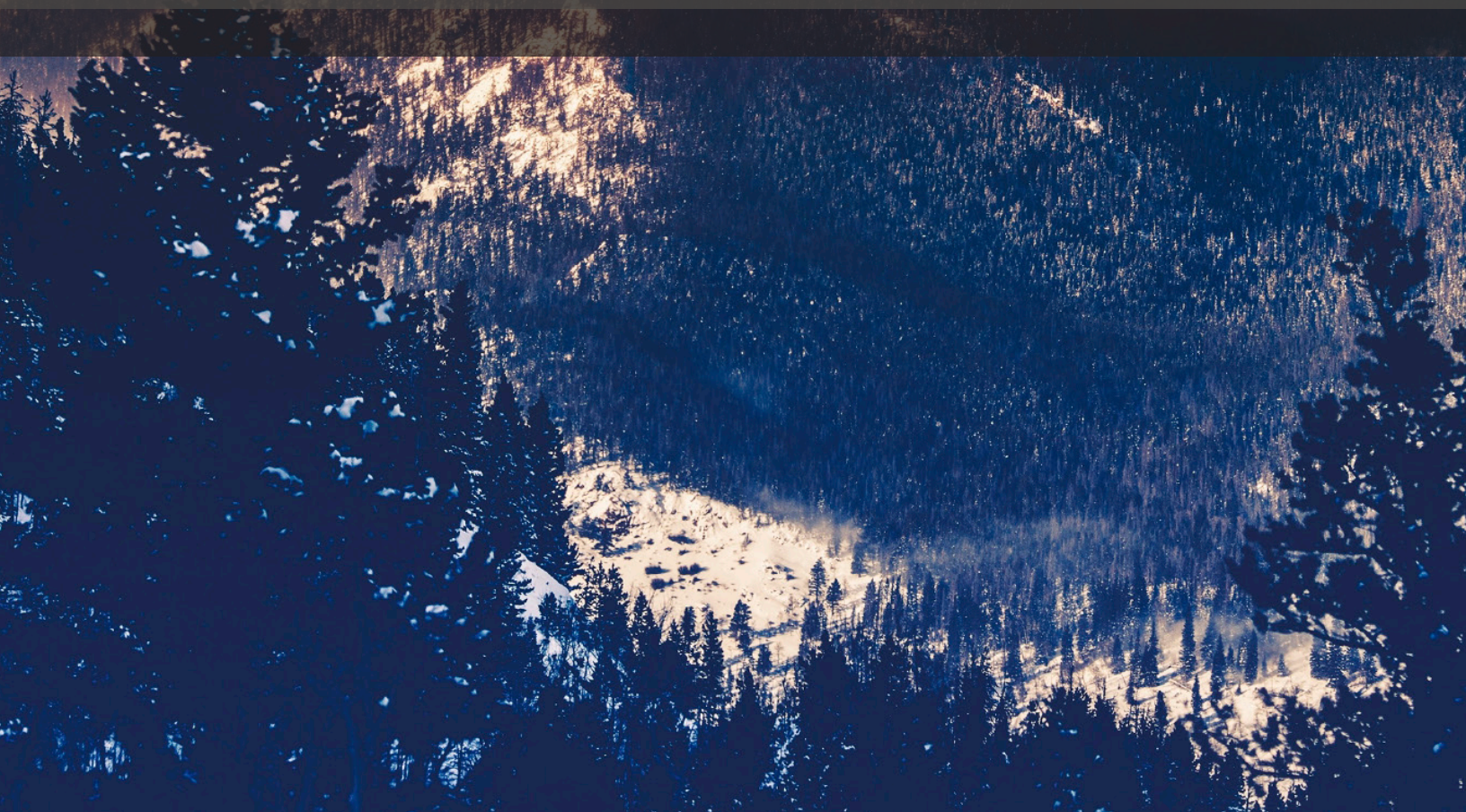
COLORADO
Energy Office

Industrial Energy Efficiency and Distributed Generation Opportunities in Colorado

JUNE 2017



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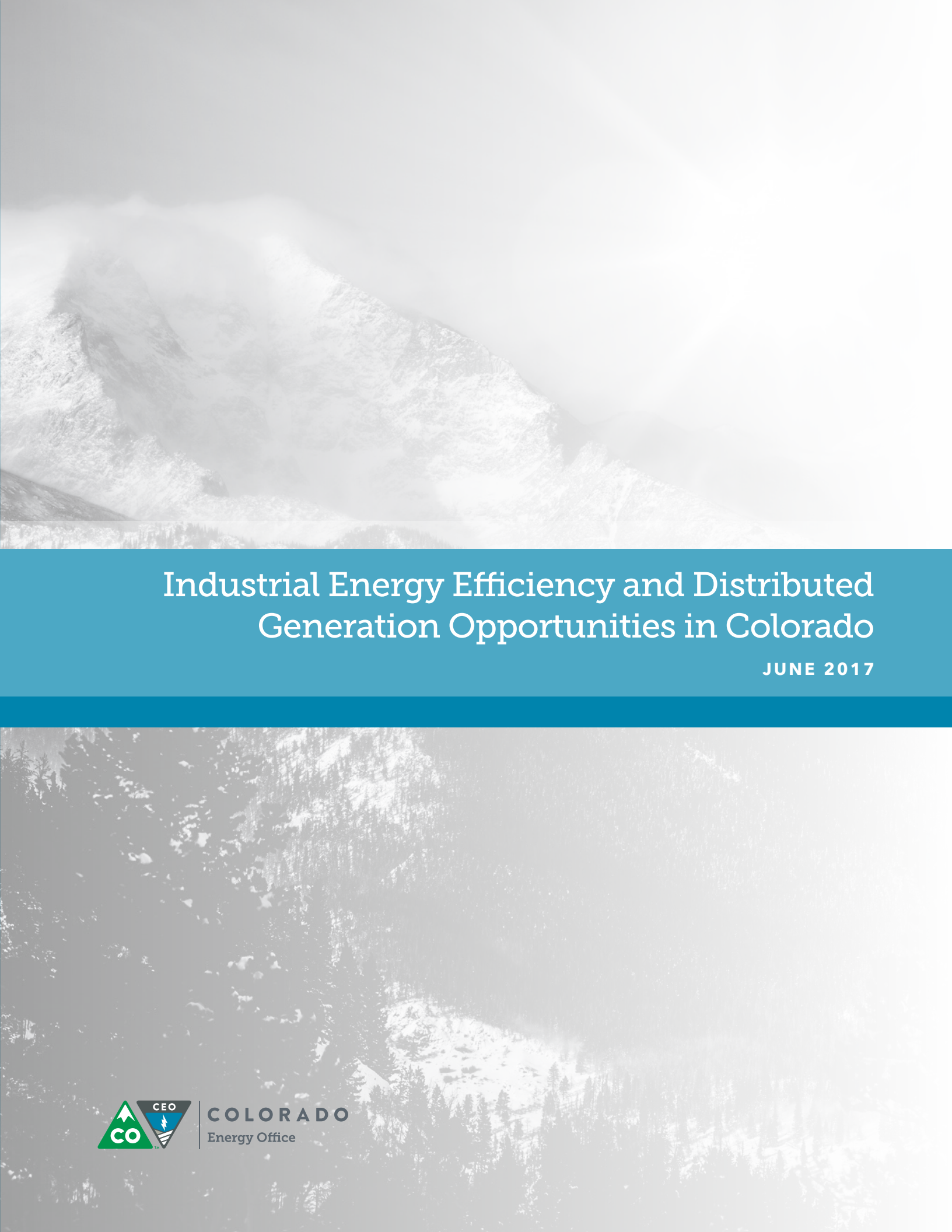

Industrial Energy Efficiency and Distributed Generation Opportunities in Colorado

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COLORADO
Energy Office

PREFACE

The goal of this project, Colorado Energy Office (CEO) PO 17-7107, is to study market opportunities for distributed generation (DG) and energy efficiency (EE) in Colorado's industrial sectors. CEO has contracted this work to Energetics Incorporated to support the following activities: 1) estimate the size of Colorado's industrial sector and identify opportunities to encourage DG and EE investment by industrial customers, 2) assess industrial customer attitudes towards distributed generation and energy efficiency, identifying barriers to investing in DG and EE, 3) create educational materials on financing and accounting tools that encourage DG and EE investment by industrial customers, 4) educate industrial customers about available programs, incentives, and financing options for industrial DG and EE, and 5) create guidelines and best practices for developing energy efficiency program that identifies and encourages DG and EE investment by industrial energy users.

To complete these objectives, Energetics relied on publicly available energy and economic statistics relevant to Colorado's industrial sectors and conducted a survey and in-depth interviews with industrial company CFOs, project managers, and sustainability managers from a variety of industries. Energetics also worked with a subcontractor, Barretto Bay Strategies, to create an investment guide that serves as an in-depth review of accounting strategies, program opportunities, and financing opportunities that are available from the local to the national level for industrial customers interested in investing in DG and EE projects.

These efforts have provided CEO a list of industrial customers interested in DG and EE and helped to identify the factors that most compel industrial firms to invest in DG and EE. This research report is intended to help shape possible programmatic efforts from the CEO to encourage and aid industrial customers in EE and DG decision making.

ACKNOWLEDGMENTS

Jonathan Rogers of Energetics Incorporated managed this projected and authored this report. Jenny Herzfeld identified many of the industrial companies and points of contact in Colorado used in the survey and interview efforts and helped to compile information on the Renewable Energy Standard resource potential. Nancy Gonzales supported efforts to design and administer the survey and conduct interviews with Colorado industrial firms. Nicholas Ward, helped to gather and conduct analysis on high-level industrial energy and economic statistics in Colorado. Thomas Finamore provided valuable document production support to prepare this report for final publication.

Josh Keller of Barretto Bay Strategies gathered information on the available incentives and programs in Colorado, and helped to identify and develop strategies to encourage distributed generation and energy efficiency investments. Thanks to Paul Lipson for his leadership at Barretto Bay Strategies.

Lastly, thanks go to Samantha Reifer and Michael Turner of the CEO for their feedback and guidance throughout this effort.

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The energy consumption values in this report are averages of energy consumption based on economic trends in employment and production outputs as well as various energy conversion factors. They should not be misconstrued to estimate total energy consumption for any particular plant or production unit within any industry considered in this analysis. Energy consumption within an industry can vary for myriad reasons including total production output and the type of equipment used. The estimates discussed in this section are intended as high-level estimates only.

Executive Summary

The industrial sector accounted for nearly 1/3rd of US energy consumption in 2016. In Colorado, industrial firms are also major employers and economic contributors in addition to being large energy consumers.. Table ES-1 identifies major industrial sectors in Colorado based on their North American Industry Classification System (NAICS) code. In 2014, these select sectors employed more than 112 thousand people, contributed over $47.4 billion to Colorado's economy, and consumed 96 TBtu of energy of which there was 5.6 billion kWh of electricity demand. This is estimated to have cost $395 million for non-electricity energy use and $346 million for electricity across Colorado's top 13 manufacturing sectors in 2014.

The Colorado Energy Office (CEO) is assessing options and strategies for an energy efficiency (EE) program that could encourage distributed generation (DG) and EE investments by industrial firms in the state. CEO should remain mindful of the available resources and motivations of the firms they are attempting to work with as they consider possible programmatic efforts. Any approach will need to be flexible to accommodate the needs and resources of different industrial firms. Any program should also enable industrial firms to learn and adopt energy management practices, investment strategies, and behaviors that can enable self-sustaining energy improvements at their facilities.

TABLE ES-1. ECONOMIC AND ENERGY STATISTICS FOR MAJOR INDUSTRIAL SECTORS IN COLORADO

Sector	NAICS	Total Colorado Employees (2014) *AMS and CBP*	Colorado 2014 Dollar Value of Shipments (thousand) *AMS and CBP*	Estimated 2014 Total CO Energy Consumption (TBtu) *Calculated*	Estimated 2014 CO Electricity Demand (million kWh) *Calculated*
Petroleum and Coal Products	324	913	$4,940,975	33.9	404
Food Processing	311	19,703	$11,689,766	17.3	1,188
Nonmetallic Mineral Products	327	6,340	$2,088,090	10.8	566
Chemicals	325	6,560	$5,554,011	8.3	633
Paper Products	322	1,188	$415,639	6.0	372
Primary Metals	331	2,055	$1,318,761	5.3	667
Wood Products	321	3,141	$780,936	3.8	177
Beverage and Tobacco Products	312	4,816	$4,479,223	2.1	285
Computer and Electronic Products	334	12,996	$4,717,293	2.4	399
Fabricated Metal Products	332	13,907	$3,720,419	2.0	275
Plastics and Rubber Products	326	5,517	$1,241,305	1.4	310
Transportation Equipment	336	9,626	$2,630,236	1.3	157
Machinery	333	11,265	$3,820,040	0.9	163
Oil and Gas Extraction	2111	8,709	n/a	n/a	n/a
Coal Mining	2121	1,993	n/a	n/a	n/a
Other Metallic Mining	2122	1,778	n/a	n/a	n/a
Non-Metallic Mining	2123	1,226	n/a	n/a	n/a
Water and Sewage Systems	2213	569	n/a	n/a	n/a

AMS is the Annual Survey of Manufacturers and CBP is the County Business Patterns Survey. Energy estimates calculated based on the Manufacturers Energy Consumption Survey. See Chapter 2 for more details on the sources and methodology.

There are various opportunities for Colorado industrial firms to save on energy costs and reduce their environmental footprints including: conducting energy assessments to identify EE opportunities; implementing energy management systems and adhering to energy related best practices; adopting energy standards that provide a framework for managing and improving energy performance; deploying EE technologies; and generating energy on-site. Industrial firms can take advantage of renewable resources around Colorado through either on-site deployment or off-site procurement depending on the industrial applicability and availability of a renewable resource in a given geography or industrial process.

Table ES-2 provides a brief summary of Colorado Renewable Energy Standard (RES) eligible resources and their current use and technical potential in the State. As can be seen these resources vary and may be: readily accessible to multiple industrial applications and geographies; specific to certain industrial processes or geographies; available only via off-site procure; or are unlikely to be available to industrial energy consumers.

Of the RES eligible resources, solar power is the most readily accessible to industrial firms. Rooftop space can accommodate the installation of solar PV panels to offset a portion of facility electricity requirements. A 50,000 ft^2 warehouse roof could produce more than 10.5 GWh of electricity annually (at 6.21 kWh/m^2/day). Industrial firms can also choose to avoid the up-front capital expense of solar arrays by using a power purchase agreement.

Given the right process conditions, recycled energy and combined heat and power systems offer a unique value proposition compared to the other technologies in that they can take advantage of waste heat to better utilize resources and save money. Energy intensive industrial processes—such as those occurring at refineries, steel mills, glass furnaces, and cement kilns—all release hot exhaust gases and waste streams that can be harnessed with common technologies to generate electricity. Additionally, Xcel Energy has a new program that will offer $500/kW of recycled energy. Each of the RES eligible resources should be evaluated on a case-by-case basis for industrial firms interested in DG.

Despite potential cost, energy, and environmental benefits, industrial firms do not always take advantage of EE and DG opportunities. Therefore, an outreach survey and follow-up interviews with industrial companies in Colorado were used to evaluate industry perspectives regarding DG and EE investments.

The majority of survey respondents indicated that energy use and consumption is becoming a higher priority at their organizations and ~95% of them responded that management will at least occasionally support energy related investments. However, only 51% of respondents indicated that they are actively pursuing EE projects and 32% of respondents are actively pursuing on-site generation. Economics appear to be the primary driver for energy decision making at organizations, outweighing factors such as environmental responsibility, regulations, or pressure from NGOs or energy activists. This does come with the caveat that larger firms (501+ employees) are willing to consider other justifiable attributes such as energy or environmental goals in addition to economics.

TABLE ES-2. SUMMARY OF RENEWABLE RESOURCE USE AND POTENTIAL IN COLORADO

RES Eligible Resource	CO Current Status	CO Technical Potential	Ease of Industrial Deployment
Anaerobic Digestion	25 operating systems	356 potential sites	Primarily applicable to wastewater treatment, food production, and animal feeding operations
Coal Mine Methane	One 3 MW project	9 active mines with 34 feasible MW of potential	Only suitable for coal mines or industrial firms located in close proximity to one
Geothermal	Used for various heating applications, 5 power projects in development	8,900 GWh annually (24MW planned)	Geographically specific with most opportunity in the mountainous areas
Hydropower	60 facilities, 1150 MW installed capacity	750 MW of undeveloped technical capacity	Conduit systems may be the best application for water intensive industrial operations
Landfill Gas	3.3 mmscfd of operating LFG	1.4 mmscfd of candidate LFG	Can be procured if there is an operating landfill nearby
MSW Pyrolysis	No operating plants	Unclear	Unlikely to be used in an industrial setting
Recycled Energy	3 projects, 7MW	70 technical feasible projects (108 MW)	Steady waste heat source of 300 degrees F or more (common for industrial processes)
Solar	391 thousand MWh of DG in CO annually (2 thousand from industrial sources)	Average 6.21 kWh/m2/day	Readily deployable across the entire state
Wind	3,026 MW	274,353 MW	Small wind turbines (<100 kW) are most suitable in the eastern plains and along the front range
Woody Biomass	One 11.5 MW wood only CHP facility	<1 GW	Suitable for industrial facilities with waste wood

The majority of survey respondents have conducted building efficiency and process efficiency audits. The survey also found that 83% of large business respondents have conducted a building efficiency audit compared to 67% of mid-sized companies and 50% of small business. All of the larger firms also responded that they have recently upgraded their facility lighting and HVAC systems. Across the board, larger firms are shown to be the most active at assessing the energy performance of their systems and taking action to improve EE.

Firms of all sizes are shown to be more interested in and willing to pursue EE projects than on-site energy generation. Industrial firms cited additional effort and a longer return on investment for DG projects than for EE, which also often uncover energy performance improvements at low or no-cost. Firms that have pursued DG have predominantly installed on-site solar systems (20% of respondents). Several large firms indicated that they are actively pursuing more solar capacity. Recycled energy systems may present an untapped opportunity for Colorado industrial firms. Eight respondent companies representing 6 different industries were identified as having a steady heat source greater than 300°F or that they have deployed CHP or waste heat recovery technology.

The survey also asked respondents to identify the factors that acted as barriers to their investments in EE or DG projects. Additionally, follow-up interviews with the survey respondents shed light on the unique challenges, approaches, resources, and motivators pertaining to energy related investments at each firm. Some of the most commonly cited factors that can hinder or enable EE and DG investments include:

- Staff and Funding Resources: There is only so much a firm can do with available staff and funding. While larger firms may have dedicated energy management staff and budgets, they still must prioritize projects and funding can vary annually. Smaller firms are often constrained due to a lack of dedicated staff or funding for energy projects. For all firms, there is often competition for funding to expand production or invest in other parts of the business.
- Performance Verification: Most of the larger firms have established processes to monitor energy performance and the measure energy savings of investments. This validation enables energy managers to justify EE and DG investments to corporate leadership and encourage additional investments. Smaller firms often struggle to track their energy consumption therefore have less insight into the performance of any EE and DG projects.
- Goals: Firms with energy or sustainability related goals and clear performance metrics are significantly more likely to realize energy savings than those that do not. Establishing an energy goal and committing to it helps provide direction for the use of available resources and requires staff to verify progress towards achieving the goal. The attention paid to by sheds light on energy-related cost savings and improved process efficiency, thus encouraging additional investments.

There are numerous support programs, rebates, tax incentives, and financial mechanisms available that can help industrial firms overcome their limitations to enable viable EE and DG investments. This report identifies 5 local, 3 statewide, and 5 federal technical support programs available to industrial firms in Colorado. These programs range from informational resources to those that offer funding, free audits, or connections to financing. The two investor owned utilities in Colorado offer a combined 8 rebate and incentive programs for EE and DG and the majority of rural electric coops offer some form of EE rebate. There are 7 relevant tax incentives available to Colorado industrial firms to support EE or DG investments. Lastly, there are several traditional and specialty financing mechanisms available that can enhance a firm's access to capital. These funding approaches have different attributes and can be designed to enable a positive cash flow from day 1 at no up-front cost to the firm.

