



TCAAP Energy Integration Resiliency Framework

March 31, 2015



TCAAP Energy Integration Resiliency Framework

Brief

Acknowledgements

The Project Team would like to thank the City of Arden Hills, Ramsey County, the Energy Resiliency Advisory Board, and the Joint Development Authority for all of their input and guidance. Their leadership and insights proved invaluable as the Project Team progressed toward the TCAAP energy vision. The Project Team is also grateful to the Minnesota Army National Guard, the University of Minnesota Center for Sustainable Building Research, and Xcel Energy for their cooperation and partnership through the development of this Framework.

About the Project Team

1.1. Ever-Green Energy

Ever-Green Energy is one of the country's premier community energy system experts, with decades of experience in developing, operating, and managing district energy systems. The unique combination of technical expertise, business acumen, and operations know-how has helped communities, colleges and universities, and government organizations advance their exploration and implementation of integrated energy systems.

1.2. Burns & McDonnell

Burns & McDonnell, headquartered in Kansas City, MO, is a full-service engineering, architecture, construction, environmental and consulting solutions firm. The company's multidisciplinary staff of nearly 5,000 employee-owners includes engineers, architects, construction professionals, planners, estimators, economists, technicians, and scientists, representing virtually all design disciplines.

1.3. Center for Energy and the Environment

The Center for Energy and Environment is a nonprofit organization that promotes energy efficiency to strengthen the economy while improving the environment. CEE conducts research and develops programs so that: businesses operate more efficiently and profitably; government agencies and nonprofits spend less on facilities and functions; utilities achieve their energy-efficiency goals at least-cost; and households save money and improve comfort.

1.4. Fresh Energy

For more than 20 years, Fresh Energy has transformed widely held economic and environmental ideas into smart energy policy. Fresh Energy works in the realm of public policy, changing the rules that govern our energy system. The organization's efforts focus on energy efficiency, clean energy, transportation and land use, and carbon reduction.

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Brief: TCAAP Energy Integration Resiliency Framework

The redevelopment of the Twin Cities Army Ammunition Plant (TCAAP) site in Arden Hills, Minnesota, offers unique and exciting opportunities to build a vibrant community that attracts residents and businesses, and serves as a national model for sustainable redevelopment. Ramsey County (County), Arden Hills (City), and neighboring property owners are working together to build a forward-looking community that optimizes innovative energy supply systems that can be developed for reliability and resiliency, increases the use of local renewable energy systems that can reduce the environmental impact of the community, and develops energy efficient buildings that can provide low-cost energy for residents and tenants.

TCAAP is a 427-acre site that has recently gone through an extensive demolition and environmental remediation program. The site is centrally located at the intersection of I-35 E and Highway 10, just ten miles from downtown Minneapolis and downtown Saint Paul. TCAAP is unique for its size, prime location, greenfield condition, and potential partnerships. The partnerships between the Minnesota Army National Guard (MNARNG), the U.S. Army, Xcel Energy, the City, and the County create dynamic and beneficial opportunities for all entities.

To facilitate TCAAP redevelopment, the County and the City have engaged in a partnership through the formation of a Joint Development Authority (JDA). For the purposes of energy planning, they have also established the Energy Resiliency Advisory Board (ERAB) and appointed community stakeholders to help define an energy vision for TCAAP. The Project Team includes Ever-Green Energy, Center for Energy and Environment, Fresh Energy, and Burns & McDonnell.

Findings

- Given current market drivers and the timing of TCAAP development, implementation of the opportunities identified in this Framework should begin immediately.
- Partnership with Xcel Energy and the Minnesota Army National Guard will be essential to achieving the vision for TCAAP.
- Implementing the opportunities recommended in this Framework can reduce greenhouse gas emissions by as much as 70%.
- A solar photovoltaic (PV) installation at the Primer Tracer site has the potential to provide sufficient power to TCAAP and AHATS when operating at peak conditions.

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- Combined heat and power (CHP) is an efficient and effective step toward developing a microgrid at TCAAP and AHATS.
- The locally treated groundwater possesses enough energy to meet all of the thermal needs of the planned TCAAP residential neighborhoods.
- Enhanced building design standards applied in the request for proposal (RFP) process can attract and streamline energy efficient development.
- Building orientation, co-location of complementary use buildings, and use of sub-meters can reduce energy consumption and improve energy efficiency.
- Integrating several of these energy opportunities would allow residents of TCAAP to achieve net-zero energy status.
- The County and JDA should allow corridors for future energy infrastructure along the Spine Road
- The JDA should begin pursuing funding opportunities that support the strategies in this Framework.
- The strategies identified in this Framework should be incorporated into the developer selection process.

The City, County, and ERAB have worked with the Project Team to develop a two-part TCAAP Energy Integration Resiliency Framework that outlines the appropriate planning guidelines and policies with careful consideration of local resources, stakeholder interests, project goals, and the best available technologies for implementation over the next 50 years. Phase one of the study was the development of the *Policy White Paper* which was accepted by the JDA and the Arden Hills City Council in November 2014. The *White Paper* helps guide policy and provides a unifying vision for the site's energy future and identifies a number of opportunities for energy efficiency and efficient energy supply options.

Phase two of the study focused on the development of this document, the Energy Integration Resiliency Framework (Framework) which provides more details about how the County, the City, and the JDA can technically achieve the vision and recommendations put forth in the *White Paper*. The Framework considers the *TCAAP Redevelopment Plan*, which outlines land use, infrastructure planning, and the site development timeline. The expectation is for TCAAP to be redeveloped as a mixed-use community with residential, commercial, and retail space. The Framework evaluates the energy supply alternatives and demand-side management strategies that were the most immediately implementable concepts from the *White Paper*. The Framework outlines the energy supply technologies that can be

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built during the early phases of site development and would be financially beneficial, financeable, practical, and achievable. The Framework also provides a detailed analysis of the optimal initial energy efficiency strategies, including site and building planning, demand-side management, advanced technology, and building design. Energy supply and energy efficiency solutions at TCAAP will also be influenced by collaboration between partners, including the MNARNG and Xcel Energy. These partnership opportunities are immediate and implementable to meet the loads of the buildings that are currently in the area, as well as the future buildings expected to be built within TCAAP and nearby.

During development of the *White Paper*, the ERAB outlined their vision and guiding principles for TCAAP energy development.

Vision Statement

TCAAP will be a vibrant development that leverages long-term energy conservation and resilience to attract investment and partnership, and achieves sustainable benefits for Arden Hills and the surrounding community.

Guiding Principles

- Establish TCAAP as a national model for development of integrated energy systems.
- Develop a resilient community for energy and other utilities.
- Implement infrastructure solutions that are flexible and scalable over the next 50 years.
- Deliver a model of efficient energy and water usage that minimizes TCAAP's impact on the environment.
- Create an economically competitive and attractive environment for developers and businesses.

Partnership Opportunities (Outlined in Section 2)

The Project Team has begun to assess several potential partnerships, including infrastructure and operations opportunities with the local utility provider, Xcel Energy, and MNARNG. The MNARNG owns and operates the Arden Hills Army Training Site (AHATS) adjacent to the TCAAP site. The MNARNG has developed a master plan for the buildings on its site that includes the goals of net-zero energy, water, and waste, and is currently working on implementation plans to achieve these goals. The MNARNG has

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expressed a strong interest in collaborating with the County and JDA on the development of energy solutions for the area.

Xcel Energy is committed to reaching energy efficiency and renewable energy goals, as well as the potential for innovative demonstration projects that showcase energy efficiency and resilient energy. Xcel Energy leadership has expressed a commitment to partnership with the County in the implementation of the energy plan for TCAAP, and the County should continue to pursue opportunities that can benefit both parties and achieve the energy vision for TCAAP.

Partnerships with Xcel Energy and MNARNG could create unique and exciting opportunities to optimize energy supply and energy efficiency at TCAAP.

Additionally, there are two areas for additional partnership. The Ramsey County Public Works (RCPW) facility on County Highway 96 is an existing facility adjacent to AHATS and TCAAP. In the Primer Tracer area on the north edge of TCAAP and AHATS, the Department of Public Safety is contemplating the installation of an emergency operations facility. Both of these facilities should be considered when planning energy solutions for the area. Through partnership discussions, a number of immediate and implementable partnership opportunities were identified to meet the loads of the buildings that are currently in the area, as well as the initial buildings expected to be built at TCAAP.

Energy Source Recommendations (Outlined in Section 3)

After evaluating a range of possible energy sources and considering the TCAAP goals, timeline, and resources, the Project Team recommends the development of solar PV, CHP, low-temperature district energy system, and the foundational components of a future microgrid. Beyond meeting the energy needs of customers and the goals of stakeholders, these recommendations are customized to the distinctive features of TCAAP.

When considering the recommended technologies, it is important to consider the potential CO₂ reductions that accompany these strategies. In total, over 8510 tons of CO₂/year can be avoided, which is the equivalent of removing 1625 cars from the road each year. The environmental benefits of reduced greenhouse gas emissions will be further increased through integration with the other energy supply alternatives recommended and implementation of demand-side management strategies, ultimately leading to more sustainable redevelopment of TCAAP and the long-term potential of reaching carbon-neutrality for the site in the future.

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Solar PV

The utilization of solar technology can enable the generation and utilization of renewable energy at TCAAP.

Solar PV at Prime Tracer

Based on generally accepted solar generation estimates, a large-scale solar installation on 40-acre of the Prime Tracer site could generate approximately 8 megawatts of electricity (MWe) in peak conditions. Conservatively, this could account for approximately 70% of the peak electric load in the area. Implementing a solar PV array in the Primer Tracer area will result in a reduction of greenhouse gas emissions by approximately 7,524 tons of CO₂ per year.

A solar PV array at the Primer Tracer site could meet the electricity needs of TCAAP and AHATS when operating at peak conditions.

Solar PV at AHATS

A 2 MWe solar PV installation at the capped soil area west of the existing AHATS Field Maintenance Shop would primarily meet a portion of the electric needs of the AHATS site, but could provide additional renewable electric energy to TCAAP during the non-peak energy usage times at AHATS.

Combined Heat and Power

The vision for the TCAAP site is for the Thumb, Town Center, and Flex areas to be served electrically and thermally by a CHP energy system located at or near TCAAP. This localized energy source would enable achievement of many of the guiding principles established by the ERAB, potentially reducing greenhouse gas emission reductions by 20%.

Depending upon the type of business that develops in the Thumb, a CHP plant located on that property could efficiently serve the electric and thermal energy needs of that business, as well as the thermal needs of buildings in the Town. A CHP plant located close to AHATS and the existing facility at Ramsey County Public Works could be used to meet the electric needs of MNARNG, while simultaneously meeting the thermal needs of MNARNG and RCPW buildings. As TCAAP development progresses, these two CHP systems could be integrated to serve the majority of the thermal energy needs of the commercial portion of TCAAP.

Implementing a CHP system at the Thumb could reduce greenhouse gas emissions by as much as 20%, reduce energy costs, increase energy efficiency, and establish the foundation of a future microgrid.

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Microgrid – There is an opportunity to implement and demonstrate “next generation” electricity grid technologies that will help achieve the TCAAP energy vision, including development of a microgrid connected to a CHP plant. It will be important for Xcel Energy, the MNARNG, and the JDA to develop a plan to expand the scope of the CHP plant and develop a microgrid for the broader area as TCAAP development proceeds.

Low-Temperature District Energy System

The residential neighborhoods planned for the TCAAP site present a unique and highly visible opportunity to leverage low-grade energy from the treated groundwater as an energy supply for the neighborhoods, distributed via a low-temperature district energy system. This energy would be sufficient to meet the heating and cooling needs of the Hill and Creek residential neighborhoods of TCAAP, with approximately 3 MMBtu/hour of excess capacity available for additional TCAAP buildings.

The available energy from the treated groundwater can serve all of the TCAAP homes with a lower-cost energy source that reduces GHG emissions by ~30%.

For the proposed system to be successfully implemented, it would need to be constructed as the first homes are being built, so that service can be provided from the outset of development. To optimize the economic benefits of the system, every home in the selected neighborhoods should be constructed with a heat pump HVAC system and be connected to the proposed system. This would provide the most financeable, cost-effective implementation plan, and also maximize energy efficiency for TCAAP.

One important advantage of a low-temperature district energy system is the reduction of greenhouse gas emissions. Comparing emission rates between traditional heating ventilation and air-conditioning (HVAC) systems and the proposed low-temperature district energy system in the Hill and Creek neighborhoods shows carbon dioxide emissions are could be reduced by almost 30% or 310 tons CO₂/year.

Implementing a low-temperature district energy system in the residential neighborhoods of TCAAP can deliver several benefits to the site and stakeholders, including the following:

- An energy system that is more energy efficient than traditional heating and cooling systems.
- Reduced fossil fuel usage and greenhouse gas emissions.
- Competitive, stable costs of energy for homeowners.
- Xcel Energy could avoid installing gas pipe in the neighborhoods

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- Installation of an infrastructure network in the neighborhoods will allow for easier integration of future energy sources or technology advancements as they become available.
- Implementation of this system would establish the TCAAP approach to sustainable neighborhoods as a national model for energy efficiency and innovative site development.

Additional Energy Technology Opportunities

While not recommended for any of the initial options in this Framework, there are two additional technologies that should be considered for future TCAAP energy system integration:

Thermal Energy Storage – On the AHATS site, there is an existing one million gallon water storage tank and related water distribution piping. This tank could be used as a thermal energy storage tank to store water for the heating and cooling needs of the area. This would work like a battery, which would fill up during non-peak energy hours and be discharged during peak energy usage times to balance out the energy usage profile for the area.

Solar Thermal – The MNARNG utilizes solar-thermal technology on its buildings and is investigating further integration of it as their site is built out. This technology should be considered for individual sites or as part of a larger energy plan for TCAAP development.

Energy Efficiency Strategies through Demand-Side Management (Outlined in Section 4)

To promote energy efficiency at TCAAP, the Project Team recommends a combined approach through flexible building design assistance, readily available technical resources, planning best practices, and development RFP criteria that will attract and streamline energy efficient development. 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 alongside development increases the opportunities for demonstration projects and resident, tenant, and commercial participation. For these efforts, Xcel Energy and the Center for Sustainable Building Research at the University of Minnesota will be valuable partners.

Throughout the development of TCAAP, the recommended demand-side initiatives will depend strongly on engaging developers, who can help implement the TCAAP energy vision. These energy efficiency recommendations make use of the truly unique opportunities at TCAAP, which include:

- A greenfield development to minimize the cost of initial installation of energy efficient systems.

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- The advantage of large scale deployment to optimize economies of scale.
- Focus on replicable designs and proven technologies to simplify developer implementation.
- Emphasis on building performance based standards, instead of only design conditions.
- Important strategic partnerships with Xcel Energy and the Center for Sustainable Building Research at the University of Minnesota.

High-Efficiency Commercial Buildings

As development moves forward it is recommended that the County, the JDA, and development consultants utilize building standards, technical resources, planning tactics, and proposal criteria to attract and streamline energy efficient development.

Utilize SB 2030

Minnesota's Sustainable Buildings 2030 (SB 2030) is a performance based building energy standard developed to incrementally move new commercial building construction to net-zero energy by 2030. On average, SB 2030 will require commercial buildings to be 35% to 45% more efficient than the new building code (IECC 2012). As nearly 75% of the energy loads for TCAAP are estimated to be in the retail, commercial, and flex areas of the development, energy conservation measures for these areas will be paramount for successful achievement of the Energy Vision. The key way to incentivize use of SB 2030 is to give preference during the RFP review process to proposals that plan to implement these standards.

On average, SB 2030 will require commercial buildings to be 35% to 45% more efficient than the new building code (IECC 2012).

Sub-metering

Commercial and multi-family building sub-metering is an important consideration because the additional design cost is relatively low when considered up front, but has the potential to maintain lower energy use since tenants directly see and pay for their energy use.

Sub-metering has been shown to save up to 21% in leased building spaces.¹ The material, software, and labor cost for each sub-meter ranges from \$5,000 to \$7,500. Several metering companies provide sub-metering services by owning, operating, and maintaining the meters. Monthly fees are based on

¹ "Tenant Occupants of Green Office Buildings: Driving the Market for Improving Existing Building Stock" McGraw-Hill Construction and CBRE. September, 2011. www.cbre.com/EN/aboutus/MediaCentre/2011/Pages/10062011.aspx

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the type of service needed and the quantity of sub-meters served, but costs per sub-meter range from \$150 to \$400.

Strategic Building Siting and Co-Location

The County and JDA could facilitate building co-location through the platting and RFP process. Building energy use types can be identified as potential candidates, and referred to energy design experts to define the specific energy benefits that could be achieved through co-location. Buildings with processes that produce hot water or heat could sell their excess to adjacent buildings that have use for it at different times of day. District energy infrastructure could enhance this load diversity and energy sharing. Businesses would be interested in this opportunity because it would improve the efficiency of their consumption, reduce upfront capital equipment and maintenance costs, and increase comfort.²

Low-Load Residential Development

Residential developments at TCAAP could feature homes that do not require natural gas, by utilizing electric appliances and serving minimal heating and cooling demands through ground-source heat pump technology. A low-load home would not require the larger heating and cooling capacity of traditional systems, but instead could meet residents' comfort needs with smaller capacity systems. The key technologies and strategies include high levels of building insulation and passive solar design, a tight building shell, and high efficiency lighting and appliances. These homes do not require significant insulation like a passive house, but are 40% to 50% more efficient than what is required by the new energy code (IECC 2012).

Homes built at TCAAP could be 40% to 50% more efficient than what is required by the new energy code.

Incorporation of high-performance technologies that have little to no impact on the up-front costs, such as efficient appliances and low-flow plumbing, will help minimize hot water use and help maximize home efficiency.

Building Orientation and Passive Solar

The process for solar-oriented development should be described in residential and commercial building RFPs and should be integrated as evaluation criteria for development proposals. It should be evaluated based on lowest total energy load of the homes or buildings to be sited under one proposal and should consider street orientation, building orientation, and passive solar building envelope design elements.

² The Primary Energy Factor (PEF) difference between district heating systems and Gas-fired heating ($0.8/1.3=0.61$)
http://www.euroheat.org/Files/File/documents/Publications/District%20Heating%20in%20buildings_final.pdf

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The thermal loads of homes and commercial buildings will be impacted by the building envelope, street orientation, lot and building orientation, and building massing. The likely locations where street orientation could vary significantly to accommodate energy implications would be the Creek, the Hill, and the Transition neighborhood on the periphery of the Town Center.

By pairing solar heat gains and window design strategies, heating energy savings can be up to 30%

By considering these variables prior to the subdivision process, planners and developers have the opportunity to produce efficient results with little or no-cost impacts.

High-Efficiency Streetlights

The City of Arden Hills has included a site-wide requirement for all streetlights to be “high-efficiency lighting, such as LED lamps.” This requirement will trigger the inclusion of high efficiency lights in the development process. Current LED technology saves approximately 50% to 70% of lighting energy use. Another significant cost savings occurs by additionally reducing maintenance costs, given the longer life of the bulbs.

Community Participation and Education

Community participation and education have been consistently mentioned as important factors for TCAAP, both to engage the wider Arden Hills community and to leverage the energy savings potential from facilitating ongoing awareness of energy use by site tenants and residents. Many details of community engagement will need to be planned once the site sees its first residents and tenants. However, certain engagement elements can be planned for or implemented during the early development stage, including:

- A TCAAP or Arden Hills-wide website that tracks energy goals and performance of buildings at the site, including energy and carbon savings. The website could promote major metrics and milestones, and issue periodic challenges (e.g. the “lowest user” challenge).
- Community-wide open house or showcase events of leading edge technologies on the site, especially for housing, that will attract and excite potential residents.
- Commissioning of design or signage elements in public spaces that connect users to the site’s energy resiliency goals and their contribution and participation in those goals. A targeted marketing campaign around community solar development, as an early symbol of community-driven, low carbon energy use at the site.

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Demonstration Opportunities

Advanced Distribution Grid

TCAAP's greenfield status, combined with the site's forward looking energy vision, make it an ideal opportunity to pilot and demonstrate advanced technologies in the electric distribution grid. Many of the opportunities outlined in this report, such as high solar PV penetration, advanced commercial building metering, or responsive electric loads, are all facilitated by a distribution system with increased communications and control functions. Implementing an advanced distribution grid can save customers money and reduce the environmental impact of their energy use.

By laying the groundwork for an advanced distribution system at TCAAP during the planning phase, residents and businesses would have access to cutting edge opportunities such as advanced rate design or real-time load response.

Innovative Energy Technologies

In addition to pilot opportunities at the grid level, TCAAP is ideal for demonstrating innovative energy technologies at scale. The Project Team recommends that the JDA and County seek and attract partnerships to demonstrate proven technologies and strategies. While the technologies may be proven, TCAAP offers scalable and living demonstration opportunities, where an apartment, house, or street of homes could serve as a living lab. Additionally, as a cold climate site that can attract multiple partners, there is great opportunity to demonstrate the synergies that can exist between multiple innovative technologies and design strategies. This might include piloting new in-road luminescent street or pedestrian path lighting products in conjunction with high efficiency overhead LED street lighting, electric vehicle storage and integration, or homes that have on-site electric storage and remote controlled appliances/electronics that communicate with each other.

Conclusion

The ERAB has adopted a very forward-thinking vision for the TCAAP site. This will be achievable through strategic partnerships with Xcel Energy, the MNARNG, the University of Minnesota Center for Sustainable Building Research, environmentally conscious citizens, and developers who see the economic and environmental value of the TCAAP energy vision. Through these partnerships, TCAAP will be uniquely poised to be the national model for the development of integrated energy systems.

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The first steps toward achieving the energy vision include implementing energy supply options that focus on efficiency, reliability, scalability, and sustainability, such as the low-temperature district energy system in the residential neighborhoods and the community solar garden at the Primer Tracer site. These specific opportunities have been shown to be financially beneficial and financeable. Developing a CHP that meets the needs of current buildings in the area and is expandable in the future provides a platform for establishing a resilient TCAAP microgrid as TCAAP development progresses.

Implementing a demand-side management strategy that focuses on building performance through the development RFP process will build a resilient community for energy use. Focusing on improving performance in the buildings to reduce the energy needs of the buildings will provide an economically attractive environment as building owners are able to take advantage of the financial savings realized by the increased efficiency, compared to traditional energy expenditures.

Initial focus should be on energy efficient designs, the low-temperature district energy system in the residential neighborhoods, and the community solar garden at the Primer Tracer site.

Schedule and Next Steps (Outlined in Section 6)

The development schedule that is currently proposed is scheduled to begin in 2016 with the construction of the interchanges of County Hwy 96 and County Road H with the Spine Road. The Spine Road construction is also expected to begin in 2016. Currently, site development is projected to begin with the residential and retail areas in the northern region of TCAAP in late 2016 or early 2017. Development is expected to progress southward from the Town and Creek neighborhoods as the market allows. The Thumb area is being actively marketed by the JDA at this time, and could be developed as soon as the right proposal is received from the development community. The current development plan is included in the appendix as Exhibit III.

Development at TCAAP will begin in 2016, therefore development and implementation of these recommended energy strategies will need to begin immediately.

