

## **Measure #1 - Greenhouse Gas Reduction Estimate- Wastewater Heat Recovery**

---

**Objective-** The objective of this analysis is to calculate the annual greenhouse gas (GHG) reduction from current levels to the year 2050 for the Lincoln Park community and the Duluth Energy Systems (DES) district energy system if supplied by a central heat pump plant that utilizes wastewater for heat extraction. The heat pumps would extract thermal energy from the wastewater stream from the Western Lake Superior Sanitary District (WLSSD) wastewater treatment plant, generate hot water, and distribute it to buildings for space heating, domestic hot water, and process heating. This document provides a comprehensive explanation of the methodology and assumptions applied in estimating the GHG emission reductions.

### **Methodology-**

**1. Collect Building Data-** Building data was gathered for structures within the Lincoln Park community, with a specific focus on those situated along W Superior Street and W Michigan Street due to the W Superior Street reconstruction (2025-2028). The collected information includes building usage, square footage, heating system types, and natural gas consumption. To establish a baseline energy scenario for Lincoln Park, five years of natural gas consumption data spanning from 2019 to 2023 was obtained from the gas utility. Then, the data underwent weather normalization based on annual heating degree days to derive a typical energy consumption value.

In addition to collecting usage data, thorough walkthroughs of buildings were conducted, covering over 1,000,000 square feet of building space, representing approximately 45% of the total building square footage in Lincoln Park. These buildings contribute to around 40% of the total energy consumed in the area. The primary focus of these walkthroughs was to understand the existing building stock and to identify viable near-term candidates for connection to a hot water district energy system.

**2. Review Electrical Grid Carbon Reduction Goals-** The carbon emissions of the electric grid are derived from the utility's schedule for achieving carbon neutrality. In Duluth, MN, the utility responsible for providing electricity is MNPower. Their target is to achieve a 70% reduction in carbon emissions from their 2005 levels by 2030, with the ultimate goal of being 100% carbon-free by 2040, as mandated by the State of Minnesota. A carbon emissions reduction schedule was formulated, outlining the gradual scaling of carbon reduction percentages on an annual basis, as opposed to relying solely on two milestone dates. The MNPower electrical grid carbon reduction schedule was based on data listed in their sustainability report, which can be found at the following link.

<https://allete.blob.core.windows.net/allete/Documents/Sustainability/ALE-Sustainability-Report.pdf>

**3. Wastewater Heat Recovery-** Data spanning 2020-2023 of daily influent and effluent measurements were obtained from the Western Lake Superior Sanitary District (WLSSD). The data provided included the influent flowrate, influent temperature, effluent flowrate, and effluent temperature and has been summarized in Table 1. The wastewater treatment plant processes an average of 33 million to 37 million gallons per day of wastewater, with effluent temperatures ranging between 85-90°F as it exits the treatment plant into the St. Louis River.

Year	Flowrate (MGD)			Temperature (°F)		
	Maximum	Minimum	Average	Maximum	Minimum	Average
2020	95	20	34	100	40	87
2021	72	17	33	103	59	89
2022	83	23	35	100	51	87
2023	103	25	37	102	47	85

*Table 1. WLSSD effluent flowrates and temperatures*

The new energy system project's objective is to harness heat from the wastewater stream before it is discharge into the bay. This captured heat will be processed through heat pumps to provide hot water for various applications including space heating, domestic hot water, and process loads through a community district heating network. Assuming an average wastewater flow rate of 24,000 gallons per minute (GPM), the energy available for extraction is calculated based on temperature differentials (the difference between the entering and leaving wastewater temperatures to and from the heat pump) as summarized as:

Temperature Differential	Capacity Available (MMBtu/hr)
5 °F	60
10 °F	120
15 °F	179
20 °F	239

*Table 2. Available energy in the wastewater stream at an average flowrate of 24,000 GPM.*

The daily capacity of available recoverable heat by temperature differential is in Figure 1.

**4. Duluth Energy Systems Connection-** Duluth Energy Systems serves steam and hot water through a district energy network providing service to downtown Duluth, the Regional Exchange District (including two hospitals), and Canal Park. Covering over 8 million square feet of building space, approximately 45 percent of which is supplied by the hot water network, the system plays a critical role in meeting the area's heating needs. The Duluth Energy Systems' plant, located in Canal Park, primarily operates natural gas-fired boilers with coal as a backup fuel. For the purpose of this analysis, of the two services provided by Duluth Energy Systems this analysis is focused is on the downtown hot water network, which is best suited to utilize thermal energy provided by the Lincoln Park heat pumps.