While the aforementioned resources and information is useful to industrial firms, it is still a lot of information to sift through. As has already been pointed out, dedicated staff for energy projects is a luxury for industrial firms and many of the support resources and strategies may be difficult to access without prior experience. CEO should remain mindful of the available resources, prior experiences, and motivations of the firms they are attempting to work with. An industrial engagement program needs to be flexible and designed to enable participating industrial firms to learn and adopt energy management practices and EE/DG investment strategies as an essential part of their day-to-day operations. In particular there are four key requirements that industrial firms should strive towards to have successful energy initiatives at their firms. CEO could help industrial firms to achieve these requirements.

- **Requirement 1: Corporate Commitment**
  Without commitment and direction from senior management, energy projects are often ignored or considered secondary to other priorities.
- **Requirement 2: "Boots on the Ground"**
  An energy champion is needed to actively measuring process performance, identify savings opportunities, and generally push projects through the myriad stages before, during, and after implementation.
- **Requirement 3: Efficient Processing Systems**
  An organization needs efficient processes and clear investment criteria to ensure that EE and DG projects can overcome internal bureaucracy or indecisiveness.
- **Requirement 4: Access to Information Resources**
  While simply publishing a list of available resources may not increase EE/DG investment on its own, committed industrial firms need up-to-date and accurate information available to support their personnel and inform their decision-making.

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1 | Introduction

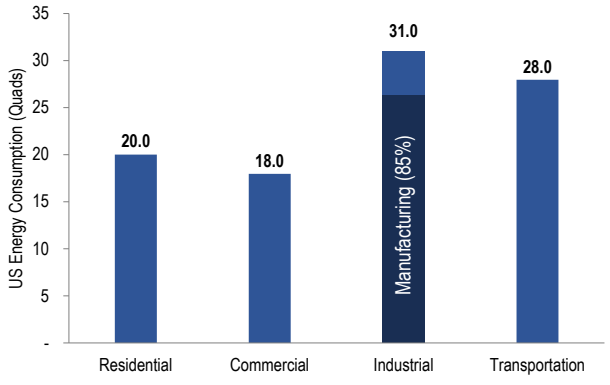
The industrial sector accounted for nearly 1/3rd of US energy consumption in 2016. Compared with the residential, commercial, and transportation sectors, the industrial sector is the largest energy-consuming sector in the US at 31.0 quadrillion Btu (quads) in 2016 (shown in Figure 1-1). Manufacturing accounts for approximately 85% of industrial energy use and the most energy-intensive manufacturing sectors—including food, paper, bulk chemicals, glass, cement, iron and steel, and aluminum products—account for more than 60% of industrial energy use alone. Additionally, non-manufacturing industries such as agriculture, construction, mining, oil and gas extraction, and wastewater treatment account for more than 18% of industrial energy.[1]

Depending on the industry and related processes, these sectors consume significant amounts of electricity and fossil fuels. The 3.2 quads of industrial electricity consumption accounted for than 25% of total industrial energy demand in 2016. Additionally, the industrial sector is the largest consumer of natural gas in the US at 7.9 quads in 2016, which accounted for more than 48% of US natural gas consumption. The industrial sector uses natural gas as a feedstock in many chemical manufacturing processes and more broadly for heat and power at industrial facilities.[2]

The energy demands of the industrial sector also results in significant carbon dioxide (CO_2) emissions. In 2016, the industrial sector produced 1,436 million metric tons of CO_2, accounting for nearly 21% of all US emissions. As shown in Figure 1-2, the majority of energy-related CO_2 emissions are attributed to natural gas (34%) and electricity (32%).

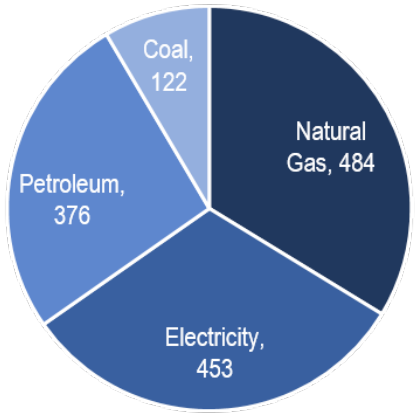
The significant energy demands of the industrial sector come with considerable economic and environmental costs. Industrial firms can pursue various opportunities to reduce energy consumption at their facilities and manufacturing plants including: conducting energy assessments to identify energy efficiency (EE) opportunities; implementing energy management systems and adhering to energy related best practices; adopting energy standards that provide a framework for managing and improving energy performance; deploying EE technologies; and generating energy on-site. Additionally, there are numerous support programs, rebates, tax incentives, and financial mechanisms available that can enhance the value proposition of energy focused projects. However, industrial firms do not always take advantage of these opportunities despite advancements in EE technologies and reduced costs of distributed energy generation (DG).

FIGURE 1-1. 2016 US ENERGY USE BY SECTOR



Data from AEO 2017, Table 2

FIGURE 1-2. 2016 US INDUSTRIAL SECTOR, ENERGY-RELATED CARBON DIOXIDE EMISSIONS BY SOURCE



Data from AEO 2017, Table 18

1 "Annual Energy Outlook 2017" US Energy Information Administration. January 5, 2017. Available from, eia.gov/outlooks/aeo/

2 "Table 2: Energy Consumption by Sector and Source" Annual Energy Outlook 2017. US Energy Information Administration. January 5, 2017. Available from, eia.gov/outlooks/aeo/

There is significant opportunity in the US to reduce industrial energy consumption by enhancing efficiency measures and taking advantage of distributed resources. For this report, the Colorado Energy Office (CEO) contracted Energetics Incorporated to identify opportunities to encourage EE and DG in Colorado's industrial sectors.

To provide a comprehensive analysis of these opportunities, Chapter 2 begins by estimating the energy consumption and economic impacts of Colorado's industrial sectors, with a particular focus on manufacturing. Chapter 2 estimates the total energy consumption and electricity demand of major industries in the state on both a cost and energy basis and shows, the energy footprint of the major industries geospatially across Colorado counties.

Chapter 3 explores the DG potential for Colorado Renewable Energy Standard (RES) eligible resources.[3] The Chapter discusses on-site deployment opportunities, off-site procurement opportunities, industrial applicability of the resource, and a high-level assessment of the resource availability across Colorado. The RES eligible resource availability can be compared to the distribution of industrial activity to help identify where DG investments may be able to make the largest impact for industrial firms in the state.

Chapter 4 describes findings from an outreach survey and follow-up interviews with industrial firms in Colorado. These efforts assess industrial firm attitudes towards EE and DG, current EE and DG actions by industrial firms, and analyzes barriers to investments in DG and EE. The survey and interviews were also used as an opportunity to educate Colorado industrial firms on available programs, incentives, and financing options for industrial DG and EE.

Lastly, Chapter 5 presents opportunities to encourage industrial investments in EE and DG. The Chapter describes various support resources, incentives, and financing options that are available to industrial firms and provides strategies for industrial firms to take advantage of these resources. Additionally, Chapter 5 offers guidelines and best practices for CEO to develop an energy efficiency program that could encourage additional DG and EE investment by industrial firms in the state.

Report Structure

2 | Energy Use and Economic Impacts of Colorado Industrial Sectors

3 | Colorado Renewable Resource Potential for Industrial Applications

4 | Industrial Efforts in Energy Efficiency and Distributed Generation

5 | Opportunities to Encourage Industrial Investments in Energy Efficiency and Distributed Generation

3 Colorado Energy Office, Renewable Energy Standard Overview. Available from, *colorado.gov/pacific/energyoffice/renewable-energy-standard*

2.1 | Major Industrial Sectors in Colorado

This report identifies major industrial sectors in Colorado, shown in the adjacent call out box. Each of these industrial sectors are defined based on the North American Industry Classification System (NAICS), an industry-accepted system developed by the US Census Bureau in 1997. NAICS sectors are defined by two- to six-digit codes (e.g. NAICS 311 for food manufacturing).

Several sources, listed in Table 2-1 were used to identify major industries in Colorado based on their energy consumption and economic impacts. The US Energy Information Administration (EIA) Annual Energy Outlook (AEO) identifies energy intensive manufacturing and non-manufacturing industries by NAICS code. The AEO also provides high-level energy and economic statistics on these sectors.

The Manufacturing Energy Consumption Survey (MECS) provides greater detail than the AEO including in-depth energy usage statistics by NAICS code and energy consumption ratios pertaining to employee and shipment values by industry sector. The MECS data allowed us to estimate a relationship between electricity consumption and total energy consumption by industry sector. The MECS data is granular to a regional level, so the energy consumption ratios were applied to Colorado industrial economic statistics to obtain state-level estimates.

NAICS Codes and Industry Descriptions of CO Major Industrial Sectors

311	Food Processing
312	Beverage and Tobacco Products
321	Wood Products
322	Paper Products
324	Petroleum and Coal Products
325	Chemicals
326	Plastics and Rubber Products
327	Nonmetallic Mineral Products
331	Primary Metals
332	Fabricated Metal Products
333	Machinery
334	Computer and Electronic Products
336	Transportation Equipment
2111	Petroleum and Natural Gas Extraction
2121	Coal mining
2122	Other Metallic Mining
2123	Non-Metallic Mining
2213	Sewage Treatment Facilities

TABLE 2-1. SOURCES USED TO IDENTIFY ENERGY AND ECONOMIC STATISTICS IN COLORADO

Source	Use	Notes
Annual Energy Outlook (2011-2017)	AEO Identifies energy intensive manufacturing and non-manufacturing industries by NAICS code Also provides energy prices by sector. *Available from:* eia.gov/outlooks/aeo/assumptions/pdf/industrial.pdf and eia.gov/outlooks/archive/aeo16/tables_ref.cfm	Table 3.8: Energy prices by sector (Mountain region) Table 6.1: Industry categories and NAICS codes Tables 26-35: Energy Use Tables by NAICS code
MECS Conversion Factors (2010)	Ratios for energy consumption per employee and per dollar of value of shipments *Available from:* eia.gov/consumption/manufacturing/data/2010/pdf/Table6_1.pdf	Table 6.1: Energy consumption ratios by manufacturing industry. (Western Region Data)
MECS Energy/Electricity Consumption Data by Industry (2010)	% electricity demand of total energy by industry *Available from:* eia.gov/consumption/manufacturing/data/2010/	Tables 1.1, 1.2, 11.1, and 11.3
Annual Survey of Manufacturers (2008-2014)	Total value of shipments and receipts for services *Available from:* factfinder.census.gov	Searched by NAICS code, specified CO, yrs '08-'14
County Business Patterns Surveys (2008-2014)	Number of establishments; Number of paid employees; First-quarter payroll; Annual payroll *Available from:* factfinder.census.gov	Searched by NAICS code, specified CO, yrs '08-'14

The energy consumption values estimated in this report are averages of energy consumption based on economic trends in employment and production outputs as well as various energy conversion factors. They should not be misconstrued to estimate total energy consumption for any particular plant or production unit within any industry considered in this analysis. Energy consumption within an industry can vary for myriad reasons including total production output and the type of equipment used. The estimates discussed in this section are intended as high-level estimates only.

2.2 | Overview of Economic and Energy Statistics by Colorado Industries

The Annual Survey of Manufacturers (ASM) and the County Business Patterns survey (CBP) provide Colorado specific employment and values of shipments by industry sector up to 2014. Table 2-2 shows the MECS energy conversion factors, the total number of employees and total dollar value of shipments obtained from the AMS and CBP surveys, and the estimated total energy consumption based on those factors for major industrial sectors in Colorado. The estimated total energy consumption by sector in Colorado uses the

TABLE 2-2. ESTIMATED 2014 TOTAL ENERGY CONSUMPTION FOR SELECT CO INDUSTRIES

Sector	NAICS	Total Colorado Employees (2014) *AMS and CBP*	Consumption per employee (MM Btu) *MECS*	Colorado 2014 Dollar Value of Shipments (thousand) *AMS and CBP*	Consumption per Dollar of Value of Shipments (thousand Btu) *MECS*	**Estimated 2014 Total CO Energy Consumption (TBtu)** *Calculated*
Petroleum and Coal Products	324	913	37,173.2	$4,940,975	6.0	**33.9**
Food Processing	311	19,703	878.9	$11,689,766	1.9	**17.3**
Nonmetallic Mineral Products	327	6,340	1,699.8	$2,088,090	6.7	**10.8**
Chemicals	325	6,560	1,268.2	$5,554,011	1.7	**8.3**
Paper Products	322	1,188	5,040.3	$415,639	10.8	**6.0**
Primary Metals	331	2,055	2,555.5	$1,318,761	3.6	**5.3**
Wood Products	321	3,141	1,196.6	$780,936	5.1	**3.8**
Beverage and Tobacco Products	312	4,816	435.0	$4,479,223	0.6	**2.1**
Computer and Electronic Products	334	12,996	183.9	$4,717,293	0.4	**2.4**
Fabricated Metal Products	332	13,907	143.9	$3,720,419	0.6	**2.0**
Plastics and Rubber Products	326	5,517	246.0	$1,241,305	1.2	**1.4**
Transportation Equipment	336	9,626	137.4	$2,630,236	0.3	**1.3**
Machinery	333	11,265	80.4	$3,820,040	0.2	**0.9**
Oil and Gas Extraction	2111	8,709	n/a	n/a	n/a	**n/a**
Coal Mining	2121	1,993	n/a	n/a	n/a	**n/a**
Other Metallic Mining	2122	1,778	n/a	n/a	n/a	**n/a**
Non-Metallic Mining	2123	1,226	n/a	n/a	n/a	**n/a**
Water and Sewage Systems	2213	569	n/a	n/a	n/a	**n/a**

average total energy estimate based each of the conversion factors. Energy consumption values are estimates based on the best available data (i.e., the MECS 2010 conversion factors and AMS/CBP economic statistics through 2014) and are only available for the manufacturing sectors. The identified industries represent 98.5% of estimated 2014 total manufacturing energy consumption in Colorado (based on NAICS codes 31-33).

Considering one of the focal points of this report is to identify industries with the opportunity to deploy Colorado Renewable Energy Standard (RES) eligible electricity generating technologies, it is important to understand the electricity demands of each sector. The MECS energy consumption data provides sufficient granularity to develop a ratio of electricity demand vs total energy consumption for each manufacturing sector. Table 2-3 shows the % electricity demand out of total energy consumption within a given manufacturing sector These percentages can be applied to the total energy values calculated in Table 2-2 to obtain estimates for 2014 electricity demand in Colorado by industry. The identified industries represent 95.9% of estimated 2014 manufacturing electricity demand in Colorado (based on NAICS codes 31-33).

2.2.1 | Aggregate Energy and Electricity Trends and Associated Economic Activity

Total energy consumption and electricity demand in Colorado was evaluated from 2008 to 2014 by industry sector using the methodology described in Table 2-2 and Table 2-3. As mentioned earlier, MECS only provides information for the manufacturing sector (NAICS 31-33), so energy consumption by non-manufacturing sectors are excluded from the energy estimates.

Figure 2-1 compares total energy consumption (TBtu) and total electricity demand (million kWh) for the select manufacturing sectors in Colorado from 2008 to 2014. As can be seen there is about a 14% decline in both total energy consumption and electricity demand from 2008 to 2010, likely related to the Great Recession. Energy and electricity usage rebound by about 10% by the end of 2012, faces a slight dip in 2013, and then continues on an upward trajectory in 2014 towards pre-recession levels.

TABLE 2-3. ESTIMATED 2014 ELECTRICITY DEMAND FOR SELECT CO MANUFACTURING SECTORS

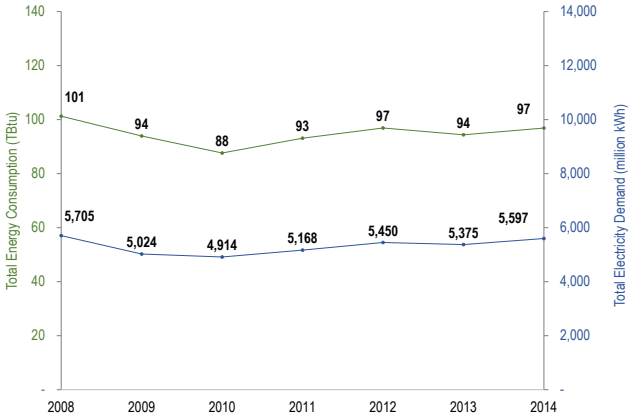
Sector	NAICS	Estimated 2014 Total CO Energy Consumption (TBtu) *Calculated (Table 2-2)*	% electricity demand of total energy *Calculated from MECS*	**Estimated 2014 CO Electricity Demand (million kWh)** *Calculated*
Petroleum and Coal Products	324	33.9	4.34%	**404**
Food Processing	311	17.3	20.49%	**1,188**
Nonmetallic Mineral Products	327	10.8	15.58%	**566**
Chemicals	325	8.3	24.29%	**633**
Paper Products	322	6.0	24.19%	**372**
Primary Metals	331	5.3	45.49%	**667**
Wood Products	321	3.8	15.61%	**177**
Beverage and Tobacco Products	312	2.1	40.70%	**285**
Computer and Electronic Products	334	2.4	63.68%	**399**
Fabricated Metal Products	332	2.0	44.22%	**275**
Plastics and Rubber Products	326	1.4	74.36%	**310**
Transportation Equipment	336	1.3	50.69%	**157**
Machinery	333	0.9	66.67%	**163**

The upward trajectory shown in Figure 2-1 is a good sign for Colorado manufacturing because the energy estimates are directly correlated to the number of employees and the value of shipments in a given industrial sector. EE and DG investments can also enable industrial firms to continue economic growth while reducing associated energy consumption and costs.

Figure 2-2 shows the thousands of employees in select manufacturing and non-manufacturing sectors in Colorado from 2008 to 2014. Transportation equipment (NAICS 336) is not included with the manufacturing sector total because of a lack of data from 2009 to 2011. Likewise, other-metallic mining (NAICS 2122) is not included with the non-manufacturing total. The energy trends and economic trends identified in this report are highly correlated because of the estimation methodology's dependence on energy consumption ratios pertaining to the number of employees and value of shipments of an industry sector.

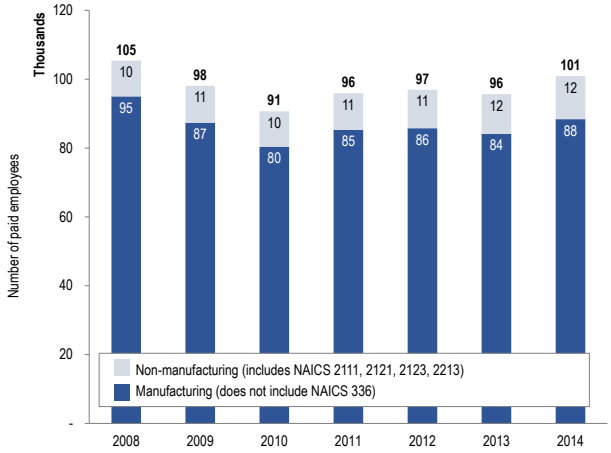
Figure 2-3 compares the total number of manufacturing and non-manufacturing industrial establishments and shows the total adjusted value (billion 2010 dollars) of shipments and receipts for services from the manufacturing sectors in Colorado. Petroleum and coal products (NAICS 324) is not include in Figure 2-3 because of missing data from 2008 through 2013. The total value of shipments and receipts rebounds more quickly than did the number of employees and the number of establishments after the 2008 to 2009 decline. Additionally, both the number of establishments and the total value of shipments and receipts for services have been on an upward trajectory in recent years.

