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**ENERGY RESEARCH AND DEVELOPMENT DIVISION**

**FINAL PROJECT REPORT**

# **California Dairies Turlock and Visalia Heat Recovery Systems**

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## PREFACE

The California Energy Commission's (CEC) Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission and distribution and transportation.

The Food Production Investment Program, established in 2018, encourages California food producers to reduce greenhouse gas (GHG) emissions. Funding comes from the [California Climate Investments](#) program, a statewide initiative that uses cap-and-trade dollars to help reduce GHG emissions, strengthen the economy, and improve public health and the environment.

The food processing industry is one of the largest energy users in California. It is also a large producer of GHG emissions.

The Food Production Investment Program will help producers replace high-energy-consuming equipment and systems with market-ready and advanced technologies and equipment. The program will also accelerate the adoption of state-of-the-art energy technologies that can substantially reduce energy use and costs and associated GHG emissions.

*California Dairies Turlock and Visalia Heat Recovery Systems* is the final report for FPI-19-022 conducted by Skyven Technologies. The information from this project contributes to the Energy Research and Development Division's FPIP Program.

For more information about the Energy Research and Development Division, please visit the [CEC's research website](http://www.energy.ca.gov/research/) (www.energy.ca.gov/research/) or contact the CEC at [ERDD@energy.ca.gov](mailto:ERDD@energy.ca.gov).

# ABSTRACT

California Dairies Inc., (CDI) is the largest milk and dairy co-op in the state of California, and has made a goal to become carbon neutral by 2050. To make strides toward their carbon neutrality goal, CDI partnered with Skyven Technologies to install condensing economizers and steam traps at their dairy facilities in Turlock and Visalia, both in California. The systems are backed by funding from the California Energy Commission (CEC) and address key elements of California's clean energy and climate goals including public health, environmental, and economic needs.

The condensing economizers recover waste heat from boiler exhaust to preheat water, reducing the amount of natural gas required for steam generation. The steam traps, equipped with monitoring technology, prevent steam loss by automatically discharging condensate and identifying failing traps for timely replacement. Together, these technologies improve boiler performance, reduce energy waste, and extend equipment life while cutting greenhouse gas (GHG) emissions and criteria air pollutants. Measurement and verification data were collected and analyzed from the condensing economizer and steam trap systems. The data show that the annual natural gas savings from the condensing economizers at Turlock and Visalia were 25,832 million metric British thermal units per year (MMBTU/year) and 41,713 MMBTU/year, respectively. This translates to an annual emissions reduction of 1,372 metric tons of carbon dioxide equivalent (MTCO<sub>2</sub>e)/year for Turlock and 2,216 MTCO<sub>2</sub>e/year for Visalia. The data shows that the annual natural gas saved from the steam traps at Turlock and Visalia is 7,665 MMBTU/year and 42,050 MMBTU/year, respectively. This translates to an annual carbon dioxide emissions reduction of 407 MTCO<sub>2</sub>e/year for Turlock and 2,234 MTCO<sub>2</sub>e/year for Visalia.

**Keywords:** Decarbonization, energy efficiency, condensing economizer, steam traps, natural gas, emissions reduction

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# Executive Summary

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## Background

California Dairies Inc. (CDI), the largest member-owned milk marketing and processing cooperative in California, has pledged to reach carbon neutrality by 2050. CDI is a milk marketing and processing cooperative co-owned by more than 300 dairy families (family-owned dairies located throughout California's rural communities). CDI is a leading manufacturer of fluid milk, butter, and milk powder products, producing annually roughly 17 billion pounds of milk, 412 million pounds of butter, and 900 million pounds of milk powder. Partnering with Skyven (which provided engineering, management, and project execution services to CDI) and backed by grant funding from the California Energy Commission (CEC), CDI is making strides toward carbon neutrality by installing condensing economizers and steam traps to reduce natural gas usage at its CDI Turlock facility, located in Turlock, California and its Visalia facility, located in Visalia, California. According to CalEnviroScreen 3.0, California's community and environmental health screening tool, CDI Turlock's dairy facility is in an area with a pollution burden in the 91<sup>st</sup> to 100<sup>th</sup> percentile; CDI Visalia's dairy facility is in an area with a pollution burden in the 81<sup>st</sup> to 90<sup>th</sup> percentile, making both locations high-priority areas for decarbonization (OEHHA, 2018).

The installation of the condensing economizers and steam traps addresses several high-impact needs of the local community, reducing both health harms and exposure to environmental contaminants. The project supports California's clean energy and climate goals by addressing the following common community needs, listed in the California Air Resources Board's funding guidelines (listed in Table 5) (CARB, 2018).

- Public Health Needs: Reduce health harms suffered disproportionately by priority populations due to air pollutants.
- Economic Needs: Revitalize local economies, support California-based small businesses and create quality jobs.
- Environmental Needs: Reduce exposure to local air pollutants.

## Project Purpose and Approach

The purpose of the project was to design and install steam traps and condensing economizers that directly offset natural-gas-provided heat. Steam traps remove condensate in steam systems and prevent steam loss to ensure system efficiency by automatically draining water. Over time, the internal components of steam traps can degrade, leading to leaks or blockages that dramatically decrease their efficiency. A condensing economizer captures waste heat from flue gases in boilers to preheat incoming water or air, reducing natural gas usage. A total of 29 steam traps was replaced and monitored at CDI Turlock, and a total of 15 steam traps were replaced and have constant monitoring at CDI Visalia. Steam trap replacement and monitoring were completed by the company Steam Management. Condensing economizers installed at CDI Turlock and CDI Visalia were designed and provided by ConDex. The primary goal of the

project was to reduce carbon dioxide (CO<sub>2</sub>) emissions at the CDI Turlock and CDI Visalia facilities. The intended audience for this project includes industrial facilities with similar production processes (that is, dairy facilities) as well as various other industries that use thermal energy year-round and seek sustainable, clean energy solutions to reduce their carbon footprints (such as food and beverage, chemicals, textiles, pulp and paper, hospitality, district heating, and wastewater treatment).

Key steps in the project approach included pre-installation data collection, system design, and project data monitoring and collection. The key metrics needed to determine success were the amount of heat generated by the condensing economizer system and the amount of steam saved by the steam traps. Various pieces of equipment were installed on the condensing economizer and boiler systems to collect the data to calculate the quantity of heat generated by the condensing economizers (see Project Approach for more information). The “smart” steam traps from the company Steam Management measure and provide a value for thousands of pounds (klbs) of steam leakage. The thermal heat generated by the condensing economizer, a fuel conversion efficiency factor, natural gas/pollutant conversions, and some assumptions on natural gas prices can be used to determine the amount of natural gas saved by the facility, cost savings, and an overall reduction in pollutants such as CO<sub>2</sub> and nitrogen oxides emissions. For the steam traps, total steam leakage savings, a fuel conversion efficiency factor, natural gas/pollutant conversions, and some assumptions on natural gas prices can be used to determine the amount of natural gas saved by the facility, cost savings realized by the facility, and the overall reduction in pollutants such as CO<sub>2</sub> and nitrogen oxides emissions. (See Results section for more information.)

**Key Results**

Skyven successfully installed and commissioned the condensing economizer system at CDI Turlock and has been actively collecting and monitoring the data from the system since August 18, 2023.

Table ES-1 shows the total million metric British thermal units (MMBTU) of natural gas saved, natural gas cost savings, annual CO<sub>2</sub> emissions savings, and annual nitrogen oxide (NO<sub>x</sub>) savings of the condensing economizer at CDI Turlock.

**Table ES-1: CDI Turlock Condensing Economizer – Post-Installation Values**

CDI Turlock Condensing Economizer - Post-Installation Values		
Annual Natural Gas Saved	25,832	MMBTU/year
Annual Natural Gas Cost Savings	\$167,908.00	dollars/year
Annual CO <sub>2</sub> Emissions Savings	1,372	MT CO <sub>2</sub> e/year
Annual NO <sub>x</sub> Emissions Savings	1,266	lbs NO <sub>x</sub> /year

Source: Skyven

Skyven successfully installed the new steam traps at CDI Turlock and has been actively collecting and monitoring data from the system since September 12, 2022.

Table ES-2 shows the total MMBTU’s of natural gas saved, natural gas cost savings, annual CO2 emissions savings, and annual NOx savings of the steam traps at CDI Turlock.

**Table ES-2: CDI Turlock Steam Traps – Post-Installation Values**

CDI Turlock Steam Traps - Post-Installation Values		
Annual Natural Gas Saved	7,665	MMBTU/year
Annual Natural Gas Cost Savings	\$49,822.50	dollars/year
Annual CO <sub>2</sub> Emissions Savings	407	MT CO <sub>2</sub> e/year
Annual NO <sub>x</sub> Emissions Savings	376	lbs NO <sub>x</sub> /year

Source: Skyven

Skyven successfully installed and commissioned the condensing economizer system at CDI Visalia and has been actively collecting and monitoring data from the system since August 24, 2022.

Due to California Air Resources Board (CARB) regulations in the San Joaquin Valley Air Pollution Control District, beginning in February of 2023, CDI installed selective catalytic reduction (SCR) equipment on their boilers, which required rerouting boiler exhaust from the existing exhaust stacks to the SCR equipment. SCR is a technology that reduces harmful NOx emissions in boilers and other industrial combustion systems. The Visalia condensing economizer project pulled boiler exhaust from the existing exhaust stacks, rerouting the exhaust eliminated energy savings from the equipment. Skyven therefore extrapolated the performance from late August 2022 to January 2023 (when the system was operating without issues) to determine the annual performance of the system (had the SCR rework not been completed).

Table ES-3 shows the observed total MMBTU’s of natural gas saved, natural gas cost savings, annual CO2 emissions savings, and annual NOx savings of the condensing economizer at CDI Visalia.

**Table ES-3: CDI Visalia Condensing Economizer – Observed Post-Installation Values**

CDI Visalia Condensing Economizer - Observed Post-Installation Values		
Annual Natural Gas Saved	9,849	MMBTU/year
Annual Natural Gas Cost Savings	\$64,018.50	dollars/year
Annual CO <sub>2</sub> Emissions Savings	523	MT CO <sub>2</sub> e/year
Annual NO <sub>x</sub> Emissions Savings	483	lbs NO <sub>x</sub> /year

Source: Skyven

Table ES-4 shows the extrapolated total MMBTU’s of natural gas saved, natural gas cost savings, annual CO2 emissions savings, and annual NOx savings of the condensing economizer at CDI Visalia.

**Table ES-4: CDI Visalia Condensing Economizer – Extrapolated Post-Installation Values**

CDI Visalia Condensing Economizer - Extrapolated Post-Installation Values		
Annual Natural Gas Saved	41,713	MMBTU/year
Annual Natural Gas Cost Savings	\$271,134.50	dollars/year
Annual CO <sub>2</sub> Emissions Savings	2,216	MT CO <sub>2</sub> e/year
Annual NO <sub>x</sub> Emissions Savings	2,044	lbs NO <sub>x</sub> /year

Source: Skyven

Skyven successfully installed the new steam traps at CDI Visalia and has been actively collecting and monitoring the data from the system since February 16, 2023.

Table ES-5 shows the total MMBTU’s of natural gas saved, natural gas cost savings, annual CO<sub>2</sub> emissions savings, and annual NO<sub>x</sub> savings of the steam traps at CDI Visalia.