Given this development timeline, the JDA will need to begin implementation on each of the individual opportunities presented in this Framework, including immediate focus on the following:

- partnerships
- combined heat and power
- solar PV

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- low-temperature district energy system
- demand-side management
- infrastructure planning
- funding pursuits
- RFP development
- education workshops

The TCAAP site is positioned to be a national model for site redevelopment. With planning and leadership, this area can be developed to meet the bold energy vision of the ERAB to become a vibrant development that leverages long-term energy conservation and resilience to attract investment and partnership, and achieves sustainable benefits for Arden Hills and the surrounding community.

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Energy Integration Resiliency Framework

1. Introduction

The Twin Cities Army Ammunitions Plant (TCAAP) site offers an incredible opportunity for Ramsey County, Arden Hills, and the surrounding community to build a forward-looking community that optimizes the energy and environmental opportunities of the next generation. Innovative energy supply systems can be developed for reliability and resiliency, increased use of local renewable energy systems can reduce the environmental impact of redevelopment, and energy efficient buildings can provide low-cost energy for residents and tenants. The TCAAP site is positioned to be a national model for site redevelopment. With planning and leadership, this area can be developed to utilize economically competitive, low-carbon energy sources, follow exceptional energy and environmental standards, and engage future residents as stewards of the energy vision.

Beyond being a greenfield, TCAAP has a number of characteristics that make it distinctive. One of the unique opportunities TCAAP redevelopment offers is the potential to partner with the local utility provider, Xcel Energy, and the MNARNG on energy supply infrastructure and operations. The MNARNG owns and operates the AHATS adjacent to the TCAAP site. The MNARNG has developed a master plan for the buildings on its site that includes the goal of net-zero energy, water, and waste, and are currently working on implementation plans to achieve this goal. The partnership between the MNARNG, the City, and County creates dynamic and beneficial opportunities for all entities.

Xcel Energy provides electricity and natural gas to the area in and around Arden Hills. Xcel Energy views the TCAAP redevelopment as an opportunity to partner with local government and the community to develop demonstration projects that showcase energy efficiency and resilient energy projects.

To facilitate TCAAP redevelopment, the County and the City have engaged in a partnership through the formation of a Joint Development Authority (JDA). For the purposes of energy planning, they have also established the Energy Resiliency Advisory Board (ERAB) and appointed community stakeholders to help define the TCAAP energy vision. The ERAB has worked with energy experts on the Project Team to develop a two part TCAAP Energy Integration Resiliency Framework that outlines the appropriate planning guidelines and policies with careful consideration of local resources, stakeholder interests, project goals, and the best available technologies for implementation over the next 50 years.

Phase one of the study was the development of the *Policy White Paper* which was accepted by the JDA and the Arden Hills City Council in November, 2014. The *White Paper* provides a unifying vision for the site's energy future and identifies the most beneficial opportunities for energy efficiency and efficient energy supply options. Phase two of the study is to develop this document, the *Energy Integration Resiliency Framework (Framework,)* which provides more details about how the County, the City, and

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the JDA can technically achieve the vision and recommendations put forth in the *White Paper*. The Framework focuses on determining which energy supply technologies can be built during the early phases of site development and would be financially beneficial, financeable, practical, and achievable. The Framework also provides more detailed analysis of the optimal initial energy efficiency strategies, including demand-side management, advanced technology, and building design. Each of these opportunities is considered with the goals, benefits, and risks for the County, City, JDA, ERAB, the MNARNG, and Xcel Energy in mind.

Through the development of the *White Paper*, the ERAB outlined their vision and guiding principles for TCAAP energy development.

Vision Statement

TCAAP will be a vibrant development that leverages long-term energy conservation and resilience to attract investment and partnership, and achieves sustainable benefits for Arden Hills and the surrounding community.

Guiding Principles

- Establish TCAAP as a national model for development of integrated energy systems
- Develop a resilient community for energy and other utilities
- Implement infrastructure solutions that are flexible and scalable over the next 50 years
- Deliver a model of efficient energy and water usage that minimizes TCAAP's impact on the environment
- Create an economically competitive and attractive environment for developers and businesses

2. Partnership Opportunities

2.1. Background

The TCAAP EIRF Project Team met with members of the Minnesota Army National Guard staff to discuss the potential for working together to meet the energy needs and goals of both sites. In those meetings, it was found that the goals of the MNARNG are very similar to the energy vision established by the ERAB. Together, the MNARNG and the Project Team identified several energy-supply opportunities that should be pursued, including solar photovoltaic (PV), combined heat and power

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(CHP) generation, energy capture from treated groundwater, and thermal energy storage. In addition, the parties identified several opportunities for collaboration on energy efficiency improvements and demand-side management.

The Project Team has also engaged in discussions between the County, the MNARNG, and Xcel Energy to gauge the utility's interest in each of these opportunities. Xcel Energy has expressed interest or support of each option, with further details provided in the following sections.

The remainder of Section 2 provides further details on each of the partnership opportunities identified in the conceptual map provided in Exhibit I.

2.2. Energy Loads

Following the development of the *White Paper*, the Project Team refined the estimated loads for the TCAAP site to reflect the changes to the TCAAP Redevelopment Plan. The Project Team also collaborated with the MNARNG to understand the energy needs of current and future buildings on the AHATS site. In addition to the AHATS and TCAAP sites, the Project Team identified one existing campus and one possible future campus that could be connected to the proposed system. The RCPW facility on County Highway 96 is an existing facility adjacent to AHATS and TCAAP that could be integrated with the initial system.

In the Primer Tracer area on the north edge of TCAAP and AHATS, the Department of Public Safety facility is contemplating the installation of an emergency operations facility that, if built, could be a strong candidate for connecting to the proposed system.

The Project Team also worked with Xcel Energy to estimate energy loads that were in line with energy usage in Minnesota. The estimated loads for all prospective customer areas are provided in Table 1.

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Estimated Energy Loads			
	Electric	Thermal	Cooling
TCAAP	8.0 ¹ MW	38.9 ¹ MMBtu/hour	617 ¹ tons
AHATS	3.4 MW	7.3 MMBtu/hour	500 tons
DPS EOC	0.07 MW	0.5 MMBtu/hour	30 tons
RCPW	0.40 MW	4.1 MMBtu/hour	240 tons
Estimated Total	11.9 MW	50.8 MMBtu/hour	1,387 tons

Note:

¹ Loads are estimated based upon the current projection of land use.

Table 1: Total estimated energy loads

2.3. AHATS Considerations

Through initial discussions with the MNARNG, the following considerations were identified as being important components of energy plan development for the MNARNG:

- The MNARNG has net-zero goals for energy, water, and waste.
- The MNARNG intends to develop an energy resiliency plan for periods of grid outage in order to meet mission requirements, including the ability to be disconnected from the larger grid.
- The MNARNG will need to receive benefit for any opportunity that is developed on its property.
- The development must not be intrusive or obstruct the training at AHATS.
- Funding is limited for the MNARNG. Third-party financing is preferred.
- Third-party operations and maintenance of the installed systems is preferred.

These fundamental goals will continue to drive much of the partnership discussions with the MNARNG and have been included in the planning for the options provided in this Framework.

2.4. Xcel Energy Considerations

TCAAP provides an opportunity for Xcel Energy to pilot advanced energy solutions that will help them meet and exceed their Minnesota energy efficiency and renewable energy goals. Through discussions with Xcel Energy, the Project Team has identified the following considerations that will be important through the course of development:

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- Consideration should be given to the potential for an Xcel Energy-owned community solar garden, which could expedite development, minimize potential risks, and visibly demonstrate partnership linkages at the TCAAP site.
- Xcel Energy would be an important support partner in any innovative energy demonstration projects at the site, and for investments at TCAAP that would help the utility further its statewide efficiency or renewable energy goals.
- As a regulated utility, Xcel Energy's investments into the TCAAP site are more likely to be supported if the ERAB, JDA, and other local partners would advocate for these investments and partnerships with the Public Utilities Commission.

Xcel Energy leadership has expressed a commitment to partnering with the County and the JDA in the implementation of the TCAAP energy plan, and the County should continue to pursue opportunities that can benefit both parties and achieve the energy vision for TCAAP.

2.5. Near-Term Partnership Opportunities

Through partnership discussions, a number of immediate and implementable partnership opportunities were identified to meet the loads of the buildings that are currently in the area, as well as the initial buildings expected to be built at TCAAP. The related technologies are introduced in this section and further explored later within the Framework.

2.5.1. Solar PV

2.5.1.1. Primer Tracer

The Primer Tracer area neighboring the AHATS and TCAAP sites is currently an area with soil contamination that requires remediation to be suitable for development. The Army Corps of Engineers has shown interest in having this site cleaned up and put to productive use, and it does present a good opportunity for the construction of a solar PV site because of the limited excavation, maintenance, and human interaction that is necessary. The site is approximately 60 acres in size, with 20 acres being considered for the Department of Public Safety State Emergency Operations Center. This would leave 40 acres for a large-scale solar installation. Based on generally accepted solar generation estimates, this 40-acre site could generate approximately 8 megawatts of electricity (MWe) in peak conditions, depending on the technology and system installed. Conservatively, this could account for approximately 70% of the peak electric load for the area.

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2.5.1.2. AHATS Solar PV

The 2009 Master Plan for AHATS produced by Jacobs Engineering identifies a two MWe solar PV installation at the capped soil area west of the existing Field Maintenance Shop. This installation would primarily meet a portion of the electric needs of the AHATS site, but could provide renewable electric energy to TCAAP during the non-peak energy usage times at AHATS.

2.5.2. Combined Heat and Power

Combined heat and power (CHP) could be used to meet the electric needs of TCAAP and adjacent properties, while simultaneously capturing the thermal energy created from electric generation to meet the thermal needs of the area. This would provide a local energy generation source to the area that could be disconnected from the grid in the event of a grid disruption. As the existing electric and thermal energy loads are based at the AHATS and RCPW buildings, it would be optimal to locate the initial CHP plant as close to those buildings as possible, with the opportunity of expanding it to meet future TCAAP energy needs. This initial proposed location provides two advantages. First, having the plant located near the initial load will reduce the up-front capital cost for the installation of the distribution network providing thermal energy. Second, this location is near the existing and proposed AHATS buildings, meaning that training operations (located in the central and northern areas of AHATS) would not be negatively impacted. Additional CHP facilities could be located in the Thumb area of TCAAP, or near other concentrated loads at TCAAP as development proceeds. The CHP system should be designed to allow for expansion to serve the thermal needs of the TCAAP site as it is developed, to align with the vision of TCAAP as a comprehensive energy program that optimizes efficiencies, minimizes costs, and reduces greenhouse gas emissions. The initial system should also be designed for future fuel flexibility, such as biogas integration, and the ability to meet growing thermal needs of the area.

2.5.3. Groundwater Treatment Station

Approximately two million gallons per day (2 MGD) are pumped to AHATS from the groundwater treatment station located on TCAAP. This pumping is required to continue until the chemical remediation goals are reached for the water, which is estimated to be at least another 25-30 years. This groundwater pumping can be useful to meet the energy goals of both AHATS and TCAAP through the implementation of a low-temperature district energy system.

In addition, kinetic energy could be captured from the pumped water at the point of discharge at the gravel pit on the AHATS site. The water is being pumped uphill to a point that provides energy which potentially could be used for micro-hydroelectric generation. This would provide a small amount of electric generation, but could be used to offset the power necessary to pump the groundwater.

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The temperature of the water in this loop is close to 52° F throughout the year. Assuming a thermal energy transfer of 11° F, the energy in the water per hour is estimated to be approximately 10 MMBtu/hour. This energy would be enough to meet the heating and cooling needs of the residential neighborhoods of TCAAP, with approximately 3 MMBtu/hour of excess capacity available for AHATS or additional TCAAP buildings. When groundwater remediation is completed, the district energy infrastructure could be utilized to distribute energy from other sources such as low-grade waste heat recovery or geothermal wells.

2.6. Future Potential Opportunities

2.6.1. Thermal Energy Storage

On the AHATS site, there is an existing one million gallon water storage tank, and related water distribution piping, that was originally used during ammunitions manufacturing. The tank was built with adequate ground cover to prevent water from freezing in the winter. This tank could be used as a thermal energy storage tank to store water for the heating and cooling needs of the area. This would work like a battery, which would fill up during non-peak energy hours and be discharged during peak energy usage times to balance out the energy usage profile for the area. The size, shape, and structural condition of the tank need to be studied to judge the feasibility of this opportunity. It is likely that the tank would require the installation of a liner or bladder to be able to hold water. While utilization of this tank is not included in any of the immediate options detailed in this Framework, it is a valuable asset that should be contemplated as each energy option is further developed, and as TCAAP redevelopment progresses.

2.6.2. Solar Thermal

Solar thermal systems are most commonly installed on residential and small commercial buildings, although larger shared systems are gaining popularity. Solar thermal systems are comprised of solar collectors and a fluid moving between the collectors and a hot water reservoir. Typically the heated fluid is pumped from the tank to a heat exchanger where heat is extracted into the air to heat space or domestic hot water. Solar thermal systems are highly efficient in their ability to capture and transfer solar energy.

When included as part of a broader energy plan, benefits of a solar-thermal system can be enhanced. For example, solar thermal can be paired with thermal storage to capture excess energy when it is available and dispatch to users during higher demand periods. The MNARNG utilizes solar thermal technology on its buildings and is investigating further integration of it as their site is built out. Solar thermal is not a priority recommendation for initial implementation, but this technology should be considered for individual sites or as part of a larger energy plan as TCAAP development progresses.

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3. Energy Source Implementation

As outlined in the partnership section, there are immense opportunities for technology development at TCAAP. The success of their implementation hinges on the effectiveness of partnerships and incorporating the right technology solution for the right project within the development. The technologies recommended in the following section were selected to fit the partner interests, development timeline, and both environmental and economic goals. This includes the reduction of greenhouse gas emissions. Through the implementation of the energy supply opportunities presented in this section, the TCAAP development will be poised to reduce the amount of CO₂ emitted into the atmosphere as the equivalent amount of CO₂ produced by 1625 automobiles³.

Greenhouse Gas Emissions Reduction Summary		
	Annual CO ₂ Reductions	% Reduction from traditional scenarios
Solar PV	7,524 (tons CO ₂ /yr)	100%
CHP	676 (tons CO ₂ /yr)	19%
Low Temp District Energy	310 (tons CO ₂ /yr)	29%
Totals	8,510 (tons CO ₂ /yr)	70%

Table 2: Greenhouse Gas Emission Reduction Summary

The environmental benefits shown in Table 2 will be further increased through implementation of demand-side management strategies outlined in section 4, and will lead to more sustainable redevelopment of TCAAP. This combination of responsible energy supply opportunities, sustainable building practices, effective demand side management, continuous commissioning of building systems, and improving occupant awareness set the stage for the possibility of the entire development being carbon-neutral in the future.

3.1. Solar PV

As noted in the *White Paper*, the utilization of solar PV technology can enable the generation and utilization of renewable energy at TCAAP. While individual property owners could choose to install roof-mounted or ground-mounted solar PV systems for some of their site needs,



³ <http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results>

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another possibility would be to install a large-scale community solar array adjacent to the TCAAP site.

3.1.1. Introduction

The most prime opportunity for solar PV is likely within the Primer Tracer area north east of the existing TCAAP site. The array, as proposed, would reach a peak of approximately 8MWe of solar PV generation, which would produce approximately 14,500,000 AC kWh of energy annually. The project could be financed by Xcel Energy or a third party developer through a combination of debt and equity, with the land leased from the County or the MNARNG. The project owner could utilize available tax incentives such as the 30% investment tax credit and 5-year accelerated depreciation to help offset the cost of the project and lower the cost of energy from the array. Electric energy sales and associated revenues could be generated from subscribers' purchases or lease interests of the solar garden system through Xcel Energy's existing community solar garden program. Alternatively, Xcel Energy could own, develop, and sell the energy from the project.

3.1.2. Implementation Strategy

3.1.2.1. Existing Project Site

Between 40 and 60 acres of land are available for the preliminary development of a solar PV array. This plot of land is relatively flat, with minimal elevation change from north to south or east to west. Although a detailed siting study was not conducted, the site characteristics determined by a Google Earth analysis all point to a feasible site with significant potential. This solar array would be built atop land with existing structures currently in place. These structures would be demolished and removed as part of the solar project construction. Current structures, above and below grade would need to be removed to a depth of approximately five feet.

3.1.2.2. Conceptual Solar Plant Site Layout

A conceptual layout of an 8 megawatt alternating current (MW_{AC}) capacity solar PV array was prepared on the proposed parcel of land to assess feasibility of this installation on a 40 acre site. If all 60 acres are able to be utilized, the array could be increased to 12 MW_{AC} . The array would consist of eight, 1 MW_{AC} (1.3 megawatts of direct current - MW_{DC}) blocks. Table 3 outlines the high-level plant characteristics for this potential array.

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Characteristic	Value
Plant Capacity (AC)	8MW
Plant Capacity (DC)	10.4MW
Block Capacity (AC/DC)	1MWAC/1.3MWDC
Module	310W poly-crystalline
Inverter	1 – 1000kW Central Inverter/block
Racking System	Fixed-Tilt @ 30°
Pitch	26.2 ft
Internal Access Roads	Inverter Access Roads: 30 ft All other internal roads: 16 ft

Table 3: Solar plant characteristics

A high-level representation of a potential site configuration is shown in Figure 1. Figure 1 depicts the manner in which an 8 MW_{AC} capacity plant might be laid out on these 40 acres, but detailed design will need to confirm this configuration.

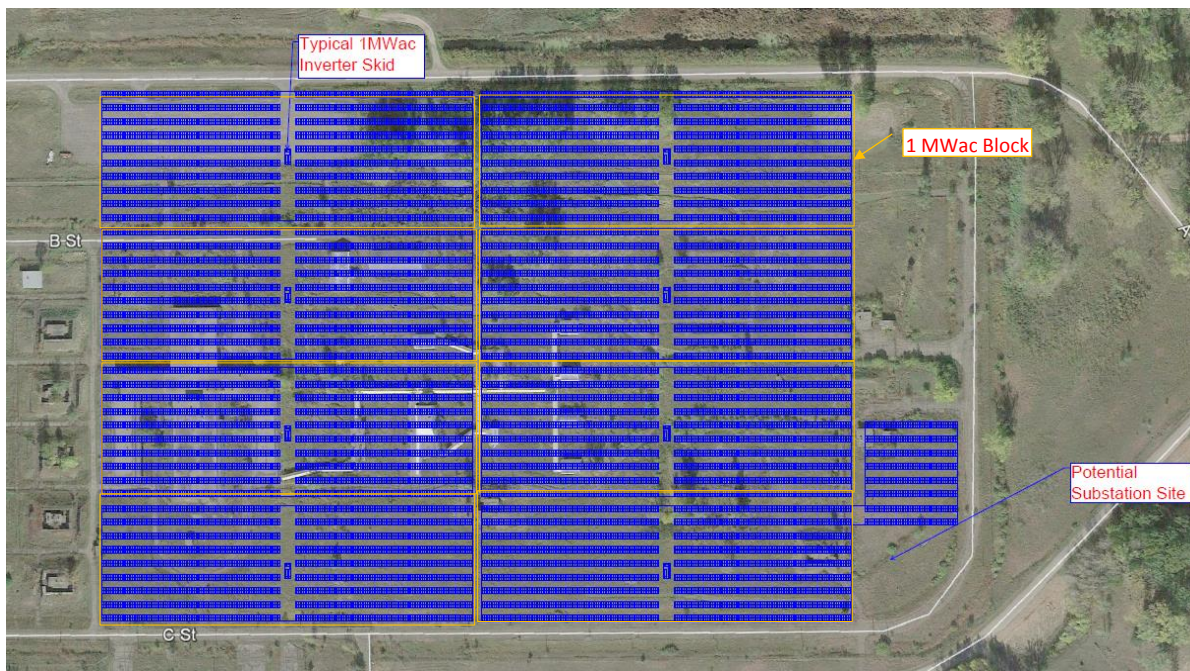


Figure 1: Solar PV plant conceptual site layout

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3.1.3. Economic Analysis

3.1.3.1. PV System Components

Solar PV power plants are simple in their operation. The main components of a solar PV plant include PV Modules, racking, inverters, transformers, combiner boxes, DC cabling and AC cabling. The modules convert the solar irradiance to DC power. A collection of modules are electrically wired together to form what is referred to as a “string.” Multiple strings are combined together into a single DC output in a combiner box. All outputs from the combiner boxes in a block are run to a central skid where they are connected to the inverter. The inverter converts the DC module power into AC power and feeds the AC output through a medium-voltage (MV) transformer. This transformer steps-up the inverter voltage to the solar arrays main collection system voltage. The inverters and medium-voltage transformers are often co-located on a platform referred to as the power conversation station, sometimes referred to as a skid. If a site has a local substation, then all the outputs from the skids feed into the substation where a generator step-up unit outputs the main interconnection voltage.

Racking is an integral part of any solar plant as it provides the support for the modules. In addition to proving a fixed point to which the modules are attached, racking serves as the means to optimize the angle between module surfaces and the solar irradiance. This angle has significant impacts on a solar plant’s energy production. There are two main classes of racking systems, tracking and fixed-tilt, the latter of which was used in this layout.

3.1.3.2. Capital and Operations and Maintenance Costs

The upfront capital construction costs are incurred during the development and construction of the plant. These costs include material costs, installation costs, contractor markup, and project indirect costs. The capital costs are impacted by relative system size (larger systems have the benefit of economies of scale), project location, and a collection of market factors. Project capital costs are commonly presented as a cost per installed watt basis (\$/W). This allows for project costs to be expressed independently of system size and provides for an easy comparison of costs for systems with difference characteristics. In addition to the cost of the solar PV array, the existing Primer Tracer site will need to have the existing infrastructure removed and the site will need to be redeveloped, before the project can be constructed. The land acquisition is expected to occur through a public benefit sale from the U.S. Government if the County acquired the property. If the MNARNG took possession it would be included in their license and remain in the ownership of the U.S. Government. The cost of the land acquisition is anticipated to be \$0 due to the nature of the site and the proposed usage. It is assumed that there will be no property taxes levied against the properties as the land owner will be a government entity. The estimated cost to remove the existing infrastructure and redevelop the 40

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acres selected for the solar PV plant project is \$1,250,000. For this analysis, the cost has been assumed to be incurred by the project; however other sources of funding may be available.

Operation and maintenance (O&M) costs are incurred on an annual basis and are the costs associated with keeping the plant in proper working order. Common tasks associated with annual O&M activities include preventative maintenance, inspection, and corrective maintenance. O&M costs are often presented as a cost per installed kilo-Watt (\$/kW) to be incurred every year. When presented as a \$/kW cost, it is assumed that this cost will be incurred annually.

Table 4 provides an approximation of capital costs and O&M costs for the proposed 8MWac system.

