



DULUTH ENERGY
SYSTEMS

DULUTH ENERGY SYSTEM 5-YEAR PLAN UPDATE

AUGUST 2022
EVER-GREEN ENERGY

ABOUT THE PLAN UPDATE

In 2012, the City of Duluth selected Ever-Green Energy to be their partner for operations, maintenance, and management of Duluth Energy Systems (formerly “Duluth Steam”). One of the first big initiatives that Ever-Green Energy led was to complete a master plan for the system. The plan identified opportunities to improve efficiency, increase reliability, enhance environmental stewardship, improve cost-competitiveness, and identify growth opportunities. The master plan served as a guide for system transformation. In ten years, many initiatives have been undertaken to modernize the system to improve reliability, efficiency, and the customer experience.

The *Duluth Energy System 5-Year Plan Update* has been developed by Ever-Green Energy and presented to the City of Duluth to provide an overview of accomplishments and a proposal for continued improvements and strategic investments. This plan is informed by City of Duluth’s climate goals, outlining opportunities to reduce carbon while continuing to prioritize service reliability and cost.

The district energy system experts at Ever-Green Energy bring decades of experience in development, operation, and management to Duluth Energy Systems. The team applies its depth of knowledge through every aspect of the system’s business, partnering with the City of Duluth to find sustainable solutions that are reliable and financially viable to secure the system’s future.

DULUTH ENERGY SYSTEM 5-YEAR PLAN UPDATE

Executive Summary

In 2013, Ever-Green Energy completed an energy system master plan, the [Duluth Steam Master Plan](#), to guide the transformation of the thermal energy systems that serve the area around downtown Duluth including Canal Park and the medical district. In 2013 these priorities included:

- Transitioning away from fossil fuels and toward locally-derived renewables
- Increasing the overall system efficiency through updates from steam with no condensate return toward the latest in hot water distribution technology
- Connecting buildings to the customer base within the system’s geographic footprint to allow the achievement of economies of scale



Since that initial report in 2013, the system has been transformed. Beginning in 2015, the City of Duluth leveraged its planned Superior Street reconstruction and \$21M in state bonding support to modernize its energy system at the same time, upgrading from steam to a closed-loop, hot water distribution system. Updating this energy infrastructure provides Duluth with a pathway to reduce the energy demands of the system and in customer buildings, providing opportunities for fuel flexibility, financial savings, and carbon reduction. This project entailed updating 11 blocks of distribution piping, converting 27 customer buildings to hot water service, and installing a new hot water transfer station in the plant. The strategic investment in Duluth Energy Systems

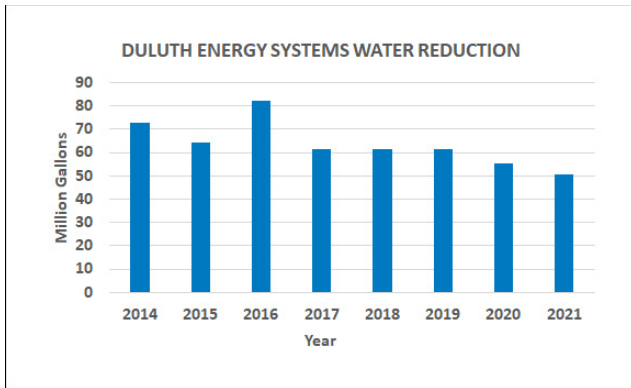
updates the infrastructure to serve generations to come while positioning the system for the integration of renewable and lower environmental impact energy resources.

Since 2014, carbon emissions for heating have been reduced by 50%.