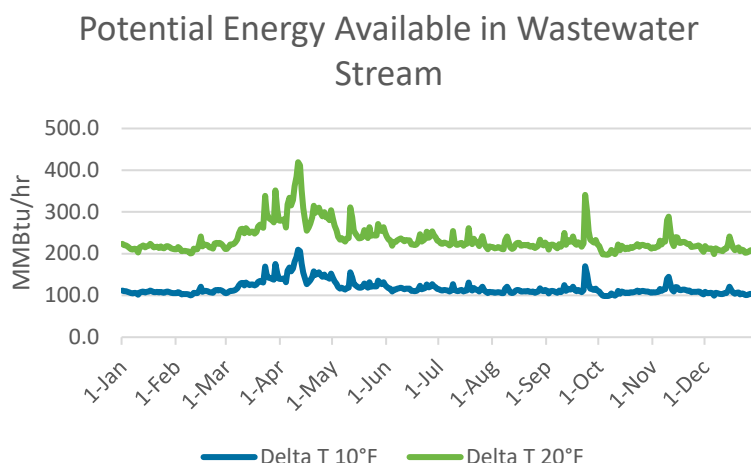


Figure 1. Potential energy available from the wastewater stream at 10°F and 20°F temperature differential.

To assess the potential utilization, the most recent hot water metering data for the downtown network was collected, providing hourly data for the Duluth Energy Systems hot water output during 2023. This year's data offers the most accurate representation of the current load profile, including the system's expansion to serve two hospitals in 2022/2023. The hourly data includes the plant's flow rate, loop supply temperature, and loop return temperature, offering insights into the integration potential of DES and Lincoln Park, as well as the amount of energy that can be supplied to DES by heat pumps.

The downtown hot water loop operates on an outside air temperature reset schedule, with a maximum supply temperature of 215°F on extremely cold days and a minimum of 170°F in the summer. The system's return temperature typically remains around 155°F year-round. It is important to note that because of Duluth Energy Systems' current plant layout, this analysis does not include the Canal Park hot water loop or the hot water loop serving the Duluth Entertainment Convention Center and AMSOIL Arena.

**5. District Energy System-** The new district heating system is designed to extract thermal energy from wastewater for use in heat pumps located at a central facility. Hot water will be distributed through insulated direct-buried supply and return pipes to the Lincoln Park community. Each building connected to the system will be equipped with an energy transfer station comprising of controls, a heat exchanger, pumps, and energy metering. In addition to serving the new energy system in Lincoln Park, the wastewater energy system could potentially extend to Duluth Energy System's hot water network serving downtown Duluth.

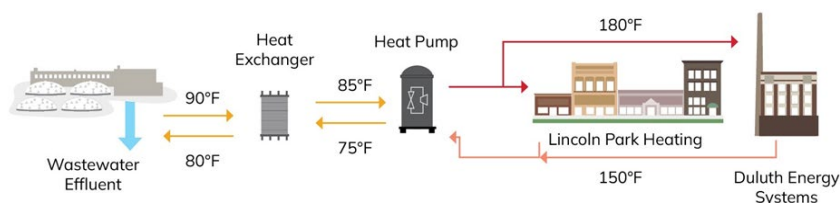


Figure 2. Illustration of the district energy system.

In the selection of equipment for the central plant heat pump, priority is given to a natural refrigerant, specifically ammonia, due to its non-flammable nature and lack of global warming potential (GWP). Alternatively, HFO refrigerants with very low GWP could be considered, although they do carry some environmental risk, including the potential for phase-out in the future—a concern already being addressed in Europe.

Preliminary equipment selection indicates an anticipated coefficient of performance (COP) exceeding 4 (4.2), signifying that for every unit of electricity input into the heat pump, over 4 units of thermal energy would be generated.

### **Analysis Assumptions**

#### **Emissions**

- Natural gas carbon emissions, 117 pounds of CO<sub>2</sub> per MMBtu.
- MNPower's 2005 emissions of 0.962 metric tons per MWh of electricity.
- MNPower will provide 100% carbon-neutral electricity by 2040.