Solar PV Costs	\$/W	Total
Solar PV Plant Cost	\$2.10/W _{DC} ; \$2.73/W _{AC}	\$21,850,000
Site Redevelopment Cost	\$0.12/ W _{DC} ; \$0.13/ W _{AC}	\$1,250,000
Total Project Capital Cost	\$2.22/W_{DC}; \$2.86/W_{AC}	\$23,100,000
O&M Cost	\$16/kW _{AC} /year	\$128,000/year

Table 4: Proposed solar PV capital, operation, and maintenance costs

3.1.4. Solar Resource Assessment and Energy Production

The annual energy production for the proposed array can be estimated with the use of the National Renewable Energy Laboratory (NREL) Solar Advisor Model (SAM). SAM uses a collection of input parameters to construct a model of the PV plant and analyze the energy production characteristics. These input parameters include: site location and meteorological data, module characteristics, inverter performance characteristics, solar array dimensions, system losses, and a collection of financial parameters. Using this information, SAM constructs a model of the solar arrays and then predicts plant performance over a typical meteorological year. The basic technical assumptions that were utilized to estimate the solar resource assessment and annual energy production from the solar array are provided in Table 5.

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Modules	Parameters
Cell material Multi-c-Si	St. Paul, MN Weather Data
Module area 1.9 m ²	Tilt (deg from horizontal) 30
Module capacity 305 DC Watts	Azimuth (deg E of N) 180
Quantity 34,083	Tracking – Fixed
Total capacity 10.4 DC MW / 8.0 AC MW	Shading – No
Total area 65,473 m ²	Soiling – Yes
	DC Losses (%) 3.0
Inverters	Annual Results (in Year 1)
Custom (Inverter Datasheet Model)	Horizontal solar 1,364 kW/m ²
Unit capacity 1000 AC kW	Incident solar 1,604 kW/m ²
Input voltage 620 DC V	Net to inverter 15,130,000 DC kWh
Quantity 8	Gross from inverter 14,675,000 AC kWh
Total capacity 8 AC MW	Net to grid 14,456,000 AC kWh
DC to AC Capacity Ratio 1.30	Capacity factor 15.9%
AC losses (%) 1.5	

Table 5: Solar advisor model solar resource and energy performance assumptions

Figure 2 shows the predicted net AC and DC energy production from the modeled solar resource. The AC energy levels are indicative of the energy exported to the grid at the point of interconnect. All system losses, both AC and DC, with the exception of substation and transmission line losses, have been taken into account.

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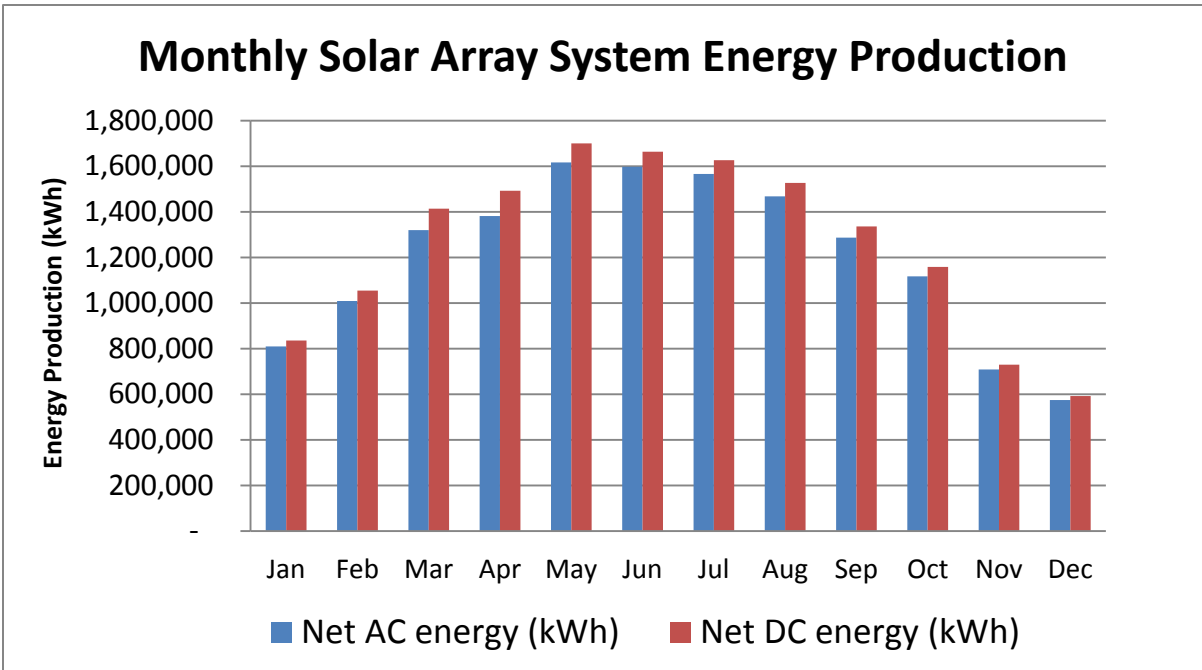


Figure 2: Solar advisor model solar energy production results

3.1.5. Financial Assumptions and Economics

SAM was used to estimate the levelized cost of energy (LCOE) and estimated price for the energy from the proposed solar plant project. The project is assumed to be financed by a developer who would be paid through subscriptions by consumers where the third party (a tax-paying entity) owns the solar plant on land leased from the County. Subscriptions with Xcel Energy retail customers are assumed to be established under the Xcel Energy Solar*Rewards® Community® solar program. The developer would utilize the federal investment tax credit, accelerated depreciation, and a combination of debt and equity to fund the solar project. The key financial assumptions are provided in Table 6. If Xcel Energy were to own the project, these financial projections would likely need to be modified.

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Project Costs Total installed cost \$23,100,000 Salvage value \$809,000	Project Debt Parameters Debt fraction 57% Amount \$13,600,000 Rate / Term 25 years, 5%
Analysis Parameters Project life 25 years Inflation rate 2.5% Real discount rate 8.2%	Tax and Insurance Rates (% of installed cost) Federal income tax 35%/year State income tax 7%/year Sales tax 0% Insurance 0.5%/year Property tax (% of assess. val.) 0%/year
Financial Targets and Constraints Solution mode Calculate Subscription Price Target IRR 10% in Year 25	Incentives Federal ITC 30% (Expires 12-31-16) Depreciation allocations defined. 5 year MACRS

Table 6: Solar advisor model financial assumptions

Based upon an assumed IRR of 10% for the project developer and other noted assumptions, the Project Team estimated a subscription price for the solar energy of \$0.129 cents/kWh (as shown in Table 7). Xcel Energy retail customers who subscribe to production from the proposed solar garden under individual subscriptions would receive a bill credit equal to the energy purchased multiplied by the retail rates.

Solar Economic Results	
25-Year Nominal LCOE	13.90 cents/kWh
Solar revenues (year one)	\$1,865,000
Project 25-year IRR	10%
Subscription price	12.90 cents/kWh ¹

Note:

1. Subscription price does not include additional \$0.02/kWh bill credit provided if RECs are owned by Xcel Energy

Table 7: Solar advisor model economic results

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3.1.6. Greenhouse Gas Emission Reductions

Implementing a solar PV array in the Primer Tracer area will result in a reduction of greenhouse gas emissions. Electricity offset by the solar output would be reduced to zero tons of CO₂ per year. The estimated greenhouse gas emission reduction is estimated to be 7,524 tons CO₂/year, calculated by comparing the current Xcel Energy emission rates for the production of electricity in the Upper Midwest Region (1,041 CO₂ lbs/MWh⁴) as detailed in Table 8.

Solar PV Greenhouse Gas Emissions Reduction	
Solar Electric Generation	14,456 MWh
Eliminated Electric Utility Emissions	1,041 lbs CO ₂ /MWh
Total CO₂ Emissions Savings per Year	7,524 tons CO₂/year

Table 8: Estimated annual carbon dioxide emissions reduction

3.1.7. Community Solar Garden Program Approach

The modeled subscription rate for solar PV assumes that solar garden developers would elect to sell the Renewable Energy Credits (RECs) to Xcel Energy, for subscribers to receive a \$0.02/kWh enhanced bill credit. If the developer were to retain the RECs for this system, the bill credit would decrease by 2 cents/kWh. The estimated subscription rate is slightly less than the current Xcel Energy average Residential and General Service bill credits; however that difference will increase over time if Xcel Energy applicable retail rates increase and the subscription rate remains fixed. Table 9 shows how this estimated first year subscription price for the electricity generated by the solar garden compares to the Xcel Energy bill credit rates for three types of Xcel Energy customers. It is assumed that the economic benefits of the solar garden subscription would improve as the electricity rate increases over the life of the subscription.

⁴ <https://www.xcelenergy.com/staticfiles/xcel/Corporate/CRR2013/environment/emissions-reporting.html>

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Rate Category	Solar Subscription (\$/kWh)	First Year Bill Credit (\$/kWh)	First Year Savings (Cost) (\$/kWh)
Xcel Energy Residential	\$0.1290	\$0.1403	\$0.0113
Xcel Energy Small General Service	\$ 0.1290	\$0.1378	\$0.0088
Xcel Energy General Service	\$0.1290	\$0.1146	\$(0.0144)

Table 9: Solar subscription and Xcel Energy bill credit comparison (REC's retained by Xcel Energy)

For the solar PV project to be developed under the Xcel Energy Solar*Rewards® Community® solar program, it will be important for the developer to have several large credit-worthy subscribers secured to allow the project to be financed at a low cost of debt. This could include the City of Arden Hills, Ramsey County, the MNARNG, and other credit-worthy businesses in the area. Once the project has secured a large portion of the revenue stream from project subscribers, the project can be financed and developed with the potential for future residents and businesses to join as subscribers in the future. \ process for developing and preparing the necessary applications for the project will need to follow the guidelines outlined in the Xcel Energy Solar*Rewards® Community® solar program⁵.

3.1.8. Next Steps

In order to capture the 30% Investment Tax Credit associated with community solar gardens, the proposed system must be in service by December 31, 2016. As such, implementation of this strategy must commence as soon as possible, and the following steps should be taken to continue development:

- Step 1** – Begin the land redevelopment process and secure funding approval. The County and the MNARNG, as potential property owners, will play key roles in this process, as a potential property owner.
- Step 2** – Secure a development partner to move the project through necessary stages of development. This could be either Xcel Energy or another solar developer, who could be selected by issuing an RFP for prospective developers.
- Step 3** – The solar garden developer will need to obtain letters of commitment from large solar garden subscribers to initiate the necessary business and financing structure. The

⁵ (2015, 02 23). Retrieved 02 23, 2015, from Xcel Solar Rewards Community:
http://www.xcelenergy.com/Energy_Solutions/Business_Solutions/Renewable_Solutions/SolarRewards_Community-MN

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County, City, JDA, MNARNG, the school district, and other partners could work with the selected developer to form an initial coalition of subscribers for the system.

3.2. Combined Heat and Power

3.2.1. Introduction

The vision for TCAAP is that the Thumb, Town Center, and Flex areas could be served by a CHP energy system located at the TCAAP site or nearby. This localized energy source would enable achievement of many of the guiding principles established by the ERAB. The MNARNG has a similar energy vision for the AHATS site, and the partnership potential for a CHP system is very attractive. The Project Team recommends that the JDA and County collaborate with the MNARNG and Xcel Energy to define a preferred initial CHP strategy, considering the following:

- Collaboration between the JDA, the County, Xcel Energy, and the MNARNG could help identify an operational strategy and location for the initial CHP that is beneficial for all parties.
- Incorporation of a CHP system that meets the energy needs of all three sites would improve the economic competitiveness of CHP, due to the potential diversity of usage and load profiles.
- Due to regulatory statutes, Xcel Energy has the exclusive authority to distribute and sell electricity across multiple properties in Arden Hills. If Xcel Energy is the owner, the CHP system could function as a microgrid system for the area, providing a local energy source for reliable electric and thermal energy for TCAAP, RCPW, and the MNARNG in the event of a grid disruption, meeting the goals of each of the sites.
- In the event that Xcel Energy is not the owner of the CHP, the proposed system may only distribute thermal energy across property lines, unless the electricity is sold to the Midwest Independent System Operators (MISO), in which case there would be an additional cost for the use of Xcel's infrastructure, which may prove to be cost prohibitive depending on the production cost and market dynamics.

While construction of independent CHP systems on both the TCAAP and AHATS sites could potentially be feasible, the economics of a connected system would be much more beneficial to both sites. However, the current uncertainty regarding the timing and type of TCAAP development restricts the opportunity to perform a complete evaluation of a CHP and district energy system for TCAAP at this time. With the unknown development conditions of TCAAP in mind, the Project Team has evaluated a scenario for CHP implementation in the Thumb and Town areas of TCAAP based on the assumed energy loads and envisioning how a CHP system could be implemented in the Thumb.

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3.2.2. Initial Proposed CHP

An initial step toward a more comprehensive microgrid could be a small-scale CHP system that serves the existing loads of the Thumb and Town areas, as shown in Figure 3. The initial CHP plant could be located within the corporate campus area of the Thumb, which would provide the advantage of reducing the up-front capital cost for the installation of the distribution network providing thermal energy to the corporate campus and the Town. The CHP plant could be designed to allow for the integration of multiple fuel sources in the future to further increase renewable generation and system sustainability. Additionally, the CHP plant and district heating network, as proposed, could be designed to allow for expansion to serve additional buildings.

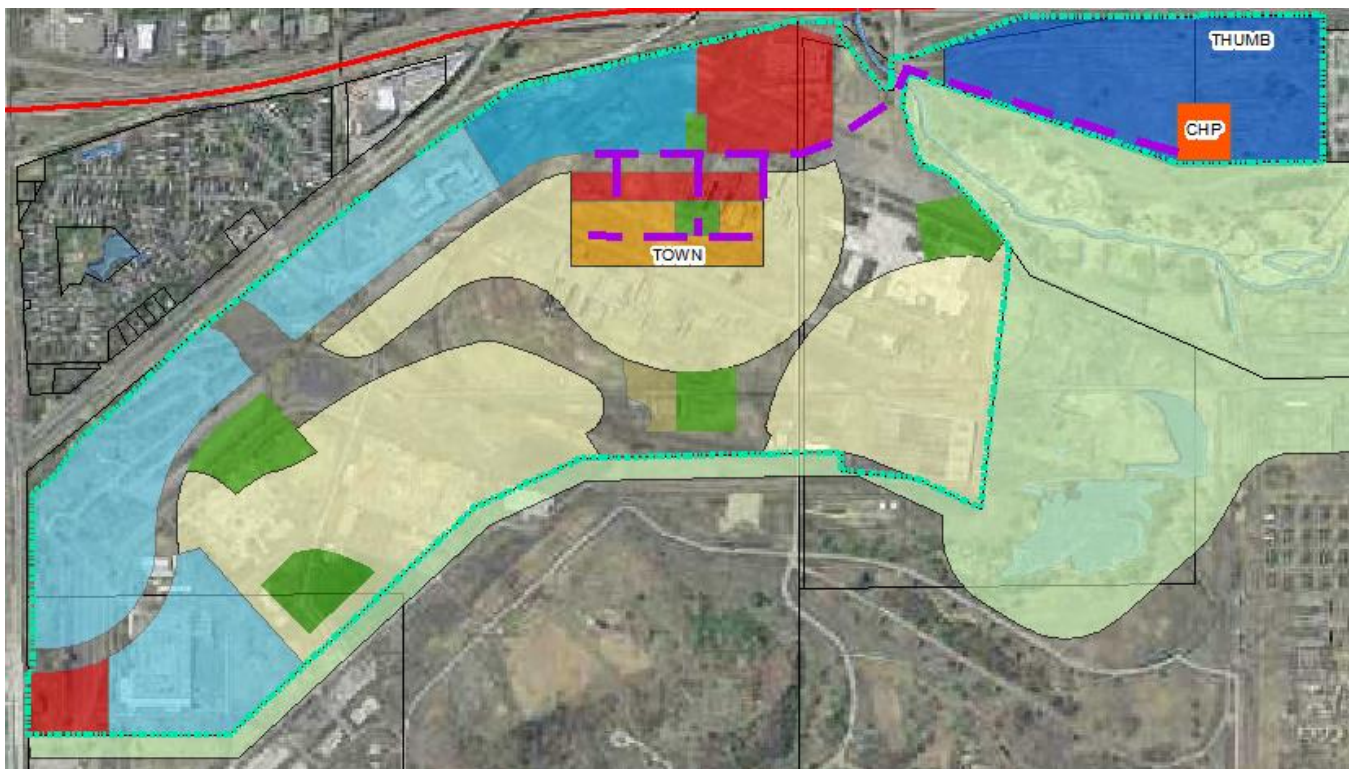


Figure 3: Initial potential CHP location and distribution plan north TCAAP

As TCAAP development progresses southward, those additional properties could also be served from the CHP facility in the Thumb by extending piping to those buildings in the Spine Road right of way, and expanding the capacity of the CHP.

In the next stage of CHP development, the design team should carefully analyze the pros and cons of the CHP application, and work with the JDA, County, and potential Thumb developers to determine the

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optimal location and operational strategy for the initial CHP system. Regardless of the system's initial configuration and location, the CHP design should allow for expansion to produce more electricity and thermal energy as energy demand in the area increases with TCAAP development. Expansion could also enable the development of a more comprehensive microgrid that would meet the MNARNG's resiliency goals and the TCAAP energy vision.

3.2.3. Development Strategy

3.2.3.1. Load Analysis

Before selecting the appropriate technology and size for a proposed CHP plant, a careful review of the potential electric and thermal loads must be considered. The proposed CHP project would be developed to serve the future electrical load of the Thumb area as well as the combined thermal loads of the Thumb and the adjacent Town area. A summary of the potential thermal and electric loads that the initial plant could serve is shown in Table 10.

	Annual Energy Usage	Annual Electrical Usage	Peak Energy Usage	Peak Electrical Usage
Town	12,485 MMBtu	2,561,111 kWh	4.06 MMBtu/hr	0.41 MW
Thumb	6,096 MMBtu	4,172,302 kWh	3.33 MMBtu/hr	1.19 MW

Table 10: Monthly Projected Energy Usage

The monthly aggregated load profiles are presented in Figure 4 and Figure 5. The Project Team assumed that the load profile for these areas would follow normal patterns of use for commercial buildings.

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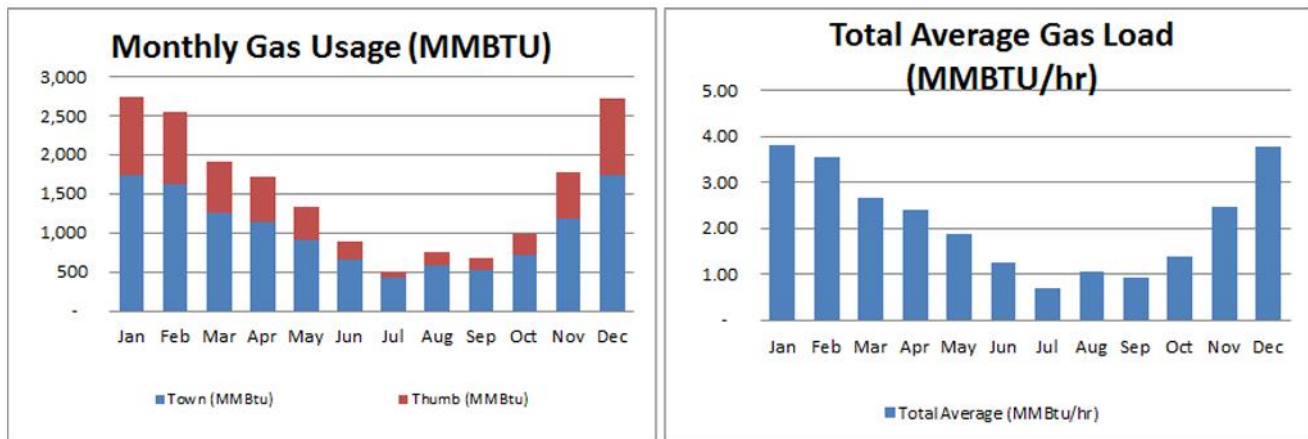


Figure 4: Monthly site gas usage

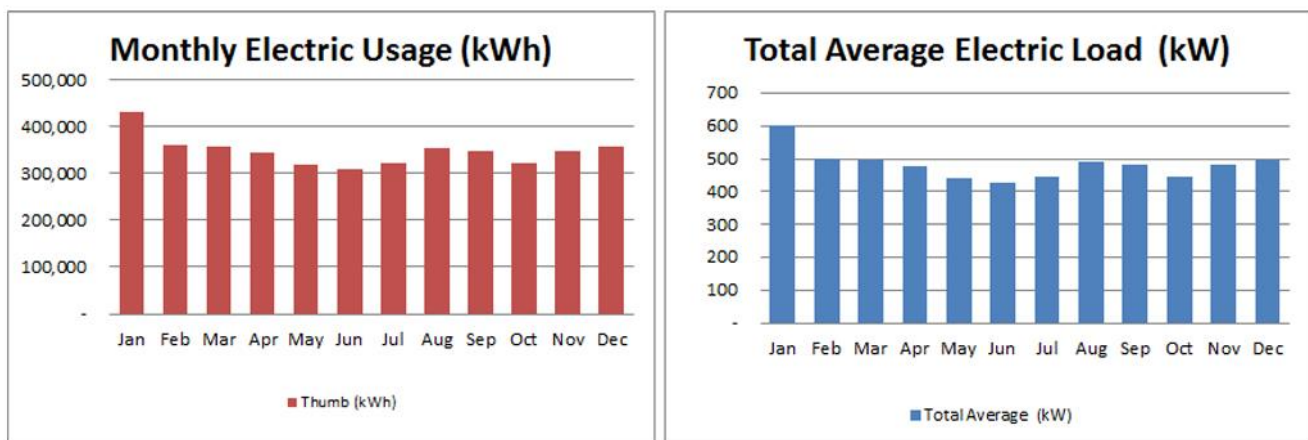


Figure 5: Monthly total site electric usage

3.2.3.2. CHP Technology Selection

Based on a review of the future electric load of the Thumb area and the thermal loads of the Town and Thumb areas, the CHP plant should have a maximum generator output no greater than 450 kW. For CHP applications in this size range, the most efficient and economical technology employed is gas fired reciprocating engines, with hot water heat recovery. Additionally, due to the limited heating load available during the summer months, it is generally more economical to employ a generation technology that has a high simple cycle efficiency resulting in a production cost lower than the utility's retail electric rate.

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For the proposed initial CHP, the Project Team assumed that a gas-fired reciprocating engine genset could provide 335 kW of electric power year round with approximately 1,372 MMBtu/hr of waste heat that would be available throughout the year. The waste heat would be utilized to offset hot water production in the existing buildings' boilers during the winter, spring, and fall. The waste heat from the CHP during the summer months would be exhausted and the plant would run in simple cycle mode at a production cost lower than the cost of purchased grid power. In the event that a year-round process heating load is added in the Thumb, additional thermal energy could be captured from the CHP and utilized, improving system economics, efficiencies, and environmental benefits. Figure 6 and Figure 7 provide a representative monthly dispatch chart showing how the plant would provide power and thermal energy to the site.

In the event that a year-round process heating load is added in the Thumb, additional thermal energy could be captured from the CHP and utilized, improving system economics, efficiencies, and environmental benefits.

