Ford Site Energy Implementation Plan

Achieving 21st Century Infrastructure for a Net Zero Site

October 2018

EVER-GREEN ENERGY™

Acknowledgements

Ever-Green Energy would like to express our gratitude to the City of Saint Paul for their support and vision throughout this process. In particular, we would like to thank Merritt Clapp-Smith, Anne Hunt, Mike Richardson, and Russ Stark for their expertise and commitment to the potential and resilience for this site. Additionally, we would like to thank Mayor Chris Coleman and Mayor Melvin Carter for their leadership and dedication to creating a new future for this important city asset.

The plan and recommendations presented here reflect and incorporate a decade of work to develop innovative and implementable recommendations for the Ford Site. Our thanks to the many volunteers, technical advisory board members, community members, and local government delegates who have led this work to this important juncture. A special thanks to the team from Ramboll (engineering group) and Underground Energy whose work in 2015-16 set the stage for achieving net zero for the Ford Site.

Project Partners

In addition to the City of Saint Paul, a special thanks to Xcel Energy and the University of Minnesota Center for Sustainable Building Research. Their contributions are incorporated throughout their report and their input was critical to the success of this plan.

Ever-Green also utilized the expertise of MEP Associates for geo-energy exchange system evaluation. MEP is an industry leader in geo-energy exchange systems and has designed and implemented multiple geo-energy solutions around the Midwest.

About Report Author Ever-Green Energy

Ever-Green was secured by the City of Saint Paul to lead this phase of planning for the Ford Site's energy infrastructure. At Ever-Green, we take pride in being one of the country's premier district energy system experts, with decades of experience in developing, operating, and managing district energy systems. Our unique combination of technical expertise, business acumen, and operations experience has helped municipalities, colleges and universities, health care campuses, and government organizations advance the study, development, and operation of district energy systems. The Ever-Green team applies its depth of knowledge through every step of a system's development and implementation, finding sustainable solutions that are reliable and financially viable to secure a community's energy future.

1. Introduction

The 122-acre Ford Site has served as an important anchor to the City of Saint Paul (City) for multiple generations. The Ford plant operated in this corner of the city from 1925-2011 and upon its closure created both challenges and opportunities for the City and Ford Motor Company (Ford), who embraced the potential to transform this site into a "21st Century Community." Their vision included an emphasis on sustainability and resilience, with a goal of a net zero energy development that could serve as a demonstration project for smart and efficient design principles. This goal was developed through several years of analysis, community engagement, benchmarking of urban design successes, and rigorous technical studies. These efforts resulted in consecutive energy studies in 2015 and 2016 that identified key technologies that could be implemented on the site by the initial build-out year of 2025 and would position the site to meet the carbon neutrality objectives.

As Ford moved closer to selecting a developer, Ever-Green Energy (Ever-Green) was hired to develop an analysis of the financial and technical feasibility for implementation planning of a district energy system (DES). This plan is intended to help decision-makers prioritize the infrastructure and technology solutions for the development. An implementation plan focuses on the framework and action steps for financing, designing, building, and operating the DES. This implementation plan includes technical analysis, and focuses on the viability of the technologies that will most likely be implementation-ready considering the site development plan and schedule. This report touches on the technical and financial findings of the aforementioned foundational reports and the entirety of those documents can be found on the City's Ford Site website[1].

Implementation Plan Workgroup

To develop a comprehensive energy plan, the City and Ever-Green convened a multi-faceted Workgroup to explore the opportunities for this site, including the University of Minnesota Center for Sustainable Building Research (CSBR) and Xcel Energy. CSBR served as the plan's expert in smart building design. CSBR also prepared several site analyses in earlier phases of the work examining the potential for solar photovoltaic (PV) and high efficiency buildings. Xcel Energy has contributed to multiple phases of this site redevelopment planning and served a critical role in examining the infrastructure, building, and utility interfaces for this plan. All parties worked together to analyze what was implementable, financeable, and would still meet expectations for sustainability, resilience, and innovation.

[1] https://www.stpaul.gov/departments/planning-economic-development/planning/ford-site-21st-century-community

During the City's evaluation of best practices and best outcomes for the Ford Site redevelopment, they developed the following site objectives, which were reinforced by the Workgroup.

- Net zero by full build out (estimated 2030)
- Cost-competitive for the market (assuming a shifting market and value-add for sustainability)
- Implementable (technically and financially)
- Achieving goals through a phased approach

Overview of Past Analyses

For the City, the energy and sustainability goals were initially identified in the Ford Site Roadmap to Sustainability (2011).[2] This included the following principles:

- To maximize the use of renewable energy.
- To reduce operating energy use in all buildings and infrastructure.
- To maximize energy self-sufficiency.
- To meet minimum performance thresholds:
    - Per the Minnesota B3 Sustainable Building 2030 (SB 2030) policy. The SB 2030 program is a progressive energy conservation program that helps buildings identify a pathway to reduce energy and carbon consumption in buildings and help building owners and operators report on their progress against these goals.[3]
    - Per the City of Saint Paul Sustainable Building Policy.[4] The City and the Saint Paul Housing and Redevelopment Authority adopted sustainable development policies for public and privately developed buildings receiving more than $200,000 in public financing.
- Meet on-site energy needs with a fully integrated district energy system
- Use all feasible types of renewable energy on-site
- Reduce fossil fuel energy consumption by utilizing low-energy building technologies.

[2] https://www.stpaul.gov/sites/default/files/Media%20Root/Planning%20%26%20Economic%20Development/FINAL%20-Ford%20Site%20Sustainability%20Report%20%28low%20res%29%205-2-11.pdf
[3] http://www.b3mn.org/2030energystandard/
[4] https://www.stpaul.gov/departments/planning-economic-development/economic-development/sustainable-building-policy

- Reduce building energy load through building insulation and energy efficiency.
- Purchase carbon free energy, as available.
- Reduce public infrastructure energy use by using low-energy or self-powered technologies (Note: current energy modeling does not reflect electricity demands of public infrastructure – streetlights, etc.).

When Ramboll analyzed the system in 2015, they narrowed these goals to focus on resilience, innovation, net zero, energy efficiency, and cost-effectiveness. As their engineering and project management team worked through the list of potential fuels and technologies, they used these key criteria to determine the viability for the site and recommended solutions. The outcome of this effort was a focus on the potential of aquifer thermal energy storage (ATES), which is a form of geothermal energy exchange that can be paired with a district energy network and building heat pumps to greatly reduce the carbon emissions of a development. Given this potential, the City hired Underground Energy to further analyze this application. This analysis included a close look at the aquifers directly beneath the Ford Site and their viability to serve the proposed low-temperature DES.

Figure 1. Aquifer thermal energy storage heating and cooling mode. Courtesy of Underground Energy.