FIGURE 2-1. ESTIMATED ENERGY CONSUMPTION AND ELECTRICITY DEMAND FOR SELECT CO MANUFACTURING SECTORS (2008 TO 20014)



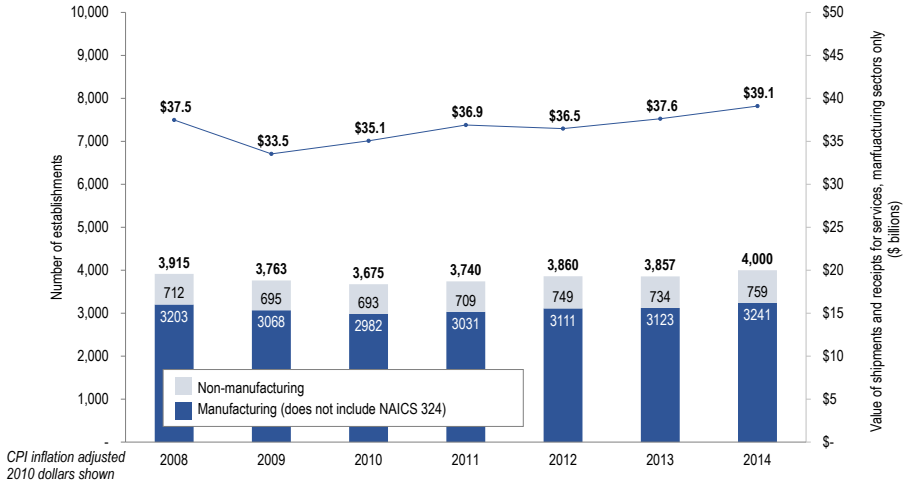
NAICS sectors: 311, 312, 321, 322, 324, 325, 326, 327, 331, 332, 333, 334, 336)

FIGURE 2-2. THOUSAND EMPLOYEES FOR SELECT CO INDUSTRIAL SECTORS (2008 TO 2014)



Manufacturing: 311, 312, 321, 322, 324, 325, 326, 327, 331, 332, 333, 334
Non-manufacturing: 2111, 2121, 2123, 2213

FIGURE 2-3. TOTAL NUMBER OF ESTABLISHMENTS AND VALUE OF SHIPMENTS AND RECEIPTS FOR SERVICES (ADJUSTED TO 2010 DOLLARS) FOR SELECT CO INDUSTRIES (2008 TO 2014)



Manufacturing: 311, 312, 321, 322, 325, 326, 327, 331, 332, 333, 334, 336
*2012 number of establishments data not available for sectors 321 and 322
Non-manufacturing: 2111, 2121, 2122, 2123, 2213 (Number of establishments data only)

2.2.2 | Top 5 Sectors by Total Energy

Figures 2-4 through 2-7 compare energy and economic statsitics for the top 5 most energy intensive manufacturing sectors based on 2014 values from Table 2-2. The top 5 sectors for total energy consumption are: 1) Petroleum and Coal Products – 324; 2) Food Products – 311; 3) Nonmetallic Mineral Products – 327; 4) Chemicals – 325; and 5) Paper Products – 322. The figures also provide an average of the remaining 8 manufacturing sectors for comparison.

The five sectors listed above are estimated to have accounted for approximately 80% of CO manufacturing energy consumption in 2014. Petroleum and coal products alone accounted for more than 30% of energy consumption, despite having fewer employees and establishments than the other major manufacturing sectors in CO. Food products has the second highest total estimated energy consumption (approximately 20%) and has double the number of employees and double the value of shipments and services (shown in 2010 dollars) than the next CO manufacturing sector.

Although each facility's suitability for EE and DG investments will vary on a case-by-case basis, the four figures help to demonstrate the multiple variables that must be considered when seeking to encourage EE and DG investments by specific industries. Industries with high energy consumption, but a comparatively low value of shipments and services may not be able to afford the up-front costs of energy related investments. Additionally, total energy consumption can also be compared to the number of establishments in CO to help identify where EE and DG investments may make the largest impact on a per facility basis.

FIGURE 2-4. TOP 5 CO MANUFACTURING SECTORS BY ESTIMATED TOTAL ENERGY CONSUMPTION (2008 TO 2014)

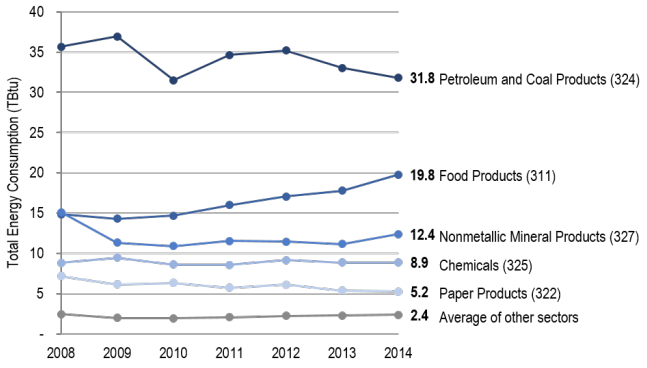


FIGURE 2-5. EMPLOYMENT TRENDS, TOP 5 CO ENERGY CONSUMING MANUFACTURING SECTORS (2008 TO 2014)

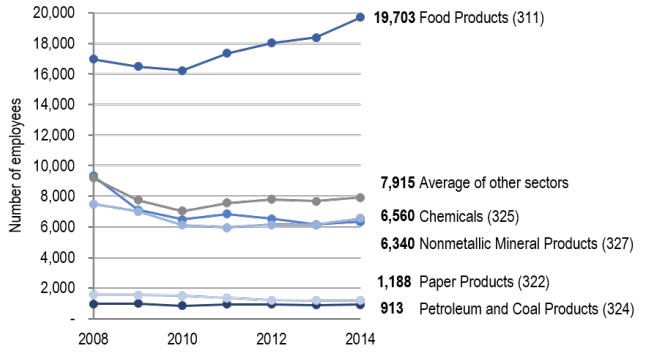


FIGURE 2-6. MMBTU PER ESTABLISHMENT, TOP 5 CO ENERGY CONSUMING MANUFACTURING SECTORS (2008 TO 20014)

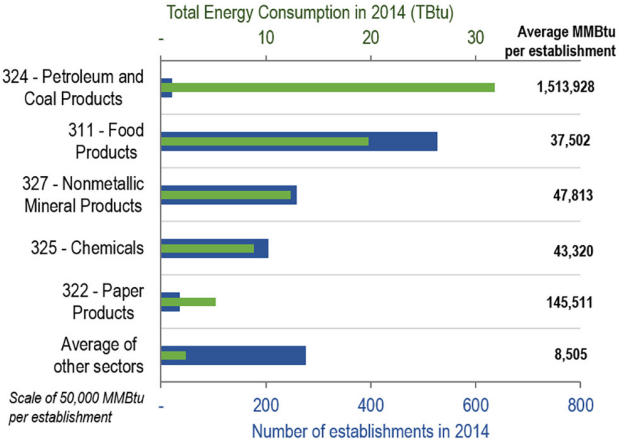
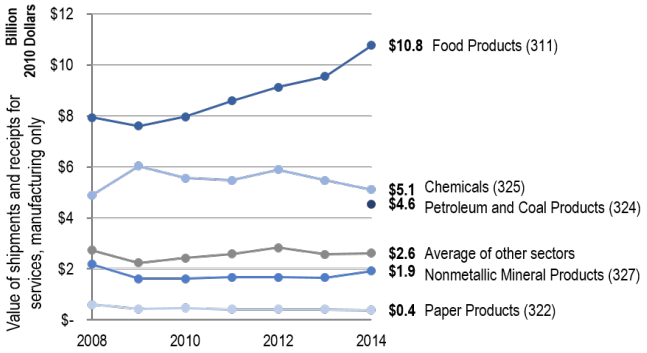


FIGURE 2-7. VALUE OF SHIPMENTS AND SERVICES, TOP 5 CO ENERGY CONSUMING MANUFACTURING SECTORS (2008 TO 2014)



2.2.3 | Top 5 Sectors by Electricity Demand

Figures 2-8 through 2-11 compare energy and economic statsitics for the top 5 manufacturing sectors by electricity demand based on 2014 values from Table 2-3. The top 5 sectors for electricity demand are: 1) Food Products – 311; 2) Primary Metals – 331; 3) Chemicals – 325; 4) Nonmetallic Mineral Products – 327; and 5) Petroleum and Coal Products – 324. The figures also provide an average of the remaining 8 manufacturing sectors for comparison.

Four of the five sectors listed above are also top 5 energy consumers (other than primary metals, which replaced paper products). The five sectors are estimated to have accounted for approximately 62% of CO manufacturing electricity demand in 2014. Food products accounted for more than 21% of electricity demand, nearly double that of the next closest major manufacturing sector in CO. The food products sector has also shown considerable growth between 2008 and 2014 while the other major sectors have remained largely stagnant.

Similar to the statement in the Top 5 Sectors by Total Energy section, each facility's suitability for EE and DG investments will vary on a case-by-case basis and it is important to be cognizant of the multiple variables that can influence EE and DG investment decision making for specific industries. Larger facilities, regardless of industry, may be able to dedicate more resources to EE and DG investments and can make a larger impact on a per facility basis. Smaller facilities in high electricity demand industries may be very interested in EE and DG investments, but require technical support or innovative third-party financing mechanisms to realize energy related improvements.

FIGURE 2-8. TOP 5 CO MANUFACTURING SECTORS BY ESTIMATED ELECTRICITY DEMAND (2008 TO 2014)

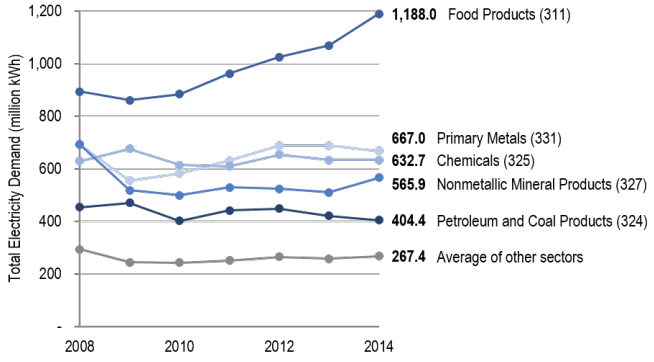


FIGURE 2-9. EMPLOYMENT TRENDS, TOP 5 CO MANUFACTURING SECTORS BY ELECTRICITY DEMAND (2008 TO 2014)

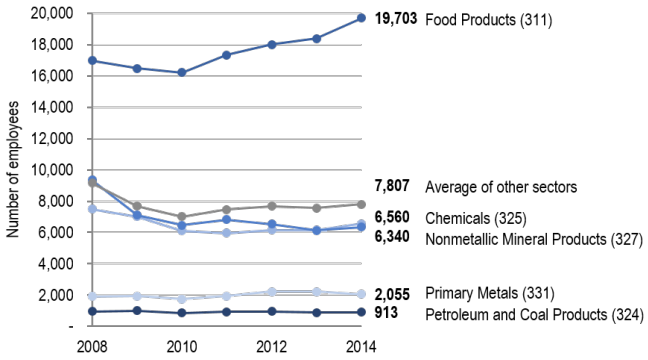


FIGURE 2-10. MILLION KWH PER ESTABLISHMENT, TOP 5 CO MANUFACTURING SECTORS BY ELECTRICITY DEMAND (2008 TO 2014)

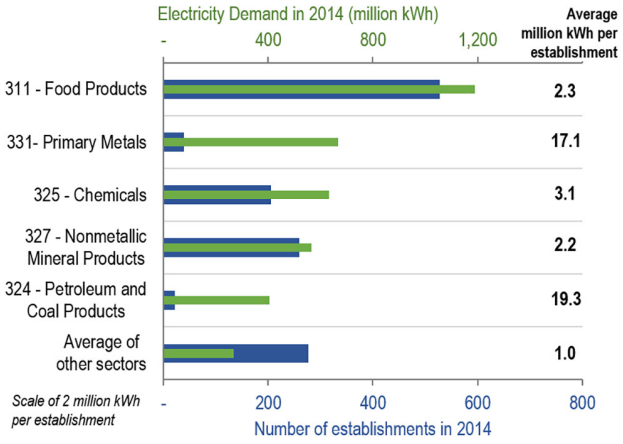
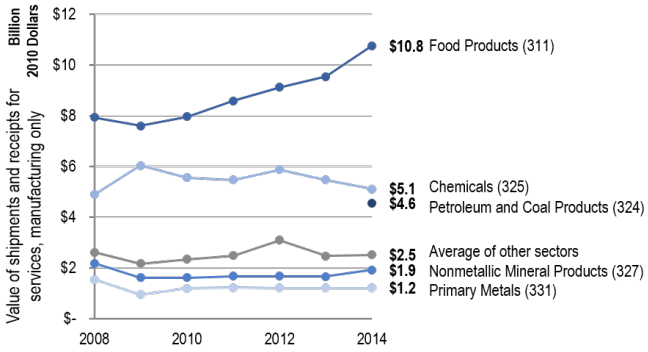


FIGURE 2-11. VALUE OF SHIPMENTS AND SERVICES, TOP 5 CO MANUFACTURING SECTORS BY ELECTRICITY DEMAND (2008 TO 2014)



2.3 | Cost of Industrial Energy

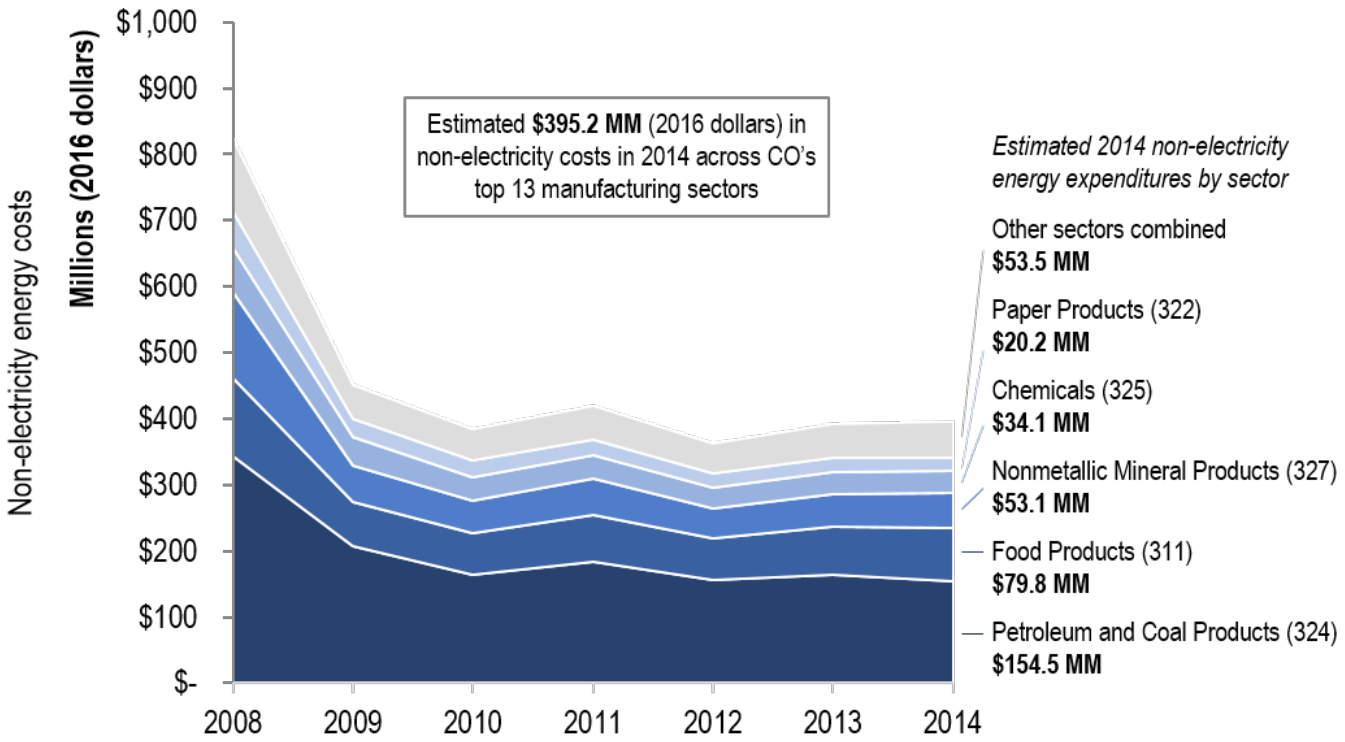
It is also useful to consider cost when assessing the energy and electricity demands of Colorado's industrial sectors. Table 3-8 of the EIA Annual Energy Outlook (AEO) provides energy price data for the industrial sector over time by region.[4] As a simplifying assumption, we assume that all non-electricity energy demands discussed throughout this chapter can be represented by natural gas. Table 2-4 presents the relevant price assumptions for natural gas and electricity obtained from the various editions of the AEO, adjusted from nominal dollars to 2016 $/MMBtu.[5]

To obtain estimates for non-electricity energy consumption we simply deduct electricity demand from the total energy consumption estimates discussed throughout this chapter. Figure 2-12 applies natural gas prices to the non-electricity estimates from 2008 to 2014. The figure separates non-electricity costs for the top 5 most energy intensive manufacturing sectors and provides an aggregate estimate for the remaining eight sectors. As can be seen, a sharp decline in natural gas prices in 2008 significantly lowered non-electricity energy costs and has kept them at comparatively low levels.

TABLE 2-4. NATURAL GAS AND ELECTRICITY PRICE DATA FOR INDUSTRY (2008 TO 2016 IN 2016 $)

2008 to 2016 Energy Price Data for Industry (2016 $) (based on EIA Annual Energy Outlooks 2011, 2015, and 2016)										
Energy Type	**Units**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Natural gas	2016 $/MMBtu	10.057	5.864	5.415	5.555	4.639	5.166	5.079	4.638	4.594
Electricity	2016 $/MMBtu	22.124	22.129	21.329	20.495	19.009	19.729	18.147	18.450	18.360

FIGURE 2-12. ESTIMATED NON-ELECTRICITY ENERGY COSTS FOR CO MANUFACTURING ('08 TO '14)

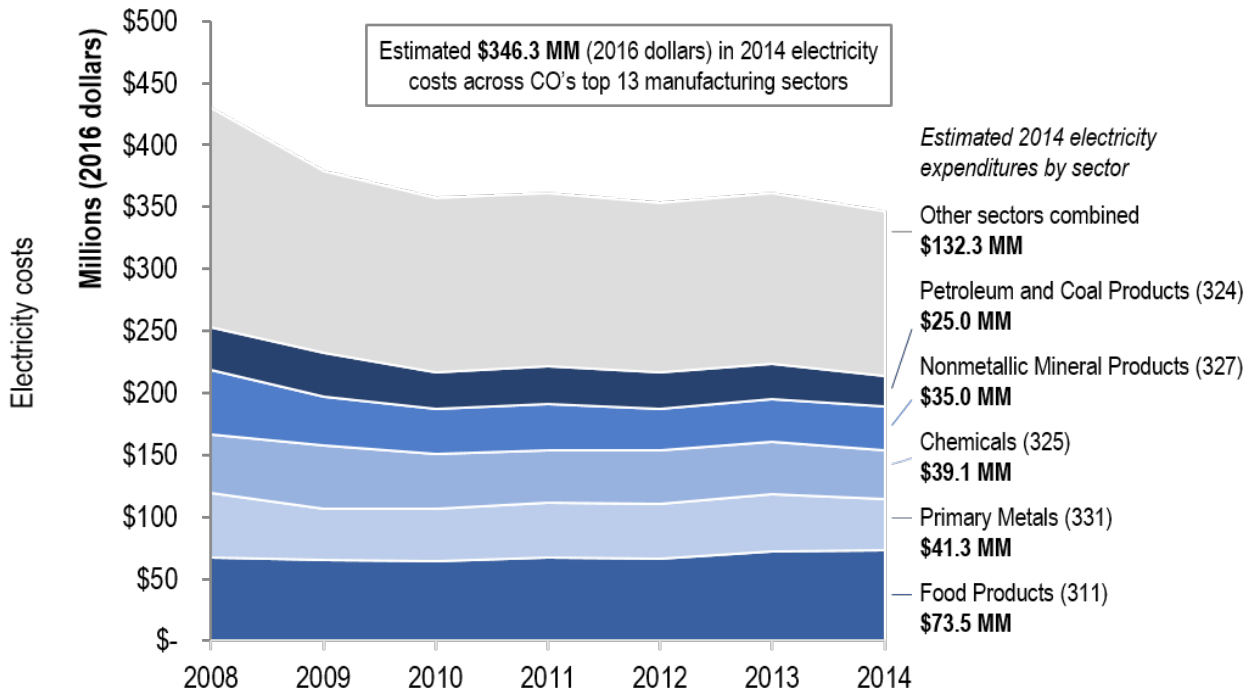


Top 13 manufacturing sectors only, from Table 2-2
Assumes all non-electricity energy is natural gas, applies 2016 $/MMBtu from Table 2-4

4 US EIA Annual Energy Outlook Archive of Products since 1979. Available from, eia.gov/outlooks/aeo/archive.cfm

5 Consumer Price Index adjustment from nominal dollars to 2016 dollars based on The Kiplinger Letter using US Bureau of Labor Statistics Data. Available from, kiplinger.com/web_docs/cpi/cpichart.pdf

FIGURE 2-13. ESTIMATED ELECTRICITY COSTS FOR CO MANUFACTURING ('08 TO '14)



Top 13 manufacturing sectors only, from Table 2-3
Applies 2016 $/MMBtu (electricity) from Table 2-4

Despite more than four times the demand of electricity on an MMBtu basis, non-electricity energy costs are estimated at $359.2 MM compared to $346.3 MM in electricity costs in 2014, as shown in Figure 2-13. There is a clear opportunity for industrial firms to lower costs by reducing their energy and electricity requirements. In particular, industries with high electricity requirements may be more willing to make EE and DG investments to avoid the relatively higher energy costs of electricity compared to natural gas.