#### **Building Connections**

- For buildings without natural gas consumption data available, their energy was estimated at 55 kBtu of thermal energy per square foot, derived as an average based on buildings with available natural gas data.
- Existing natural gas combustion equipment at 80% annual efficiency.
- Peak loads were estimated by dividing the annual energy by 1,900 EFLH

#### **Duluth Energy Systems Connection**

- A supply temperature of 180°F is assumed to be delivered to the Duluth Energy Systems plant via a heat exchanger, with a 5°F approach resulting in 175°F available to the DES distribution system.
- Energy from the Lincoln Park heat pumps is expected to serve the Duluth Energy Systems summer load and increase their hot water return temperature year-round.
- The assumption includes 3.5 MW of heat pump capacity at the Lincoln Park central plant serving Duluth Energy Systems, with the heat pump offsetting Duluth Energy System's natural gas consumption.

#### **District Energy System**

- Central plant heat pump COP of 4.2, based on manufacturer provided specification sheet.
- Heat pump with refrigerant that has zero global warming potential.
- Distribution pumping energy at 5 kWh electric per MMBtu of thermal energy output.
- Connectable load includes an additional 20% of building load, accounting for additional interest in building connections if the project becomes real.
- District energy system load diversity factor of 80%.
- The system is fully operational by 2028.

**Scenarios-** There are potentially eight combinations of GHG scenarios between Lincoln Park and Duluth Energy Systems that can be derived from the analysis. The following summary narrows the eight combinations down to the two most implementable solutions.

### Lincoln Park Community

The analysis outlines two scenarios for the Lincoln Park Community, encompassing all buildings along West Superior Street and a selection of connectable buildings. The full buildout scenario incorporates over 2.1 million square feet of building space with an annual gas consumption of 124,000 MMBtu. The connectable load comprises buildings with either hot water internals, those expressing keen interest in connecting to a district system, or high-profile buildings with the largest load such as the Heritage Center ice arena, United State Postal Service, Duluth Transit Authority, MidTowne I & II (214 units of public housing), and the LNPK Resilience Hub. This connectable load represents approximately 1.1 million square feet of building space and an annual gas consumption of 46,000 MMBtu. Table 3 below provides a summary of each Lincoln Park scenario.

	Building Area	Annual Energy	Peak Load
	GSF	MMBtu	MMBtu/hr
Lincoln Park – Full Load	2,100,000	124,000	68
Lincoln Park Connectable	1,100,000	61,000	35

*Table 3. Lincoln Park building square footage, energy consumption, and estimated peak load.*

### Duluth Energy System District Energy System Connection

The DES hot water network currently serves 3,650,000 square feet of multifamily residential, hospital, entertainment, and commercial space. Two load scenarios were assessed for the Duluth Energy Systems connection: one provides all of the hot water energy for the Duluth Energy Systems hot water network from a heat pump plant, and the other provides up to a certain capacity/supply temperature to Duluth Energy Systems driven by utilization hours and system temperatures.

#### **Heat Pump Selection for Duluth Energy Systems Load**

Analyzing Duluth Energy Systems metering data and examining various heat pump capacities offers insights into selecting an appropriate size heat pump to align with Duluth Energy Systems' current downtown hot water load profile. The analysis reveals diminishing returns as heat pump capacity increases. Figure 3 illustrates how larger gains are achieved at smaller capacities. Notably, a heat pump with a supply temperature output of 180°F is only capable of providing 66% of Duluth Energy Systems' 2023 annual energy, while a heat pump larger than 17.1 MMBtu/hr (5 MW) offers no offset to Duluth Energy Systems' annual natural gas combustion.