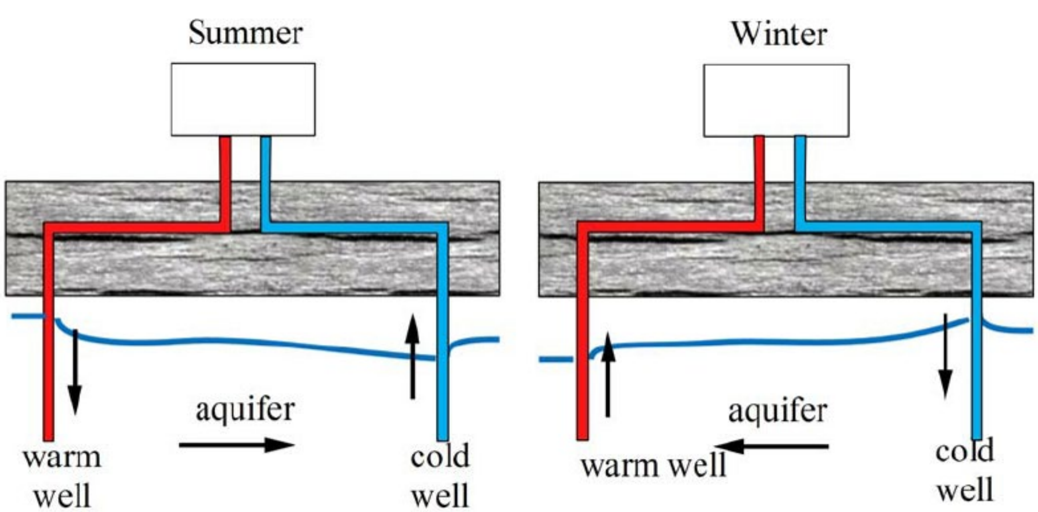
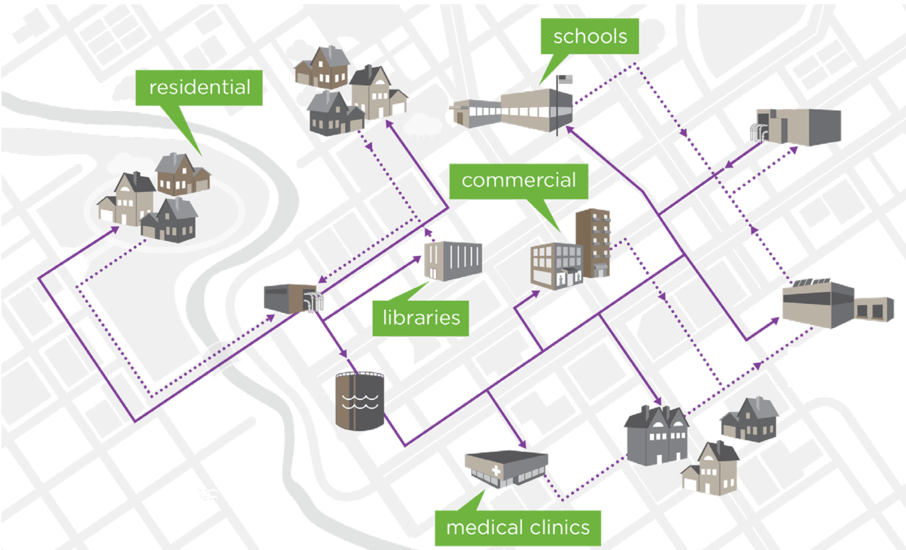


Figure 2. District energy facility



Overall, the ATES evaluation was quite promising for cost-effectiveness and carbon reductions. These results are discussed further in Section 2 Approach and Section 5 Source Energy Alternatives.

Implementation Plan Objectives

Cities are currently playing a critical role in energy planning in the United States. Local leaders are driving development solutions that maximize energy efficiency, renewable integration, and financial stewardship, as part of a commitment to affordability and growth. Additionally, it is common to see progressive city planners advocate for the following:

- Adaptable infrastructure – serving the city for today's needs, but creating flexibility for the next generation of technological advances, which are coming to market faster than ever.
- Smart design – identifying savings or successes that can be achieved by starting out on the right foot, including site layout, making buildings solar-ready, and considering long-term needs such as increased electric vehicle (EV) parking.
- Resilience – energy infrastructure has always emphasized reliability, but today's planners, businesses, and citizens are expecting the infrastructure to withstand everything from 200-year storms to major swings in commodity pricing or fuel/energy availability.

- Utility integration – with major infrastructure investments on the horizon, local government is getting more adept at looking at how major infrastructure can be integrated and save costs both upfront and over the life-cycle. This includes looking across energy, water, waste, and fiber/data networks.

2. Approach

At the onset of this Study, Ever-Green and the City initiated a project kickoff where the City shared its vision for a district energy system that would serve the Ford Site. CSBR and Xcel helped shape the focus and identify the challenges for the work ahead. It was important to outline issues early on that could pose technical, financial, or political challenges. From there, Ever-Green's engineering team began incorporating the major elements into an energy and cost-assessment model, with a primary objective of achieving net zero as it relates to the GHG profile of the energy systems of the site. In order to design a net zero development, the team looked at both building efficiency alternatives and energy source options.

The City approved a public realm and zoning plan for the site in fall 2017 that split the parcel into six districts, allowing for a mix of uses. More information about the zoning and development plans are available on the City website for the Ford Site[5]. The planning and development process also produced a buildout scenario with square footage assigned to different uses. This concept was used as the base information for estimating the potential building loads, DES distribution network, and energy source options (primarily used for geothermal, ATES, and solar PV analysis).

The previous technical evaluations were considered thorough and effective in narrowing plausible options for the site and were used as a basis for the financial modeling that was the focus of this phase. To validate the results for the financial modeling, some assumptions were updated to reflect market conditions, including current market pricing for construction (labor and equipment). One significant change from the 2015 report was updating the business as usual (BAU) scenario for heating ventilation and air conditioning (HVAC) equipment. In the previous report, it was assumed that boilers and chillers would be the market standard to heat and cool buildings. However, in the past five years, multi-family construction has shifted to heating and cooling through unitary systems that are not central to a building, most commonly a Packaged Terminal Air Conditioner (PTAC) unit. A well-known product in this genre is Magic-Paks, which can be seen commonly in multi-family construction in Minnesota. This type of unitary system is considered the BAU for meeting code in this analysis and can be much less expensive than installing centralized heating and

[5] Department of Planning and Economic Development, 2017. City of Saint Paul. https://www.stpaul.gov/departments/planning-economic-development/planning/ford-site-21st-century-community/zoning

cooling through boilers, chillers, or other systems that require a water-based loop throughout the building.

Another significant element to assessing energy and carbon for the site is analyzing the building load profile, which estimates the buildings' heating and cooling energy needs based on an energy use intensity (EUI). EUI is a projection of a building's energy use that is developed with consideration to the building's size, its use (programming), the effectiveness of the building envelope (materials and insulation), and other factors. For the purposes of this Study, two different energy profiles (EUIs) were evaluated. The first profile would meet the State of Minnesota current energy code using the most common HVAC applications for multi-family and commercial construction. The second profile assumed higher efficiency building design and HVAC equipment to be utilized, which would meet Minnesota B3 Sustainable Building 2030 (SB 2030) Energy Standard. Of the two different energy profiles, Ever-Green concluded that the ATES was only economically feasible to serve higher efficiency buildings, so two energy scenarios were used throughout feasibility analysis. This feasibility conclusion was based on the additional costs of capital that would be involved for the ATES if building load was substantially higher. The reduced energy profile for SB2030 allows pipes, pumps, and other equipment and operating costs to be more competitive with alternatives.

Scenario 1 - BAU/Code: Scenario 1 assumes that the buildings for this site would be built to current market standards, using PTAC units to provide heating and cooling and with the building envelope and HVAC equipment designed to meet state building code. This scenario would assume traditional gas and electric service to the site, with no additional onsite renewables in the first phase of development. Buildings with this noncentralized HVAC approach would not be compatible with an ATES/district energy system, because they do not include a water loop in buildings to circulate hot water or chilled water. PTAC units would generally not meet the SB2030 requirements for the site without significant investment in other efficiencies and renewables, so this scenario is primarily for cost comparison with other approaches.

Scenario 2 – Heat Pumps Paired with ATES and District Energy: Scenario 2 assumes that the buildings for this site would be built to above average market standards, meeting the sustainability requirements for the Ford Site. To meet these standards in multi-family and commercial buildings, a temperate district energy water loop would draw and release energy from an onsite aquifer. At the building, energy would be exchanged from the district energy water to the building's loop. Heat pumps would then optimize this energy for use in the buildings to heat or cool. This scenario assumes limited to no gas service for the site, with increased electric service to accommodate heating and cooling through electricity (i.e. heat pumps).