2.4 | CO Distribution of Industrial Activity

The adjacent call out box lists the most energy-intensive manufacturing sub-sectors as identified in Table 6.1 of the AEO.[6] As described in Sections 2.2.2 and 2.2.3, the 3-digit NAICS sectors for these industries have the highest energy and electricity demands in Colorado. The MECS energy conversion factors and approach described in Section 2.2 can be applied to county specific economic statistics from the ASM and the CBP surveys to map the distribution of industrial activity in Colorado. In some cases, the ASM and CBP surveys withhold information to protect company confidentiality, such as if there are a limited number of employers in an area that operate in a specific industry. These withholdings are infrequent, especially for the prominent industrial sectors. This approach provides the best available information and offers a high-level estimation of industrial activity across Colorado.

Figure 2-14 and Figure 2-15 estimate the distribution of the cumulative energy and electricity demands for the major manufacturing sectors and sub-sectors across Colorado. The identified manufacturing sectors represent more than 80% of estimated energy consumption and more than 60% of estimated electricity demand in Colorado in 2014 (based on NAICS codes 31-33). As shown in the figures, industrial activity is fairly concentrated into a few areas of the state.

Additionally, Table 2-5 lists the top 15 counties in Colorado by estimated total energy consumption, electricity demand, and various economic statistics. These top 15 counties account for 96% of total energy consumption and 95% electricity demand for the select manufacturing sectors identified in Colorado. The top 6 counties alone—Adams, Boulder, Pueblo, Denver, Freemont, and Weld—account for 75% of estimated energy consumption for the selected manufacturing sectors. While the majority of industrial activity is concentrated in the northern and central parts of the state, the western counties of Mesa, Delta, and Montrose also show some industrial activity.

NAICS Codes and Subsectors of Major Energy and Electricity Consumers in CO

Food Processing	311
Paper Products	322
Petroleum Refining	32411
Bulk Chemicals	325
Glass and Glass Products	3272, 327993
Cement and Lime	32731, 32741
Iron and Steel	3311, 3312
Aluminum	3313

6 Table 6.1. Annual Energy Outlook. US EIA. Available from, eia.gov/outlooks/aeo/assumptions/pdf/industrial.pdf

FIGURE 2-14. DISTRIBUTION OF 2014 MANUFACTURING TOTAL ENERGY CONSUMPTION IN CO (SELECT NAICS CODES)

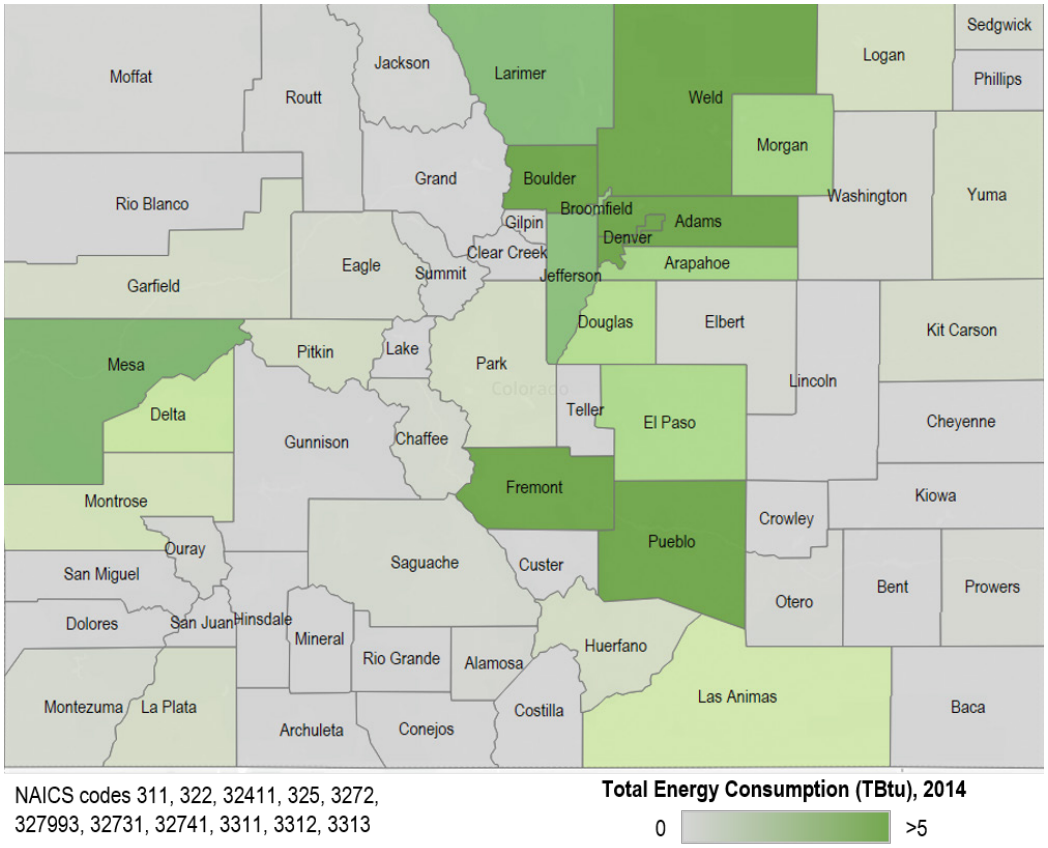


FIGURE 2-15. DISTRIBUTION OF 2014 MANUFACTURING ELECTRICITY DEMAND IN CO (SELECT NAICS CODES)

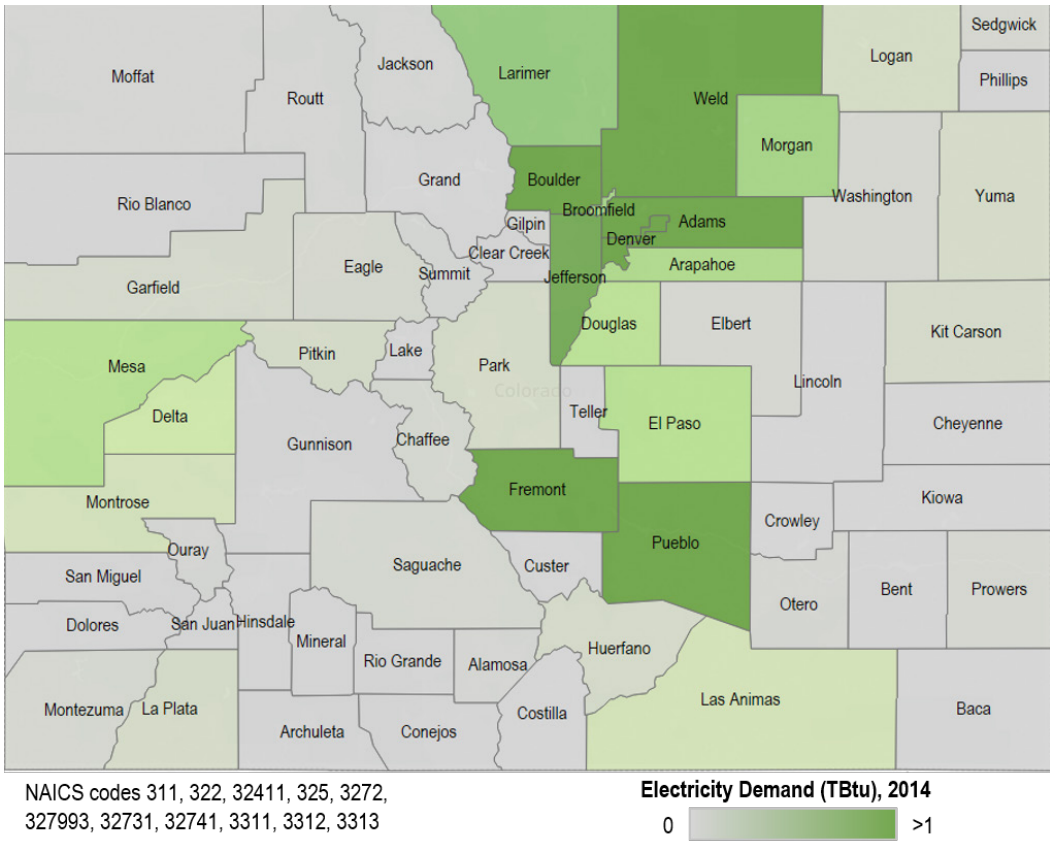


TABLE 2-5. TOP 15 COLORADO COUNTIES BY 2014 ESTIMATED ENERGY AND ECONOMIC STATISTICS

County	2014 Energy Estimates (Calculated using MECS conversion factors)		2014 Economic Estimates (AMS and CBP surveys)		
	Total Energy Consumption (TBtu)	*Net Electricity Demand (TBtu)*	*Value of shipments and services ($1,000)*	*Number of establishments*	*Paid employees*
Adams County	26.721	1.965	3.899	76	3,631
Boulder County	11.328	1.828	1.866	113	3,611
Pueblo County	10.852	1.678	0.989	18	1,337
Denver County	10.167	1.619	2.602	169	5,522
Fremont County	9.965	1.420	0.386	4	194
Weld County	7.760	1.838	2.421	47	6,283
Mesa County	4.018	0.277	0.543	21	375
Larimer County	3.525	0.560	0.507	50	1,101
Jefferson County	3.384	0.938	0.363	55	920
Broomfield County	2.621	0.421	0.356	7	759
Morgan County	2.171	0.435	1.088	14	2,576
Arapahoe County	2.026	0.341	0.463	59	1,031
El Paso County	1.734	0.274	0.357	54	1,128
Douglas County	1.455	0.239	0.250	14	549
Delta County	0.809	0.123	0.113	13	413
Other	3.506	0.594	0.862	112	2,031

NAICS codes 311, 322, 32411, 325, 3272, 327993, 32731, 32741, 3311, 3312, 3313

In 2004, Colorado passed the first voter-led Renewable Energy Standard (RES) in the nation, requiring electricity providers to obtain a minimum percentage of their power from renewable energy sources. The RES requires investor-owned utilities to generate 30%, and cooperative utilities to generate 20%, of their electricity from renewable energy by 2020.

The following sections discuss the RES eligible resources, their current and potential deployment in Colorado, and how they may be applicable for industrial firms to procure or deploy on-site.

3.1 | Anaerobic Digestion

Anaerobic digestion (AD) is a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen. One of the end products is biogas, which is combusted to generate electricity and heat, or processed into renewable natural gas and/or transportation fuel.

On-site deployment: Organic waste can be used as a feedstock for an anaerobic digester. Various industries produce suitable sources of organic material, such as those from wastewater treatment facilities, agricultural operations, and food processers.

US Wastewater treatment plants (WWTP) regularly use anaerobic digesters to break down sewage sludge and eliminate pathogens in wastewater. Often, biogas is captured from digesters and used to heat nearby facilities. Some municipalities have even begun to divert food waste from landfills to WWTPs; this relieves waste burdens placed on local landfills and allows for energy production.[7]

The food industry produces large volumes of solid and liquid wastes that have as much as 15 times the methane production potential that dairy cattle manure does. Anaerobic wastewater treatment has been demonstrated for most agro-food and beverage industries. Food waste substrates may also be combined with manure to improve methane generation in a process known as co-digestion.

Off-site procurement: An often-overlooked value component of digester projects is the "waste" heat generated as a process byproduct. This is akin to a CHP project scenario that is more often seen at large natural gas plants. Industrial firms located nearby operating AD systems could potentially purchase the waste heat from those systems.[8]

Industrial Generation: As of March 2017, the US EPA Livestock Anaerobic Digester Database listed one anaerobic digester in Colorado at Christensen Farms, with 2,285 metric tons of avoided CO_2 equivalent emissions per year and a population of 5,500 animals feeding the digester.[9] AgEnergy has constructed Heartland Biogas, a six-tank (10.2 million gallons) multi-substrate complete mix AD facility located in LaSalle, Colorado, however it is not currently operating.[10]

Colorado Renewable Energy Standard

30% Renewable Electricity by 2020 (IOUs)

- Anaerobic Digestion
- Coal Mine Methane
- Geothermal
- Hydropower
- Landfill Gas
- Recycled Energy
- Solar
- Wind
- Woody Biomass
- Pyrolysis

CEO RES Overview, *colorado.gov/pacific/energyoffice/renewable-energy-standard*

Colorado Anaerobic Digestion Overview

Operating Biogas Systems:	25
Potential Biogas Projects:	356

Primary Sources of Organic Waste for AD:

- Wastewater treatment facilities
- Food production/processing
- Animal feeding operations

CEO AD Overview, *colorado.gov/pacific/energyoffice/waste-energy*

7 Anaerobic Digesters. Available from *c2es.org/technology/factsheet/anaerobic-digesters*

8 Anaerobic Digestion Implementation Analysis. Available from *stateenergyoffice.wi.gov/docview.asp?docid=25255*

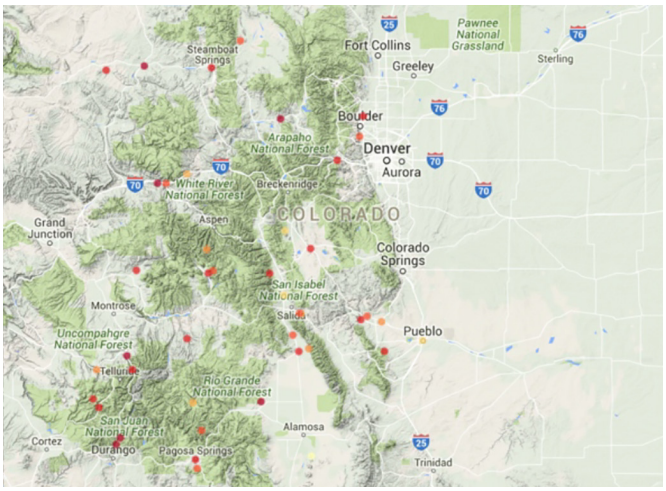
9 US EPA, Livestock Anaerobic Digester Database. Available from, *epa.gov/agstar/livestock-anaerobic-digester-database*

10 Colorado Market Assessment of Agricultural Anaerobic Digesters. Available from, *colorado.gov/pacific/energyoffice/atom/15101*

Colorado anaerobic digestion resources: Figure 3-1 shows operational wastewater and agricultural biogas systems in Colorado. Figure 3-2 shows the estimated methane generation potential for select biogas sources across the US. These images can be viewed at a larger scale by clicking the links in the figure captions. AD could be used at municipal wastewater systems across the state. Suitable agricultural resources are primarily identified in the north and northern eastern parts of the state, particularly in Weld and Morgan counties.

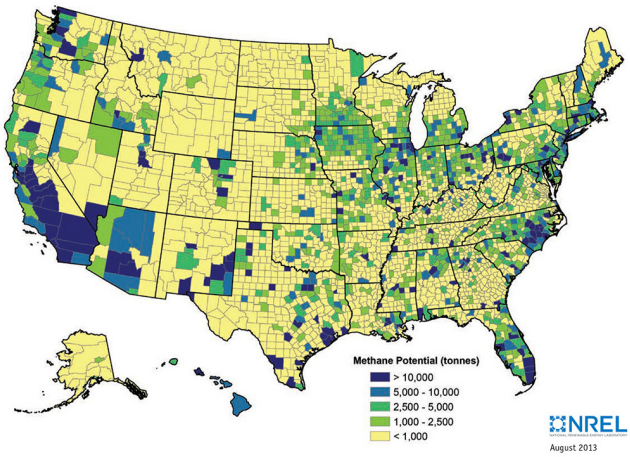
According to the American Biogas Council, Colorado ranks #34 among US states for methane production potential from biogas sources. Currently Colorado has 25 operational biogas systems and has the near-term potential for more than 356 projects (295 wastewater; 12 landfills; 12 food waste; and 37 agriculture) to be developed based on the estimated amount of available organic material.[11] Stewart Environmental, a consulting group, conducted a study for the Colorado Department of Agriculture that identified seven sites in Weld and Morgan counties suitable for regional anaerobic digesters (access to 5,000 dairy cows within a 2-mile radius).[12]

FIGURE 3-1. OPERATIONAL BIOGAS SYSTEMS IN COLORADO



Blue dots represent wastewater. Red show agriculture.
Full size image available from, *americanbiogascouncil.org/biogas_maps-19dec16.asp*

FIGURE 3-2. ESTIMATED METHANE GENERATION POTENTIAL FOR SELECT BIOGAS SOURCES



Note: figure includes potential biogas sources from wastewater, landfills, animal manure, and industrial, institutional, and commercial organic waste.
Full size image available from, *nrel.gov/docs/fy14osti/60178.pdf*

TABLE 3-1. ADDITIONAL ANAEROBIC DIGESTION RESOURCES

Source	Learn more at
Colorado Energy Office, Anaerobic Digestion	*colorado.gov/pacific/energyoffice/waste-energy*
American Biogas Council: Colorado State Profile	*americanbiogascouncil.org/State%20Profiles/ABCBiogasStateProfile_CO.pdf*
Colorado Market Assessment of Agricultural AD	*colorado.gov/pacific/energyoffice/atom/15101*
NREL: Biogas Potential in the US	*nrel.gov/docs/fy14osti/60178.pdf*
Biofuels and Bioproducts from Wet and Gaseous Waste Streams. US DOE, Bioenergy Technologies Office	*energy.gov/sites/prod/files/2017/02/f34/biofuels_and_bioproducts_from_wet_and_gaseous_waste_streams_full_report.pdf*

11 "Biogas State Profile: Colorado." American Biogas Council. Published August 7, 2015. Available from, *americanbiogascouncil.org/State%20Profiles/ABCBiogasStateProfile_CO.pdf*

12 Wolton, L. Lozo, S. "Colorado Market Assessment of Agricultural Anaerobic Digesters." Prepared for the Colorado Energy Office. University of Colorado, Boulder. Accessed March 23, 2017. Available from, *colorado.gov/pacific/energyoffice/atom/15101*

3.2 | Coal Mine Methane

Methane is a common byproduct of active and abandoned coal mines. In addition to coal mine methane (CMM), ventilation air methane (VAM) and abandoned mine methane (AMM) can also be extracted from active and abandoned coal sites. The methane, once safely extracted and treated, can be fed into gas generators to produce electric and thermal power. Infrastructural and energy efficiency projects can be undertaken by coal mining companies to produce electricity for their own consumption or for sale to the grid.[13]

On-site deployment: CMM can be used to generate power for on-site use or sale to local utilities. Most large underground coal mines have surface preparation plants and administrative and maintenance facilities, that may use coal mined on-site to provide energy for surface operations. CMM recovered from the mine can be used as a fuel source in addition to or as an alternative to coal.[14]

Off-site procurement: Industrial facilities could purchase recovered CMM. These facilities would require a continuous fuel supply to power operations such as fuel for cogeneration, to fire boilers or chillers, or for heating.

Industrial generation: The greatest barrier to using CMM at industrial facilities is proximity. The industrial facility must be located within 5 miles of an active, inactive, or abandoned coal mine with CMM recovery to be economical. As of 2015, only one 3MW CMM project has been developed in Colorado.

Colorado Coal Mine Methane Overview

Active underground coal mines:	5
Active surface coal mines:	4
Electric potential (MW)	**Feasible (Total)**
Coal Mine Methane	12 (23)
Ventilation Air Methane	10 (46)
Abandoned Mine Methane	12 (20)
Total	34 (89)

CEO CMM Overview, colorado.gov/pacific/energyoffice/methane-capture

Colorado CMM resources: The EIA reports that Colorado had 5 active underground and 4 active surface coal mines in 2015, which produced a combined 18,879 short tons of coal. The majority of underground mining activity occurs in Gunnison, Routt, and Rio Blanco and the largest surface mine is in Moffat.[15] A 2016 CMM report prepared for the CEO by Ruby Canyon Engineering, identified a total of 89 MW of electricity generating potential (46 MW from VAM, 23 MW from CMM, and 20 MW from AMM). Of that total, the analysis suggests 34 MW is technically feasible for development (10 MW from VAM, 12 MW from CMM, and 12 MW from AMM). 80% of this opportunity originates in the Somerset area.

Figure 3-3 lists the 5 active underground mines in Colorado and their estimated methane emissions as of 2011. The 5 mines could produce a combined 9,423 million cubic feet of methane annually.