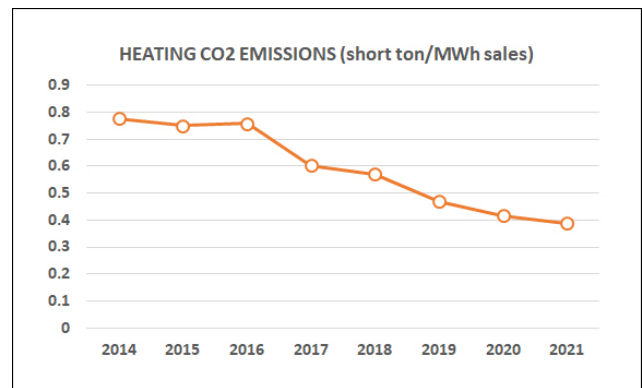
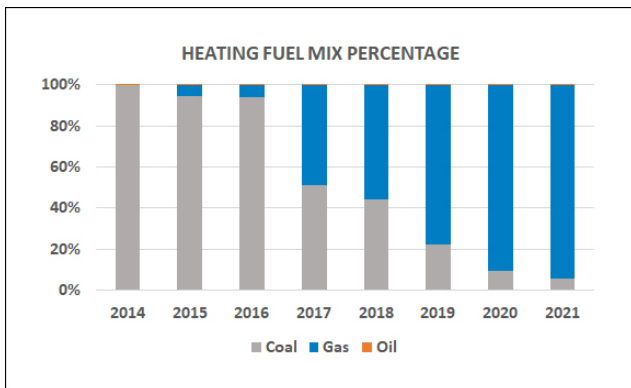
Improvements have benefitted customers through improved efficiency and cost savings while reducing carbon for customers and the community. Coal has been virtually eliminated from the fuel mix, although it is still being utilized for peaking and backup, in favor of lower-carbon intensity natural gas purchased under a favorable rate structure specifically developed for Duluth Energy Systems. Since 2014, carbon emissions for heating have been reduced by 50%.



The management team is collaborating closely with the city to continue to explore renewable fuel and energy source options while prioritizing reliability and cost-effective service for system customers. Nearly 40% of the system’s load has been converted from steam to energy and cost-saving hot water during the Superior Street transformation and Regional Exchange District expansion deploying nearly \$30 million in state funding to these community energy systems. Many of the system customers now contribute to the stability and advancement of the system through longer-term contracts that allow planning and investment that better serves the needs of customers and the community.



In addition to carbon savings, Duluth Energy Systems’ water use has been reduced by 20 million gallons annually. Customers that have converted to hot water have realized average thermal energy consumption reductions of over 25%. During the large-scale project work, Duluth Energy Systems also addressed long-standing deferred maintenance items to prepare the plant and distribution network to serve the community for future generations.



DULUTH ENERGY SYSTEMS FUEL MIX AND CARBON EMISSIONS DATA 2014 - 2021

This update will guide operational and investment decisions for the next 5-years in alignment with priorities already established by the community in its [City of Duluth Climate Action Work Plan](#). In particular:

Phase 1, strategy 2, action 1.2: Continue to improve the fuel emissions factor and efficiency for Duluth Energy System

- Identify clean energy resources to replace fossil fuel inputs; eliminate coal in the next 5 years
- Encourage a transition to more efficient hot-water loop for new and existing customers of Duluth Energy Systems.

The team at Ever-Green Energy is closely aligned with the priorities of the Duluth community – supporting energy systems that are cost-effective and flexible to allow the deployment of new technologies to achieve high levels of resiliency and reliability while reducing carbon emissions.

The recommendations for the 5-year planning period as detailed in this document include:

- Eliminate coal to improve the emissions profile of energy production. This entails adding natural gas fuel capabilities to the two boilers at the Duluth Energy Systems plant that are coal-only and adding distillate fuel oil capabilities to all 4 boilers to provide backup in the event of a natural gas supply disruption.
- Identify and opportunistically pursue energy sources for the thermal grid that are locally derived and promote emissions reductions and overall system efficiency and cost-effectiveness. These include biomass/wood-based fuel inputs, right-sized, high-efficiency natural gas boiler, and waste heat recovery at WLSSD in conjunction with the West Superior Street/Lincoln Park Geothermal Coalition projects.

- Study the feasibility and pursue implementation of beneficial electrification by utilizing waste heat recovery and heat pumps. With approximately 40% of the total system load supplied by hot water, the use of lower-grade energy resources such as waste heat recovery becomes viable. Electricity tends to be cost-prohibitive as an input to heating systems unless there are waste heat sources that can be recovered for the benefit of the system. One such option is the waste heat associated with the water treated at the water treatment facility operated by WLSSD (Note - this has potential to align with the proposed West Superior Street renovation and Lincoln Park Geothermal Coalition projects.).
- Systematically expand the hot water network to replace less efficient steam services by prioritizing distribution runs that only deliver a modest amount of energy due to the number of customer connections or smaller customer loads. Several opportunities are currently being considered.
- Expand the availability of customer meter data through investment in meter communication systems to enhance Duluth Energy Systems' ability to assist customers with energy efficiency.
- Further enhance production efficiency through installation of economizers in the boilers which will enhance fuel conversion efficiency by 5% to 10% depending on the design. Alternatively, install a modest-sized, high-efficiency boiler as baseload to improve efficiency throughout the year.