These scenarios are reviewed throughout the remainder of the report to validate financial feasibility and alignment with City and State goals.

3. Building Design and Efficiency

Establishing Efficiency in Building Design and Construction

The energy profile of the future buildings is a critical component of determining what is technically and financially feasible. The most cost-effective approach to reducing the energy profile and carbon emissions for the site is to design, construct, and operate high-efficiency buildings. To this end, the Workgroup benefited greatly from the depth of research and analysis previously developed by the CSBR team. The CSBR team's previous work on the Ford Site included an EUI analysis which was used to develop the building load profiles presented within this section.

The most cost-effective approach to reducing the energy profile and carbon emissions for the site is to design, construct, and operate high-efficiency buildings.

To promote the most efficient approach for the Ford Site, it is recommended the City and the developer continue working with CSBR to identify potential building design assistance and implement best practices for building development. Xcel Energy and any other utility partners should also be involved in optimizing the building profile for the site's energy goals and alternatives. High-performance buildings with a lower energy profile will provide an economically attractive environment where building owners save money through increased efficiency and lower energy bills. The implementation of improved building energy efficiency will be as important as the energy sources to achieving the community's low-carbon, resiliency goals. Considering demand-side management during development increases the opportunities for demonstration projects and resident, tenant, and commercial participation.

Evolving Design Considerations and Efficiency Implementation

With the expectation of public funding for the site development, the Workgroup assumed the application of the City of Saint Paul's Sustainable Building Policy, which will set the expectation that buildings meet SB 2030 design standards. The evaluation scenarios show the comparison between code and SB 2030 to clarify the potential energy, carbon, and cost variances between the approaches.

Looking forward, it will be important that the expectations for the building energy profile be identified early so utilities, practitioners, engineers, and the developer can maximize the potential opportunities for energy and cost savings. The efficiency of the buildings will ultimately determine the viability of renewable energy integration for the site.

4. Estimating Building Load

4.1 Introduction to Building Load Estimation and Assumptions

Estimation of building load profiles was completed by the Ever-Green engineering team. This analysis incorporated the team's experience with building design, building operation and performance, alternative source connections (PTAC or district energy), International Energy Conservation Code 2012 (IECC 2012 - current code), and the SB 2030 program. Based on the obligations of the City of Saint Paul Sustainable Building Policy, The 80% SB 2030 threshold takes effect in 2020 and would be applicable to the initial buildout. Buildings built and occupied between 2025 and 2030 would be expected to meet 90% progress to the SB 2030. In addition to the efficiency gains, SB 2030 also has several advantages as a framework for the building design.

- SB 2030 is designed and tailored for Minnesota buildings.
- SB 2030 is a performance based standard, providing guidance for the design of energy efficient buildings beyond prescriptive requirements, giving developers site-specific flexibility, however, prescriptive guidelines are available.
- It has building use based standards that cover all development types applicable to Ford: commercial, multi-family, and detached residential (requested by Ryan Companies in their October 2018 proposal to amend the Ford Site Zoning and Public Realm Master Plan).

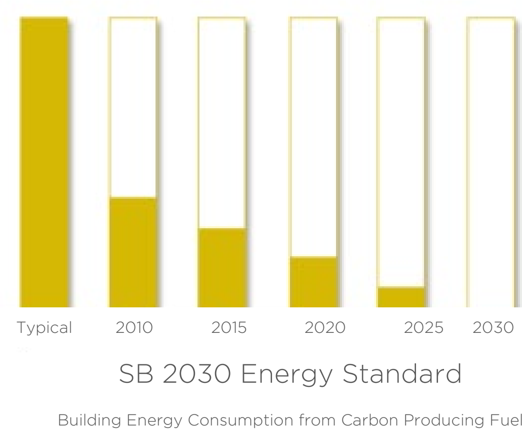


Figure 3.

As a comprehensive, performance-based energy standard, SB 2030 looks at all of the systems in a building and how they collectively impact the building's efficiency. Systems that are modeled or calculated under this standard are:

- Building envelope
- Equipment energy efficiency
- Lighting power density and controls
- Domestic hot water
- Mechanical systems
- Use of renewables

The building load estimate was derived from two sources: the building square footage extrapolated from the City's Ford Site Zoning and Public Realm Master Plan, and the EUI factors developed by CSBR for purposes of examining energy efficiency design principles and solar PV development for the site. The City plan assumes a breakdown of building-use square footage shown in Table 1. A developer master plan for the site is anticipated in 2018 and this analysis will need to be revised based on the actual building square footage in that development plan.

Table 1. Ford Site Planning. Square footage by building type per the 2017 Ford Site Zoning and Public Realm Master Plan

Type	SQFT
Low Density Housing	812,481
Med Density Housing	1,679,580
High Density Housing	1,959,836
Civic	135,324
Retail and Mixed Use	300,651
Office	455,702
Total	5,343,574

To develop total heating, cooling, and electric load profiles, the following assumptions were applied to the model:

- Business as usual load profile - based on the EUI at current code – IECC 2012, ASHRAE 2010
- SB2030 - this higher efficiency alternative load profile is based on predictive SB 2030 EUI, which is 80% of the ultimate SB 2030 standards (approximately 35-50% more efficient than code).
- The code scenario in the model is based on current state codes. These codes are slated to be updated in 2020, but that update is not contemplated in this model.
- The model does not designate a shift in load based on site development phasing. The Workgroup assumed a phasing strategy and this should be applied to the model after the developer submits a plan to the City. A major shift in construction to the latter end of phasing or a site layout that does not optimize distribution, could be detrimental to the ATES strategy.

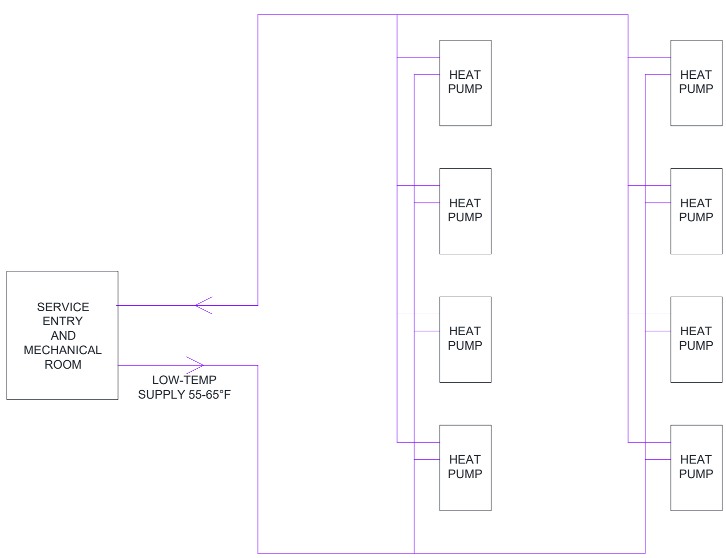
- The model does not currently include assumptions for increased EV usage onsite. This should be included in the next version of modeling after the master developer provides additional information on anticipated units, parking, and strategies for EV integration.

These scenarios provide a baseload profile for which the life-cycle cost analysis was developed. Additional load profile information for SB2030 80% is included in Appendix III.