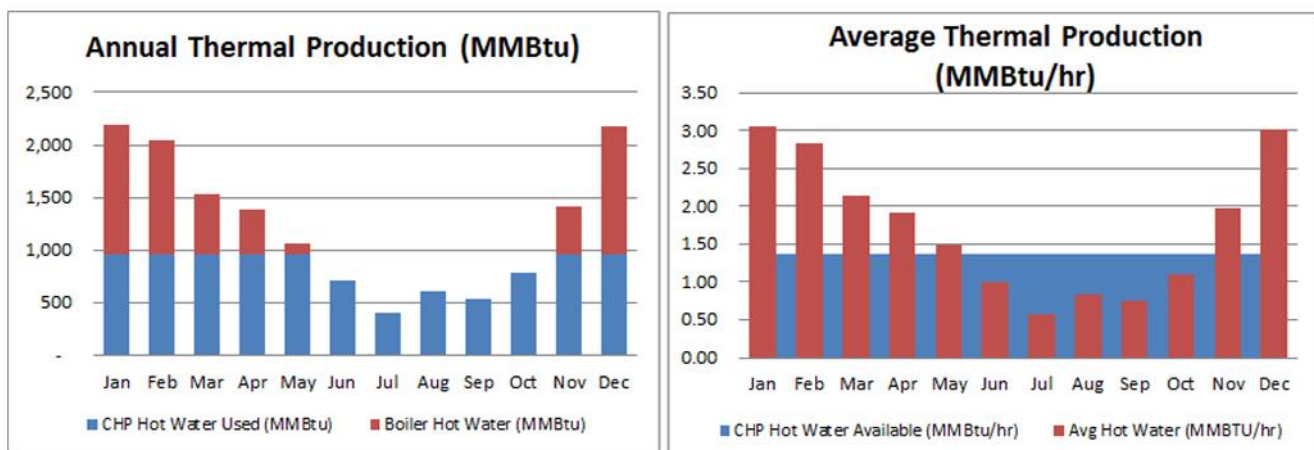


Figure 6: Monthly site thermal energy production by resource

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Energy Source Implementation

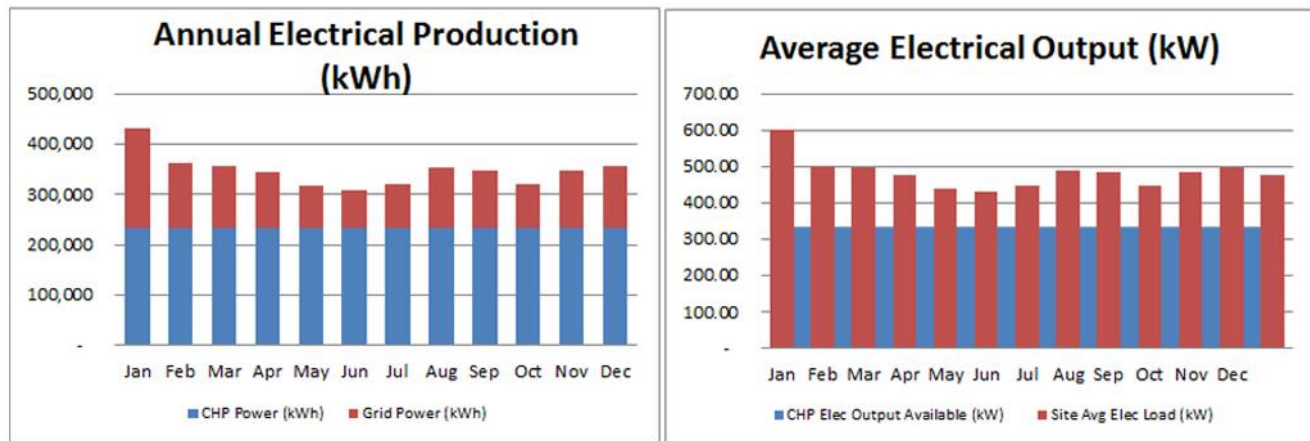


Figure 7: Monthly site electric energy production by resource

3.2.3.3. CHP Plant System Components

One new packaged cogeneration unit could meet the energy needs presented above. Waste heat from the engine cooling water loop and engine exhaust would be recovered to produce 1,372 MMBtu/hr of hot water at full-load. The hot water would be delivered to a hot water distribution system to provide heating energy to the Thumb and Town. The engine cooling water loop would produce 180-185 degree hot water, which would be used to provide the necessary thermal energy for heating the buildings and heating domestic hot water. A supplementary radiator located atop the CHP unit would remove heat from the engine cooling water loop when there is no need for building heating during the summer months.

In addition to the CHP plant, new hot water distribution piping and pumping would need to be installed to provide hot water supply and return to the connected buildings from the CHP plant. This distribution piping is assumed to be direct buried and would be routed as efficiently as possible to each of the buildings' central mechanical rooms. The district heating building interface, based on initial site investigations, could be achieved through a direct connect interface allowing for a low-cost installation at each building. The distribution configurations shown in Figure 8 are possible layouts for the initial system, but the actual location of the plant and routing of the pipe will need to be determined in the next stage of system development.

The full-load electric output of the genset is proposed to be 335kW at 480V. The genset power is assumed to be electrically interconnected to provide power to the future facility located at the Thumb, with standby and supplemental service provided by the electrical grid. The power from the CHP plant would be delivered to each of the Thumb buildings behind the meter and would offset retail electric purchases from Xcel Energy at the existing retail rate. For the economic evaluation, it was assumed the

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Energy Source Implementation

genset would be operated at full-load with an availability of 95%. A conceptual process diagram of the proposed CHP plant is provided in Figure 8.

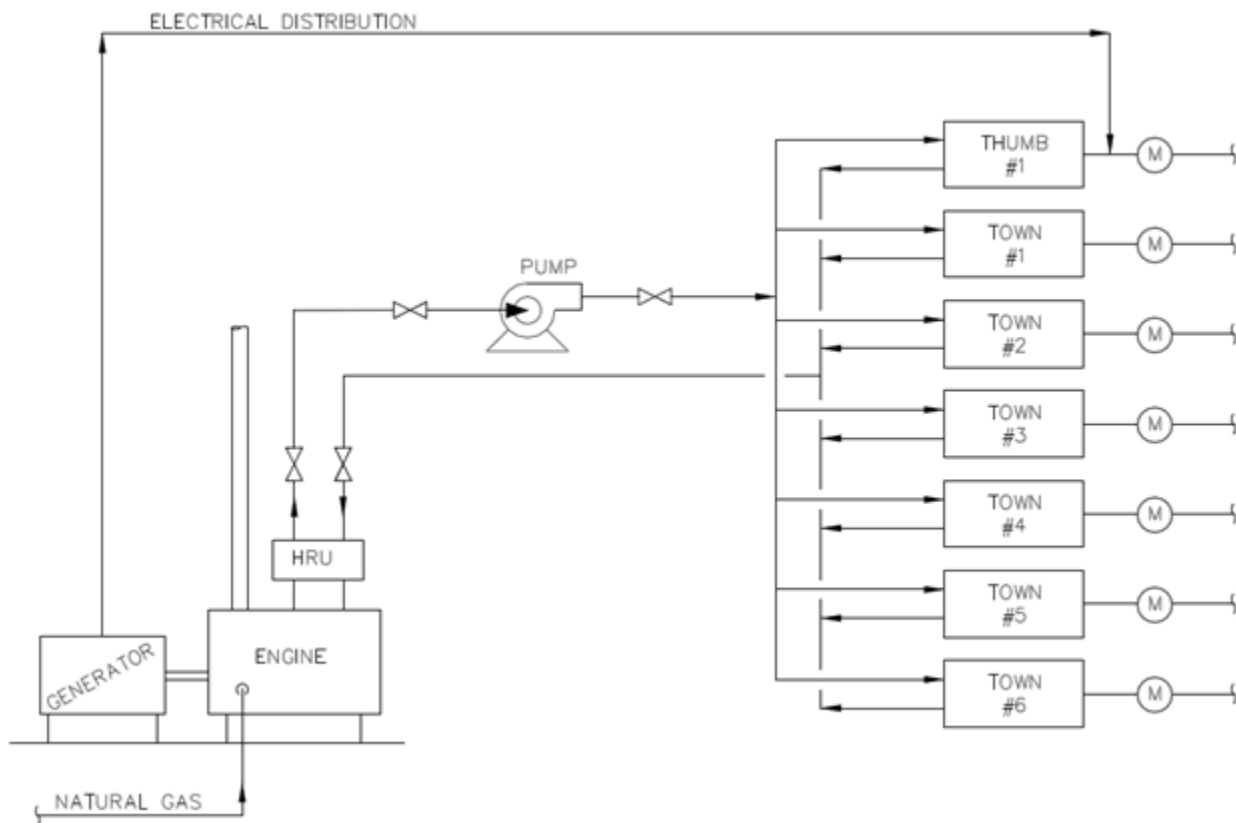


Figure 8: CHP project conceptual process diagram

The thermal needs of the Town are assumed to be met by the CHP system through the thermal energy distribution system. For the purposes of the economic model, the Project Team has assumed that Xcel Energy will not own the CHP facility and the Town will receive electricity from the electric grid. If Xcel Energy were the owner of the CHP, the initial plant size could be increased to also meet the electric needs of the Town, as well as the surrounding TCAAP developments.

3.2.4. Economic Analysis

3.2.4.1. CHP Plant System Capital and O&M Costs

Estimated costs for the CHP plant were developed based on major equipment budgetary pricing and a conceptual distribution system layout. The initial CHP project primarily consists of the CHP plant, the distribution piping connecting the buildings, and the electric infrastructure required to connect the

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output from the engine generator into the Thumb buildings. For the analysis, the Project Team has assumed that the CHP plant will be located within the Thumb to minimize the cost of electrical distribution to the corporate campus. A summary of the costs are provided in Table 11.

CHP Initial Capital Costs		
	Traditional Scenario	CHP Scenario
Heating Plant	\$800,000 ¹	\$1,800,000
HW Distribution Piping	\$0	\$2,000,000
HW Building Connections	\$0	\$120,000
Electric Distribution Infrastructure	\$0	\$700,000
Total Project Cost	\$800,000	\$4,600,000

Note:

1. Includes boiler equipment, mechanical equipment and piping, electrical connections, controls, civil construction, direct and indirect costs.

Table 11: CHP project initial capital costs

The O&M cost difference associated with the proposed CHP project would consist of a long-term service agreement for the gas fired engine. Service contracts for small gas engines can be structured on an hourly basis or annual fixed fee basis. The annual O&M cost assumed for the project is \$0.02/kWh which equals \$56,000 per year.

3.2.4.2. Financial Assumptions and Economics

CHP facilities provide energy savings greater than the traditional scenario of purchasing power from the local electric utility and generating thermal energy on-site with gas-fired or oil-fired boilers. The annual life cycle costs of the traditional scenario were compared to that of the proposed CHP plant to determine the overall savings provided by the project. At this stage in the development process, the ultimate owner of the project is yet to be determined and the capital financing structure and funding source is unknown. For the purposes of the assessment, the project was assumed to be structured as a private, non-profit, funded with a cost of capital of 4.7%, financed over 25 years, with the annual debt service paid through energy sales revenues. The basic economic assumptions for the project are provided in Table 12.

CHP facilities provide energy savings over the traditional scenario of purchasing power from the local electric utility and generating thermal energy on-site with gas-fired or oil-fired boilers.

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CHP Economic Assumptions		
	Traditional Scenario	CHP Scenario
Description	Purchased Grid Power with Gas Boilers	Gas Engine CHP with District Energy
Site	Thumb & Town	Thumb & Town
Analysis Term	25 years	25 years
Gas Price	\$7.00/MMBtu ¹	\$5.50/MMBtu ²
Electric Price	\$0.10/kWh	\$0.10/kWh
Escalation	3%	3%
Project Cost	\$800,000	\$4,600,000
O and M Cost³	\$0/yr	\$56,000/yr

Notes:

1. Firm commercial gas rate
2. Interruptible gas rate
3. Incremental cost difference

Table 12: CHP project economic assumptions

The economic assumptions provided above were coupled with the CHP energy production numbers developed to estimate the annual savings generated by the CHP project. The annual energy usage, annual utility costs, and economic performance of the project are provided in Table 13.

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CHP Economic Results		
	Traditional Scenario	CHP Scenario
Grid Power	4,172,302 kWh	1,364,734 kWh
CHP Power	-	2,807,568 kWh
Total Power	4,172,302 kWh	4,172,302 kWh
Boiler Heating	14,865 MMBtu	5,105 MMBtu
CHP Heating	-	9,760 MMBtu
Total Heating	14,865 MMBtu	14,865 MMBtu
Electric Costs	\$417,000	\$136,000
Boiler Gas	\$130,000	\$35,000
CHP Gas	\$ -	\$145,000
CHP O and M¹	\$ -	\$56,000
Annual Costs	\$547,000	\$372,000
CHP Project Cost	\$800,000	\$4,600,000
25-Year Cost	\$21,520,000	\$21,505,000
25-Year Difference	\$ -	\$15,000

Note:

1. Incremental cost difference

Table 13: CHP project economic results

3.2.4.3. Interpretation of the economic analysis

The economics of the CHP system are tied to the energy loads connected to the system. As shown in Table 13, the annual costs of the initial proposed CHP operations are significantly reduced from the traditional scenario. The primary factor contributing to the 25-year cost of the CHP is the capital cost for the initial construction of the system. If additional energy load was connected to the initial system, the debt service payments could be spread out across more energy consumers, and energy rates could be decreased. In order to optimize the economic return of a CHP system, the remaining capacity of its thermal energy output (approximately 1 MMBtu/hr) could be utilized. If the thermal demand of TCAAP development included higher continuous loads (light manufacturing processes, restaurants, domestic hot water, etc.), the 25-year savings could be increased by an estimated \$900,000.

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Additionally, the economic analysis did not take into account any rebates, grants, or savings for which the project could be eligible. These potential funding sources could be used to offset the cost of the initial construction, thus making the initial CHP system more economically attractive. The list of potential funding sources is provided in Exhibit IV.

3.2.5. Greenhouse Gas Reduction

One of the advantages of a CHP system is the reduction of greenhouse gas emissions due to the higher efficiency of the CHP system. Implementation of a CHP system to meet the energy loads in Section 3.2.2.1 could reduce carbon dioxide emissions by approximately 20%, as shown in Table 14.

Estimated Annual Carbon Dioxide Emissions Reductions		
	Traditional Scenario	CHP Scenario
Natural Gas Usage	18,581 MMBtu/yr	32,772 MMBtu/yr
CO ₂ Emission Rate ¹	117 lb/MMBtu	117 lb/MMBtu
CO ₂ Emissions from Natural Gas Usage	1,087 tons/yr	1,917 tons/yr
Electric Usage	4,172 MWh/yr	1,365 MWh/yr
CO ₂ Emission Rate ¹	1,041 lb/MWh	1,041 lb/MWh
CO ₂ Emissions from Electricity Usage	2,172 tons/yr	710 tons/yr
Total CO ₂ Emissions	3,259 tons/yr	2,628 tons/yr
Total CO ₂ Emissions Reduction		631 tons/yr

Note:

1. <https://www.xcelenergy.com/staticfiles/xcel/Corporate/CRR2013/environment/emissions-reporting.html>

Table 14: Estimated annual carbon dioxide emission reductions

The greenhouse gas emission savings presented in Table 14 are based upon a CHP operational strategy of meeting the Thumb's electrical needs from a gas-fired generator. In the event that other renewable energy sources are included in the CHP solution, the greenhouse gas emission reductions would increase.

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3.2.6. Developing a Microgrid for the Area

While an initial CHP approach might be focused on the current campuses of the Thumb and the Town, the energy vision adopted by the ERAB includes developing a resilient energy system for the greater community, including the remainder TCAAP and the adjacent properties. The initial CHP plant is one implementable opportunity. However, to achieve the TCAAP energy vision, it will be important for the partner organizations to develop a plan to expand the scope of the CHP plant and develop a microgrid for the broader area as TCAAP development proceeds.

3.2.7. Suggested Next Steps

As part of the Thumb development, the County and JDA could develop a CHP strategy for the developer selection process, so that the CHP project, electric distribution, and thermal distribution systems designs can be integrated into the development plans. Several of the initial activities that will need to occur prior to the RFP are listed below:

- The ownership and initial project funding strategy for CHP will need to be established to allow initial project development activities to commence. An agreement will need to be developed to establish the initial energy system concept and conduct additional due diligence on the technical, business, and regulatory issues that are associated with the project. The JDA should work with Xcel Energy to define Xcel Energy's interest in owning the proposed CHP. Xcel Energy ownership will provide the benefit of increasing the plant size and system efficiency as electric and thermal demand grows.
- If Xcel Energy is interested in owning a CHP system, the JDA should collaborate with Xcel Energy to develop an initial CHP plant that could serve as the foundation of a broader microgrid strategy for TCAAP, AHATS, and the community. If Xcel Energy is not an owner of the CHP, the initial electric output could be sized to meet the needs of the Thumb, with thermal energy distributed to the other sites. Additional electric output could be added on other sites and integrated into a district energy system as the energy needs of the future buildings are defined, or the CHP electrical output could be increased if the developer secured a power-purchase agreement with Xcel Energy.
- The JDA should integrate and reserve space within easements and right of way for the future construction of district energy distribution facilities during the platting of the development and the design of the Spine Road.
- During site marketing, the JDA should emphasize the benefits and opportunities presented by the incorporation of CHP into the Thumb development, and could pursue businesses that have coincidental thermal and electric energy needs. Additionally, prioritizing site marketing to

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companies with additional process or domestic hot water load would optimize the efficiency of the CHP system.

3.3. Low-Temperature District Energy System

3.3.1. Introduction

The residential neighborhoods of TCAAP present a unique and highly visible opportunity to leverage low-grade energy from the treated groundwater as an energy supply for the neighborhoods, distributed via a low-temperature district energy system. The proposed system would utilize thermal energy from the TCAAP Groundwater Treatment station described in section 1.5.4 by transferring energy from the groundwater to the district energy system. The groundwater, which is consistently ~52°, can be used to transfer energy to and from the closed-loop distribution system to meet heating and cooling demand in the buildings, while not affecting the quality of the treated groundwater. The pumped groundwater is estimated to have 9.8 MMBtu of energy available. The Hill and Creek neighborhoods are projected to demand 68% of this energy. Thus, an additional 3.1 MMBtu could be available for utilization in other areas of TCAAP or AHATS.

3.3.2. System Description

The proposed energy system would require an energy transfer station to be constructed at, or near, the current pumping location for the groundwater treatment station. This energy transfer station would consist of a heat exchanger to separate the groundwater from the system water, pumps to circulate the distribution loop, controls, metering, and piping.

The existing building that houses the groundwater treatment station was originally the domestic water treatment plant for the TCAAP site during the ammunitions manufacturing period. This building was decommissioned, as the groundwater treatment system is housed in a building addition, and is now largely vacant. The facility is more than adequate to house the proposed energy transfer station. The building is owned by the Army, and will remain in the custody of the Army until the groundwater treatment operations cease. Given these conditions, there would need to be an agreement between the district energy district energy business and the Army for the use of this building.

As noted in Section 1.5.3, the operations of the groundwater treatment system are anticipated to continue for a minimum of 30 years. By the end of this period, an alternative energy source may need to be identified should the groundwater pumping be discontinued or unavailable for energy transfer. At that stage, there would be multiple technologies that could be incorporated:

- A separate field of geothermal heat exchange wells could be constructed in the vicinity of the energy transfer station.

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- Construction of a solar thermal garden in the vicinity of the energy transfer station.
- Installation of a commercial size heat pump at the energy transfer station.
- Future technologies that are currently unavailable in the market.

The proposed distribution system would consist of two pipes, supply and return, spanning from the energy transfer station to the homes. To prevent the pipes from freezing, and to efficiently transfer the energy, these pipes can be insulated and buried at shallow depths, or uninsulated, and buried at greater depths. To keep the initial construction costs of the distribution system to a minimum, the proposed district energy business could construct the distribution system and service extensions to the homes, in coordination with site development.

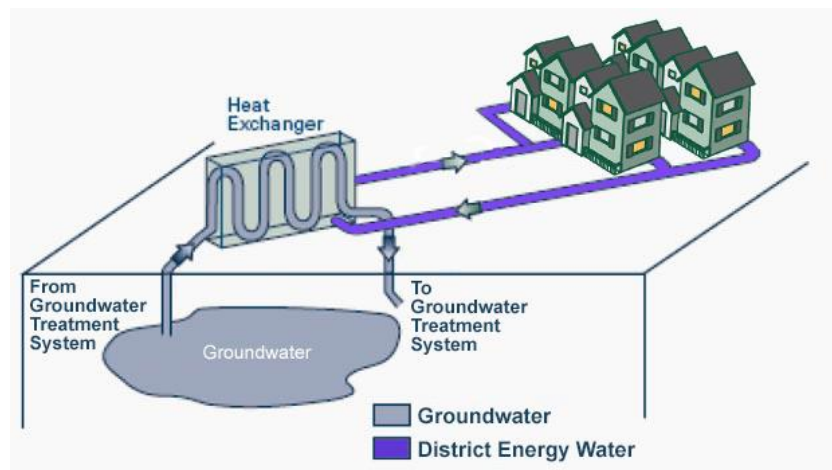


Figure 9: Distributed ground source heat pump schematic

A set of two pipes would span between each home and the distribution system, one delivering water to the home and one returning water to the distribution system. Each home would be equipped with a water source heat pump unit, powered by electricity. This would replace the need for traditional forced-air furnaces and electrically-driven air-conditioners. During the winter months, the heat pump would take heat from the distribution system water and use it to heat the air inside the home. Conversely, during the summer months, the heat pump will take heat from inside the home and reject it to the distribution system, which is how the home is cooled. Figure 10 shows how home heat pump systems operate inside the homes.

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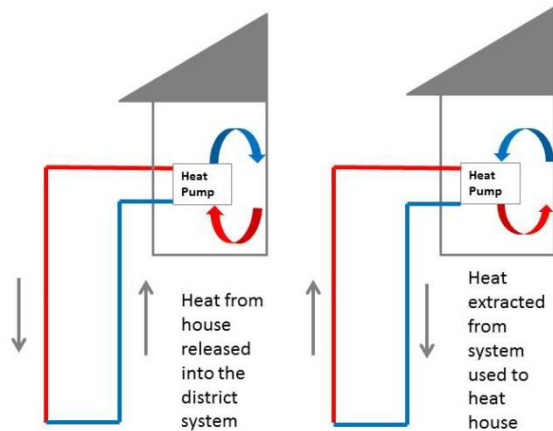


Figure 10: Ground source heat pump operation

3.3.3. Greenhouse Gas Reduction

One important advantage of a low-temperature district energy system is the reduction of greenhouse gas emissions. Carbon dioxide is the primary greenhouse gas emission that is monitored and measured for the heating and cooling of buildings. The carbon dioxide emission rates used to calculate the savings of the low-temperature district energy system are included in Table 15.