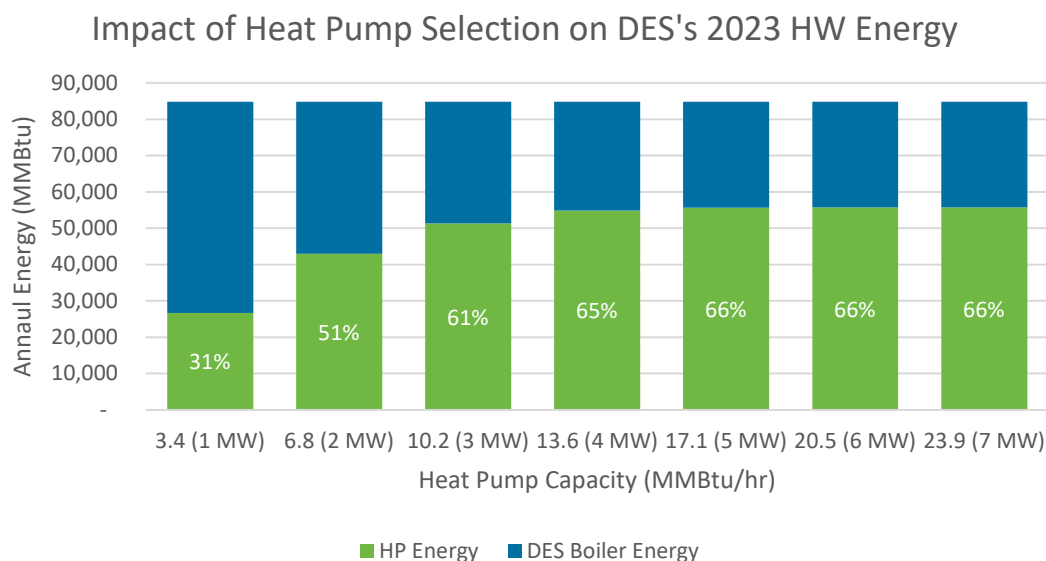


Figure 3. Heat pump capacity and impact on Duluth Energy Systems' HW energy profile (2023)

For the GHG analysis, a 3.5 MW heat pump was used for the baseload. However, a larger unit or an additional unit could be installed to accommodate future growth of Duluth Energy Systems. Figure 4 provides an illustration of load increases, particularly during the fall and winter of 2023, coinciding with additional hospital loads. The chart also illustrates the utilization of various heat pump capacities against Duluth Energy Systems' 2023 hot water output.

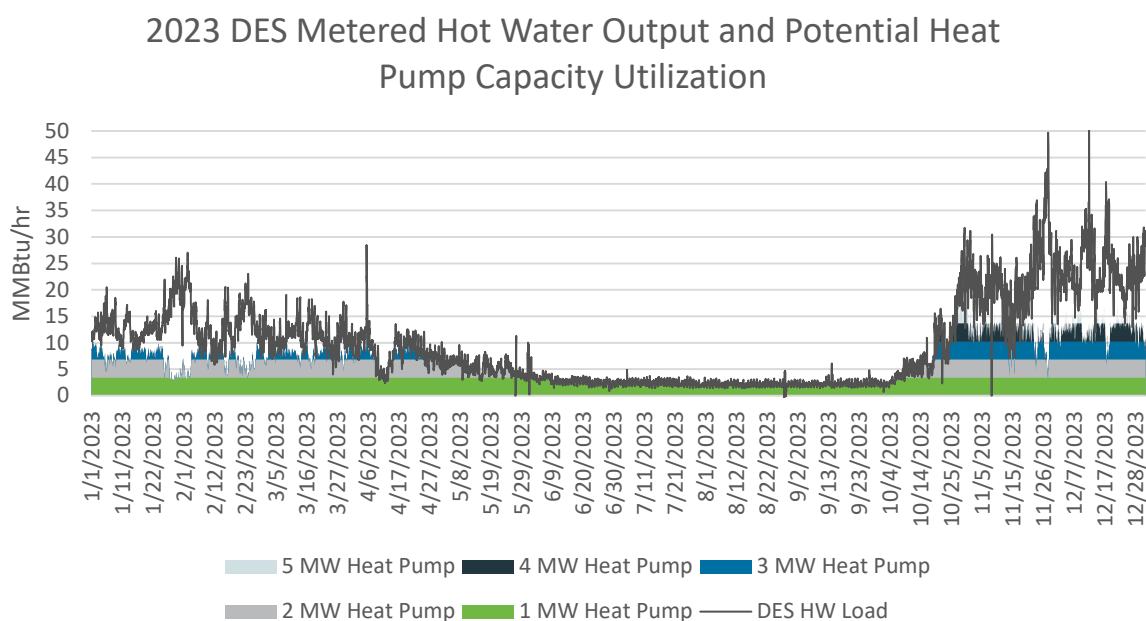


Figure 4. 2023 Duluth Energy Systems hot water energy and potential heat pump utilization

Table 4 illustrates Duluth Energy Systems' hot water output for the year 2023 alongside the estimated energy contribution from a 3.5 MW heat pump (not inclusive of preheat\*).

	Annual Energy MMBtu	Peak Load MMBtu/hr
DES HW Downtown HW System – Full Load	85,000	54
DES HW Downtown HW System - Baseload	53,500	11.9

Table 4. Duluth Energy Systems' 2023 hot water energy and peak load.

The trend of increasing hot water usage towards the end of 2023, driven by additional loads from hospitals connected to the network, is expected to persist into 2024 and beyond. Consequently, as the hot water load profile expands, the energy supplied by the Lincoln Park heat pump system will also increase.