The team is closely aligned with the priorities of the Duluth community – supporting energy systems that are cost-effective and flexible to allow the deployment of new technologies to achieve high levels of resiliency and reliability while reducing carbon emissions.

Ultimately, the 5-year capital planning goals are to:

- Eliminate coal from its fuel mix
- Incorporate locally-derived renewable energy sources
- Continue to upgrade the efficiency of the thermal grid through hot water deployment and the plant through the use of economizers or right-sized, high-efficiency boiler
- More firmly establish itself as a community resource that moves Duluth toward a best-in-class energy system fully prepared for the future

PLAN

Decarbonize and the Elimination of Coal from Fuel Mix

Given the priorities already established by the City of Duluth in its *City of Duluth Climate Action Work Plan*, Duluth Energy Systems' top priority is the elimination of coal from its fuel mix. Since 2012, the deployment of natural gas as the system's primary fuel has reduced the percentage of coal used from 98% to 2%. While Duluth Energy Systems has 4 coal boilers, there are only two that are also capable of firing natural gas. The limited amount of coal that continues to be utilized is deployed to meet peak demand during extreme cold, when natural gas has been interrupted due to pipeline issues, or when maintenance on the natural gas boilers necessitates alternative fuels.

Given the priorities already established in the City of Duluth Climate Action Work Plan, Duluth Energy Systems' top priority is to eliminate coal from its fuel mix.

In order to fully eliminate coal as a primary fuel source, the two boilers at the Duluth Energy Systems plant that cannot burn gas must be modified to utilize natural gas. This includes adding burners to the existing boilers that enable natural gas combustion, as well as control systems (called the burner management systems). The cost of this upgrade is estimated to be \$1.5 million (2022 USD) but does not account for the need to have a backup fuel when natural gas is unavailable which is more fully explained below.



To eliminate coal as a backup fuel and maintain service reliability during extreme weather conditions or natural gas interruptions, an alternative fuel source or combination of fuels besides natural gas must be implemented to meet the entire customer load with redundancy in case of a malfunction of one production asset. The most readily-available fuel to economically fill the role is fuel oil. The cost of adding fuel oil to the four boilers at the Duluth Energy Systems plant as the backup fuel and to allow coal to be eliminated is \$4.5 million (2022 USD) which includes the natural gas burners on two boilers as described above. This cost includes fuel oil storage in sufficient quantities to meet initial peak load, piping, and burners with a burner management/protection control system. Fuel oil has a higher carbon intensity than natural gas. Alternatives exist and more solutions are expected as low-carbon fuels continue to develop. Potential alternatives include

renewable fuel oil that could utilize this proposed fossil fuel oil infrastructure. Additional options with existing technology could include electric boilers and heat pumps.

Another resource that contributes to the further reduction in coal needed to meet peak load is the long-term agreement between Duluth Energy Systems and Essentia. Under this agreement, Essentia is installing backup boilers fueled by natural gas and fuel oil to meet the applicable regulatory standards for Level 1 trauma center hospitals. These boilers will be available as an asset to be dispatched as needed on behalf of the Duluth Energy Systems. This additional natural gas-fired boiler capacity is expected to be sufficient to eliminate the need for coal for peaking, but Duluth Energy Systems will still need a backup fuel alternative to natural gas fuel.

DULUTH ENERGY SYSTEMS HEAT PRODUCTION ASSETS

	Current		Post-5-Year Plan Implementation	
	Fuel	Capacity	Fuel	Capacity
Boiler 1	Coal	55 kpph	Natural Gas & Fuel Oil	70 kpph
Boiler 2	Natural Gas & Coal	70 kpph	Natural Gas & Fuel Oil	70 kpph
Boiler 3	Natural Gas & Coal	70 kpph	Natural Gas & Fuel Oil	70 kpph
Boiler 4	Coal	55 kpph	Natural Gas & Fuel Oil	70 kpph
Essentia Boiler			Natural Gas & Fuel Oil	70 kpph
TOTAL		250 kpph		350 kpph

Expand Hot Water to Improve Thermal Distribution Network Efficiency

Converting customers from the steam distribution system to the new hot water network has provided cost and energy savings for customers and the system. Expansion of these conversions and the hot water network is a goal of this plan with the following parameters:

- Adding new customers to the system, with an emphasis on additions to the hot water network, will continue to be a top priority. Opportunities will be identified and prioritized within an economically feasible distance of the existing system.
- Identify and prioritize existing customers to convert from steam to hot water. The goal will be to convert three to five customers per year, subject to the following criteria:
 - Customers will be evaluated based on cost associated with converting the building system from receiving steam to hot water and any infrastructure required to connect the building system to the hot water distribution network, including potential mainline expansion.
 - Availability of capital funds, including but not limited to bond funds, grants, low interest loans, etc.
 - Timing and coordination with the City of Duluth on future street projects to minimize disruption and share as much of the civil and restoration costs as possible.

- Beneficial contraction of the steam distribution network where practical and without significantly impacting the economics of the entire system.

The team will continue to provide updates on specific opportunities as they progress.

DULUTH ENERGY SYSTEMS STEAM AND HOT WATER SERVICES		
	2013	2022
Steam Customers	154	139
Hot Water Customers	5	36
% Hot Water Service	3%	26%

Identify & Opportunistically Pursue Locally-Derived Energy Sources for the Thermal Grid

A forward-looking community energy system is one that utilizes locally-derived energy sources, especially waste energy sources, to provide resilience and reduce cost impacts of fossil-fuel price escalation. There are a number of resources and strategies that would provide fuel flexibility, especially with the recent expansion of hot water piping that provides the opportunity to deploy lower-grade, and often lower-carbon energy resources.

The options here are quite diverse and include:

- **Electrification** – Utilizing electricity as an input energy source has become more viable with the expansion of the hot water thermal network to Superior Street and the Regional Exchange/Medical District. With approximately 40% of the total system load supplied by hot water, the use of lower-grade energy resources such as waste heat recovery becomes viable. Electricity tends to be cost-prohibitive as an input to heating systems unless there are waste heat sources that can be injected into the system through the efficiencies (coefficient of performance) of heat pumps.

One such option is the waste heat associated with the water treated at the water treatment facility operated by WLSSD.

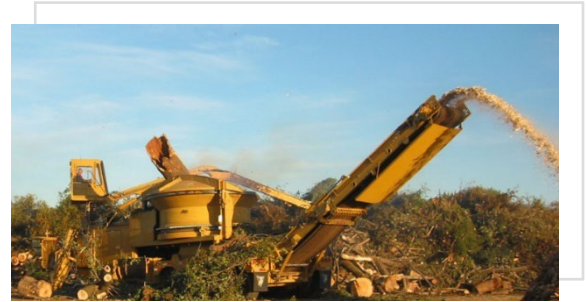
While a considerable investment is needed to extend a pipeline nearly 7000 feet from Duluth Energy Systems to WLSSD, the energy that could be captured could become a low-cost, low-carbon resource for generations into the future.

Coordination with the Lincoln Park Geothermal Coalition project could provide a once-in-a-generation opportunity to coordinate infrastructure and expand the use of this renewable and carbon-free resource.

There are other possibilities for electrification that include the use of electrode boilers, but these direct heating solutions usually are cost-prohibitive due to electricity rates.

Capturing carbon-free, waste heat from WLSSD with the Lincoln Park Geothermal Coalition project is a once-in-a-generation opportunity.

- **Use of locally-derived biomass** – the local forest industry produces significant waste in the form of tops and branches of harvested logs. Tree waste biomass is recognized as lower carbon than fossil fuels and considered carbon-neutral by the EPA. A modest-sized biomass boiler or gasifier could provide baseload energy year-round and help to meet peak energy use in the coldest weather to reduce the use of less-desirable fossil fuels. A boiler of approximately 50 MMBtu/hr heat input would convert 25% of the Duluth Energy Systems load from fossil fuel to locally-derived biomass and would require an investment of \$17 million (2022 USD).