Carbon Dioxide Emission Rates

Natural Gas ¹	117 CO ₂ lb/MMBtu
EPA MROW Emission Factor ²	1,536 CO ₂ lb/MWh
Electric Utility ¹	1,041 CO ₂ lb/MWh

Notes:

- <https://www.xcelenergy.com/staticfiles/xcel/Corporate/CRR2013/environment/emissions-reporting.html> <http://www.epa.gov/climateleadership/documents/emission-factors.pdf>
- <http://www.epa.gov/climateleadership/documents/emission-factors.pdf>

Table 15: Carbon dioxide emission rates

When comparing emission rates between traditional HVAC systems and the proposed low-temperature district energy system in the Hill and Creek neighborhoods, carbon dioxide emissions are reduced by almost 30%. The comparison of the estimated greenhouse gas emissions is shown in Table 16.

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Estimated Annual Carbon Dioxide Emission Reductions for Low-Temperature District Energy		
Gas Furnace - Heating	15,874 MMBtu/yr	929 tons CO ₂ /yr
Air conditioner - Cooling	836 MMBtu/yr	128 tons CO ₂ /yr
Total Conventional Emissions		1,057 tons CO₂/yr
Heat Pump - Heating	3562 MMBtu/yr	544 tons CO ₂ /yr
Heat Pump - Cooling	484 MMBtu/yr	74 tons CO ₂ /yr
Pumping Station (kWh)	247,280 MMBtu/yr	129 tons CO ₂ /yr
Total Heat Pump Loop Emissions		747 tons CO₂/yr
Savings		310 tons CO₂/yr
% Emissions Reduction		29%

Table 16: Estimated annual carbon dioxide emissions reduction

This calculation does not take into account the opportunities for carbon-neutral electricity production that would be available to the TCAAP development. These calculations use the base emissions rate from the electric grid, published by Xcel Energy for the Upper Midwest service territory. As the local electricity sources become less dependent on the primary grid, through implementation of community solar gardens or other technologies, the carbon dioxide emissions could be further reduced.

3.3.4. Financial Analysis

The initial cost of the low-temperature district energy system was estimated based on the Project Team's historical data for installation of piping and equipment. The pumping station, heat pumps, furnaces, and air conditioning units were estimated based on major equipment budgetary pricing that is readily available from manufacturers. The distribution piping was estimated based on historical data for similar material installations in Minnesota. The low-temperature of the water allows for flexibility of the piping system construction. The Project Team evaluated the material costs for a number of materials and based the estimate on a high-density polyethylene piping system, due to the material cost and ease of installation. A summary of the initial capital costs are provided in Table 17.

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Energy Source Implementation

Total System Capital Cost Comparison			
District Energy Capital Costs		Traditional System Capital Costs	
Pump Station	\$375,950	Xcel Energy Infrastructure	\$0
Distribution Pipe	\$2,527,500		
Service Laterals	\$533,200		
Domestic Water Heaters	\$493,000	Domestic Water Heaters	\$591,600
Heat Pumps	\$2,563,000	High Efficiency Furnaces	\$1,005,720
		AC Units	\$1,135,872
Total	\$6,493,250	Total	\$2,733,192

Table 17: Total system capital cost comparison

For the economic analysis, the Project Team assumed that the district energy facilities at the energy transfer station and the distribution piping would not be paid for by the TCAAP developer. Typically, the district energy entity pays for the production and distribution facilities. The Project Team did assume that the developer would pay for the procurement and installation of the heat pumps, and hot water heaters in the homes. The Project Team also assumed that the developer would pass the minimal additional cost of the heat pump installation on to the homeowner through an increased mortgage amount, and would be able to use the eco-friendly aspects of the system as a selling point. The analysis was completed for straight costs, and did not include any rebates or tax credits that may be applicable for these energy efficient homes. A summary of the initial costs to be paid by the developer is shown in Table 18.

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Energy Source Implementation

Developer Capital Cost Comparison			
Heat Pump Capital Costs		Traditional System Capital Costs	
Domestic Water Heaters	\$493,000	Domestic Water Heaters	\$591,600
Heat Pump Units	\$2,563,600	High Efficiency Furnaces	\$1,005,720
		AC Units	\$1,135,872
Total	\$3,056,600	Total	\$2,733,192
Per Unit Cost ¹	\$9,102	Per Unit Cost ¹	\$6,930

Note:

1. 394 homes based on density projections for Hill and Creek neighborhoods available at time of publication

Table 18: Developer capital cost comparison

The capital costs for the construction of the district energy system are shown below in Table 19 and are assumed to be financed over a period of 30 years.

District Energy System Capital Costs	
Pump Station Construction	\$375,950
Distribution Mainline Construction	\$2,527,500
Distribution Service Laterals	\$533,200
Total	\$3,436,650

Note:

1. Includes engineering and indirect costs for the service laterals to each home.

Table 19: District energy system capital costs

The proposed low-temperature district energy system is modeled as a private, non-profit business, with cost-based energy rates. The model assumptions are provided in Table 20.

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Energy Source Implementation

Financial Assumptions			
Energy and Demand Rates		Escalation Rates	
Summer Residential Electricity Rate (\$/kWh) ¹	\$ 0.0867	Inflation Rate	2.0%
Winter Residential Electricity Rate (\$/kWh) ¹	\$ 0.0739	Natural Gas Rate Acceleration (EERC Real) ²	3.93%
Electric Service Charge per Unit Annually ¹	\$ 96.00	Electricity Rate Acceleration ³	2.53%
Sales Tax ⁴	\$ 0.0763	Water and Sewage Acceleration	3.00%
Natural Gas Rate (\$/MMBtu) ¹	\$ 8.3983	Cost of Capital - Developer	6%
Natural Gas Service Charge per Unit Annual ⁵	\$ 108.00	Cost of Capital – District Energy Entity	4%
		Payment Periods	30

Equipment Efficiency		Unit Costs	
Air Conditioning (SEER ⁵)	14.00	Housing Units	394
Air Conditioning (EER ⁶)	11.76	High-Efficiency Furnace Unit Cost with Install	\$ 2,550
Air Conditioning COP ⁷	3.45	Natural Gas Water Heater Cost with Install	\$ 1,500
Air Conditioning kW/ton	1.02	Air Conditioner Unit Cost with Install	\$ 2,880
High Efficiency Furnace ⁸	92%	Operation and Maintenance Annually per Unit	\$ 400
Heat Pump Cooling EER ⁹	20.30	Heat Pump Unit Cost with Install ¹⁰	\$ 6,500
Heat Pump Heating COP ¹¹	4.10	Hot Water Heater with Heat Pump ¹²	\$ 1,250
		Heat Pump Maintenance Per Unit Annually	\$150

Expected Unit Life Expectancy	
High-Efficiency Furnace	18-20 Years
Air Conditioner	12-15 Years
Heat Pump	18-20 Years
Franchise Fees/Easements	\$0

Notes:

1. <http://www.xcelenergy.com/staticfiles/xcel/Regulatory/Regulatory%20PDFs/rates/MN/MNResRateCard.pdf>

2. Energy Escalation Rate Calculator - 2% inflation, start date is 2015, duration is 30 years. Annual energy escalation rate is 1.89% (Real) and 3.93% (Nominal).

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3. Energy Escalation Rate Calculator - 2% inflation, start date is 2015, duration is 30 years. Annual energy escalation rate is 0.52% (Real) and 2.53% (Nominal).
4. Sales tax not applied to heating due to state heating fuels law.
5. Seasonal Energy Efficiency Ratio (Btu/Watt-hr) – the cooling output during a typical cooling season divided by the total electric energy input during the same period.
6. Energy Efficient Ratio (Btu output/Watt input) – the ratio of output cooling energy (in Btu) to input electrical energy (in W).
7. Coefficient of Performance – the ratio of output energy (in Btu or W) to input electrical energy (in the same units).
8. http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/highefficiency_gas_furnaces.pdf
9. <http://www.waterfurnace.com/literature/3series/SC2300AL.pdf>
10. <http://www.homeadvisor.com/cost/heating-and-cooling/install-a-heat-pump/#>, <http://home.costhelper.com/geothermal-heat-pump.html>, Estimate for 4-loop heat pump provided by S&B Geothermal (adjusted for economies of scale and 1 loop unit)
11. <http://www.waterfurnace.com/literature/3series/SC2300AL.pdf>
12. Heat pump to supply DHW to tank, electric element in tank as redundant source.

Table 20: Financial assumptions

Using the energy usage estimates prepared as part of this study, the Project Team estimated the annual cost of providing heating and cooling to the areas homes under a traditional scenario (independent high efficiency furnaces and AC units) and under a low-temperature district energy scenario (energy transfer station, distribution system, heat pump HVAC units). The life cycle cost analysis for the low-temperature district energy system, including the costs covered by the developer, was compared to the traditional scenario. The 30-year costs include systems operation, maintenance, and equipment replacement, but do not account for any profit for the district energy business. This analysis is summarized in Table 21.

District Energy Life Cycle Cost Comparisons for Connected Homes			
	Initial Cost	30-Year Cost	Average Annual Costs Per Home
Traditional Service	\$ 2,733,192	\$20,288,675	\$1,715
District Service	\$3,056,600	\$18,482,181	\$1,562
District Service Savings (Cost)	\$(323,408)	\$1,806,494	\$153

Table 21: District energy system life cycle cost comparison for all homes connected

As shown, the district system is lower in cost over the-30 year period than a traditional gas-fired furnace and electric A/C unit; however, it is assumed that the benefits beyond the 30-year initial agreement would be significantly greater as the debt payment for the initial system construction is completed.

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Lastly, to validate that this system is the optimal means of capturing ground-source energy, the Project Team compared the life-cycle cost for the low-temperature district energy system to a scenario where homeowners would install independent geothermal systems that would serve each home. In this comparison, both homes would have heat pumps to meet their comfort needs. Because this would add initial cost to the developer, it was assumed that the developer would pass this cost along to the home owner in the form of a premium added to the mortgage amount. This analysis is summarized in Table 22.

Ground-Source Loop System Life Cycle Cost			
	Initial Cost	30-Year Cost	Average Annual Costs Per Home
Individual Geothermal ¹	\$9,600 ²	\$45,596	\$1,521
District Service	\$ -	\$46,862	\$1,562
District Service Savings (Cost)	\$9,600	\$(1,266)	\$(41)

Notes:

1. Assumes that home owners would be required to pay a premium to the developer for the construction of geothermal well field.
2. Estimate provided by S&B Geothermal, \$2,400/well, assumed four wells.

Table 22: Independent geothermal loop system life cycle cost comparison

Independent geothermal systems could be built for the residents in TCAAP, and would be less costly than the district energy system capturing energy from the treated groundwater. However, the relatively small gains in cost over 30 years would be offset by the volatility of natural gas markets, inconvenience of maintaining independent systems in each home, the initial cost of the systems, and the future flexibility provided by installing district energy infrastructure.

3.3.5. Potential Savings Opportunities

Under the assumptions provided in this Framework, the implementation of a low-temperature district energy system that utilizes energy from the treated groundwater appears to be technically and financially implementable. The economic benefits of this system could be improved by realizing one or more of the following cost reduction opportunities.

- The distribution piping is the single largest cost for the implementation of the low-temperature system. The primary opportunity to reduce this cost is through coordinating the distribution piping construction with the construction of the public utilities. This coordinated construction has been assumed in the financial model.

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Additional savings could be realized if the piping were installed in a joint trench with the water main, meaning that the distribution piping and water main would be constructed at the same depth and in the same trench. This would eliminate the need for a second trench excavation for the distribution piping, and would only require a marginal increase in the size of the excavation of the water main trench.

- Xcel Energy could partner with the County, JDA, and the City to further evaluate and promote a neighborhood development that does not utilize natural gas. This promotion would include providing technical assistance, contributing electric vehicle charging stations, or promoting the efficiency and low-carbon possibilities of the neighborhood.
- Energy efficiency savings related to micro-hydro, community solar garden subscription, or other renewable electric generation were not included in the model for the energy transfer station or customer properties. Utilization of these technologies could improve the payback time for the system.

Equipment rebates and tax credits were not included into the model, though Xcel Energy offers rebates on high efficiency equipment and variable frequency drives, for which the energy transfer station will be eligible. Xcel Energy also has a number of other energy conservation programs that could be leveraged to offset initial capital costs of the system. None of these rebates were assumed in the current model.

- The Federal Government offers a 30% tax credit to home owners who install a groundwater heat pump that is applicable from the date of occupancy by the homeowner for new homes. However, this tax credit is only applicable if the home is used as a residence by the taxpayer, and is scheduled to end on December 31, 2016.⁶ The inherent ambiguity regarding construction date and owner usage, the Project Team has not included this tax credit in the model.

3.3.6. Implementation Planning and Suggested Next Steps

Implementing a low-temperature district energy system in the residential neighborhoods of TCAAP can deliver several benefits to the site and stakeholders, including the following.

- An energy system that is more energy efficient than traditional heating and cooling systems.
- Reduced fossil fuel usage and greenhouse gas emissions.
- Competitive, stable costs of energy for homeowners.

⁶ <http://energy.gov/savings/residential-renewable-energy-tax-credit>

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- Xcel Energy could avoid gas pipe distribution infrastructure costs in the neighborhoods, saving rate payers money.
- Installation of a flexible infrastructure network in the neighborhoods will allow for easier integration of future energy sources or technology advancements as they become available.
- Implementation of this system would establish the TCAAP approach to sustainable neighborhoods as a national model for energy efficiency and innovative site development.

For the proposed system to be successfully implemented, it would need to be constructed as the first homes are being built, so that service can be provided from the outset of development. To optimize the economic benefits of the system, every home in the selected neighborhoods should be constructed with a heat pump HVAC system and be connected to the proposed system. This would provide the most financeable, cost-effective implementation plan, and also maximize energy efficiency for TCAAP.

Implementing the low-temperature district energy system requires several areas of focus, including the following next steps.

3.3.6.1. Develop the System Business Plan

Before beginning the implementation of the proposed system, a business will need to be formed to facilitate the distribution of energy to the customers it will serve. As part of determining the ownership structure, a business plan should be developed to resolve a number of organizational preferences for the business. Resolving these items will be important to help guide development of the proposed system. Among those preferences, the following should be determined:

- The mission of the organization
- The organizational structure
- Governance of the business
- The energy sales rate structure
- The system financing strategy
- The expected structure of energy service agreements with customers
- The engineering strategy
- The construction contracting strategy
- The system operational strategy
- The system management strategy
- The energy transfer station location strategy
- Permitting and regulatory strategy
- Developer outreach and education strategy
- Easement and franchise agreement strategy, needs, or restrictions

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Energy Source Implementation

The City, County and JDA should resolve these items prior to commencing with the site development RFP process. While all of the items listed above are important for development, the following items will likely require the most attention.

Forming the Business

Unless Ramsey County or Arden Hills is the owner of the low-temperature district energy system, an ownership entity should be developed, based upon the system mission. The ownership entity will handle the system operations, maintenance, and billings. The business could be best served by one of the following structures: Municipally Owned, Private Non-Profit, Private For-Profit, or a Hybrid Publically-Owned Infrastructure/Private Non-Profit Company. Each structure has inherent benefits and detriments, which will need to be evaluated as the business structure is determined.

The private, non-profit model operational structure is the business structure that was assumed in the financial analysis. This business structure operates under the governance of local stakeholders and customers. This type of business model has several advantages, the most prominent being that the rates would be cost-based, meaning that the rates would cover the cost of operating the system and debt service, without mark-ups for profit or return on investment.

Developer Outreach and Education

A critical aspect of this system is that each home in the system service area should be connected to the system. This will require developers to install heat pump units in each home, instead of traditional forced air furnaces and air conditioner units. The developers should be properly educated on this opportunity and this direction should be clearly stated in the RFP language, so that the developers can understand and implement the strategy from the onset.

Reach Agreement with U.S. Army for use of Existing Building and Treated Groundwater

The ownership entity will need to negotiate with the Army for the use of energy from the treated groundwater and the existing building to which the groundwater treatment station is attached. This agreement will, at a minimum, need to provide for access to and operation of the energy transfer station equipment. Ideally, an agreement would include ownership transfer of the building and groundwater pumping system at the termination of the groundwater treatment operations, so that the heat pump loop can continue to meet the heating and cooling needs of the development.

System Financing

Depending upon the preferred ownership structure, the financing strategy for the system could be very different. If the system is publicly owned, it could be financed through the public institution or in private markets. If a private, non-profit, the system could be 100% debt-financed based upon long-

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term agreements with homeowners. Under this scenario, the phasing of housing development may require City or County backing of the debt as not all homes will be occupied when the system begins operation.

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Energy Efficiency Strategies

4. Energy Efficiency Strategies (Demand Side Management)

Given the pressing timeline of near-term infrastructure investments, much of the Framework is focused on energy supply options for TCAAP and the Arden Hills community. However, implementation of improved building energy efficiency will be necessary to achieve the community's low-carbon, resiliency goals. The following are the leading opportunities for near-term, low energy use development at the site. Unlike many next steps for energy supply and infrastructure, the demand-side initiatives will strongly depend on engaging developers who can help implement the TCAAP energy vision. These recommendations make use of the truly unique opportunities at TCAAP, which include:

- Availability of a local, renewable ground heat energy source via the site remediation process.
- Advantages of both greenfield development and large scale deployment to optimize economies of scale.
- Focus on replicable designs and technologies to simplify developer implementation.
- Emphasis on actual building performance, beyond prescriptive design requirements.
- Important strategic partnerships with Xcel Energy and the Center for Sustainable Building Research at the University of Minnesota.

4.1. Energy Resilient Design and Construction

To meet the energy resilience goals for TCAAP, building design verification and benchmarking will be needed on an ongoing basis. As development moves forward it is recommended that the County, the JDA, City Staff, and development consultants utilize the following building standards, technical resources, planning tactics, and proposal criteria to attract and streamline energy efficient development.

4.1.1. Meeting SB 2030 Guidelines

All commercial developments on the TCAAP site can be measured against the requirements of Minnesota's Sustainable Buildings 2030 (SB 2030), a performance based building energy standard developed to incrementally move new construction to net zero energy design by 2030. The standing program is not only a standard for design and construction, but an ongoing energy performance benchmarking program and guideline. The standard is designed specifically for Minnesota's climate, is administered by the Center for Sustainable Building Research (CSBR), and is supported by both the State of Minnesota's Division of Energy Resources and Xcel Energy.

SB 2030 has several advantages as a consistent site standard, as outlined in the *Policy White Paper*. To recap:

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- 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 TCAAP: commercial, multi-family, and detached residential.

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

- Building Envelope
- Equipment Energy Efficiency
- Lighting Power Density & Controls
- Domestic Hot Water
- Mechanical Systems
- Use of Renewables

Resources & Benefits

- Xcel Energy's Energy Design Assistance Program is a free resource for designers and developers to help meet some of the SB 2030 requirements and will help developers navigate rebate opportunities. (Additional assistance is available when design teams commit to designing at 30% more efficient than typical design.)
- Xcel Energy's custom efficiency program allows large users to obtain tailored, performance based efficiency assessments and rebates.

On average, SB 2030 will require commercial buildings to be 35 to 45% more efficient than the new building code (IECC 2012). Table 23 outlines specific efficiency improvements for a few building types relevant for TCAAP.⁷

⁷ For single-family homes and townhomes, SB 2030 will be more efficient than the residential IECC 2012 code, but not to the extent of commercial building requirements.

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Increase in Energy Efficiency Above Commercial Building Code (IECC 2012)				
Medium Office	Stand-Alone Retail	Small Hotel	Restaurant	Warehouse
42%	29%	50%	55%	60%

Table 23: SB 2030 (70% benchmark) Energy Efficiency Improvement over Code⁸

The key way to incentivize use of SB 2030 is to give preference to proposals designing to these standards during the RFP review process (outlined below). Development teams would have access to SB 2030 tools and case studies that outline recommended cost-effective design approaches. During schematic design and design development phases, the design team will set goals and targets for the project with guidance from the SB 2030 team. When construction documents are nearly complete, the SB 2030 team provides a full plan review with course corrections and feedback to achieve the project targets. After construction, the SB 2030 team will again work with project stakeholders to initiate the energy benchmarking and tracking process. The cost to the developer/builder for all of these program services is approximately \$8,000 to \$10,000 per commercial site, a greater value than comparable certification programs that do not provide review services.

Given the scale and visibility of TCAAP, there are potential adjustments that can be made to streamline this process for developers.

- Targeted education and design guidelines that are site specific and assist developers to quickly identify what major design features to focus on for a specific site and building type.
- Potential cost buy-down for the upfront cost of the study and review

SB 2030 may face a challenge in that while it is relevant for Minnesota buildings it does not yet have the market visibility of other national standards such as LEED. Marketing of the TCAAP site could include a marketing campaign around the benefits of SB 2030, to increase awareness, acceptance, and a value reflection in the market. The County or City may also consider sharing review costs with developers to help grow collaboration and buy-in.

⁸ Analyzed by comparing improvements in ASHRAE 90.1 and applying the 70% reduction compared to the 1989 baseline by building use type (CEE).

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4.3. Leading Near-Term DSM Opportunities

4.3.1. Low-Load Residential Development

Recommendation:

The JDA should consider all residential neighborhoods as eligible areas for development of low-load homes and utilization of a shared ground source water loop for retrieving low-cost heat.

Section 6.4.1.1 (p. 34-35) of the *Policy White Paper* outlined the concept of a residential development featuring low-energy, all electric homes, fed by the ground source heat for heating and cooling needs. A low-load home would not require the larger heating and cooling capacity of traditional systems, but instead could meet residents' comfort needs with smaller capacity systems. A low-load home does not have to cost significantly more than a traditionally built home, and can be valued more in the marketplace.⁹

The Project Team estimates that low-load homes in Minnesota could obtain a maximum combined space heating and cooling load of less than 10 Btu/hour/square foot (conditioned floor area).¹⁰ The key technologies and strategies include high levels of building insulation and passive solar design, a tight building shell, and high efficiency appliances. These homes do not require significant insulation like a passive house, but are 40% to 50% more efficient than what is required by the new IECC 2012 code.

The primary opportunity for implementing low-load homes at TCAAP is the integration of a low-temperature district energy system fed by the treated groundwater on-site. This energy source could be implemented in homes in the Creek, Hill and eastern Town residential developments, given their proximity to the treated ground water. This opportunity deserves significant consideration since the homes at TCAAP have the unique ability to tap the renewable resource of the pumped ground water through a district energy system combined with in-home water-to-air heat pumps.

Incorporation of high-performance technologies that have little to no impact on the up-front costs, such as efficient appliances and low-flow plumbing, will help minimize hot water use and help maximize home efficiency. The following is a summary of the specific technologies and design elements that can be considered for a low-load, all electric home at TCAAP:

⁹ Multiple recent housing market studies have shown that homebuyers are willing to pay a 9-15% premium for homes that perform more efficiently. (CA Housing Study 2012; NHBA Market Study 2013)

¹⁰ <http://www.nrel.gov/docs/fy14osti/60712.pdf>

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- Insulation, air sealing, and passive solar design to reduce space conditioning load to 10 Btu/hr/square foot
- Ground source heat pump technology (electric driven)
- High-efficiency appliances such as refrigerators, dishwashers, washer/dryers (with additional consideration of low water use)
- Consideration of heat pump dryers
- Propane on localized natural gas stoves and grills
- Magnified benefit from rooftop PV electricity or purchase of community solar shares

Some marketing benefits of implementing these solutions include:

- Availability of high-tech, low maintenance equipment
- Cutting edge all-electric design
- True net-zero or net-zero ready potential
- Low-cost energy living

Low Load Home Performance Verification

Coordination between ground water system capacity and home design will be necessary up-front and on an ongoing basis. This will provide developers and users with the necessary assurance that the designed loads will be compatible with the capacity of the system. Verification of home energy design and performance can most easily be achieved by a third-party with design and construction expertise. The County and JDA could specify building standards to help homes reach these performance targets, such as SB 2030, which has standards for single-family homes that could be personalized for TCAAP. This program could be administered between utility energy-efficiency verification programs like Energy Star for New Homes and coordination help from the City's inspection division.