FIGURE 3-3. METHANE FROM ACTIVE UNDERGROUND MINES IN CO

METHANE FROM ACTIVE UNDERGROUND MINES

Mine	Owner	Location (County)	Methane (CH4) *(million cubic feet per year)*	CO_2 equivalent *(metric tons per year)*
Foidel Creek	Peabody Twentymile Mining	Oak Creek (Routt)	46	18,517
Deserado	Blue Mountain Energy	Rangely (Rio Blanco)	53	21,296
Bowie No. 2	Bowie Resources	Paonia (Delta)	725	293,205
West Elk	Mountain Coal Company	Somerset (Gunnison)	2,747	1,110,757
Elk Creek	Oxbow Mining	Somerset (Gunnison)	5,852	2,366,742
TOTAL			9,423	3,810,518

Source: Updated data courtesy of Ron Collings, Ruby Canyon Engineering. Compiled for EPA for 2011.

Figure and supporting information available from, *vesselscoalgas.com/*

13 Converting coal mine methane into electric power. Accessed April 4, 2017. Available from, *miningreview.com/magazine_articles/in-depth-converting-coal-mine-methane-into-electric-power/*

14 Coal Mine Methane in Colorado Market Research Report. Accessed April 4, 2017. Available from, *colorado.gov/pacific/sites/default/files/atoms/files/Coal%20Mine%20Methane%20Report%202016.pdf*

15 "Table 2. Coal Production and Number of Mines by State, County, and Mine Type, 2015" US Energy Information Administration. Available from, *eia.gov/coal/annual/pdf/table2.pdf*

Figure 3-4 shows active and abandoned coal mines with methane recovery opportunities and Figure 3-5 shows surface and underground coal mines in Colorado. These images can be viewed at a larger scale by clicking the links in the figure captions.

The following abandoned coal mines have potential power generation capacity (see source for specific MW potential of each mine):[16]

1. Redstone Area mines
   (Dutch Creek #1, Dutch Creek #2, LS Wood, Coal Basin)

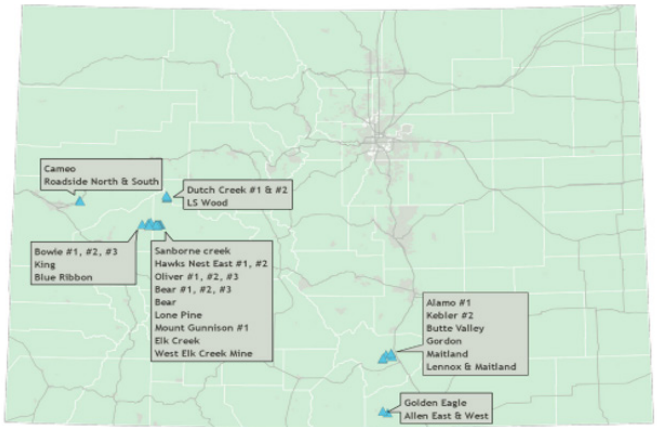
2. Somerset mines
   (Sanborn Creek Mine, Hawks Nest East, Somerset, Hawks Nest #1, Hawks Nest #3, Oliver #1 & 3, Oliver #2, Bear #1, 2, 3, Bowie #1, King, Blue Ribbon Coal, Bowie #3, Bear, Lone Pine, Mount Gunnison #1)

3. Trinidad mines
   (Golden Eagle, Allen-East and West Portals)

4. Book Cliff – Cameo mines
   (Cameo, Roadside No. & So. Portals)

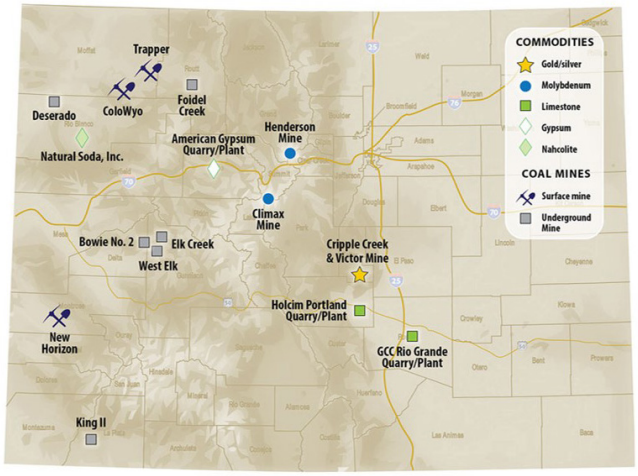
5. Walsenburg mines
   (Alamo No. 1, Gordon, Maitland #1, Kebler #2, Lennox and Maitland, Butte Valley)

FIGURE 3-4. COLORADO'S ACTIVE AND ABANDONED COAL MINES WITH METHANE RECOVERY OPPORTUNITIES



Full size image available from, colorado.gov/pacific/sites/default/files/atoms/files/Coal%20Mine%20Methane%20Report%202016.pdf

FIGURE 3-5. SURFACE AND UNDERGROUND COAL MINES IN CO



Full size image available from, coloradomining.org/mining-in-colorado/

TABLE 3-2. ADDITIONAL COAL MINE METHANE RESOURCES

Source	Learn more at
Colorado Energy Office, Coal Mine Methane	colorado.gov/pacific/energyoffice/methane-capture
Coal Mine Methane in Colorado Market Research Report	colorado.gov/pacific/sites/default/files/atoms/files/Coal%20Mine%20Methane%20Report%202016.pdf
EPA Coalbed Methane Outreach Program	epa.gov/cmop
Vessel Coal Gas, CMM in Colorado Fact Sheet	vesselscoalgas.com/COAL%20MINE%20METHANE%20TO%20ELECTRICITY%20IN%20COLORADO%20-%20August%201%20version%20(3).pdf
Ruby Canyon Engineering, 2013 CMM Presentation	vesselscoalgas.com/Ron%20Collings%20(Ruby%20Canyon%20Eng.pdf

16 Project/Resource Assessment and Converting Coal Mine Methane to Electricity. Accessed April 5, 2017. Available from, vesselscoalgas.com/Ron%20Collings%20(Ruby%20Canyon%20Eng.pdf

3.3 | Geothermal

Geothermal power is power generated by geothermal energy (heat energy generated and stored in the Earth). Geothermal resources are ideal for three main uses: heat pumps; direct use; and electricity generation. Each use depends on the temperature of the resource and the needs of the user. Electricity generating technologies include dry steam power, flash steam power, and binary cycle power stations. Electricity generation has primarily been deployed at utility scales.

On-site deployment: Geothermal heat pumps (GHPs) circulate water or other liquids to pull heat from the Earth through pipes in a continuous loop through a heat pump and conventional duct system. The loop system can be used almost everywhere in the world at depths below 10 ft to 300 ft.[17] GHPs can be 45% more energy efficient than standard heating and cooling system options and can be used by industrial facilities.[18]

Industrial processes primarily use geothermal resources in direct use applications, in which geothermal heat is used directly without a power plant or a heat pump. Geothermal direct uses are applied at aquifer temperatures between 90˚F and 200˚F and geothermal water or steam is accessed and brought to a plate heat exchanger for use.

Off-site procurement: Although not currently available in Colorado, there are examples of some companies producing geothermal energy and marketing it to other entities or to a local utility for purchase via a power purchase agreement (PPA). In March 2017, Ormat Technologies, Inc. announced that its subsidiary entered into a 25-year PPA with the Southern California Public Power Authority to deliver electricity from its Ormesa geothermal complex in Imperial Valley, California beginning November 30, 2017 at a rate of $77.25 per megawatt hour.[19] Similar procurement opportunities may become available if geothermal development occurs in Colorado.

Industrial generation: As of January 2016, there were 5 geothermal power projects in development in Colorado. Additionally, there are over 30 operating geothermal direct-use projects in Colorado.

Colorado Geothermal Overview

Colorado's geothermal resources are currently used for heat pumps and various heating applications.

As of January 2016, there were 5 geothermal electric power projects in development.

CEO Geothermal Overview,
colorado.gov/pacific/energyoffice/geothermal-0

For example, at Glenwood Hot Springs, the geothermal system heats the pool, many of the lodge's rooms, its indoor water needs, and warms snow-melt systems under sidewalks, the parking lot, and the north eaves of the lodge's roofline. Geothermal heat pumps are used at buildings such as the Colorado State Capital building, which was retrofitted with geothermal heat pumps in 2013. The first year of operation with the geothermal system realized $95,000 in utility-bill savings and full payback on the system is estimated to be 10 years.[20] Examples of geothermal use for large industrial operations include onion dehydration and heap leaching. Smaller industrial uses include applications at laundromats, breweries, mushroom production, and mineral water processing.[21]

Colorado geothermal resources: Figure 3-6 shows potential hydrothermal sites in Colorado. Figure 3-7 shows the potential for geothermal resources across the US with specific locations identified for deep enhanced geothermal systems. These images can be viewed at a larger scale by clicking the links in the figure captions. Colorado has a favorable geothermal profile for most applications. Additionally, Colorado has four sites identified that would be suitable for deep enhanced geothermal systems. Colorado could produce as much as 8,900 GWh of power annually, which could provide renewable power to offset some of the 53,600 GWh total power produced in 2013. At this point however, Colorado only has 24 MW of planned nameplate capacity for geothermal power generation. Additionally, hydrothermal direct-use resources in Colorado could offset as much as 14.1 Trillion BTU of annual heating consumption (out of an estimated 217 Trillion BTU of annual heat consumption in Colorado).

17 Geothermal Basics. Geothermal Energy Association. Accessed May 11, 2017. Available from, *geo-energy.org/basics.aspx#directuse*

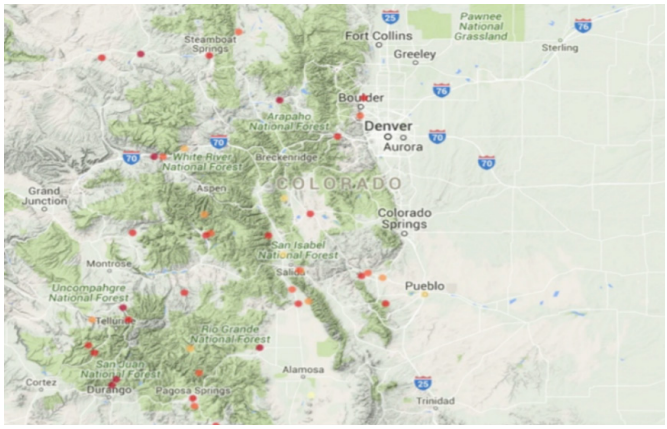
18 Industrial Applications for Ground Source Heat Pumps. Accessed March 17, 2017. Available from, *antaresgroupinc.com/industrial/geothermal-industrial-applications/*

19 Ormat Technologies Signs 25-year Power Purchase Agreement for the Ormesa Geothermal Complex in California. Accessed March 17, 2017. Available from, *globenewswire.com/news-release/2016/11/29/893381/0/en/Ormat-Technologies-Signs-25-year-Power-Purchase-Agreement-for-the-Ormesa-Geothermal-Complex-in-California.html*

20 "Geothermal Energy Potential: State of Colorado." Geothermal.org. January 2016. Available from, *geothermal.org/PDFs/Final_Colorado.pdf*

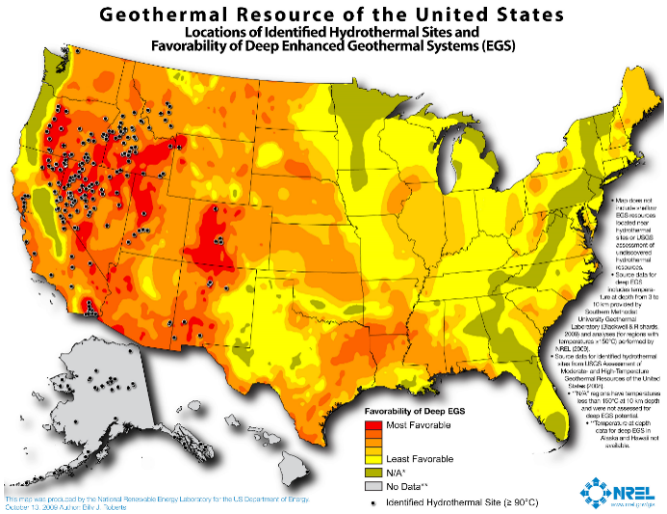
21 Industrial Uses of Geothermal Energy in the USA. US DOE. Accessed March 17, 2017. Available from, *energy.gov/sites/prod/files/2015/07/f24/11-Industrial-Uses-Geothermal-J-Lund.pdf*

FIGURE 3-6. CO POTENTIAL HYDROTHERMAL SITES



Full size image available from, geothermal.org/PDFs/Final_Colorado.pdf

FIGURE 3-7. US GEOTHERMAL RESOURCES



Full size image available from, nrel.gov/gis/images/geothermal_resource2009-final.jpg

TABLE 3-3. ADDITIONAL GEOTHERMAL RESOURCES

Source	Learn more at
Colorado Energy Office, Geothermal	colorado.gov/pacific/energyoffice/geothermal-0
Geothermal Energy Association	geo-energy.org
US Department of Energy, Geothermal Energy	energy.gov/eere/geothermal
Geothermal Energy Potential, Colorado	geothermal.org/PDFs/Final_Colorado.pdf
2016 Annual US & Global Geothermal Power Production Report, Geothermal Energy Association	geo-energy.org/reports/
National Renewable Energy Laboratory, Geothermal Technologies	nrel.gov/geothermal/

3.4 | Hydropower

Hydropower is power derived from the energy of falling or running water, which may be harnessed for useful purposes. Small hydro is the development of hydroelectric power on a scale suitable for local community and industry, or to contribute to distributed generation in a regional electricity grid. The definition of a small hydro project varies, but a generating capacity of 1 to 20 megawatts (MW) is common.

On-site deployment: Of course, to build a small hydropower system, you need access to flowing water. A sufficient quantity of falling water must be available, which usually, but not always, means that hilly or mountainous sites are best. In run-of-the-river hydro projects, a portion of a river's water is diverted to a channel, pipeline, or pressurized pipeline (penstock) that delivers it to a waterwheel or turbine. The moving water rotates the wheel or turbine, which spins a shaft. The motion of the shaft can be used for mechanical processes, such as pumping water, or it can be used to power an alternator or generator to produce electricity.[22] Conduit hydropower is perhaps the most applicable option for industrial firms in Colorado with significant water requirements in their processes. Conduit projects fit electric generating equipment into pipelines that carry water and are therefore able to extract power without the need for a large dam or reservoir. Conduit projects are efficient, cost-effective and environmentally friendly, as they are able to generate electricity from existing water flows and exploit synergies with infrastructure that is already in place.[23]

Colorado Hydropower Projects Overview

Operating hydropower facilities:	60
Combined installed capacity:	1150 MW
Annual electricity production:	680 GWh
Undeveloped annual technical capacity (conventional):	750 MW
Undeveloped annual electricity production (conventional):	632-737 GWh

CEO Hydropower Overview, colorado.gov/pacific/energyoffice/hydropower

22 Small Hydropower Systems. Accessed March 14, 2017. Available from, nrel.gov/docs/fy01osti/29065.pdf

23 "Conduit Hydropower." National Hydropower Association. Accessed May 10, 2017. Available from, hydro.org/policy/technology/conduit/

Off-site procurement: Hydropower provides about 5% of Colorado's electricity and contributes to the standard electricity mix reaching consumers depending on the utility. Power Purchase Agreements (PPA) through independent power producers or electric utilities allow electricity customers to source a greater portion of their electricity from renewable sources such as hydropower. PPAs are increasingly becoming the most common green power solution for large-scale electricity consumers that want renewable energy while avoiding large up-front capital expenses.

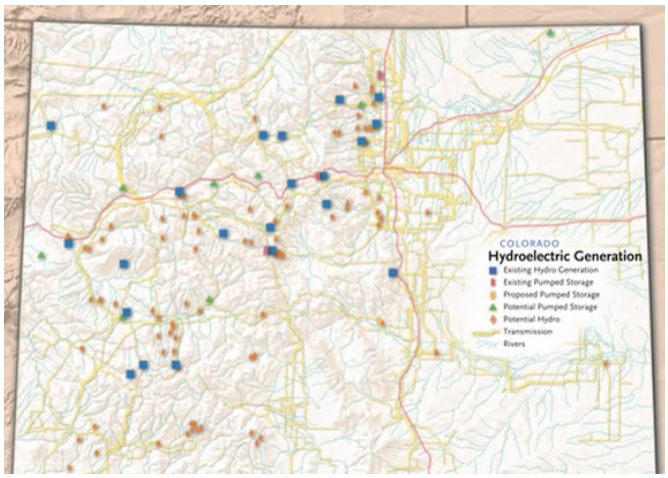
Industrial generation: As shown in Table 3-4, no conventional hydropower is generated by industrial entities in Colorado. Industrial firms with large water requirements should explore conduit hydropower as an opportunity to take advantage of an otherwise underutilized resource. Industrial firms also have the opportunity to enter into off-site hydro PPAs.

Colorado hydropower resources: Figure 3-8 shows the existing and potential conventional hydropower sites in Colorado. Figure 3-9 additionally shows the annual electric generation associated with the existing conventional hydroelectric plants. These images can be viewed at a larger scale by clicking the links in the figure captions. Opportunities for conduit hydropower projects will need to be assessed on a case-by-case basis and as of the writing of this report, a resource map for potential conduit projects was not identified. The mountainous areas and elevation changes prominent in the central and western parts of Colorado make it a strong candidate for hydropower projects.

TABLE 3-4. CO, NET GENERATION FROM CONVENTIONAL HYDROPOWER (EIA ELECTRIC POWER ANNUAL)

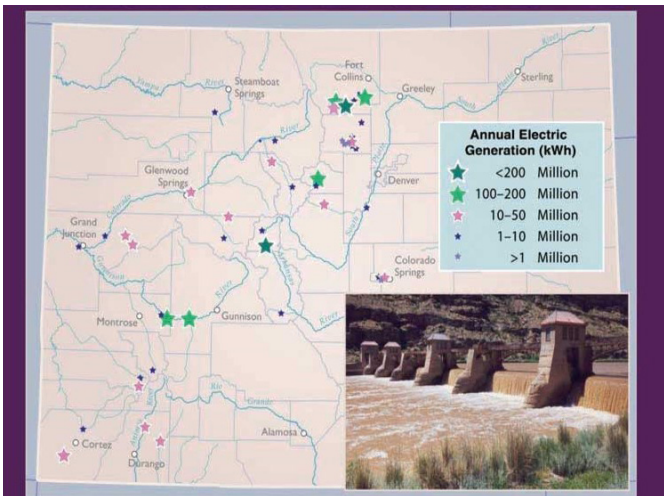
Colorado, Net Generation from Conventional Hydroelectric Power[24]				
	Generation (thousand MWh)			
Sector	2015	2014	% Change	2015 % of total
Industrial	**0**	**0**	**0.0%**	**0.0%**
Electric Utilities	1430	1568	-8.8%	88.3%
Independent Power Producers	184	196	-6.1%	11.4%
Commercial	6	6	0.0%	0.4%
Total	**1620**	**1770**	**-8.5%**	**100%**

FIGURE 3-8. EXISTING AND POTENTIAL HYDRO SITES IN COLORADO



Full size image available from, coloradogeologicalsurvey.org/energy-resources/electricity/map/

FIGURE 3-9. CO HYDROELECTRIC PLANTS AND ELECTRIC GENERATION



Full size image available from, smallhydro.co/about_us

TABLE 3-5. ADDITIONAL HYDROPOWER RESOURCES

Source	Learn more at
Colorado Energy Office, Hydropower	colorado.gov/pacific/energyoffice/hydropower
Colorado Water Resources & Power Development Authority	cwrpda.com/
Colorado Water Conservation Board (water project loan program)	cwcb.state.co.us/LoansGrants/
National Hydropower Association	hydro.org/
Colorado Small Hydro Association	smallhydro.co/about_us
Federal Energy Regulatory Commission (active licensed hydropower projects in the US)	ferc.gov/industries/hydropower/gen-info/licensing/licenses.xls

24 "Table 3.14. Net generation from hydroelectric (conventional) power by state by sector" EIA Electric Power Annual. November 21, 2016. Available from, eia.gov/electricity/annual/html/epa_03_14.html

3.5 | Landfill Gas

Landfill gas (LFG) is a natural byproduct of the decomposition of organic material in landfills. LFG is composed of roughly half methane and half CO_2 along with a small amount of non-methane organic compounds. LFG can be collected from landfills using a series of wells and a blower/flare (or vacuum) system. This system directs the collected gas to a central point where it can be processed and treated depending upon the ultimate use for the gas. In current landfills, LFG is either disposed of by venting or flaring, or used beneficially in various ways including electricity generation, fossil fuel replacement in industrial and manufacturing operations, and upgrading so the gas may be injected in natural gas pipelines or processed into alternative vehicle fuel.[25]

On-site deployment: Considering this resource requires a landfill for recovery, LFG is not really applicable as an on-site renewable generation option for industrial firms in Colorado. From the perspective of smaller landfill operators, microturbines are an emerging LFG energy recovery technology option when larger electric generation plants are not generally feasible. Several LFG microturbine projects have come on line recently, demonstrating both the risks and benefits of these small-scale applications.[26]

Off-site procurement: Industrial firms can establish contractual agreements with landfill owners for the sale of LFG, treated LFG, or the electricity generated by an LFG energy project. For direct-use applications, landfill gas is typically delivered offsite to industrial customers and used as an alternative fuel source. Current industries using LFG include auto manufacturing, chemical production, food processing, pharmaceuticals, cement and brick manufacturing, wastewater treatment plants, consumer electronics and products, paper and steel production, and prisons and hospitals.[27]

Colorado Landfill Gas Projects Overview

Operating LFG Projects	
Number	2
Collected mmscfd LFG	3.334
Candidate LFG Projects	
Number	13
Candidate mmscfd LFG	1.394
Potential LFG Projects	
Number	15
Potential mmscfd LFG	0.517

mmscfd = Million standard cubic feet per day

CEO LFG Overview, colorado.gov/pacific/energyoffice/methane-capture

Colorado landfill gas resources: The EPA landfill methane outreach program (LMOP) identified two currently operational landfill gas projects in CO, with a total of 3.334 mmscfd of LFG collected and 6.4 MW capacity.[28] Additionally, the LMOP database identifies 13 candidate landfill gas projects in CO, with a total of 1.394 mmscfd of LFG collected, and 15 potential LFG projects in CO, with a total of 0.517 mmscfd of LFG collected. Candidate landfills are landfills that are accepting waste or have been closed for five years or less, have at least one million tons of waste, and do not have an operational, under-construction, or planned project; can also be designated based on actual interest by the site. Potential landfills are landfills that do not meet the candidate definition or have incomplete data.

