Overlake Village District Energy Feasibility Study

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Acknowledgements

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Executive Summary

The City of Redmond (the City) has investigated the feasibility of establishing a district energy system in Overlake Village as part of the City's climate action planning efforts. District energy has the potential to reduce energy use, carbon emissions, and energy costs while creating a competitive edge in redevelopment by eliminating the need to provide onsite heating and cooling equipment.

Puget Sound Energy (PSE) and the City, in partnership with McKinstry and Sound Energy Investments, developed this feasibility study report to examine specific district energy system configurations and determine whether such a system would reduce energy costs, reduce carbon emissions, meet the City's Climate Action Implementation Plan, and be economically feasible to construct and operate in Overlake Village. This report considers district energy technologies, ownership structures, operations, regulatory considerations, and financial analysis. Included are recommendations and considerations to be used in the next phase of district energy development for Overlake Village. The analysis also identifies specific energy efficiency considerations and distributed generation technologies that could be implemented in Overlake Village even without the development of the district energy system.

The evaluation process. The City evaluated district energy for Overlake Village in a two-step process: a pre-feasibility study completed in late 2013, and a feasibility study completed in December 2014.

The 2013 pre-feasibility study was funded by a HUD grant. This initial study indicated that a district energy system could reduce energy use by 10–30 percent, reduce heating and cooling energy costs by 10–50 percent, and reduce carbon emissions by 15–45 percent. The higher end of each of these ranges represents the reduction that might be achieved by combining generation technologies like natural gas and geothermal.

The 2014 comprehensive feasibility study was performed by a partnership of the City and PSE, and was funded almost entirely by PSE. This study assessed district energy technology to help determine the economic feasibility of district energy for Overlake Village. As a baseline for the 2014 evaluation, PSE and the City defined several "business-as-usual" (BAU) scenarios to model the future energy performance of the Overlake Village study area if district energy is not implemented. The evaluation criteria for the feasibility study required that:

1. Rates are to be competitive with BAU energy rates.
2. Greenhouse gas emissions are to be lower than BAU greenhouse gas emission levels.
3. Energy use is to be lower than BAU energy use.
4. The system's central plant is to be financially viable and must meet the investors' objectives.

PSE and the consultant team – McKinstry and Sound Energy Investments – incorporated the following general methodology:

1. Compile energy use data for the Overlake Village.
2. Select suitable technologies for district energy systems.
3. Assess ownership structures and demarcation for district energy systems.

4. Evaluate the economic benefits, energy use, and greenhouse gas emissions of the proposed district energy systems based on assumed adoption rates.
5. Compare the proposed district energy systems to the BAU scenarios.

Seven conceptual design options were considered for the central plant that would serve the Overlake Village district energy system.

Table 1: Central Plant Design Options

Option	System design
A	Central heating hot water and chilled water plant consists of natural-gas-fired hot water boilers, chillers, cooling towers, and distribution pumps located in a central facility and connected to the district by a network of buried distribution piping.
B	Central heating hot-water-only plant consists of natural-gas-fired hot water boilers and distribution pumps located in a central facility and connected to the district by a network of buried distribution piping.
C	Central heating hot water and chilled water plant with geothermal would add a part-load open-loop ground source geothermal heat pump system to Option A.
D	Combined heat and power plant would add a combined heat and power system to Option A, sized for the minimum continuous heating load of the district energy system.
E	Demand response/thermal energy storage would add a thermal energy storage system with demand response controls to Option A.
F	Waste heat recovery plant would add waste heat recovery to Option A.
G	Waste heat recovery plant with distributed heat pumps would install gas-fired condensing boilers, cooling towers, and distribution pumps in a central facility connected to the district by a network of buried distribution piping.

After establishing this range of design options for the central plant, the team framed four scenarios, with each scenario focusing on a particular aspect of the evaluation criteria as its main objective. The team then identified the design option that would best fit each scenario.

Table 2: Development Scenarios

Scenario	Objective	Best-fit option
1	Minimize carbon footprint.	**G**
2	Minimize carbon footprint with geothermal.	**C**
3	Minimize district energy implementation, operations, and maintenance costs.	**B**
4	Hold customer rates to parity with BAU-gas heating rates.	**A**

The recommended ownership structure to ensure successful development and implementation of the district energy system is public-private ownership. The financial analysis assumed that the rate of return would be similar to PSE's, but also compared the investment opportunities to keeping the cost in line with BAU.

Economic feasibility. The economic feasibility results are shown in Table 3, below.

Table 3: Economic Results

	BAU: Gas Heat	BAU: Electric Heat	Scenario 1: Low Carbon	Scenario 2: Low Carbon, Geothermal	Scenario 3: Low Cost	Scenario 4: Rate Parity
25-year NPV total capital and O&M costs for building systems	$53.5M	$61.6M	N/A	N/A	$25.6M	N/A
25-year NPV total capital and O&M costs for district energy systems	N/A	N/A	$51.7M	$56.0M	$24.3M	$55.5M
Internal rate of return	N/A	N/A	6.7%	12%	6.7%	-0.25%
Blended retail rate ($/MMBTU)	$21.17	$42.92	$34.79	$50.06	$33.36	$21.17

Scenario 3 appears to be the most economical. It would reduce customer rates compared to today's electric heating rates, which are what most customers pay since most new construction in Overlake Village uses electric heating. Scenario 3 also assumes City or PSE ownership, which reduces the required rate of return.

In contrast to Scenario 3:

- Scenario 1, which includes waste heat recovery, is more technically complex and more costly.
- Scenario 2 assumes a private third-party owner, and because a private owner would require competitive rates of return commensurate with risk, the result would be unacceptably high customer utility rates.
- Scenario 4 holds customer rates constant at today's low natural gas costs. This results in unacceptably low returns.

Environmental feasibility. Carbon emission reduction was an important success criterion, because this study is part of the City's climate action planning efforts. As Figure 1 and Figure 2 show, the low-carbon Scenarios 1 and 2 perform best. All district energy scenarios out-perform the BAU scenarios, and do much better than the BAU electric heat scenario. Overall energy usage, including heating, cooling, and other electric loads such as appliances, is the lowest in the low-carbon scenarios. (Note that although greenhouse gas emission reductions are an important objective for the City, they are not mandated by regulation or law, and as a result have not been monetized in this study.)

Figure 1: Carbon Emissions Results for BAU and Selected Scenarios

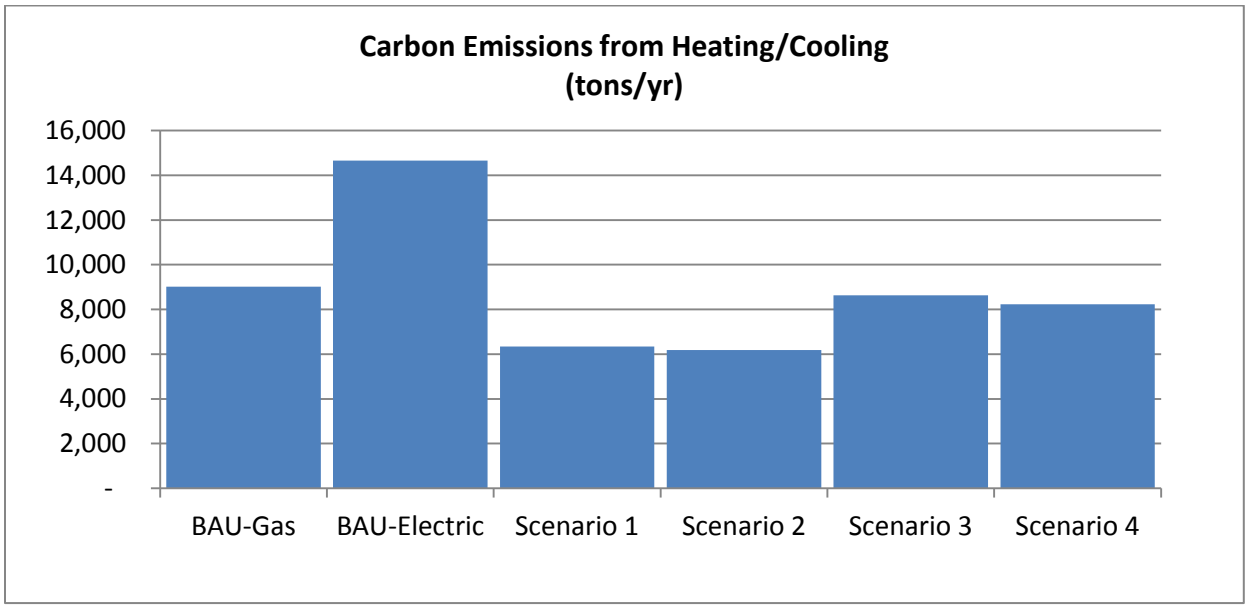
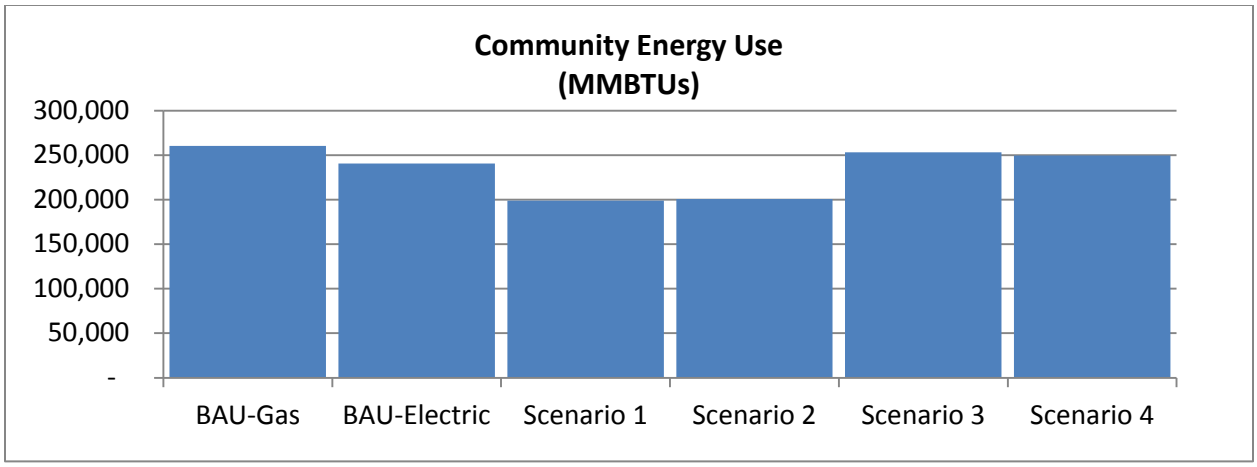


Figure 2: Energy Use Results for BAU and Selected Scenarios



Owning and operating a district energy system. Establishing a district energy system at reasonable customer rates would likely require the City or PSE to own the distribution system and central plant. District energy would be a new venture for both the City and PSE, requiring new resources and expertise. For PSE, this venture would represent a departure from its current technology and service models, and would serve only a very small part of PSE's service area, thereby making it a relatively low priority. For the City, district energy has potential benefits, but the benefits do not appear sufficient to offset the resources needed to launch and maintain a new utility, considering the City's existing service responsibilities and the other initiatives underway. The cost estimates would need to be much more detailed before any future phases of this project could be considered feasible.

The Recommendation. The City's staff does not believe that the potential benefits of district energy outweigh the potential costs and risks associated with establishing a new utility, nor does the staff

believe that the City is equipped to take on a new utility. If the potential benefits were spread over a much wider area, or if other partnership opportunities existed, the recommendation might be more favorable.

While the City's staff does not recommend proceeding with a district energy system, the study notes other, more feasible ways to advance economic and environmental goals. For example, natural gas heating is cheaper for customers and less carbon-intensive than electric heating, and yet electric heating is frequently included in new multifamily construction because it is less costly to install. The team recommends exploring ways to achieve natural gas, rooftop solar, and other carbon-light and economically competitive heating sources in new construction. This could yield benefits in Overlake Village and across the city. Also, the City recently won PSE's Green Power Challenge; building on that success would also yield reductions in the community's carbon footprint.

1 Introduction

Overlake Village is an approximately 175-acre portion of the Overlake neighborhood within the city of Redmond, Washington, bounded by SR-520 to the north, 156th Avenue NE to the east, NE 20th Street to the south, and 148th Avenue NE to the west. Overlake Village is transforming into an urban mixed-use neighborhood where people may enjoy a mix of work and living space coupled with open areas to gather and explore. In accordance with Redmond's Climate Action Strategy, the City has been investigating the implementation of district energy concepts as part of the Overlake Village redevelopment.

District energy generally refers to a system of centralized heating – and optionally cooling – that can be implemented using a variety of energy sources and distribution systems. District energy systems produce steam, hot water, or chilled water at a central plant. The steam, hot water, or chilled water is then piped underground to individual buildings for space heating, domestic hot water heating, or air conditioning. As a result, individual buildings served by a district energy system don't need their own boilers or furnaces, chillers, or air conditioners. The district energy system does that work for them. There are more than 700 district energy systems in the United States, with ample opportunities for future development or expansion.

At Overlake Village, district energy has the potential to reduce energy use, carbon emissions, and energy costs while creating a competitive edge in redevelopment by eliminating the need to provide onsite heating and cooling equipment.

In 2013, the City received a HUD-funded Growing Transit Communities study, which included an initial evaluation of district energy concepts by Puttman Infrastructure (Puttman). Puttman's pre-feasibility study estimated energy use, cost of fuel, and carbon emissions savings in comparison to conventional in-building heating and cooling systems for the 175-acre mixed-use area described above. Although Puttman's assumptions, findings, and recommendations were preliminary in nature, they provided a useful basis for further investigation.

This report builds on the assumptions and recommendations made in the Puttman pre-feasibility study, and clearly outlines any deviations from the Puttman study's assumptions and results due to the more detailed feasibility analysis performed in 2014.

2 Study Approach

2.1 Scenario Objectives and Approach

There are many different ways to develop a district energy system. The team used a scenario approach in which district energy system scenarios were developed and evaluated based on the success criteria and priorities for the City. The economic and environmental benefits are the most important criteria for evaluating the district energy scenarios, according to the City's Climate Action Strategy and the Comprehensive Plan. A viable scenario must result in:

- A market advantage for building developers/owners.
- Low customer energy rates.
- A resilient infrastructure.
- A sustainable community.
- Greenhouse gas emission reductions.

Along with the available information and future plans, numerous assumptions have been made at this feasibility level to formulate likely scenarios for Overlake Village. The general methodology used for this study can be simplified into several key elements:

1. Compile energy use data for the Overlake Village.
2. Select suitable technologies for district energy systems.
3. Assess ownership structures and demarcation for district energy systems.
4. Evaluate the economic benefits, energy use, and greenhouse gas emissions of the proposed district energy systems based on assumed adoption rates.
5. Compare the proposed district energy systems to the BAU scenarios.

The BAU scenarios model what would happen in terms of heating and cooling technology in the absence of district energy. Two BAU scenarios are considered for comparison. One BAU scenario represents buildings in which a majority of the heating is provided by electricity (BAU-Electric Heat), and second BAU scenario represents a majority of heating provided by natural gas (BAU-Gas Heat). Economic and environmental benefits were evaluated for the BAU scenarios and compared against alternative district energy scenarios.

Although greenhouse gas emission reductions are an important objective for the City, they are not mandated by regulation or law, and as a result have not been monetized in this study. Future legislation and participation in carbon markets may enable carbon emission reductions to be monetized.

2.2 Assumptions

Several assumptions have been made in the BAU scenarios as well as the district energy scenarios. The assumptions important for the BAU scenarios are as follows:

- Each building will have its own heating and cooling systems.
- Heating and cooling systems are installed by individual developers at time of construction.

- Heating and cooling systems are ultimately owned, operated and maintained by building owners and homeowners.
- Heating and cooling needs are met with a combination of electricity and natural gas, depending on the BAU scenario.
- Electricity and natural gas service will be provided by PSE.
- New construction maximizes conservation savings through the use of modern equipment and energy-efficient design.

The following assumptions drive the district energy scenarios:

- Central heating and cooling equipment is not located in the individual buildings.
- Electricity and natural gas to serve the central plant and other district energy system needs are provided by PSE.
- The City will enact an ordinance mandating new construction connection to a district energy system, or will provide significant incentives to guarantee connection.
- If PSE owns and operates the system's central plant, PSE will earn a return comparable to a regulated rate of return, and will operate as a regulated entity.

Although thermal energy systems do not require WUTC regulation, and the provision of hot or chilled water would not require tariff schedules approved by the WUTC, an unregulated PSE ownership and operation model has not been evaluated in this analysis.

2.3 Pre-feasibility Study Recommendations

The pre-feasibility study conducted by Puttman made several recommendations for the alignment of responsibility for district energy. The recommendations are summarized in Table 4, and were used in the development of scenarios in this study.

Table 4: Recommendations from Pre-Feasibility Study

Criterion	Recommended Alignment
Ownership	Public-Private Partnership
Funding for Central Plant	District Energy Provider
Funding for Distribution Network	City of Redmond
Design/Build/Permit	District Energy Provider
Policy Support	City of Redmond mandates connection
City Operations	District Energy Provider
Customer Relationship	District Energy Provider
Revenue	Share between City/DE Provider based on ownership and risk

2.4 Evaluation Criteria

To meet the City's objectives, the district energy scenarios were compared to the BAU scenarios, and an assessment was made based on the following criteria.

1. Rates must be competitive with BAU energy rates.
2. Greenhouse gas emissions must be lower than BAU greenhouse gas emission levels.
3. Energy use must be lower than BAU energy use.
4. The central plant must be financially viable and must meet the investors' objectives.

PSE's decision criteria for involvement in a district energy project follows the Washington Utilities and Transportation Commission (WUTC) rules regarding the acquisition of new resources (WAC 480-107). PSE is required to submit a request for proposals (RFP) when the company's most recent biennial Integrated Resource Plan (IRP) demonstrates a need for new electric capacity resources within the next three years.

The IRP guides PSE's efforts to acquire new energy resources to meet the needs of customers at the lowest reasonable cost. PSE's overall strategy for integrated resource planning is to:

- Examine their customers' electric and gas resource needs over the next twenty years, and analyze the mix of conservation programs and supply resources that might best meet those needs.
- Establish the strategic direction to acquire a diversified, balanced electric resource portfolio that meets customer needs, results in reasonable energy supply costs, and mitigates market risks.
- Identify the key factors related to various resource decisions, and establish a method for evaluating a resource acquisition in terms of cost, risk, and other factors at the time a decision needs to be made. The IRP does not commit to or preclude the acquisition of a specific resource type, project, or facility.

PSE's resource evaluation process is designed to be consistent with guidance set forth in the Washington Administrative Code (WAC) and the Revised Code of Washington (RCW), which encourage utilities to seek resources that provide clean, safe and reliable power to meet their needs using lowest reasonable cost as a criterion. RCW 19.280.020 defines "lowest reasonable cost" as "the lowest cost mix of generating resources and conservation analysis of a wide range of commercially available resources." Further, WAC 480-107-035 provides guidance regarding the minimum criteria that must be considered when evaluating and comparing resources:

> At a minimum, the ranking criteria must recognize resource cost, market-volatility risks, demand-side resource uncertainties, resource dispatchability, resource effect on system operation, credit and financial risks to the utility, the risks imposed on ratepayers, public policies regarding resource preference adopted by Washington state or the federal government and environmental effects including those associated with resources that emit carbon dioxide. The ranking criteria must recognize differences in relative amounts of risk inherent among different technologies, fuel sources, financing arrangements, and contract provisions. The ranking process must complement power acquisition goals identified in the utility's integrated resource plan.

PSE's RFP process involves a two-phased approach designed to quickly identify the most promising proposals for a thorough combination of quantitative and qualitative evaluation.[1] This approach enables PSE to organize its efforts efficiently and target the most promising proposals with thorough scrutiny.

PSE's most recent IRP (www.pse.com/irp) describes generally the process to create optimal portfolios and evaluate costs and risks, and offers in-depth descriptions of the AURORA model, the PSM I Screening Model, and the PSM III Optimization Model.

Once the evaluation process is complete and the team has satisfactorily resolved open issues, the Resource Acquisition team lists the proposals with the lowest reasonable cost and risk that best complement PSE's resource and timing needs, and presents the list to PSE's Energy Management Committee (EMC) for approval. PSE may then pursue negotiations with individual counterparties to establish the terms and conditions of Definitive Agreements. Individual resource acquisitions are approved by the EMC and, when appropriate, PSE's Board of Directors.

[1] According to WAC-480-107, the RFP is not the only method by which PSE may acquire new electric generation resources. Given its obligation to provide electricity at the lowest reasonable cost to customers, PSE also evaluates opportunistic proposals submitted outside the RFP process, and in-house development opportunities. PSE evaluates all resources in a consistent manner, using the same methods and criteria as the RFP process.

3 Data Acquisition

3.1 Data Acquisition Process

The first task of the feasibility study was data acquisition. Initial data was provided by the City. This information was supplemented during the study, as the City put the project team in touch with a sample of property owners and developers in the district. The project team also brought in data from its prior experience, and example information from other district energy systems including the City of Vancouver (Canada) Southeast False Creek system. The data provided the foundation for subsequent analysis and recommendations.

3.1.1 Data Provided by the City of Redmond

The City provided the project team with prior studies and reports, future development estimates, and contact information for a sample of property owners.

The prior studies and reports included:

- A pre-feasibility report titled "Overlake Village District Energy Concepts and EcoDistrict Applicability" dated December 2013, prepared by Otak, Inc. in association with BAE Urban Economics, Nelson/Nygaard Consulting Associates, and Puttman Infrastructure.
- An Overlake Village district energy concepts memo and powerpoint presentation dated November 2013, prepared by Puttman Infrastructure.
- A Group Health – Overlake Village (Zone 4) Master Plan dated August 29, 2011, prepared by CollinsWoerman for Group Health Cooperative represented by Capstone Partners, with assistance from Brumbaugh & Associates Landscape Architecture, Coughlin Porter Lundeen, Davis Wright Tremaine, and Transportation Engineering NorthWest.
- A KCC Limited Edition Master Plan – Overlake Village (Zone 1) dated June 5, 2014, prepared by CollinsWoerman for KCC Limited Edition represented by Melody Westerdal of the KCC Limited Edition Owners Association, with assistance from Williamson Law Office, Concept Engineering Landscape Services, Coughlin Porter Lundeen, Northwest Landscape Services, and Transportation Engineering NorthWest.
- The City of Redmond Climate Action Implementation Plan dated May 7, 2013.
- The City of Redmond Comprehensive Plan dated December 17, 2011.

3.1.2 Stakeholder Outreach Process and Information Acquired

The feasibility of a district energy system in Overlake Village will be affected by the participation of private property owners in the area. During the feasibility study, selected property owners were contacted for information-gathering and collaboration. The purpose was to improve the accuracy of engineering and financial feasibility models.

The sponsors of some major planned developments were contacted, as they have the potential to be anchor customers for a district energy system. There may also be the potential to integrate district energy equipment into their facilities as a central plant or node. This outreach is time-sensitive, as planning is already underway for some of these developments. It was found that the first few buildings

were being designed to have electric resistance space heating, which would be incompatible with a district energy system. Central natural-gas-fired boilers were being designed to serve domestic hot water loads. Beyond those first few buildings, there were no specific heating or cooling plans for the new developments.

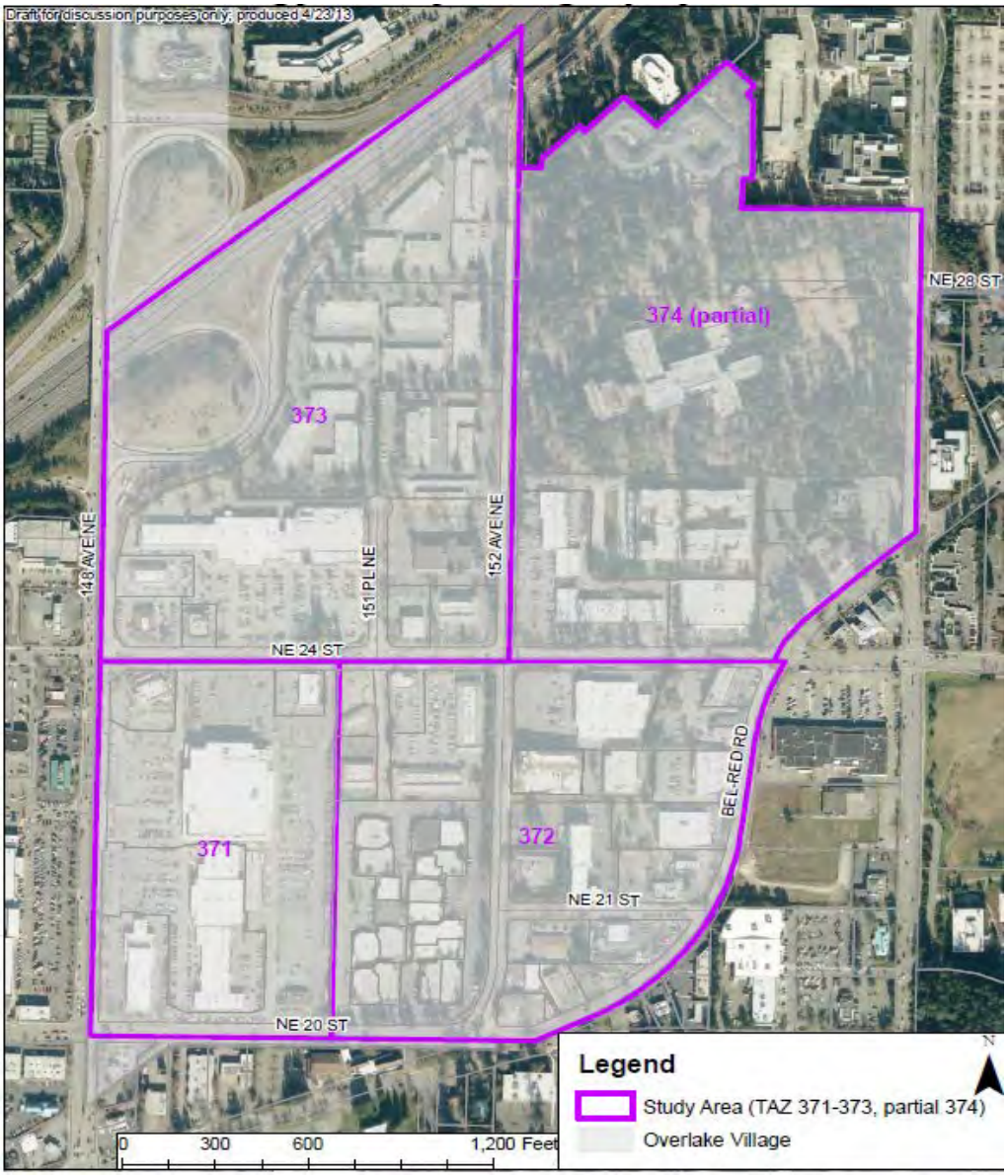
3.2 Planning and Space Use Assumptions

Since the potential district energy system would primarily serve planned new construction in Overlake Village, the City provided development estimates through the year 2030. Table 5 shows the expected amount of square footage of development and number of multi-family dwelling units. Figure 3 shows the associated geography and the locations of the four Transportation Analysis Zones (TAZ).