4.3.1.1. Case Studies

Zero Carbon Residential Development | Bainbridge Island, Washington

Bainbridge Island is a mixed residential development of 24 single-family homes, rental apartments, senior-living, and condos. Buildings were designed to meet the criteria of a stringent building certification program, the Living Building Challenge, and included “ultra-insulated” envelopes, high-efficiency appliances, and an opt-in opportunity to buy or finance roof-top solar. Mini-split heat pumps with energy recovery ventilators provide high-efficiency heating. Additionally, all parking is underground and broader sustainability innovations are woven in such as walkability, water

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conservation, and edible landscapes. All of the single family homes sold out quickly and all home buyers opted to install solar PV systems.

Low Load Housing Development / Townsend, Massachusetts

A premiere example of low-load homes being built at scale is the 35 single-family houses on Coppersmith Way in Townsend, MA. These homes, each 1,700 square feet, were built to meet a strict efficiency standard with an additional cost of approximately \$8.40 per square foot (incorporating a \$4,550 Massachusetts rebate).¹¹ The resulting thermal load was served by two efficient “mini-split” systems – one on each floor – and homes continue to be reported by residents as a comfortable and responsive living environment.

Carbon Zero Residential Development / Issaquah, Washington

At a built cost of about \$375,000 each, the 10 townhome development outside of Seattle (started in 2008) sold out completely within the first year with homebuyers showing a willingness to pay \$20 to \$40 more per square foot than less efficient homes of similar size and location.¹² The neighborhood, similar to what is being proposed at TCAAP, successfully utilized a community-based ground source system in combination with in-home heat pumps. The shared walls between townhomes contributed to reduced heating loads that made it financially viable. The builder/developer attests that the visible elements of the net zero energy homes, such as the in-floor radiant heating, heat pump technology, roof-top solar, and triple pane windows were key to the value that homebuyers saw. The developer (Ichijo U.S.A.) continuous to build low-load homes and sees ROI that makes sense in the market.

Ground Source Heat Pump Housing Development / Kennewick, Washington

SouthCliffe is a 400+ lot residential development in southeastern Washington that is comprised of low-load homes serviced by a ground source water loop and heat pumps, very similar to what is being proposed at TCAAP. Heating and hot water needs of each home are both serviced by this combination of technologies. The ground source water loop added approximately 5% to the cost of each lot, but led to immediate monthly energy cost savings. Milo Bauder and Grant Young were the developers of this project, and have worked with ThermLink in Duluth: a pioneer in ground source installations and equipment.¹³

¹¹ Homes achieved a HERS score of 40. The exterior walls were built to R-46, the basement walls were R-20, the attic was insulated to R-63 and the under basement slab was insulated with 2 inches of rigid foam with an R-value of 10.

¹² Conversation with Nick Neid, project manager with Ichijo USA, the developer and builder (February 2015)

¹³ <http://www.distinctiveprop.com/files/files/soiuthcliffepressrelease.pdf>

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4.3.2. Building orientation and passive solar

Recommendation:

The process for solar oriented development should be described in residential and commercial building RFPs and should be integrated as evaluation criteria for development proposals. It should be evaluated based on lowest total energy load of the homes or buildings to be sited under one proposal and should consider street orientation, building orientation, and passive solar building envelope design elements. As part of the platting process, the County could plat the land and maximize building orientation prior to sale to developers.

The TCAAP *Policy White Paper* included the recommendations for the TCAAP subdivision review process to assess the energy implications of street and building orientation on solar heat gain and loss. Beyond the building envelope, street orientation, lot and building orientation, and building massing, all impact the thermal loads of homes and commercial buildings. By jointly considering these variables prior to the subdivision process, planners and developers have the opportunity to make tradeoff decisions while still producing efficient results. Site orientation is potentially a no-cost way to reduce building energy loads and improve daylighting when considered in site planning.

In line with solar oriented design, homes should be designed and sited so that the longest sides of a house face south and southern faces have the greatest window area.¹⁴ This general window orientation is a proven strategy to reduce a home's heating energy by approximately 4% and cooling costs by 2%, without affecting any other parts of the design. Figure 11 shows the energy savings achieved from southern window orientation, assuming that the largest exterior walls are facing north and south, but without optimizing any other window characteristics or the window to wall ratio on each side.

Alone, window orientation results in moderate energy savings, but when paired with improved window insulation, higher solar heat gain coefficients, and optimum window to wall ratios, the heating energy savings will be 20% to 30%.¹⁵ Proper building and window orientation magnify the impact of the remaining window decision. When aligned, homes with a well-insulated double or triple pane windows

¹⁴http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Residential/Water_Heating/2013_CASE_R_Solar_Ready_Solar_Oriented_Developments_Sept_2011.pdf

¹⁵ <http://www.efficientwindows.org/downloads/ColdDesignGuide.pdf>

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and optimum window to wall ratios, annual energy cost savings for homes in central Minnesota have been shown to be approximately \$300 annually.

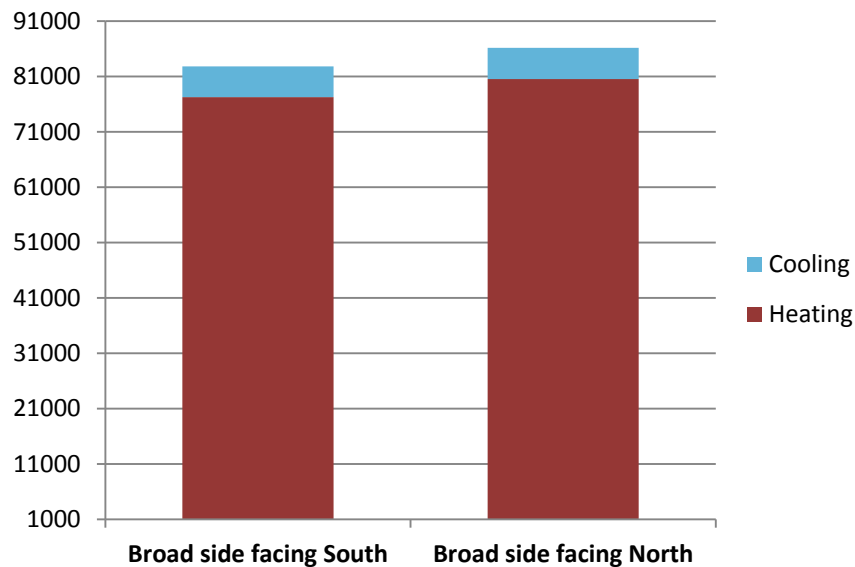


Figure 11: Thermal Load with Respect to House Orientation

The likely locations where street orientation could vary significantly to accommodate energy implications would be the Creek, the Hill, and the Transition neighborhood on the periphery of the Town. It is important to remember that in order to utilize building orientation and passive solar at TCAAP; two mutually dependent factors are required:

- Optimizing street orientation during the subdivision process
- Designing homes to take advantage of the passive solar resource

Optimizing orientation during the subdivision process would be appropriate to solicit during the RFP process. These goals can be included as RFP evaluation criteria.

4.3.3. High efficiency commercial buildings

4.3.3.1. Utilizing SB 2030

As shown in the *White Paper*, the primary energy loads for TCAAP are estimated to be in the retail, commercial, and flex areas of the development. Thus DSM energy conservation measures for these areas of the development will be paramount for successful achievement of the Energy Vision. However, until specific use types are more clearly defined during the RFP process, specific commercial building efficiency strategies are challenging to define. The Project Team recommends that the JDA

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establish the SB 2030 process into the commercial development RFPs, as the SB 2030 process provides an overarching framework for pursuing high commercial efficiency performance. The process for how to use SB 2030 is described above.

4.3.4. Sub-metering

Commercial and multi-family building sub-metering (*Policy White Paper*, p. 31) is included as an important consideration because it is a relatively low additional design cost when considered up front, but has the potential to help maintain low energy use since tenants directly see and pay for their energy use.

Sub-metering has been shown to save up to 21% in leased building spaces.¹⁶ The material, software, and labor cost for each sub-meter point ranges from \$5,000 to \$7,500. Several metering companies provide sub-metering services by owning, operating, and maintaining the meters. Monthly fees are based on the type of service needed and the quantity of sub-meters served, but costs per sub-meter range from \$150 to \$400.

Value Add for Sub-Metering		
Item	Application Level(s)	Primary Use
Energy Procurement and billing	Building	Management
Baselining & optimizing building performance	Building; System	Management; Diagnostics
Project energy measurement & verification	System; Circuit	Management; Diagnostics
Equipment and plug-load diagnostics	Tenant; Circuit; Device	Management; Diagnostics; Utility efficiency programs
Occupant awareness and behavior change	Tenant; Circuit; Device	Management; Diagnostics; Utility efficiency programs; Research

Table 24: Value add for sub-metering¹⁷

¹⁶ “Tenant Occupants of Green Office Buildings: Driving the Market for Improving Existing Building Stock” McGraw-Hill Construction and CBRE. September, 2011. www.cbre.com/EN/aboutus/MediaCentre/2011/Pages/10062011.aspx

¹⁷ http://www.gsa.gov/portal/mediaId/181031/fileName/Sub-metering_Business_Case_How_to_calculate_cost-effective_solutions_in_the_building_context

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Estimated Savings from Sub-Metering	
Action	Observed Savings
Sub-meter bills allocated to all tenants	2.5% - 5% (improved occupant awareness)
Building tune-up & load management	5% - 15% (improved awareness, identification of simple O&M improvements, and load management)
Ongoing commissioning	15% - 45% (improved awareness and ongoing monitoring & commissioning)

Table 25: Estimated savings from sub-metering (DOE 2006)¹⁸

4.3.4.1. Case Study

Legrand North America | Better Building, Better Plants Challenge¹⁹

Legrand, an international provider of information networks, installed sub-meters in its 14 largest manufacturing and assembly facilities in North America.

- The Company had to achieve energy savings of 1.5% of total energy consumption for the dashboard to pay for itself in just 1.5 years. Project ROI was 83%.
- Actions enabled by sub-metering dropped the minimum (baseload) usage by a factor of two.
- The systems empowered Legrand to engage in conservation competition across facilities, something that TCAAP businesses could do across the site.

Building sub-metering should be considered by architects and engineers at the building design stage. While SB 2030 guidelines require minimum sub-metering, additional sub-metering would offer business opportunities like those capitalized on at Legrand properties. Once sub-meters are in place, ongoing energy feedback program opportunities could also be pursued in coordination with the electric utility.

¹⁸ FEMP, *Guidance for Electric Metering in Federal Buildings*. 2006. www1.eere.energy.gov/femp/pdfs/adv_metering.pdf.

¹⁹ <http://www4.eere.energy.gov/challenge/sites/default/files/uploaded-files/submeter-guide.pdf>

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4.3.6. Co-location and strategic siting strategies

Recommendation:

Attract high energy use businesses and building types through RFP materials and developer workshops, and help facilitate energy savings opportunities for these projects through strategic siting.

One opportunity for energy supply alternatives that has been recommended in the *White Paper* is the development of a district energy system, possibly fed from a CHP plant. Planned siting and co-location can bring increased efficiency to a district system or create opportunities for miniature district systems in areas that are not connected (e.g. some of the Flex areas).

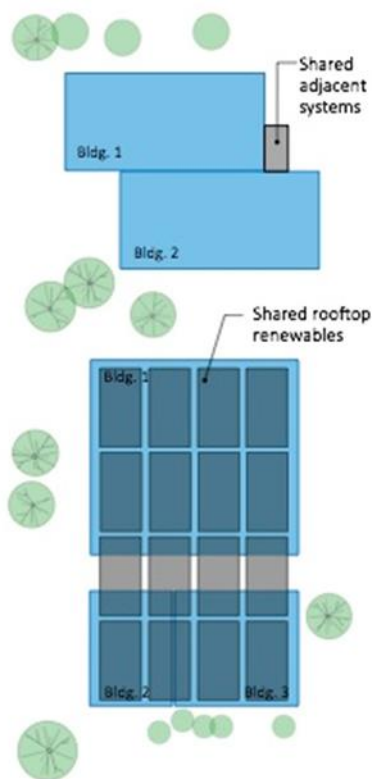


Figure 12: Building co-location examples

Because of the greenfield advantage, high energy use businesses and building use types could be motivated to develop at TCAAP because of the future energy cost savings. For those on the district

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system, they may be able to benefit from the efficiency that they bring to the system through lower rates or even bill credits when they decrease their return temperature.

For businesses that may not be in proximity to a future district energy system, the County and JDA could facilitate building co-location. Certain project types can be identified as potential candidates for co-location. Table 26 outlines business and building types that are high users of hot water or have concentrated periods of high electricity use. As proposals are reviewed, the County and JDA should identify projects that are the same use as those listed in Table 26. Such candidates could be grouped and referred to energy design experts as to the specific energy benefits that could be achieved through co-location. For example, a hotel development could be sited adjacent to a laundromat to make their combined hot water load more even throughout the day and surface the opportunities to share hot water heating and recovery equipment.

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Solar Thermal Sharing Opportunities	Peak Times	Hot Water ¹
Hotels and lodging	Mornings	31.4 kBtu/SF
Multifamily buildings	Morning/Night	na
Health Care (inpatient)	All Day	48.4 kBtu/SF
Bars and restaurants	Afternoon/Night	40.4 kBtu/SF
Laundromats/cleaning services	Daytime	na
Car washes	Late afternoons	na
Small manufacturing	Night/All Day	variable
Gardens/Nurseries		na

Photovoltaics Sharing Opportunities	Peak Times	Total Electric ²
Education facilities ³	Morning/ Afternoon	11.01 kWh/SF
Offices	Daytime	17.3 kWh/SF
Health Care (inpatient)	All Day	27.5 kWh/SF
Restaurants	Night	38.4 kWh/SF
Grocers/Food sales	All Day	49.4 kWh/SF
Retail (malls in particular)	Afternoon/ Night	22.3 kWh/SF
Data Centers	All Day	na

Notes:

1. E2A base on historic CBECS 2003 data

2. E3A base on historic CBECS 2003 data

3. Education facilities are seasonal, but high demand 9 out of 12 months.

Table 26: Applicable Business Types for Building Co-Location

Co-locating buildings does not require the sharing of exterior walls. The proximity to one another may even render opportunities to create unique outdoor employee or community spaces. The hot water or heat producers could sell their excess to adjacent buildings that have use for it at different times of day. Shared decentralized hot water storage units could even be used in some cases. Businesses would be interested in this opportunity because it would improve the efficiency of their consumption, reduce upfront capital equipment and maintenance costs, and increase comfort.²⁰

²⁰ The Primary Energy Factor (PEF) difference between district heating systems and Gas-fired heating ($0.8/1.3=0.61$)
http://www.euroheat.org/Files/File/documents/Publications/District%20Heating%20in%20buildings_final.pdf

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Co-location opportunities will require coordination on the part of the JDA and County, but communicating the interest to facilitate co-location upfront for developers and business will make coordination easier. High energy use project types may be motivated to propose a project at TCAAP if efforts are being made to facilitate energy savings. Marketing materials and RFP language that highlights appropriate co-location building use types can help attract these projects.

4.3.7. Streetlights

The City of Arden Hills has included a site-wide requirement for all streetlights to be “high-efficiency lighting, such as LED lamps” in the *TCAAP Redevelopment Code*. This requirement will trigger the inclusion of high efficiency lights in the development process. Current LED technology saves approximately 50% to 70% of lighting energy use. A significant cost savings occurs by additionally reducing maintenance costs, given the longer life of the bulbs. The City can work with Xcel Energy to utilize any future high efficiency streetlight program offerings that support this effort in a manner that is timely and commensurate with current development staging.

4.3.8. Community participation and education

Community participation and education have been consistently mentioned as important factors at TCAAP, both to engage the wider Arden Hills community and to leverage the energy savings potential from facilitating ongoing awareness of energy use by site tenants and residents. Many details of community engagement will need to be planned once the site sees its first residents and tenants. However, certain engagement elements can be planned for or implemented during the early development stage, including:

- A TCAAP or Arden Hills-wide website that tracks energy goals and performance of buildings at the site, including energy and carbon savings. The website could promote major metrics and milestones, and issue periodic challenges (e.g. the “lowest user” challenge).
- Community-wide open house or showcase events of leading edge technologies on the site, especially for housing, that will attract and excite potential residents (e.g. cook a meal in an all-electric kitchen)
- Commissioning of design or signage elements in public spaces that connect users to the site’s energy resiliency goals and their contribution and participation in those goals. A targeted marketing campaign around community solar development, as an early symbol of community-driven, low carbon energy use at the site.

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4.4. Demonstration Opportunities

4.4.1. Advanced Distribution Grid

TCAAP's greenfield status, combined with the site's forward looking energy vision, make it an ideal opportunity to pilot and demonstrate advanced technologies in the electric distribution grid. Many of the opportunities outlined in this report, such as high solar PV penetration, advanced commercial building metering, or responsive electric loads, are all facilitated by a distribution system with increased communications and control functions.

Features that could be piloted at the site might include increased reliability testing, or load management strategies that rely on advanced metering and communications throughout the distribution network. Load management—the real-time increase or reduction of electric demand in response to external signals—can change customer electricity use in response to signals such as physical constraints or environmental signals, such as an excess renewable energy capacity. The results can save customers money and reduce the environmental impact of their energy use.

By laying the groundwork for an advanced distribution system at TCAAP during the planning phase, residents and businesses would have access to cutting edge opportunities such as advanced rate design or real-time load response. Moving forward on these opportunities would likely require the collaboration of Xcel Energy, the Public Utilities Commission, and the Minnesota Department of Commerce, Division of Energy Resources.

4.4.2. Innovative Energy Technologies

In addition to pilot opportunities at the grid level, TCAAP is ideal for demonstrating innovative energy technologies at scale. The Project Team recommends that the JDA and County seek and attract partnerships to demonstrate proven technologies and strategies. While the technologies may be proven, TCAAP offers scalable and living demonstration opportunities, where an apartment, house, or street of homes could serve as a living lab. Additionally, as a cold climate site that can attract multiple partners, there is great opportunity to demonstrate the synergies that can exist between multiple innovative technologies and design strategies. This might include piloting new in-road luminescent street or pedestrian path lighting products in conjunction with high efficiency overhead LED street lighting or homes that have on-site electric storage and remote controlled appliances/electronics that communicate with each other.

The following case studies outline how demonstration opportunities can make economic sense for developers, the partnerships that brought opportunities to life, and key technologies that could be demonstrated at scale.

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Energy Efficiency Strategies

4.4.3. Technology Demonstration: Case Studies

4.4.3.1. Builders Leading with Home Connectivity | Standard Pacific Homes, KB Homes, TruMark Co.

A number of leading home builders in the U.S. are capitalizing on the benefits of developing homes that are connected – to the internet, to smart phones, cars, on-site renewables, thermostats, lighting, and other home electronics and appliances. Basic network capabilities are being installed in homes as a new standard feature and then buyers can specify additional features they want making buyer costs incremental and personalized. Control capability for homeowners may range from remote control of lights and programmable thermostats, to automatic shutoff of leaky faucets and geofencing capabilities as users approach home. Networks and devices need to achieve this have dropped significantly in price and developers are starting to see these home features as low-cost ways to improve market value. Costs to developers start around \$200 and top out around \$2,000.



Figure 13: Geofencing enabled demand-side management

Examples of Potential Demonstration Technologies:

- 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)

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- 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 System²¹)
- In-home zoned temperature controls (e.g. Honeywell)

4.4.3.2. Net Zero Energy Commercial Building Envelopes | Guardian Industries Detroit, MI

Guardian Industries, a glass and building products manufacturer demonstrated a PV spandrel panel system on its new Science and Technology Center in suburban Detroit. The 12,000 square foot building showcases a cutting edge building panel system that brings solar power generation capability to the vertical surfaces of one or two story commercial buildings. The panels convert sunlight in to electricity at an efficiency of 17% allowing each square foot of panel to produce eight watts of power. Builder Turner Construction also incorporated Guardian's own transparent PV glass to demonstrate ease of integration into the panel system. Eligible for federal modified accelerated cost-recovery System depreciation and a first year federal tax credit of 30% (available through 2017), the 2014 built project expects to achieve 100% payback in two years.



Figure 14: Building integrated PV panel systems

²¹ <http://www.hondasmarthome.com/>

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Energy Efficiency Strategies

Examples of Potential Demonstration Technologies:

- Building integrated photovoltaic panel systems (e.g. BISEM)
- Photovoltaic or electrochromatic glass (e.g. Guardian Ecoguard glass)

Vehicle & Storage Integration Demonstration / SMUD Sacramento, CA

Many major automakers have been working with Sumitomo Electric to demonstrate the value of a cloud-based communication system between electric vehicles and utilities.²² The communication software allows the utility to ask charging cars if they want to temporarily stop charging, based on how much charge a user has programmed in to the charger. Users can opt into this program to receive discounted electricity rates or other incentives while the utility would see less stress on the grid and achieve greater service reliability.²³ Most recently this two-way communication system was demonstrated at the Sacramento Municipal Utility District's (SMUD) Service Center.

There are opportunities to demonstrate these grid benefits and customer incentives in Minnesota at TCAAP. The integration of these communication capabilities into the grid could be demonstrated across multiple individual EV users or a fleet (from a future TCAAP business or other TCAAP neighbors such as Ramsey County or AHATS). The synergy of additional technologies, such as on-site electric storage and renewables and in-home DC power access could be incorporated as part of such a grid integration project. Such an effort could be achieved in partnership with Xcel Energy with the opportunity for the University of Minnesota or other third-parties to play a role in research and community learning.

²² <http://www.epri.com/Press-Releases/Pages/EPRI,-Utilities,-Automakers-to-Demonstrate-Technology-Enabling.aspx>

²³ <http://www.af.mil/News/ArticleDisplay/tabid/223/Article/554343/af-tests-first-all-electric-vehicle-fleet-in-california.aspx>

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Energy Efficiency Strategies



Figure 15: Integrating electric vehicles & storage with utility communication software

Examples of Potential Demonstration Technologies:

- Cloud-based communication software for a utility (e.g. Sumitomo Electric)
- Electric vehicles (e.g. Honda, BMW, Nissan)
- Intelligent electric vehicle integration software (e.g. Nuvve, EURISCO)
- On-street charging stations (e.g. AeroVironment EV Solutions)

4.5. Recommended Development Request for Proposal Language

In order to embed the energy resilience principals of TCAAP into the fabric of the site, it is recommended that the JDA incorporate evaluation language as part of the Request for Proposal (RFP) for all commercial development projects. The language below presents conservation guidelines as criteria by which each proposal could be evaluated. In the cases where it is possible to provide direct incentives or funnel state economic development fund to developers, these standards could be made requirements for these resources.

