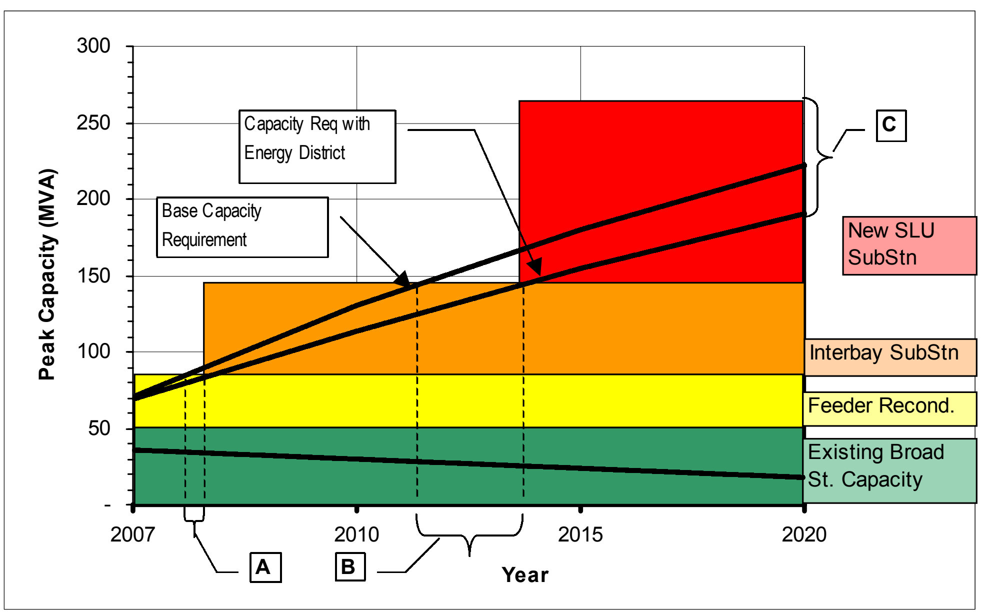
The Energy District is estimated to reduce total peak summer capacity requirements in the combined study by 16-38 MegaVolt-Amperes (MVA) depending on the Energy District technology. The Energy District is estimated to reduce total peak summer capacity requirements in the combined study area as summarized in Figure ES-9.

Figure ES-9. Impact of Energy District on Total Study Area Peak Capacity Requirements



The two sub-areas are served by two different electricity distribution systems. Of particular interest is the impact on potential capacity requirements in South Lake Union. Based on analysis by Kurt Conger of Energy Expert Services, the projected impact of the Energy District Scenario 2 is summarized in Figure ES-10. This indicates that the Energy District may enable a 2-3 year delay (interval "B") in adding a new substation to serve SLU.

Figure ES- 10. Impact of Energy District Scenario 2 on South Lake Union Capacity Requirements



Economic Analysis

A full 20-year economic proforma analysis was prepared for Scenario 1 (natural gas boilers and electric chillers) and Scenario 4 (deep water cooling and heat pumps). These two scenarios were chosen because Scenario 1 offers the lowest overall costs and Scenario 4 offers the greatest carbon dioxide reductions. The proforma analyses included:

- full capital costs including financing costs and an operating reserve;
- debt service;
- depreciation;
- operating costs and other annual costs such as franchise fees;
- revenue and expense statement;
- cash flow; and
- calculation of internal rate of return.

A non-profit public-private entity was assumed for financing and ownership, with 100% debt assumed for the base case proforma. Variable costs were passed through to the customers in a variable energy rate, with a levelized demand rate charge based on customer peak demand. The demand rate level was set to yield a 5% internal rate of return on total capital.