**Table ES-5: CDI Visalia Condensing Economizer – Extrapolated Post-Installation Values**

CDI Visalia Steam Traps - Post-Installation Values		
Annual Natural Gas Saved	42,050	MMBTU/year
Annual Natural Gas Cost Savings	\$273,325.00	dollars/year
Annual CO <sub>2</sub> Emissions Savings	2,234	MT CO <sub>2</sub> e/year
Annual NO <sub>x</sub> Emissions Savings	2,060	lbs NO <sub>x</sub> /year

Source: Skyven

## Knowledge Transfer and Next Steps

To date, Skyven has released two press releases highlighting the installation, commissioning, and successful operation of the condensing economizer and steam trap projects at CDI Turlock and CDI Visalia (along with solar thermal projects that were also completed at the facility). The press releases themselves, as well as the website links where the press releases reside, appear in Appendix A. Additionally, Skyven developed an in-depth case study for this project, which was published on the Skyven [website](https://skyven.co/) (https://skyven.co/) and is permanently linked to the Resources page on the website.

The key takeaway from this project is that steam traps and condensing economizers have good decarbonization potential, and that installation of this equipment should be evaluated when industrial facilities consider decarbonization. Going forward, Skyven will continue to monitor the condensing economizer and steam trap projects to ensure continued fuel and emissions savings at the facility.

# CHAPTER 1:

## Introduction

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California Dairies Inc. (CDI), is the largest milk marketing and processing cooperative in California, representing over 300 family-owned dairies across the state. As a leading producer of fluid milk, butter, and milk powder they generate approximately 17 billion pounds of milk annually. CDI plays a central role in California's dairy industry, and has pledged to achieve carbon neutrality by 2050. The cooperative is actively pursuing innovative energy solutions to reduce its environmental footprint.

The purpose of the project is to install condensing economizers and steam traps at CDI Turlock and CDI Visalia that will reduce natural gas (NG) usage and reduce emissions. The successful installation of the condensing economizers and steam traps at the Turlock and Visalia facilities, both in California, is important and timely, given the context of California's clean energy and climate goals, for several key reasons, which follow.

**Priority Population:** According to CalEnviroScreen 3.0, CDI Turlock's facility is in an area with a pollution score of 91 to 100 percent. Visalia's facility is in an area with a pollution score of 81 percent to 90 percent. The pollution burden percentile, which represents exposures to pollutants and the adverse environmental conditions caused by pollution, in both Turlock and Visalia, is the highest possible (90 percent to 100 percent). The population characteristics percentile, representing biological traits, health status, or community characteristics that can increase vulnerability to pollution, is in the 60 percent to 70 percent range for Turlock and the 70 percent to 80 percent range for Visalia, which are also very high (OEHHA, 2018).

**Environmental and Health Benefits:** Given the high pollution score and pollution burden percentile, reducing health harms and environmental contaminants in the local community is crucial for improving the well-being of residents. The project's focus on reducing on-site criteria air pollutants and toxic air contaminants by transitioning from fossil fuel consumption is aligned with California's commitment to clean energy. Furthermore, by reducing exposure to air pollutants, the project directly contributes to public health.

**Reducing Air Pollutants:** By promoting renewable resources and efficiency improvements, the project contributes to reducing greenhouse gas (GHG) emissions, which is crucial for meeting the state's ambitious climate goals.

In summary, the CDI Turlock and CDI Visalia condensing economizer and steam trap projects address the critical environmental, health, economic, and clean energy needs of their communities. The projects align with California's clean energy and climate goals by reducing emissions, providing renewable energy, and promoting economic development in high-priority population areas.

# CHAPTER 2:

## Project Approach

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### Project Collaboration

Turlock and Visalia Condensing Economizer Projects: Skyven worked with the company, ConDex, to design and install a condensing economizer at both the CDI Turlock and Visalia facilities, located in California. The ConDex energy recovery system was designed using data from the baseline monitoring that performed on the existing boilers. Data were collected on the fuel/air ratio of the NG to characterize the exhaust of the boilers; data were also collected on the temperature of the incoming feedwater. ConDex then used this data to size the condensing economizers.

Turlock and Visalia Steam Trap Projects: Skyven worked with the company, Steam Management, to monitor and replace failing steam traps at both the CDI Turlock and Visalia facilities. Skyven added monitors and gateways to the existing steam traps to measure the baseline steam leakage rate for each trap and determine which steam traps needed replacement.

### Pre-Installation Measurements and Data

Condensing Economizer Projects Pre-Installation Measurement and Verification (M&V) Protocol: The following is the protocol followed for M&V of the pre-installation values on the Turlock and Visalia condensing economizer projects.

- Baseline monitoring was performed on existing boilers.
- Skyven reviewed the boiler performance data and current NG consumption, generating a baseline of million metric British thermal units per hour (MMBTU/hr).
- Skyven relied on existing instrumentation and controls of NG stations and boilers at the site to take baseline measurements.

Turlock Condensing Economizer Pre-Installation Data: The following are the pre-installation data and calculations used to determine baseline NG consumption and GHG emissions on the Turlock Condensing Economizer Project:

- The Turlock plant has two boilers that serve the needs of the plant.
- Pre-installation measurements of the gas flow to each boiler were determined from May 1, 2020, to August 1, 2020.

The following table shows the average NG usage for each boiler during the pre-installation measurement period (Table 1).

**Table 1: CDI Turlock – Pre-Install Boiler NG Usage (MMBTU/hr)**

CDI Turlock Pre-Installation Average Natural Gas Usage (MMBTU/hr) from May 1st, 2020 to August 1st, 2020	
Boiler 1	Boiler 2
24	27

Source: Skyven

The total average NG usage at CDI Turlock was 51 MMBTU/hr.

The following table shows the average NG usage for each boiler, extrapolated for a year’s consumption (Table 2).

**Table 2: CDI Turlock – Pre-Install Boiler NG Usage (MMBTU/yr)**

CDI Turlock Pre-Installation Average Annual Natural Gas Usage (MMBTU/year)	
Boiler 1	Boiler 2
205,884	239,724

Source: Skyven

The total average annual NG usage at CDI Turlock was 445,608 million metric British thermal units per year (MMBTU/year).

- Average annual NG cost is calculated using the following equation:

$$\text{Annual NG Cost} = \text{Annual NG Usage} \times \text{CARB Price of NG}$$

Where: California Air Resource Board (CAB) Price of NG = \$6.50/MMBTU

$$\text{Annual NG Cost} = 445,608 \text{ MMBTU/year} \times \$6.50/\text{MMBTU}$$

$$\text{Annual NG Cost} = \$2,896,452$$

- Average annual CO2 Emissions are calculated using the following equation:

$$\text{Annual CO2 Emissions} = \text{Annual NG Usage} \times \text{CARB Factor (NG)} \times \text{Unit Conversion}$$

Where: CARB Factor (NG) = 117.1 pounds (lbs) carbon dioxide equivalent (CO2e)/MMBTU

$$= \frac{445,608 \text{ MMBTU}}{\text{year}} \times \frac{117.1 \text{ lbs CO2e}}{\text{MMBTU}} \times \frac{1 \text{ MTCO2e}}{2,204.62 \text{ lbs CO2e}}$$

$$\text{Annual CO2 Emissions} = 23,669 \text{ MTCO2e}$$

- Average annual NOx Emissions are calculated using the following equation:

$$\text{Annual NOx Emissions} = \text{Annual NG Usage} \times \text{CARB Factor (NOx)}$$

Where: CARB Factor (NOx) = 0.049 lbs NOx/MMBTU

$$= 445,608 \text{ MMBTU/year} \times 0.049 \text{ lbs NOx/MMBTU}$$

$$\text{Annual NOx emissions} = 21,835 \text{ lbs NOx}$$

Visalia Condensing Economizer Pre-Installation Data:

Following are the pre-installation data and calculations used to determine baseline NG consumption and GHG emissions for the Visalia Condensing Economizer Project.

- The Visalia plant has three boilers that provide steam needs for the plant.
- Pre-installation measurements of the steam flow were taken on each boiler from February 20 to April 22, 2022.

The following table shows the average steam flow rate for each boiler during the pre-installation measurement period (Table 3).

**Table 3: CDI Visalia – Pre-Install Boiler Steam Flow Rate (lbs/hr)**

CDI Visalia Pre-Installation Average Steam Production Flow Rate (lbs/hr) from February 20th, 2022 to April 22nd, 2022		
Boiler 1	Boiler 2	Boiler 3
36,214	25,508	20,230

Source: Skyven

The total average steam production flow rate at CDI Visalia is 81,952 pounds per hour (lbs/hr).

The following table shows the average steam flow rate for each boiler, extrapolated to a year’s worth of steam production (Table 4).

**Table 4: CDI Visalia – Pre-Install Boiler Steam Flow Rate (lbs/yr)**

CDI Visalia Pre-Installation Average Annual Steam Production Flow Rate (lbs/year)		
Boiler 1	Boiler 2	Boiler 3
317,232,413	223,453,792	177,215,193

Source: Skyven

The total average annual steam production at CDI Visalia is 717,901,398 pounds per year (lbs/yr).

Based on the boiler label plate rating of 51,750 lbs/hr and the burner label plate rating of 63 MMBTU/hr, the boilers can produce 821.43 lbs of steam/MMBTU of NG.

The following table shows the average NG usage for each boiler during the pre-installation measurement period (Table 5).

**Table 5: CDI Visalia – Pre-Install Boiler NG Usage (MMBTU/hr)**

CDI Visalia Pre-Installation Average Natural Gas Usage (MMBTU/hr) from February 20th, 2022 to April 22nd, 2022		
Boiler 1	Boiler 2	Boiler 3
44	31	25

MMBTU/hr = million metric British thermal units per hour

Source: Skyven

The total average NG usage at CDI Visalia is 100 MMBTU/hr.

The following table shows the average NG usage for each boiler, extrapolated to a year's worth of NG usage (Table 6).

**Table 6: CDI Visalia – Pre-Install Boiler NG Usage (MMBTU/yr)**

CDI Visalia Pre-Installation Average Annual Natural Gas Usage (MMBTU/year)		
Boiler 1	Boiler 2	Boiler 3
386,196	272,031	215,740

Source: Skyven

The total average annual NG usage at CDI Visalia is 873,966 MMBTU/year.

- Average annual NG cost is calculated using the following equation:  

$$\text{Annual NG Cost} = \text{Annual NG Usage} \times \text{CARB Price of NG}$$
 Where: CARB Price of NG = \$6.50/MMBTU  

$$\text{Annual NG Cost} = 873,966 \text{ MMBTU/year} \times \$6.50/\text{MMBTU}$$

$$\text{Annual NG Cost} = \$5,680,779$$
- Average annual CO2 emissions were calculated using the following equation:  

$$\text{Annual CO2 Emissions} = \text{Annual NG Usage} \times \text{CARB Factor (NG)} \times \text{Unit Conversion}$$
 Where: CARB Factor (NG) = 117.1 lbs CO2e/MMBTU  

$$= \frac{873,966 \text{ MMBTU}}{\text{year}} \times \frac{117.1 \text{ lbs CO2e}}{\text{MMBTU}} \times \frac{1 \text{ MTCO2e}}{2,204.62 \text{ lbs CO2e}}$$

$$\text{Annual CO2 Emissions} = 46,421 \text{ MTCO2e}$$
- Average annual NOx Emissions were calculated using the following equation:  

$$\text{Annual NOx Emissions} = \text{Annual NG Usage} \times \text{CARB Factor (NOx)}$$
 Where: CARB Factor (NOx) = 0.049 lbs NOx/MMBTU  

$$= 873,966 \text{ MMBTU/year} \times 0.049 \text{ lbs NOx/MMBTU}$$

$$\text{Annual NOx Emissions} = 42,824 \text{ lbs NOx}$$

Steam Trap Projects Pre-Installation M&V Protocol:

Following is the protocol for M&V of the pre-installation values on the Turlock and Visalia steam trap projects:

- Baseline monitoring was performed on existing steam traps.
- Skyven added monitors and gateways to the existing steam traps to measure the baseline steam leakage rate for each trap and determine which steam traps needed replacement.