Building HVAC Systems

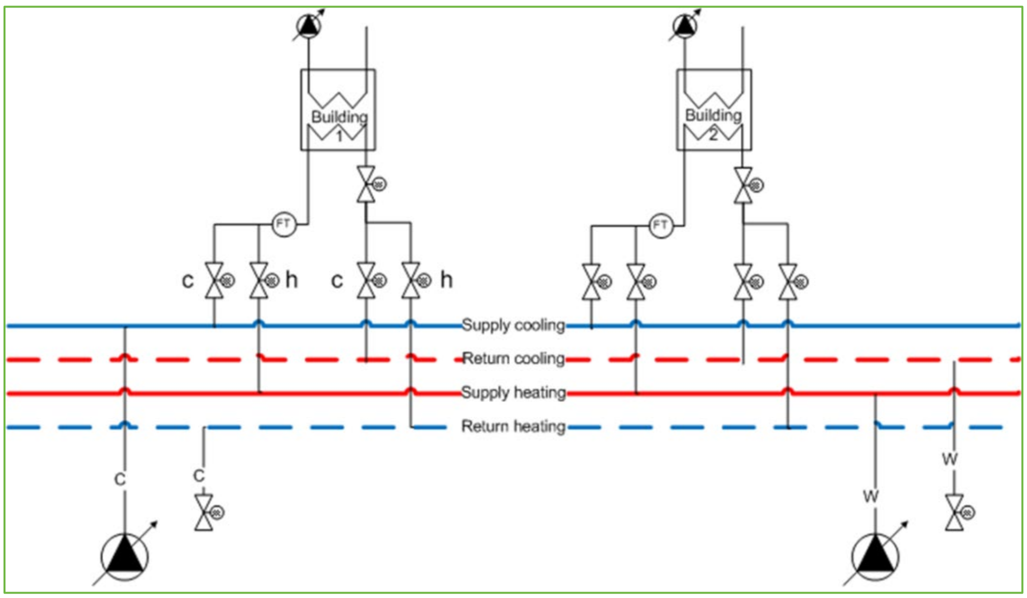
The Ford Site development will include different building types, including commercial, multi-use with commercial and residential, health care/clinic, and both multi-family and single-family homes. Each of these building types would utilize a different approach for heating and cooling (HVAC) systems, depending on its programming and the energy scenario selected. In the case of the proposed ATES system, a pumping mechanism will draw water from the aquifer and transfer energy via a heat exchanger into a low-temperature district energy system. This is done without mixing the aquifer water and the district energy system water. The low-temperature district energy system then carries the energy to the end users at the building's service entry where water-source heat pumps installed in the buildings raise or lower the water temperature for heating or cooling purposes.

Figure 4. Distributed heat pumps served by a low-temperature district energy loop in multi-family residential buildings



Another method that buildings can use with a low-temperature loop are fan coil units. A fan coil unit is a basic piece of equipment that can exchange heating or cooling within an HVAC system through a fan and coil within the device. It is commonly used in residential and commercial buildings. A water-source heat pump serves the fan coil units from separate hot and chilled water distribution loops in the building, as shown in Figure 5. The hot water could also be used for radiant heating. The water-source heat pump is similar to an electric chiller and would be located in a mechanical room in the building. Domestic hot water can be generated through the heat recovery process and distributed and stored similarly to a central domestic hot water plant.

Figure 5. Water-to-water heat pump and four-pipe fan coil system



5. Source Energy Alternatives

Previous studies examined the options for source energy for this site at great length. The consensus from these efforts was that either ATES or traditional geothermal offered the most advantages to the project. This recommendation had been based on these technologies being implementable, cost-effective, and their potential to significantly reduce carbon. The primary exploration of this approach was first completed by Underground Energy in 2016 with a focus on ATES implementation.

What is ATES?

According to Underground Energy's Feasibility Study Report for the City of Saint Paul (2016), ATES is a sustainable geothermal heating and cooling technology that can yield significant, large-scale energy savings for buildings and energy districts that have large heating and cooling requirements and that overlie at least one productive aquifer. ATES is an open-loop, low-temperature geothermal technology that uses high-capacity wells for both withdrawal and injection of groundwater on a seasonal basis. ATES is well suited to application in low-temperature district energy systems, and the technology is well established in the Netherlands, where over 2,500 ATES projects have been commissioned.

Figure 6. Aquifer Thermal Energy Storage Cross-Section for Cooling Mode. Courtesy of Underground Energy.

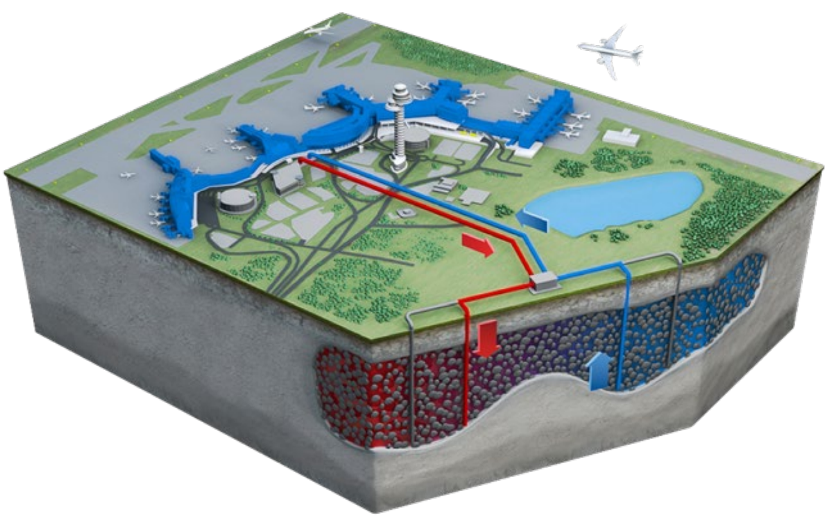
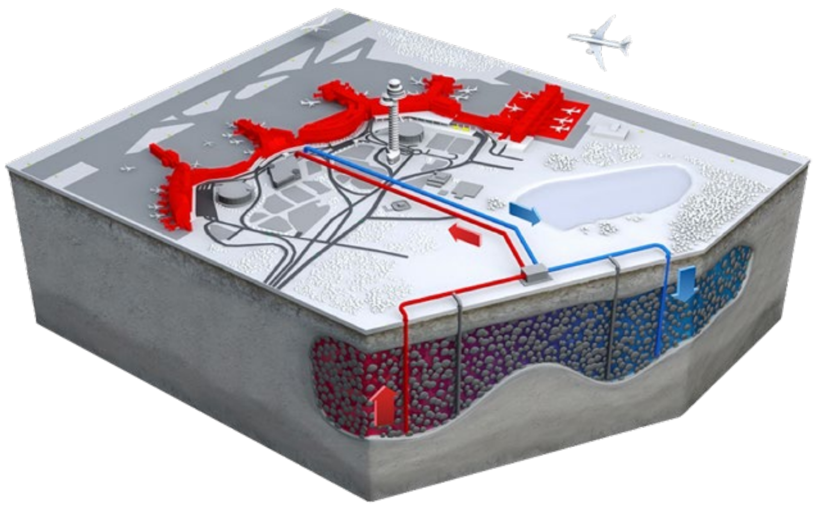
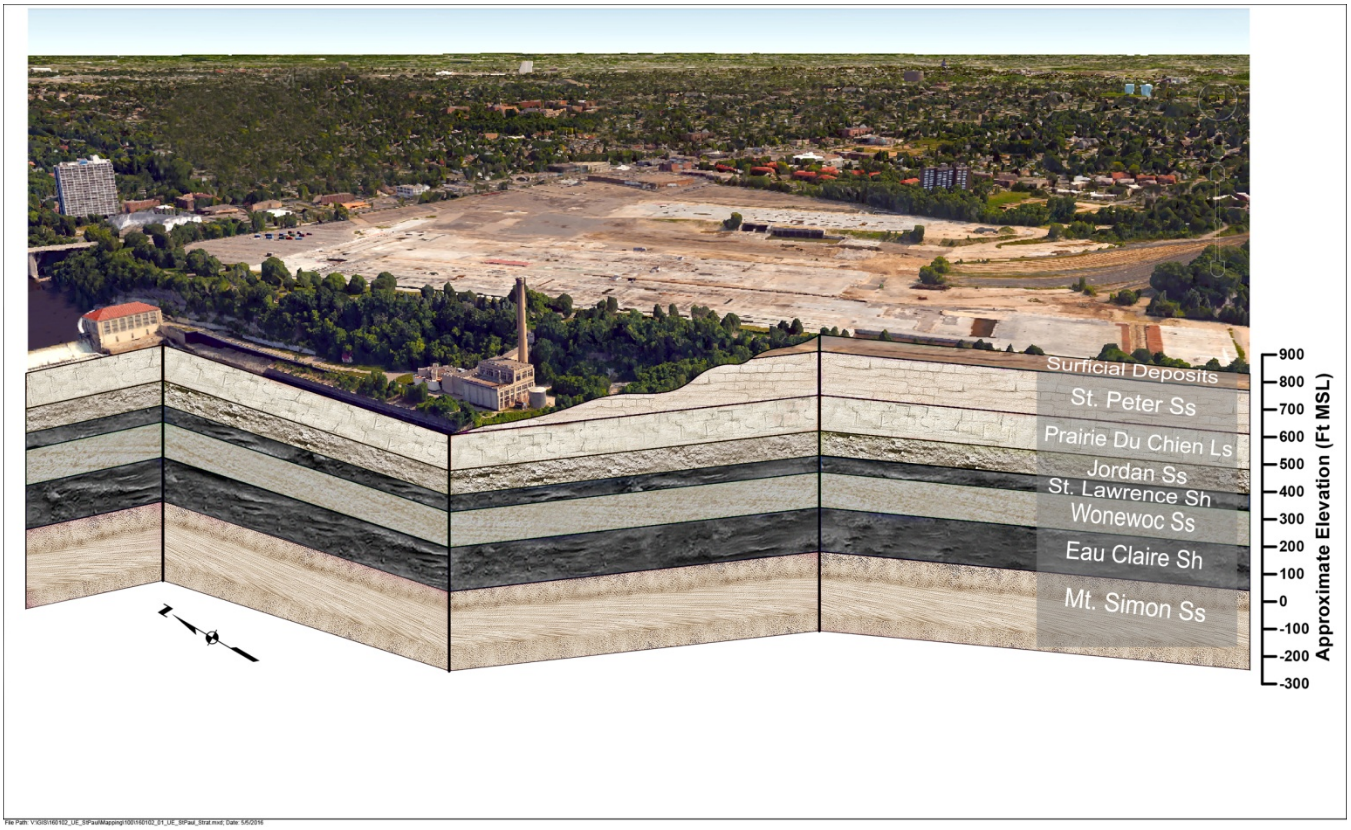