Energy District costs were then compared to three prototype potential customers, summarized below:

Case #1 – biotech research building
Building use: research and related office
Heating: natural gas boilers with hot water serving air handling units
Cooling: water-cooled centrifugal chillers serving air handling units

Case #2 -- residential plus mixed use
Building use: mixed use (residential/hotel/retail)
Heating: water loop heat pumps with perimeter electric heat peaking
Cooling: water loop heat pumps

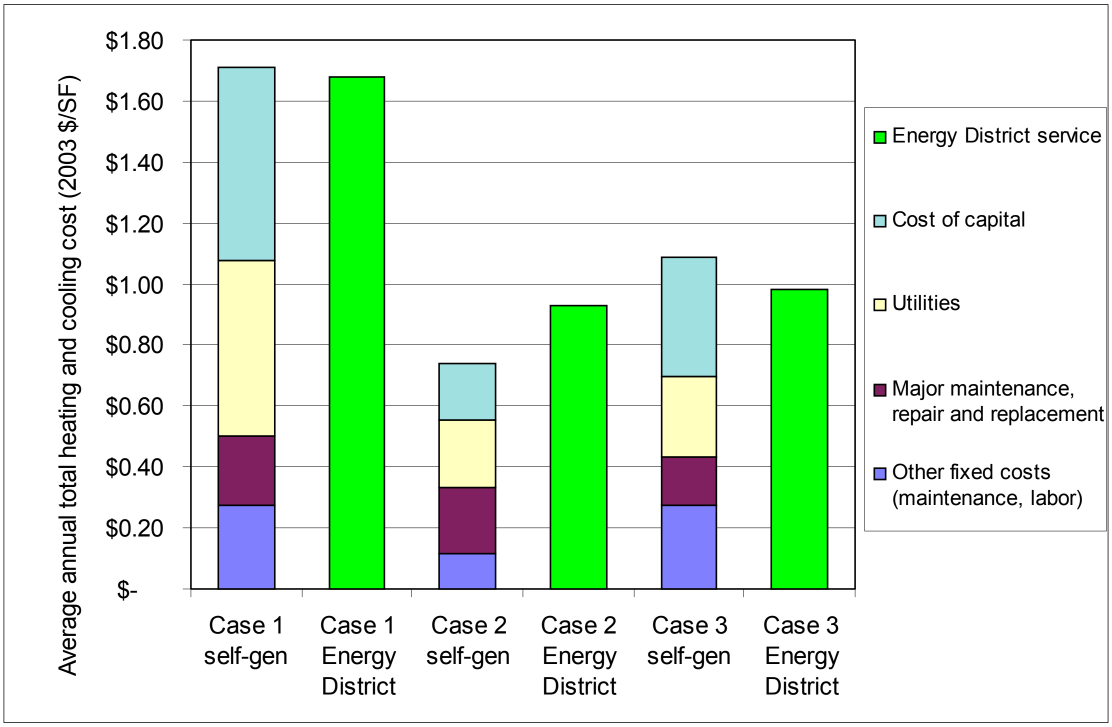
Case #3 -- office building
Building use: office
Heating: natural gas boilers with hot water serving air handling units
Cooling: water-cooled centrifugal chillers serving air handling units

Energy District costs, and costs for "self-generation" of heating and cooling, for a given customer may be higher or lower depending on energy requirements and usage patterns. Figure ES-11 illustrates the estimated total costs for self-generation for the three cases outlined above, and compares these costs with projected Energy District costs with the Scenario 1 technology concept.

It is important to note that the costs usually thought of as "utilities" are only one part of the total cost of providing heating and cooling for a building. Conventional heating and cooling requires not only capital investment but also ongoing expenses for fuel, electricity, labor, supplies, maintenance, and replacement.

The Energy District offers cost savings in Cases 1 and 3, and somewhat higher costs in Case 2. The cost of Energy District heating and cooling service for most customers is projected to be $0.90-1.00 per square foot per year (2003 dollars), depending on the technologies employed and the building energy usage pattern. Costs for buildings with most space devoted to intensive research activities would be higher – an estimated $1.70 per square foot – due to higher energy intensity. However, self-generation costs for energy intensive buildings are also expected to be significantly higher than self-generation for other building types, and higher than the Energy District cost for these energy-intensive buildings.

Figure ES- 11. Total Heating and Cooling Costs for Three Self-Generation Cases with 9% Weighted Average Cost of Capital



Energy District service is expected to be competitive with the total costs of conventional approaches for many customers with Scenario 1 and, depending on the value of CHP power production, with Scenario 2. With technology Scenarios 3 or 4, an Energy District would require significant financing assistance to be competitive with self-generation.