**DES Full load scenario** - To meet the current full load, based on the 2023 hot water system peak, a significantly large heat pump exceeding 16 MW would be necessary, with requirements increasing as additional load is added to the hot water network. Additionally, the heat pump would need to supply a much higher temperature, necessitating a shift from a high-temperature rated HDPE piping system to a carbon steel piping system. While this scenario was analyzed, it would require significant operational adjustments and capital investment into adapting the DES hot water networks. Also, sizing a heat pump to service the full demand is likely not economically feasible. The system load peaks occur for limited hours each year, an alternative energy source to cover these periods at the DES plant is more cost effective.

The GHG analysis reviews covering the full load of DES however, it is much more likely the heat pump would be sized to cover the energy requirements of the DES hot water network as explained in the previous section.

**\*Preheat of Make Up Water for Steam Production** – With the total of 10MW of heat pump capacity as proposed for DuluthWWHR, it is recognized that excess thermal capacity can be used during summer and shoulder seasons to preheat make up water for the one-way steam portion of DES. Monthly water consumption for 2022 and 2023 was averaged, average GPM consumed determined, and the MMBtu/hr to raise the temperature and associated GHG calculated. DuluthWWHR would reduce the temperature raise needed by a conservative 100-degree F compared to the municipal water supply temperatures which could result in an average 2,575 tons of GHG annually. This number was reduced based upon available heat pump energy capacity each month per the schedule provided in the attachment.

### Other Considerations for Connections

In addition to the primary scenarios, several other factors require consideration but have not been added to the current GHG analysis. These include:

- Community snowmelt system (adds GHG and is cost prohibitive, but examined at neighborhood request).

- Future developments, such as Lot D (design would allow for expansion as development is better defined).
- DES's Canal Park and DECC hot water loops (could absorb additional summer load for higher than reported GHG reductions).

### Summary

Table 5 below summarizes the energy consumption and peak load for each scenario analyzed. Notably, the DuluthWWHR scenarios with includes the Lincoln Park Connectable with DES at 3.5 MW is highlighted in gray (not inclusive of preheat for steam).

	Annual Energy MMBtu	Peak Load MMBtu/hr
Lincoln Park - Connectable Load	49,000	28
Lincoln Park - Full Load	100,000	55
DES HW Downtown HW System - Full Load	85,000	54
DES HW Downtown HW System - Baseload	53,500	12
DuluthWWHR- Lincoln Park Connectable Load + DES Baseload	102,500	40
Lincoln Park Connectable Load + DES Full Load	134,000	82
Lincoln Park Full Load + DES Baseload	153,500	66
Lincoln Park Full Load + DES Full Load	185,000	109

Table 5. Potential energy and load scenarios for the wastewater heat recovery district heating system.

**Carbon Reduction Results-** The table below presents the carbon emissions avoided for the per the DuluthWWHR project inclusive of the Lincoln Park, DES hot water loop, and preheat of make-up water for steam system when excess production is available. The results are divided into two periods: 2025-2030 and 2025-2050. It is worth noting that the analysis assumes the district energy system will be operational in 2028, resulting in no GHG reduction in the initial years. The estimated cost per metric ton of carbon ranges. The capital cost per metric ton of CO<sub>2</sub> avoided is \$2,843 from 2025 to 2030 and reduces to \$271 per metric ton when evaluated over the period of 2025-2050. Creating the DES connection and applying excess heat capture to the steam system, significantly reduces the cost of carbon reduction.

	CPRG Time Period			
	2025-2030		2025-2050	
	Tons of CO <sub>2</sub> Emissions Avoided	\$/Ton of CO <sub>2</sub>	Tons of CO <sub>2</sub> Emissions Avoided	\$/Ton of CO <sub>2</sub>
DuluthWWHR- Lincoln Park Connectable + DES Baseload + preheat	16,900	\$2,843	177,000	\$271

Table 6. Metric tons of GHG emissions avoided.