- Skyven reviewed the steam trap leakage data to come up with a baseline thousand pounds per hour (klbs/hr) of steam leakage for the plant.

Turlock Steam Traps Pre-Installation Data:

The following is the pre-installation data and calculations used to determine baseline NG consumption and GHG emissions on the Turlock steam trap project:

- The Turlock plant has a total of 15 steam traps that Skyven monitored and replaced on August 28, 2022.
- Pre-installation measurements of the steam leakage from the steam traps were taken from April 7, 2022 to August 28, 2022.
- The following table shows the steam leakage for each steam trap during the pre-installation measurement period (Table 7). Note that where traps were not leaking for the entire baseline period only the time frame where the trap was leaking was used for establishing the baseline.

**Table 7: CDI Turlock – Pre-Install Steam Leakage (klbs/hr)**

Monitor Number	Pre-Installation Steam Leakage (klbs/hr)
CDI Turlock - 11	0.0460
CDI Turlock - 15	0.0155
CDI Turlock - 20	0.0135
CDI Turlock - 27	0.0073
CDI Turlock - 28	0.0851
CDI Turlock - 29	0.0385
CDI Turlock - 30	0.0124
CDI Turlock - 31	0.1974
CDI Turlock - 40	0.0015
CDI Turlock - 47	0.0067
CDI Turlock - 51	0.0320
CDI Turlock - 54	0.1582
CDI Turlock - 57	0.1335
CDI Turlock - 65	0.2842
CDI Turlock - 66	0.1424

Source: Skyven

The total average steam leakage of the steam traps that were replaced at CDI Turlock is 1.174 klbs/hr.

The following table shows the average steam leakage extrapolated for a year’s worth of steam leakage (Table 8).

**Table 8: CDI Turlock – Pre-Install Steam Leakage (klbs/yr)**

<b>Monitor Number</b>	<b>Pre-Installation Annual Steam Leakage (klbs/year)</b>
CDI Turlock - 11	403
CDI Turlock - 15	136
CDI Turlock - 20	119
CDI Turlock - 27	64
CDI Turlock - 28	746
CDI Turlock - 29	337
CDI Turlock - 30	108
CDI Turlock - 31	1,729
CDI Turlock - 40	13
CDI Turlock - 47	58
CDI Turlock - 51	280
CDI Turlock - 54	1,386
CDI Turlock - 57	1,170
CDI Turlock - 65	2,490
CDI Turlock - 66	1,248

Source: Skyven

The total average annual steam leakage of the steam traps replaced at CDI Turlock is 10,288 thousand pounds per year (klbs/yr). One klb/hr is equivalent to one MMBTU/hr. Using a 0.75 efficiency factor to account for boiler efficiency and losses; the NG wasted by each steam trap can also be calculated.

The following table shows the average NG wasted by each steam trap during the pre-installation measurement period (Table 9).

**Table 9: CDI Turlock – Pre-Install NG Wasted (MMBTU/hr)**

<b>Monitor Number</b>	<b>Pre-Installation Natural Gas Wasted (MMBTU/hr)</b>
CDI Turlock - 11	0.0614
CDI Turlock - 15	0.0207
CDI Turlock - 20	0.0180
CDI Turlock - 27	0.0098
CDI Turlock - 28	0.1135
CDI Turlock - 29	0.0513
CDI Turlock - 30	0.0165
CDI Turlock - 31	0.2632
CDI Turlock - 40	0.0020
CDI Turlock - 47	0.0089
CDI Turlock - 51	0.0426
CDI Turlock - 54	0.2110
CDI Turlock - 57	0.1780
CDI Turlock - 65	0.3790
CDI Turlock - 66	0.1899

Source: Skyven

The total average NG wasted due to leaking steam traps at CDI Turlock is 1.566 MMBTU/hr.

The following table shows the average NG wasted for each steam trap, extrapolated to a year's worth of NG usage (Table 10).

**Table 10: CDI Turlock – Pre-Install NG Wasted (MMBTU/yr)**

Monitor Number	Pre-Installation Annual Natural Gas Wasted (MMBTU/year)
CDI Turlock - 11	538
CDI Turlock - 15	182
CDI Turlock - 20	158
CDI Turlock - 27	86
CDI Turlock - 28	994
CDI Turlock - 29	449
CDI Turlock - 30	144
CDI Turlock - 31	2,306
CDI Turlock - 40	18
CDI Turlock - 47	78
CDI Turlock - 51	373
CDI Turlock - 54	1,848
CDI Turlock - 57	1,560
CDI Turlock - 65	3,320
CDI Turlock - 66	1,664

Source: Skyven

The total average annual NG wasted at CDI Turlock is 13,717 MMBTU/year.

- Average annual NG cost is calculated using the following equation:

$$\text{Annual NG Cost} = \text{Annual NG Usage} \times \text{CARB Price of NG}$$

$$\text{Where: CARB Price of NG} = \$6.50/\text{MMBTU}$$

$$\text{Annual NG Cost} = 13,717 \text{ MMBTU/year} \times \$6.50/\text{MMBTU}$$

$$\text{Annual NG Cost} = \$89,160.50$$

- Average annual CO2 Emissions are calculated using the following equation:

$$\text{Annual CO2 Emissions} = \text{Annual NG Usage} \times \text{CARB Factor (NG)} \times \text{Unit Conversion}$$

$$\text{Where: CARB Factor (NG)} = 117.1 \text{ lbs CO2e/MMBTU}$$

$$= \frac{13,717 \text{ MMBTU}}{\text{year}} \times \frac{117.1 \text{ lbs CO2e}}{\text{MMBTU}} \times \frac{1 \text{ MTCO2e}}{2,204.62 \text{ lbs CO2e}}$$

$$\text{Annual CO2 Emissions} = 729 \text{ MTCO2e}$$

- Average annual NOx Emissions are calculated using the following equation:

$$\text{Annual NOx Emissions} = \text{Annual NG Usage} \times \text{CARB Factor (NOx)}$$

Where: CARB Factor (NO<sub>x</sub>) = 0.049 lbs NO<sub>x</sub>/MMBTU  
= 13,717 MMBTU/year × 0.049 lbs NO<sub>x</sub>/MMBTU  
Annual NO<sub>x</sub> Emissions = 672 lbs NO<sub>x</sub>

Visalia Steam Traps Pre-Installation Data:

The following are the pre-installation data and calculations used to determine the baseline NG consumption and GHG emissions on the Visalia steam trap project:

- The Visalia plant has a total of 152 steam traps that Skyven is monitoring. Of these, 29 were replaced in February 2023.
- Pre-installation measurements of the steam leakage from each steam trap were taken from August 1, 2022, to January 6, 2023.

The following table shows the steam leakage for each steam trap during the pre-installation measurement period (Table 11).

**Table 11: CDI Visalia – Pre-Install Steam Leakage (klbs/hr)**

Monitor Number	Pre-Installation Steam Leak Average (klbs/hr)
CDI Visalia - 12	0.0277
CDI Visalia - 15	0.1951
CDI Visalia - 18	0.0355
CDI Visalia - 21	0.0776
CDI Visalia - 30	0.4768
CDI Visalia - 32	0.2211
CDI Visalia - 33	0.3349
CDI Visalia - 36	0.0334
CDI Visalia - 37	0.0408
CDI Visalia - 60	1.4942
CDI Visalia - 61	0.0998
CDI Visalia - 70	0.7949
CDI Visalia - 74	0.0235
CDI Visalia - 93	1.0156
CDI Visalia - 97	0.0251
CDI Visalia - 100	0.0357
CDI Visalia - 102	0.0772
CDI Visalia - 110	0.0219
CDI Visalia - 111	0.0759
CDI Visalia - 112	0.0632
CDI Visalia - 113	0.0749
CDI Visalia - 117	0.0142
CDI Visalia - 120	0.0199
CDI Visalia - 126	0.0321
CDI Visalia - 127	0.0252
CDI Visalia - 128	0.0134
CDI Visalia - 130	0.0425
CDI Visalia - 131	0.0269
CDI Visalia - 133	0.0228

Source: Skyven

The total average steam leakage of the steam traps replaced at CDI Visalia is 5.4416 klbs/hr. The following table shows the average steam leakage extrapolated to a year's worth of steam leakage (Table 12).

**Table 12: CDI Visalia – Pre-Install Steam Leakage (klbs/yr)**

Monitor Number	Pre-Installation Annual Steam Leak Average (klbs/year)
CDI Visalia - 12	243
CDI Visalia - 15	1,709
CDI Visalia - 18	311
CDI Visalia - 21	680
CDI Visalia - 30	4,177
CDI Visalia - 32	1,937
CDI Visalia - 33	2,933
CDI Visalia - 36	292
CDI Visalia - 37	357
CDI Visalia - 60	13,089
CDI Visalia - 61	874
CDI Visalia - 70	6,963
CDI Visalia - 74	206
CDI Visalia - 93	8,897
CDI Visalia - 97	220
CDI Visalia - 100	313
CDI Visalia - 102	676
CDI Visalia - 110	192
CDI Visalia - 111	665
CDI Visalia - 112	553
CDI Visalia - 113	656
CDI Visalia - 117	124
CDI Visalia - 120	174
CDI Visalia - 126	281
CDI Visalia - 127	221
CDI Visalia - 128	117
CDI Visalia - 130	372
CDI Visalia - 131	236
CDI Visalia - 133	199

Source: Skyven

The total average annual steam leakage of the steam traps which were replaced at CDI Visalia was 47,669 klbs/yr. One klb/hr is equivalent to one MMBTU/hr. Using a 0.75 efficiency factor to account for boiler efficiency and losses, the NG wasted by each steam trap can be calculated.

The following table shows the average NG wasted by each steam trap during the pre-installation measurement period (Table 13).

**Table 13: CDI Visalia – Pre-Install NG Wasted (MMBTU/hr)**

Monitor Number	Pre-Installation Natural Gas Wasted (MMBTU/hr)
CDI Visalia - 12	0.0370
CDI Visalia - 15	0.2601
CDI Visalia - 18	0.0473
CDI Visalia - 21	0.1035
CDI Visalia - 30	0.6357
CDI Visalia - 32	0.2948
CDI Visalia - 33	0.4465
CDI Visalia - 36	0.0445
CDI Visalia - 37	0.0544
CDI Visalia - 60	1.9922
CDI Visalia - 61	0.1330
CDI Visalia - 70	1.0598
CDI Visalia - 74	0.0314
CDI Visalia - 93	1.3542
CDI Visalia - 97	0.0334
CDI Visalia - 100	0.0476
CDI Visalia - 102	0.1029
CDI Visalia - 110	0.0292
CDI Visalia - 111	0.1011
CDI Visalia - 112	0.0842
CDI Visalia - 113	0.0999
CDI Visalia - 117	0.0189
CDI Visalia - 120	0.0266
CDI Visalia - 126	0.0428
CDI Visalia - 127	0.0336
CDI Visalia - 128	0.0179
CDI Visalia - 130	0.0567
CDI Visalia - 131	0.0359
CDI Visalia - 133	0.0304

Source: Skyven

The total average NG wasted due to leaking steam traps at CDI Visalia was 7.2555 MMBTU/hr.