Figure 3-10 shows operational and candidate LFG to electricity sites in Colorado. Figure 3-11 show a summary of operational and candidate LFG projects across the US. These images can be viewed at a larger scale by clicking the links in the figure captions. Table 3-6 provides the names and locations of operating and candidate LFG project sites in Colorado.

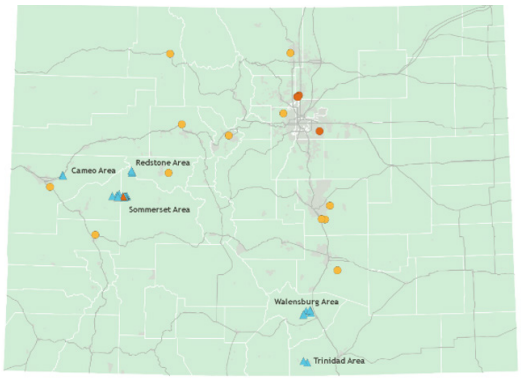
25 "Basic Information about Landfill Gas." US EPA, Landfill Methane Outreach Program. Accessed March 27, 2017. Available from, epa.gov/lmop/basic-information-about-landfill-gas

26 Powering Microturbines with Landfill Gas. Accessed March 27, 2017. Available from, energy.gov/sites/prod/files/2013/11/f4/microturbine_landfill.pdf

27 Landfill Gas Contracts and Permitting. Accessed March 27, 2017. Available from, epa.gov/sites/production/files/2016-09/documents/pdh_chapter5.pdf

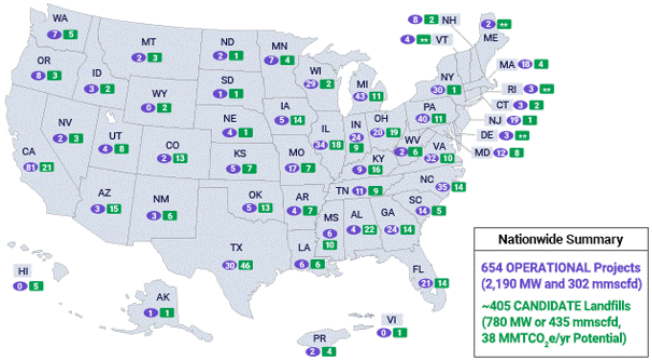
28 "Landfill Gas Energy Project Data and Landfill Technical Data." US EPA, Landfill Methane Outreach Program. Accessed March 27, 2017. Available from, epa.gov/lmop/landfill-gas-energy-project-data-and-landfill-technical-data

FIGURE 3-10. OPERATIONAL AND CANDIDATE LANDFILL GAS TO ELECTRICITY SITES IN COLORADO



Operational LFG sites (red circles). Candidate LFG sites (yellow circles)
Note: Coal mine methane projects shown (triangles)
Full size image available from, colorado.gov/pacific/energyoffice/methane-capture

FIGURE 3-11. US SUMMARY OF OPERATIONAL AND CANDIDATE LFG PROJECTS



Full size image available from,
epa.gov/lmop/landfill-gas-energy-project-data-and-landfill-technical-data

TABLE 3-6. NAMES AND LOCATIONS OF OPERATING AND CANDIDATE LANDFILL GAS PROJECT SITES IN CO

Operating Landfill Gas Project Sites	
Denver Arapahoe Disposal Site (DADS), Aurora	Front Range Landfill, Erie
Candidate Landfills Gas Project Sites	
Broadacres Landfill Inc., Pueblo	Midway Landfill, Pueblo
Colorado Springs Landfill, Colorado Springs	Milner Landfill, Milner
Eagle County Landfill, Wolcott	Montrose County Landfill, Montrose
Foothills Landfill, Golden	North Weld SLF, Ault
Fountain Landfill, Fountain	Pitkin County Solid Waste Center, Snowmass Village
Larimer County Landfill, Fort Collins	Summit County Landfill, Dillon
Mesa County Landfill, Grand Junction	

TABLE 3-7. ADDITIONAL LANDFILL GAS RESOURCES

Source	Learn more at
Colorado Energy Office, Landfill Gas	colorado.gov/pacific/energyoffice/methane-capture
EPA Landfill Methane Outreach Program	epa.gov/lmop
EPA LFG Energy Project Development Handbook	epa.gov/sites/production/files/2016-11/documents/pdh_full.pdf
LFG to Energy Project Cost Calculator	epa.gov/lmop/lfgcost-web-landfill-gas-energy-cost-model

3.6 | Pyrolysis of Municipal Solid Waste

Pyrolysis of municipal solid waste (MSW) reduces the amount of waste that ends up in landfills and produces a combustible, synthetic gas comprised of hydrogen, methane, carbon monoxide, and other hydrocarbons referred to as syngas. Syngas can be combusted to generate electricity much like natural gas. The Colorado General Assembly has classified electricity generated from "synthetic gas produced by pyrolysis of municipal solid waste" as eligible for Colorado's RES if the project is greenhouse gas neutral.[29]

On-site deployment: Unlike combustion, which burns fuel in the presence of oxygen, pyrolysis is the process of heating material to extremely high temperatures in the absence of oxygen. It would be difficult for industries to deploy pyrolysis technology to produce electricity on-site. Pyrolysis has high costs associated with the machinery and heating and is dependent on a supply of cheap biomass to be economically viable. Additionally, the bio-oil produced in pyrolysis processes is low grade and requires further upgrading steps or refining. Although pyrolysis and hydrothermal liquefaction technologies are being researched for use at wastewater treatment facilities, those processes are not applicable to meet the Colorado RES.

Off-site procurement: Waste to Energy International supports the construction and purchase of electricity from pyrolysis plants around the world. Plants are currently located in Australia, China, Italy, Romania, South Korea, and the USA. Many of these facilities have signed PPAs with grid companies.[30]

Colorado Pyrolysis Overview

Industrial processes with organic waste streams could provide a viable feedstock as a partner for a pyrolysis project. There are currently no operating waste to energy plants or gasification plants in CO.

CEO MSW Pyrolysis Overview, colorado.gov/pacific/energyoffice/waste-energy

Pyrolysis resources: Pyrolysis of MSW typically accommodates a mix of waste streams including food, paper, wood, textiles, rubber & leather, plastics & tires, metal, glass, and other organic and inorganic materials.[31] There are currently no large scale pure MSW-fed gasification plants and pyrolysis units in the US. However, there are currently 30 gasification plants in the US that use various other feedstocks and have a total syngas capacity of 8.9 GW of thermal output.[32] Figure 3-12 shows the locations of operating gasification plants in the US. Colorado currently does not have an operating facility.

FIGURE 3-12. OPERATING GASIFICATION PLANTS IN THE US

Full size image available from, *gasification-syngas.org/resources/map-of-gasification-facilities*

TABLE 3-8. ADDITIONAL MSW PYROLYSIS RESOURCES

Source	Learn more at
Colorado Energy Office, MSW Pyrolysis	*colorado.gov/pacific/energyoffice/waste-energy*
NREL WTE Economic Viability Report, 2013	*nrel.gov/docs/fy13osti/52829.pdf*
EPA, MSW Key Facts and Figures	*epa.gov/smm/advancing-sustainable-materials-management-facts-and-figures*

29 "Waste-to-Energy." Colorado Energy Office. Accessed April 11, 2017. Available from, *colorado.gov/pacific/energyoffice/waste-energy*

30 Waste to Energy International Project Portfolio. Accessed April 11, 2017. Available from, *wteinternational.com/project-portfolio/*

31 "Greenhouse Gas Neutrality Assessment of Coal Mine Methane and Waste-to-Energy Pyrolysis Projects." Colorado Energy Office. June 2016. Accessed April 11, 2017. Available from, *colorado.gov/pacific/sites/default/files/atoms/files/GHG_Neutral_Report_FINAL_June_2016%20%281%29_1.pdf*

32 "The Gasification Industry." Gasification & Syngas Technologies Council. Available from, *gasification-syngas.org/resources/the-gasification-industry/*

3.7 | Recycled Energy

Recycled energy, also known as waste heat to power, is the process of capturing heat discarded by an existing process and using that heat to generate electricity. Under the Colorado RES, recycled energy systems must have a nameplate capacity of 15 megawatts (MW) or less, convert the otherwise lost energy from the heat from exhaust stacks or pipes to electricity, and not combust additional fossil fuel.

On-site deployment: Energy intensive industrial processes—such as those occurring at refineries, steel mills, glass furnaces, and cement kilns—all release hot exhaust gases and waste streams that can be harnessed with common technologies to generate electricity.[33]

Off-site procurement: Facilities unsuitable for on-site recycled energy or waste heat to power deployment can purchase electricity from another facility or indirectly through their utility. One example is a 20-year PPA between Ormat Technologies, Inc. and Great River Energy for electricity produced by an ORMAT® Recovered Energy Generation facility. The new facility will have a net capacity of 5.3 MW and converts waste heat from gas turbine exhaust into electricity.[34]

Industrial generation: A 2016 Colorado Energy Office report (prepared by ICF International) evaluates the recycled energy market, the technical potential for various industrial processes, and specific opportunities and deployments in Colorado. Temperature ranges of waste heat differ substantially across the different industries. For example, the petroleum refining sector's waste heat is primarily 450 to 1200°F, while waste heat in the chemical industry is often 300°F or less. The report identifies NAICS 324 Petroleum and Coal Products, NAICS 325 Chemical Manufacturing, and NAICS 327 Non-Metallic Mineral Products as the three most suitable industries for recycled energy.[35]

Colorado Recycled Energy Overview

Current CO Waste Heat Projects

Number	3
Energy Capacity (MW)	7

Technically Feasible Projects

Number	70
Energy Potential (MW)	108

Primary Industries for Recycled Energy

- Petroleum refining
- Chemical manufacturing
- Non-metallic mineral products

CEO Recycled Energy Overview,
colorado.gov/pacific/energyoffice/recycled-energy

Colorado recycled energy resources: The 2016 Colorado Energy Office report and a similar 2015 Oak Ridge National Laboratory waste heat to power report (also prepared by ICF International) identify three waste heat to power projects in Colorado with a total capacity of 7 MW.[36,37] Only one of the three waste heat to power projects is eligible under Colorado's RES. This 3.5 MW, Highline Electric Co-op system is owned by Ormat and was constructed along a natural gas compression station in Peetz, CO in 2009. Colorado's Sterling and Yuma ethanol facilities' waste heat systems are not eligible under the RES because the systems provide not only electric power, but heat for industrial usage to the plants.

Table 5 of the 2016 Colorado report identifies 70 technically feasible sites for waste heat systems that could provide 108.4 MW of on-site energy generation. Nearly all of this potential is identified in the petroleum refining (39.4 MW), primary metals (26.5 MW), pipeline transportation (23.7), and non-metallic minerals (18.5 MW) sectors. Additionally, 10 of the identified sites, which contain 54 percent of the technical energy potential, exhibit paybacks less than five years.

The recently launched Colorado Energy Office and Xcel Energy Recycled Energy Programs may help encourage more recycled energy projects in the state. Xcel will offer $500/kW for each project within its territory that will be paid out over 10 years (annuitized over 10-years).

In addition to harnessing waste heat from industrial processes, US power plants can make use of their waste heat resources for recycled energy purposes. Figure 3-13 shows potential waste heat resources from US power plants by temperature range. As can be seen there are several potential opportunities in Colorado.

33 "Waste Heat to Power Systems." US EPA, Combined Heat and Power Partnership. May 2012, Accessed March, 2017. Available from, *epa.gov/sites/production/files/2015-07/documents/waste_heat_to_power_systems.pdf*

34 Ormat Press Release. Published April 16, 2008. Accessed March 15, 2017. Available from, *ormat.com/news/ormat-technologies-signs-new-power-purchase-agreement-great-river-energy-power-be-produced-orma/*

35 Rackley, J. Hampson, A. Fucci, M. "Colorado Recycled Energy Market Overview." Prepared by ICF International for the Colorado Energy Office. February 2016. Accessed March 15, 2017. Available from, *colorado.gov/pacific/sites/default/files/atoms/files/2016%20CEO%20Recycled%20Energy%20Market%20Overview.pdf*

36 Elson, A. Tidball, R. Hampson, A. "Waste Heat to Power Market Assessment." Prepared by ICF International for Oak Ridge National Laboratory. March 2015. Accessed March 2017, Available from, *heatispower.org/wp-content/uploads/2015/02/ORNL-WHP-Mkt-Assessment-Report-March-2015.pdf*

37 "Opportunities for Recycled Energy." Xcel Energy Recycled Energy program, collaboration with the CEO. Available from, *xcelenergy.com/programs_and_rebates/business_programs_and_rebates/renewable_energy_options_business/recycled_energy*

FIGURE 3-13. WASTE HEAT RESOURCES FROM US POWER PLANTS BY TEMPERATURE RANGE

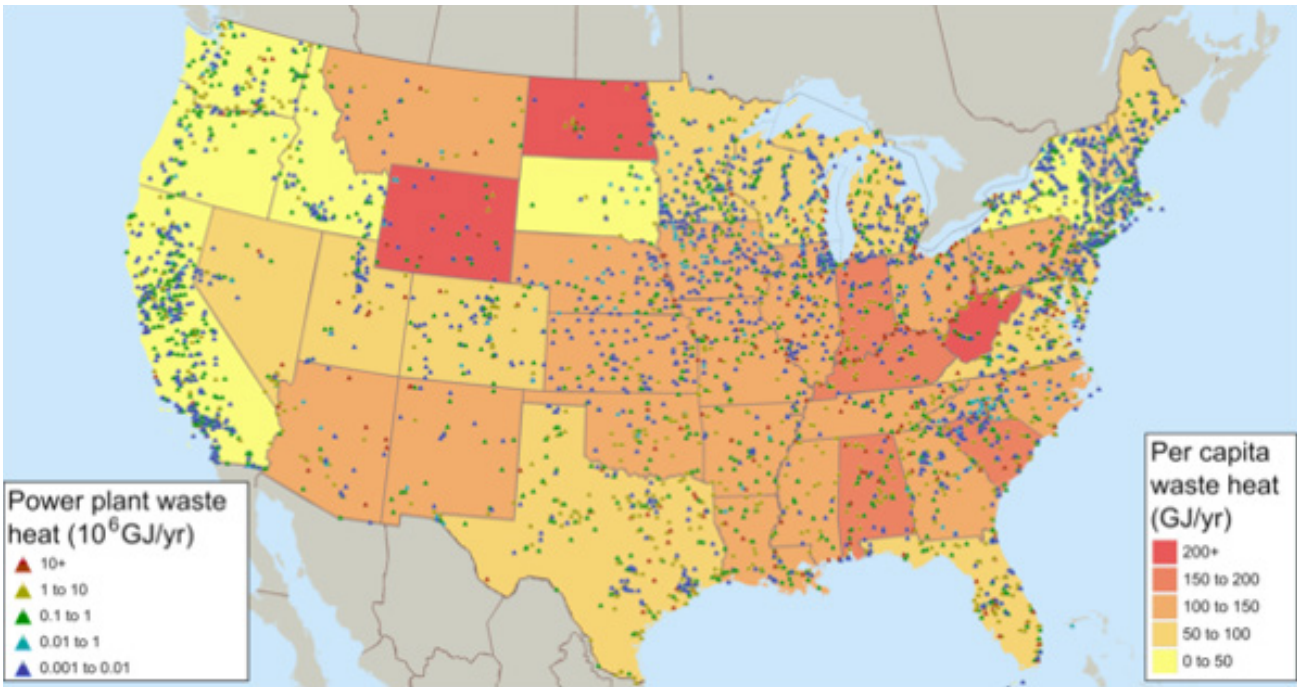


Image available from, stwing.upenn.edu/~salexa/Research-WasteHeat.htm

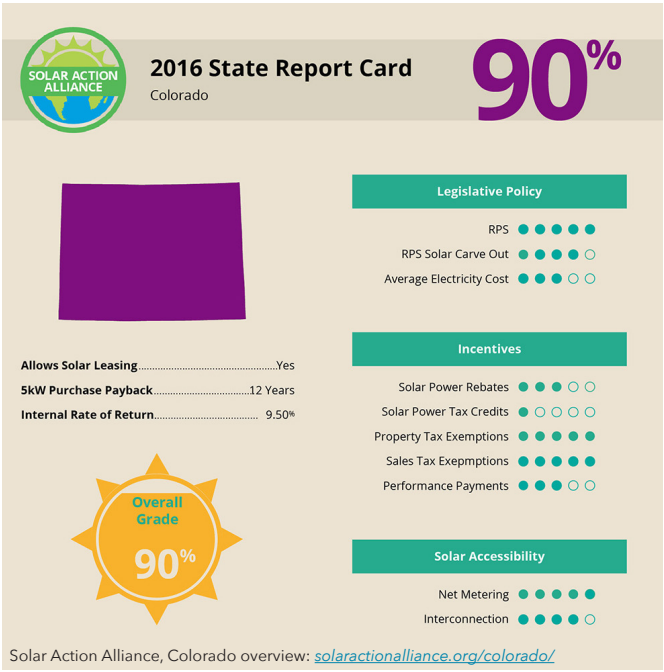
TABLE 3-9. ADDITIONAL RECYCLED ENERGY RESOURCES

Source	Learn more at
Colorado Energy Office, Recycled Energy	colorado.gov/pacific/energyoffice/recycled-energy
Heat is Power Association	heatispower.org/
Xcel Energy Recycled Energy Program	xcelenergy.com/programs_and_rebates/business_programs_and_rebates/renewable_energy_options_business/recycled_energy
US DOE, Southwest CHP Technical Assistance Partnership	southwestchptap.org/waste-heat-to-power
CEO Recycled Energy Market Overview, 2016	colorado.gov/pacific/sites/default/files/atoms/files/2016%20CEO%20Recycled%20Energy%20Market%20Overview.pdf

3.8 | Solar

Solar power is the conversion of energy from sunlight into electricity, either directly using photovoltaics (PV), or indirectly using concentrated solar power. Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaic cells convert light into an electric current using the photovoltaic effect. Additionally, solar thermal technology uses the sun's energy, rather than fossil fuels, to generate low-cost, environmentally friendly thermal energy.