Figure 7. Aquifer Thermal Energy Storage Cross-Section for Heating Mode. Courtesy of Underground Energy.



More simply put, an ATES system utilizes the low flow nature of the aquifer to reject heat into it during the summer and extract heat from it in the winter. In the summer, heat is extracted from customer buildings, and it is stored in the aquifer on one side of the site. Conversely, in the winter, heat is extracted from that aquifer water to heat customer buildings, and the cooled water is stored on another side of the site. Each building on the system will extract or input heat into the core water loop through heat pumps or heat recovery chillers.

Figure 8. Aquifer Cross-Section. Courtesy of Underground Energy.



Advantages

These types of systems are proven and reliable; having been in use for decades around the world. Energy cost reductions are a result of no natural gas being consumed with this system. A low-temperature district energy system also has a better opportunity to integrate renewable electricity through wind or solar photovoltaic generation. Integrating renewables into the electric source composition of an ATES system could enable buildings connected to the district energy system to be considered net zero carbon buildings.

Integrating renewables into the electric source composition of an ATES system could enable buildings connected to the district energy system to be considered net-zero carbon buildings.

Disadvantages

Currently, the ATES is proposed for the Prairie Du Chen Aquifer under the Ford Site parcel. To install this system, the project developer or utility would need to secure a permit from the Minnesota Department of Health (MDH). The proposed approach (detailed in the full Underground Energy report), is diligent about minimizing this risk by keeping any necessary water treatment isolated from the aquifer. Additional discussions and planning with MDH, as well as other state agencies will be critical to protecting the aquifer throughout the development process and operation of the ATES.

Viability

In order to enable the use of an ATES system for a larger site, district energy would be utilized as the distribution system and customer interface. District energy, in this approach, would deliver the energy from the ATES interface to the buildings within the site via a separated fresh water loop operating at temperatures of between 45°F and 65°F. Once it reaches the buildings, heat can be extracted or rejected dependent on mode. Today's high-efficiency, advanced heat pumps have a higher coefficient of performance, meaning they use less energy to add or subtract heat from the building, which has enabled more effective introduction of large-scale ATES installations.

The district energy system not only allows movement of energy to and from the ATES, it also helps balance the load across the site as some buildings may be rejecting heat at a time when other buildings can use it.

Overall, the ATES modeling yields a positive picture for advancing this solution.

- This aquifer can yield more than 1,000 gallons per minute (GPM) to water wells between about 220 and 490 feet deep.
- The well flow rate is 900 GPM per well (5,400 aggregate).
- The model estimated 12 ATES wells (6 warm/6 cold) with outputs of 53.6 MMBtu/hr peak (115,800 MMBtu annual) for heating. And output of 3,450 tons peak (66,900 MMBtu annual) for cooling. Assuming approximately 5.4 million square feet of conditioned space, this is enough energy to cover 75% of the heating and 100% of the cooling needs of the development. The system is scalable, and additional wells can be added to accommodate a future increase in building loads.

Traditional Geothermal

MEP Associates was consulted to examine traditional geothermal exchange, which would require significantly more wells and area for operations. MEP conducted a preliminary investigation of geothermal implementation feasibility with the purpose of establishing site geological conditions, available open land area, and whether financial feasibility supports installation of a geothermal heat exchanger. Their analysis found that to meet peak loads, the geothermal system would need between 15-23 acres using traditional U-bends. MEP did examine the potential of utilizing Rygan coaxial heat exchangers, as they require less area than traditional U-bends and would reduce geothermal space needs. However, the Rygan grout is not acceptable in Minnesota, thus the Rygan coaxial heat exchangers could not be used. Given that this type of green space is not available at Ford, this option was not modeled within the scenarios.

Business as Usual (BAU) – PTAC Units, Boilers, and Chillers

Of the two scenarios, the first assumes a standard approach to multi-family residential and commercial buildings, which relies on PTAC or Magic-Pak units for the residential buildings and a combination of boilers and chillers for the commercial buildings.

Advantages

Individualized energy solutions, such as those suggested for the BAU scenario, allow for more individualized choice in energy/HVAC solutions. There may be some future tenants or business owners who prefer to not be connected to a larger thermal grid, although they will likely remain connected to a gas and electric grid for service. However, there are some energy customers who prefer to have more ownership of on-site production equipment, which may outweigh their valuation of environmental benefits and lower cost energy.

Disadvantages

Individualized units, such as the BAU options, may limit long-term flexibility for a building. For instance, it may be harder to add renewables or other decarbonizing solutions to the building energy profile with traditional HVAC equipment. Additionally, these units may create greater challenges with maintaining an efficient building envelope and long-term efficiency performance.

6. Financial Model

Ever-Green utilized the estimated capital costs presented in this report and the financial assumptions shown in the appendices to develop a life-cycle cost analysis (LCCA) for the proposed district energy system. The capital costs and estimated savings of the district energy system will be dependent upon the final development plan, distribution network, load profile, buildings connected to the district system, and other variables that have yet to be determined. The results of the LCCA analyses are summarized in the following tables.

Life-Cycle Costs Analyses Summary

A 30-year life-cycle cost analysis was completed for the two scenarios. This included analyzing upfront costs, financing costs, assumed energy and demand rates, operations and maintenance costs, and the costs of equipment and equipment replacement.

The upfront costs for building HVAC systems to meet current code were found to be approximately 10% lower than the upfront costs for those same buildings to meet SB 2030.