The following table shows the average NG wasted for each steam trap, extrapolated to a year's worth of NG usage (Table 14).

**Table 14: CDI Visalia – Pre-Install NG Wasted (MMBTU/yr)**

Monitor Number	Pre-Installation Annual Natural Gas Wasted (MMBTU/year)
CDI Visalia - 12	324
CDI Visalia - 15	2,279
CDI Visalia - 18	414
CDI Visalia - 21	907
CDI Visalia - 30	5,569
CDI Visalia - 32	2,582
CDI Visalia - 33	3,911
CDI Visalia - 36	390
CDI Visalia - 37	476
CDI Visalia - 60	17,452
CDI Visalia - 61	1,165
CDI Visalia - 70	9,284
CDI Visalia - 74	275
CDI Visalia - 93	11,863
CDI Visalia - 97	293
CDI Visalia - 100	417
CDI Visalia - 102	902
CDI Visalia - 110	256
CDI Visalia - 111	886
CDI Visalia - 112	738
CDI Visalia - 113	875
CDI Visalia - 117	166
CDI Visalia - 120	233
CDI Visalia - 126	375
CDI Visalia - 127	295
CDI Visalia - 128	156
CDI Visalia - 130	497
CDI Visalia - 131	314
CDI Visalia - 133	266

Source: Skyven

The total average annual NG wasted at CDI Visalia was 63,558 MMBTU/year.

- Average annual NG cost is calculated using the following equation:  
Annual NG Cost = Annual NG Usage × CARB Price of NG  
Where: CARB Price of NG = \$6.50/MMBTU  
Annual NG Cost = 63,558 MMBTU/year × \$6.50/MMBTU  
Annual NG Cost = \$413,127
- Average annual CO2 Emissions are calculated using the following equation:  
Annual CO2 Emissions = Annual NG Usage × CARB Factor (NG) × Unit Conversion

Where: CARB Factor (NG) = 117.1 lbs CO<sub>2</sub>e/MMBTU

$$= \frac{63,558 \text{ MMBTU}}{\text{year}} \times \frac{117.1 \text{ lbs CO}_2\text{e}}{\text{MMBTU}} \times \frac{1 \text{ MTCO}_2\text{e}}{2,204.62 \text{ lbs CO}_2\text{e}}$$

Annual CO<sub>2</sub> Emissions = 3,376 MTCO<sub>2</sub>e

- Average annual NO<sub>x</sub> Emissions are calculated using the following equation:

Annual NO<sub>x</sub> Emissions = Annual NG Usage × CARB Factor (NO<sub>x</sub>)

Where: CARB Factor (NO<sub>x</sub>) = 0.049 lbs NO<sub>x</sub>/MMBTU

$$= 63,558 \text{ MMBTU/year} \times 0.049 \text{ lbs NO}_x\text{/MMBTU}$$

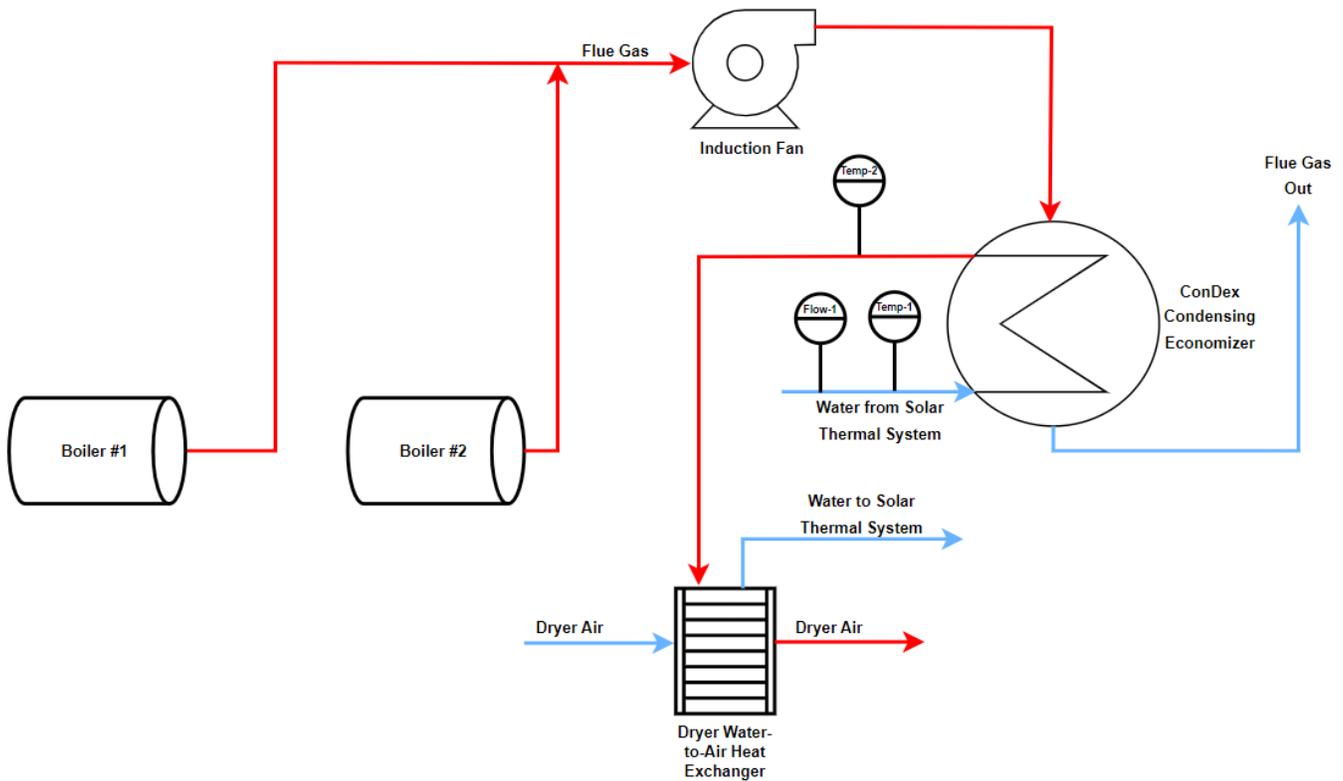
Annual NO<sub>x</sub> Emissions = 3,114 lbs NO<sub>x</sub>

## **System Design & M&V:**

### Turlock Condensing Economizer:

In the system installed at CDI Turlock, the condensing economizer is part of a closed-loop system where cold water leaves the dryer, goes to the solar thermal system heat exchanger, and is then sent to the ConDex condensing economizer for additional heat before being sent to the dryer. This water then pre-heats the dryer air to a setpoint of 138°F (59°C). The condensing economizer was provided by ConDex and uses the heat pulled from the two existing boiler stacks to heat water, using the boiler exhaust. The condensing economizer has an effective heating surface area of 19,421 square feet. There is an induction fan to move the boiler exhaust, which was supplied by AirPro. A simplified diagram of the Turlock condensing economizer is illustrated in Figure 1.

**Figure 1: Simplified System Diagram – Turlock Condensing Economizer**



Source: Skyven

The metering points relevant to calculating total heat recovered (and therefore fuel savings for the plant) are listed in Table 15. Note that additional metering points are monitored to ensure proper functional control of the system but are not used in measuring the useful thermal energy provided by the system.

**Table 15: CDI Turlock – Metering Datasets**

PLC Signal Description		
Label	Type	Description
Temp - 1	Temperature	Load Supply Temperature
Temp - 2	Temperature	Load Return Temperature
Flow - 1	Flow	Load Flowrate

Source: Skyven

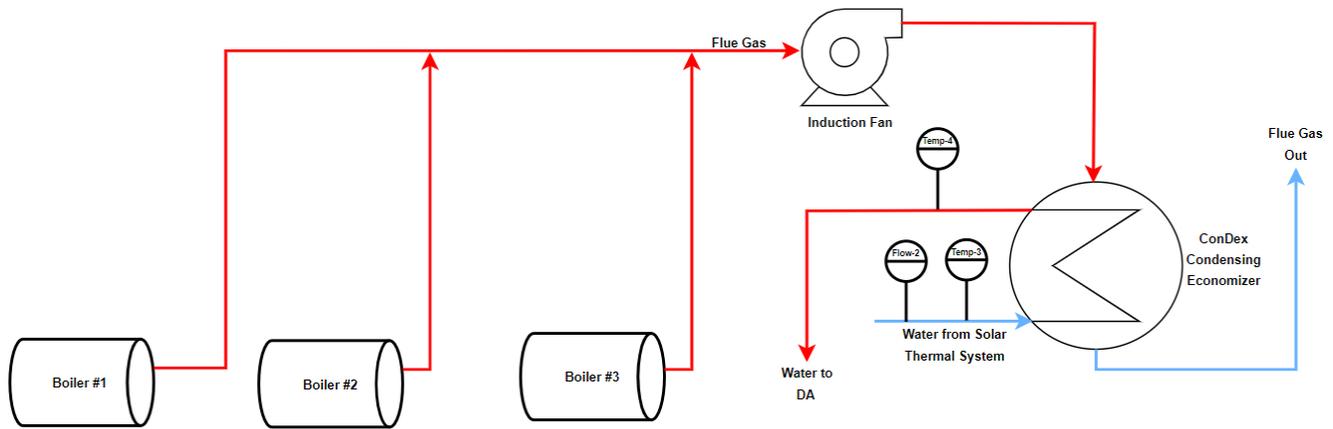
The datapoints contained in Table 15 are sent to the Programmable Logic Controllers (PLC) to calculate the thermal energy delivered to the water from the ConDex system.

Visalia Condensing Economizer:

The following is a brief description of the system and the protocol followed for M&V of the post-installation savings for the Visalia Condensing Economizer Project.

In the system that was installed at CDI Visalia, the condensing economizer creates an open loop where makeup water from the city is sent to the solar thermal system, then to the condensing economizer to be heated by the boiler exhaust, and finally sent to the deaerator to pre-heat boiler feedwater as much as possible. The condensing economizer system was provided by ConDex and uses heat pulled off the three existing boiler stacks to preheat boiler water with boiler exhaust. The condensing economizer has an effective heating surface area of 25,894 square feet. There is an induction fan to move the boiler exhaust, which was supplied by AirPro. A simplified diagram of the Visalia Condensing Economizer system is illustrated in Figure 2.

**Figure 2: Simplified System Diagram – Visalia Condensing Economizer**



Source: Skyven

The metering points relevant to calculating total heat recovered (and therefore fuel savings for the plant) are listed in Table 16. Note that additional metering points are monitored to ensure proper functional control of the system but are not used to measure the useful thermal energy provided by the system.

**Table 16: CDI Visalia – Metering Datasets**

PLC Signal Description		
Label	Type	Description
Temp - 3	Temperature	Load Supply Temperature
Temp - 4	Temperature	Load Return Temperature
Flow - 2	Flow	Load Flowrate

Source: Skyven

The datapoints contained in Table 16 were sent to the PLC to calculate the thermal energy delivered to the water from the ConDex system.