Although Energy District service would come at a cost premium in Case 2, it would also provide significant advantages relative to better indoor temperature controllability and comfort, improved reliability, ease of building operation and elimination of the headache of maintaining many heat pump units.

Recommendations

Redevelopment in the study area brings with it an opportunity to develop a flexible and sustainable energy infrastructure for the area that meets developer business objectives. Based on this study, there appear to be significant public and private benefits realizable from an Energy District.

It is important to understand that an Energy District opens up many options for energy supply, some of which may not be anticipated currently. For an insight into how Energy Districts can evolve to provide energy, environmental and economic flexibility, it is useful to examine the experience of St. Paul, Minnesota. This Energy District started as a highly efficient hot water district heating system in the early 1980s, initiated by the building owners (through the Building Owners and Managers Association) and the City of St. Paul with technical and financial assistance from the State of Minnesota and the U.S. Department of Energy. Since then it has evolved to incorporate:

- Chilled water district cooling including electric and absorption chillers
- Thermal energy storage to reduce peak power demand
- Biomass combined heat and power (CHP) using waste wood to produce power, heating and cooling

The St. Paul system is owned and operated by a private non-profit corporation governed by a seven-member board of directors composed of City appointees and representatives elected by the customers.

Implementing an Energy District in Seattle will not be easy. It will require multiple private sector and public sector entities to work together. It will involve a variety of regulatory hurdles. And it will require significant capital investment – capital that is front-loaded ahead of the revenue-generating customer base.

A private non-profit company is the most promising approach for implementing an Energy District in the study area, for several reasons:

- It could be used to facilitate low-cost financing, thereby helping keep costs down for a capital-intensive energy infrastructure;
- It facilitates a governance approach that enables the stakeholders, including most importantly the customers, a voice in decision-making; and
- It has been proven to work successfully, for example in St. Paul, Minnesota.

An "Energy District Development Corporation" (EDDC) could be the non-profit vehicle for system development (just as the District Heating Development Company did in St. Paul, eventually morphing into District Energy St. Paul, an operating utility company). The stakeholders, both public and private, could participate in governance and decision-making of this ownership entity. EDDC could contract with a developer to design, construct and commission the system. EDDC could also contract with an operator to manage the system on a day-to-day basis. For example, Seattle Steam, which has many years of management and operations experience, could be excellent candidate for this role.

If the stakeholders agree that the potential benefits are significant enough to warrant further investigation, Phase 2 studies should be initiated to clarify the technical, economic, permitting, financial and organizational issues surrounding this opportunity. Key steps in Phase 2 studies are outlined below in two sub-phases. In this outline, reference will be made to "Initial System." This is intended to refer to the first phase of development of the Energy District system.

Phase 2a

1. Communication with potential customers regarding the benefits and costs of Energy District service, including potential service contract terms and costs, and comparison to customer alternatives.
2. Investigation of alternative technologies for the Initial System, including groundwater and small-scale CHP.
3. Development of a conceptual design for the Initial System, including plant siting, distribution routing, customer connections and related capital and operating costs.
4. Additional analysis of impacts of Energy District on electricity transmission and distribution systems.
5. Development of the organizational and financing approach for Energy District system design, permitting, construction and operation.
6. Development of a detailed plan and timeline for Initial System implementation including design, permitting, construction and operation.
7. Revision of Energy District economic and financial analysis based on the above.
8. Recommendations regarding proceeding.

Phase 2b

1. Negotiation with potential customers regarding the benefits and costs of Energy District service, including potential service contract terms and costs, and comparison to customer alternatives.
2. Design and preliminary implementation of a public outreach and involvement plan.
3. Updating of projections for building development and related customer heating and cooling loads.
4. Scoping and assessment of permitting issues and potential water quality and fish migration benefits associated with deep water cooling/heat pump technology.

5. Initiation of permitting and regulatory processes and environmental assessments in view of public input and permitting discussions with regulators.
6. Specification/negotiation of terms and conditions for electricity and gas service, and, as applicable, grid connection for power export.
7. Interactive with the above, revision of technology concept and economic analysis for full Energy District development.
8. Development of specific financing plan, including identification of funding sources and basic contractual relationships between capital sources, system developer, system owner and customers.
9. Presentation and communication of the Phase 2 Study results with public and private sector stakeholders.