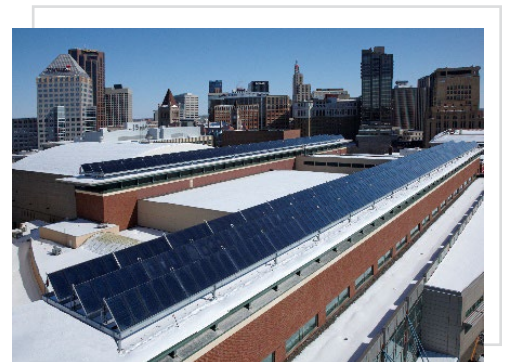


- **Preserve the boiler plant at St. Mary’s Hospital to use as a resource for Duluth Energy Systems** – already connected to Duluth Energy Systems’ network and fired by natural gas, these boilers could be part of the solution that eliminates coal from the fuel dispatch at Duluth Energy Systems. These boilers are currently expected to be decommissioned to make room for redevelopment as Essentia’s operations move from St. Mary’s Hospital to their new Vision Northland hospital complex.
- **Plant upgrades to reduce total steam production or boost production efficiency** – although more study and analysis are needed, investments in the Duluth Energy Systems plant have been identified that would reduce peak steam load and enhance the amount of useful energy that can be derived from the plant without increasing fuel consumption. These opportunities include (1) converting some of the steam-powered pumps and fans in the plant to electric motors, making more steam available from the boilers to meet customer load; (2) adding economizers to the existing boilers to recover more heat from the fuel being combusted and directing that heat into the thermal grid, instead of being lost through the exhaust stack; and (3) installing a high-efficiency, smaller-capacity boiler to meet year-round baseload.
- **Renewable Fuel Oil** – In 2018, Duluth Energy Systems secured a 5-year agreement with Ensyn Fuels for the supply of a fuel oil derived from wood that would provide one-half of the fuel needs of Duluth Energy. Shortly after this agreement was put into place, the EPA placed a hold on the program that allows for the cost-effective supply of renewable fuel oil. While the agreement with Ensyn Fuels remains in place, the potential for the resolution of the issue with EPA is beyond our control, and we must pursue alternatives. As of early 2023, there are indications that RFO may be viable due to action by EPA.
- **Hydrogen** – Currently cost-prohibitive and supplies are limited to use as fuel at scale.

Other Thermal System Enhancements

After the highest-priorities are addressed, there is a range of service and decarbonization enhancements that could be evaluated for feasibility, cost, and carbon saving. These features can also add to the service value proposition for customers. Potential projects include:

- Hot water storage
- Customer meter communication system (see “Customer Upgrades”)
- Solar thermal



- DECC boilers added to system fleet
- Chilled water system redundancy/expansion
- Sub-concrete snow melt systems as a service

Customer Upgrades

A key to district system efficiency is making sure that buildings on the network are utilizing energy as optimally as possible. More so, understanding the requirements of each building and how they operate can help guide future decisions on system development and resource selection.

Customer meter interval data provides the information required to understand building operations and start to identify potential opportunities for efficiency improvement. Duluth Energy Systems would need to add data loggers (roughly one per customer), network switches, a front-end database and reporting tool, and terminate fiber optic cable in order to bring this data back to the plant in real-time (rough estimate of this is \$300k)

Having this data will allow Duluth Energy Systems to develop future benchmarking, energy audits, and customer tools to assist the system efficiency from the customer-side of the meter. It enhances customer relations as the team at Duluth Energy Systems can be proactive and seen as a resource to assist buildings with their energy efficiency needs.

Financial Summary

A detailed financial projection is included as an appendix.

This projection includes the following projects as described above:

- Natural Gas and Fuel Oil conversion to eliminate coal in an amount of \$4.5 million in years 2023 through 2025
- Installation of boiler economizers to improve efficiency of the production assets in the amount of \$1.2 million in years 2026 and 2027
- Upgrade boiler controls to enhance reliability and efficiency of the production assets in the amount of \$450,000 in years 2023 through 2025
- Expected customer connections (service lines and energy transfer stations) in the amount of \$5.05 million over the 5-year planning period
- Capital maintenance in the amount of \$250,000 per year (total of \$1.25 million over the 5-year planning period)

Not included in the 5-year financial plan are two projects that would greatly enhance the system energy inputs – the installation of a wood-fired boiler that uses local forest residuals and a connection to the WLSSD treatment plant to allow thermal energy capture with heat pumps. Due to the high cost of this infrastructure, these projects are not financially viable in the 5-year planning period, but would be possible if a source of grant funding becomes available or the opportunity to integrate/coordinate with other public works projects (West Superior Street reconstruction). The wood-fire boiler system is estimated at \$17 million based on a 2016 proposal received by Duluth Energy. The WLSSD thermal energy recovery and interconnecting pipeline is estimated at \$15 million.