The steam traps are equipped with a steam leak monitoring system provided by Steam Management, which measures the amount of steam leakage occurring in the trap in klbs/hr. At CDI Turlock, a total of 15 steam traps was replaced.

### Visalia Steam Traps:

The steam traps are equipped with a steam leak monitoring system provided by Steam Management which measures the amount of steam leakage occurring in the trap in klbs/hr. At CDI Visalia, a total of 29 steam traps was replaced.

# CHAPTER 3:

## Results

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### CDI Turlock and CDI Visalia Results

#### Turlock Condensing Economizer

The following is the post-installation data and calculations used to determine the NG and GHG emissions savings on the Turlock Condensing Economizer Project:

- Post-Installation measurements were taken from August 18, 2023 through August 31, 2024.
- The PLC calculates the heat recovered by the condensing economizer system using the values from the metering dataset in Table 1 in the following equation:

$$\dot{q} = P_{water} * 60 \text{ min/hr} * \dot{V} * C_p * (T_{Hot \text{ Water from ConDex}} - T_{Cold \text{ Water to ConDex}})$$

Where:  $\dot{q}$  = Instantaneous heat recovered (btu/hr)

$P_{water}$  = Density of water = 8.34 lb/gallon (constant)

$\dot{V}$  = Volumetric flowrate of water from solar thermal system / meter label in Table 1: Flow-1

$C_p$  = Specific heat of water = 1.0 BTU/lb-°F (constant)

$T_{Hot \text{ Water from ConDex}}$  = Temperature of hot water leaving the ConDex system / meter label in Table 1: Temp-2

$T_{Cold \text{ Water to ConDex}}$  = Temperature of cold water entering the ConDex system / meter label in Table 1: Temp-1

The following table shows the thermal energy produced by the condensing economizer system for each month of the post-installation M&V period (Table 17). The average annual energy produced is provided at the end of the table and was calculated by totaling the MMBTUs produced each month and dividing by the total number of years of data (1.04 years).

**Table 17: CDI Turlock – Condensing Economizer Energy Produced**

CDI Turlock Post-Installation Thermal Energy Produced (from Condensing Economizer)	
Month - Year	MMBTUs Produced
August - 2023*	493
September - 2023	1,260
October - 2023	1,591
November - 2023	2,018
December - 2023	2,076
January - 2024	3,100
February - 2024	2,610
March - 2024	2,297
April - 2024	2,155
May - 2024	2,134
June - 2024	1,540
July - 2024	1,356
August - 2024**	168
Average Annual MMBTUs of Thermal Energy Produced	21,957

Source: Skyven

\*August – 2023 was a partial month including the days of August 18, 2023 to August 31, 2023.

\*\* August – 2024 data was low due to the CDI maintenance team unexpectedly turning the system off. Skyven noticed this via the data system, and Skyven sent a maintenance crew to check the system. The system was working properly, so it was turned back on; this issue was addressed with CDI to prevent future turnoffs.

**The average annual MMBTUs produced by the system were 21,957 MMBTUs.**

The following equation is used to convert MMBTUs produced by the system to MMBTUs of NG saved:

$$\text{MMBTUs of NG Saved} = \text{MMBTUs Produced} * 1/(\text{Conversion Factor})$$

Where: Conversion Factor (the efficiency of conversion of fuel to thermal energy useable by the applicable manufacturing process) = 0.85

The following table shows the NG fuel savings by the condensing economizer system for each month of the post-installation M&V period (Table 18). The average annual NG savings is provided at the end of the table and were calculated by totaling the NG saved for each month and dividing by the total number of years of data (1.04 years).

**Table 18: CDI Turlock – Condensing Economizer NG Saved**

CDI Turlock Post-Installation Fuel Savings (from Condensing Economizer)	
Month - Year	MMBTUs of NG Saved
August - 2023*	580
September - 2023	1,482
October - 2023	1,872
November - 2023	2,374
December - 2023	2,442
January - 2024	3,647
February - 2024	3,071
March - 2024	2,703
April - 2024	2,535
May - 2024	2,511
June - 2024	1,812
July - 2024	1,596
August - 2024**	198
<b>Average Annual MMBTUs of NG Saved</b>	<b>25,832</b>

Source: Skyven

\*August – 2023 was a partial month including the days of August 18, 2023 to August 31, 2023.

\*\*August – 2024 data was low due to the CDI maintenance team unexpectedly turning the system off. Skyven noticed this via the data system, Skyven sent a maintenance crew to check it out. The system was working properly, so it was turned back on and this was addressed with the CDI to prevent future turnoffs.

**The average annual MMBTUs NG Savings Were 25,832 MMBTUs.**

- Average annual NG cost savings is calculated using the following equation:

$$\text{Annual NG Fuel Cost Savings} = \text{Annual NG Fuel Savings} \times \text{CARB Price of NG}$$

Where: CARB Price of NG = \$6.50/MMBTU

$$\text{Annual NG Fuel Savings Cost} = 25,832 \text{ MMBTU/year} \times \$6.50/\text{MMBTU}$$

**Annual NG Fuel Savings Cost = \$167,908**

- Average annual CO2 Emissions reductions are calculated using the following equation:

$$\text{CO2 Emissions Saving} = \text{Annual NG Saving} \times \text{CARB Factor (NG)} \times \text{Unit Conversion}$$

Where: CARB Factor (NG) = 117.1 lbs CO2e/MMBTU

$$= \frac{25,832 \text{ MMBTU}}{\text{year}} \times \frac{117.1 \text{ lbs CO2e}}{\text{MMBTU}} \times \frac{1 \text{ MTCO2e}}{2,204.62 \text{ lbs CO2e}}$$

**Annual CO2 Emissions Reductions = 1,372 MTCO2e**

- Average annual NOx Emissions reductions are calculated using the following equation:

$$\text{Annual NOx Emissions Savings} = \text{Annual NG Savings} \times \text{CARB Factor (NOx)}$$

$$\text{Where: CARB Factor (NOx)} = 0.049 \text{ lbs NOx/MMBTU}$$

$$= 25,832 \text{ MMBTU/year} \times 0.049 \text{ lbs NOx/MMBTU}$$

$$\text{Annual NOx Emissions Reductions} = \mathbf{1,266 \text{ lbs of NOx}}$$

### Visalia Condensing Economizer Project

The following is the post-installation data and calculations used to determine the NG and GHG emissions savings on the Visalia Condensing Economizer Project:

- Post-Installation measurements were taken from August 24, 2022 through August 31, 2024.
- The PLC calculates the heat recovered by the condensing economizer system using the values from the metering dataset in Table 1 in the following equation:

$$\dot{q} = P_{\text{water}} * 60 \text{ min/hr} * \dot{V} * C_p * (T_{\text{Hot Water from ConDex}} - T_{\text{Cold Water to ConDex}})$$

Where:  $\dot{q}$  = Instantaneous heat recovered (BTU/hr)

$$P_{\text{water}} = \text{Density of water} = 8.34 \text{ lb/gallon (constant)}$$

$\dot{V}$  = Volumetric flowrate of water from solar thermal system / meter label in Table 1: Flow-2

$$C_p = \text{Specific heat of water} = 1.0 \text{ BTU/lb-}^\circ\text{F (constant)}$$

$T_{\text{Hot Water from ConDex}}$  = Temperature of hot water leaving the ConDex system / meter label in Table 1: Temp-4

$T_{\text{Cold Water to ConDex}}$  = Temperature of cold water entering the ConDex System / meter label in Table 1: Temp-3

### Observed Data:

The following table shows the observed thermal energy produced by the condensing economizer system for each month of the post-installation M&V period (Table 19). The average annual energy produced is provided at the end of the table and calculated by totaling the MMBTUs produced each month and dividing by the total number of years of data (2.02 years).

**Table 19: CDI Visalia – Condensing Economize Energy Produced (Observed)**

CDI Visalia Observed Post-Installation Thermal Energy Produced (from Condensing Economizer)	
Month - Year	MMBTUs Produced
August - 2022*	509
September - 2022	3,361
October - 2022	3,051
November - 2022	2,608
December - 2022	3,168
January - 2023	2,943
February - 2023	633
March - 2023	77
April - 2023	34
May - 2023	44
June - 2023	35
July - 2023	44
August - 2023	41
September - 2023	41
October - 2023	41
November - 2023	28
December - 2023	18
January - 2024	19
February - 2024	27
March - 2024	42
April - 2024	46
May - 2024	37
June - 2024	20
July - 2024	37
August - 2024	46
<b>Average Annual MMBTUs Produced</b>	<b>8,371</b>

Source: Skyven

\*August – 2023 was a partial month including the days of August 24, 2022 to August 31, 2022.

**The average annual MMBTUs produced by the system were 8,371 MMBTUs.**

The following equation was used to convert MMBTUs produced by the system to MMBTUs of NG saved:

$$\text{MMBTUs of NG Saved} = \text{MMBTUs Produced} * 1/(\text{Conversion Factor})$$

Where: Conversion Factor (the efficiency of conversion of fuel to thermal energy useable by the applicable manufacturing process) = 0.85

The following table shows the NG fuel savings by the condensing economizer system for each month of the post-installation M&V period (Table 20). The average annual NG savings is provided at the end of the table and were calculated by totaling the NG saved for each month and dividing by the total number of years of data (2.02 years).

**Table 20: CDI Visalia – Condensing Economizer NG Savings (Observed)**

CDI Visalia Observed Post-Installation Fuel Savings (from Condensing Economizer)	
Month - Year	MMBTU's of NG Saved
August - 2022*	599
September - 2022	3,954
October - 2022	3,590
November - 2022	3,068
December - 2022	3,727
January - 2023	3,462
February - 2023	745
March - 2023	90
April - 2023	41
May - 2023	52
June - 2023	41
July - 2023	52
August - 2023	48
September - 2023	48
October - 2023	48
November - 2023	33
December - 2023	21
January - 2024	22
February - 2024	32
March - 2024	50
April - 2024	54
May - 2024	44
June - 2024	24
July - 2024	44
August - 2024	54
<b>Average Annual MMBTUs of NG Saved</b>	<b>9,849</b>

Source: Skyven

\*August – 2023 was a partial month including the days of August 24, 2022 to August 31, 2022.

**The average annual MMBTUs of NG savings was 9,849 MMBTUs.**

- Average annual NG cost savings is calculated using the following equation:  

$$\text{Annual NG Fuel Cost Savings} = \text{Annual NG Fuel Savings} \times \text{CARB Price of NG}$$
 Where: CARB Price of NG = \$6.50/MMBTU  

$$\text{Annual NG Fuel Savings Cost} = 9,849 \text{ MMBTU/year} \times \$6.50/\text{MMBTU}$$
**Annual NG Fuel Savings Cost = \$64,018.50**
- Average annual CO2 Emissions reductions are calculated using the following equation:  

$$\text{CO2 Emissions Saving} = \text{Annual NG Saving} \times \text{CARB Factor (NG)} \times \text{Unit Conversion}$$
 Where: CARB Factor (NG) = 117.1 lbs CO2e/MMBTU  

$$= \frac{9,849 \text{ MMBTU}}{\text{year}} \times \frac{117.1 \text{ lbs CO2e}}{\text{MMBTU}} \times \frac{1 \text{ MTCO2e}}{2,204.62 \text{ lbs CO2e}}$$
**Annual CO2 Emissions Reductions = 523 MTCO2e**
- Average annual NOx Emissions reductions are calculated using the following equation:  

$$\text{Annual NOx Emissions Savings} = \text{Annual NG Savings} \times \text{CARB Factor (NOx)}$$
 Where: CARB Factor (NOx) = 0.049 lbs NOx/MMBTU  

$$= 9,849 \text{ MMBTU/year} \times 0.049 \text{ lbs NOx/MMBTU}$$
**Annual NOx Emissions Reductions = 483 lbs of NOx**

Extrapolated Data:

Due to regulations in the San Joaquin Valley Air Pollution Control District starting in February 2023, CDI installed SCR equipment on their boilers, which required rerouting boiler exhaust from the existing exhaust stacks to the SCR equipment. The Visalia Condensing Economizer Project pulled boiler exhaust from the existing exhaust stacks so rerouting of the exhaust essentially eliminated energy savings from the equipment. Skyven is working to reintegrate the condensing economizer with the SCRs to obtain access to the boiler exhaust again in its new location, but that work is progressing slowly and is still underway.