This could be prohibitive to developing the more sustainable system, however, when examined across a 30 year life-cycle, there are significant savings realized from the ATES/district energy approach. Primarily due to access to low-interest, long-term financing strategies and the savings of the ATES system compared to long-term gas prices and forecasting. These savings can be applied to overall sustainability investments, including HVAC equipment (heat pumps) through the long-term financing strategy for the district energy system (DES) business. However, if the site were to be developed only to current code standards, the additional costs shifted to the DES would make rates less competitive or create too much risk for the overall business structure. Due to the lack of cost-effectiveness, both upfront and life-cycle, it was determined that an ATES/district energy interface was only viable if the site stays on course to meet SB 2030 standards. This is represented in the two scenarios compared throughout the report.

Table 2. Life-Cycle Cost Analysis Summary

Scenarios	30 Year Life-Cycle Cost
Scenario 1 - BAU – Code/PTAC	$249,040,000
Scenario 2 – SB 2030/ATES/District Energy	$242,560,000
Total Savings	$6,480,000

Life-Cycle Cost Factors

Overall financial results are affected by the following circumstances: interest rate increase, higher than expected construction bids, or fewer customers than anticipated connect to the system. There are also several opportunities to reduce cost and provide better savings that will need to be examined closer to the start of infrastructure development. These options include:

- Utilization of rebates for energy conservation. This will be dependent on future discussion related to fuel-switching, currently under evaluation by the Minnesota Division of Energy Resources.
- Availability of grants for demonstration projects and other integration of innovative technologies, efficiency measures, renewables, or carbon reduction strategies.
- Coordinating distribution piping construction with other site civil works could create the opportunity for cost sharing and reduced energy rates.

Project Financing

In order to support an ATES scenario, the financing would need to be publicly backed to mitigate the impact of a phased development schedule and non-rated system customers. This would offer access to long-term, low-interest financing, and lower overall energy-related costs.

If the ATES were to proceed, a non-profit business structure, with local stakeholder governance, would be optimal for the district energy system (DES) business. Additional models are noted in the report and could be considered in the next business planning phase, should this scenario move forward. An owner/operator for the DES is not defined.

7. Environmental and Greenhouse Gas Profile – Pathways to Net Zero

Achieving carbon neutrality and greater resilience are key tenets of the Ford Site vision for a 21st Century community. In reviewing the previous energy analyses for the site, it was clear that the immediate path forward needed to find a methodology that was implementable and financeable, while leading the development toward net zero. The SB 2030 building design approach coupled with the ATES district energy system, is the best-positioned approach for reaching these important goals for the site. To demonstrate the benefits of this approach, we conducted a GHG emissions analysis.

Greenhouse Gas Emissions Analysis

A GHG analysis was completed to compare the energy source alternatives. The report focused on SB 2030 as the standard for building efficiency. Buildings built to the SB2030 standard have a GHG profile that is 37% lower than buildings built to current code. When these high efficiency buildings are paired with ATES, the site can achieve 62% GHG savings in early phases. As Xcel continues to decarbonize the grid, the Ford energy system will also decarbonize, with an estimate of 75% savings beyond BAU in 2030. These savings are a combination of avoided energy use in high efficiency buildings, substituting natural gas service with low-temp district energy and ATES, and continued decarbonization of the electric grid. The ATES is key to enabling this beneficial electrification approach, meaning buildings energy consumption is primarily electric.

Table 3. 2020 GHG Emission Scenarios (electric grid - 881 lbs CO2/MWh)

	Energy and GHG			
	MMBtu	kWh	GHG (Tons)	Percent Savings
BAU Code	145798	6584720	11430	62%
ATES SB2030	0	9928539	4373	

Table 4. 2030 GHG Emission Scenarios (electric grid - 521 lbs CO2/MWH)

	Energy and GHG			
	MMBtu	kWh	GHG (Tons)	Percent Savings
BAU Code	145798	6584720	10244	75%
ATES SB2030	0	9928539	2586	

Table 5. 2020-2030 GHG Scenario Comparison

Scenario	GHG-Tons
BAU Code	11430
ATES SB2030	4373
2030 BAU Code	10244
2030 ATES SB2030	2586

Figure 9. 2020-2030 GHG Scenario Comparison

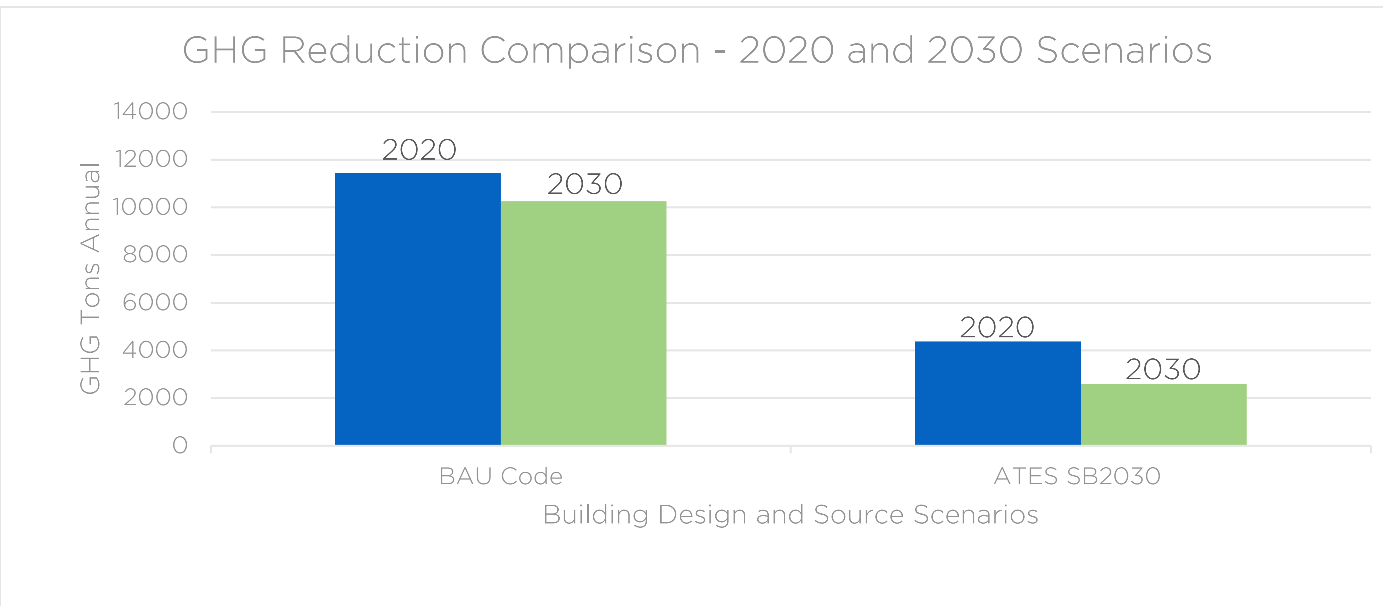


Table 6. Thermal Load Shifting Scenarios Gas-Electric

Energy Comparison (MMBtu)		
	Gas load	Electric load
BAU Code	145798	22450
ATES SB2030	0	33851