TCAAP Energy Integration Resiliency Framework

Energy Efficiency Strategies

4.5.1. Energy Resilience Proposal Evaluation Criteria

Sustainable Buildings 2030 Design Standards – HIGHLY RECOMMENDED

Commercial and residential development proposals will be evaluated based on a demonstrated commitment to building to meet or exceed the State of Minnesota’s Sustainable Building 2030 (SB 2030) energy standards. Proposals should highlight design and constructing team experience in developing high-performance buildings and sites. Proposals should also outline preliminary strategies and processes that will be used to meet higher energy performance.

This would include:

- Early design phase energy modeling to inform building orientation, daylighting, passive solar heating, and building envelope decisions
- Specification of high efficiency lighting, operator controls, and mechanical systems/district energy connection
- Integration of tenant and equipment level sub-meters that will monitor ongoing building performance and opportunities for demand response

Further Sub-metering – RECOMMENDED

Beyond meeting SB 2030, it is recommended that all commercial buildings on the TCAAP site be equipped with local sub-metering. Proposals should describe generally the plans for installing circuit or equipment level sub-meters within each tenant space (e.g. individual building or tenant building systems such as lighting or venting) and power monitoring systems to inform behavior and ongoing commissioning efforts.

Innovative Energy Demonstrations & Partnerships – RECOMMENDED

The RFP should state the interest in TCAAP servings as a national model and demonstrating proven energy innovations that will help make renewables, energy efficiency, and energy awareness more visible at TCAAP.

- Proposals may describe a unique energy technology to be incorporated at the building or site level.
- Proposals that layout collaboration opportunities with other TCAAP developers or the community will receive additional consideration (e.g. building co-location interest)

Advanced Metering – RECOMMENDED

TCAAP Energy Integration Resiliency Framework

Energy Efficiency Strategies

This infrastructure will help track and report detailed building performance data to building operators and the utility. It would also allow for the potential of rate programs that give building owners more control of their energy costs and savings (dynamic pricing). All electric utility meters should have two-way, real-time communication capabilities. Xcel Energy could work with developers to help specify and install any advanced meters, and the site development partners could help Xcel Energy obtain the necessary regulatory approvals for piloting these installations.

Solar Oriented Development -- RECOMMENDED

While SB 2030 guidelines will encourage building orientation and site planning that optimizes load minimizing solar heat gains, developers that show intent to incorporate passive solar design will be given additional consideration or even site location preference. This may include conceptual drawings, plans, and other documentation that show how building orientation, building massing, window placement, and site landscaping will utilize passive solar heating and achieve solar access for immediate or future on-site renewables.

TCAAP Energy Integration Resiliency Framework

Schedule

5. Schedule

5.1. Overall TCAAP Development Schedule

The development schedule that is currently proposed is likely to begin in 2016 with the construction of the interchanges of County Hwy 96 and County Road H with the Spine Road. The Spine Road construction is also expected to begin in 2016. Currently, site development is projected to begin with the residential and retail areas in the northern region of TCAAP in late 2016 or early 2017. Development is expected to progress southward from the Town and Creek neighborhoods as the market allows. The Thumb area is being actively marketed by the JDA at this time, and could be developed as soon as the right proposal is received from the development community. The current development plan is included in the appendix as Exhibit III.

5.2. Integrating with the TCAAP Development Schedule

Given the development timeline in section 5.1, development of the concepts presented in this Framework will need to follow varying schedules, as provided below.

5.2.1. Future Thermal Energy Grid

While the most cost-effective time to install thermal energy grids is in coordination with initial site development, this is likely not feasible given the uncertainty of when and what will be developed at TCAAP. Alternatively, a corridor for future energy infrastructure (i.e. district energy piping) could be preserved in the engineering and construction plans for the Spine Road. The Project Team is in discussions with Ramsey County staff to include that corridor in the Spine Road design.

5.2.2. Community Solar

The proposed community solar garden is technically not located on the TCAAP site, rather it is recommended for the Primer Trace site. As such, TCAAP development will not necessarily have an impact on the schedule for this opportunity. Rather, the community solar garden will need to be completed and in service by December 31, 2016 to be eligible for the 30% income tax credits, assuming they are not extended. If the tax credit is not needed in the developer's business model, this schedule is driven more by market conditions than the TCAAP development schedule.

5.2.3. Low-Temperature District Energy

Construction of the low-temperature district energy system in the residential neighborhoods will need to coincide with development in order to be ready to serve the initial neighborhood development, avoid any unnecessary developer costs, and minimize the cost of pipe installation. RFPs are likely to be

TCAAP Energy Integration Resiliency Framework

Schedule

issued in late 2015, so the business plan for this system will need to be fully developed in early to mid-2015.

5.2.4. Combined Heat and Power

Development of the initial CHP system is more directly related to the needs of the existing buildings than to the development timeline of TCAAP. Therefore, construction of the initial CHP system should be coordinated with the MNARNG's plans for site expansion, so that the proposed future buildings could be served by the system from the initial construction and unnecessary equipment costs can be avoided. Connection to the other buildings should be completed at this time to take advantages of the economies of scale and optimize thermal energy capture. Expansion of the CHP system to serve development of TCAAP should coincide with that development, and the JDA should engage early with selected developers to identify how the CHP system can be expanded to meet their buildings' needs.

5.2.5. Demand-Side Management

The JDA should work with partner organizations to develop greater comprehension of SB 2030 guidelines by hosting informational gatherings for the development companies that are interested in the TCAAP site. Builders and contractors familiar with the SB 2030 process could be asked to provide insight and feedback about the process. Developer education will build developer acceptance and understanding of process to make the site more attractive.

The JDA should also assess current residential market potential in Twin Cities region by conducting market research and outreach on all-electric, low load home concept. This will help to assuage developer and future resident concerns about unfamiliar technologies and utility structure.

The JDA should lastly work with the site marketing team to market energy conservation concepts to potential developers, builders, and tenants, focusing on the business opportunities available through these concepts.

TCAAP Energy Integration Resiliency Framework

Next Steps and Conclusion

6. Next Steps and Conclusion

6.1. Next Steps

To achieve the TCAAP energy vision and achieve sustainable benefits for the City and the surrounding community, the JDA will need to begin implementation on each of the individual opportunities presented in this Framework. The Project Team recommends the following immediate actions related to each opportunity.

6.1.1. Partnerships

Continue partnership discussions with the MNARNG, Xcel Energy, the University of Minnesota Center for Sustainable Building Research, and other stakeholders as development of the site and the various energy opportunities progress.

6.1.2. Solar PV

Develop an RFP for the development of a solar array on the Primer Tracer site. The RFPs could be sent to Xcel Energy and local community solar developers. In parallel to the site development RFP process, the County and the MNARNG should begin the process needed to secure the Primer Tracer land for a solar development.

6.1.3. Combined Heat and Power

As part of the developer selection process, the JDA should work with prospective developers to identify opportunities for serving those buildings' electric and thermal energy needs with a CHP facility. The JDA and County should also coordinate with the MNARNG and Xcel Energy to define an initial CHP facility that can serve the current loads in the area, align with the energy goals of the MNARNG, and be expanded in the future to meet the emerging TCAAP energy loads as they occur.

6.1.4. Low-Temperature District Energy System

The JDA should develop the business plan for the proposed low-temperature district energy system and form the operational organization in preparation for the site development request for proposals. In addition, the County should work with the Army and the appropriate regulatory authorities to obtain approval to extract energy from the treated ground water, and utilize the existing pump house for the low-temperature district energy distribution loop. Lastly, the JDA should continue collaboration with Xcel Energy to explore a neighborhood that is independent of the natural gas system, through district energy and electric grid services.

TCAAP Energy Integration Resiliency Framework

Next Steps and Conclusion

6.1.5. Demand-Side Management

The JDA should adopt the energy savings design standards it would like to incorporate into the site development RFP process, both for commercial and residential developments. The JDA should also inform developers on the various energy efficiency opportunities that are available to them by developing informational and educational material for prospective developers. Lastly, the JDA should collaborate with developers and Xcel Energy to identify opportunities for an advanced distribution grid and meters, building co-location, and passive-solar design deployment.

6.1.6. Infrastructure Planning

The County should develop a utility coordination program that enables cost-effective implementation of initial utilities and infrastructure on the site, while allowing for future infrastructure to be added as opportunities come available. The County should also incorporate solar orientation into the platting process.

6.1.7. Funding Pursuits

The JDA should identify the funding opportunities that it could be the most successful in pursuing, and collaborate with the City, County, MNARNG and other stakeholders, as appropriate, to develop funding requests for each selected opportunity. In parallel, the stakeholders should develop and implement an outreach campaign to inform decision makers on the energy opportunities that are available at TCAAP.

6.1.8. RFP Development

The JDA and the County should include energy planning in the development of RFPs for the site, and through negotiations and discussions with individual developers. Opportunities for co-location, waste energy capture, energy efficiency improvements, district energy integration, and other options discussed in the *White Paper* and the Framework should be discussed with developers throughout TCAAP development process to achieve the energy vision.

6.2. Conclusion

The ERAB has adopted a very forward-thinking vision for the TCAAP site. This will be achievable through strategic partnerships with Xcel Energy, the MNARNG, the University of Minnesota Center for Sustainable Building Research, environmentally conscious citizens, and developers who see the economic and environmental value of the TCAAP energy vision. Through these partnerships, TCAAP will be uniquely poised to be the national model for the development of integrated energy systems.

The first steps toward achieving the energy vision include implementing energy supply options that focus on efficiency, reliability, scalability, and sustainability, such as the low-temperature district

TCAAP Energy Integration Resiliency Framework

Next Steps and Conclusion

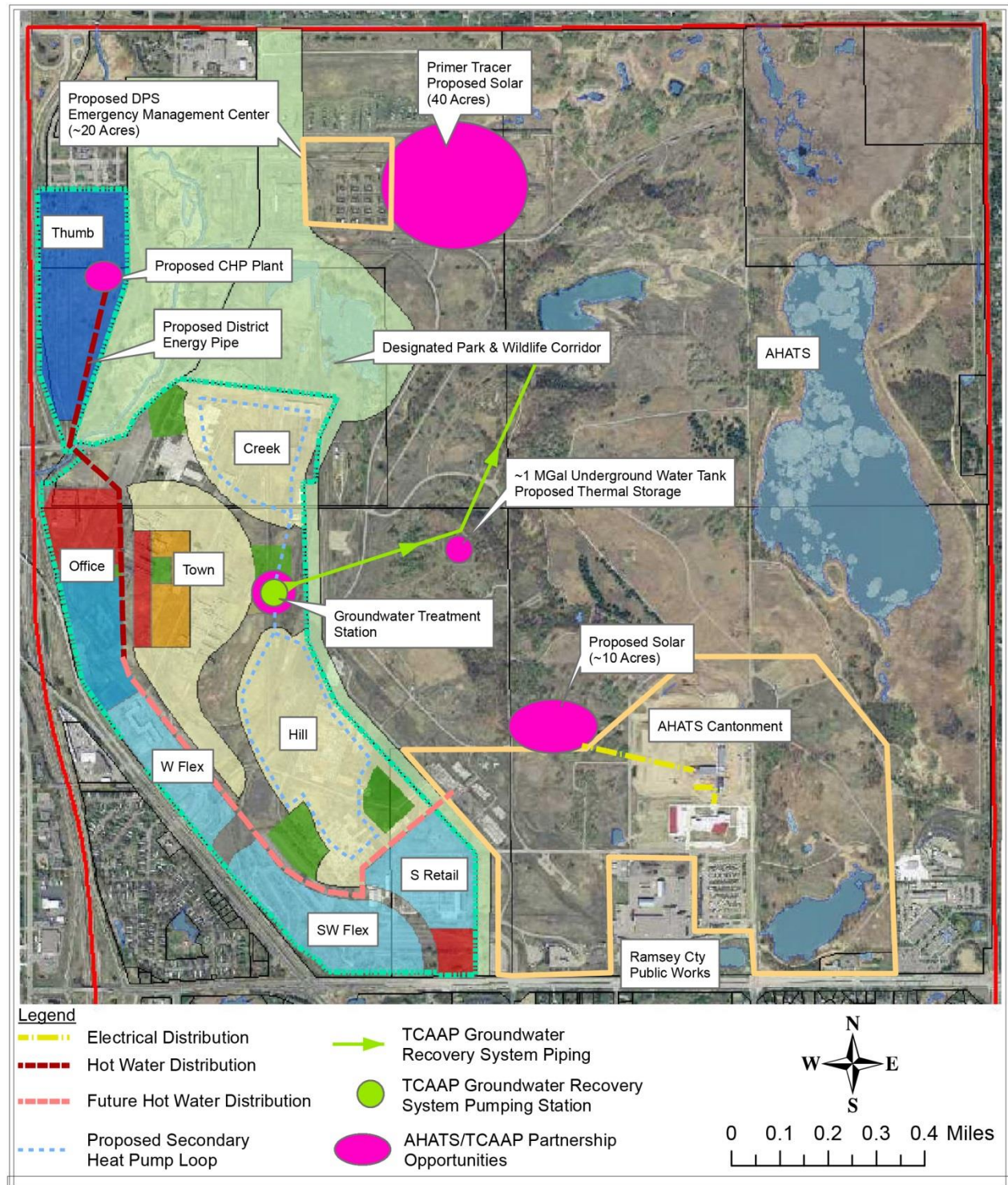
energy system in the residential neighborhoods and the community solar garden at the Primer Tracer site. These specific opportunities have been shown to be financially beneficial and financeable. Developing a CHP approach that meets the needs of current buildings in the area, and is expandable in the future as development proceeds, provides a platform for establishing a resilient TCAAP microgrid in the future.

Implementing a demand-side management strategy that focuses on building performance through the development RFP process will build a resilient community for energy use. Focusing on improving performance in the buildings to reduce, or even eliminate, the energy needs of the buildings will provide an economically attractive environment as building owners are able to take advantage of the financial savings realized by the increased efficiency, compared to traditional energy expenditures.

TCAAP Energy Integration Resiliency Framework

Exhibits

Exhibit I – Partnership Opportunities Map



TCAAP Energy Integration Resiliency Framework

Exhibits

Exhibit II – Demand Side Management Recommended Roles Matrix

	County/City	JDA	Development Broker	Development Engineer	Xcel Energy
Fiber (Spine Road)		Support the installation of TCAAP-wide fiber optic infrastructure. Coordinate with the appropriate utilities so that this infrastructure is installed at the most cost effective development phases.	Convey to developers the benefits of having fiber optic hooked up.	Plan for the installation of TCAAP-wide fiber optic infrastructure. Coordinate with the appropriate utilities so that this infrastructure is installed at the most cost effective development phases.	
Snow melt piping (Spine road)	Invest in this infrastructure as a future maintenance cost savings measure and draw for businesses and residents in the more populated neighborhoods and the Town.	Support the installation of a low-grade heat piping system.	Convey to developers considering Town Center sites the convenience benefits of the street snow melt system.	Plan for the installation of a low-grade heat piping system by keeping green space available along the spine road.	
Low load homes	Help to build a constituency for low-load developments. Also, facilitate the formation of a low temperature district energy business for integration of low-load homes.		Communicate the attractiveness of low-load homes for future home buyers and share the status of constituency interest.		

TCAAP Energy Integration Resiliency Framework

Exhibits

	County/City	JDA	Development Broker	Development Engineer	Xcel Energy
Save on natural gas extension trunklines	Support residential development RFPs with preferences for low-load homes and the benefits of not extending natural gas trunkline infrastructure in these neighborhoods.	Coordinate the location of the low-load neighborhoods so that natural gas infrastructure costs can be avoided. Include in residential development RFPs the preference for low-load homes and the benefits of not extending natural gas trunkline infrastructure in these neighborhoods.	Include cost saving information from not having to extend natural gas trunklines onto specific plats or subdivisions.	Help to visually communicate the location of the low-load neighborhoods as they are determined by proposals and the JDA.	
Attracting businesses with electric vehicle fleets		Help identify (with 3rd party help) appropriate locations for such businesses if there is interest.	Market TCAAP to MN and national businesses that have or may have electric vehicle fleets. Convey that TCAAP would help demonstrate reliable EV charging infrastructure at scale through microgrid and local renewables integration.		
Energy Resilience RFP language	Help structure incentive opportunities that would motivate developers to implement options presented in the EIRF and White Paper. This may include being the arbiter of standing federal, state or local incentives for job creation or tax benefits.	Integrate recommended Energy Resilience criteria into proposal evaluation.	Include recommended RFP language in RFP packets, including sell-sheets that describe the benefits of these preferences. Pursue developers with experience implementing energy efficient developments.		

TCAAP Energy Integration Resiliency Framework

Exhibits

	County/City	JDA	Development Broker	Development Engineer	Xcel Energy
Street Planning and House Orientation	Be stewards of energy resilient street planning and platting. Work with developers to maximize solar heat gain potential by siting lots that allow for the longer sides of houses to be oriented East/West.	Include RFP language that requests for solar isolation optimization (land grading and building orientation), passive solar house design, passive ventilation, and PV-ready roof size and direction (west or southwest).		Support the County and City in dividing up residential neighborhoods with lots that are North/South oriented, or within 15 degrees.	
Developer Education		Help coordinate developer education sessions to help inform developers of TCAAP Energy Resilience goals and opportunities for support services. Discuss potential partnerships, and cost benefits before proposal submission. After developer selection, share information on specific building or home technologies, answer questions, discuss opportunities for integrating with district systems, and initiate design support.			
Sharing costs: SB 2030 & ENERGY STAR Home certifications	Support the development of high-performance design and development by sharing the administrative costs of the SB 2030 certification with developers (50/50 split).				Provide additional technical support for those projects committed to meeting SB 2030.
Co-locating buildings		Facilitate building co-location by making developers aware of the energy cost benefits of siting on a particular plot of land and even offering potential incentives for doing so.	Communicate to developers what co-location is, why it would be advantageous, and what building use types best leverage this opportunity. Make a special effort to market to developers or businesses that building these types of projects.		

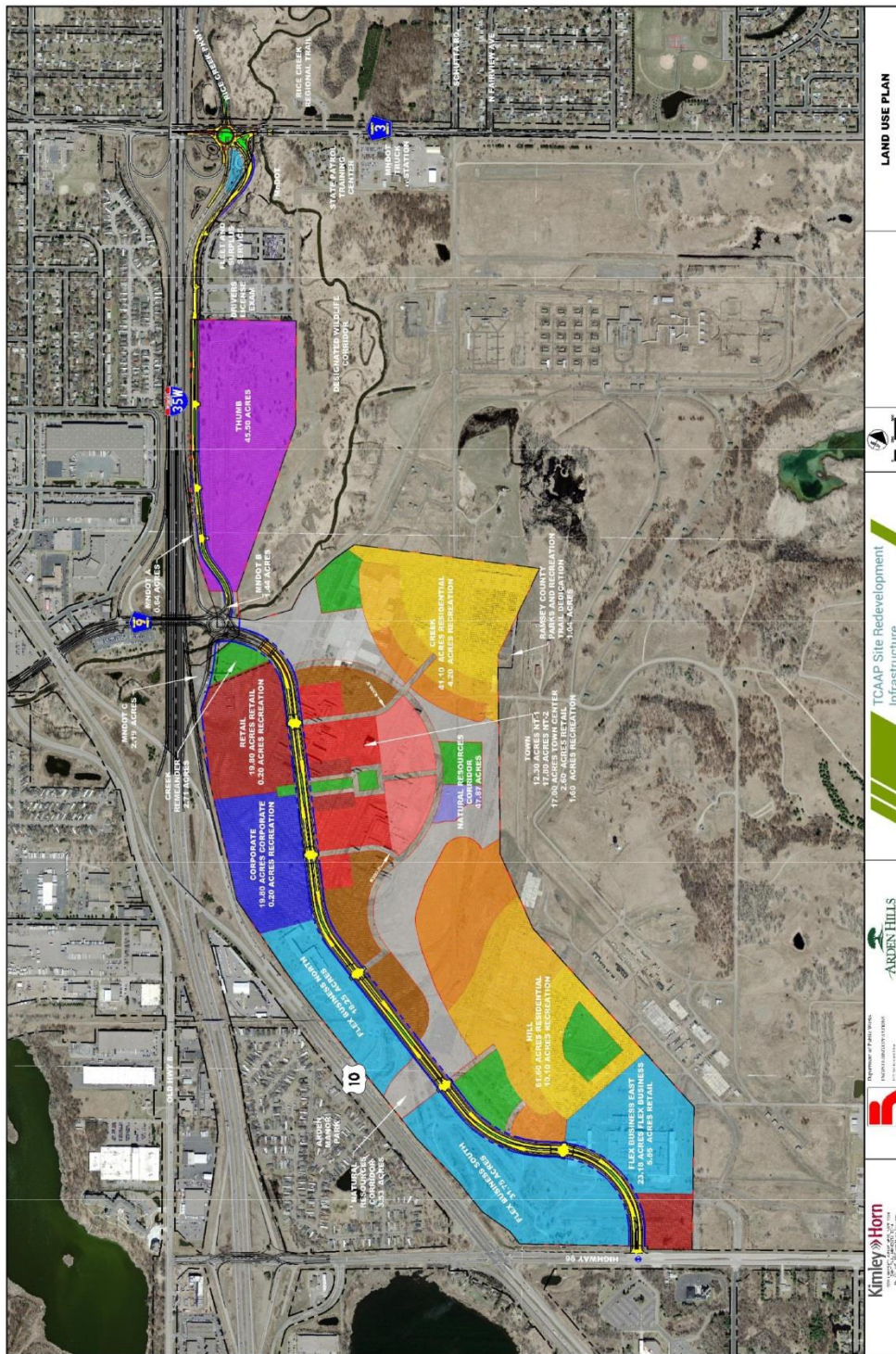
TCAAP Energy Integration Resiliency Framework

Exhibits

	County/City	JDA	Development Broker	Development Engineer	Xcel Energy
Advanced Meters					Make advanced meters the standard offering for buildings and homes built on the TCAAP site.