The following table shows the extrapolated thermal energy expected to be produced by the condensing economizer system (had the boiler rerouting not taken place) for each month of the post-installation M&V period (Table 21). The extrapolated values were calculated by summing the total energy produced by the system from August 2022 to January 2023 and dividing it by the total hours to determine MMBTU/hr value. That value was then multiplied by the hours in each month to get an expected MMBTU produced value. The average annual energy produced is provided at the end of the table and was calculated by totaling the MMBTUs produced each month and dividing it by the total number of years of data (2.02 years).

**Table 21: CDI Visalia – Condensing Economizer Energy Produced (Extrapolated)**

CDI Visalia Extrapolated Post-Installation Thermal Energy Produced (from Condensing Economizer)	
Month - Year	MMBTUs Produced
August - 2022*	777
September - 2022	2,914
October - 2022	3,011
November - 2022	2,914
December - 2022	3,011
January - 2023	3,011
February - 2023	2,720
March - 2023	3,011
April - 2023	2,914
May - 2023	3,011
June - 2023	2,914
July - 2023	3,011
August - 2023	3,011
September - 2023	2,914
October - 2023	3,011
November - 2023	2,914
December - 2023	3,011
January - 2024	3,011
February - 2024	2,817
March - 2024	3,011
April - 2024	2,914
May - 2024	3,011
June - 2024	2,914
July - 2024	3,011
August - 2024	3,011

<b>Average Annual MMBTUs Produced</b>	<b>35,456</b>
---------------------------------------	---------------

Source: Skyven

\*August 2023 was a partial month, including the days of August 24, 2022 to August 31, 2022.

**The average annual MMBTUs produced by the system were 35,456 MMBTUs.**

The following equation was used to convert MMBTUs produced by the system to MMBTUs of NG saved:

$$\text{MMBTUs of NG Saved} = \text{MMBTUs Produced} * 1/(\text{Conversion Factor})$$

Where: Conversion Factor (the efficiency of conversion of fuel to thermal energy useable by the applicable manufacturing process) = 0.85

The following table shows the NG fuel savings by the condensing economizer system for each month of the post-installation M&V period (Table 22). The average annual NG savings are provided at the end of the table and were calculated by totaling the NG saved for each month and dividing by the total number of years of data (2.02 years).

**Table 22: CDI Visalia – Condensing Economizer NG Savings (Extrapolated)**

CDI Visalia Extrapolated Post-Installation Fuel Savings (from Condensing Economizer)	
Month - Year	MMBTU's of NG Saved
August - 2022*	914
September - 2022	3,428
October - 2022	3,543
November - 2022	3,428
December - 2022	3,543
January - 2023	3,543
February - 2023	3,200
March - 2023	3,543
April - 2023	3,428
May - 2023	3,543
June - 2023	3,428
July - 2023	3,543
August - 2023	3,543
September - 2023	3,428
October - 2023	3,543
November - 2023	3,428
December - 2023	3,543
January - 2024	3,543
February - 2024	3,314
March - 2024	3,543
April - 2024	3,428
May - 2024	3,543
June - 2024	3,428
July - 2024	3,543
August - 2024	3,543
<b>Average Annual MMBTUs of NG Saved</b>	<b>41,713</b>

Source: Skyven

\*August 2023 was a partial month, including the days of August 24, 2022 to August 31, 2022.

**The average annual MMBTUs of NG savings was 41,713 MMBTUs.**

- Average annual NG cost savings is calculated using the following equation:  
 Annual NG Fuel Cost Savings = Annual NG Fuel Savings × CARB Price of NG  
 Where: CARB Price of NG = \$6.50/MMBTU  
 Annual NG Fuel Savings Cost = 41,713 MMBTU/year × \$6.50/MMBTU  
**Annual NG Fuel Savings Cost = \$271,134.50**
- Average annual CO2 Emissions reductions are calculated using the following equation:  
 CO2 Emissions Saving = Annual NG Saving × CARB Factor (NG) × Unit Conversion  
 Where: CARB Factor (NG) = 117.1 lbs CO2e/MMBTU  

$$= \frac{41,713 \text{ MMBTU}}{\text{year}} \times \frac{117.1 \text{ lbs CO}_2\text{e}}{\text{MMBTU}} \times \frac{1 \text{ MTCO}_2\text{e}}{2,204.62 \text{ lbs CO}_2\text{e}}$$
**Annual CO2 Emissions Reductions = 2,216 MTCO2e**
- Average annual NOx Emissions reductions are calculated using the following equation:  
 Annual NOx Emissions Savings = Annual NG Savings × CARB Factor (NOx)  
 Where: CARB Factor (NOx) = 0.049 lbs NOx/MMBTU  
 = 41,713 MMBTU/year × 0.049 lbs NOx/MMBTU  
**Annual NOx Emissions Reductions = 2,044 lbs of NOx**

Turlock Steam Traps:

The following are the post-installation data and calculations used to determine the NG and GHG emissions savings on the Turlock Steam Traps Project:

- Post-installation measurements were taken from September 12, 2022, to August 31, 2024.
- The average steam leakage rate of each trap during the period (month) were added up to determine the period leakage rate, which was then subtracted from the baseline leakage rate (as established in the pre-installation M&V report) to obtain the total steam savings rate for the period. This steam savings rate was then multiplied by the number of hours in the period (hours in the month) to calculate the total steam savings for the period, using the following equation:

$$\text{Period Steam Savings} = (\text{Baseline Leakage Rate} - \text{Period Leakage Rate}) * \text{Hours in Period}$$

Where: Period Steam Savings = Steam Saved from Steam Traps during Period (klbs)

Baseline Leakage Rate = 1.174 klbs/hr (established in Pre-Installation M&V Report)

Period Leakage Rate = sum of average leakage rate for each trap (klbs/hr)

Hours in Period = Hours in the Month

Data:

The following table shows the total steam saved by all the steam traps for each period (month) of the post-installation M&V period (Table 23). Average annual steam savings is provided at the end of the table and were calculated by totaling the steam savings for each month and dividing them by the total number of years of data (1.97 years).

**Table 23: CDI Turlock – Steam Traps Steam Savings (klbs)**

<b>CDI Turlock Post-Installation Steam Savings (from Steam Traps)</b>	
<b>Month - Year</b>	<b>Klbs of Steam Saved</b>
September - 2022*	247
October - 2022	649
November - 2022	423
December - 2022	391
January - 2023	417
February - 2023	580
March - 2023	518
April - 2023	425
May - 2023	635
June - 2023	652
July - 2023	673
August - 2023	675
September - 2023	566
October - 2023	601
November - 2023	556
December - 2023	416
January - 2024	422
February - 2024	437
March - 2024	409
April - 2024	396
May - 2024	515
June - 2024	328
July - 2024	211
August - 2024	199
<b>Average Annual klbs of Steam Saved</b>	<b>5,749</b>

Source: Skyven

\*September - 2022 was a partial month including the days of September 12, 2022 to September 30, 2022.

**The average annual klbs of steam saved were 5,749 klbs.**

The following equation was used to convert klbs of steam saved to MMBTUs of NG saved:

$$\text{MMBTU of NG Saved} = \text{Steam Saved} * (1 \text{ klb of Steam}/1 \text{ MMBTU}) * (1/\text{Conversion Factor})$$

Where: Conversion Factor (the efficiency of conversion of fuel to thermal energy useable by the applicable manufacturing process) = 0.75

The following table shows the total NG saved by all the steam traps for each period (month) of the post-installation M&V period (Table 24). The average annual NG savings are provided at the end of the table and were calculated by totaling the NG savings for each month and dividing them by the total number of years of data (1.97 years).

**Table 24: CDI Turlock – Steam Traps NG Savings (MMBTUs)**

<b>CDI Turlock Post-Installation Fuel Savings (from Steam Traps)</b>	
<b>Month - Year</b>	<b>MMBTU's of NG Saved</b>
September - 2022*	329
October - 2022	865
November - 2022	564
December - 2022	522
January - 2023	556
February - 2023	773
March - 2023	690
April - 2023	566
May - 2023	847
June - 2023	869
July - 2023	897
August - 2023	900
September - 2023	754
October - 2023	802
November - 2023	742
December - 2023	555
January - 2024	563
February - 2024	583
March - 2024	545
April - 2024	528
May - 2024	687
June - 2024	438
July - 2024	281
August - 2024	265
<b>Average Annual MMBTU's of Fuel Savings</b>	<b>7,665</b>

Source: Skyven

\*September - 2022 was a partial month including the days of September 12, 2022 to September 30, 2022.

**The average annual MMBTUs of NG savings were 7,665 MMBTUs.**

- Average annual NG cost savings is calculated using the following equation:

$$\text{Annual NG Fuel Cost Savings} = \text{Annual NG Fuel Savings} \times \text{CARB Price of NG}$$

Where: CARB Price of NG = \$6.50/MMBTU

$$\text{Annual NG Fuel Savings Cost} = 7,665 \text{ MMBTU/year} \times \$6.50/\text{MMBTU}$$

**Annual NG Fuel Savings Cost = \$49,822.50**

- Average annual CO2 Emissions reductions are calculated using the following equation:

$$\text{CO2 Emissions Saving} = \text{Annual NG Saving} \times \text{CARB Factor (NG)} \times \text{Unit Conversion}$$

Where: CARB Factor (NG) = 117.1 lbs CO2e/MMBTU

$$= \frac{7,665 \text{ MMBTU}}{\text{year}} \times \frac{117.1 \text{ lbs CO2e}}{\text{MMBTU}} \times \frac{1 \text{ MTCO2e}}{2,204.62 \text{ lbs CO2e}}$$

**Annual CO2 Emissions Reductions = 407 MTCO2e**

- Average annual NOx Emissions reductions are calculated using the following equation:

$$\text{Annual NOx Emissions Savings} = \text{Annual NG Savings} \times \text{CARB Factor (NOx)}$$

Where: CARB Factor (NOx) = 0.049 lbs NOx/MMBTU

$$= 7,665 \text{ MMBTU/year} \times 0.049 \text{ lbs NOx/MMBTU}$$

**Annual NOx Emissions Reductions = 376 lbs of NOx**

Visalia Steam Trap Project

Following are the post-installation data and calculations used to determine the NG and GHG emissions savings on the Visalia Steam Traps Project:

- Post-Installation measurements were taken from February 16, 2023, through August 31, 2024.
- The average steam leakage rate of each trap during the period (month) were added up to get the period leakage rate, which was then subtracted from the baseline leakage rate (as established in the pre-installation M&V report) to obtain the total steam savings rate for the period. This steam savings rate was then multiplied by the number of hours in the period (hours in the month) to calculate the total steam savings for the period, using the following equation:

$$\text{Period Steam Savings} = (\text{Baseline Leakage Rate} - \text{Period Leakage Rate}) * \text{Hours in Period}$$

Where: Period Steam Savings = Steam Saved from steam traps during period (klbs)

Baseline Leakage Rate = 5.4416 klbs/hr (established in Pre-installation M&V report)

Period Leakage Rate = sum of average leakage rate for each trap (klbs/hr)

Hours in Period = Hours in the month

Data:

The following table shows the total steam saved by all the steam traps for each period (month) of the post-installation M&V period (Table 25). The average annual steam savings are provided at the end of the table and were calculated by totaling the steam savings for each month and dividing them by the total number of years of data (1.54 years).