## Potential Risks and Uncertainties

- The pounds of CO<sub>2</sub> per MMBtu of natural gas is a known value at 117 lbs per MMBtu of burned natural gas. However, the rate of the electric grid decarbonization is an estimation and beholden to the electric providers maintaining their carbon neutrality targets.
- Greenhouse gas reduction calculations assume the system becomes fully operational by 2028, with no reductions expected prior to that. Any shift in the project schedule would directly impact the calculated reductions. For example, if the project were delayed by one year, resulting in full operation by 2029, there would be a 31% reduction in avoided GHG emissions for the 5-year period (2025-2030) and a 3% reduction for the 25-year period (2025-2050). Conversely, if the project were accelerated to 2027, the reductions would increase by 31% for the 5-year period and 3% for the 25-year period.
- The wastewater source will not dry up, however, the source of the high temperature influent wastewater could be impacted by industrial changes. The higher temperatures seen in the influent and effluent are highly dependent industry including two paper mills. The temperature of the source water has an impact the heat pump efficiency. The paper mills also make up a large portion of the influent. Diversity of industry can mitigate this impact.
- Building connections are not finalized. While there has been interest in connecting to a hot water district energy system, no customer agreements have been signed, however, DES has experience in customer acquisition as demonstrated on E Superior St.

**Exhibits-** GHGcalcs\_City of Duluth.xlsx

## **Measure #2 - Greenhouse Gas Reduction Estimate- Commercial REE Grant Program**

---

**Objective** – 2% of grant funds would be issued as small grants to commercial businesses. Our goal would be to coordinate an expanded reach and breadth of services, using energy design assistance funding to provide external expertise to commercial and industrial building owners, with a focus on buildings within Duluth’s J40 neighborhoods. By bringing together the electric utility, gas utility, and district energy providers, this design assistance can help further understand building opportunities and identify the biggest opportunities for energy efficiency and carbon savings for commercial and industrial building owners. Assistance can also help to weave together the varied incentive programs (utility, State of MN, and Inflation Reduction Act) to maximize affordability of the lowest carbon pathway.

**Methodology** – Minnesota Power, Duluth’s IOU electricity provider to determine GHG reductions on existing Minnesota Power customized commercial building programs. Minnesota Power’s program includes an energy analysis to better understand how a building uses electricity, analysis of new building construction plans, and analysis of equipment replacement types to help decision-making. They offer plan reviews, design recommendations, energy modeling and rebate calculations. This is an imperfect methodology as Minnesota Power focuses on electric savings and not natural gas, however, it serves as a baseline for expected energy savings per dollar spent currently on commercial properties in Duluth.

**Analysis Assumptions** - We assumed that by addressing heating emissions, we would achieve similar results in terms of cost/metric ton of greenhouse gas emissions avoided as Minnesota Power's electric conservation programs.

- The carbon dioxide equivalent emissions (CO<sub>2</sub>e) for Minnesota Power's system from their 2023 sustainability report is 0.380 metric tons per MWh. (Source: <https://allete.blob.core.windows.net/allete/Documents/Sustainability/ALE-Sustainability-Report.pdf> – pages 28 & 77)
- In 2023, Minnesota Power saved 53,059 MWh through commercial programs and spent \$4,532,567 between delivery and customer incentives resulting in a program cost of \$85/MWh saved. (Source: Katie Frye, Minnesota Power, March 2024, and soon to be published in filing submitted in April 2024)
- Cost per tonne of GHG reduction for MN Power program is \$85/MWh divided by .380 tonnes/MWh = \$223.68
- To be extra conservative, as the program will be designed during grant quarter 1 and 2, only the \$1,000,000 of small grants has been used to calculate GHG reductions resulting in \$1,000,000 divided by \$223.80/tonne = 4,468 tonnes reduced during the 2025-2030 timeframe with no additional reduction beyond program completion in 2027. Calculation does not include staffing amount for delivery of services that is embedded in MN Power's number. Program design will include full modeling of acceptable measures, GHG reductions, and lifespan of improvements.
- Program design will be informed by existing ComStock analysis per Project Narrative

	CPRG Time Period			
	2025-2030		2025-2050	
	Tons of CO <sub>2</sub> Emissions Avoided	\$/Ton of CO <sub>2</sub>	Tons of CO <sub>2</sub> Emissions Avoided	\$/Ton of CO <sub>2</sub>
Commercial REE Grants Program	4,500	\$222	4,500	\$222

### Summary of GHG Reductions for DuluthWWHR CPRG Application

	CPRG Time Period			
	2025-2030		2025-2050	
	Tons of CO <sub>2</sub> Emissions Avoided	\$/Ton of CO <sub>2</sub>	Tons of CO <sub>2</sub> Emissions Avoided	\$/Ton of CO <sub>2</sub>
Measure 1- Waste Heat Recovery	16,900	\$2,843	171,000	\$271
Measure 2- Commercial REE Grants	4,500	\$222	4,500	\$222
Total Grant- Includes Staff and Outreach costs of \$876,844 not allocated to either measure.	21,400	\$2,333	181,500	\$275