Table 5: Projected Land Use for Overlake Village

Transportation Analysis Zone	Land Use (sq. feet)				Dwelling Units	
	Office	Retail	Institutional	Hotel	Multi-family	Hotel Rooms
371	63,575	360,261	0	0	296	0
372	159,402	341,600	7,163	23,880	629	144
373	429,124	158,862	0	0	1,767	0
374	958,123	252,646	0	75,932	2,296	200
Total	**1,610,224**	**1,113,369**	**7,163**	**99,812**	**4,988**	**344**

Figure 3: District Energy Study Geography

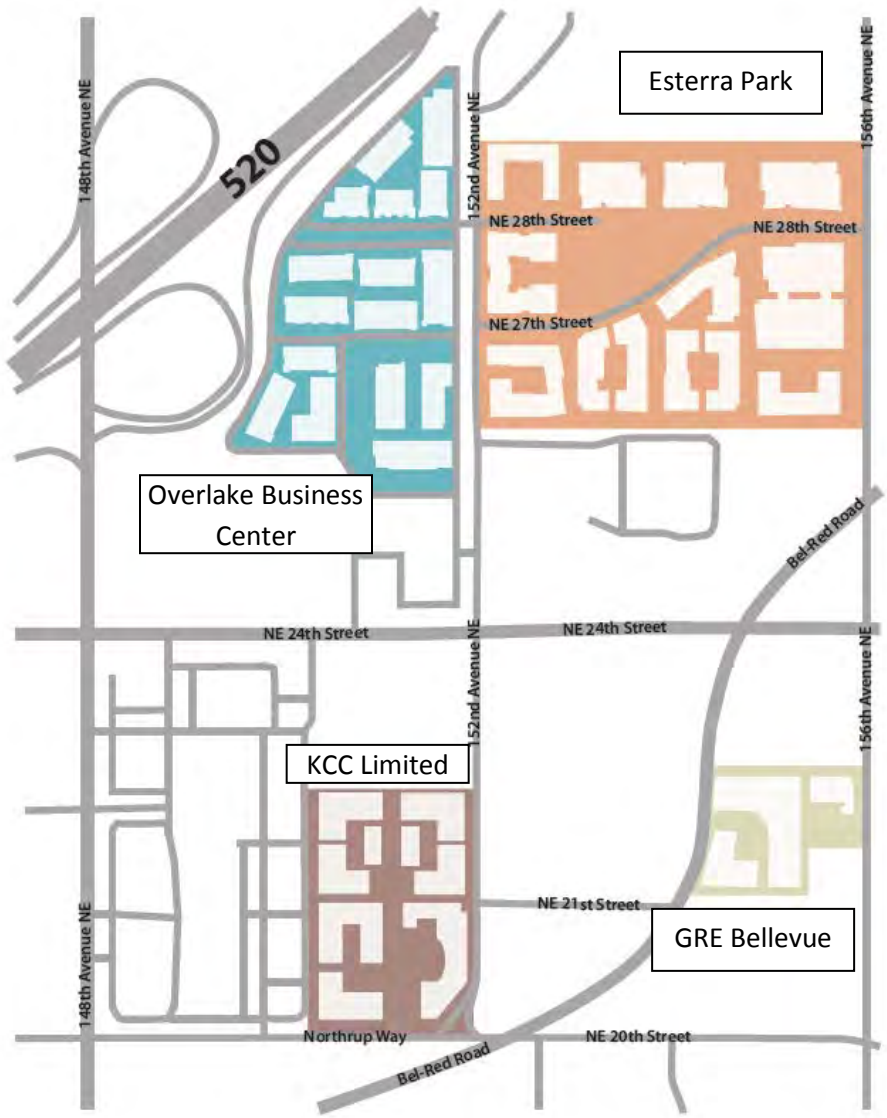


3.3 Planned Development

Development is already underway, planned, or expected on few properties in or near Overlake Village. Figure 4 shows the locations of four of these properties:

- GRE Bellevue
- Esterra Park
- KCC Limited Edition
- Overlake Business Center

Figure 4: Planned Development Locations



The GRE Bellevue property is under construction and approaching completion at the time of this report. The property will consist of 452 apartments with a layout as shown in Figure 5 and Figure 6.

Figure 5: GRE Bellevue Aerial Rendering

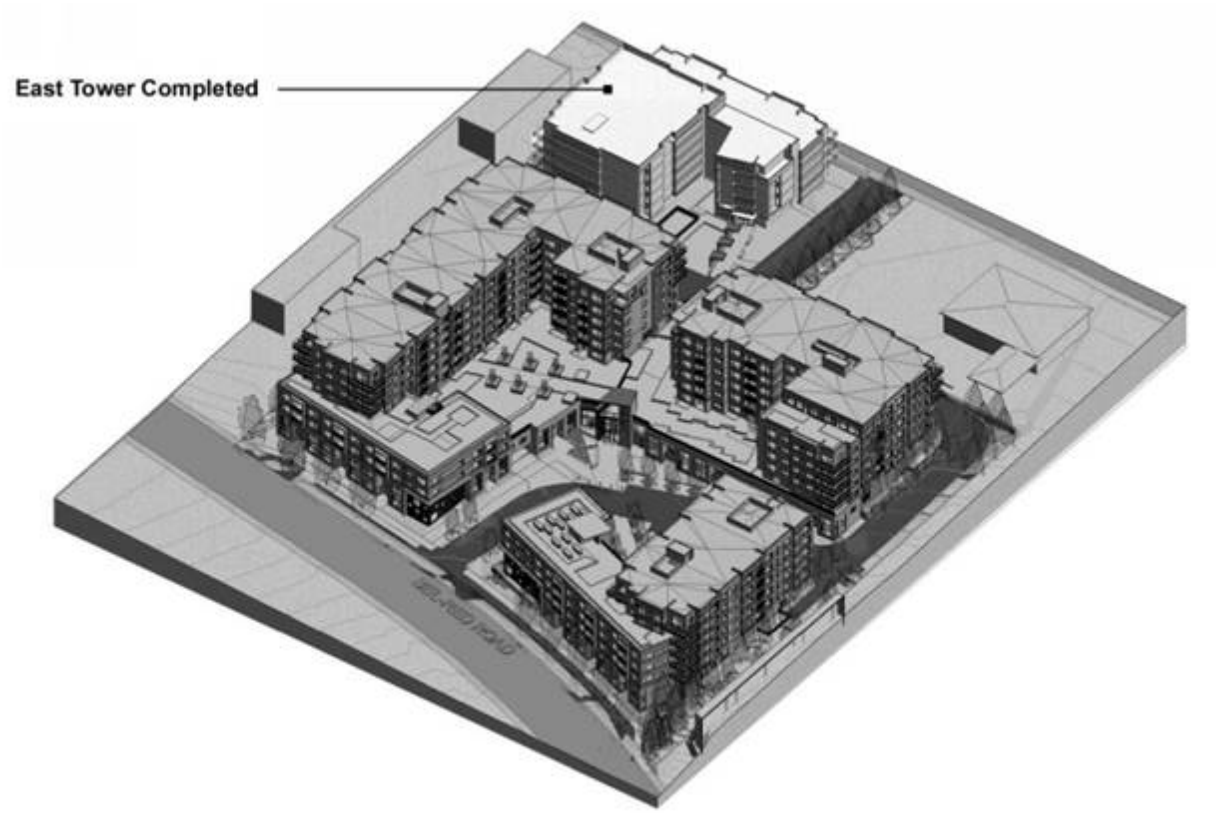


Figure 6: GRE Bellevue Bel-Red Elevation

Esterra Park is also under construction at the time of this report, but only general site work and excavation for the first of several buildings has been completed. The property will consist of 1,400 apartments, 1,200,000 square feet of office space, 25,000 square feet of retail space, and a hotel and conference center. Figure 7 and Figure 8 illustrate the proposed development.

Figure 7: Esterra Park Proposed Site Plan

Figure 8: Esterra Park Rendering

KCC Limited Edition is a proposed future development which would occupy the south side of Overlake Village. As currently envisioned, the property would consist of 885 apartments, 173,000 square feet of

office space, 36,350 square feet of retail space, and 66,800 square feet of hotel space. Figure 9 illustrates the proposed development.

Figure 9: KCC Limited Edition Rendering

Overlake Business Center is an existing property immediately adjacent to the planned light rail station. There are no specific plans for re-development of this property at this time, but this is a likely location for a portion of the new development expected in the district energy area.

3.3.1 Existing Building Assumptions

The existing buildings in the Overlake area have a variety of different ages and types of construction. The buildings range from less than 10 years old, such as The Village at Overlake Station, back to the 1960s and 70s for some of the older properties. A mix of electric and gas equipment heats the existing buildings. Most of the existing heating and cooling equipment is unitary-type, such as packaged rooftop units. Hence, there is a significant opportunity to improve the efficiency of the heating systems in both new and existing buildings when the properties are redeveloped.

One of the larger existing properties is The Village at Overlake Station, a King County Housing Authority residential complex just to the south of the Esterra Park development and co-located with a King County transit center. This property has electric space heating, but it also has a central gas-fired domestic hot water boiler plant. With additional investigation of the size of this plant and the existing load profile, it may make sense to connect the district energy system to the plant for energy transfer to or from the

plant. Other larger existing properties include a Sears department store, Overlake Terrace Retirement Community, a Safeway store, and White Swan Condominiums.

It is assumed at this stage that there is little likelihood of connecting the district energy system to the existing buildings, due mainly to the types of heating and cooling systems already installed. There may be a greater opportunity in the future. For example, if an existing building were to undergo a major remodel or replacement of its heating and cooling systems, the building could be connected to the district energy system at that time.

3.3.2 Rate of Development Assumptions

The estimated yearly rate of development through 2030 is based on short-term and long-term development projections. Currently planned developments are estimated to phase in over the next 6 years, based loosely on their current construction status. Future developments are estimated to be evenly distributed over the remaining years to allow for full build-out of the projections outlined in Table 5. The GRE Bellevue development's square footage is added to the City's 2030 development projections, since this is an adjacent property outside of the Overlake Village boundaries. Table 6 shows the resulting rate of development assumptions. The rate of development is used in the cost modeling of the district energy development scenarios. Section 6 discusses the assumption that new development will adopt district energy.

Table 6: Projected Rate of Development for Overlake Village through 2030

Year	New Development Square Footage Completed	Cumulative New Development Square Footage (Forecasted)	Notes
2015	450,000	450,000	GRE Bellevue
2016	506,905	956,905	Esterra Block 4, 7
2017	405,908	1,362,813	Esterra Block 1, 3
2018	940,782	2,303,595	Esterra Block 2, 5, 6
2019	940,782	3,244,377	Esterra Block 8, 9, 10
2020	542,500	3,786,877	LCC Limited Phase 1
2021	542,500	4,329,377	LCC Limited Phase 2
2022	368,077	4,697,454	Other Development
2023	368,077	5,065,531	Other Development
2024	368,077	5,433,607	Other Development
2025	368,077	5,801,684	Other Development
2026	368,077	6,169,761	Other Development
2027	368,077	6,537,838	Other Development
2028	368,077	6,905,914	Other Development
2029	368,077	7,273,991	Other Development
2030	368,077	7,642,068	Other Development

3.3.3 Conservation for New Development Assumptions

Because sustainability concepts are a feature of modern development master planning documents, particularly for some recent local construction projects used as examples, it is assumed that new developments in this area will include energy conservation strategies and designs. Energy-efficient building envelope, lighting, heating, and cooling systems will be used at the building level where applicable. A full description of baseline modeling is included in the following section, but in general it is assumed that planned new developments will exceed the Washington State Energy Code by approximately 10%.

4 Energy Study

4.1 Modeling Approach

The district energy system will mainly serve buildings that have yet to be designed. In order to estimate future thermal loading and energy use, McKinstry assembled a portfolio of comparable newly-constructed facilities for which detailed heating and cooling load modeling is available. The portfolio includes both commerical and residential buildings. Estimated values are used for retail, hotel, and institutional categories. These comparable facilities were used first to estimate the BAU energy performance. Once the BAU performance was determined, McKinstry substituted a district energy solution for the heating and cooling equipment and re-computed the energy performance.

The following information demostrates this technique for the office building category.

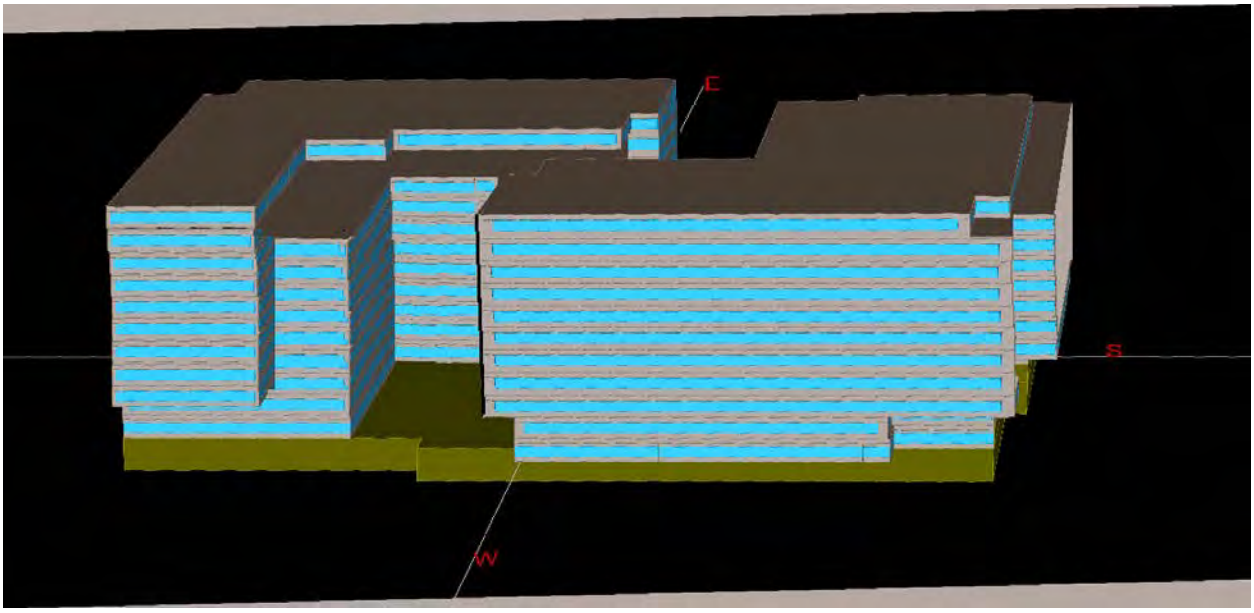
Using Block 3 of the Esterra Park development as a guide, McKinstry searched for comparable recent new construction facilities. Esterra Park Block 3 is planned to be a 223,000-square-foot, 6-story office building, with a typical floorplate of 40,000 square feet. It will be designed and planned for technology companies. Figure 10 shows a comparable facility, Troy Block, which is currently under construction in Seattle. Troy Block consists of a North Tower and South Tower. The North Tower is 422,000 square feet in 13 stories, and the South Tower is 395,000 square feet in 12 stories. Both towers feature 33,000- to 34,000-square-foot floorplates, and are designed for technology companies.

Figure 10: Example Comparable Office Building (source Troy Block)

Detailed energy model information for this comparable facility is available for use in analysis. This information includes end-use breakdowns, peak heating and cooling loads, hourly rates of energy use, and monthly energy use totals. This facility was modeled using eQUEST energy modeling software. Figure 11 shows the rendered eQUEST computer energy model, which illustrates the three dimensional

surface area and space volume programming used. This enables accurate heating and cooling estimates that account for building materials, systems, occupancy, controls, and local weather conditions.

Figure 11: Example Comparable Office Building eQUEST Model



The heating and cooling requirements for the BAU scenario were analyzed using the comparable facility portfolio. The BAU scenario assumes that each building has its own heating and cooling system, and is served 100% by its system.

As the buildings will be heated by either electricity or natural gas in the BAU scenario, both types of heat generation were modeled. For the BAU-Gas Heat scenario, natural gas boilers and hot water coils or radiators were modeled. For the BAU-Electric Heat scenario, electric resistance duct or wall heaters were modeled. It is assumed that all other loads (e.g. cooling, lighting, plug loads) in the district are served by electricity, and use the same equipment in both BAU scenarios.

The project team has provided these two BAU comparison scenarios to illustrate the gamut of mechanical systems that developers might choose for new construction. These two BAU scenarios provide upper and lower limits to the estimated costs and rates that could be experienced in Overlake Village. It is not unusual to see either of these two types of heating technologies, and other types as well, in recent building construction. Because the buildings in this area will be constructed with a variety of mechanical systems, the actual costs will fall between these two scenarios.

While the construction costs for the BAU-Electric Heat scenario are lower, the operational costs for that scenario are significantly higher due to the higher cost of electricity over natural gas. Hence, when the district energy scenarios are compared against these two baseline options in Section 6.4, the economic case for choosing a district energy system is most compelling when evaluated against the BAU-Electric Heat scenario.

4.2 Business-As-Usual Energy Requirements

Energy consumption for the redeveloped Overlake Village under both BAU scenarios was estimated using the modeling approach described above. The energy requirements listed below represent the estimated heating, cooling, and other electric usage of the new development as outlined in Table 6.

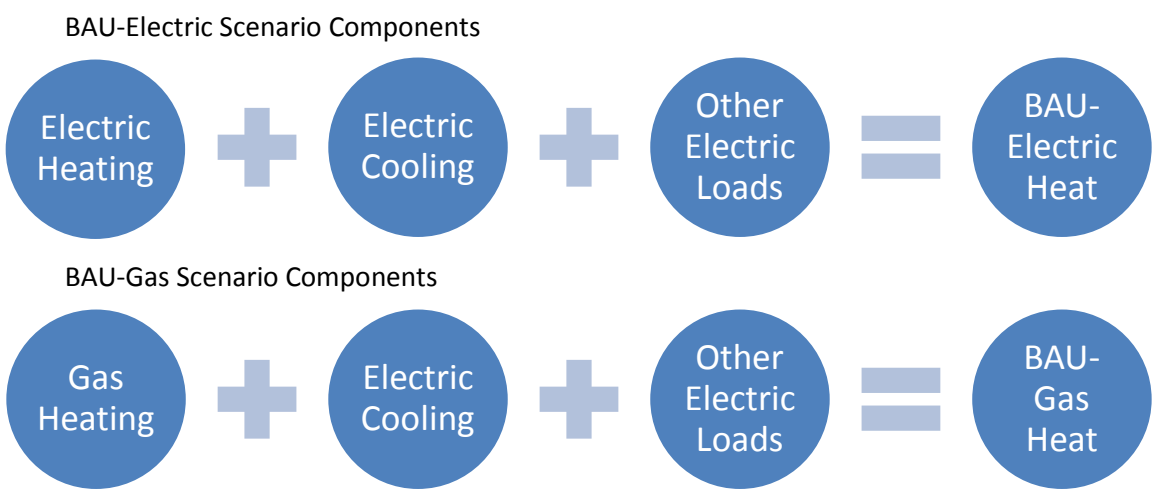
Non-heating/cooling loads for buildings such as lighting and plug/appliance loads are a significant portion of the electric energy use in the district. BAU assumptions for the size of these loads are derived from the same modeling process used for the heating/cooling loads. The other electric loads estimated for BAU are used throughout each of the scenarios in the calculation of community energy usage. The annual energy usage estimated for heating, cooling, and other electric loads is shown in Table 7.

Table 7: Summary of Annual Energy Consumption for Study Area for BAU

Building Type	Annual Energy			
	Electric Heating (kWh/yr)	**Gas Heating (therm/yr)**	**Electric Cooling (kWh/yr)**	**Other Electric Loads (kWh/yr)**
Residential (Multi-family)	24,787,577	995,300	2,806,000	13,106,000
Office	4,424,260	177,600	1,587,000	15,532,000
Retail	3,164,372	127,100	716,000	3,346,000
Hotel	556,695	22,400	64,000	300,000
Institutional	29,300	1,200	7,000	69,000
Total	**32,962,204**	**1,323,600**	**5,180,000**	**32,353,000**

Figure 12 shows the energy consumption components that make up the BAU-Electric Heat and BAU-Gas Heat scenarios.

Figure 12: BAU Scenario Components



The estimated construction costs for distributed heating and cooling systems in the BAU-Gas Heat scenario are $35–45 million. This represents the installed cost of the mechanical and electrical systems that would be required to heat and cool all of the district energy buildings individually. The systems would include boilers, chillers, cooling towers, central system primary pumps, and switchgear. The estimated costs do not include the water-side or air-side distribution systems within the buildings.

The estimated construction costs for distributed heating and cooling systems in the BAU-Electric Heat scenario are $20–30 million. Construction cost estimates are lower for this scenario because electric resistance heaters are less expensive to install than hot water heating systems, though they cost more to operate than natural-gas-based systems.

4.3 District Energy Facility

4.3.1 Central Plant Technologies

After analysis of the BAU scenarios, the comparable facility portfolio was run through several conceptual design options for a district energy system. Various options were considered that would meet the following basic requirements.

- Replace the need for central heating and cooling systems in the individual buildings.
- Provide heating and cooling from centralized district facilities.
- Connect to building water-side and air-side distribution systems via heat exchangers.
- Support the combined heating and cooling loads of the entire district.

The options considered are summarized in Table 8.

Table 8: Design Options

Option	System design
A	Central heating hot water and chilled water plant
B	Central heating hot-water-only plant
C	Central heating hot water and chilled water plant with geothermal
D	Combined heat and power plant
E	Demand response/thermal energy storage
F	Waste heat recovery plant
G	Waste heat recovery plant with distributed heat pumps

Each option is described below.

4.3.2 Option A: Central Heating Hot and Chilled Water Plant

Option A consists of natural-gas-fired hot water boilers, chillers, cooling towers, and distribution pumps located in a central facility and connected to the district by a network of buried distribution piping. The boilers would be high-efficiency condensing type. The chillers would be high-efficiency water-cooled type. The construction costs for this option are estimated at $40–50 million. The plant might be located in the parcel north of NE 24th Street and west of 152nd Ave NE.

Figure 13 and Figure 14 show the major components of a central heating hot water and chilled water plant. Figure 15 provides couple examples of the exterior of district energy central plants.

Figure 13: Example Boiler Plant Photos

Figure 14: Example Chiller Plant Photos

Figure 15: Example Central Plant Exterior Photos

Figure 16 is a major equipment system diagram for a central plant serving hot water and chilled water to typical building heat exchangers for energy transfer.

Figure 16: Central Heating Hot Water and Chilled Water Plant Equipment System Diagram

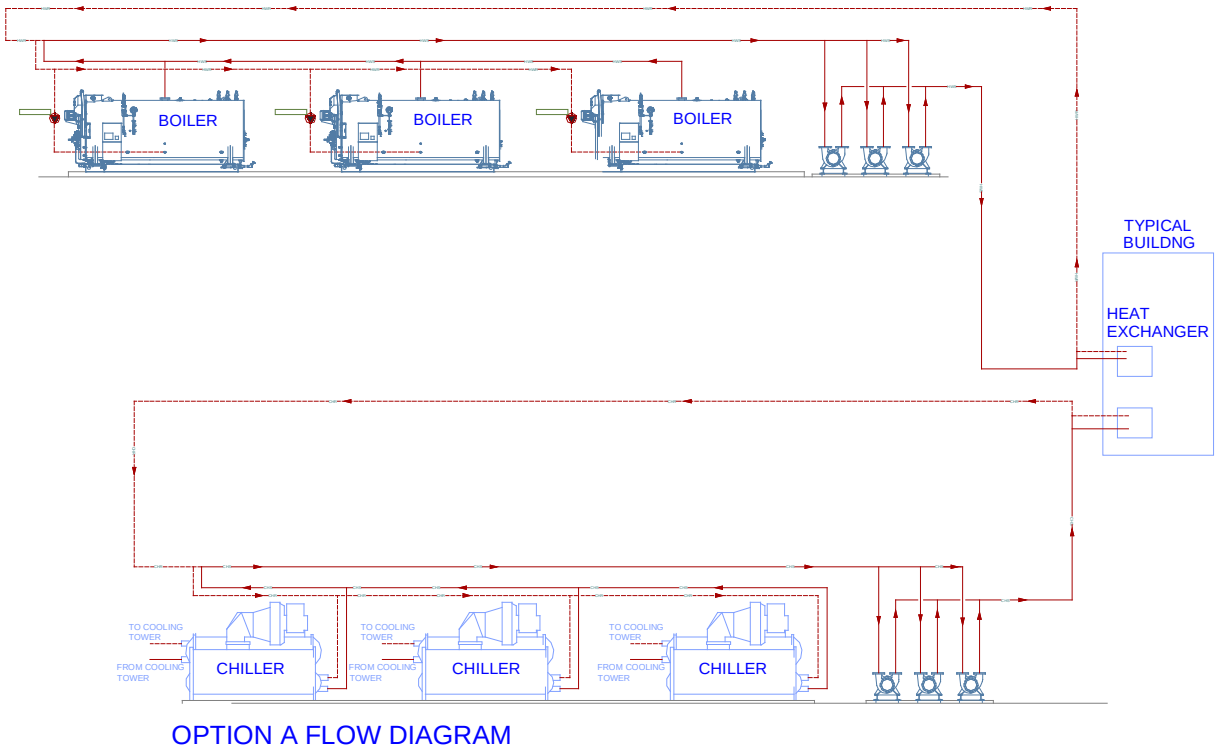


Figure 17 is a site plan for a central plant serving hot water and chilled water through major branch pipes to potential Overlake Village developments.

Figure 17: Central Heating Hot Water and Chilled Water Plant Site Plan

4.3.3 Option B: Central Heating Hot-Water-Only Plant

Option B consists of natural-gas-fired hot water boilers and distribution pumps located in a central facility and connected to the district by a network of buried distribution piping. The boilers would be high-efficiency condensing type. Cooling equipment would be installed in each of the individual buildings as was analyzed in the BAU condition. The construction costs for this option are estimated at $37.5–47.5 million. This plant might be located in the parcel north of NE 24th Street and west of 152nd Ave NE. Figure 18 shows a major equipment system diagram for a central plant serving heating hot water to a typical building heat exchanger for energy transfer.

Figure 18: Central Heating Hot Water-Only Plant Equipment System Diagram

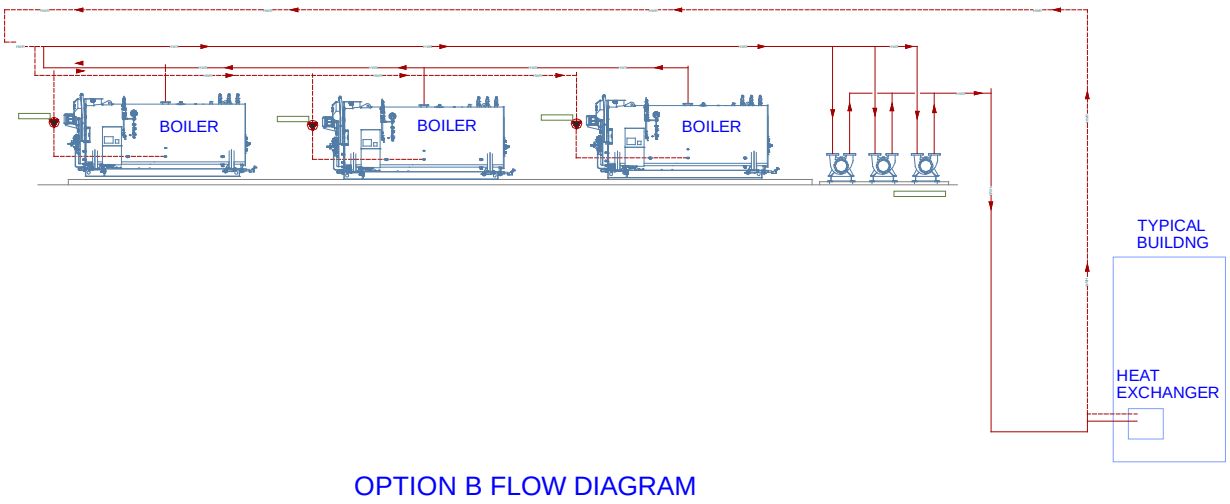


Figure 19 shows a site plan for central plant serving heating hot water through major branch pipes to potential Overlake Village developments.