**Table 25: CDI Visalia – Steam Traps Steam Savings (klbs)**

CDI Visalia Post-Installation Steam Savings (from Steam Traps)	
Month - Year	Klbs of Steam Saved
February - 2023*	1,230
March - 2023	2,453
April - 2023	2,622
May - 2023	3,260
June - 2023	3,036
July - 2023	3,124
August - 2023	3,067
September - 2023	2,960
October - 2023	2,684
November - 2023	2,733
December - 2023	2,480
January - 2024	1,606
February - 2024	1,820
March - 2024	1,921
April - 2024	2,802
May - 2024	3,233
June - 2024	2,978
July - 2024	2,559
August - 2024	2,077
<b>Average Annual klbs of Steam Saved</b>	<b>31,537</b>

Source: Skyven

\*February 2023 was a partial month including the days of February 16, 2023 to February 28, 2023.

**The average annual klbs of steam saved were 31,537 klbs.**

The following equation was used to convert klbs of steam saved to MMBTUs of NG saved:

$$MMBTU \text{ of NG Saved} = \text{Steam Saved} * (1 \text{ klb of Steam} / 1 \text{ MMBTU}) * (1 / \text{Conversion Factor})$$

Where: Conversion Factor (the efficiency of conversion of fuel to thermal energy useable by the applicable manufacturing process) = 0.75

The following table shows the total NG saved by all the steam traps for each period (month) of the post-installation M&V period (Table 26). The average annual NG savings are provided at

the end of the table and were calculated by totaling the NG savings for each month and dividing them by the total number of years of data (1.54 years).

**Table 26: CDI Visalia – Steam Traps NG Savings (MMBTUs)**

CDI Visalia Post-Installation Fuel Savings (from Steam Traps)	
Month - Year	MMBTU's of NG Saved
February - 2023*	1,641
March - 2023	3,270
April - 2023	3,496
May - 2023	4,346
June - 2023	4,048
July - 2023	4,165
August - 2023	4,089
September - 2023	3,947
October - 2023	3,578
November - 2023	3,645
December - 2023	3,307
January - 2024	2,141
February - 2024	2,426
March - 2024	2,561
April - 2024	3,736
May - 2024	4,311
June - 2024	3,970
July - 2024	3,412
August - 2024	2,769
<b>Average Annual MMBTU's of Fuel Savings</b>	<b>42,050</b>

Source: Skyven

\*February 2023 was a partial month including the days of February 16, 2023 to February 28, 2023.

**The average annual MMBTUs of NG savings were 42,050 MMBTUs.**

- Average annual NG cost savings is calculated using the following equation:  

$$\text{Annual NG Fuel Cost Savings} = \text{Annual NG Fuel Savings} \times \text{CARB Price of NG}$$
 Where: CARB Price of NG = \$6.50/MMBTU  

$$\text{Annual NG Fuel Savings Cost} = 42,050 \text{ MMBTU/year} \times \$6.50/\text{MMBTU}$$
**Annual NG Fuel Savings Cost = \$273,325**
- Average annual CO2 Emissions reductions are calculated using the following equation:  

$$\text{CO2 Emissions Saving} = \text{Annual NG Saving} \times \text{CARB Factor (NG)} \times \text{Unit Conversion}$$

Where: CARB Factor (NG) = 117.1 lbs CO<sub>2</sub>e/MMBTU

$$= \frac{42,050 \text{ MMBTU}}{\text{year}} \times \frac{117.1 \text{ lbs CO}_2\text{e}}{\text{MMBTU}} \times \frac{1 \text{ MTCO}_2\text{e}}{2,204.62 \text{ lbs CO}_2\text{e}}$$

**Annual CO<sub>2</sub> Emissions Reductions = 2,234 MTCO<sub>2</sub>e**

- Average annual NO<sub>x</sub> Emissions reductions are calculated using the following equation:

Annual NO<sub>x</sub> Emissions Savings = Annual NG Savings × CARB Factor (NO<sub>x</sub>)

Where: CARB Factor (NO<sub>x</sub>) = 0.049 lbs NO<sub>x</sub>/MMBTU

$$= 42,050 \text{ MMBTU/year} \times 0.049 \text{ lbs NO}_x\text{/MMBTU}$$

**Annual NO<sub>x</sub> Emissions Reductions = 2,060 lbs of NO<sub>x</sub>**

## Compiled Results and Results Compared with Projections:

CDI Turlock (Tables 27 and 28):

**Table 27: CDI Turlock – Condensing Economizer Savings Values**

CDI Turlock Condensing Economizer - Post-Installation Values		
Annual Natural Gas Saved	25,832	MMBTU/year
Annual Natural Gas Cost Savings	\$167,908.00	dollars/year
Annual CO <sub>2</sub> Emissions Savings	1,372	MT CO <sub>2</sub> e/year
Annual NO <sub>x</sub> Emissions Savings	1,266	lbs NO <sub>x</sub> /year

Source: Skyven

**Table 28: CDI Turlock – Steam Traps Savings Values**

CDI Turlock Steam Traps - Post-Installation Values		
Annual Natural Gas Saved	7,665	MMBTU/year
Annual Natural Gas Cost Savings	\$49,822.50	dollars/year
Annual CO <sub>2</sub> Emissions Savings	407	MT CO <sub>2</sub> e/year
Annual NO <sub>x</sub> Emissions Savings	376	lbs NO <sub>x</sub> /year

Source: Skyven

The following table compares the actual CO<sub>2</sub> emissions reductions provided by the condensing economizer and steam trap systems to what was projected earlier in the project (Table 29).

**Table 29: CDI Turlock – Actual vs. Predicted Values**

CDI Turlock - Actual vs. Predicted		
	Actual	Predicted
Condensing Economizer - Annual CO <sub>2</sub> Emissions Reduction (MT CO <sub>2</sub> /yr)	1,372	1,705
Steam Traps - Annual CO <sub>2</sub> Emissions Reduction (MT CO <sub>2</sub> /yr)	407	815

Source: Skyven

For the condensing economizer, the delta in the actual and predicted values were in part due to the lack of savings in the month of August 2024 when the system was turned off, and also due to an issue with the dryers onsite, which caused CDI to decrease the operating hours of the dryer (thereby decreasing the overall amount of heat that can be provided to the dryers). For the steam traps, the delta in the actual and predicted values were in part due to some issues with the steam trap monitors where steam traps appeared to keep failing due to caustic washdown. Additionally, the original steam traps were in better shape than Skyven thought they were when Skyven replaced them so the initial assessment of how many traps had failed was overly aggressive.

CDI Visalia (Tables 30 through 32):

**Table 30: CDI Visalia – Condensing Economizer Savings Values (Observed)**

CDI Visalia Condensing Economizer - Observed Post-Installation Values		
Annual Natural Gas Saved	9,849	MMBTU/year
Annual Natural Gas Cost Savings	\$64,018.50	dollars/year
Annual CO <sub>2</sub> Emissions Savings	523	MT CO <sub>2</sub> e/year
Annual NO <sub>x</sub> Emissions Savings	483	lbs NO <sub>x</sub> /year

Source: Skyven

**Table 31: CDI Visalia – Condensing Economizer Savings Values (Extrapolated)**

CDI Visalia Condensing Economizer - Extrapolated Post-Installation Values		
Annual Natural Gas Saved	41,713	MMBTU/year
Annual Natural Gas Cost Savings	\$271,134.50	dollars/year
Annual CO <sub>2</sub> Emissions Savings	2,216	MT CO <sub>2</sub> e/year
Annual NO <sub>x</sub> Emissions Savings	2,044	lbs NO <sub>x</sub> /year

Source: Skyven

**Table 32: CDI Visalia – Condensing Economizer Savings Values (Extrapolated)**

CDI Visalia Steam Traps - Post-Installation Values		
Annual Natural Gas Saved	42,050	MMBTU/year
Annual Natural Gas Cost Savings	\$273,325.00	dollars/year
Annual CO <sub>2</sub> Emissions Savings	2,234	MT CO <sub>2</sub> e/year
Annual NO <sub>x</sub> Emissions Savings	2,060	lbs NO <sub>x</sub> /year

Source: Skyven

The following table compares the actual CO<sub>2</sub> emissions reductions provided by the condensing economizer and steam trap systems to earlier projections (Table 33).

**Table 33: CDI Visalia – Actual vs. Predicted Values**

CDI Visalia - Actual/Observed vs. Extrapolated vs. Predicted			
	Actual/Observed	Extrapolated	Predicted
Condensing Economizer - Annual CO <sub>2</sub> Emissions Reduction (MT CO <sub>2</sub> /yr)	523	2,216	2,537
Steam Traps - Annual CO <sub>2</sub> Emissions Reduction (MT CO <sub>2</sub> /yr)	2,234	N/A	2,756

Source: Skyven

For the condensing economizer, the delta in the extrapolated and predicted values was due to the lack of data available for extrapolation. Additionally, there were occasions where one or more of the boilers were offline at various times, thereby decreasing available heat in the ConDex system. For the steam traps, the delta in the actual and predicted values were due to issues with the steam trap monitor failures that required replacements. While the monitors failed, steam leakage could not be measured, so steam savings could not be calculated.

# CHAPTER 4:

## Conclusion

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In conclusion, CDI, which is the largest milk and dairy cooperative in California, set the ambitious goal to achieve carbon neutrality by 2050. To progress toward this goal, CDI partnered with Skyven to implement condensing economizer and steam trap upgrades at their dairy facilities in Turlock and Visalia, both in California. These systems reduced NG consumption and curtailed emissions from the two CDI facilities.

Supported by funding from the California Energy Commission, these projects align with crucial aspects of California's clean energy and climate objectives: public health, environmental preservation, and economic development. By reducing emissions from the CDI Turlock and Visalia plants, which are in areas marked by high pollution levels, these projects additionally address the California Energy Commission's public and environmental health goals.