Colorado has excellent net metering laws, that require each utility to monitor how much energy is produced, and to credit customers for any excess over what they use. Colorado also has a fairly strong interconnectivity law, which governs what utilities can charge or demand—in return for hooking up to the grid. Interconnectivity is fairly simple and cost-effective in Colorado. Solar is also exempt from state sales and property taxes in Colorado.



Solar Action Alliance, Colorado overview: solaractionalliance.org/colorado/

TABLE 3-10. SOLAR POTENTIAL BY WAREHOUSE SURFACE AREA

Warehouse Surface Area (ft^2)	Warehouse Surface Area (m^2)	Solar Potential (MWh/day) (average 6.21 kWh/m2/day)	Solar Potential (MWh/year)
10,000	929	5.8	2,104.7
25,000	2,323	14.4	5,261.9
50,000	4,645	28.8	10,523.7
100,000	9,290	57.7	21,047.4

On-site deployment: Factories and warehouses typically have rooftop space that can accommodate the installation of solar PV panels. It can meet a percentage of the electricity requirements for the facility and can help to offset peak consumption. Although some facilities choose to use adjacent land to deploy solar projects, rooftop solar takes advantage of available space on-site. Additionally, industrial facilities and commercial buildings can use solar thermal technology to heat water or other fluids or to power solar cooling systems.

Solar panels offer a significant opportunity for many factories and manufacturers due to their expansive roof space, intensive machinery, and enormous energy bills.[38] Table 3-10 compares daily and annual solar potential based on warehouse surface area.

Off-site procurement: Inspired by residential solar leasing products, organizations have adopted commercial rooftop leasing as a cost-effective way to leverage solar energy. Rather than making up-front investments in the equipment and installation costs of solar power systems, property owners would grant project developers access to rooftop space in exchange for a share of the economic benefits of the installation.

Utilities and independent power producers also offer opportunities for customers to procure solar energy. Depending on the location and electricity provider, off-site solar electricity can be procured at fixed or variable rates that are competitive with fossil derived alternatives.

Industrial generation: As shown in Table 3-11, industrial facilities only account for 0.5% of distributed solar photovoltaic generation in Colorado. However, success in the commercial and residential sectors indicate that industrial firms can also benefit from deploying distributed solar at their facilities.

Colorado solar resources: Figure 3-14 and Figure 3-15 show the solar resource potential for Colorado and across the entire US. These images can be viewed at a larger scale by clicking the links in the figure captions. As can be seen in the figures, Colorado is one of the top locations for solar potential in the US with particularly favorable resources in the southern and eastern parts of the state.

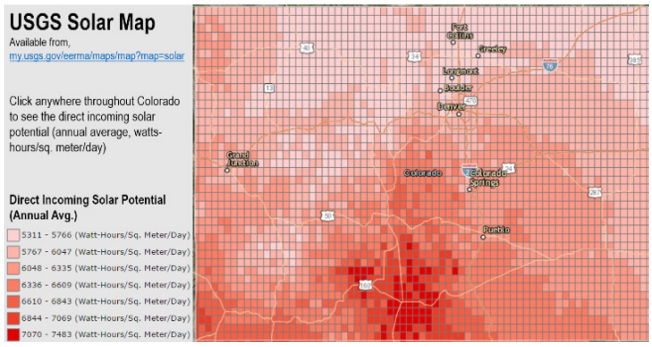
TABLE 3-11. COLORADO, SOLAR PHOTOVOLTAIC GENERATION (EIA ELECTRIC POWER ANNUAL)

Colorado, Solar Photovoltaic Generation[39]								
	Generation (thousand MWh)							
	2015		2014		% Change		2015 % total	
Sector	Utility Scale	Distributed	Utility Scale	Distributed	Utility Scale	Distributed	Utility Scale	Distributed
Industrial	**0**	**2**	**0**	**2**	**0.0%**	**0.0%**	**0.0%**	**0.5%**
Electric Utilities	0	0	0	0	0.0%	0.0%	0.0%	0.0%
Independent Power Producers	238	0	241	0	-1.3%	0.0%	94.8%	0.0%
Commercial	13	179	12	174	7.7%	2.8%	5.2%	45.8%
Residential	0	210	0	177	0.0%	15.7%	0.0%	53.7%
Total	**251**	**391**	**253**	**353**	**-0.8%**	**9.7%**	**100%**	**100%**

38 64% of US warehouses are larger than 25,000 square feet in size and 37% are greater than 100,000 square feet. Information available from, cisco-eagle.com/industries-served/order-fulfillment/the-typical-warehouse

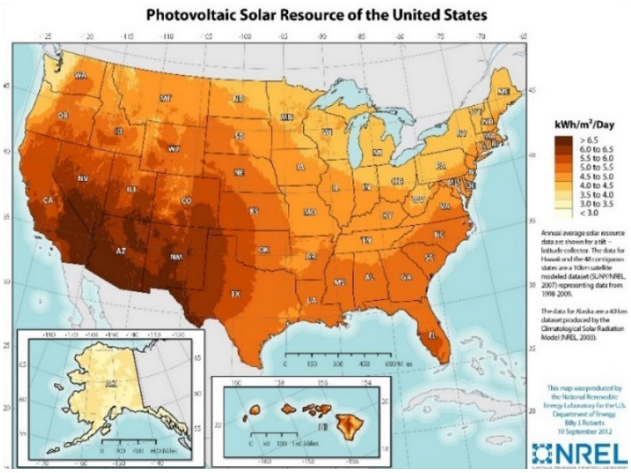
39 "Table 3.21. Net generation from solar photovoltaic by state by sector." EIA Electric Power Annual. November 21, 2016. Available from, eia.gov/electricity/annual/html/epa_03_21.html

FIGURE 3-14. COLORADO DIRECT SOLAR POTENTIAL



Full size image available from, *my.usgs.gov/eerma/maps/map?map=solar*

FIGURE 3-15. US – SOLAR RESOURCE MAP



Full size image available from,
nrel.gov/gis/images/eere_pv/national_photovoltaic_2012-01.jpg

TABLE 3-12. ADDITIONAL SOLAR POWER RESOURCES

Source	Learn more at
Colorado Energy Office, Solar	*colorado.gov/pacific/energyoffice/solar*
Colorado Solar Energy Industries Association (COSEIA)	*coseia.org/*
COSEIA Solar Installers List and Contractors	*coseia.org/join-coseia/member-directory/*
Solar Energy Industries Association (SEIA)	*seia.org/*
Solar Power Rocks Colorado Solar Report Card	*solarpowerrocks.com/2016-state-solar-power-rankings/#CO*
National Renewable Energy Laboratory (NREL), Solar Data Resources	*nrel.gov/gis/data_solar.html*

3.9 | Wind Power

Wind power is the use of air flow through wind turbines to mechanically power generators for electric power. Wind power, as an alternative to burning fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, consumes no water, and uses little land. The net effects on the environment are far less problematic than those of non-renewable power sources.

On-site deployment: Small wind is defined as wind turbines with a capacity rating of less than or equal to 100 kW. Turbines in this category range in size from smaller than 1 kW for off-grid applications to 100-kW turbines that can provide village power. Unlike utility-scale turbines, small turbines can be suitable for use on properties as small as one acre of land in most areas of the country. Fifty-four small turbine models are offered commercially in the US for applications including homes, schools, commercial and industrial facilities, telecommunications, farms and ranches, and communities. By the end of 2012, more than 150,000 small wind turbines were installed in the US.[40]

Colorado Wind Projects Overview

Installed wind capacity: 3,026 MW

State rank for installed wind capacity: 10th

Number of wind turbines: 1,913

Wind projects online: 25 (Projects >10 MW: 17)

Wind capacity under construction: 76 MW

Wind capacity in advanced development: 600 MW

Technical potential at 80m height: 274,353 MW

AWEA Colorado State Fact Sheet, January 2017,
awea.files.cms-plus.com/FileDownloads/pdfs/Colorado.pdf

40 Small & Community Wind. Accessed March 8, 2017. Available from *awea.org/small-and-community-wind*

Off-site procurement: For large electricity users without adequate rooftop space for solar, off-site wind power purchase agreements (PPAs) offer a good alternative. PPA customers pay a fixed price for each kWh produced over a contract term – ranging from 10-25 years – allowing organizations to hedge against rate increases and to reap both the economic and environmental benefits of renewable energy. In 2010, Google announced a series of deals with Florida-based NextEra Energy, including a 20-year offsite wind PPA that captured national attention. Because of wind PPA's compelling economic and environmental story, major organizations like Amazon, Yahoo, Microsoft and Wal-Mart recently joined the bandwagon of institutional wind buyers.

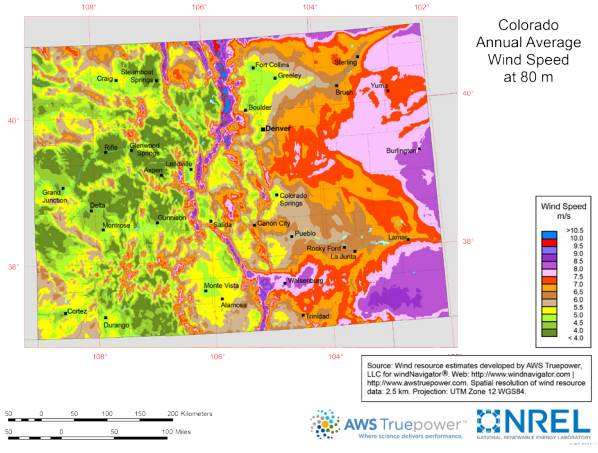
Industrial generation: As shown in Table 3-13, a negligible portion (3 thousand MWh) of utility scale wind power in Colorado is generated by industrial entities. Regardless, there is ample opportunity for industrial firms to install small on-site wind turbines at their factories or warehouses or to enter into off-site wind PPAs.

Colorado wind resources: Figure 3-16 and Figure 3-17 show the predicted mean annual wind speeds at an 80-m height in Colorado and wind resources across the entire US. These images can be viewed at a larger scale by clicking the links in the figure captions. Areas with annual average wind speeds around 6.5 meters per second and greater at 80-m height are generally considered to have a resource suitable for wind development. Utility-scale, land-based wind turbines are typically installed between 80- and 100-m high although tower heights for new installations are increasing–up to 140 m–to gain access to better wind resources higher aloft. As can be seen in the figures, Colorado has ample wind resources, particularly in the eastern part of the state and along the front range.

TABLE 3-13. CO, UTILITY SCALE NET ELECTRICITY GENERATION FROM WIND (EIA)

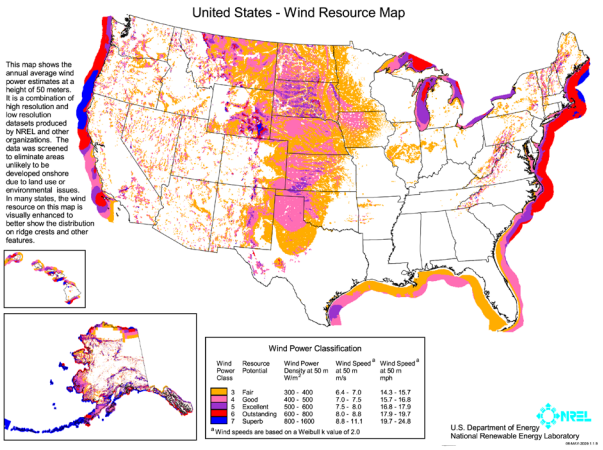
Colorado, Utility Scale Facility Net Electricity Generation from Wind[41]				
	Generation (thousand MWh)			
Sector	2015	2014	% Change	2015 % total
Industrial	**3**	**3**	**0.0%**	**0.0%**
Electric Utilities	135	169	-20.1%	1.8%
Independent Power Producers	7334	7196	1.9%	98.1%
Commercial	4	0	n/a	0.1%
Total	**7475**	**7369**	**1.4%**	**100%**

FIGURE 3-16. COLORADO ANNUAL AVERAGE WIND SPEED AT 80M



Full size image available from, apps2.eere.energy.gov/wind/windexchange/pdfs/wind_maps/co_80m.pdf

FIGURE 3-17. US – WIND RESOURCE MAP



Full size image available from, nrel.gov/gis/pdfs/windsmodel4pub1-1-9base200904enh.pdf

41 "Table 3.18. Net generation from wind by state by sector." EIA Electric Power Annual. November 21, 2016. Available from, eia.gov/electricity/annual/html/epa_03_18.html

TABLE 3-14. ADDITIONAL WIND POWER RESOURCES

Source	Learn more at
Colorado Energy Office, Wind	colorado.gov/pacific/energyoffice/wind
NREL WINDExchange Resource Maps	apps2.eere.energy.gov/wind/windexchange/wind_resource_maps.asp?stateab=co
OpenEI's Small Wind Guidebook	en.openei.org/wiki/Colorado/Wind_Resources
American Wind Energy Association (AWEA)	awea.org/
Distributed Wind Energy Association (DWEA)	distributedwind.org/
The US Small Wind Turbine Industry Roadmap: A 20-year industry plan for small wind turbine technology	nrel.gov/docs/gen/fy02/31958.pdf

3.10 | Woody Biomass

The Colorado RES allows electricity generated from the combustion of woody biomass including agricultural crops, wood waste, mill residue, and forest slash or brush. Woody biomass to generate electricity helps to increase use of renewable energy and to maintain the health of Colorado's forests.[42] Wood can be used as the sole source of fuel to produce electricity or heat or can be mixed with another fuel source such as coal or urban waste in a process referred to as co-firing. As a supplement to coal, biomass may lower fuel costs and reduce emissions of sulfur dioxide and nitrogen oxides.[43] Additionally, woody biomass is often regarded as "carbon neutral" because of the balance between CO_2 released during combustion and CO_2 sequestration during growth.

On-site deployment: There are numerous conversion technologies for industries with a steady supply of waste woody biomass resources, such as the pulp and paper industry, to utilize biomass resources on-site. Advanced direct-combustion burns biomass in a modern boiler or furnace system. Cogeneration is the production of both thermal and electrical energy by a combustion system. Biomass can also be converted to fuels such as ethanol, methanol, syngas, bio-oil, and biodiesel through fermentation, gasification, pyrolysis, hydrothermal liquefaction, and other techniques.[44]

Off-site procurement: Industries with a steady supply of waste woody biomass could offer their waste resources as feedstock to biomass conversion facilities, rather than pursuing on-site utilization of those resources. Dedicated biomass conversion facilities, or co-fired coal power plants, could then sell their electricity, heat, or biomass-derived products to the grid or directly to customers.

Colorado Woody Biomass Overview

Facilities using wood energy	9
Wood only facilities in CO	1
CO woody biopower potential	<1 GW

The majority of wood energy facilities in CO are relatively small scale wood chip or wood pellet boilers. The one wood only facility has an 11.5 MW nameplate capacity.

CEO Woody Biomass Overview, colorado.gov/pacific/energyoffice/waste-energy

Industrial generation: There are currently nine facilities in Colorado using wood energy, shown in Table 3-15.[45] Only Evergreen Clean Energy's 11.5 MW project in Gypsum Colorado uses woody biomass exclusively. This project generates electricity primarily using beetle kill trees.

Colorado woody biomass resources: Figure 3-18 shows the estimated sustainable tons of woody biomass available annually in Colorado. Figure 3-19 shows total estimated technical potential for biopower across the US. These images can be viewed at a larger scale by clicking the links in the figure captions. As can be seen, Colorado has less technical potential for biopower than other states with more ample resources.

A 2012 NREL report found that Colorado's total biopower potential is <1 GW of capacity, producing approximately 4,138 GWh annually.[46] At just below 20% timberland, Colorado ranks 35th in the percentage of timberland by state.[47] While there may be limited opportunity for large scale biopower deployment in Colorado, there may be viable, smaller scale, industry specific opportunities for on-site utilization of biomass resources and power production.

42 "Waste-to-Energy." Colorado Energy Office. Accessed April 6, 2017. Available from, colorado.gov/pacific/energyoffice/waste-energy

43 "Bioenergy from Forests: The Power Potential of Woody Biomass." USDA Forest Service. June 2015. Accessed April 6, 2017. Available from, fs.fed.us/pnw/sciencef/scifi174.pdf

44 "Woody Biomass Energy: Local Renewable Fuel for Commercial, Institutional, and Industrial facilities." MA Sustainable Forest Bioenergy Initiative. June 2008. Available from, mass.gov/eea/docs/doer/renewables/biomass/woody-biomass-energy.pdf

45 "Wood to Energy Program." Colorado State Forest Service, Colorado State University. Accessed May 12, 2017. Available from, csfs.colostate.edu/cowood/wood-to-energy/

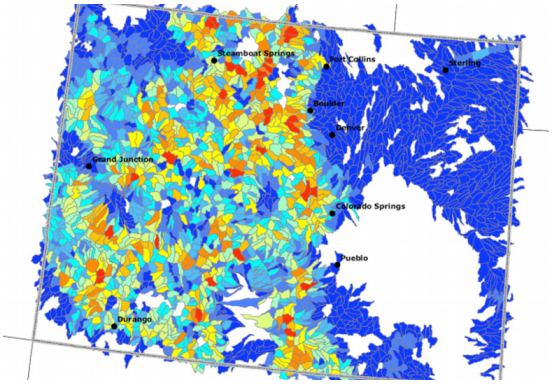
46 Lopez, A., Roberts, B., Heimiller, D., Blair, N., Porro, G. "US Renewable Energy Technical Potentials: A GIS-Based Analysis." National Renewable Energy Laboratory. July 2012. Available from, nrel.gov/docs/fy12osti/51946.pdf

47 Smith, W., Miles, P., Perry, C., Pugh, S. "Forest Resources of the US, 2007." Technical document supporting the US Forest Service 2010 RPA Assessment. 2009. Available from, fs.fed.us/nrs/pubs/gtr/gtr_wo78.pdf

TABLE 3-15. CURRENT FACILITIES IN CO USING WOOD ENERGY (FROM CO STATE FOREST SERVICE, WOOD TO ENERGY PROGRAM)

Facilities in Colorado Using Wood Energy	
Location	**Facility Type**
Jim Hubbard Fire Management Building, Fort Collins	0.15 MMBtu/hr wood pellet boiler
Mountain Park Environmental Center, Beulah	Two manually fed 0.4 MMBtu/hr cordwood boilers
South Routt School District, Oak Creek	0.6 MMBtu/hr wood pellet boiler
Mountain Parks Electric, Granby	1.1 MMBtu/hr wood pellet boiler
Colorado State University Foothills Campus, Fort Collins	1.5 MMBtu/hr wood chip boiler
Boulder County, Longmont	3.3 MMBtu/hr wood chip boiler
Gilpin County, Black Hawk	3.3 MMBtu/hr wood chip boiler
National Renewable Energy Lab, Golden	9.9 MMBtu/hr wood chip boiler
Evergreen Clean Energy, Gypsum	11.5 MW woody biomass CHP (only wood only facility in CO)

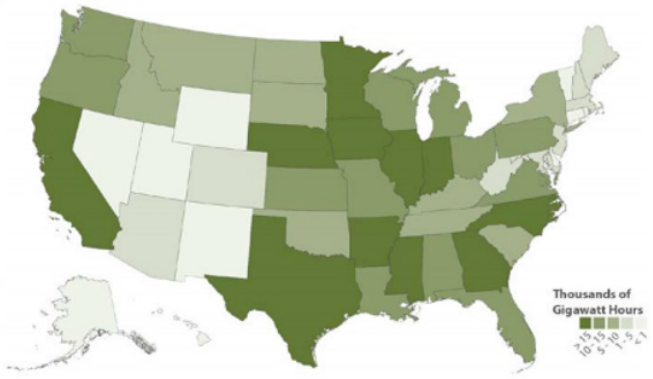
FIGURE 3-18. COLORADO SUSTAINABLE TONS OF WOODY BIOMASS AVAILABLE ANNUALLY



Dark Blue < 1,000 dry tons/ year
Light blue < 5,000 dry tons/ year
Yellow < 12,000 dry tons/ year
Orange < 22,000 dry tons/ year
Red > 22,000 dry tons/ year
White = no resources

Full size image available from, *jw-associates.org/Resources/Biomass%20Supply%20Assessment%20V4.pdf*

FIGURE 3-19. TOTAL ESTIMATED TECHNICAL POTENTIAL FOR BIOPOWER



Full size image available from, *nrel.gov/docs/fy12osti/51946.pdf*

TABLE 3-16. ADDITIONAL WOODY BIOMASS RESOURCES

Source	Learn more at
Colorado Energy Office, Woody Biomass	*colorado.gov/pacific/energyoffice/waste-energy*
NREL Biopower Atlas	*maps.nrel.gov/biopower-atlas*
US DOE, Bioenergy Knowledge Discovery Framework	*bioenergykdf.net*
Colorado State Forest Service, Wood to Energy Program	*csfs.colostate.edu/cowood/wood-to-energy/*
Evergreen Clean Energy, LLC	*evergreencleanenergy.com/*

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4 | Industrial Efforts in Energy Efficiency and Distributed Generation

An outreach survey and follow-up interviews with industrial companies in Colorado were used to assess energy users' mindsets on adopting renewable energy in the industrial sector, and evaluate how open each industry is to the idea of investing in DG and EE measures.[48] As a proactive step, the surveys and interviews included educational material on financing and accounting strategies, audits and technology improvement recommendations, tax incentives and rebates, and information on local, State, and Federal technical assistance programs. These resources are discussed in greater detail in Chapter 5.1.