Figure 19: Central Heating Hot Water-Only Plant Site Plan

4.3.4 Option C: Central Heating Hot and Chilled Water Plant with Geothermal

Option C would add a part-load open-loop ground source geothermal heat pump system to Option A. A geothermal heat pump system uses heat exchange with the earth and groundwater as the source for both heating and cooling, depending on seasonal system loads. Either hot or chilled water can be generated by operating a refrigeration cycle heat pump to transfer energy and temporarily raise or lower the temperature of the groundwater. At the same time, the heat pump raises or lowers the temperature of the hydronic heating and cooling loops serving the district buildings. The preliminary sizing for this system is 1500 tons. A system of this size would provide a partial base load to the district energy system to operate as the first stage of heating or cooling. Boilers and chillers similar to those in Option A would serve the peak capacity. In this way, the investment in the geothermal system would be maximized by maintaining a high utilization rate on that portion of the plant. Figure 20 shows an example of a geothermal injection well and a ground source heat pump used in an open loop configuration. The ground souce heat pump appears similar to a chiller, but is capable of operating under different conditions.

Figure 20: Example Injection Well And Example Ground Source Heat Pump

The construction costs for the district energy system with open-loop geothermal option are estimated at $43–54 million. This plant might be located in the parcel north of NE 24th Street and west of 152nd Ave NE, with extraction and injection wells located nearby.

Figure 21 shows a major equipment system diagram for the geothermal portion of a plant serving hot water and chilled water to typical building heat exchangers for energy transfer.

Figure 21: Geothermal Plant Equipment System Diagram

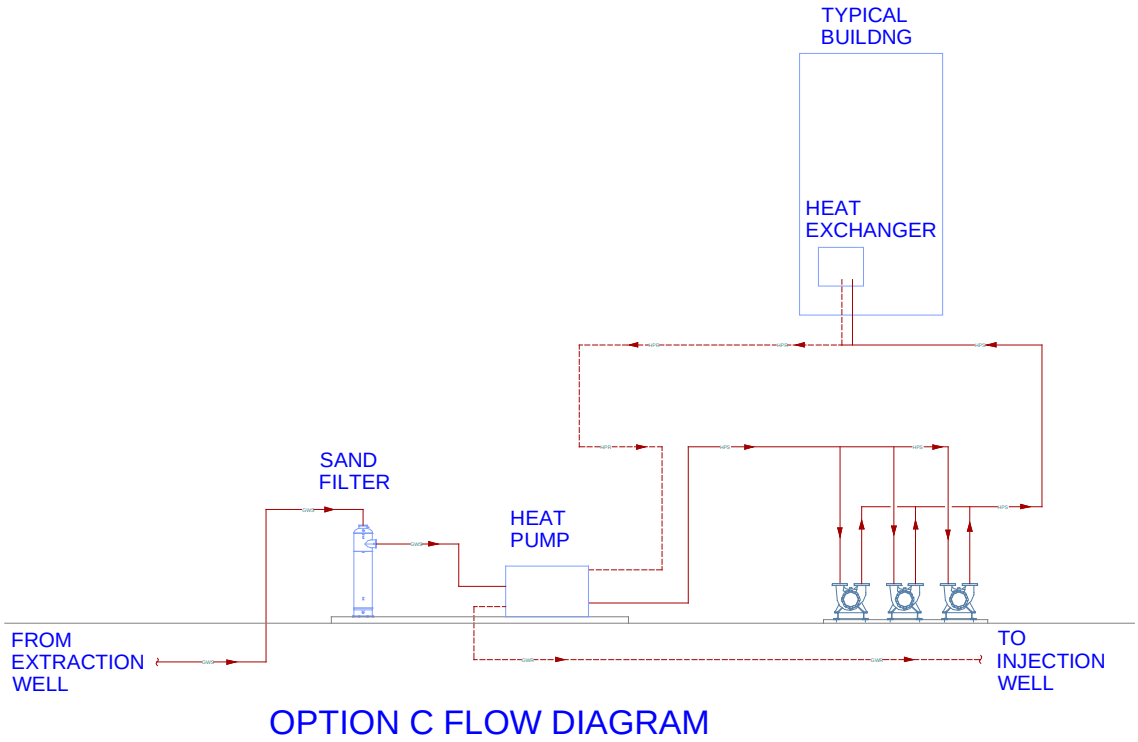
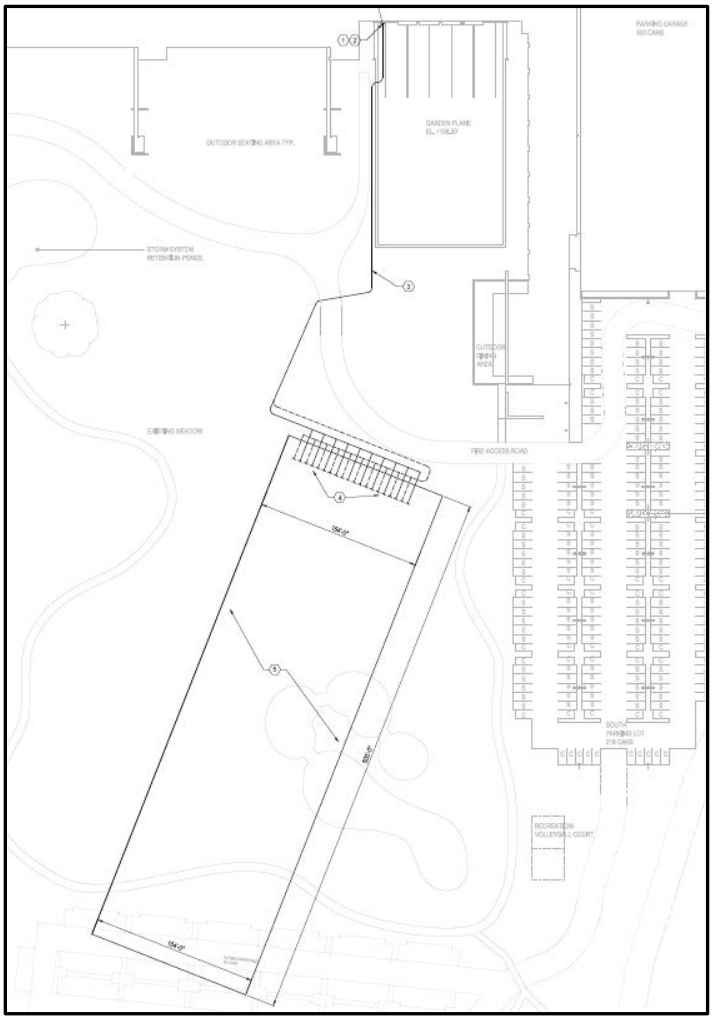


Figure 22 shows a site plan for a central geothermal plant serving heating hot water and chilled water through major branch pipes to potential Overlake Village developments.

Figure 22: Geothermal Plant Site Plan

A closed-loop geothermal system is a variation on this technology that exchanges heat through a network of underground pipes connected in a continuous loop. This type of system is not recommended for an installation this large, as it would either require drilling over one thousand vertical wells to a depth of 300 feet each, or horizontal boring in an area equivalent to several football fields. Figure 23 shows a site plan of an 80,000-square-foot horizontal closed-loop ground source field and a photo of the installation of this field. This is a 200-ton system.

Figure 23: Example Closed Loop Geothermal System



4.3.5 Option D: Combined Heat and Power Plant

Option D would add a combined heat and power system to Option A, sized for the minimum continuous heating load of the district energy system. This would consist of a natural-gas-fired reciprocating engine generator, which would generate both electricity and circulate hot water from gas-fired boilers. The preliminary sizing for this equipment is 335 kW. The hot water would meet the base heating load for the district, with a smaller boiler plant meeting the peak loads. The construction costs for this option are estimated at $41-52 million. This plant might be located in the parcel north of NE 24th Street and west of 152nd Ave NE. Figure 24 shows an example major equipment system diagram for the generator portion of a plant serving heating hot water and chilled water to a typical building housing heat exchangers for energy transfer.

Figure 24: Combined Heat and Power Plant Equipment System Diagram

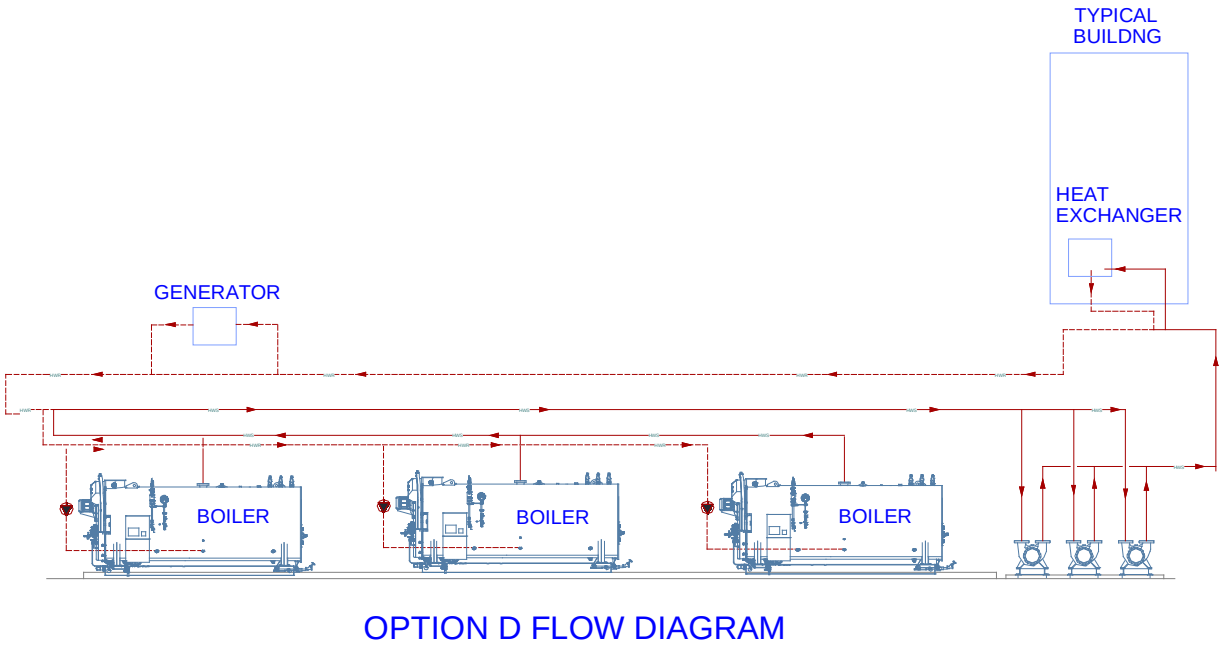
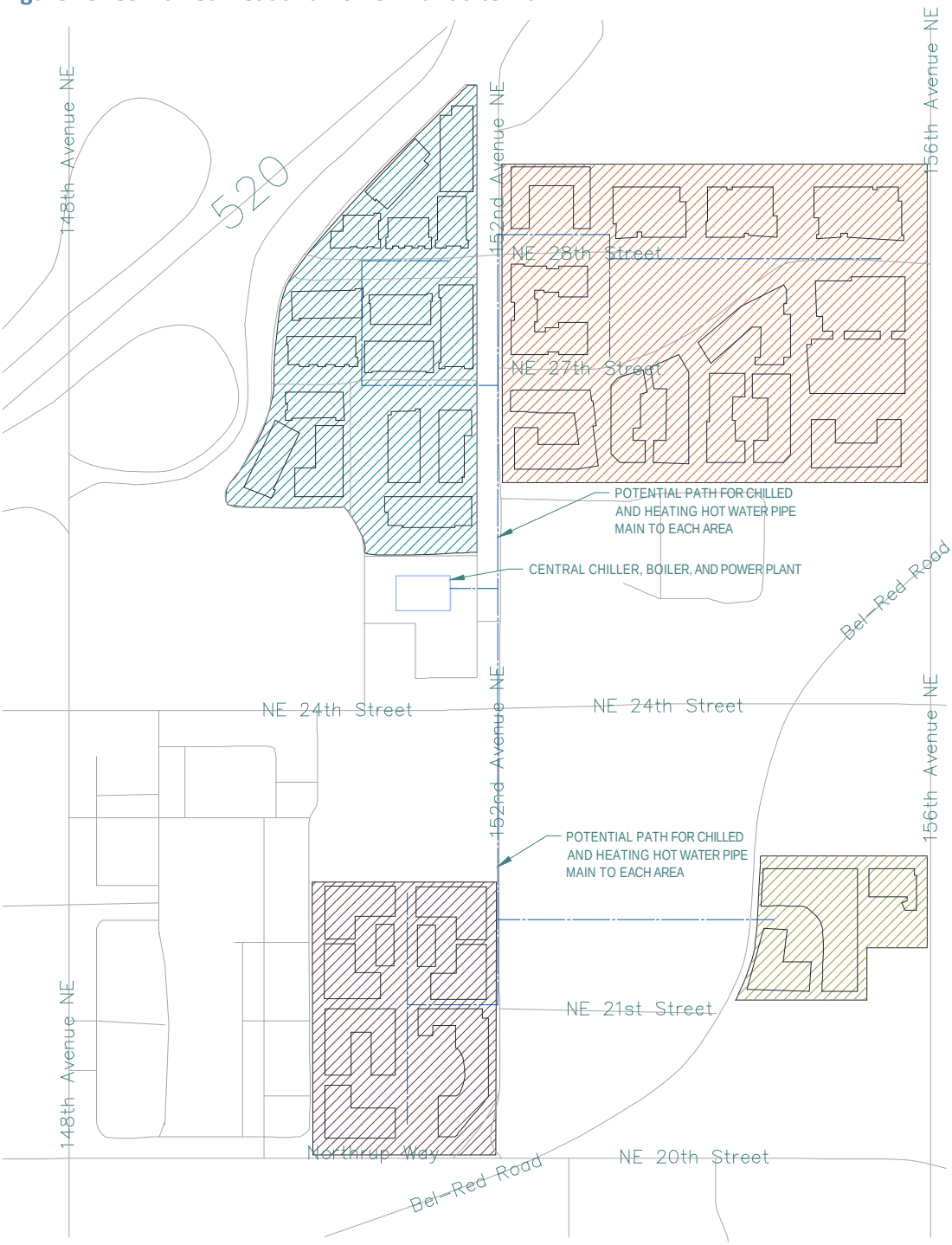


Figure 25 shows a site plan for a central plant with combined heat and power serving hot water and chilled water through major branch pipes to potential Overlake Village developments.

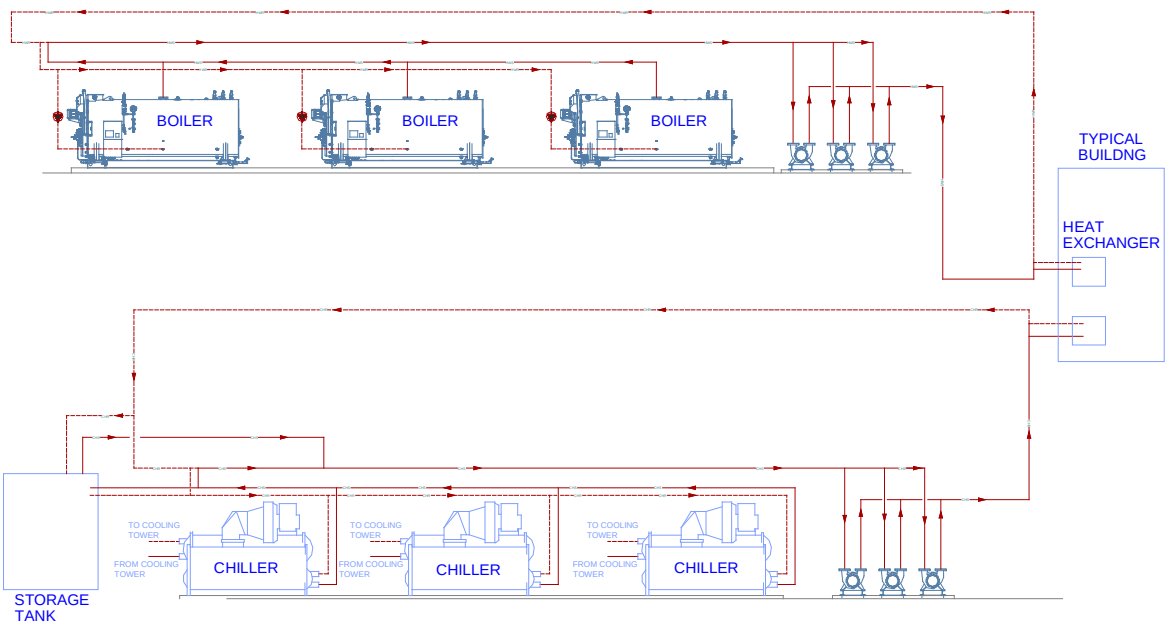
Figure 25: Combined Heat and Power Plant Site Plan



4.3.6 Option E: Demand Response / Thermal Energy Storage Plant

Option E would add a thermal energy storage system with demand response controls to Option A. This system would consist of a large insulated chilled water storage tank and the associated pumps and controls to provide chilled water peaking capacity or capacity to draw on when there is a need to limit demand. Demand would be reduced by operating fewer chillers for a given cooling load termporarily. This system would also have the capability of charging the tank with chilled water at night when the mechanical system operating efficiency is higher compared with the heat of the day. The preliminary sizing for this equipment is 2 million gallons. The construction costs for this option are estimated at $41–51 million. This plant might be located in the parcel north of NE 24th Street and west of 152nd Ave. NE. Figure 26 shows a major equipment system diagram for a plant with thermal energy storage serving hot water and chilled water to typical building heat exchangers for energy transfer. The storage tank could also be incorporated into an underground parking garage in an urban location.

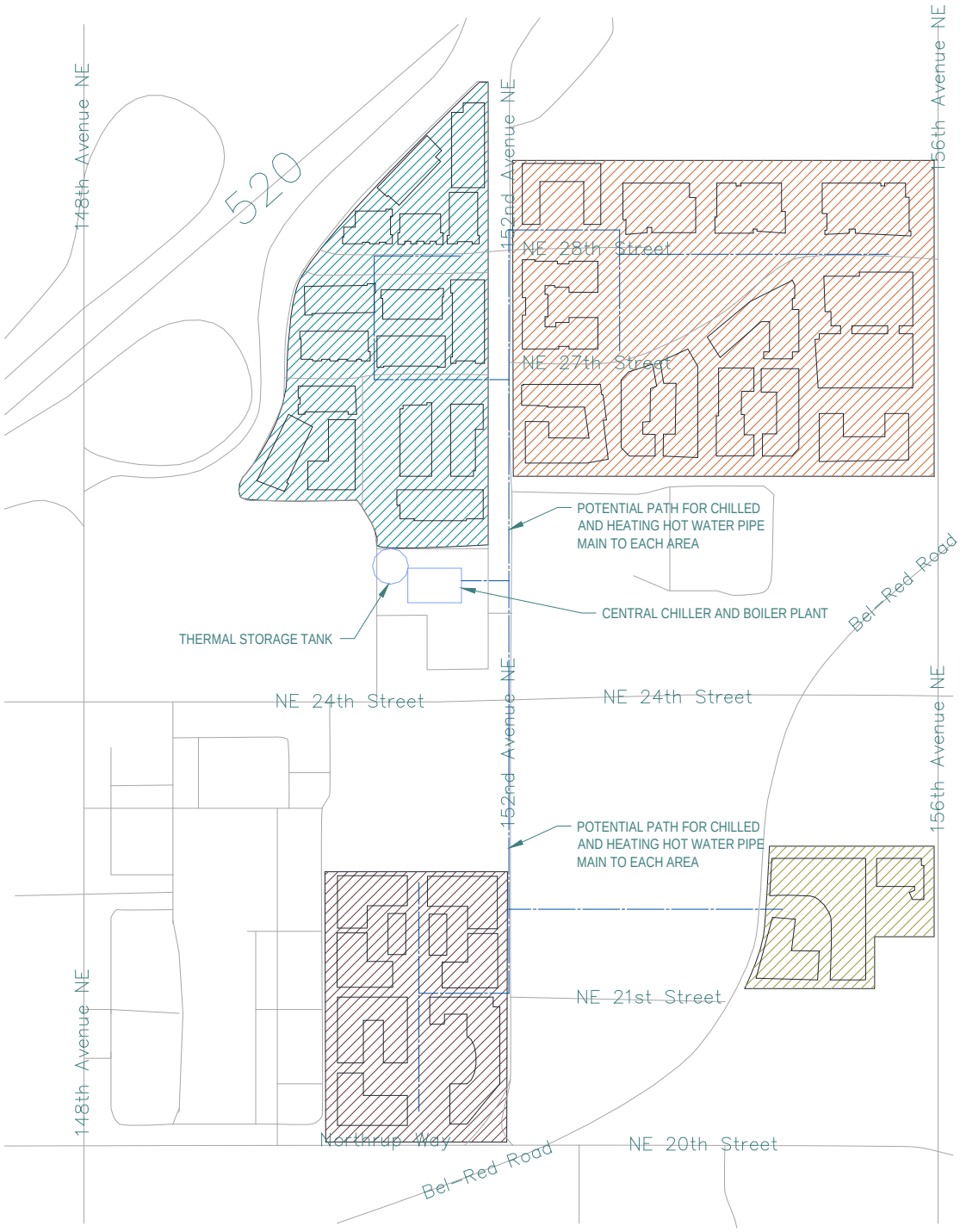
Figure 26: Demand Response / Thermal Energy Storage Plant Equipment System Diagram



OPTION E FLOW DIAGRAM

Figure 27 shows a site plan for a central plant with thermal energy storage serving hot water and chilled water through major branch pipes to potential Overlake Village developments.

Figure 27: Demand Response / Thermal Energy Storage Plant Site Plan



4.3.7 Option F: Waste Heat Recovery Plant

Option F would add waste heat recovery to Option A. Two potential waste heat sources have been identified. The first is data center waste heat from the Microsoft Troon facility, which is located just north of Esterra Park Block 2. The second is wastewater heat recovery from the sewer main that runs down 152nd Avenue. These sources would provide base load heating for the district, with associated improvements in energy efficiency and a reduction in traditional mechanical equipment sizing. The preliminary sizing for the heat recovery equipment is 1 MW. The construction costs for this option are estimated at $41–51 million. This plant might be located within or near the Esterra Park development. Figure 28 shows a major equipment system diagram for a plant with waste heat recovery serving hot water and chilled water to typical building heat exchangers for energy transfer.

Figure 28: Waste Heat Recovery Plant Equipment System Diagram

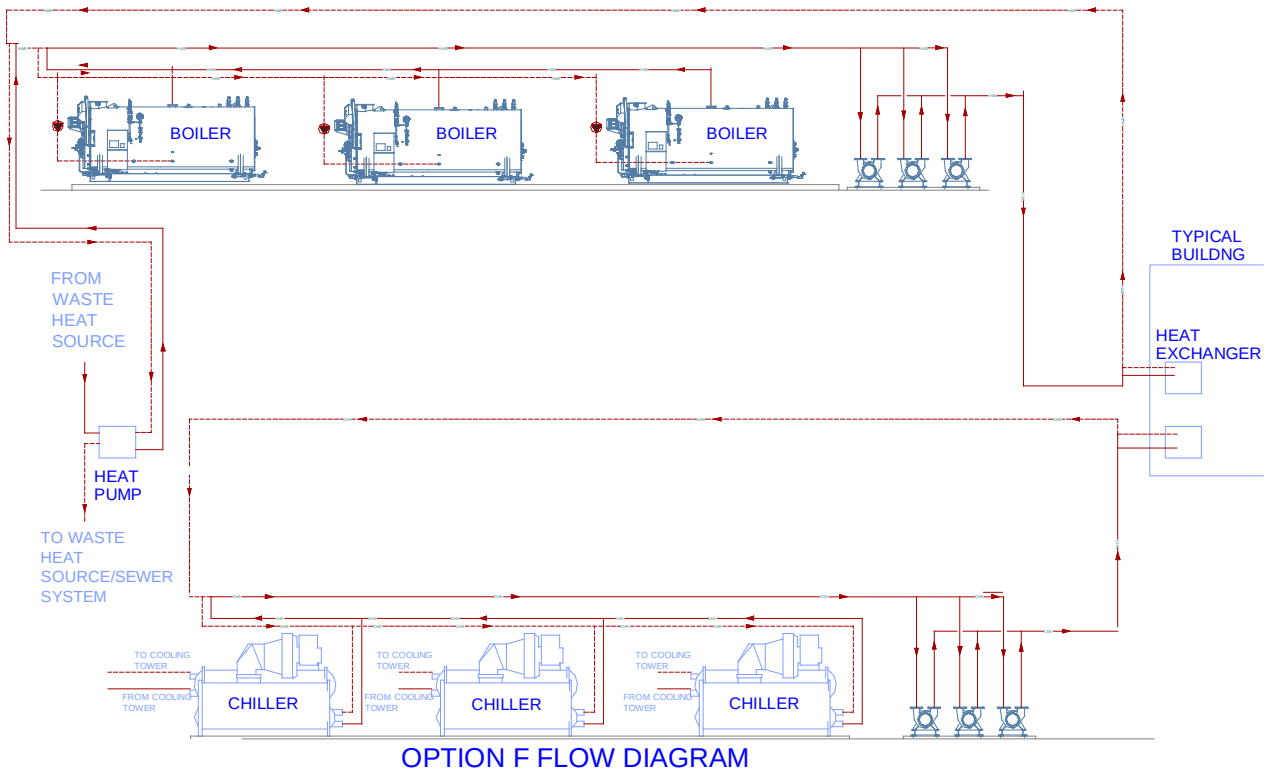
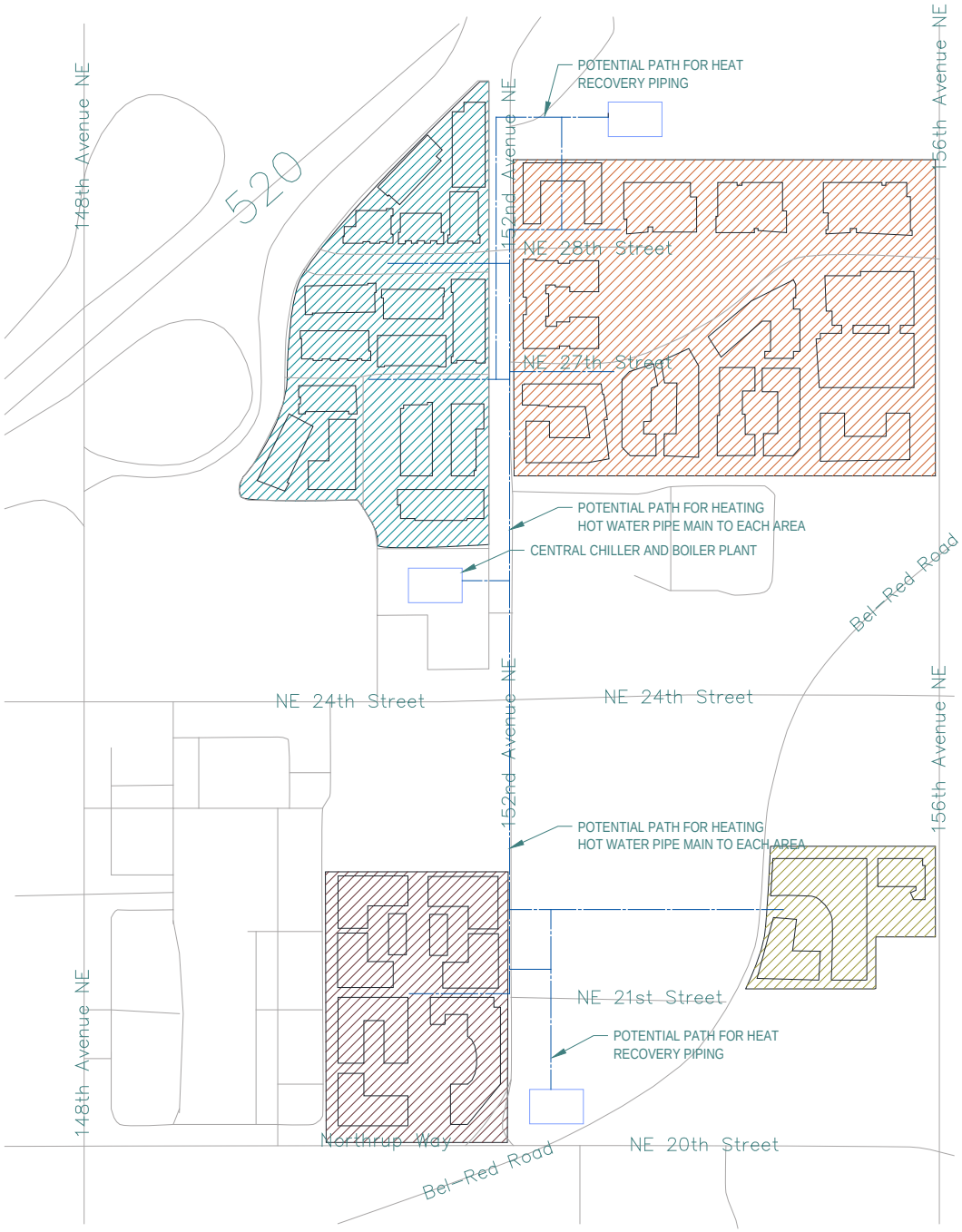


Figure 29 shows a site plan for a central plant with waste heat recovery serving hot water and chilled water through major branch pipes to potential Overlake Village developments.