Exhibits

Exhibit III – TCAAP Land Use Map



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Exhibits

Exhibit IV – Funding Source Matrix

Funding Name	Type of Funding	Funding Source	Funding Description	Funding Criteria	Limitations	Deadline	Suggested Next Steps	Notes and Additional Info
Property Assessed Clean Energy (PACE)	Financing through Property Assessment	Municipal Financing District	Revenue bonds backed by special assessments and made available to property owners through loans, which are repaid through an annual special tax on individual property bills.	1. Energy efficiency improvements; 2. Renewable energy systems, and 3. Electric Vehicle charging systems.	Loan cannot be longer than the useful life of improvements (max. 20 years), assessed over 10 years. Limited to the cost of the improvement or 10% of property, whichever is less. Energy audit or feasibility study required. Must demonstrate ability to repay (current on taxes and mortgage). Must demonstrate cost effectiveness, and receive consent of first mortgage lender.	None	Arden Hills City Council should work with the Saint Paul Port Authority (SPPA) to develop a Joint Powers Agreement to allow SPPA to administer PACE program.	http://mn.gov/commerce/energy/images/PACE-Minnesota-Presentation.pdf www.pacenow.org
Legislative-Citizen Commission on Minnesota Resources	Grant	Environment and Natural Resources Trust Fund	Permanent fund in the state treasury established for the public purpose of the conservation or enhancement of natural resources.	Alignment with LCCMR strategic plan, multiple beneficiaries, outcomes, knowledge base of applicant, extent of impacts, innovation, scientific or technical basis, urgency, capacity and readiness, and leverage.	Natural resource education, capital projects for the protection of unique natural resources, activities that preserve impaired natural resources.	4:30 PM on Monday, May 11, 2015	Immediately review 2016 projects for alignment with LCCMR eligibility and criteria and proceed with application.	Funds from the 2015 application process would be available July 1, 2016. http://www.lccmr.org/legislation/proposals/2016/2016_lccmr_rfp.pdf
Renewable Development Fund	Public Benefits Fund	Xcel Energy	Minnesota Legislature has required Xcel Energy to contribute towards the development of renewable-energy resources for each cask of nuclear fuel stored at Prairie Island and Monticello nuclear power plants. Annual contribution to the fund is approximately \$26 million. Up to \$10.9 million annually must be allocated to support renewable energy production.	Request for proposals issued, and awards based on proposals received. PUC must approve RDF grant awards.	Funds in the RDF account may only be used for: increasing the market penetration of renewable electric energy resources in Minnesota at a reasonable cost, promoting the start-up, expansion, and attraction of renewable electric energy projects and companies within Minnesota, stimulating in-state research and development into renewable electric energy technologies, and developing near-commercial and demonstration scale electric infrastructure delivery projects if those delivery projects enhance the delivery of renewable electric energy.	Next cycle dates not published	Monitor for announcements of next funding and review cycle.	http://www.xcelenergy.com/environment/renewable_energy/development_fund
Investment Tax Credit	Corporate tax credit	Internal Revenue Service	The ITC is a 30 percent tax credit for solar systems on residential (under Section 25D) and commercial (under Section 48) properties.	eligible for solar			Evaluate this opportunity if a solar garden agreement is not reached.	

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Exhibits

Funding Name	Type of Funding	Funding Source	Funding Description	Funding Criteria	Limitations	Deadline	Suggested Next Steps	Notes and Additional Info
Production Tax Credit	Corporate tax credit	Internal Revenue Service	The federal renewable electricity production tax credit (PTC) is a per-kilowatt-hour tax credit for electricity generated by qualified energy resources and sold by the taxpayer to an unrelated person during the taxable year.	eligible for geothermal			Research eligibility and applicability of this fund for a ground-source heat pump district energy system and determine whether this program is still fully funded.	http://energy.gov/savings/renewable-electricity-production-tax-credit-ptc
Qualified Energy Conservation Bonds (QECB)	Taxable Bonds	Department of Energy	Taxable bond that enables qualified state, tribal, and local government issuers to borrow money at attractive rates to fund energy conservation projects (e.g. capital expenditures related to reducing energy consumption in public buildings, implementing green community programs, designing/running demonstration projects to promote the commercialization of technologies to reduce peak use of electricity, etc.)		At least 70 percent of the allocations must be used for government projects. No more than 30 percent may be used for private activities. Private activity QECB proceeds may only be used for capital expenditures. Additionally, 100 percent of the available project proceeds of QECBs are to be used for one or more qualified conservation purposes.	September 10, 2010 or Expiration of funds		http://mn.gov/mmb/images/Notice-of-Guidance-581-5D.pdf http://program.sdsireusa.org/system/program/detail/3098
Made in Minnesota Solar Incentive	Performance Incentive	Department of Commerce	Incentive for customers of investor owned utilities to utilize solar PV modules or solar thermal panels, up to 40 kW-DC system, manufactured at a registered facility located in Minnesota.	Manufacturer located in the state and be registered and authorized to manufacture in the state. Utility must provide meter, and utility owns the RECS.	40 kW-DC system maximum	February 29 of every year	Evaluate this solar garden agreement is not reached. Or if solar thermal is pursued for development.	
Trillion BTU	Revolving Loan Fund	Saint Paul Port Authority	Money saving opportunities are identified by energy audits and engineering studies (Xcel Energy co-funding and CEE technical assistance available). SPPA is using Federal stimulus monies through the Minnesota Department of Commerce to create this program for Minnesota businesses. Customer chooses the project and contractors, Xcel Energy provides the rebate, SPPA provides the financing. 100% financing available.	Must be an Xcel Energy commercial or industrial customer with a qualified rebate project.	Must be in Xcel service territory	Revolving	Determine need for this mechanism.	http://sppa.com/wp-content/uploads/sellsheet_03_08.pdf

TCAAP Energy Integration Resiliency Framework

Exhibits

Funding Name	Type of Funding	Funding Source	Funding Description	Funding Criteria	Limitations	Deadline	Suggested Next Steps	Notes and Additional Info
Energy Savings Partnership	Revolving Loan Fund	Saint Paul Port Authority - MN Department of Commerce	Established by a grant from the MN Department of Commerce, a municipal leasing program with U.S. Bank that offers reduced interest rate loans to participants.	Any project that provides energy efficiencies, energy savings, or renewable energy is eligible.	Minimum loan size is \$50,000. Must be a city counties, public schools, or regional government entity.	Revolving	Determine need for this mechanism.	http://sppa.com/wp-content/uploads/2014/03/newESP2014.pdf
New Market Tax Credits	Tax Credit	Eligible Financing Agency	The New Markets Tax Credit Program (NMTC Program) was established by Congress in 2000 to spur new or increased investments into operating businesses and real estate projects located in low-income communities. The NMTC Program attracts investment capital to low-income communities by permitting individual and corporate investors to receive a tax credit against their Federal income tax return in exchange for making equity investments in specialized financial institutions called Community Development Entities (CDEs). An organization wishing to receive awards under the NMTC Program must be certified as a CDE by the Fund.	Must be located in an eligible distressed zone. The credit totals 39 percent of the original investment amount and is claimed over a period of seven years (five percent for each of the first three years, and six percent for each of the remaining four years).	The investment in the CDE cannot be redeemed before the end of the seven-year period.	Dispatched annually	Determine need for this mechanism and a financing partner.	
The Resilient Electricity Delivery Infrastructure (REDI) Initiative	Grant	Department of Energy (NETL)	DOE initiative that focuses on technology transfer of smart grid advances to support the White House actions to respond to the needs of communities nationwide that are dealing with the impacts of climate change. Maximum awards range from \$600,000 to \$1,000,000 by topic area.	1) Implementation and deployment of the best, pre-commercial and/or commercial smart grid technologies/tools (Topic Area 1) and 2) technologies/tools utilizing smart grid from the DOE National Laboratories (Topic Area 2).	Only available to units of local government. The improvements must be measurable, tangible within 24 months of project start, substantial over a long period of time, accountable for resilience to environmental stressors (e.g., more frequent extreme weather events and other climate change impacts).	4-May-15	Determine if any projects are prepared and eligible to proceed with application.	https://www.fedconnect.net/FedConnect/?do=c=DE-FOA-0001219&agency=DOE

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Exhibit V – Definitions

Air Handling Unit (AHU) – A central unit consisting of a blower, heating and cooling elements, filter racks or chamber, dampers, humidifier, and other central equipment in direct contact with the airflow. This does not include the ductwork through the building.

Active solar – As an energy source, energy from the sun collected and stored using mechanical pumps or fans to circulate heat-laden fluids or air between solar collectors and a building.

Alternating Current (AC) – An electric current that reverses its direction at regularly recurring intervals. AC is the form in which electric power is delivered to businesses and residences.

Alternative-rate Energy Efficiency program assistance – An Energy Efficiency (demand-side management) program assistance that offers special rate structures or discounts on the consumer's monthly electric bill in exchange for participation in Energy Efficiency programs aimed at cutting peak demands or changing load shape. These rates are intended to reduce consumer bills and shift hours of operation of equipment from on-peak to off-peak periods through the application of time-differentiated rates. For example, utilities often pay consumers several dollars a month (refund on their monthly electric bill) for participation in a load control program. Large commercial and industrial customers sometimes obtain interruptible rates, which provide a discount in return for the consumer's agreement to cut electric loads upon request from the utility (usually during critical periods, such as summer afternoons when the system demand approaches the utility's generating capability).

Arden Hills Army Training Site (AHATS) – A military training area of Minnesota National Guard and the Minnesota Department of Military Affairs that is directly adjacent to the Rice Creek Commons Project to the east.

ASHRAE Bin temperature data – Temperature frequency in 5 F intervals available from American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Boiler – A device for generating steam for power, processing, or heating purposes; or hot water for heating purposes or hot water supply. Heat from an external combustion source is transmitted to a fluid contained within the tubes found in the boiler shell. This fluid is delivered to an end-use at a desired pressure, temperature, and quality.

British Thermal Unit (Btu) – The amount of heat required to raise the temperature of one pound of water 1 degree Fahrenheit. The Btu is a small amount of heat equivalent to the heat released by a burning matchstick. For district heating systems, heat is often measured in million Btus (MMBtu) which is equivalent to one million Btu's.

Building Commissioning - a building performance quality assurance process that begins during design and continues through construction, occupancy, and operations. Commissioning ensures that the new building operates initially as intended by design and that building staff are prepared to operate and maintain its systems and equipment.

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Capacity – The maximum output, commonly expressed in megawatts (MW), that generating equipment can supply to system load, adjusted for ambient conditions.

Chiller – Any centrally located air conditioning system that produces chilled water in order to cool air. The chilled water or cold air is then distributed throughout the building, using pipes or air ducts or both. These systems are also commonly known as “central chillers,” “centrifugal chillers,” “reciprocating chillers,” or “absorption chillers.” Chillers are generally located in or just outside the building they serve. Buildings receiving district chilled water are served by chillers located at central physical plants.

Chilled Water – The product of a Chiller that is distributed through a building or, in the case of a District Cooling system, other adjacent buildings for the purposes of air conditioning.

Coefficient of Performance (COP) – Ratio of work or useful output to the amount of work or energy input, both represented in the same unit. Used generally as a measure of the energy-efficiency of chillers and heat pumps.

Combined Heating and Power (CHP) – A plant designed to produce both heat and electricity from a single heat source.

Conservation – A reduction in energy consumption that corresponds with a reduction in service demand. Service demand can include buildings-sector end uses such as lighting, refrigeration, and heating; industrial processes; or vehicle transportation. Unlike energy efficiency, which is typically a technological measure, conservation is better associated with behavior. Examples of conservation include adjusting the thermostat to reduce the output of a heating unit, using occupancy sensors that turn off lights or appliances, and car-pooling.

Constant Air Volume (CAV) – A system designed to provide a constant air flow. This term is applied to HVAC systems that have variable supply-air temperature but constant air flow rates. Most residential forced-air systems are small CAV systems with on/off control.

Consumer (energy) – Any individually metered dwelling, building, establishment, or location using natural gas, synthetic natural gas, and/or mixtures of natural and supplemental gas for feedstock or as fuel for any purpose other than in oil or gas lease operations; natural gas treating or processing plants; or pipeline, distribution, or storage compressors.

Cooling Degree Days – A degree day is the difference in temperature between the outdoor mean temperature over a 24-hour day and a given base temperature. Cooling degree days occur when the outdoor mean temperature is above 65 F.

Cubic Feet per Minute (CFM) – A common means of assigning quantitative values to volumes of air or fluid in transit.

Customer conversion – The equipment in a customer building mechanical room that transfers thermal energy from the district heating system to the building systems to allow the heat to be distributed throughout the building. The customer conversion usually consists of heat exchangers, pumps, piping, control sensors, and control valves to enable heat to be efficiently transferred from the higher temperature district heating system to the lower temperature building system.

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Daylighting – Designing buildings to maximize the use of natural daylight to reduce the need for electricity.

Demand-Side Management (Energy Efficiency) – A utility action that reduces or curtails end-use equipment or processes. Energy Efficiency is often used in order to reduce customer load during peak demand and/or in times of supply constraint. Energy Efficiency includes programs that are focused, deep, and immediate such as the brief curtailment of energy-intensive processes used by a utility's most demanding industrial customers, and programs that are broad, shallow, and less immediate such as the promotion of energy-efficient equipment in residential and commercial sectors.

Demand-side management costs – The costs incurred by the utility to achieve the capacity and energy savings from the Demand-Side Management Program.

Differential temperature (dT , delta T) – The difference between the supply temperature and return temperature of the district heating water delivered to users. This is an indication of the amount of energy delivered to the customer.

Direct Current (DC) – The unidirectional flow of electric charge. Direct current is produced by sources such as batteries, thermocouples, and solar cells. The electric current flows in a constant direction, distinguishing it from alternating current (AC).

Distributed Control System (DCS) – A control system of an energy production plant and process wherein control elements are not only located in central location but are also distributed throughout the system with each component sub-system controlled by one or more controllers so the intelligence is distributed across the sections of the system.

Distribution – The delivery of energy to retail customers.

District energy – A thermal energy delivery system that connects energy users with a central production facility.

Diversified load – The actual peak load on an energy system. The diversified load is less than the sum of the peak loads of individual users due to the difference in time of day that each individual user realizes their peak load.

Distribution system – The underground piping network that delivers hot water from an energy production facility to the customer buildings. Hot water is circulated through this distribution system using pumps that are located at the production facility.

Domestic hot water – Potable water that is heated for use in faucets, showers, laundry, and similar uses.

Energy Conservation Measure (ECM) – This includes building shell conservation measures, HVAC conservation measures, lighting conservation measures, any conservation measures, and other conservation measures incorporated by the building. However, this category does not include any Energy Efficiency program participation by the building. Any Energy Efficiency program participation is included in the Energy Efficiency Programs.

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Energy Transfer Station – Equipment installed at the point of customer connection to the district energy system. The energy transfer station is utilized to transfer and measure the thermal energy delivered from the district energy distribution network to the customer's building(s) or other thermal loads.

Energy Usage Intensity - The quantity of total energy that a building consumes per square foot per year. Energy is usually expressed in terms of thousand British thermal units (KBtu/SF/year).

Energy Utilization Index (EUI) – Measure of the total energy consumed in cooling or heating of a building or facility in a period, expressed as British thermal unit (Btu) per (cooled or heated) gross square foot.

Equivalent Full Load Hours – Annual energy usage divided by the peak capacity used.

Fixed Operations and Maintenance (FOM) – Costs other than those associated with capital investment that do not vary with the operation, such as maintenance and payroll.

Fuel Cell CHP – Electrochemical power generation process generating both electricity and thermal energy suitable for making steam or hot water.

Geothermal energy – Hot water or steam extracted from geothermal reservoirs in the earth's crust. Water or steam extracted from geothermal reservoirs can be used for geothermal heat pumps, water heating, or electricity generation.

Geothermal plant – A plant in which the prime mover is a steam turbine. The turbine is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rock.

Green Spine – The corridor through the Rice Creek Commons development that will be designated green space for the use of stormwater management, recreational trails, and parks.

Greenhouse gases (GHG) – Those gases, such as water vapor, carbon dioxide, nitrous oxide, methane, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride, that are transparent to solar (short-wave) radiation but opaque to long-wave (infrared) radiation, thus preventing long-wave radiant energy from leaving Earth's atmosphere. The net effect is a trapping of absorbed radiation and a tendency to warm the planet's surface.

Ground Source Heat Pump – A heat pump in which the refrigerant exchanges heat (in a heat exchanger) with a fluid circulating through an earth connection medium (ground or ground water). The fluid is contained in a variety of loop (pipe) configurations depending on the temperature of the ground and the ground area available. Loops may be installed horizontally or vertically in the ground or submersed in a body of water.

Heat pump – Heating and/or cooling equipment that, during the heating season, draws heat into a building from outside and, during the cooling season, ejects heat from the building to the outside. Heat pumps are vapor-compression refrigeration systems whose indoor/outdoor coils are used reversibly as condensers or evaporators, depending on the need for heating or cooling.

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Heating Degree Days – A degree day is the difference in temperature between the outdoor mean temperature over a 24-hour day and a given base temperature. Heating degree days occur when the outdoor mean temperature is below 65 F.

Heat exchanger – A pressure vessel that contains plates or tubes and allows the transfer of heat through the plates or tubes from the district heating system water to the building heat distribution system. A heat exchanger is divided internally into two separate circuits so that the district heating system water and the building heat distribution system fluids do not mix.

Heating coil – A heating element made of pipe or tube that is designed to transfer heat energy to a specific area or working fluid.

Hot water supply and return lines – The district heating system piping that distributes hot water for heating purposes to customers (supply) and returns the cooler water to the Plant for reheating (return).

Kilowatt (kW) – A unit of power equal to one thousand Watts (W)

Kilowatt-hour (kWh) – A measure of electricity defined as a unit of work or energy, measured as 1 kilowatt (1,000watts) of power expended for 1 hour. One kWh is equivalent to 3,412 Btu.

Load – The amount of energy used by a customer. Typically refers to the Peak Load on the system.

Levelized Cost of Energy (LCOE) – The present value of the total cost of building and operating a generating plant over its economic life, converted to equal annual payments. LCOE is determined by dividing the project's total cost of operation by the energy generated.

Medium temperature hot water – Thermal heat transferred via hot water at a temperature between 190 °F and 250 °F.

Megawatt (MW) – One million Watts (W)

Megawatt-hour (MWh) – One thousand kilowatt-hours

Microgrid – A group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that act as a single controllable entity with respect to the grid and can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.

Million BTU (MMBTU) – One million British Thermal Units (BTU). One MMBTU is equivalent to 293.07 kWh.

Net Present Value (NPV) – The difference between the present value of the future cash flows from an investment and the amount of investment. Present value of the expected cash flows is computed by discounting them at the required rate of return. A zero net present value means the project repays original investment plus the required rate of return. A positive net present value means a better return, and a negative net present value means a worse return, than the return from zero net present value.

Non-diversified load – The sum of the peak loads of individual users. This is a theoretical maximum system peak load.

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Normalized – Adjusted annual data of monthly building usage values measured on different monthly heating degree scales to a common scale prior to averaging.

N+1 Redundancy – A measure of system component redundancy to provide backup in the event of failure of any one component. N+1 refers to the number of units installed to carry normal load plus one additional unit as backup. For example, if a system has three chillers to achieve the total design load, each is rated at 33% of the total load, or N=3. For this example, an N+1 system will have a total of four chillers of 33% capacity for a total installed capacity of 133% with one chiller providing backup in the event of failure of any one chiller.

Operations and Maintenance (O&M) – The activities related to the performance of routine, preventive, predictive, scheduled, and unscheduled actions aimed at preventing equipment failure or decline with the goal of increasing efficiency, reliability, and safety.

Outside Air Temperature (OAT) – A measure of the air temperature outside a building. The temperature and humidity of air inside and outside the building are used in enthalpy calculations to determine when outside air can be used for free heating or cooling.

Passive solar heating – A solar heating system that uses no external mechanical power, such as pumps or blowers, to move the collected solar heat.

Peak load/ Peak demand – The maximum load during a specified period of time

Photovoltaic and solar thermal energy – Energy radiated by the sun as electromagnetic waves (electromagnetic radiation) that is converted at electric utilities into electricity by means of solar (photovoltaic) cells or concentrating (focusing) collectors.

PSI – An abbreviation for pounds per square inch. PSI is a unit of pressure measurement.

Rice Creek Commons (RCC) – The name of the land development project that is being led by Ramsey County, as the land owner, on the site formerly known as the Twin Cities Army Ammunitions Plant (TCAAP).

Recommissioning - A type of commissioning that occurs within an existing, operating building to identify ways the building operation is sub-optimal. The decision to recommission may be triggered by a change in building use or ownership, the onset of operational problems, or some other need. *Renewable energy resources* – Energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include biomass, hydro, geothermal, solar, wind, ocean thermal, wave action, and tidal action

Resiliency – The ability to withstand disruptions to the regional or national energy grids or significant volatility to the market price for energy sources.

Return on Investment (ROI) – The earning power of assets measured as the ratio of the net income (profit less depreciation) to the average capital employed (or equity capital) in a company or project. Expressed usually as a percentage, return on investment is a measure of profitability that indicates whether or not a company is using its resources in an efficient manner. For example, if the long-term return on investment of a company is lower

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than its cost-of-capital, then the company will be better off by liquidating its assets and depositing the proceeds in a bank.

Seasonal energy efficiency ratio (SEER) – Ratio of the cooling output divided by the power consumption. It is the Btu of cooling output during its normal annual usage divided by the total electric energy input in watt hours during the same period. This is a measure of the cooling performance for rating central air conditioners and central heat pumps.

Service line/service piping/customer connection – The segment of the district heating distribution system that extends from the main lines to the inside of the customer building. The service line is typically sized to meet the peak hot water flow requirements for the individual building served by the piping.

Square Foot (SQ FT or ft²) – Unit of measure to quantify the footprint area of a customer building, used to estimate the Load of a building based on the usage of the building.

Source Energy - The total amount of raw fuel that is required to operate an energy-using device or facility. Source energy includes all transmission, delivery, and production losses, thereby enabling a complete assessment of energy efficiency in a building. On the other hand, “Site Energy” is the amount of heat and electricity consumed by a building as reflected in utility bills.

Solar cooling – The use of solar thermal energy or solar electricity to power a cooling appliance.

Solar Photovoltaic Systems (PV) – Systems that directly convert sunlight into electricity either for use locally or for delivery to the electric grid.

Solar Thermal – Systems that directly convert sunlight into heat, generally for domestic hot water though they can also be used to produce space heating.

Substation – Facility equipment that switches, changes, or regulates electric voltage.

Sustainability - Meeting the needs of the present generation without compromising the ability of future generations to meet their own needs.

Therm – One hundred thousand (100,000) Btu

Thermal energy – Energy that is generated and measured in the form of heat.

Thermal Energy Storage – The storage of heat energy during utility off-peak times at night, for use during the next day without incurring daytime peak electric rates.

Thumb – That portion of the Rice Creek Commons development that is at the extreme northwest of the site, and is separated from the remainder of the site by Rice Creek.

Transit Oriented Development (TOD) – Land development that takes into account transportation choices as a means of reducing oil and other energy use. Typically it would combine public transit with walkable, mixed-use communities, and approaches to minimize the impact of individual vehicles and commuting.

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Waste Heat Recovery – An energy conservation system whereby some space heating or water heating is done by actively capturing byproduct heat that would otherwise be ejected into the environment. In nonresidential buildings, sources of waste heat include refrigeration/air-conditioner compressors, manufacturing or other processes, data processing centers, lighting fixtures, ventilation exhaust air, and the occupants themselves. Not to be considered is the passive use of radiant heat from lighting, workers, motors, ovens, etc., when there are no special systems for collecting and redistributing heat.

Water source heat pump – A type of (geothermal) heat pump that uses well (ground) or surface water as a heat source. Water has a more stable seasonal temperature than air thus making for a more efficient heat source.

Variable Air Volume (VAV) – An HVAC system that has a stable supply-air temperature, and varies the air flow rate to meet the temperature requirements. Compared to constant air volume (CAV) systems, these systems conserve energy through lower fan speeds during times of lower temperature control demand.

Variable frequency drive – an electronic controller that controls the speed of an electric motor by modulating input frequency and voltage to match motor speed to the specific demands of the work being performed.