Figure 10. Thermal Load Shifting Scenarios Gas-Electric

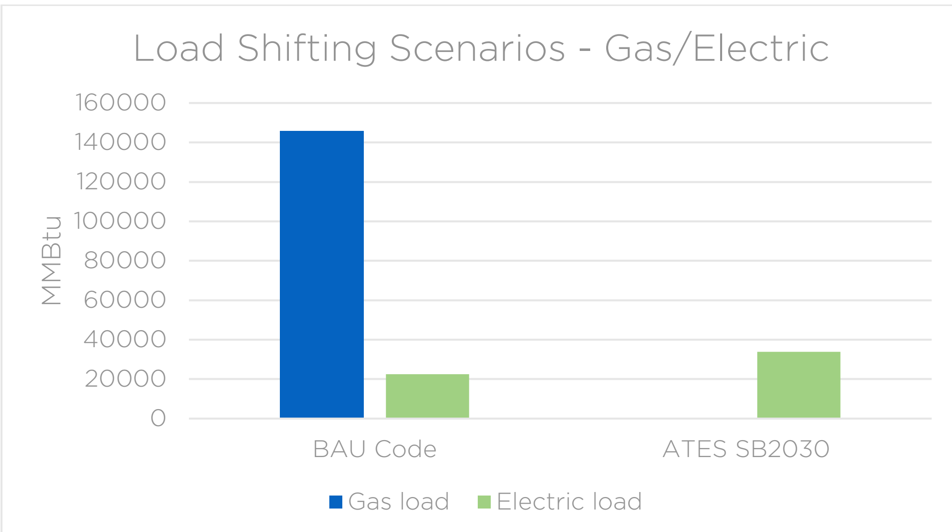
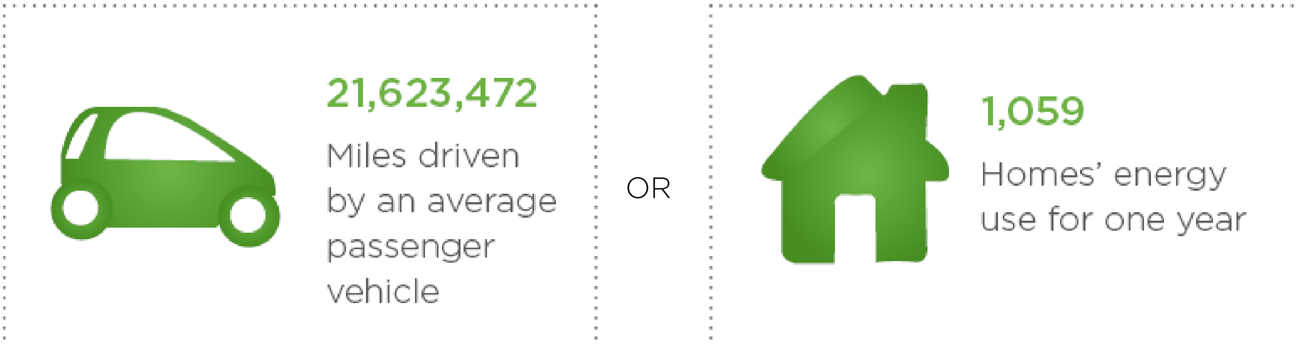


Figure 11. Carbon Equivalent – Greenhouse Gas Savings 8,844 Metric Tons. According to the Environmental Protection Agency's Greenhouse Gas Equivalencies Calculator



Findings

Combining high efficiency building design and construction (SB 2030) with a low-temperature district energy system ATES is an implementable path forward to achieve significant GHG reductions and should be pursued as the priority approach.

This approach will significantly reduce the carbon profile of the site, but does not completely eliminate the carbon footprint. As the plans with the master developer are refined, it will be important to spend additional time identifying the intermediary strategies that will supplement the high-performance buildings and ATES approach. These additional discussions should include the following:

- Offset programs – these programs reinforce the commitment of the City and the master developer to carbon neutrality, while recognizing some of the limitations of the site and the phased approach of development.
- Solar PV and battery storage – these are explored in Section 9 and are recommended to be a priority tactic to explore closer to development.

8. Innovation

The City's commitment to a 21st Century community sets the stage for the Ford Site to incorporate leading-edge technology. The plan for this site takes the long-term view for success, which creates the opportunity to get started with the solutions that are the best fit for the site objectives and are both technically and economically feasible for near-term infrastructure development. The Workgroup recommends continued evaluation of the preferred solution, which pursues the higher efficiency building profiles (SB 2030) and ATES district energy. Together, this approach helps the site achieve a 58% carbon reduction beyond the business as usual approach (standard building code with PTAC units). The district energy approach will also create a flexible infrastructure that will allow additional renewable and efficiency technologies to be integrated as they become market ready. It is also anticipated that the electric grid will continue to decarbonize (as noted in Section 8), allowing for the delivered electricity to the site to see significant carbon reductions by 2030.

In support of both the net zero carbon and innovation goals, the Workgroup identified several areas of potential for the site; 1) Near-term demonstration projects 2) Ongoing advancement opportunities (blue-sky alternatives) 3) Data and Energy Tracking

Near-Term Demonstration Projects

The Ford Site presents several opportunities to integrate advanced technology, renewable energy, and energy efficiency strategies. The following list represents opportunities that are expected to be implementable during site development and through the early years of building occupancy.

Tactic 1 – Beneficial Electrification

Over the past three years, there has been a significant push in the energy industry to accelerate electrification of all sectors; electricity, heating and cooling buildings, transportation, and industrial. This campaign has been motivated by the increasing decarbonization and flexibility in the modern electric grid and particularly the Xcel electric grid serving this region. By increasing electric service, the intention is to increase renewable options and decarbonize all sectors. The beneficial (or strategic) electrification approach, takes this into consideration, but also emphasizes customization to incorporate renewables and low-carbon solutions beyond electricity. For example – there are several sites in Minnesota considering an interface with sanitary sewer lines and groundwater to use them as a heat source and sink, similar to geothermal. When paired with heat pumps, the ATES approach shifts the Ford site load away from fossil fuels, but does not exclusively shift to electricity. The advantage of this approach is focusing the solution on efficiency and carbon savings, regardless of the energy source.

Applying this strategy for the Ford Site comes in the form of the ATES paired with low-temperature district energy distribution. This approach allows for the Ford Site to minimize natural gas service to the site, instead using heat stored in the aquifer paired with heat pumps to displace natural gas heating. Implementation of this approach would put Saint Paul on the forefront of modern development strategies, balancing resilience goals with affordability. This infrastructure would make the Ford Site a destination for other communities planning major brownfield or greenfield redevelopment. That said, the site holds much more potential to integrate both small and large-scale solutions.

Tactic 2 - Advanced building design

The University of Minnesota Center for Sustainable Building Design Research has extensive information regarding best practices for building design to meet the SB 2030 design guidelines and operationalize best practices in building design and efficiency. Working with this team and other regional experts will provide the most financially viable and implementable pathways to smart building design that works for this site and its planned uses.

Tactic 3 – Solar PV paired with battery storage

The Workgroup agreed that solar PV and battery storage would be the two most likely technology advancements that could be market ready by 2023. The PV technology is already thoroughly demonstrated in Minnesota, but was not modeled during this phase of work because the costs for the development timeline are unknown. It is recommended that this solution be planned for in the site infrastructure and thoroughly discussed with the master developer in the early stages of planning. This will give the utilities sufficient lead time to plan for any necessary changes to their infrastructure and service to the site. Within 12 months of major infrastructure implementation, these solutions should be thoroughly vetted and a cost analysis done with best available information about the market trajectory.

The ownership structure for these assets should be considered at a future date. Legislative changes and available programs should determine the most cost-efficient way to tie these resources into this localized grid.

Tactic 4 – Electric Vehicle (EV) stations

The carbon neutrality approach for this site should also consider reduction of car trips and optimization of EV infrastructure. EVs are the fastest growing automobile market segment,

with most major manufacturers expecting to have EV representing 50% of their market by 2030. Several European countries are contemplating bans of fossil-fuel vehicles as early as 2025. Access to EV charging and public transportation will be critical to both the carbon reductions attributed to the site, but also the marketability of the site to multi-generational tenants.

To remain competitive, the master developer should consider integration of Level 2 charging stations, which would require access to 240 volt (240V) service within their parking structures. The DCFC (Level 3) chargers are on the rise, however, they are more expensive and require a 480 volt connection. They are also targeted at charging on shorter timelines and may not be necessary for this application.