Figure 29: Waste Heat Recovery Plant Site Plan



4.3.8 Option G: Waste Heat Recovery Plant with Distributed Heat Pumps

Option G would install gas-fired condensing boilers, cooling towers, and distribution pumps in a central facility connected to the district by a network of buried distribution piping. Water would be distributed at low temperatures and boosted or dropped to heating and cooling temperatures at nodes closer to or within the end-use buildings. This option also includes the waste heat recovery described above. The construction costs for this option are estimated at $42–52 million. Option G provides more flexibility in plant location and the number of plants. Plants could be located near potential waste heat recovery sources. Figure 30 shows a major equipment system diagram for a low-temperature system with heat recovery serving condenser water to a typical building heat pump.

Figure 30: Low Temperature Condenser Water System with Distributed Heat Pumps Equipment System Diagram

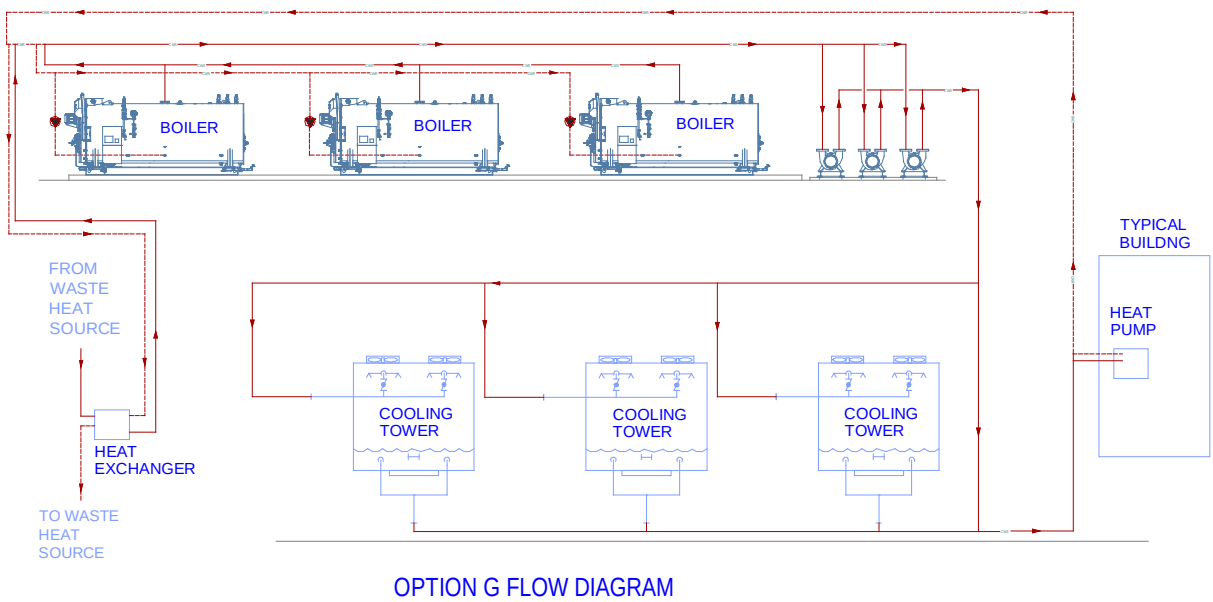


Figure 31 shows a site plan for a for a low-temperature system with heat recovery serving condenser water through major branch pipes to potential Overlake Village developments.

Figure 31: Low Temperature Condenser Water System with Distributed Heat Pumps Site Plan

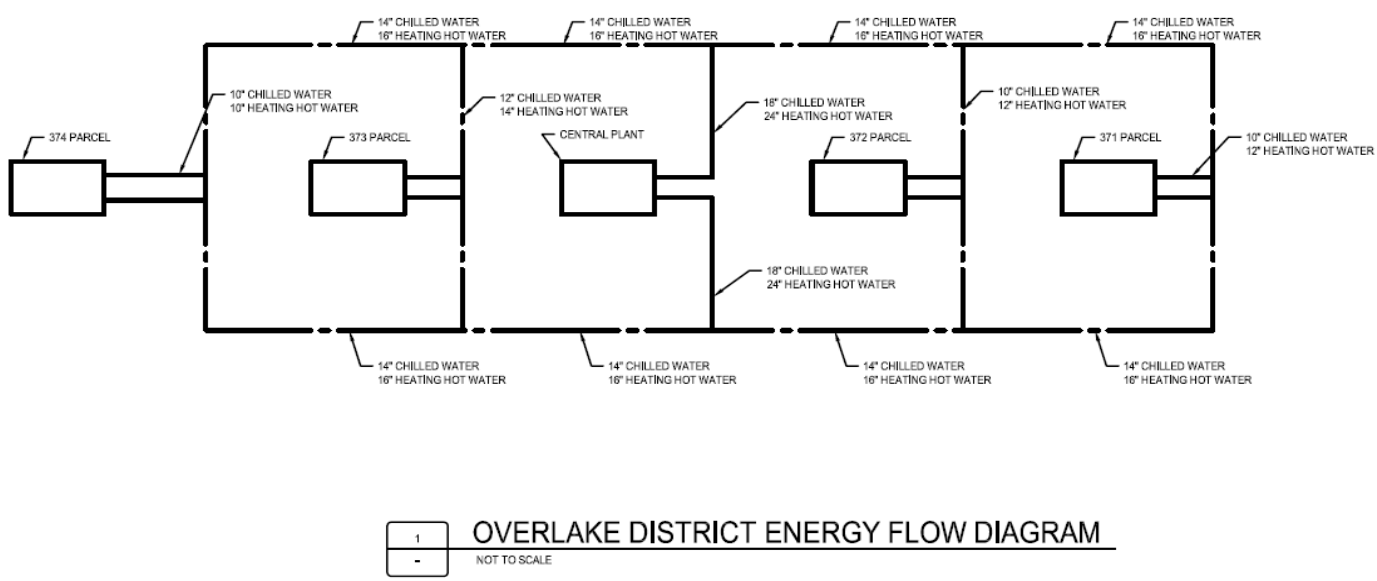
4.3.9 Hot/Chilled Water Distribution System

All of the district energy technology options will requre a network of buried distribution piping to distribute thermal energy around Overlake Village. The following distribution system requirements provide additional detail to the site plan pipe routing examples presented above. Figure 32 shows a schematic piping flow diagram for a central plant serving hot water and chilled water to the four Transportation Analysis Zones identified in Figure 1.

The right-of-way (ROW) requirements for the distribution piping specify that:

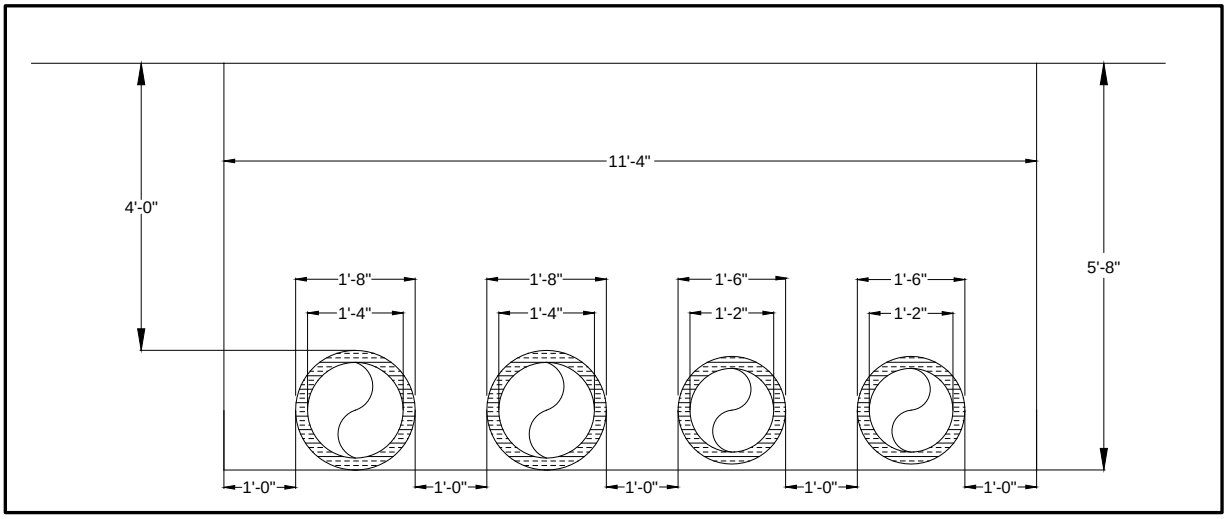
- The top of the pipe should be buried 4 feet deep.
- There are supply and return lines for both hot and chilled water (4 pipes total).
- Pipes should be separated in the trench by 1 foot of horizontal clearance on each side.
- Pipe diameter may range from 10 inches to 24 inches, requiring up to 12 feet of horizontal ROW for the main loop; branch loops may require as little as 8 feet 4 inches of horizontal ROW.
- Pipes should be separated from other utilities by a certain distance which will depend on the final system design temperatures.

Figure 32: Central Plant Piping Schematic



Pipe sizes are shown for a full build-out of the district energy system. Figure 33 shows an example cross-sectional detail of buried distribution piping for the corresponding main loop pipe sizes with required insulation and spacing.

Figure 33: Distribution Piping Example Cross Sectional Detail



4.3.10 Maintenance and Replacement Requirements

4.3.10.1 Central Plant

The technology selected for the central plant will dictate the specific type of maintenance required. However, in general these plants are not likely to need 24/7 operational support. Support personnel should be available on-call to support any operational issues that arise. The plant should employ Supervisory Control and Data Acquisition (SCADA) to support automated operations, alarming, and diagnostics. The plant should be designed with redundant subsystems that enable the plant to be kept online during maintenance.

4.3.10.2 Distribution Piping

Distribution piping systems are built for long useful lives with limited need for maintenance and replacement. A typical useful life for a hot/chilled water distribution piping system is 50–60 years. Over the course of many years, these systems will require some work, such as identifying and repairing leaks that may have formed due to stresses on the piping. Failure points may include unions and fittings or cracks in insulation jacketing that allow moisture to come in contact with piping material. Regular periodic maintenance to inspect for leaks and measure and evaluate the performance of the materials is recommended to ensure the integrity of the system.

4.3.11 Implementation Strategy

The recommendation is that the district energy system be built out in phases to optimize:

- The plant's capacity to serve loads.
- The ability to connect new developments to the distribution system as they are built.
- Road and site construction opportunities.
- Capital investment based on adoption.

The adoption projections indicate that the central plant can be constructed in two phases: an initial plant sized for 50% of the total loads anticipated for Overlake Village, and an addition to the initial plant that doubles the capacity of the district energy system once the initial adoption is achieved. The central plant should be designed to accommodate the two-phase implementation so that minimal reconstruction and adaptation are required to expand the system's capacity.

Similarly, the distribution system can be incrementally expanded as new developments require connection. For example, an initial distribution system may be implemented in the vicinity of one major development. When a second major development is expected to come online, a distribution system for that development could be implemented and a main loop constructed to join the two. Next, branch loops could be constructed off the main loop to serve future developments.

4.4 District Energy Technology Assessment Results

Through the modeling effort described above, McKinstry evaluated BAU scenarios and each proposed district energy technology for the following.

- **Annual Gas Heating**: This value corresponds to the amount of natural gas energy required by a heating system (in-building or district) to meet the annual heating needs for new Overlake Village developments.
- **Peak Heating**: Either the building systems or the district plant will need to meet the community's peak heating needs, which will occur on the coldest weekday of the year. The amount of energy required to meet this need is presented for each option.
- **Annual Electric Cooling**: This value corresponds to the amount of electrical energy required by a cooling system (in-building or district) to meet the annual cooling needs for new Overlake Village developments.
- **Peak Cooling**: Either the building systems or the district plant will need to meet the community's peak cooling needs, which will occur on the hottest weekday of the year. The amount of energy required to meet this need is presented for each option.
- **Annual Heating and Cooling Equivalent Carbon Emissions**: The carbon footprint from the energy consumption of the heating and cooling equipment was calculated using the U.S. EPA Emissions & Generation Resource Integrated Database (eGRID) emissions factors for the Northwest Subregion. For electricity, a conversion of 0.84697 pounds CO_2e per kWh was used. For natural gas, a conversion of 11.707 pounds of CO_2e per therm was used.
- **Approximate Capital Costs**: The capital cost for implementing the plant and associated distribution system was estimated based on the type of equipment required to implement each technology solution.

A summary of the BAU results is shown in Table 9, and the results for the technology assessment described above are shown in Table 10. The number of technology options to be caried forward for financial evaluation will be reduced based on alignment with project priorities.

Table 9: BAU Scenario Summary

	BAU-Gas Heat	BAU-Electric Heat
Annual Gas Heating (million therms/year)	1.324	-
Peak Heating from Building Systems (MMBtu/hour)	104	104
Annual Electric Heating & Cooling (MWh/year)	5,180	38,153
Peak Cooling from Building Systems (tons)	13,010	13,010
Annual Carbon Emissions (tons/year)	9,021	14,658
Capital Cost	$40M	$25M

Table 10: Summary of District Energy Technology Assessment Results

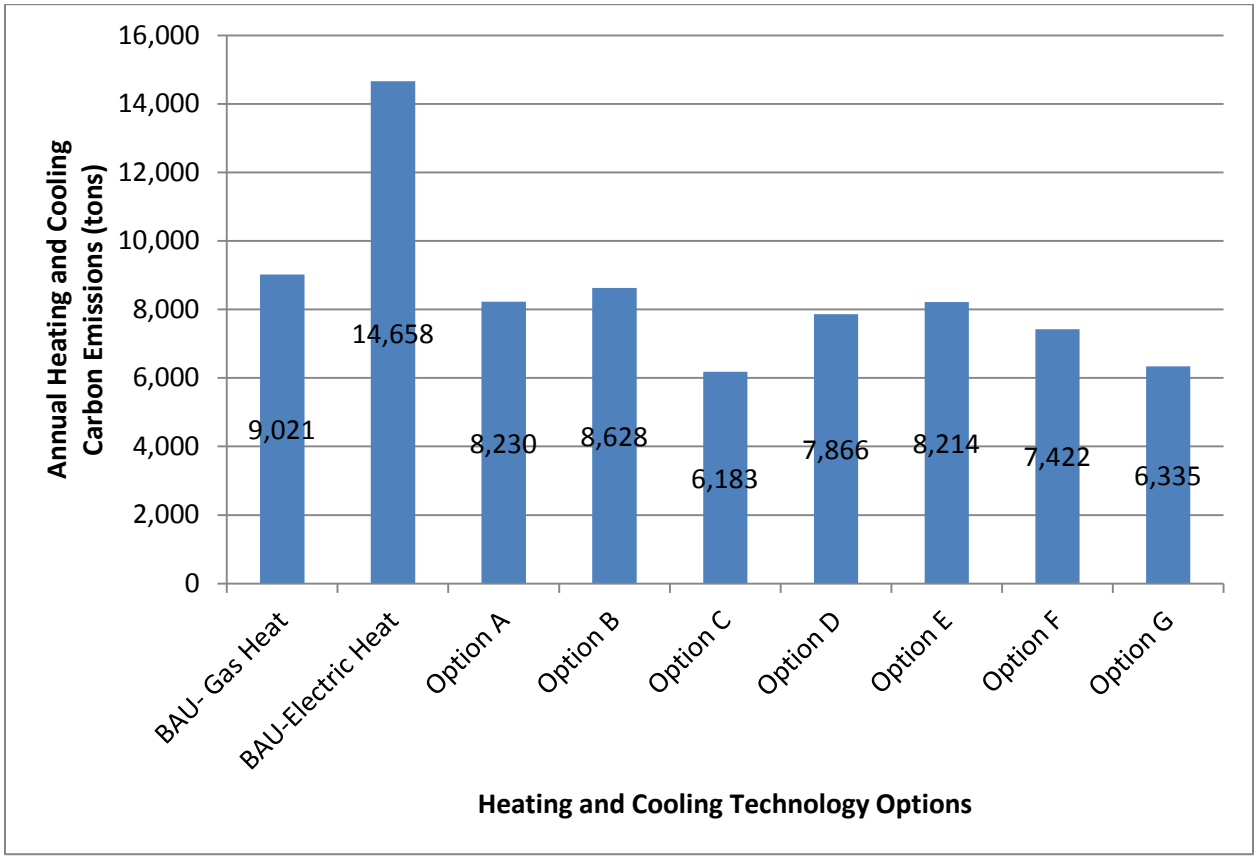
	Option A	Option B	Option C	Option D	Option E	Option F	Option G
Annual Gas Heating (Million therms/year)	1.250	1.250	0.628	1.381	1.250	0.926	0.611
Peak Heating from DE Systems (MMBtu/hour)	109	109	109	108	109	105	106
Annual Electric Heating & Cooling (MWh/year)	4,144	5,180	7,413	1,386	4,102	6,520	8,045
Peak Cooling from DE Systems (tons)	13,412	-	13,412	13,412	13,412	13,412	13,412
Peak Cooling from Building Systems (tons)	-	13,010	-	-	-	-	-
Annual Carbon Emissions (tons/year)	8,230	8,628	6,183	7,866	8,214	7,422	6,335
Capital Cost	$44M	$42M	$49M	$45M	$46M	$46M	$47M

The central plant technologies analyzed in Table 10 are listed again here for reference:

Option	System design
A	Central heating hot water and chilled water plant
B	Central heating hot-water-only plant
C	Central heating hot water and chilled water plant with geothermal
D	Combined heat and power plant
E	Demand response/thermal energy storage
F	Waste heat recovery plant
G	Waste heat recovery plant with distributed heat pumps

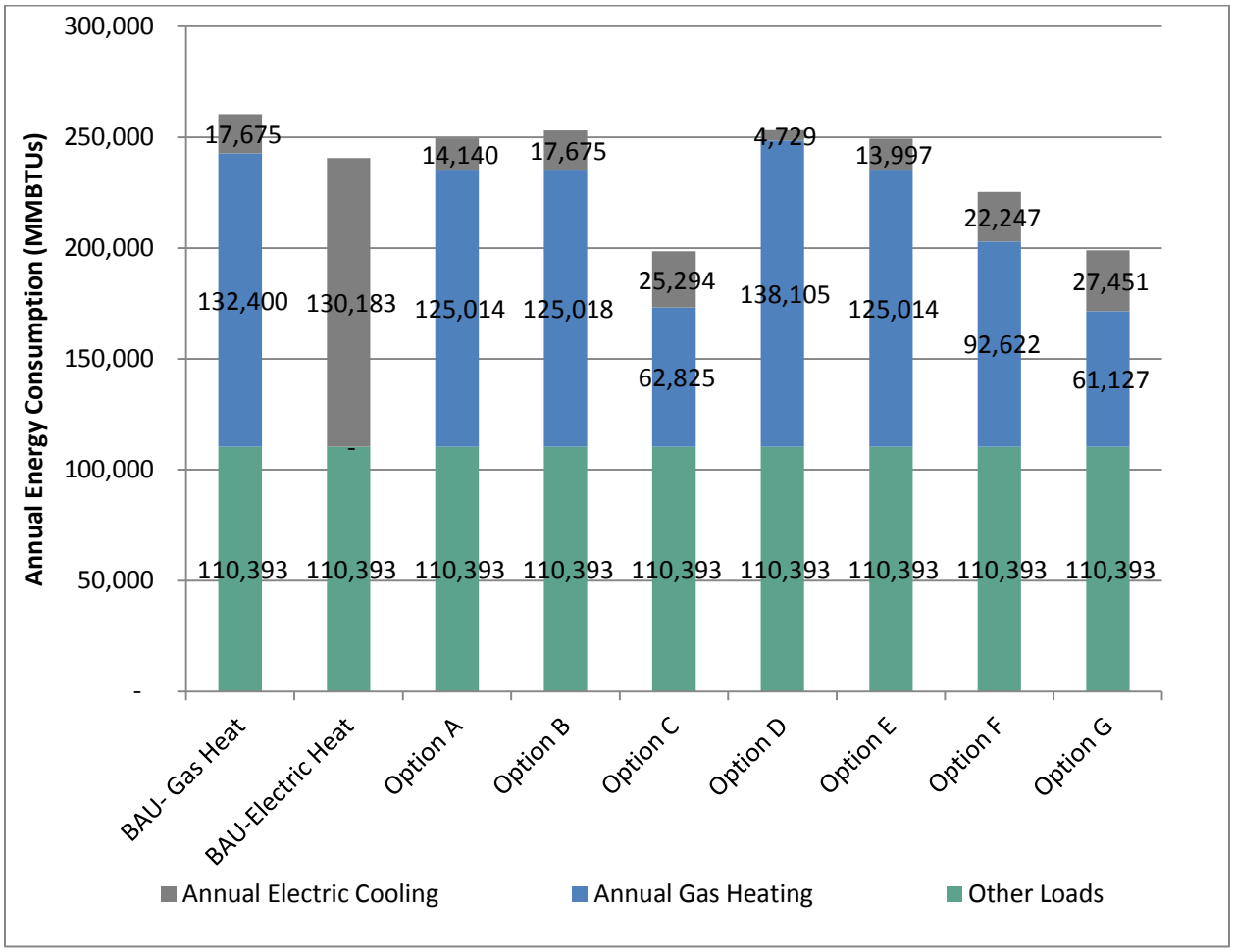
The results show that while the BAU-Electric Heat scenario has the lowest upfront capital cost, it also has the largest carbon footprint. Also, since electricity is more expensive than natural gas, the BAU-Electric Heat scenario will also have the highest energy cost. Of the district energy technology options, Options C and G have the lowest carbon footprint, as shown in Figure 34. Because Option C has a higher capital cost to develop, the technology recommendation to minimize the carbon footprint is Option G. The results from the assessment of the technology options have been incorporated into the financial analysis described in Section 6.

Figure 34: Annual Carbon Emissions for BAU and District Energy Technology Options



A summary of the estimated annual energy loads for Overlake Village are shown in Figure 35. All three components of the electric, gas, and other plug loads are included in the graph. Options C and G have the lowest energy consumptions, and have been incorporated into the financial analysis described in section 6.

Figure 35: Annual Energy Consumption for BAU and District Energy Technology Options



The estimated monthly energy and demand profiles for each of the options to serve the Overlake Village heating and cooling loads are provided in Table 11, Table 12, and Table 13.

Table 11: Summary of Annual Energy Consumption – Electrical Consumption (kWh)

	BAU: Gas Heat	BAU: Electric Heat	Option A	Option B	Option C	Option D	Option E	Option F	Option G
January	2,000	6,213,544	2,000	2,000	326,000	(232,000)	2,000	200,000	197,000
February	101,000	3,792,767	81,000	101,000	393,000	(131,000)	80,000	279,000	264,000
March	91,000	3,284,671	73,000	91,000	386,000	(161,000)	72,000	271,000	256,000
April	209,000	2,025,584	167,000	209,000	466,000	(60,000)	165,000	365,000	344,000
May	398,000	1,833,687	318,000	398,000	595,000	84,000	315,000	516,000	489,000
June	644,000	1,903,889	515,000	644,000	762,000	288,000	510,000	713,000	686,000
July	1,368,000	2,657,188	1,094,000	1,368,000	1,254,000	860,000	1,083,000	1,292,000	1,265,000
August	1,255,000	2,514,889	1,004,000	1,255,000	1,178,000	770,000	994,000	1,202,000	1,175,000
September	943,000	2,173,589	754,000	943,000	965,000	527,000	746,000	952,000	925,000
October	160,000	2,093,783	128,000	160,000	433,000	(106,000)	127,000	326,000	305,000
November	7,000	3,874,565	6,000	7,000	329,000	(221,000)	6,000	204,000	189,000
December	2,000	5,774,048	2,000	2,000	326,000	(232,000)	2,000	200,000	197,000
Total	**5,180,000**	**38,142,203**	**4,144,000**	**5,180,000**	**7,413,000**	**1,386,000**	**4,102,000**	**6,520,000**	**6,292,000**

Table 12: Summary of Annual Energy Consumption – Electrical Demand (kW)

	BAU: Gas Heat	BAU: Electric Heat	Option A	Option B	Option C	Option D	Option E	Option F	Option G
January	-	15,000	-	-	200	-	-	100	100
February	700	10,000	600	700	700	(35)	500	700	700
March	700	9,000	600	700	700	(35)	500	700	700
April	1,500	6,000	1,200	1,500	1,200	565	900	1,300	1,300
May	2,800	7,000	2,200	2,800	2,100	1,565	1,700	2,300	2,300
June	4,600	9,000	3,700	4,600	3,400	3,065	2,800	3,800	3,800
July	9,800	16,000	7,800	9,800	6,900	7,165	5,900	7,900	7,900
August	9,000	15,000	7,200	9,000	6,300	6,565	5,400	7,300	7,300
September	6,700	12,000	5,400	6,700	4,800	4,765	4,100	5,500	5,500
October	1,100	6,000	900	1,100	1,000	265	700	1,000	1,000
November	100	10,000	100	100	300	-	100	200	200
December	-	14,000	-	-	200	-	-	100	100

Table 13: Summary of Annual Energy Consumption – Natural Gas (therms)

	BAU: Gas Heat	BAU Electric Heat	Option A	Option B	Option C	Option D	Option E	Option F	Option G
January	212,000	-	200,000	200,000	100,000	211,000	200,000	173,000	123,000
February	126,000	-	119,000	119,000	60,000	129,000	119,000	92,000	62,000
March	109,000	-	103,000	103,000	52,000	114,000	103,000	76,000	50,000
April	62,000	-	59,000	59,000	30,000	70,000	59,000	32,000	17,000
May	49,000	-	46,000	46,000	23,000	57,000	46,000	19,000	7,000
June	43,000	-	41,000	41,000	21,000	52,000	41,000	14,000	4,000
July	44,000	-	42,000	42,000	21,000	53,000	42,000	15,000	4,000
August	43,000	-	41,000	41,000	21,000	52,000	41,000	14,000	4,000
September	42,000	-	40,000	40,000	20,000	51,000	40,000	13,000	3,000
October	66,000	-	62,000	62,000	31,000	73,000	62,000	35,000	19,000
November	132,000	-	125,000	125,000	63,000	136,000	125,000	98,000	67,000
December	197,000	-	186,000	186,000	93,000	197,000	186,000	159,000	112,000
Total	**1,125,000**	**-**	**1,064,000**	**1,064,000**	**535,000**	**1,195,000**	**1,064,000**	**740,000**	**472,000**

5 Ownership Structures and Financing Models

5.1 Ownership Structures

In the pre-feasibility study, Puttman conceptually described a range of possible ownership structures, funding mechanisms, typical contracting methods, operating conditions and agreements, and customer relationships. The following sections build on these concepts, defining and detailing ownership structures, roles and responsibilities, and potential financing strategies and revenues.