Skyven has collected extensive M&V data since the commissioning of the projects and analyzed that data to determine the annual performance metrics of the condensing economizers and steam traps at both facilities. For the Turlock Condensing Economizer Project, the data revealed that the system provides an annual heat output of 21,957 MMBTUs/year. Using a conversion factor of 0.85, the condensing economizer provides an annual NG savings of 25,832 MMBTUs/year and an annual reduction of 1,372 MTCO<sub>2</sub>e/year. For the Visalia Condensing Economizer Project, the extrapolated data revealed that the system provides an annual heat output of 35,456 MMBTUs/year. Using a conversion factor of 0.85, the condensing economizer provides an annual NG savings of 41,713 MMBTUs/year and an annual reduction of 2,216 MTCO<sub>2</sub>e/year. For the Turlock Steam Traps Project, the data revealed that the traps provide annual steam savings of 5,749 klbs/year. Using a conversion factor of 0.75, the steam traps provide an annual NG savings of 7,665 MMBTUs/year and an annual reduction of 407 MTCO<sub>2</sub>e/year. For the Visalia Steam Traps Project, the data revealed that the traps provide an annual steam savings of 31,537 klbs/year. Using a conversion factor of 0.75, the steam traps provide an annual NG savings of 42,050 MMBTUs/year and an annual reduction of 2,234 MTCO<sub>2</sub>e/year.

The key takeaway from this project is that steam traps and condensing economizers have good decarbonization potential and the installation of this equipment should be considered when industrial facilities are seeking ways to decarbonize. Moving forward, Skyven will continue to monitor the condensing economizer and steam trap projects to ensure continued fuel and emissions savings for these facilities.

## GLOSSARY AND LIST OF ACRONYMS

Term	Definition
BTU	British thermal units – the amount of heat needed to raise one pound of water at maximum density through one degree Fahrenheit
CARB	California Air Resources Board
CDI	California Dairies Inc. – the largest milk and dairy cooperative in the state of California. This report details an energy-saving project at two California dairies.
CEC	California Energy Commission – the state of California’s primary energy policy and planning agency
CO <sub>2</sub>	carbon dioxide – a colorless, odorless gas produced by burning carbon and organic compounds
CO <sub>2</sub> e	carbon dioxide equivalent
GHG	greenhouse gases: Gases that contribute to the greenhouse effect by absorbing infrared radiation
klbs	thousand pounds
klbs/yr	thousand pounds per year
lbs	pounds
lbs/hr	pounds per hour
lbs/yr	pounds per year
M&V	movement and verification
MMBTU	million metric British thermal units
MMBTU/hr	million metric British thermal units per hour
MMBTU/yr	million metric British thermal units per year
MTCO <sub>2</sub> e	metric tons of carbon dioxide equivalent – the number of metric tons of CO <sub>2</sub> emissions with the same global warming potential as one metric ton of another greenhouse gas
MTCO <sub>2</sub> e/yr	metric tons carbon dioxide equivalent per year
NG	natural gas
NO <sub>x</sub>	nitrogen oxide
PLC	Programmable Logic Controllers – industrial computers with various inputs and outputs (such as those listed in Table 2, which are used to control and monitor industrial equipment based on custom programming.
SCR	selective catalytic reduction – removes nitrogen oxides from flue gas emitted by power plant boilers

# References

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- CARB (California Air Resources Board). 2018. "[Funding Guidelines for Agencies that Administer California Climate Investments](https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/2018-funding-guidelines.pdf)." August. Available at <https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/2018-funding-guidelines.pdf>.
- OEHHA (Office of Environmental Health Hazard Assessment). 2018. "[Version 3.0 of the California Communities Environmental Health Screening Tool \(CalEnviroScreen\)](https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30)." California Environmental Protection Agency. June. Available at <https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30>.

# Project Deliverables

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The following is a list of all the products produced under this agreement:

- Site Preparation and Equipment Procurement Memo
- M&V Plan
- Pre-Installation M&V Findings Report
- Post-Installation M&V Findings Report
- Critical Project Review (CPR) Report
- Quarterly Progress Reports (QPR)

The above project deliverables, including the CPR and QPR interim project reports, are available upon request by submitting an email to [pubs@energy.ca.gov](mailto:pubs@energy.ca.gov).



**CALIFORNIA  
ENERGY COMMISSION**



**ENERGY RESEARCH AND DEVELOPMENT DIVISION**

# **APPENDIX A: Press Releases**

**August 2025 | CEC-500-XXXX-XXX**



# APPENDIX A:

## Press Releases

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The first press release was published in Yahoo Finance on September 28, 2023 (Figure A-1). The [release](https://finance.yahoo.com/news/skyven-technologies-inc-announced-today-123500517.html) can be found at the following website address: <https://finance.yahoo.com/news/skyven-technologies-inc-announced-today-123500517.html>.

**Figure A-1: Yahoo Finance Press Release**



### **Skyven Technologies, Inc. Celebrates Successful Integration of Decarbonization Solutions with California Dairies, Inc.**

*Skyven and California Dairies, Inc have successfully eliminated over 3,500 metric tons of CO<sub>2</sub> emissions over the past year*

**VISALIA, California** (September 28, 2023) -- Skyven Technologies, an Energy-as-a-Service company with a mission to decarbonize industrial process heat, and California Dairies, Inc. (CDI), the largest member-owned milk marketing and processing cooperative in California, have successfully implemented three state-of-the-art decarbonization technologies designed to increase energy efficiency and reduce emissions without affecting facility operations.

As one of the largest dairy co-ops in the nation, CDI has pledged to reach carbon neutrality by 2050, and Skyven's decarbonization solutions are helping them meet that goal.

Skyven and CDI have worked together to design, install, and replicate a first-of-its-kind integration of three decarbonization technologies at each of CDI's two largest facilities. The six total projects include two of the largest solar thermal systems for industrial process heat in the world. These renewable heat systems are each integrated with a smart steam trap solution that uses state of the art internet-connected sensors to reduce steam loss at each facility. The integration also includes a boiler heat recovery system to boost the efficiency of the boilers by nearly 10%. This innovative integration allows CDI to achieve deeper decarbonization at their processing facilities, helping them to meet their carbon neutrality goals and to contribute to the sustainable future of California's dairy industry.

In total, Skyven's innovative solutions have saved over 3,500 metric tons of CO<sub>2</sub> and over 65,000 MMBtu of natural gas at the two CDI facilities, the equivalent of removing 788 gasoline-powered passenger vehicles from the road annually. In a full year of operation, these installed solutions will save over 4,700 metric tons of CO<sub>2</sub> and over 89,000 MMBtu of natural gas. Skyven and CDI are currently working toward the implementation of additional decarbonization solutions at more facilities.

This project also represents a first-of-its-kind financial structure that leverages grant funding from the California Energy Commission's Food Production Investment Program (FPIP), utility incentive funding from Pacific Gas & Electric and Southern California Gas Company, third party project finance, and investment from Skyven's balance sheet to allow the integrated decarbonization technologies to pay for themselves from the resulted energy savings, meaning no capital outlay was required from CDI.

"We are thrilled to combine the manufacturing expertise of California Dairies, Inc with the industrial decarbonization expertise of Skyven," said Arun Gupta, CEO of Skyven Technologies. "We look forward to the continued partnership, and to supporting CDI in meeting their carbon neutrality goals."

“Skyven has played a key role in our mission to create more sustainable dairy products for a healthy world,” said Darrin Monteiro, Vice President of Sustainability and Member Relations at California Dairies, Inc. “Skyven’s ability to design and implement these successful solutions with no cost and no interruption to our process was a vital component to success.”

To learn more about Skyven Technologies, visit <https://skyven.co/>.

### **About Skyven Technologies**

Skyven Technologies is an energy-as-a-service company with a mission to decarbonize industrial process heat. Skyven works with manufacturers in hard-to-decarbonize industries to reduce their onsite CO2 emissions by delivering clean, emissions-free process heat at prices lower than natural gas. Skyven installs their latest decarbonization technology, including the Arcturus line of steam generating heat pumps, with no capital cost to the manufacturer. For more information, visit <https://skyven.co/>.

### **About California Dairies, Inc**

California Dairies, Inc. is the largest member-owned milk marketing and processing cooperative in California, producing approximately 40 percent of California’s milk. Co-owned by 300 dairy producers who ship 17 billion pounds of Real California Milk annually, California Dairies, Inc. is a manufacturer of quality butter, fluid milk products, and milk powders. In addition, California Dairies, Inc. is the home of two leading and well-respected brands of butter – Challenge and Danish Creamery – and a leading global brand of milk powders - DairyAmerica. California Dairies, Inc.’s quality dairy products are available in all 50 United States and in more than 60 foreign countries.

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The second press release was published in AP News on October 12, 2023 (Figure A-2). The [release](https://apnews.com/press-release/pr-newswire/government-programs-8796380ae6927d21f92286ab3c85b764) can be found at the following website address: <https://apnews.com/press-release/pr-newswire/government-programs-8796380ae6927d21f92286ab3c85b764>.

### Figure A-2: AP News Press Release



## Skyven Technologies Transforms the Financing of Industrial Decarbonization Projects

*Skyven's unique Energy-as-a-Service model demonstrates the impact of public-private funding*

**RICHARDSON, Texas** (October 12, 2023) - Skyven Technologies, Inc., an Energy-as-a-Service company with a mission to decarbonize industrial process heat, and Kyotherm, Inc., an investment company that specializes in the third-party financing of renewable thermal projects, have demonstrated public-private funding to decarbonize America's industrial manufacturing sector. This innovative financial approach was used to successfully implement the six decarbonization projects recently announced by Skyven and California Dairies, Inc (CDI), enabling more than 3,500 metric tons of CO<sub>2</sub> reduction over the past year.

This public-private project financing, built on Skyven's Energy-as-a-Service (EaaS) model, combines direct financing from Skyven, third-party financing from Kyotherm, and public funding from the California Energy Commission's Food Production Investment Program (FPIP). Skyven's EaaS model is compatible with state and federal grant funding, including the FPIP program, serving a growing need for public-private partnership.

Under the EaaS model, the clean emissions-free heat delivered by Skyven's systems is measured and verified with meters and IoT data monitoring. The manufacturing facility pays for the delivered heat at prices lower than their current natural gas costs. The savings are shared by the manufacturer, third party financiers, and Skyven for the life of the contract.

"When we first announced this partnership back in 2021, it was unproven - no one was doing this for industrial heat," said Arun Gupta, CEO of Skyven Technologies. "Today we're proud to report that the combination of public and private funding sources has led to fully operational industrial decarbonization projects that are outperforming original expectations - with no cost to the industrial manufacturer."

"Skyven's Energy-as-a-Service model removes the major financial barrier to industrial decarbonization projects," said Arnaud Susplugas, CEO of Kyotherm Inc. "It is great to see that Kyotherm's access to competitive capital and our dedication to energy efficiency projects are helping lead the industrial decarbonization revolution."

### About Skyven Technologies

Skyven Technologies is an Energy-as-a-Service company with a mission to decarbonize industrial process heat. Skyven works with manufacturers in hard-to-decarbonize industries to reduce their onsite CO<sub>2</sub> emissions by delivering clean, emissions-free process heat at prices lower than natural gas. Skyven installs their latest decarbonization technology, including the Arcturus line of steam generating heat pumps, with no capital cost to the manufacturer. For more information, visit <https://skyven.co/>.

## About Kyotherm

Kyotherm is an Energy-as-a-Service investment company and energy producer dedicated to renewable heating and energy efficiency projects, with varied technologies including waste heat recovery, solar thermal, biomass, geothermal, storage as well as district heating networks and installations allowing reduced energy consumption. As of August 2023, it has financed, owns, manages, or has committed to fund a total of 45 projects, representing an aggregate capacity of 230 MW and a production of more than 3,050,000 MMBtu per year in savings or renewable energy. More information on [www.kyotherm.com/en](http://www.kyotherm.com/en)

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