Finding

This infrastructure should be established to adapt to the market penetration of EVs. As a starting place, we recommend the master developer consider providing EV charging for 10% of its parking spaces during the initial phase of development, while ensuring that more stations can be added within this same parking infrastructure. Future phases should increase minimum requirements in line with market increases and best available technology.

Metering and Data Management

Beyond carbon, it is important for this modern infrastructure approach to also emphasize data availability to energy consumers and building operators. To support this effort, Ever-Green recommends the following to be considered for this site:

- Sub-metering has the potential to lead to lower energy use since tenants directly see and pay for their energy use. Smart home appliances (e.g. Samsung)
- In-home network hubs, software and apps (e.g. SmartThings)
- Smart switches, plugs, and plug switching capabilities (e.g. Belkin WEMO)
- Connect light bulbs (e.g. Philips Hue)
- In-home energy storage/fuel cells and car-to-car charging (e.g. Honda's Home Energy Management System)
- In-home zoned temperature controls (e.g. Honeywell)

Ongoing Advancement Opportunities (Blue Sky Discussion)

There are several technologies and renewable applications that could be considered for the site at a future date in development. They are outlined here to serve as a reference to the discussions with the master developer.

- A microgrid does not appear to achieve high priority status for deployment to this site, based on the expectation that electricity production options are somewhat limited on-site and the current master plan does not identify critical functions for the site. As plans are refined, this could be revisited to maximize resilience planning and onsite options.
- Building integrated photovoltaic panel systems (e.g. BISEM)
- Photovoltaic or electrochromatic glass (e.g. Guardian Ecoguard glass)

9. Community Engagement

To-date there has been extensive outreach and engagement for the Ford Site as it has moved through phases of study, planning, remediation, and now the prospect of development on the horizon. The City of Saint Paul and regional stakeholders clearly care about the future of this site. The former Ford plant production, jobs, and role in the community created a connection that will follow the site as it establishes new purpose, develops innovative and resilient infrastructure, and sees new stewards implementing its next evolution.

Because of this high level of both tangible and intangible investment in this property, it is critically important that the next phase of energy discussions involve both the geographic community and the many stakeholders who are interested in what's next. These efforts will need to merge the interests of the City of Saint Paul, Ford, and the master developer to achieve the best outcomes. In an effort to facilitate this engagement, Ever-Green recommends consideration of the following activities:

- Development and sharing of community education materials, which could include web content, handouts, illustrations, animation, video, and other content that can help vested individuals and organizations understand the potential infrastructure and innovation being recommended. This should be seen as an opportunity to celebrate the innovation and possibilities that can be realized on the site and what sets it apart from other developments.
- Establish a series of public workshops to learn more about what the solution means to the community, how it will be experienced for those living and working on the site, and what the sustainability and financial benefits would be realized by the preferred approach. These sessions should be designed intentionally around the needs and interests of the stakeholder groups, so the level of technical discussion and opportunity to share questions and concerns is welcomed in the forum.
- Provide opportunities to organizations previously engaged or now engaged through Mayor Carter's administration to schedule sessions with the Project Team or other subject matter experts to discuss their interests.

10. Organizational Structure Alternatives

The determination of a system's organizational and financing model will have a lasting impact on the success of the system. The right business model depends upon a number of factors, including the project goals, the needs of the prospective customers, and the objectives of key stakeholders. Some options for potential structures include publicly owned, a private non-profit structure, a private for-profit structure, and a hybrid publicly-owned infrastructure operated as a private non-profit company.

Public business structures can be owned by a public entity like a city, county, or state. In this case, system financing could be based upon long-term customer contracts or it could be part of the public body's capital infrastructure budget and rates could be cost-based. A public system approach could provide access to low-cost financing and cost savings by implementing in parallel with other infrastructure projects. However, this approach may have challenges from blending private market development with the public sector model. Montpelier, Vermont has successfully implemented this model with District Heat Montpelier.

A private business model could be set up as a non-profit or a for-profit business. Both could be operated and managed by a third party, potentially utilizing a customer-represented board and third party operations and management partner, and would raise debt and equity based upon long-term customer contracts. The for-profit version may rely on the investors' balance sheets. The non-profit model would operate much like a cooperative, which may be more enticing for establishing long-term contracts. However, private financing of a non-profit model may be more challenging in certain markets. District Energy St. Paul has successfully used the non-profit model for nearly forty years. If developed as a private for-profit company, accelerated depreciation could allow the business to be more profitable in its early development. However, this approach may conflict with the community energy vision if it does not align with the interests of the system owner or stockholders.

There is also the option of a hybrid system with publicly-owned infrastructure and a private non-profit company. Under this scenario, a public body could invest in the infrastructure for the energy system, but a private non-profit entity could be formed for purposes of the energy business. Governance of this structure could be similar to the private, non-profit model, where the public body, customers, and local stakeholders cooperate in setting the strategic direction for the business. This hybrid model would leverage many of the benefits of each of the other business models. Energy Park Utility Company in Saint Paul, MN is one version of the hybrid model.

Organizational Development Recommendation

Given the existing local utility partnerships, the City should work with the Master Developer to review options and approaches. The Master Developer will likely have a preferred approach to business partnership and infrastructure development that will need to be integrated with the City's expectations, franchise agreements, financing approaches, and organizational readiness.

11. Conclusion and Next Steps

The following are the primary conclusions from the implementation planning:

- The ATES scenario is the best-positioned option to provide a cost competitive solution that meets sustainability objectives for the site.
- The developer costs for services from the ATES would be equal to the BAU alternative.
- To achieve net zero goals, gas service to the site should be limited to strategic placement for essential services or as density or development schedules necessitate.

- Energy efficiency (as outlined by SB 2030 building load scenarios) is key to meeting the carbon, energy savings, and cost savings objectives for the project.
- Ever-Green Energy also recommends a discussion with the Minnesota Housing Finance Agency about how these approaches fit into the affordability index and potential to promote affordable housing that works with sustainable solutions.

Effective implementation of an ATES system assumes the following:

- Credit enhancement of financing is available.
- Minnesota Department of Health (MDH) will permit the ATES interface.

Next Steps

Should the ATES be recommended to proceed by the City and master developer, the following would be the next steps:

- Engage MDH and other relevant state agencies to proceed with permitting activities
- Install test wells at the site to validate the aquifer water flow assumptions.
- Engage the master developer (and other stakeholders) in business planning.
- Finalize a site development timeline, which will dictate energy infrastructure next steps.
- Determine an education and outreach plan for community stakeholders.
- Discuss credit enhancement strategies with City/others as appropriate.
- Establish or identify a business to develop, own, and operate the DES.
- In order to achieve a net zero plan for development, solar PV and energy storage should be modeled closer to developer build out, leaving enough time for construction integration, financing, and utility integration. Modeling at this time will provide a more accurate market valuation and utilize best available technologies.

Summary

The opportunities at the Ford Site offer a viable and feasible pathway to carbon neutrality that will position this development as a national demonstration project for integrated energy efficiency, renewables, and beneficial electrification. An ATES district energy approach sets the stage for a phased approach for additional pilot projects and technology innovation, while also providing for reliable and effective energy to the many new residents and businesses who will be served by the system. As final planning proceeds with the master developer, the Workgroup will continue to serve as an important resource to refining the approach and helping the partners achieving the important objectives set forth by the City.

Appendices

Appendix I: Aquifer Thermal Energy Storage Feasibility Study Report – Underground Energy

Appendix II: Building Load Profiles

Appendix III: Life Cycle Cost Analysis Assumptions

Appendix IV: MEP Assessment of Geothermal for the Site

Appendix V: University of Minnesota Center for Sustainable Building Research Site Analysis