5.1.1 Overview

There are many facets to a district energy system. It is important to align the ownership and operating responsibilities with stakeholders who can succeed in these roles when the system is deployed for commercial operation. The design life for a system typically ranges from 25 to more than 40 years, with some components lasting less than the whole term, which means that future investments will be needed to ensure continued operation of the district energy system.

Four typical ownership structures that are commonly used for projects like the Overlake Village district energy system.

- Public
- Private
- Public-private partnership (P3)
- Cooperative

Pragmatic considerations influence the choice of ownership structure, such as authority to build, funding mechanisms, bond and risk exposure, regulatory considerations, investment return requirements, and compatibility with the operating model for each stakeholder.

5.1.2 Public Ownership Structure

Generally, cities get involved in asset ownership situations that best support community public interests, including environmental and sustainability goals, vital services, and social trust. The City would be the single party responsible for the district energy system. The City may choose to create a district energy utility, either as a City department or as a wholly-owned subsidiary of the City.

The City would be the single point of accountability for supplying thermal energy to Overlake Village, and would assume 100% of thee operating risk. PSE would provide gas and electricity to both the City-owned district energy system and the Overlake Village community under existing tariff schedules, as is consistent with PSE's role as a utility services provider. Table 14 summarizes the advantages and disadvantages associated with public ownership.

Table 14: Public Ownership Risk Benefit Summary

Advantages	1. The City is experienced in working with professional service providers, and has the ability to organize capital funding and fund operations through bond measures and future utility fees. 2. The City has higher control over the cost of energy in Overlake Village. 3. The City can mandate connection to district energy systems. 4. The City can meet its priorities for Overlake Village. 5. The City could distribute some of its cost among developers and building owners.
Disadvantages	1. All financial, implementation, and operational risks are borne by the City. 2. Significant political support is required. 3. The project is not in the City's CIS planning, and would take time to incorporate — especially if capital funds are required instead of alternate financing methods. 4. The City has no experience as an energy provider.

5.1.3 Private Ownership Structure

In a private ownership structure, a private entity is wholly responsible for the thermal energy generation and delivery business. To ensure a maximum return on their investment, a private owner would require complete responsibility to design, build, own, operate, and maintain the facility. This is the simplest of all ownership structures. Private investors will likely seek support from the City in the form of accelerated planning approvals, changes to local ordinances, community awareness efforts, and permitting. The big risk for a private party is in estimating the rate of adoption and connection to the system. Without a mandate from the City, this project would have more risk, which would affect how much the investor would have to charge for the thermal resources delivered.

A private investor is motivated to fund infrastructure projects like this one if they are likely to provide a good return on investment, include comprehensive agreements for building and operating the facility, and offer opportunities to improve on their returns through more efficient operations. Return risk can be mitigated in a wide variety of ways, including contracts and flexible rate adjustment mechanisms that hedge against unmanageable risks such as rising fuel prices and future regulation changes.

As mentioned above, the City will likely be asked to support the project in a variety of ways, including mandating local connectivity. Supporting a private entity, other than a regulated entity, could create political risk for the City – leaving the impression that the City endorses the private investor/owner.

PSE would provide gas and electricity to both the district energy system and the Overlake Village community, according to their role as a utility services provider, using existing tariff schedules. Table 15 summarizes the advantages and disadvantages associated with private ownership.

Table 15: Private Ownership Risk Benefit Summary

Advantages	1. Private entity can make decisions and take quick action when necessary. 2. Private entity organizes its own financing and contributes its own equity as capital. 3. The City does not have any financing or operational risks.
Disadvantages	1. Private entity will expect high returns, probably greater than those available under the BAU equivalent, thus negatively affecting the adoption rate and customer rates. 2. Unknown political risks for the City if the private entity seeks support to mandate connection. 3. The City does not have full control over energy rates in Overlake Village.

5.1.4 Public-Private Ownership Structure

Public-private partnerships are used when parties come together and leverage their individual strengths to develop, implement, and operate a new facility. Projects are justified based on their return on investment, public interest, and regulation.

According to the *National Council for Public-Private Partnerships*, a P3 partnership is defined as:

> *A contractual agreement between a public agency (federal, state or local) and a private sector entity. Through this agreement, the skills and assets of each sector (public and private) are shared in delivering a service for the use of the general public. In addition to the sharing of resources, each party shares in the risks and rewards potential in the delivery of the service and/or facility.*

In this structure, both the City and a private entity share the responsibilities for a district energy system, with the division of responsibilities depending on the role each party wants to take as part of a public-private agreement. All functional activities of the system need to be performed by the partnership, and they are best aligned with the ownership structure. For example, a private entity might invest in the central plant, and therefore is best positioned to take responsibility for the operation and maintenance of the plant equipment. The private entity (possibly PSE) could operate the central plant using their own staff, likely coupled with maintenance service level agreements for major equipment. Either a private entity or the City could operate the distribution system. Maintenance would likely be supported by service level agreements.

It is reasonable to assign ownership responsibilities based on separate system components. Examples of separate components include:

- Boilers and chillers, which can be considered stand-alone subsystems.
- The distribution system, which is independent of the central plant.
- The metering and IT network that gathers data, tracks performance, and becomes the basis for invoicing customers.

PSE would provide gas and electricity to both the private owner of the district energy system and Overlake Village, in consistence with their role as a utility services provider, using existing tariff

schedules. If PSE is involved as a private owner, they will need to sponsor a new tariff schedule for the thermal energy delivered. Table 16 summarizes the advantages and disadvantages associated with a public-private ownership.

Table 16: Public-Private Ownership Risk Benefit Summary

Advantages	1. Both public (City) and private (PSE) entities participate on a regulated basis. 2. Each party could determine its optimal share of responsibilities. 3. The City has a wide range of participation options, as discussed in Section 8.5. 4. The City has lower political risk to mandate connection if the private entity is regulated. 5. A regulated model may provide lower customer energy rates in comparison to an un-regulated model.
Disadvantages	1. A district energy system would be a new responsibility for both the City and PSE. Each would have to decide whether they want to participate in this kind of business model, based on their investment needs and strategic goals. 2. The City would likely not mandate connectivity if the private entity is not PSE. They would run the risk of endorsing a known party who might fail or be unreliable at providing thermal resources.

5.1.4.1 Central Plant and Distribution System Demarcation

Demarcation is important for defining the physical boundary between two system components, which is also the point at which responsibility for ownership, operations, maintenance, repair, and replacement shifts from party to party. Two practical segments of a district energy system are easily understandable: (1) the central plant, and (2) the distribution system.

The central plant describes the building that houses the equipment, space for storage, and offices for the plant operator staff. The systems contained in the central plant include:

- Chiller equipment.
- Boiler equipment.
- Pumps and plant controls.
- Manifold and internal plant piping.
- Transition piping from the central plant to the central plant metering point.

The initial distribution system piping will be based on the system's first adopters and extended as new customers come online. Part of the project strategy is to establish an initial load to serve and incorporate new customers based on the adoption rate. The systems contained within the distribution system include:

- Transition piping from the central plant metering point.
- Pumps and valves.
- Interface piping at the building.
- Metering and telecommunication systems.

- Heat exchangers located in the buildings.

Consumption is measured at the point at which thermal energy transfer occurs at the building, and this data is totalized to calculate monthly consumption.

5.1.5 Cooperative Ownership Scenario

A cooperative ownership structure (co-op) would likely involve many owners, most likely the property owners. Usually the co-op will identify a single party to take the lead as the primary responsible party, able to administer the operation of the asset. There is typically an agreement to share responsibility across the member base, including how costs are paid and revenues are invoiced.

The fundamental characteristic for this kind of ownership structure is the creation of a closely held entity (a registered corporation or special purpose entity) that can own assets, arrange capital funding, and operate and maintain the district energy system with a high degree of efficiency for up to 25 years. Stakeholder involvement for this duration may not appeal to some parties, especially property owners who might consider this too long for their business models. As a result, the co-op might contract operations, maintenance, repair, and replacement to a qualified independent service provider.

There is a low probability of the project ever getting built using a co-op model because of the model's complex structure, its duration, and its operating risks. There hasn't been an obvious pool of potential stakeholders that would commit to creating a district energy system.

The City would not have inherent or perceived risks in this scenario, since they would have no role in the development, implementation, or operation of a district energy system. If the City does get involved in a co-op structure, they would face a certain amount of risk relative to the degree of their involvement in the Project. The advantages and disadvantages associated with co-op ownership are summarized in Table 17.

PSE would provide gas and electricity to both the co-op and Overlake Village, in consistence with their role as a utility services provider.

Table 17: Cooperative Ownership Risk Benefit Summary

Advantages	1. Participation is the key for co-op structure. The vertical integration of property developers and owners would result in significant control over generation, consumption, and end-user relationships, which avoids the challenges of a multi-stakeholder structure. 2. Ownership and operation of the system holds a strong common interest for co-op stakeholders, especially around cost control, reliability, and quality of customer service. 3. The City does not face any implementation or operational risks.
Disadvantages	1. Co-op structures are complicated initially, and can be challenging to manage over the life of the facility. 2. The timing of the individual developments is not conducive to a co-op structure, and is not favorable with an optimal build plan. 3. None of the property owners appear to have any interest in the co-op arrangement.

5.2 Project Phases and Functional Activities

5.2.1 Project Phases

The district energy system may be executed in four main phases.

- **Development Phase** – The project is developed across all of its technical, contractual and financial aspects, resulting in a comprehensive project plan.
- **Design Phase** – The project plan is developed through to design ready for implementation. This phase is critical because commitments are made which will affect the structure, the stakeholders, and the Overlake Village community.
- **Implementation Phase** – The district energy system is built. This phase follows on the work completed in the Design Phase and progresses into engineering, procurement, and construction.
- **Operational Phase** – Once the new facility is built, commissioned, and accepted as ready for commercial operation, the operational mode begins, providing thermal services to customers of the new district energy system. Key functional activities that need to be performed and managed during the operational phase include:
    - ***Customer Service and Community Relations*** – The management of the tasks necessary for the transactional relationship between the district energy system and its customers, including the community at large, such as meter reading, billing, handling payments, etc. As the district energy system evolves, there is a need for community outreach and general awareness programs.
    - ***Plant Operation*** – The day-to-day operational activities necessary for the system to operate.
    - ***Maintenance*** – Preventative maintenance, including minor repairs, ensures efficient operation and reliable performance.

- ***Factory Service*** – Major equipment maintenance involving specialized technicians.
- ***Performance Monitoring and Reporting*** – District energy facilities need to be monitored to ensure that performance targets are met. Regular reporting to investors, the City, the Overlake Village community, and other entities is expected.
- ***Regulatory Relations and Environmental Reporting*** – The owner of the district energy system must perform periodic documentation and testing to comply with environmental reporting requirements.

5.2.2 Functional Activities

As part of an asset management program, there are functional areas of responsibility that are needed for optimal operation. Each activity is needed for the district energy system to operate. Once the central plant is built, it will not change much unless the system is expanded beyond its initial capacity. The distribution system will evolve over time as new load is brought online. Expansion creates the need for additional capital to fund extensions. It will be critical to manage changes to the system so that the system is appropriately modified and operates reliably. Efforts must be highly coordinated between the development community, the central plant owner, and the City. The recommended stakeholder functional activities are summarized in Table 18.

Table 18: Stakeholder Functional Activities

Group	Functional Activities	Recommended Stakeholder
Plant operation and related services	• Plant operation • Factory service contracts • Maintenance / service level agreements • Commodities purchases • Janitorial and rubbish services	For the central plant activities, the asset owner is party best suited for the responsibility of operations and maintenance – either PSE or a private party. For the distribution loop, either the City or a private party is recommended.
Reporting and customer relations	• Economic reporting for City planners, staff, and investors • Communication services, such as public relations and customer-relation services • Regulatory reporting and relations	Reporting and customer service activities are best managed by the same party responsible for energy consumption and revenue capture. These two are dependent upon each other. It is recommended that the City lead this responsibility.
Energy consumption and revenues	• Meter reading and data management (meter to cash) • Contract management and Invoicing • Billing and collections	These responsibilities are at the heart of the project economics, and have a tangible effect on customer relations. The best stakeholder for these activities is the same as the stakeholder for reporting and customer relations.

5.3 City of Redmond Participation Options

The City has several different ways in which they could participate in the district energy system. They have the culture, leadership, and mechanisms to participate as a primary project stakeholder. Participation options range from simple activities, such as project promotion in the community without significant capital burden, to moderate involvement such as funding part or all of the development phase activities and possibly the metering, billing, and collections functions as well. On the comprehensive end of the range is a much greater involvement in all phases of the project, either with partial responsibility for the distribution system or as the sole owner of all aspects of the system. An optional mix can be examined in the next development phase with a well-balanced assessment of the individual facets.

The following list describes a range of responsibilities the City might consider for participating in this project.

- Create a communications campaign targeted at the Overlake Village community, developers, and project stakeholders to promote a district energy system.
- Encourage property owners and developers to connect to the district energy system through ordinances and permitting processes.
- Take responsibility for or potentiality fund one or more of the following activities:

Development Phase *Development costs range between 2% to 4% of capital funding – i.e. a $50M project would cost between $1.0M to $2.0M* *Timeframe for this phase – 12 to 18 months*	Choose one of the following: 1. **Simple Engagement** - Lead community awareness and promote the project without significant capital burden and manage media relations for the project. 2. **Moderate Engagement** - Fund part or all of the development phase activities. 3. **Significant Engagement** - Lead Development Phase, either as sole entity or as stakeholder on the Development Team with PSE and/or with Project Developer.

Design Phase *Design costs range between 3% and 5% of capital funding – i.e. a $50M project would cost between $1.5M to $2.5M* *Timeframe for this phase – 6 to 9 months*	Support the project with some or all of the following: 1. Fast-tracking the permitting process based on the Strategic Plan. 2. Procuring land or designating land the City already owns for the central plant. 3. Public relations with the community, property owners, and media. 4. Successful contract management and design/build processes, depending on desired involvement.
Implementation Phase *Implementation costs range between $40M and $50M – see scenarios for more detail* *Timeframe for this phase – 12 to 15 months*	Tools the City might use include: 1. Issuing EPC-type procurement contract with district energy developer. 2. Enforcing conditional project acceptance for district energy developer. 3. Funding for some aspect of implementation. 4. Continuing project promotion targeting developers and property owners. 5. Capital funding for infrastructure.

Operational Phase *Operational costs range between $2.0M and $2.5M for the first year of operation, then escalated for the term of the project – see scenarios for more detail* *Timeframe for this phase – 25 to 30 years*	The range the City may consider include: 1. A continuous community awareness campaign focused on the performance of the project. 2. Managing media relations for the project. 3. Performing operations and/or maintenance of the district energy system. 4. Managing environmental performance tracking and/or recording. 5. Using telemetry and data aggregation systems for billing purposes. 6. Implementing data hosting and web dashboard services. 7. Administering bill preparation activities and collection of monthly energy and capacity fees. 8. Leading back-office distribution of revenues and fees to asset holders.

5.4 Financing Strategies and Risk Mitigation

5.4.1 City of Redmond Capital Investment Strategy

The City understands the value of identifying and prioritizing capital investments. The Capital Investment Strategy (CIS) is a testament to the commitment made by the City to invest strategically in alignment with the Redmond Comprehensive Plan. The CIS contains a range of options for raising capital. It is suggested that the City consider these as potential mechanisms for investing in district energy.

The following excerpts from the 2013–2030 Vision Blueprint validate that the City has the capital planning processes needed to pursue capital projects of this magnitude, including the use of a strong public-private project structure.

The CIS extends the City's capital planning program a step further by showing what improvements are needed to achieve Redmond's vision and functional plans, and what they will cost. The CIS is updated every other year, alternating years with the budgeting process.

According to the City's August 2014 Progress Report:

> *Given the funding gap, the City will need to continually prioritize and sequence capital projects to most effectively achieve Redmond's vision. Support for capital investments should also involve consideration of alternative financing approaches to ensure projects are aligned with the vision, coordination is achieved, and taxpayers get the best value for investment.*

This report also states that near-, mid-, and long-term capital investment projects for the Overlake community total nearly $220 million. Most of the near-term capital will be spent on storm water management, transportation, and infrastructure projects.

Public-Private Partnership projects advance the City's vision for the future by providing needed physical infrastructure and related programs. By improving physical infrastructure and supporting key private development, capital investments have a dual function in fulfilling the City's land use vision. These types of capital improvements help to facilitate economic development. For example, the City's investments in the Downtown and Overlake areas are tangible steps towards realizing the vision for these locations, and encourage continued private long-term investment in the City.

The City's Capital Planning Vision Blueprint states that *"in some cases, public-private partnerships are forged to meet mutual service goals for the public and private sector."* For example, private developers might install utilities and improve streets and sidewalks to serve new housing or commercial developments. Once a new project is constructed, the financial burden shifts from one-time construction costs to ongoing operations and maintenance.

The City has several alternative financing mechanisms, as described in the 2013–2030 CIS, which may be used when capital improvements cannot be reasonably financed on a pay-as-you-go basis. The City will seek out the most cost-effective form of financing, based on project scope and terms of indebtedness. Each of these alternative funding tools is defined as bonds with many underlying conditions that

determine and define their application. Acceptable uses of bond funds include use for assets that can be capitalized and depreciated. In the case of this project, it is clear that the City could use one or more of these alternative financing mechanisms to develop, implement, and operate the new district energy system. The capital funds needed for the project will be proportional to the roles and responsibilities agreed to with all stakeholders included in the public-private ownership structure. Timing for these types of funds is another consideration — some require voter approval, while others don't.

5.4.2 Private Investment Project Financing Methods

The financing structures a private investor might use include municipal bonds, debt, equity, tax credit, or a blend of public-private partnership funding that employs all or part of these. Private investors typically need return levels ranging from 5% on the low side to 8-9% at the midpoint, and upwards of 15%. With each structure come the questions regarding the breakeven point, credit risk, performance risk, force majeure, and potential early termination penalties. Answers to these questions influence the investor's opinion and confidence in the repayment strategy. Risks are inherent in a financed capital project, and a private investor will want to mitigate their exposure whenever possible.

5.4.3 Typical Strategies to Manage Risks

Managing risks is part of any project, and is certainly necessary for all phases of a district energy project. In the beginning, the parties involved need to organize a long list of responsibilities and negotiate who will take what role in the project. At the cornerstone are the project relationships, the form of contracting that both supports development and is consistent with the stakeholder charter. For example, a design/build or design/bid/build model best serves a public-private partnership structure. Establishing a clear and detailed responsibility matrix for each of the three phases (Development, Implementation, and Operation) is strongly recommended.

Risks can be defined based on technical, financial, and contractual considerations. This is easily accomplished when a single party has full responsibility for a project, like in the case of a public or private ownership structure. It is more challenging to assign risk for each of these conditions in a multi-stakeholder scenario, like a public-private partnership model. Recommended ways to manage risks are:

- Create a well-developed roles and responsibilities matrix to minimize confusion about each phase of the project lifecycle.
- Provide political support for project development, implementation, and operation, with appropriate exit strategies based on progress and purpose, should the project fail to meet expectations.
- Provide or secure sufficient capital to support each phase.
- Match each responsible party with stakeholder charter and investment requirements.

5.5 Revenue Model

The project economics here are similar to rates for other utilities, and are best supported by a two-tier revenue structure: an energy charge for the valuable thermal resources delivered, and a capacity charge that supports connectivity and infrastructure that benefits the end customer. The revenue streams are further discussed in Section 6.

Depending on roles and responsibilities for both PSE and the City, we assume that the revenues collected would be considered regulated returns and divided in a reasonable fashion. The modeling of thermal resource revenues is affected by several considerations, but is primarily influenced by the price charged to the end user. In the next development phase, revenue forecasts should be created and analyzed in far greater detail to better understand the variations in cash flow and return on investment, specifically the use of coverage ratios as a way to manage economic risk as well as the timing of capital infusions during the operational phase.

5.6 Ownership Structure Recommendation

The recommended approach for this project, based upon evaluation of the different ownership structures described above, is a public-private partnership ideally made up of the City, PSE, and an experienced project developer.

Using a public-private partnership model is recommended because:

- The City's involvement is consistent with their current philosophy of investing in Overlake Village.
- The ownership model is familiar for the City, and can be easily authorized and embraced by the leadership and the management departments.
- The City is already providing utility services within the city limits, and has the capability to operate and maintain the Overlake Village system.
- Participation ranges from simple City support for the district energy system to a comprehensive model in which the City invests capital and operates part of the new system.
- The City might perform development functions such as planning, design, policy direction, tariff and regulatory structuring, capital investment in physical assets, or billing services. Determining exactly how the City might participate needs to be explored further as part of the Development Phase.
- Projects like this one need all the stakeholder buy-in possible to get started and ultimately completed. With the City's involvement, the project's commercial viability is significantly improved.

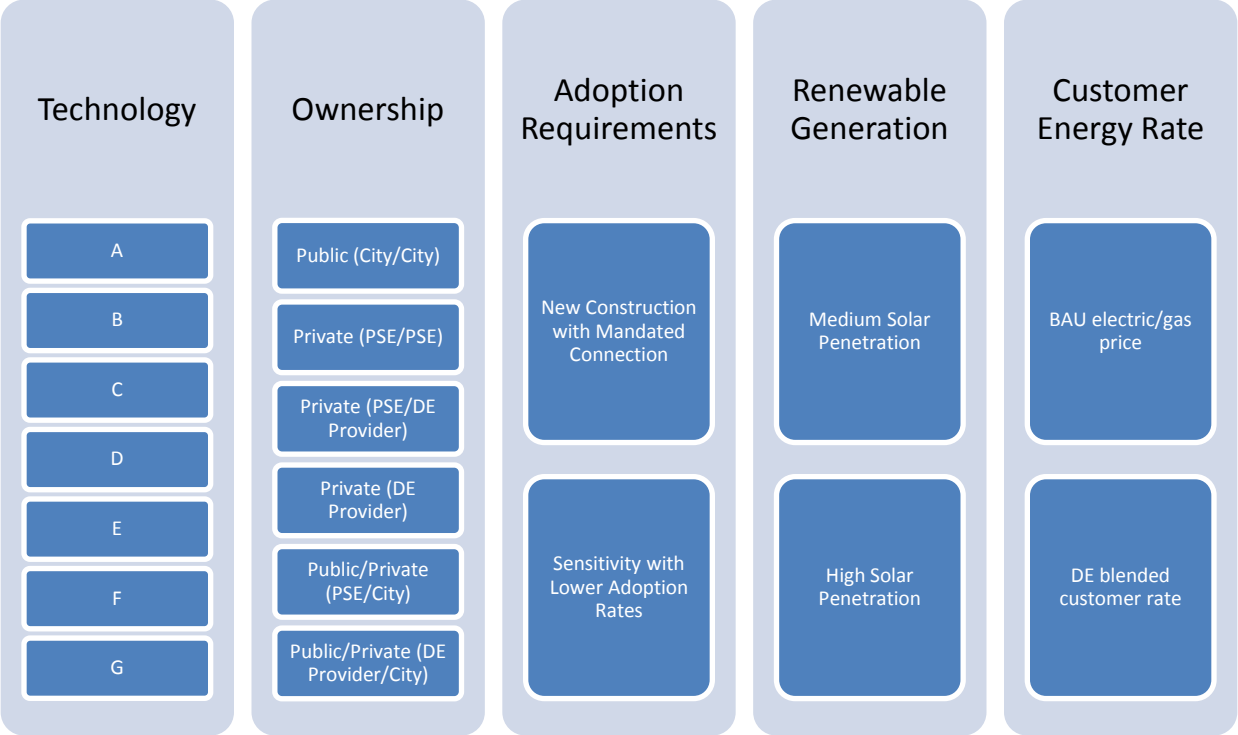
As mentioned in the pre-feasibility study, it is important to engage with key stakeholders early in the Development Phase to ensure support. The value of the City, PSE, and private developers coming together and combining strengths to create this new system gives the project the best possible chance of being built.

6 Results

6.1 Scenario Criteria

The district energy scenarios can be assembled in hundreds of different ways. The team focused on bringing together economically and environmentally balanced scenarios, and had to rely on experience and judgment through this process. The most significant criteria that drove the outcome are summarized in Figure 36 and discussed further below.

Figure 36: District Energy Scenario Components



Assembly of the scenarios was based on:

- Reduction of greenhouse gas emissions and energy use.
- Alignment with the City's environmental and economic priorities.
- Ease of development and operation.
- Providing a spectrum of scenarios for the City to consider.

With these considerations in mind, the team framed four scenarios that achieve a specific key objective, and selected components that are optimized to accomplish one of the objectives listed in Table 19.

Table 19: Scenarios and Objectives

Scenario	Objective
1	Minimize carbon footprint.
2	Minimize carbon footprint with geothermal.
3	Minimize district energy implementation, operations, and maintenance costs.
4	Hold customer rates to parity with BAU-gas heating rates.

The conceptual design of the seven technologies evaluated as viable options for the central plant are shown in Section 4.3. From those technologies, the team selected a unique central plant technology for each scenario. The preliminary data indicates that the seven technologies do not differ significantly in cost; however, each technology provides various levels of energy use and carbon footprint reductions. The four technologies selected are as follows.

- **Scenario 1**: waste heat recovery and distributed heat pumps (**Option G**, Section 4.3.8)
- **Scenario 2**: central heating hot and chilled water plant with geothermal (**Option C**, Section 4.3.4)
- **Scenario 3**: central heating hot water-only plant (**Option B**, Section 4.3.3)
- **Scenario 4**: central heating hot water and chilled water plant (**Option A**, Section 4.3.2)

The recommended ownership structure to ensure successful development and implementation of the district energy system is the public-private partnership. While the team analyzed several combinations of ownership structures in which PSE owns the central plant and the City owns the distribution system, neither entity made any commitments to lead these roles related to this feasibility study. The ownership structure is important from the revenue requirement perspective, as an unregulated private entity will be seeking a higher rate of return on the project than would a regulated entity such as PSE, which has a fixed rate of return. As long as the revenue requirements are comparable to the assumptions made in the financial analysis, the actual ownership for this feasibility study is interchangeable. If the cost of capital is dramatically different between parties, this could affect the return on investment. This study assumes the regulated rate of return to be 6.7%, which is consistent with guidance from the WUTC.

The assumed rate of return for a non-regulated private developer is much higher than PSE's assumed rate, and this made it challenging to meet the financial expectations of a private developer while keeping customer rates in line with BAU. Therefore the team limited the analysis to include one scenario in which the customer energy rate is fixed to the BAU rate to determine what would be the return for a private developer. The complete financial analysis was conducted for the four scenarios summarized in Table 20.

Table 20: Overview of District Energy Scenarios

	Scenario 1: Low Carbon	Scenario 2: Low Carbon, Geothermal	Scenario 3: Low Cost	Scenario 4: Rate Parity
Objective	Minimize carbon footprint	Minimize carbon footprint	Minimize implementation and O&M costs	Hold customer rate steady
DE Technology	Waste heat recovery & distributed heat pumps (Option G)	Hot water & chilled water plant with geothermal (Option C)	Central heating hot water-only plant (Option B)	Central heating hot water & chilled water plant (Option A)
Ownership – Central Plant	PSE	Private entity	PSE	PSE
Ownership - Distribution System	City of Redmond	Private entity	City of Redmond	Private entity
Regulatory Considerations	WUTC and city council regulation	Unregulated	WUTC and city council regulation	WUTC and city council regulation

The adoption of the district energy system is critical to the success of the project. The team developed the adoption curve and applied it to the analysis of the investment necessary to finance the implementation of the central plant and the distribution system. A sensitivity analysis showed that a 25% decrease in the adoption rate would increase the customer rate by 23%. Since a lower adoption rate results in a much lower likelihood of project success, no further sensitivity analysis was completed.

Customer retail rates for heating and cooling energy were the output the analysis in all scenarios except Scenario 4, in which the retail rate was fixed. The results are presented in Section 6.4.

6.2 Financial Modeling Approach

To model the cost of implementing a district energy system for Overlake Village, PSE used a regulated rate of return model to evaluate each of the scenarios. The regulated rate of return model uses a potential project's capital costs and its operating and maintenance (O&M) expenses as inputs to determine the project's revenue requirement. The revenue requirement is the annual amount of revenue necessary to account for a regulated utility's O&M expense, income tax expense, and depreciation expense on regulated assets, along with the utility's regulated operating income. The regulated operating income in the model assumes that the utility earns a fixed regulated return on the assets it owns, otherwise known as the utility's rate base. In the analysis, the 25-year revenue requirement for each of the scenarios being evaluated was calculated using the regulated rate of return model as a means of comparison.

The analysis also assumed that the revenue requirement would be collected through two rates:

1. A fixed capacity charge (in dollars per square foot per year), which is based on the amount of developed space connected to the district energy system; and
2. An energy charge which is based on the amount of MMBTUs consumed at the development.

The capacity charge of $0.36/sq. feet/year was based on the fixed cost projections and the project adoption rate curve. Fixed capital costs need to have a stable, reliable revenue stream that supports the recovery risks associated with the investment in physical assets. The capacity charge calculation was based on a number of factors.

- Cost estimates associated with plant, equipment, and distribution system were based on their lifecycles over a 20-year period.
- Revenues from the capacity charge were projected and then adjusted based on the adoption rate curve.
- District energy project costs were compared against typical new-construction allowances for mechanical equipment.
- The capacity charge was compared with the South False Creek project in Vancouver, Canada, which adopted a very similar methodology.

The energy charge was calculated based on the revenue requirement of the given district energy system such that over a 25-year period the amount of revenue collected from the capacity charge and energy charge would be equivalent to the district energy system's 25-year revenue requirement.

Finally, to create a single metric to use as a basis of comparison between the different options, the annual capacity charge revenue and energy charge revenue was combined and then divided by the annual amount of MMBTUs consumed to calculate a single blended rate ($/MMBTU). Table 21 provides an example of the blended rate calculation.

Table 21: Blended Rate Calculation Example

Capacity Charge	
Capacity Charge ($/sq. feet/year)	$0.36
DE Utilizing Development (sq. feet)	100,000
Annual Capacity Charge ($/year)	$36,000
Energy Charge	
Energy Price ($/MMBTU)	$10.00
DE Energy Consumed (MMBTU/year)	5,000
Annual Energy Charge ($/year)	$50,000
Total Charge	
Total Capacity + Energy Charge ($)	$86,000
DE Energy Consumed (MMBTU/year)	5,000
Blended Rate ($/MMBTU)	$17.20

6.3 Financial Model Inputs

For each of the scenarios modeled in the analysis, estimates for capital cost and O&M expenses were provided by McKinstry to be used as the primary inputs in the regulated rate of return model. In addition to capital costs and O&M expenses, the following critical input assumptions were used to model the costs of each scenario.

- Capital spending curve
- Overlake Village development forecast
- Adoption rate curve for district energy
- Annual gas and power consumption at the plant

6.3.1 Capital Spending Curve and Project Construction Schedule

The capital spending curve was used in the financial model to estimate the total capital cost annually based on the district energy system's development schedule. The resulting estimate was then used to determine the annual capital expense for each of the scenarios. The total capital cost estimate was split between the central plant and distribution system, and thus each portion followed its own respective capital spending curve based on an assumption of how capital dollars would be spent through the project's construction and development schedule.

It was assumed that at the beginning of the project, 50% of the total capital dollars allocated to the central plant would be spent on developing district energy generation capacity sufficient to meet half of Overlake Village's projected maximum demand. A second capital investment would be made in year 6 to meet increasing demand for district energy as the Overlake Village development ramps up in years 6 to 11. For the distribution portion of the project, it was assumed that 25% of the distribution capital dollars would be allocated at the beginning of the project to build core distribution infrastructure, and that another 25% of the distribution capital dollars would be allocated in year 6 for distribution infrastructure to handle greater demand in later years. The remaining 50% of the distribution capital dollars would be divided evenly across each year to handle incremental distribution piping extensions as the project reaches full capacity. The spending curves are shown in Table 22.

Table 22: Capital Spending Curve for Central Plant and Distribution System

Year	Central Plant	Distribution System
0	50%	25%
1	0%	5%
2	0%	5%
3	0%	5%
4	0%	5%
5	0%	5%
6	50%	25%
7	0%	5%
8	0%	5%
9	0%	5%
10	0%	5%
11	0%	5%

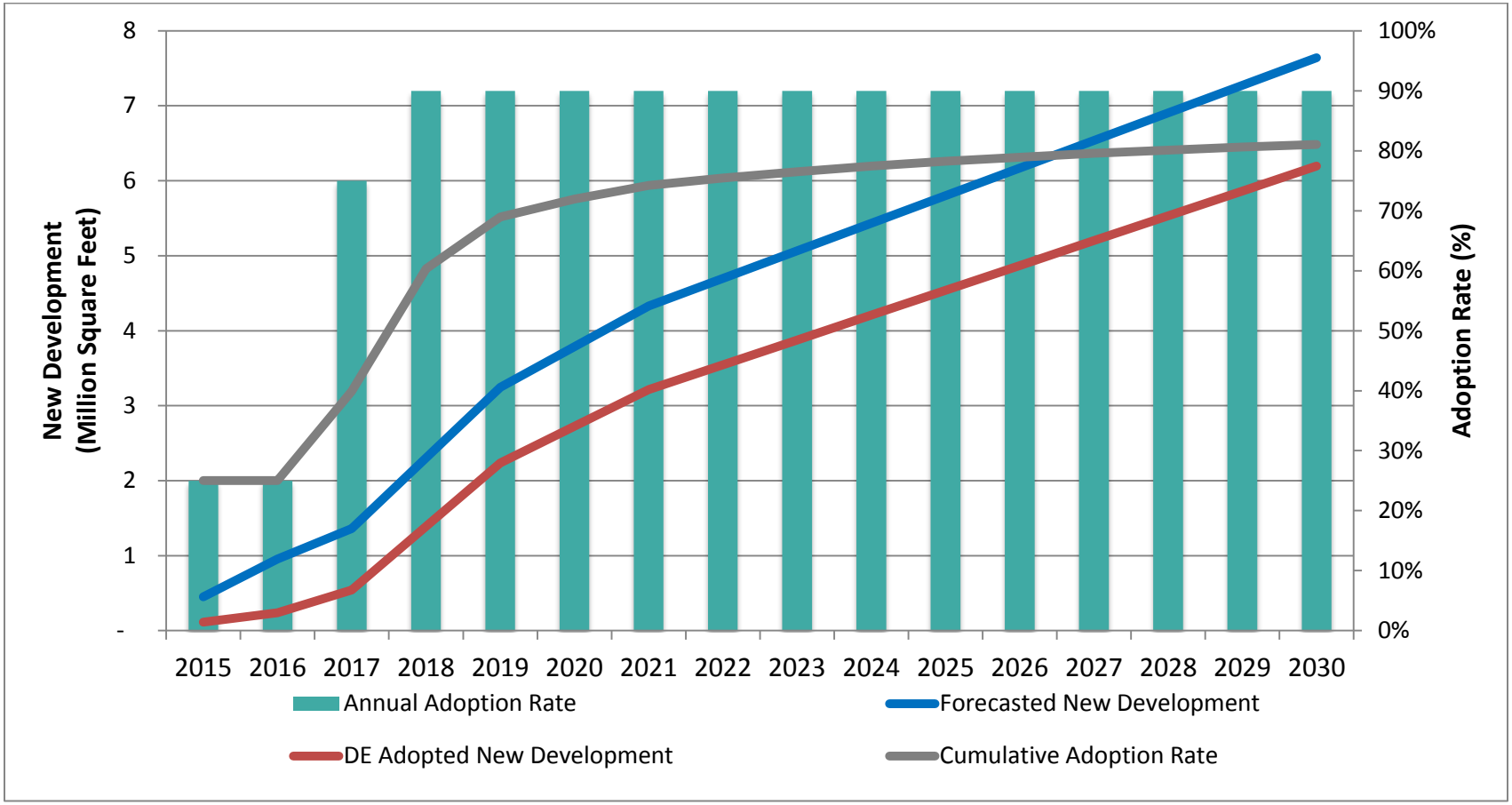
6.3.2 District Energy Adoption Rate Curve & Overlake Village Development Forecast

The analysis used a development forecast for Overlake Village and an adoption rate to model the rate at which new space is built annually. The total amount of square footage connected to the district energy system determines the total annual O&M costs as well as the annual electricity and gas consumption expense. The total costs for these three categories are proportional to the amount of square footage developed at the site connected to the district energy system. The analysis also assumes that the district energy system will be fully developed over a period of 15 years, at which point the development is assumed to have reached its maximum level of energy consumption. In addition, the analysis assumes that by the end of the 15-year period, 81% of the new development will be connected to the district energy system. The development forecast and the adoption rate curve are shown below in Table 23 and Figure 37.

Table 23: Overlake Village New Development Forecast and Adoption Rate Curve

Year	New Development Forecast (sq. ft.)	Cumulative New Development Forecast (sq. ft.)	DE Adoption Rate for New Development	DE Adoption New Development (sq. ft.)	Total DE Adoption (sq. ft.)	% of Cumulative Development Utilizing DE (sq. ft.)	Forecasted Total MMBTU's Consumed by DE	Cumulative Adoption Rate
0	450,000	450,000	25%	112,500	112,500	25%	2,871	1.5%
1	506,905	956,905	25%	126,726	239,226	25%	6,104	3%
2	405,908	1,362,813	75%	304,431	543,657	40%	13,872	7%
3	940,782	2,303,595	90%	846,704	1,390,361	60%	35,477	18%
4	940,782	3,244,377	90%	846,704	2,237,065	69%	57,082	29%
5	542,500	3,786,877	90%	488,250	2,725,315	72%	69,541	36%
6	542,500	4,329,377	90%	488,250	3,213,565	74%	81,999	42%
7	368,077	4,697,454	90%	331,269	3,544,834	75%	90,452	46%
8	368,077	5,065,531	90%	331,269	3,876,103	77%	98,905	51%
9	368,077	5,433,607	90%	331,269	4,207,372	77%	107,358	55%
10	368,077	5,801,684	90%	331,269	4,538,641	78%	115,811	59%
11	368,077	6,169,761	90%	331,269	4,869,910	79%	124,264	64%
12	368,077	6,537,838	90%	331,269	5,201,179	80%	132,717	68%
13	368,077	6,905,914	90%	331,269	5,532,449	80%	141,170	72%
14	368,077	7,273,991	90%	331,269	5,863,718	81%	149,622	77%
15	368,077	7,642,068	90%	331,269	6,194,987	81%	158,075	81%

Figure 37: Overlake Village New Development Forecast and Adoption Rate Forecast



6.4 Discussion of Results

The results for the scenario analysis, shown in Table 24, are presented with the present 25-year revenue requirements, 25-year combined capital and O&M expenses, internal rate of return (IRR), number of years to cash-positive, and blended retail rate ($/MMBTU) for each of the scenarios. The 25-year capital and O&M costs for the scenarios are split into two components: (1) the costs for the in-building heating and cooling systems and (2) the costs for the equipment that makes up the district energy system. Both BAU scenarios and Scenario 3 with its heating-only district system have heating or cooling equipment that will be installed in-building. These in-building system costs will be borne by the building developer while the costs for the district systems will be borne by the district energy system investors.

Table 24: District Energy Scenario Results

	BAU-Gas Heat	BAU-Electric Heat	Scenario 1: Low Carbon	Scenario 2: Low Carbon, Geo-thermal	Scenario 3: Low Cost	Scenario 4: Rate Parity
25-year NPV Total Capital and O&M Costs for Building Systems	$53.5M	$61.6M	N/A	N/A	$25.6M	N/A
25-year NPV Total Capital and O&M Costs for District Energy Systems	N/A	N/A	$51.7M	$56.0M	$24.3M	$55.5M
25-year Total Revenues	N/A	N/A	$59.0M	$81.9M	$32.6M	$36.9M
Internal Rate of Return	N/A	N/A	6.7%	12%	6.7%	-0.25%
Years to Cash-Positive	N/A	N/A	16	13	16	25
Blended Retail Rate ($/MMBTU)	$21.17	$42.92	$34.79	$50.06	$33.36	$21.17

Scenario 1 uses a waste heat recovery system with distributed heat pumps, which is the technology with the lowest carbon footprint. Scenario 1 assumes that PSE would own and operate the generation portion of the district energy system, while the City would own and operate the distribution system. In this scenario, PSE and the City operate as regulated entities charging a regulated rate for district energy heating and cooling at Overlake Village while earning a regulated rate of return. The total capital cost of the project was estimated at $47 million, with $35.5 million allocated to the central plant and the remaining $11.5 million allocated to the distribution system. This scenario most closely approximates the recommendation in the pre-feasibility study.

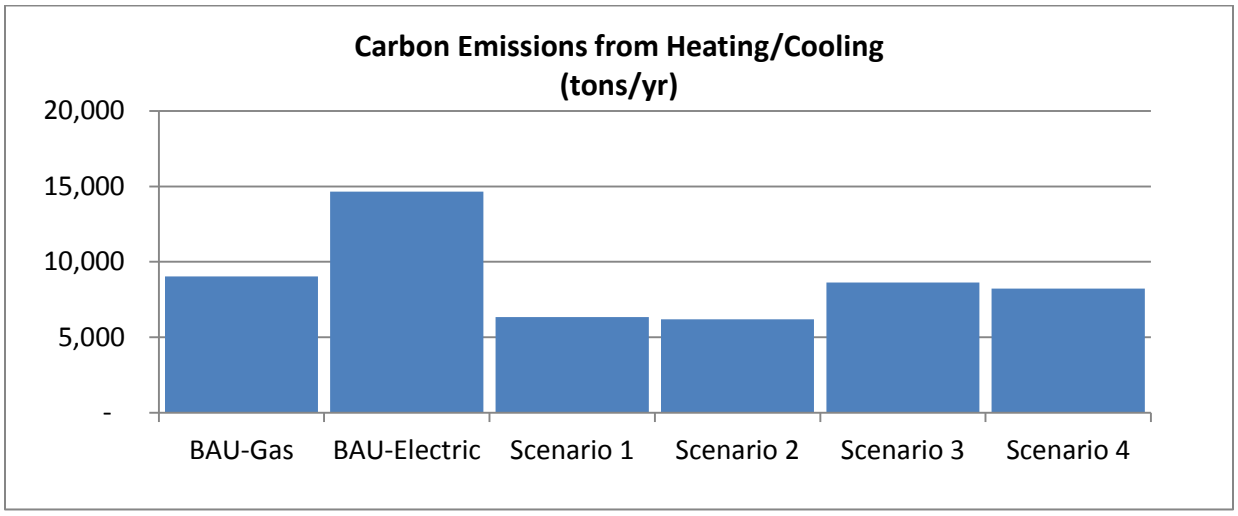
Scenario 2 uses a central heating hot and chilled water plant with a geothermal heat pump system, a low-carbon technology in which the City has expressed a strong interest. In this scenario, a private party owns and operates the entire district energy system as an unregulated entity. A private party was selected for this scenario to provide some contrast to Scenario 1. The total capital cost of the project was estimated at $49 million, with $36.5 million allocated to the central plant and the remaining $12.5 million allocated to the distribution system. This scenario assumes that the private entity would require a higher rate of return than either PSE or the City, to compensate for the additional risk it would undertake as an unregulated entity. In order to account for the additional risk, the analysis assumed that the unregulated entity would require an internal rate of return (IRR) of up to 12% before proceeding with the project. The analysis solved for a blended retail rate of $50.06/MMBTU, as this rate would allow the private company to earn a 12% IRR; this rate contrasts to the lower blended retail rates calculated in the regulated Scenarios 1 and 3. This scenario resulted in the highest customer rates of all four scenarios.

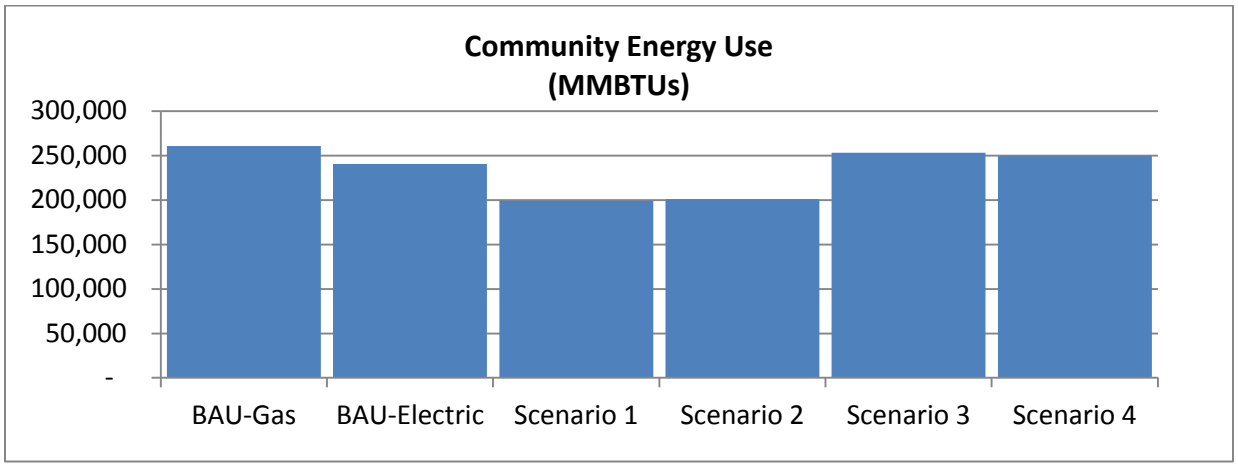
Scenario 3 uses a hot-water-only plant with boilers and distribution heat pumps. Because chilled water is not included, the up-front construction costs of the district energy system are lowest. As was the case in Scenario 1, Scenario 3 assumes that PSE would own the central plant while the City would own the distribution system. A private party would be contracted by the owners to operate the entire district energy system. Both PSE and the City would be regulated, charging a regulated rate for district energy heating in Overlake Village while earning a regulated rate of return. The private party would be unregulated, and would earn a 10% rate of return on their services. The total capital cost of the project was estimated at $42 million, with $34 million being allocated to the central plant and the remaining $8 million allocated to the distribution system. From a blended retail rate standpoint, Scenario 3 offers a slightly lower rate than the other scenarios.

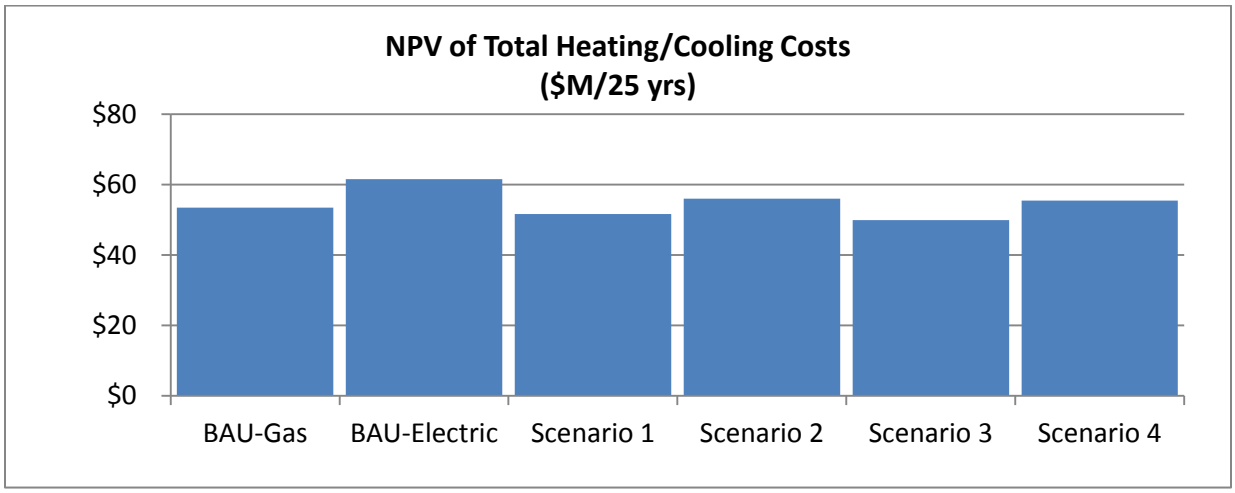
Scenario 4 uses a central hot water and chilled water plant with high-efficiency natural-gas-fired condensing boilers and high efficiency water-cooled chillers. Scenario 4 assumes that PSE would own and operate the central plant, while a private party would own and operate the distribution system. Scenario 4 was constructed to determine how competitive the district energy solution would be under the BAU-Gas Heat blended retail rate of $21.17/MMBTU. Based on the BAU pricing for the retail rate, the analysis shows that Scenario 4 appears unfavorable: the IRR of the project is slightly negative over the 25-year time horizon, while the total costs exceed the total revenue on a present value basis. The blended retail rates for Scenarios 1 and 3 are relatively higher than the rate for Scenario 4, as both of those scenarios account for a regulated rate of return.

The results of these four scenarios compared to the BAU scenarios for energy consumption, carbon emissions, and costs are provided in Figure 38.

Figure 38: BAU and District Energy Results







7 Conclusions and Recommendations

The results of this feasibility study were assessed against the evaluation criteria identified by the team and discussed earlier in this report:

1. Rates must be competitive with BAU energy rates.
2. Greenhouse gas emissions must be lower than BAU greenhouse gas emission levels.
3. Energy use must be lower than BAU energy use.
4. The central plant must be financially viable and meet the investors' objectives.

While all of the technologies evaluated were similar in cost at the current preliminary level of maturity of the design, the economics of a district energy system may be favorable to investors only under some scenarios. With a regulated rate of return of 6.7% (after taxes), the economics of the project may be attractive to investors and can support a retail energy rate that is competitive with BAU. However, the unregulated model, in which investors seek a higher return and adjust rates to meet that objective, results in a retail energy rate that far exceeds the BAU scenario. At this study's level of feasibility analysis, the district energy system rates are competitive only when compared with buildings heated by electricity, and are more expensive when compared with buildings heated by natural gas.

The greenhouse gas emission reductions are an important objective for the City. However, since they are not mandated by regulation or law and cannot be monetized in the market, they were not monetized in this study. All of the district energy technology options resulted in greenhouse gas reductions. Two technologies emerge as the best options for greenhouse gas reduction: geothermal and waste heat recovery with distributed heat pumps.

A technology's energy consumption should be assessed along with its greenhouse gas emission reduction and its financial feasibility. This study based its assessment of energy use on the amount of heating and cooling energy consumed annually by each type of district energy technology. Not all of the district energy options reduced energy consumption from BAU levels. Furthermore, the technology options with the lowest energy use and greenhouse gas emissions were also the most expensive.

Establishing a district energy system at reasonable customer rates would likely require the City or PSE to own the distribution system and central plant. Whereas district energy would have potential benefits, it would be a new venture for both the City and PSE, requiring new resources and expertise. For PSE, this venture would represent a departure from its current technology and service models, and would serve only a very small part of PSE's service area, thereby making it a relatively low priority. For the City, the benefits of district energy do not appear sufficient to offset the costs, risks and resources required to launch and maintain a new utility. There is not an identified funding source for this proposal and the likelihood for new funding to be approved is low. City resources that are dedicated to existing utility and transportation service commitments cannot be diverted to this proposal. Additionally, City staff had significant concerns about the feasibility of locating district energy distribution system pipes within roadway rights of way due to the locations of existing underground utilities. While a different proposal with additional funding partners and a different geographic extent and system infrastructure layout may

be feasible, for the reasons described above, both the City and PSE believe that the system as studied is not feasible.

Implementing energy efficiency and distributed generation in Overlake Village are options available to the City and other entities regardless of whether the district energy system is developed. Energy efficiency and distributed generation using solar PV are widely-implemented strategies for reducing energy consumption and carbon footprint. Further, the use of renewable energy credits is a low-cost, effective approach to offsetting the City's carbon footprint. These strategies support the City's Climate Action Strategy and the Comprehensive Plan, and should be emphasized for adoption.

Through the outreach process, some developers expressed interest in a waste heat recovery option involving a Microsoft campus data center. Although that analysis is out of the scope of the study, the City should engage with the developers and explore possible partnerships to facilitate this.

Appendix A: Energy Efficiency Assessment

PSE and the City have a shared vision for an efficient Overlake Village. The widespread redevelopment of this neighborhood provides significant opportunities to meet City goals for carbon reduction, livability, and economic opportunity. Foremost among these opportunities is the prospect of building energy-efficient buildings. The Washington State Energy Code was established to drive the selection of efficient building systems, and modern buildings are significantly more efficient than their predecessors. However, building efficiencies beyond the energy code minimums are achievable, and are common in both new and retrofit construction.

Regardless of the direction the City takes for a district energy system, the City can emphasize, encourage, and incent private developers to build high-efficiency buildings that far exceed the Washington State Energy Code (WSEC). Energy efficiency is a cornerstone of the plan for implementing the City's Climate Action Strategy.

Several PSE resources and programs are available to support the City in driving energy efficiency. Incentives are available for new commercial and residential buildings that achieve energy efficiency in excess of the Washington State Energy Code and Energy Use Index Targets (residential). The Commercial and Residential Program overview and associated requirements are listed below.

The following sections describe the PSE incentive programs available today that can be used to encourage the development and operation of efficient buildings.

Commercial New Construction

Commercial projects are eligible for grants and rebates up to 100% of the incremental cost (cost difference between the baseline and high efficiency options). There are two paths for commercial projects: the Whole Building Approach and the Component Approach. Both paths require at least 10% energy efficiency improvements beyond the WSEC (in electric efficiency measures) for grant eligibility.

Whole Building Approach

The Whole Building Approach uses energy modeling and integrated building design to determine energy efficiency strategies. PSE reviews and validates the energy modeling results, and may consult the Integrated Design Lab (or other consultants) to review proposed energy models and work with the design team(s) to recommend additional energy efficiency savings. Incentive levels for the Whole Building Approach are:

- From \$0.60/ft^2 for 10% energy savings up to \$1.80/ ft^2 for 30% energy savings beyond the WSEC requirements.
- Buildings exceeding the energy code by 11% to 29% will receive a prorated incentive. The following formula can be used to estimate the WBA incentive, given the square footage and

percentage of energy savings beyond WSEC: $6 x [*square footage*] x [*percentage energy savings*] = PSE incentive[2].

Component Approach

The Component Approach focuses on improving the energy efficiency of individual components or systems such as HVAC, lighting, domestic water heating, and the building envelope. Proposed improvements will be reviewed on a component-by-component or system-by-system basis, not at the whole building level, and must provide at least a 10% electric energy improvement beyond the baseline design or the WSEC. Gas does not have a 10% requirement. The Component Approach cannot be used in conjunction with Whole Building Approach unless the improvement measures are outside the building envelope (e.g., parking garage systems or exterior lighting). Incentives are determined using incremental cost data (the cost difference between the baseline and the high efficiency option).

New Construction Post Occupancy Commissioning

Post occupancy commissioning occurs after occupancy, typically 9 months after the building warranty period starts and within 18 months of occupancy. The commissioning agent shall be a third party. A contract indicating designated funds for only post occupancy work is required. The commissioning agent will meet specific experience requirements and will provide:

- A post occupancy commissioning plan.
- A post occupancy investigation details form (or Cx report if not using an Investigation Form).
- An ongoing training plan and training documentation.
- A facility guide (i.e., a building operator's manual).

The maximum new construction post-occupancy commissioning incentive is $0.25 per square-foot.

Residential New Construction (Residential/Multifamily/Mixed-Use)

The Residential New Construction program provides incentives to projects that have residential living units. The program has two components: the Prescription Measures and Incentives list and the Whole Building Target Energy Use Intensity (EUI) and Actual-Use incentive. Projects that are eligible to participate in either component must choose one; they are not allowed to participate in both.

The prescriptive measures in Table 25 are only available for new multifamily residential buildings, including mixed-use buildings, with three or more units.

[2] This incentive is an estimate. The final grant will be in the form of a grant agreement between PSE and the customer.

Table 25: 2014 Prescriptive Measures and Incentives

Electric Measures	Description	Incentive
Clothes washer in-unit	2.4 MEF min	$75 each
Showerhead, in-unit	1.5 GPM max	$25 each, if electric water heat
Showerhead, in-unit	1.75 GPM max	$15 each, if electric water heat
Bi-level fixture w/ occupancy sensor	67 / 17 watts max	$70/stair landing, 4 story min.
Corridor lighting power density	5% min below WSEC	$0.017/sf per % below WSEC
Garage lighting power density	5% min below WSEC	$0.005/sf per % below WSEC

Natural Gas Measures	Description	Incentive
Condensing boiler	space heat	$5.00 per therm
Solar thermal	hot water	$5.00 per therm
Condensing boiler	service water heat	$4.40 per therm
Condensing water heater	service water heat	$2.25 per therm
Low flow showerheads can be included in the therm energy conservation calculations.		

Whole Building: Target EUI and Actual-use Incentive

An EUI target is used to determine the incentive potential for multifamily and mixed-use buildings pursuing the Whole Building Approach. The EUI target is a low energy use goal set by the development team. To qualify for the incentive, the building design must demonstrate with computer modeling an energy goal which is at least 10% below the state energy code equivalent baseline values[3] in Table 26 and Table 27. Project owners must also commit to monitoring actual energy use for two years with at least 85% occupancy. Projects with actual energy use performance within 20% of the energy model (either above or below) become eligible for an actual-use bonus incentive. Projects that perform better than the energy use model receive a higher bonus incentive.

The EUI baseline value is unique to each building design. It is calculated based on the space use type (common areas, residential, parking garage, etc.) and the square footage for each use. EUI is calculated by dividing total yearly energy usage (often expressed in kBTU) by total floor space (in square feet). Thus a building or area with an EUI of 1 would use one kBTU per square foot per year.

Only a proposed energy model is required; there is no need for a baseline energy model. Project teams are encouraged to strive for very low EUI targets, as there is no cap on the percentage of improvement over code. Projects seeking to meet a high-performance status, net-zero design/capable status, LEED, or Passive House certifications are great candidates for this incentive.

[3] The energy code values are derived from a variety of sources, including: Washington State Building Code Council, Washington State Department of Commerce, PNNL, ASHRAE, NEEA, Ecotope, GGLO, and City of Seattle.

Table 26: Multi-Family Buildings

IECC/WSEC Code Section[4]	Space Use	Space Heating Fuel	Site Energy kBTU/ ft^2/yr
Commercial	Residential	Gas	29.31
Commercial	Residential	Electric	27.95
Commercial	Common Area	Gas	70.35
Commercial	Common Area	Electric	66.96
Residential	Residential	Electric	29.63
Residential	Common Area	Electric	71.05
Residential	Residential < 3 units	Electric	27.56

Table 27: Mixed-Use Buildings

IECC/WSEC Code Section	Code Occupancy	Occupancy Type	Site Energy kBTU/ ft^2/yr
Commercial	B	Office	38.2
Commercial	B	Medical Office	50.0
Commercial	M	Retail	55.5
Commercial	Garage	Enclosed	10.0
Commercial	Garage	Open	6.0

An example five-story multi-family building with 80% residential area and 20% common area using electric space heat will have an EUI baseline of 35.75 kBTU/ft^2/yr. To qualify for an incentive, the multi-family building design must be a minimum of 10% below the baseline, or 32.175 kBTU/ ft^2/yr.

A mixed-use project example with multi-family residential, ground floor retail space, and underground parking might have an EUI baseline of 30. The incentive becomes available for building designs with an EUI under 27. If the design target is 40% savings at an EUI of 18, the project receives a design incentive for reducing its EUI by 12. The actual-use incentive becomes possible when actual energy use achieves at least 80% of the design savings or an EUI under 20.4.

Incentive rates are based on $0.30 per kWh and $5 per therm for all estimated energy savings below the total building energy baseline. Incentive payments (for the Whole-Building Incentive only) will be made in three phases. The first payment (half the design incentive) occurs at the completion of a weather-tight structure. The second payment (half the design incentive) occurs after all energy conservation measures are installed and the energy meter locations are verified. The third potential bonus payment

[4] Multifamily buildings 4 stories and higher use the IECC/WSEC Commercial code, buildings 3 stories and lower use the IECC/WSEC Residential code.

(the actual use incentive), which occurs after the Project has monitored the actual energy use for two years, is based on the best continuous 12-month period.

District Energy Facility

The proposed district energy system is eligible for incentives under the Commercial New Construction Program: Component Approach. Measures that exceed standard practice or energy code can be included. Measures will depend on the type of system selected, and will likely include heat recovery, pre-heating, and potentially controls. Facility lighting would also be eligible for incentives.

Appendix B: Distributed Generation

Distributed Generation has been rapidly growing in adoption over the last decade in the PSE territory. Small commercial renewable energy projects include three wind generators, four solar photovoltaic (PV) generators, and eight bio-methane generators, all of whom currently sell their energy output to PSE. For residential customers, solar power has rocketed in popularity due to the net metering program, decreasing equipment prices, and high government incentives. Net energy metering allows a customer to put energy back onto the grid and pay for only the net energy used. PSE's net energy metering program has over 2,000 participants, with a total production capacity of over 12 MW.

Rooftop Solar

One of the most widely adopted technologies in the Puget Sound region is rooftop solar PV panels. Despite our reputation for gloomy skies, this technology performs fairly well in the Northwest.

One of the primary hindrances to retrofitting commercial buildings with solar PV panels is the absence of planning for solar during a building's design. Most rooftops have various forms of HVAC, skylights, and vents dispersed throughout, which significantly reduce the available area for PV. With foreknowledge that the roof will hold PV, the various items can be combined or clustered to limit the space they occupy.

The following assumptions are reasonable when calculating the potential energy production from solar PV in the Puget Sound region.

- Usable rooftop space: 65-70% of total space
- Capacity: 15 W of PV panel generation per square foot
- Installed cost: $2.75/W
- Yearly production: 1,000 kWh per kW of capacity

Example Calculation

For a 20,000 ft^2 roof:

Annual Energy Production:
20,000 ft^2 * 70% usable rooftop* 15 W/ ft^2/ 1,000 W/kW * 1,000 kWh/kW-yr = 210,000 kWh/year

Capital Cost:
20,000 ft^2 * 70% usable rooftop * 15 W/ ft^2* $2.75 = $577,500 cost before incentives

Solar generation cannot replace the proposed district energy system, because the solar panels generate most of their energy in the summer and very minimal energy during the winter peak hours. But this technology can significantly offset the load for other electrical demands in the community, many of which are likely coincide with the generation production of solar PV panels. PSE has provided hourly annual production curves for PV that can be used for modeling the district load/resource balance.

In the Puget Sound region, customers can reasonably expect to generate 15 kWh per square foot of PV panel per year, which equals 1,000 kWh per installed kW of PV capacity per year. Figure 39 shows the monthly average output for 1 kW of PV capacity. The most productive six months, April through September, produce 72% of the year's output. This is chart is from a sample of sites in PSE territory for the years 2008-2011.

Figure 39: Average Monthly Energy Output (kWh) of 1 kW of Solar PV Capacity

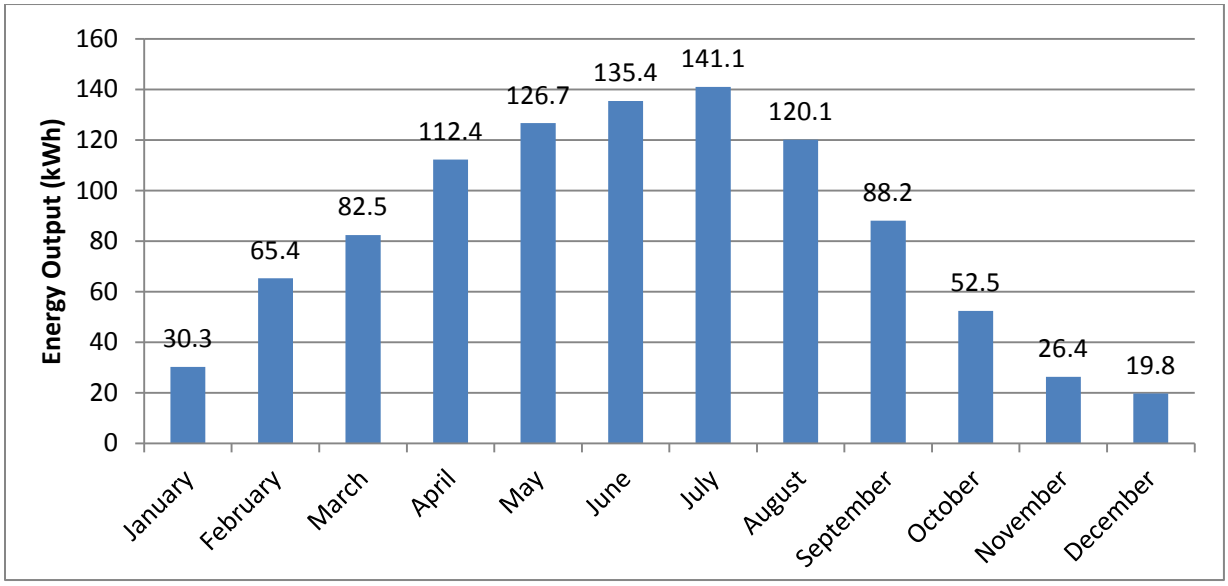


Table 28 below shows the technical potential for electricity generation from rooftop solar in Overlake Village. These estimates are based on the land use assumptions from Table 5 and an average building height of 6 stories. In this case, the total rooftop space available is assumed to be one sixth of the total square footage of all buildings. It is assumed that 70% of the rooftop space is available for solar PV installation.

Table 28: Technical Potential of Solar Generation in Overlake Village

Month	Generation Produced (KWh)
January	380,929
February	822,459
March	1,038,058
April	1,413,936
May	1,594,188
June	1,704,048
July	1,775,271
August	1,511,709
September	1,109,338
October	660,113
November	332,638
December	248,676
Annual Totals	**12,591,363**

As mentioned above, current production capacity for all net metering in PSE's service territory is 12 MW. If solar PV generation was maximized in Overlake Village, resulting in approximately 12.6 MW of new generation, the amount of production capacity around PSE's service territory could be doubled. While these figures represent what is technically possible, there are economic and political considerations that affect the adoption.

Currently, the State of Washington and the Federal Government offer incentives[5] to encourage adoption of solar PV technologies.

- The State of Washington offers up to $0.54/kWh[6] of energy produced from solar as a production credit (expires 2020).
- The State of Washington exempts solar PV systems from sales and use tax (expires June 2018).
- The State of Washington requires utilities to net meter (does not expire).
- The federal government provides an income tax credit for 30% of the total system cost for solar PV systems (expires 2016).

Because these incentives are scheduled to expire over the next several years, the economics of solar are variable. The incentives go a long way to making the purchase of these systems financially viable for the purchaser. The state and federal legislatures are expected to evaluate these incentives before they expire, and may choose to renew or extend them.

Renewable Energy Credits

PSE currently has 40,000 customers purchasing renewable energy credits from its Green Power Program. This amounts to over 4% of PSE's residential electric load supported by renewable energy credits. The program secures renewable energy credits from a wide variety of resources in the Northwest. The renewable portfolio includes contracts with 20 projects located within the PSE service area, including small wind, dairy digesters, and numerous smaller solar projects. The Green Power Program provides renewable energy credits to customers for as little as $0.006/kWh above the standard retail rate. To ensure that a renewable energy source meets program criteria, PSE uses the Green-e standard and is audited annually.

PSE's Carbon Balance program was created for natural gas customers who want to offset the carbon dioxide created from using methane gas. Offsets are created by organizations that develop new methane capture and destruction projects. The price for carbon offsets is about 10% above the retail price of natural gas.

The Green Power and Carbon Balance programs make it easy for retail customers to substitute renewable energy for their standard energy mix from the utility. Both of these programs are available to individual customers in all of PSE's service area. Customizations of these programs could be considered

[5] These incentives are provided for illustration. Solar array size and ownership requirements may affect a customer's eligibility.

[6] The $0.54/kWh production credit is for an all Washington-made solar array. Solar systems manufactured outside of the state have a smaller production credit, starting at $0.15/kWh.

if a consortium of customers such as a neighborhood council would like to purchase these alternatives in bulk.

Recommendation

Distributed generation, energy storage, and renewable energy credits are mechanisms for customers to generate and use cleaner energy more efficiently. Net metering and renewable energy credits are mature programs offered by PSE, and are recommended for consideration because they directly support the City's Climate Action Strategy. The City should keep a close eye on the political efforts affecting incentives for solar PV technologies, because these incentives have historically driven the adoption. If the incentives are extended or enhanced, the likelihood of adoption of solar should increase and provide a favorable financial return for qualifying customers.

Appendix C: Renewable Energy and Storage Technologies

High Solid Anaerobic Digestion

High Solid Anaerobic Digestion, or HSAD, is a proven technology that uses food waste and some kinds of garden waste as the feedstock for anaerobic composting. An enclosed system without oxygen allows certain bacteria to consume the waste and produce methane, which is captured, filtered, and combusted to produce electricity. In addition to producing energy from waste, this system also reduces fuel use significantly by not hauling the waste to distant landfills.

HSAD is a base load resource, meaning that it runs continually. The waste heat is used to evaporate the water content of the residual compost before it is packaged and sold commercially. An HSAD plant would reduce the planned capacity of the district energy plant.

While the population and waste production potential is not certain at this time, there are some general guidelines for an HSAD power plant. These are from an HSAD developer, Orbit Energy.

- *A typical community of about 175,000 residents in the U.S. generates about 100 tons per day of food waste. Population of Redmond is about 60,000.*
- *Economies of scale (based on PSE rates and King County type waste tip fee) indicate that an optimal capacity is about a 4.5 MW size project, as is the case in Des Moines. That would require 150 tons per day, or a population of 260,000 (Redmond, Bellevue, Kirkland and Sammamish).*
- *The footprint of this plant will be about 3 acres total and a 60,000-80,000 ft^2 building on it.*
- *At 100 tons per day, an Orbit Energy HSAD plant will produce about 3 MW.*

The Overlake Village site will probably not generate enough solid waste for an HSAD system, so additional waste input from neighboring towns would be needed to make this feasible.

A smaller version of this technology is available, but not yet commercially proven. A small plant could take 15 tons per day and produce 300 kilowatts. Fifteen tons would require a population of approximately 26,000 residents, so a plant of this size may be a better fit for a development the size of Overlake Village.

Energy Storage Technologies

The term “energy storage” generally refers to a wide range of technologies such as batteries, flywheels, superconducting magnets, and large-scale pumped storage. A variety of potential energy storage technologies exists for grid applications, each with unique operational, performance, cost, and market readiness characteristics. Many energy storage technologies are not suitable for the Overlake Project, such as pumped hydro (requiring vast land area and specific geography) and superconducting magnets (not commercially mature). Advanced batteries (such as lithium-ion) are currently the most technologically mature option that could apply to the Overlake project.

Batteries have not traditionally been an integral part of the electric grid, primarily due to their high cost and concerns about safety, durability, and efficiency. Today, however, technological advances in

electrochemistry have enabled a new generation of advanced batteries to start playing an important role in grid management.

Table 29 provides a summary of the types of energy storage technologies that are available and the common applications of these technologies.

Table 29: Applicable Energy Storage Technologies

Application	Typical Size[7]	Common Uses	Example Image
Residential	5kW/10kWh	Time-of-use load shifting, backup power for critical circuits	
Commercial & Industrial	50kW/50kWh	Demand charge reduction, time-of-use load shifting, backup power for critical circuits, power quality.	
Utility	20MW/7.5MWh	Grid frequency regulation, spinning reserves, peak shaving, outage mitigation, power quality	

PSE experience

PSE believes that advanced battery energy storage systems show significant promise for use in the electric grid, and is closely following developments in this industry. In order to gain valuable first-hand experience, PSE is currently developing two pilot battery storage projects. Both projects are made possible with grant funding from external partners. The overarching goal of these projects is to test the performance and operational realities of these grid-scale systems, and to evaluate actual value provided by such systems. The results of these projects will guide our future potential acquisition of further energy storage resources.

[7] Battery storage systems are typically rated by both power (kW or MW) and energy storage capability (kWh or MWh).

It should be noted that many energy storage project developers are now making significant progress on projects for retail electricity customers and utilities. These developers often take the technology risk and provide financing for the energy storage systems, or will install them at no up-front cost under a shared savings model that closely resembles an energy service company (ESCO) arrangement.

Battery energy storage systems could make electricity supply and grid operations more efficient and resilient, while also increasing power quality and reliability. From an environmental perspective, distributed energy storage may be less resource-intensive than building traditional grid infrastructure such as thermal power plants, transmission lines, and distribution systems. Distributed storage can potentially reduce the need for all forms of upstream infrastructure. To be fair, deploying large amounts of batteries also requires significant resources. More studies are needed on the life-cycle benefits of distributed storage versus traditional grid infrastructure.

Energy Storage Capabilities

Some of the potential uses for storage and the associated benefits are described in greater detail below:

Peak Shaving

Peak shaving means using storage to shift roughly 1-2 hours of electricity consumption from periods of high demand to low-demand periods. Peak shaving can be performed on the customer side of the meter as a response to time-of-use electricity rates or demand charges. It can also be done on the utility distribution or transmission system to reduce congestion on specific feeders, substations, and grid sections. Given that the grid must be built to ensure supply during “peak load,” which generally happens for a few hours several times per year, use of distributed storage to meet these critical peaks may be less expensive and less resource-intensive than adding capacity through traditional grid infrastructure additions (generation, transmission, distribution).

Renewables Integration & EV Charging

Battery systems can act like shock absorbers for the grid, helping with the integration of distributed and generally intermittent renewables such as solar PV. Storage could also be used to mitigate potential demand spikes due to electric vehicle charging.

Backup Power

Some battery storage systems can provide backup power to critical circuits, or even to sections of the utility distribution system. This functionality adds significant complexity, and has been demonstrated in several projects to date.

Power Quality

Reactive power or voltage spikes or sags can damage equipment throughout the grid. Regulating these fluctuations is essential to maintaining the safety and reliability of the grid. Grid operators use grid equipment and generator asset management to regulate power fluctuations throughout the grid and at areas of high congestion. Most battery systems can provide this functionality.

Business Model Considerations

Energy storage systems can provide many benefits. The key challenge for energy storage is first to capture the many potential benefits that it provides. Given the current high cost of storage systems, multiple value streams must be captured. Unfortunately, these benefits are often split between the customer and the utility, which poses challenges to the business case.

For example, a storage system deployed at the customer site may be used to shave demand charges, but if that particular customer's typical peak load doesn't correspond with the peak on the utility's T&D system or grid-wide load, then the system will save money for the customer but not actually defer the need for the utility to add more grid capacity.

If the storage system is located on customer property but can't be dispatched by the utility when a peak shaving event is unlikely (most of the year), the flexible capacity from the system is unavailable for use in renewables integration and other grid services. This means that significant value is left on the table.

Energy storage is just starting to emerge as a viable and cost-effective technology, and the industry may take several more years to mature. During this time, PSE will continue to track progress and determine whether such storage technologies are able to deliver good value for a good price. We encourage the City of Redmond to continue the discussion on market readiness for energy storage with PSE, the Overlake developers, and distributed generation owners.

Appendix D: Utility Infrastructure and Related Technologies

Electric Utility Infrastructure

The Overlake Village area is currently served by Ardmore (ARD) and Northup (NRU) substations. Ardmore substation is located in the Village boundaries at 15335 NE 24th Street. Northup substation is located about 1 mile west of the Village at 13021 NE 24th. Since Ardmore is the closest substation to the area, any future development would most likely be served exclusively by Ardmore. Ardmore substation currently has two 25 MVA transformer banks and 10 feeders, with space for an additional two 25 MVA transformer banks and 14 additional feeders. At a power factor of 0.95, a 25 MVA bank can serve 31.35 MW in the winter and 25.65 MW in the summer. Most of the electrical distribution networks in Overlake Village are underground, and it is anticipated that new electrical distribution infrastructure will also be underground.

Today, customers within the Overlake Village boundary have a coincident peak load of approximately 9.2 MW, as seen in Table 30. With the increased density of the redevelopment, the total additional load for Overlake Village is estimated to be between 3.4[8] and 16.3[9] MW. For urban feeders of this type, PSE typically plans for 7 MW of load per feeder. Hence, the redevelopment of Overlake Village will likely require one to three new feeders when fully built-out. One new transformer may need to be installed at the Ardmore substation as well.

[8] Based on eQUEST energy models for similar recently constructed buildings.
[9] Based on PSE construction standards that estimate loads of 5.95 W/sf for office space, 5.1 W/sf for retail, 5.59 W/sf for hotels, and 3,320 Watts per multi-family dwelling unit.

Table 30: Existing Feeders Serving Overlake Village

Feeder	Peak Load (MVA)	Estimated Overlake Peak Load (MVA)	Service Area
ARD-15	2.1	0.5	One switch in Overlake Village area, thought mostly south of Overlake Village.
ARD-14	0.3	0.3	100% in Overlake Village area
ARD-13	8.6	1	Has one switch in Overlake Village, but mostly serves the area west of Overlake Village
NRU-14	0.3	0.3	Almost 100% in Overlake Village
ARD-12	2.4	2.4	Almost 100% in Overlake Village
ARD-41	0.4	0.4	100% in Overlake Village. Serves former Group Health property.
ARD-11	5.4	1	Has 2 switches in Overlake Village but primarily serves Microsoft campus.
ARD-43	3.3	3.3	100% Overlake Village area
Totals	**22.8**	**9.2**	

Because the designs and plans for redevelopment are still preliminary and unspecific, the electrical demand may fall considerably below the high end of these load estimates. Nonetheless, the infrastructure required for the more conservative load projections is manageable. After the construction of Ardmore substation in 2012, a significant amount of extra conduit was installed in anticipation of future growth in the area. Because of this, any future feeders needed to serve the redeveloped Overlake Village area should be straightforward to implement.

Additional Engineering Considerations

While right-of-way for the feeder infrastructure has been mostly addressed today, the City and PSE will continue to need to partner on permitting and siting underground transformers, switches, and other pad-mount and underground equipment that will serve the area. PSE prefers to locate these underground facilities in the street, but can also locate them under and above sidewalks as well as on private easements if obtainable.

Electric System Reliability

Since the Ardmore substation was just built in 2012, only one year of reliability data has been compiled for its feeders in their present configuration. Table 31 contrasts the 2013 reliability for the Overlake Village area with the reliability figures from all of north King County and all of the PSE service area.

Table 31: System Reliability

Region	SAIDI[10]	SAIFI[11]
Overlake Village	127	0.49
North King County	102	0.62
PSE Service Area	125	0.86

Today, Overlake Village has better-than-average reliability due to the predominance of underground circuits that are minimally affected by PSE's largest causes of outages: stormy weather and vegetation overgrowth. Customers in the Overlake Village area are less likely to experience outages than other customers in north King County and PSE's service area as a whole. However, with underground circuits, when outages do occur, they are typically more difficult to troubleshoot and thus take longer to repair than overhead lines. Hence, Overlake Village currently experiences outages of longer duration than the system average. PSE may be able to further shorten the duration of outages by introducing technologies that more precisely pinpoint the location of underground faults on the circuits and isolate the faulted section through the use of automated sectionalizing switches. This technology is discussed in Section 11.4.

Natural Gas Utility Infrastructure

The Overlake Village area is strategically located close to both high-pressure and intermediate gas pipelines. In general, the high-pressure pipelines serve as a "transmission or highway" for the gas to get close to the customer location. Typically, the intermediate pressure pipelines will provide the gas network that connects to the actual services at the commercial/residential locations. Proximity to both types of infrastructure is advantageous to a large development, as it assures a good source of gas at a good pressure. It also reduces the amount of infrastructure (pipelines) necessary, as much of that is likely to already be in place in an area that is built-out with both types of pipelines. The high-pressure pipelines can also be used directly if a particular customer (typically industrial) requires higher volumes and pressures. This would not generally be needed for a development like Overlake Village, but it is there if needed arises.

The Overlake Village area is currently served by a 250 psig MAOP (maximum allowable operating pressure) 8-inch high pressure lateral that runs north to south on 148th Ave NE and a pressure-reducing district regulator (RS-0532) located at the intersection of 148th Ave NE and NE 24th Street that feeds the intermediate gas system. A project of this type will generally be served by the intermediate pressure pipelines downstream of the pressure-reducing stations. There is sufficient capacity on the intermediate-pressure system for a project of this size. The available capacity at district regulator RS-0532 to feed the intermediate pressure system is estimated to be approximately 250.0 MMBtu/hour. If that capacity is exceeded, modifications or rebuilding may be required; a new district regulator could

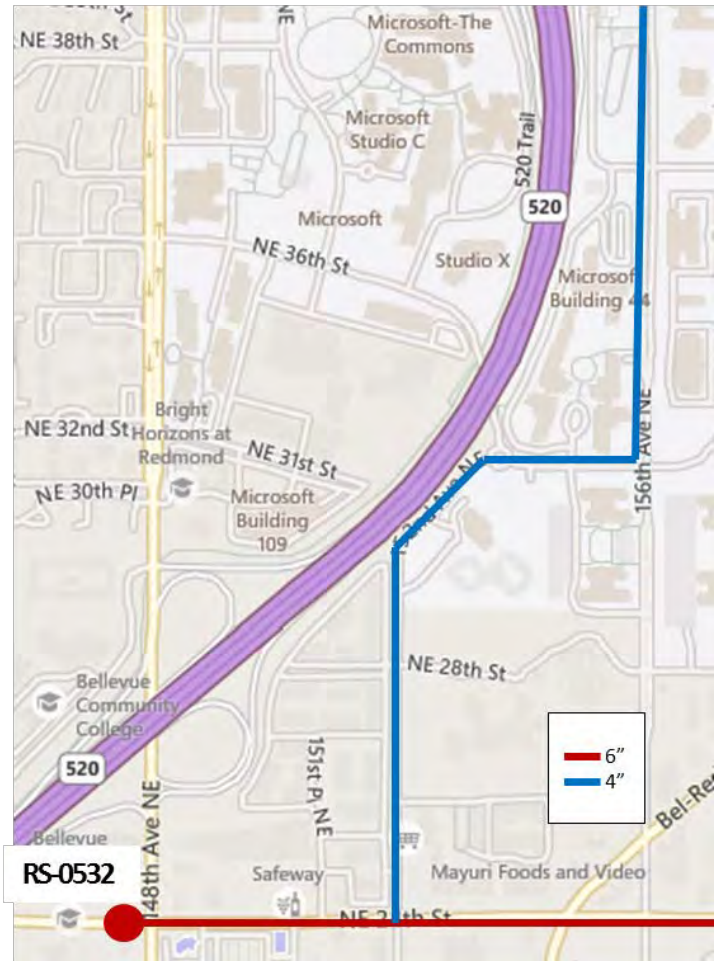
[10] The System Average Interruption Duration Index (SAIDI) is the average outage duration (minutes) per customer.
[11] The System Average Interruption Frequency Index (SAIFI) is the average number of interruptions that a customer would experience.

also be proposed. However, current peak estimates for the gas loading at this development are 103 MMBtu/hour, which is well within the serving capacity of the existing infrastructure.

The intermediate pressure system is fed by a network of roughly six separate pressure-reducing district regulators, with the majority of the load for this development occurring at RS-0532.

The intermediate pressure system in the area of this development is depicted below in Figure 40, and consists of a significant 6-inch backbone on NE 24th Street. A significant 4-inch intermediate pressure system runs from NE 24th Street and 152th Ave NE northward and eastward up 156th Avenue NE. Smaller-diameter pipes spread throughout the area.

Figure 40: Intermediate Pressure System for PSE Natural Gas Infrastructure



A district energy solution facility would best be located near the larger 6-inch backbone and the district regulator, which are both on NE 24th Street. However, only minor distribution pipe upgrades should be required if the plant is located in another nearby location. Exact design would require knowing maximum loads and the location of the consumption points. Even if a district energy plant uses just one

gas pipe, smaller apartments and commercial locations that need direct use of natural gas would require separate gas pipeline mains/services. If running additional mains to these smaller loads proves unfeasible, then the existing distribution pipelines would need to be extended.

PSE has a process for determining the customer cost for installing gas service. Existing tariffs require this evaluation to ensure that each project does not financially burden the existing gas customer base unduly. Therefore all projects in Overlake Village will need to be analyzed based on the load and the cost of infrastructure to determine what the necessary up-front customer contribution would be (if any).

Additional Engineering Considerations

Coordination of all gas facilities and water/wastewater infrastructure for the Village within the development is important. Without coordination, there is a risk of needing to install new pipe in streets that may have already been overlaid and restored to serve additional customers – especially direct use customers. This coordination is difficult to achieve, as future property use can't always be predicted with any certainty. Ideally, PSE recommends installing the gas piping ahead of the need to prevent this additional cost of disruption to the streets. These gas facilities installed ahead of the need will require up-front payment as mentioned above, since PSE cannot be responsible for future developer assumptions that may or may not occur.

Generally, PSE installs gas infrastructure in the public right-of-way. If the City of Redmond prefers that PSE locate main pipes on private property, then easements will need to be obtained from the owner. Easements tend to require longer project timelines, and can incur limitations on allowable uses of property with utility easements. However, PSE is comfortable with installing in easements, as they protect PSE's right to be in a location and provide protection from the risk of being required to move in the future without compensation. Historically, owners have preferred not to encumber their properties with gas pipeline easements that can limit the use of that parcel in the future without significant compensation. These easements can be expensive, but in some development cases, the owner is motivated to have PSE install on easements provided by the owner. Securing easements from multiple land owners can be costly and time consuming, and one owner can block the entire project.

Advance Meter Infrastructure

Advanced metering infrastructure (AMI) is an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers. While new uses and applications of AMI technology are being introduced regularly, several core capabilities are mature and have broad adoption. These include:

- Basic, advanced, and net meter reading.
- Outage notification and outage restoration verification.
- Remote connection/disconnection of power.
- Time-of-use rate implementation and interval energy use information.

AMI also provides a path for interfacing with customer systems. Customer systems include in-home displays, home area networks, energy management systems, and other customer-side-of-the-meter equipment that enable smart grid functions in homes and businesses.

PSE's Experience

Today, PSE has an automated meter reading (AMR) system that uses one-way communication to perform the core business function of delivering meter data to be used for customer billing. Going forward, PSE is evaluating replacement of the aging AMR system with a modernized AMI system that provides interval load profile data for all customers. This data can be used by customers to understand usage patterns and to make decisions about how and when to use energy. Furthermore, AMI is an enabling technology for programs such as automated demand/response and time-based rates that encourage customers to shift their energy use to off-peak times. From an operations perspective, AMI provides the utility the ability to remotely connect and disconnect power to customers, to measure and control voltage levels on the distribution system, and to quickly pinpoint where outages are occurring. Finally, the AMI network can be used for distribution automation communications.

AMI Capabilities

In the redeveloped Overlake Village District, AMI could be used to enable demand/response or similar programs to flatten out the demand for electricity and natural gas. Economically, the customers in the District would benefit from reduced demand charges. Ecologically, maintaining a steady or flat demand allows the utility to more efficiently produce and deliver power, benefiting the greater region.

While the developers in the District are likely to provide efficient appliances, lighting, and heating/cooling systems in the new buildings, even efficient systems can be operated wastefully. Working in concert with customer-driven conservation efforts, AMI solutions can provide data and analytical tools that support customers in using energy wisely.

Market Readiness

Through the Recovery Act of 2009, the Department of Energy issued $31 billion in grants for clean energy projects. Many of these projects included substantial AMI deployments. As a result, nearly 50 million US households now have smart metering. AMI is a widely used technology that has substantial market penetration in the US, Europe, Asia, and the Americas. PSE has already piloted small quantities of smart meters, and is building a plan to replace the existing AMR system with this new technology. While AMI may not be in place for the early stages of the Overlake Village redevelopment, it can be introduced at a later time with minimal customer inconvenience.

Distribution Automation

Distribution automation (DA) is a set of tools that enable automated control of distribution equipment. One of the main purposes of DA is to quickly restore power to big sections of the electric grid when a fault occurs. Fault location, isolation and service restoration (FLISR) involves the control of switching devices on the electric distribution system to improve system reliability by quickly reconfiguring the system to minimize the number of customers affected by an outage.

Sensitive commercial or industrial loads in Overlake Village may reap the greatest benefit from FLISR. The Overlake Village area is fed mostly from underground circuits and has a high degree of reliability; however, outages on underground systems can be lengthy because it is difficult to troubleshoot and locate faults when the cable is not visible. Remote control or automation of isolating devices could reduce outages to some customers from hours to minutes or seconds.

PSE's Experience

PSE has operated an automated FLISR scheme on the circuits that feed the campus of a large commercial customer since 2000. If an outage occurs for this customer, automated circuit reconfigurations can restore power significantly faster than a manual restoration effort. Since this automation scheme was initially introduced, the technology available has evolved to an effective and ubiquitous reliability solution for utilities. PSE continues to build its expertise with automation, and ultimately aims to bring this capability to more areas of our service territory to benefit many more of our customers over the next 5 to 10 years.

Distribution Automation Technologies

Implementing automation would require installing or replacing manual pad-mount switches in the Overlake area with controllable, motor-operated pad-mount switches. These switches and their controllers may require more space than existing switches and may be located in sidewalks, along busy streets, or in parking garages. Close coordination between PSE, city planners, and property owners is essential to finding adequate space for these devices.

Remote control or automation of the distribution system at Overlake Village would require communications to distribution devices. PSE has experience communicating to underground systems using radios, cellular networks, and fiber optic cable networks, and an advanced metering infrastructure (AMI) network may be a future possibility. Which network is used will depend on the communications infrastructure available and the ability of automated devices to send and receive a clear signal.

Siting the communication infrastructure is one key engineering consideration. Radio networks are likely to be a preferred telecommunication solution in the Overlake Village area, and finding structures that are tall enough to provide line-of-sight for radio receivers and repeaters will be critical. Without electric distribution poles in the area, PSE will need to mount the equipment on street lights and possibly rooftops in the area. The City of Redmond and the property owners can support radio network and DA implementation by providing easements and access to these facilities.

Demand Response

A demand response (DR) program coupled with energy efficiency will help reduce greenhouse gas emissions, conserve natural resources, and reduce the size of a central plant. The key principle of DR is to provide some incentive for customers to shift their energy use to off-peak periods, thus flattening the system demand curve. As the demand curve flattens out, systems can be sized and operated more efficiently. DR reduces the need for peaking generation, and when combined with energy efficiency

measures, could assist in reshaping the load curve and end-use consumption patterns, reducing the need for additional generation and distribution infrastructure.

PSE's Experience

In 2009-2010, PSE piloted two DR programs; one focused on commercial loads and one focused on residential loads. For the commercial pilot, about 25 business customers, ranging from office to manufacturing to education facilities, were enrolled and asked to curtail electric usage up to 8 times per season for up to 4 hours. Customers identified the amount of load they would be willing and able to curtail, and were paid a stipend based on the nominated amount. The pilot was successful in enrolling approximately 4 MW of curtailable load across the 25 customers. Minimal technology was employed to accomplish this; the customers manually shut down systems to reach the loads when they were given notice of the start of the event.

In the residential pilot, approximately 500 customers were given a one-time monetary incentive to participate in the program. Customers with electric space heat and electric water heaters were targeted for participation in the program. PSE hired a contractor to install load-control switches on customer's water heating equipment and a new controllable thermostat to control the space heat. When a program event was initiated, the load control switches were activated through the customer's broadband internet network. The temperature set point on the thermostat was also lowered.

Demand Response Technologies

The technology required to implement DR varies based on the type of program selected. Minimally, metering infrastructure is required to measure the energy use of the participants. In addition, automation devices like load-control switches and controllable thermostats can improve the likelihood for success. Finally, communication technology allows for remote control and dynamic control and monitoring of the loads.

Market Readiness

Demand response is widely used in the U.S. in all segments of the market: residential, commercial, and industrial. Much of the success of DR has been in shifting the summer air-conditioning loads. This opportunity exists in most of the U.S., but is a considerably smaller opportunity in the Pacific Northwest where electricity demand is actually highest in the colder months. Because much of the technology and economies of scale have been built around air-conditioning controls, utilities in the Northwest experience a higher cost to entry and some unique challenges to implementation. (For example, air conditioning units are outdoors and easily accessible for retrofit, whereas heating equipment is typically indoors and thus requires additional customer coordination to retrofit.)

Another factor in a DR program is the cost of DR relative to the cost of traditional supply-side resources. At the time of the pilots, the cost for capacity in the Northwest energy markets was well under the cost for the capacity realized through implementing these DR programs. This dynamic has not changed yet, but the margin has narrowed and DR in the region is becoming more cost-competitive with the alternatives. After fully evaluating the results of the pilots, PSE decided not to implement DR; but PSE reviews its viability periodically.

Electric Vehicle Integration

Electric vehicles are growing in PSE's service territory. In 2014, PSE estimates that there are approximately 550 electric vehicles in Redmond (zip codes 98052, 98053, 98073). Electric vehicle adoption has grown at a faster rate than hybrid vehicles when first introduced and will continue to be a growing share of new vehicle purchases as more automotive manufacturers offer electric vehicles and consumers become more comfortable with electric vehicles.

Electric vehicles use a relatively small amount of electricity, an estimated 2,408 kWh/electric vehicle/year, which is only about a quarter of an average residential household usage in PSE's electric service territory. At the current time, most electric vehicle charging is completed at residences, though there is growing demand for workplace and/or public recharging. Over the long term and at high relative usage of electric vehicles, these different types of loads must be considered in planning and could offer potential demand response type capabilities.

PSE's Experience

PSE is launching a pilot program to look at residential electric vehicle charging, its demand on the electric system, and the relative costs and capabilities of different technologies to manage the time of charging. This pilot program will run through 2016 and will provide the basis for potential future electric vehicle related programs. The pilot program offers a $500 incentive to electric vehicle owners towards the purchase of an AC Level 2 electric vehicle charger. Any currently planned projects could participate in the program and PSE would be interested in including them as larger multi-family developments. Depending on pilot results and future program designs, there could also be other program opportunities over the longer term.

Planning Considerations

While the pilot program will help determine the value and direction of future programs and potential technologies to implement them, a number of factors could be included in the Overlake Village plan to provide for electric vehicle use in the future. Specifically, these would include:

1) **Planning for electric vehicle charging in electric system sizing and layouts in building design.** Standard parking garage designs typically do not include planning for electric vehicles. These can be a significant load in sizing electrical systems as well, affecting both the building's systems and the utility's transformers. If a project includes a plan for electric vehicles in its design, the required infrastructure can be incorporated during initial construction, where incremental costs are significantly lower than the cost of future retrofits. This can be taken one step further by installing wiring conduits for future electric vehicle chargers, which also saves on future construction costs.
2) **Ensuring communications connectivity in areas where electric vehicles would park.** PSE's residential pilot program will help evaluate charging technologies and the potential value of improving charging times in the future. If installing and operating these stations proves to be cost-effective, it is highly likely that connectivity will be required with either the chargers, or the vehicles. This could be using a number of communications protocols, including cellular signals, Wi-Fi, the protocol used with the AMI solution, or other standards. Installing the necessary

conduit and connectivity in covered or underground garages as a retrofit project can be very expensive. By planning ahead for communications equipment in parking areas, cost-effective communications can be enabled in the future as standards are better developed.

3) **Planning for workplace and public charging.** Overlake Village will clearly be a new hub of employment. Planners should evaluate the importance of providing adequate electric vehicle charging support to both local commuters and visitors alike. Sufficient EV charging capability will help the Village be a hub for electric vehicle use, offsetting emissions from commuting or other travel.

Direct Use of Natural Gas

In addition to being a potential fuel source for a district energy plant, natural gas will be used for several end-use applications within Overlake Village. Direct use of natural gas is a preferable way to minimize energy waste. Direct use of natural gas for home and water heating is twice as efficient as using natural gas to produce electricity and transmitting it to a home. And with the use of energy-efficient gas appliances, even more efficiency is achieved. Natural gas is also about half the price of electricity.

Typically, natural gas is used for space and water heating. While natural gas will likely be a key fuel source for the district energy plant, it can also heat buildings which are not hooked up to the district energy plant or provide supplemental heat, through appliances such as gas fireplaces in multi-family dwelling units. Natural gas is also frequently used for cooking and laundry, both in restaurants and in dwelling units. In both cases, consumers typically prefer the versatility of natural gas for cooking and laundry.

Natural gas technologies are well-established and are offered in highly efficient equipment, much of which qualifies for conservation incentives through PSE. For the developers in the Village, specifying high-efficiency natural gas appliances will ensure efficient use of resources. Including natural gas appliances such as fireplaces, clothes dryers, and cooktops in individual buildings could also be a means to provide desirable amenities for residents.

In addition to the infrastructure required for a district energy plant, PSE is able to serve individual facilities under its current gas-line extension rules. The services would use the existing intermediate-pressure mains in the area, unless these service locations have no mains in the area.

Appendix E: Tariff Rate Schedules and Applicable Laws

The central plant which serves Overlake Village may be a large consumer of natural gas, and as such would use the existing PSE natural gas tariff rate schedules including electric tariff options for interconnection and selling electricity to PSE. Schedule 150, "Net Metering Service for Small Customer-Generator Systems," covers the option when a customer-generator wants to use the benefits of remaining generation connected to PSE's distribution system. If a larger customer-generator wishes to sell the electricity they produce, they can do so under Schedule 91, "Cogeneration and Small Power Production."

The district energy facility would likely consume a large amount of natural gas in order to heat water. While there is one line extension rule (Rule 7) to facilitate the connection of the district energy facility to the natural gas system, there are variety of options for the ongoing service of natural gas. The most likely relevant natural gas service options and electric rate schedules are listed in Appendix D. The natural gas line extension policy is contained in Rule 7, and is available at pse.com.

A thermal energy company that owns a district energy system and sells thermal energy services is not regulated by the WUTC. An excerpt from the relevant law is included below. PSE currently provides electricity and natural gas as a regulated company, operating under state-approved tariffs.

Natural Gas Tariff Rate Schedules

The most likely relevant natural gas service options are listed in below.

Schedule 31- COMMERCIAL AND INDUSTRIAL GENERAL SERVICE

Available throughout territory served to any commercial or industrial customer.

Schedule 31T - DISTRIBUTION SYSTEM TRANSPORTATION SERVICE (FIRM COMMERCIAL AND INDUSTRIAL)

Available throughout territory served by the Company to Customers who otherwise meet all the requirements for service under sales service Rate Schedule 31.

Schedule 41- LARGE VOLUME HIGH LOAD FACTOR

Available throughout territory served for large volume use where, in the Company's opinion, its facilities and gas supply are adequate to render the required service.

Schedule 41T- DISTRIBUTION SYSTEM TRANSPORTATION SERVICE (FIRM-LARGE VOLUME HIGH LOAD FACTOR)

Available throughout the territory served by the Company to Customers who otherwise meet all the requirements for service under sales service Rate Schedule 41.

Schedule 85 - INTERRUPTIBLE GAS SERVICE WITH FIRM OPTION

Available to any non-residential customer upon execution of a service agreement. Service subject to curtailment. Unauthorized use of gas invokes penalty pursuant to Rule 23, in addition to basic charges.

Schedule 85T - DISTRIBUTION SYSTEM TRANSPORTATION SERVICE (INTERRUPTIBLE WITH FIRM OPTION)

Available throughout the territory served by the Company to Customers who otherwise meet all the requirements for service under sales service Rate Schedule 85.

Schedule 86 - LIMITED INTERRUPTIBLE GAS SERVICE WITH FIRM OPTION

Available to any non-residential customer for steam and hot water boilers, gas engines, gas turbines, or student-occupied buildings. Other terms same as Rate Schedule No 85.

Schedule 86T - DISTRIBUTION SYSTEM TRANSPORTATION SERVICE (Interruptible with Firm Option)

Available throughout the territory served by the Company to Customers who otherwise meet all the requirements for service under sales service Rate Schedule 86.

Schedule 87 - NON-EXCLUSIVE INTERRUPTIBLE SERVICE WITH FIRM OPTION

Available to any non-residential customer whose interruptible requirement exceeds 1,000,000 therms per year. Annual contract volume may be revised annually under certain conditions and proration for curtailment is provided. Other terms same as Rate Schedule No. 85.

Schedule 87T - DISTRIBUTION SYSTEM TRANSPORTATION SERVICE (Non-Exclusive Interruptible with Firm Option)

Available throughout the territory served to Customers who otherwise meet all the requirements for service under sales service Rate Schedule 87.

Electric Tariff Rate Schedules

The PSE electric tariff rate schedules that may apply are listed below.

Schedules 24 & 8* - GENERAL SERVICE

SCHEDULE 24 For commercial or industrial customers with demand less than 50 KW.

SCHEDULE 8 * (Residential & Farm General Service)

Schedules 25 & 11* - SMALL DEMAND GENERAL SERVICE

SCHEDULE 25 For commercial or industrial customers with demand greater than 50 kW but less than or equal to 350 kW.

Schedule 11 * (Residential & Farm Small Demand General Service)

Schedules 26 & 12* - SECONDARY - LARGE DEMAND GENERAL SERVICE

SCHEDULE 26 For commercial or industrial customers with demand greater than 350 kW.

SCHEDULE 12* (Residential & Farm Large Demand General Service)

Schedules 31 & 10* - PRIMARY GENERAL SERVICE

For commercial or industrial customers with delivery at primary voltage (600 volts or higher). Customer provides all transformation and facilities beyond the point of delivery. *

Schedule 10 * (Residential & Farm Primary General Service)

Schedule 40 - LARGE DEMAND GENERAL SERVICE GREATER THAN 3 aMW

This schedule applies to customers with over 3 average MW of load on a distribution feeder. Service under this schedule is voluntary for three years after the date of approval of the original version of this schedule. See tariff Schedule 40 for details of the charges.

Schedule 49 - HIGH VOLTAGE GENERAL SERVICE

For commercial or industrial customers with billing demands not less than 4,400 kVa. Delivered at high voltage (50,000 volts or higher) and the customer provides all transformation and facilities beyond the point of delivery.

Schedule 46 - HIGH VOLTAGE INTERRUPTIBLE SERVICE

For commercial and industrial customers with billing demands not less than 4,400 kVa who may be interrupted during certain hours of the day. Customer provides all transformation and facilities beyond the point of delivery with delivery at high voltage (50,000 or higher)

Schedule 73 - CONVERSION TO UNDERGROUND SERVICE FOR CUSTOMERS OTHER THAN GOVERNMENT ENTITIES

Provides for conversions of existing overhead electric systems to underground.

Schedule 74 - CONVERSION TO UNDERGROUND SERVICE FOR GOVERNMENT ENTITIES

Provides for conversions of existing overhead electric systems to underground.

Schedule 91 - COGENERATION AND SMALL POWER PRODUCTION

Limited to qualifying facilities within the company's service area.

Schedule 150 - NET METERING SERVICES FOR CUSTOMER-GENERATOR SYSTEMS

Available to customer generators taking service on schedules 7, 24, 25, and 29 who operate fuel cells or hydroelectric, solar or wind power generators with a total capacity of no more than 25kW.

Schedule 135 - GREEN ENERGY OPTION - PURCHASE RIDER

Available to all customers as an option designed to provide Customers an opportunity to purchase qualified alternative energy resources. Customers may purchase an unlimited number of blocks of green energy at $2.00 each. A block is equivalent to a 160 kWh purchase. Monthly minimum purchase is two blocks per month. Customers may alternatively purchase green energy that is equal to 100% of their total monthly energy usage at a rate of $0.0125 per kWh. A monthly charge applies in both cases.

Schedule 136 - LARGE VOLUME GREEN ENERGY

Available to customers who wish to purchase 1,000,000 or more kWh per year of green energy under a service agreement for a minimum term of one year. The rate is $0.006 per kWh in addition to a monthly charge.

Applicable Existing Laws

Excerpts from the law which may apply to the district energy system are included below.

RCW 80.04.550

Thermal energy – Restrictions on authority of commission.

(1) Nothing in this title shall authorize the commission to make or enforce any order affecting rates, tolls, rentals, contracts or charges for service rendered, or the adequacy or sufficiency of the facilities, equipment, instrumentalities, or buildings, or the reasonableness of rules or regulations made, furnished, used, supplied, or in force affecting any district thermal energy system owned and operated by any thermal energy company.

(2) For the purposes of this section:

(a) "Thermal energy company" means any private person, company, association, partnership, joint venture, or corporation engaged in or proposing to engage in developing, producing, transmitting, distributing, delivering, furnishing, or selling to or for the public thermal energy services for any beneficial use other than electricity generation;

(b) "District thermal energy system" means any system that provides thermal energy for space heating, space cooling, or process uses from a central plant, and that distributes the thermal energy to two or more buildings through a network of pipes;

(c) "Thermal energy" means heat or cold in the form of steam, heated or chilled water, or any other heated or chilled fluid or gaseous medium; and

(d) "Thermal energy services" means the provision of thermal energy from a district thermal energy system and includes such ancillary services as energy audits, metering, billing, maintenance, and repairs related to thermal energy.

Summary of Affiliated Interest Rules

Several business structures and scenarios are being considered, some of which may contemplate transactions between potential affiliated interests. Excerpts from the WUTC's rules regarding affiliated interests are below. As the project goes into the Development phase, further analysis is needed address the affiliated interest rules.

WAC 480-90-245

Affiliated interests-Contracts or arrangements.

Prior to the effective date of any contract or arrangement described in RCW 80.16.020, each gas utility must file a verified copy or a verified summary, if unwritten, of contracts or arrangements, except for transactions provided at tariff rates, with any affiliated interest. Prior to the effective date of any modification or amendment, the utility must file verified copies of the modifications or amendments to the contracts or arrangements. If the contract or arrangement is unwritten, the utility must file a verified summary of any modification or amendment. The commission may institute an investigation and disapprove the contract or arrangement if the commission finds the utility has failed to prove that it is reasonable and consistent with the public interest.

[Statutory Authority: RCW 80.01.040, 80.04.160, 81.04.160 and 34.05.353. WSR 05-06-051 (Docket No. A-021178 and TO-030288, General Order No. R-518), § 480-90-245, filed 2/28/05, effective 3/31/05.]

WAC 480-90-264

Affiliated interest and subsidiary transactions report.

(1) Each gas utility must file an annual report summarizing all transactions, except transactions provided at tariff rates, that occurred between the utility and its affiliated interests, and the utility and its subsidiaries. The report is due one hundred twenty days from the end of the utility's fiscal or calendar year (reporting period). The report must include a corporate organization chart of the utility and its affiliated interests and subsidiaries.

(2) When total transactions with an affiliated interest or a subsidiary are less than one hundred thousand dollars for the reporting period, the utility must provide the name of the affiliated interest or subsidiary participating in the transactions and the total dollar amounts of the transactions. When total transactions with an affiliated interest or subsidiary equal or exceed one hundred thousand dollars for the reporting period, the utility must provide:

(a) A balance sheet and income statement for such affiliated interest;

(b) A description of the products or services provided to or from the utility and each such affiliated interest or subsidiary;

(c) A description of the pricing basis or costing method, and procedures for allocating costs for such products or services, and the amount and accounts charged during the year;

(d) A description of the terms of any loans between the utility and each such affiliated interest or subsidiary and a listing of the year-end loan amounts and maximum loan amounts outstanding during the year;

(e) A description of the terms and total amount of any obligation or liability assumed by the utility for each such affiliated interest or subsidiary;

(f) A description of the activities of each such affiliated interest or subsidiary with which the utility has transactions; and

(g) A list of all common officers and directors between the gas utility and each such affiliated interest or subsidiary, along with their titles in each organization.

(3) The report required in this section supersedes the reporting requirements contained in previous commission orders authorizing affiliated interest transactions pursuant to chapter 80.16 RCW.

(4) The utility is obligated to file verified copies of affiliated interest contracts and arrangements as stated in WAC 480-90-245 (Affiliated interest—Contracts and arrangements).

[Statutory Authority: RCW 80.01.040, 80.04.160, 81.04.160 and 34.05.353. WSR 05-06-051 (Docket No. A-021178 and TO-030288, General Order No. R-518), § 480-90-264, filed 2/28/05, effective 3/31/05.]