The survey was developed in an iterative process in collaboration with CEO. The first draft of the survey contained 54 questions and was piloted on March 2, 2017 to a select group of contacts. Feedback indicated that the original survey was too long and that it was too difficult for companies to report actual energy consumption and savings statistics. Therefore, there is no effort to quantify the extent and impact of DG and EE measures for industrial entities that have implemented them. However, information is available regarding the number and types of firms that have implemented DG and EE measures and qualitative assessments of the impact of those activities.

The final version of the survey was reduced to 32 questions, removed difficult to answer questions, and was designed to take approximately ten minutes to complete. The shortened survey launched on March 9, 2017 to approximately 370 industrial companies in Colorado. Weekly follow-up emails throughout March and early April helped to nearly double the survey response rate to 46 total respondents (35 of which fully completed the survey). The survey and outreach efforts confirmed direct point of contact (POC) information for 63 industrial companies and increased our level of confidence in 362 direct emails (that did not return error messages when contacted) for industrial companies in Colorado. 28 of the 35 survey respondents that fully completed the survey indicated that they would like to be contacted by CEO with more information regarding EE and DG opportunities.

The survey and interview results helped to validate numerous POCs at industrial organizations, identify many that are interested in DG and EE, identify those that have a steady source of waste heat and would be good candidates for the CEO recycled energy program, and provide considerable insight regarding the factors that most compel each sector to invest in DG and EE.

Colorado Industrial EE and DG Outreach Survey and Interviews: Summary Statistics

35	Fully completed survey respondents
46	*Total Survey Respondents (including partial)*
28	Survey respondents open to follow-up contact from CEO
16	3-digit NAICS industries represented
549	Industrial companies prioritized (based on size and industry)
362	Direct contact emails for CO industrial companies (did not return an error)
17	Follow-up interviews with industrial companies
10	Interviews with financial providers and technical support program administrators

Survey and interview respondent company and individual names are not provided in this report for confidentiality reasons. Company attribution is for internal use only.

4.1 | Attitudes and Outlook on EE/DG

The majority of survey respondents indicated that energy use and consumption is becoming a higher priority at their organizations and ~95% of them responded that management will at least occasionally support energy related investments. Respondents appear to be more inclined to invest in energy efficiency opportunities (51% active pursuit) vs on-site or renewable energy generation (32% active pursuit).

Regardless of company size, respondents indicated that energy use and consumption is increasingly becoming a higher priority in investment decisions (shown in Figure 4-1). However, large companies are the most likely to be actively pursuing these investments. This could be due to the scale of their operations, their available resources, and the potential cost savings that could be achieved through energy reductions and process efficiencies.

As shown in Figure 4-2 and Figure 4-3, respondents are more likely to be actively pursuing EE investments than on-site or renewable generation. Additionally, the larger firms indicated that they have dedicated staff and more resources available to invest in energy management software, conduct investment grade audits, and develop multi-year strategic plans to achieve energy goals.

48 In this section, DG is also referred to as "on-site renewable energy generation" and focuses on technologies and energy sources that are acceptable under the Colorado Renewable Energy Standard, colorado.gov/pacific/energyoffice/renewable-energy-standard

FIGURE 4-1. ATTITUDE TOWARDS ENERGY USE AND CONSUMPTION BY EMPLOYMENT RANGE

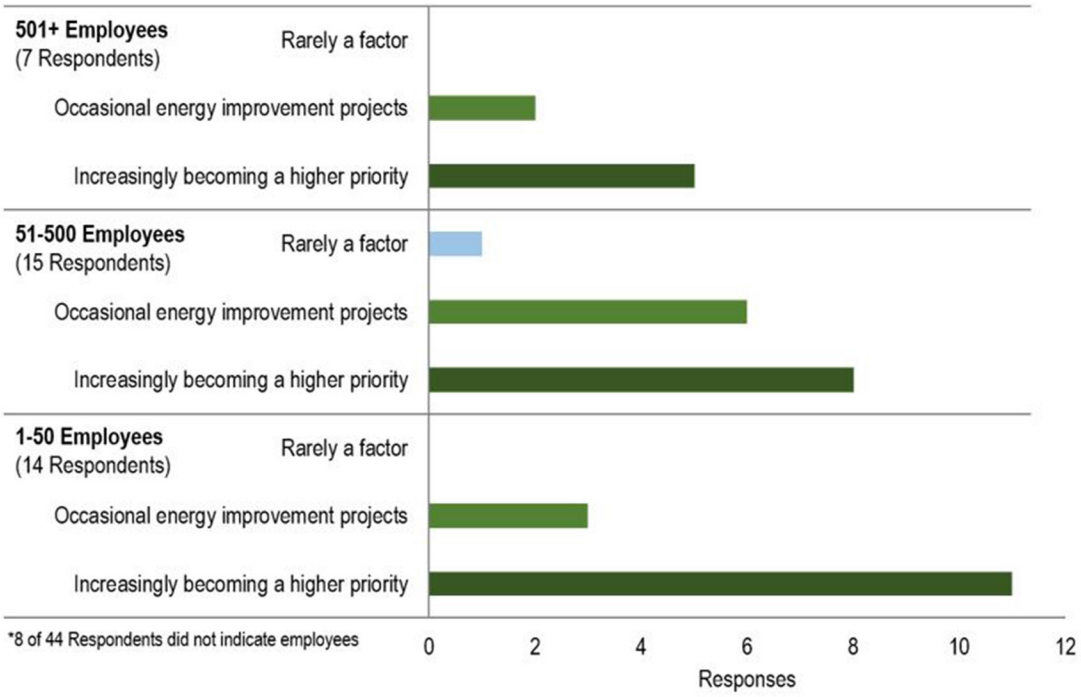


FIGURE 4-2. INDUSTRIAL EE INVESTMENT OUTLOOK BY EMPLOYMENT RANGE

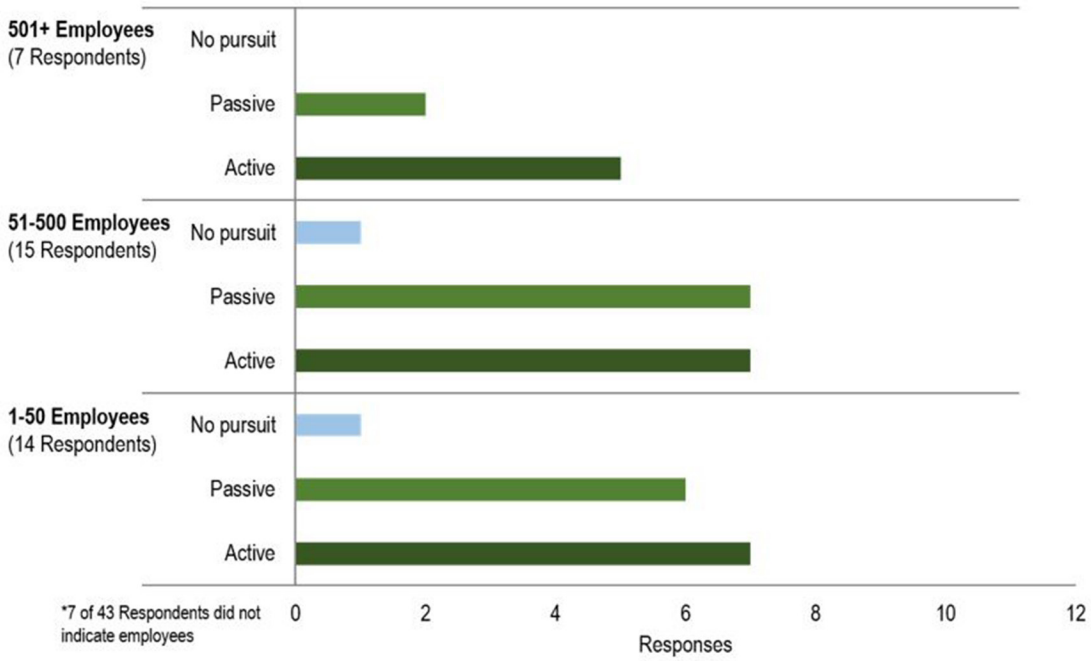
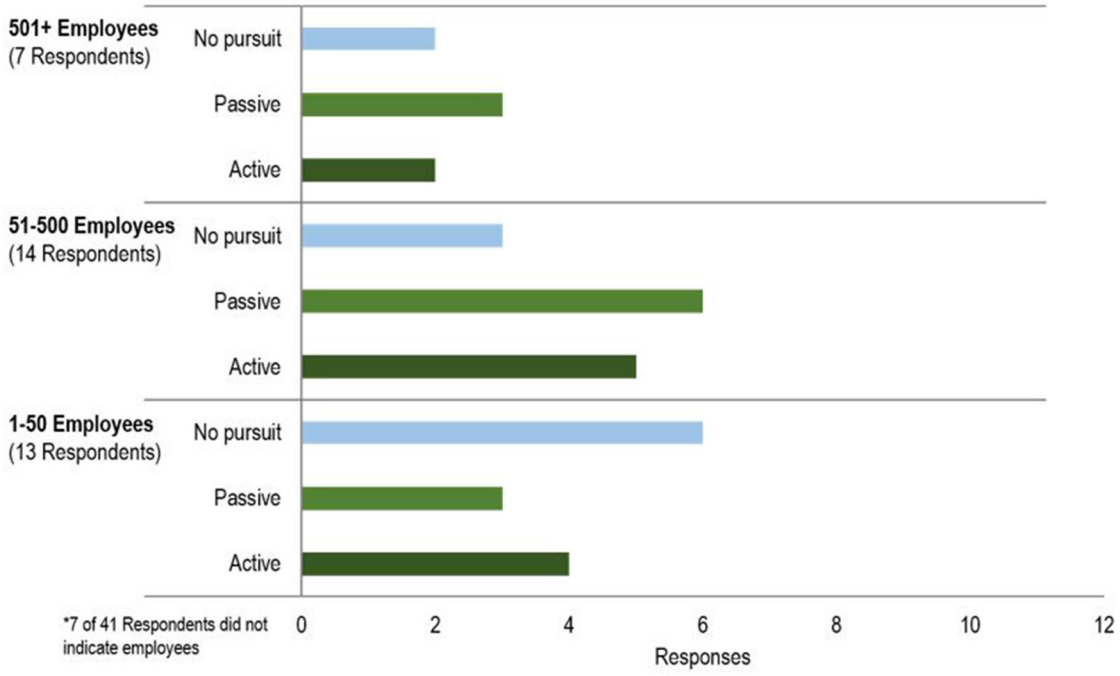


FIGURE 4-3. INDUSTRIAL DG INVESTMENT OUTLOOK BY EMPLOYMENT RANGE



The larger businesses also frequently mentioned low and no/cost options to improve process efficiencies and obtain cost reductions. On the other hand, most small and mid-sized businesses identified simpler measures such as facility lighting upgrades and process optimization as their primary opportunities to reduce energy consumption.

Follow-up interviews with survey respondents indicate that on-site or renewable generation has a lower ROI than energy efficiency projects. Despite many of the companies stating that they are very interested in securing more of their energy from renewable sources only a few have been able to do so and more than 30% of companies indicated that they are not even passively interested in renewable energy opportunities.

In some cases, investments in renewable energy options have primarily been in efforts to achieve organizational sustainability goals and at best have negotiated an equivalent rate to fossil derived electricity from their utility or provider. In another case, one company with a solar clad rooftop reported that they are a net electricity producer.

Based on the 17 companies interviewed, larger firms are more likely to have corporate energy and/or sustainability goals than mid-size or small companies. 5 out of 7 large companies interviewed identified a corporate goal with specified units and annual targets they are working to meet. In comparison, 1 out of 10 small to mid-size companies interviewed identified a corporate environmental goal.

Nearly all of the small to mid-size companies have not established any energy or environmental goals and are primarily interested in energy projects as a way to help meet revenue or production goals and operational needs. Some smaller companies expressed challenges with defining energy goal setting metrics, while others mentioned many on-going efforts to track energy use at individual sites and comply with local or state ordinances.

Energy management challenges and goals could be mitigated through best practices and strategies such as the ISO 50001 principles, which helps organizations to develop policies for efficient energy use, set targets and objectives, use data to measure results and make decisions, and continually improve energy management. However, in a similar vein to many of the other findings from the survey and interviews, the organizations with the most resources are also the ones that are most aware of, interested in, and active in energy management. Importantly, the larger organizations are more likely to have staff dedicated to energy related improvements and decisions. Whether or not the organizations with dedicated staff follow ISO 50001, those with resources and dedicated responsibilities are able to make the most meaningful strides in planning, measuring, and managing energy decisions for their organizations.

4.2 | Actions Towards EE/DG

Economics appear to be the primary driver for energy decision making at organizations, outweighing factors such as environmental responsibility, regulations, or pressure from NGOs or energy activists. Even regulatory influences

for certain industries are economically driven in some cases. Conversations with representatives from oil and gas companies indicated a strong desire to reduce methane flaring to avoid environmental fines.

Large businesses are found to place more value on environmental and social responsibility than the smaller companies that responded. The large businesses perceive themselves to have additional responsibility when it comes to energy and environmental practices. One company elaborated on this idea stating that, "If we want to advocate for sound energy & carbon policy at the local & national level, we need to be putting our money where our mouths are, and serving as a model for other businesses." While favorable economics for investments are still highly import for large businesses, they are more likely to consider other justifiable attributes to meet energy and/or sustainability goals.

4.2.1 | Energy Audits

The majority of survey respondents have conducted building efficiency and process efficiency audits. Follow-up interviews indicated that building audits and improvements represents low-hanging fruit for most companies. Opportunities to improve building efficiency are similar across industries with verified solutions leading to predictable savings outcomes. Again, there is a trend showing that large businesses more actively pursue energy related opportunities, which could be attributed to their available resources and scale of potential benefits from reductions. Figure 4-4 shows that 83% of large business respondents have conducted a building efficiency audit compared to 67% of mid-sized companies and 50% of small business.

Medium-sized businesses also show some activity regarding audit execution and as a group are the most interested in pursuing opportunities if they have not yet conducted audits. This could be due to increasing energy expenses that have grown along with the company, however they do not yet have dedicated resources or sufficient knowledge of EE opportunities. Smaller companies have the least interest in pursuing energy related audits, however several companies have already done so. Medium-sized companies may present a good target for CEO to share informational resources on energy audits and technical support resources that could benefit their organizations.

When assessing these responses, it is important to remain cognizant that process differences between industries may make certain audits or energy related opportunities more practical than others. For example, process efficiency and waste heat recovery/CHP opportunities are more likely to vary by industry than building improvements.

4.2.2 | Equipment Installation and Retrofits

Building efficiency improvements, such as lighting and HVAC, are the most likely to have been implemented, planned, or being considered. The survey responses also demonstrate that compressed air systems are highly energy intensive and are a common target for EE upgrades.

Common systems with energy saving opportunities

- **Waste heat recovery and CHP**
- **On-site energy generation, non-CHP** (e.g., solar, wind, fuel cells, biomass)
- **Process Efficiency** (e.g., heating, pumping, fuel consumption)
- **Building Efficiency** (e.g., HVAC, lighting, heating, refrigeration, insulation)

FIGURE 4-4. AUDIT EXECUTION AND INTEREST BY EMPLOYMENT RANGE

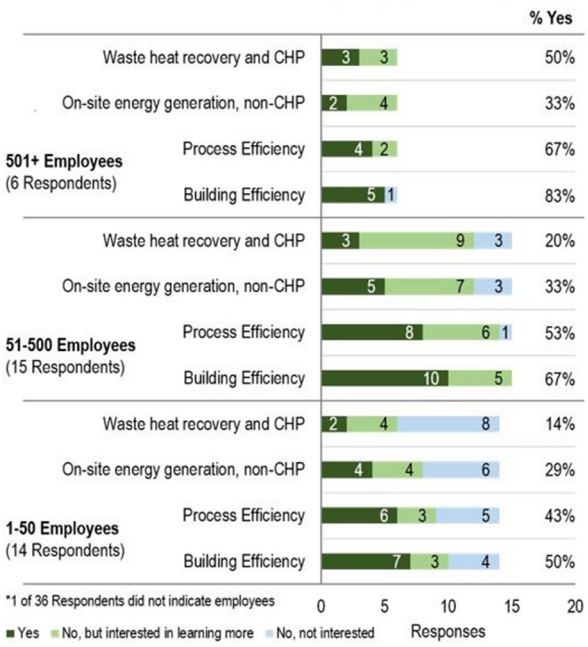
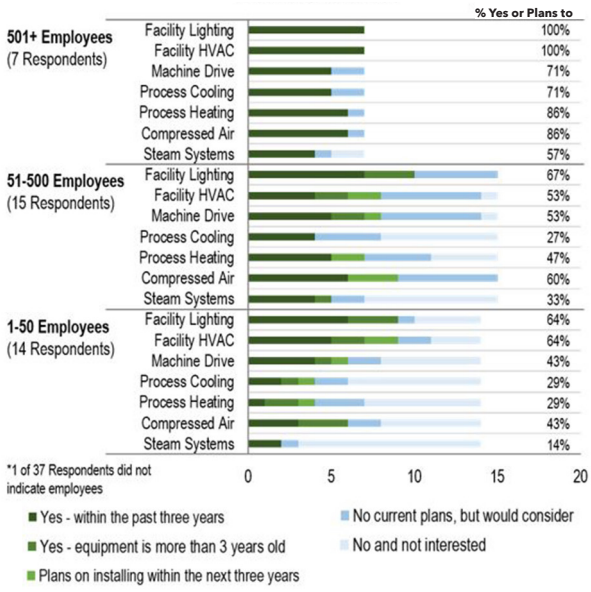


Figure 4-5 shows that large businesses are the most active group to have implemented equipment installations or retrofits. All of the large business respondents indicated that they have upgraded their facility lighting and HVAC systems. They are also the most active in pursuing process related improvements. Follow-up interviews show that large businesses also place great value and attention on identified low or no cost process efficiency improvements. Conversations with large businesses found that they work with their engineers and actively review energy consumption data to find more efficient ways to run their equipment and processes without the need to make capital investments.

FIGURE 4-5. EQUIPMENT INSTALLATIONS AND RETROFITS BY EMPLOYMENT RANGE



Medium-sized businesses showed less activity, but great interest in pursuing energy related upgrades, process improvements, and retrofits. There may be an opportunity to learn best practices from the large businesses to help the smaller companies better identify low or no cost process improvements. Similarly to the audit findings, medium-sized businesses may be a good target for the CEO to share informational resources and access to technical support that could benefit their organizations.

Common equipment upgrade and retrofit opportunities

- **Facility lighting** (e.g., occupancy controls, daylight harvesting, efficient lamp upgrade)
- **Facility HVAC system** (e.g., filters, belts, ducts, setback controls, equipment)
- **Machine drive** (e.g., variable speed drives, ramp speeds, motors, pumps, fans)
- **Process cooling and refrigeration systems** (e.g., insulation, VSDs, refrigerant pressure)
- **Steam systems** (e.g., boilers, burners, insulation, piping, steam traps)
- **Process heating systems** (e.g., insulation, burner, furnace, refractory)
- **Compressed air systems** (e.g., compressor, drain traps, leak management, equipment)

Colorado RES Eligible Resources

- Anaerobic Digestion
- Coal Mine Methane
- Geothermal
- Hydropower
- Landfill Gas
- Recycled Energy
- Solar
- Wind
- Woody Biomass
- Pyrolysis

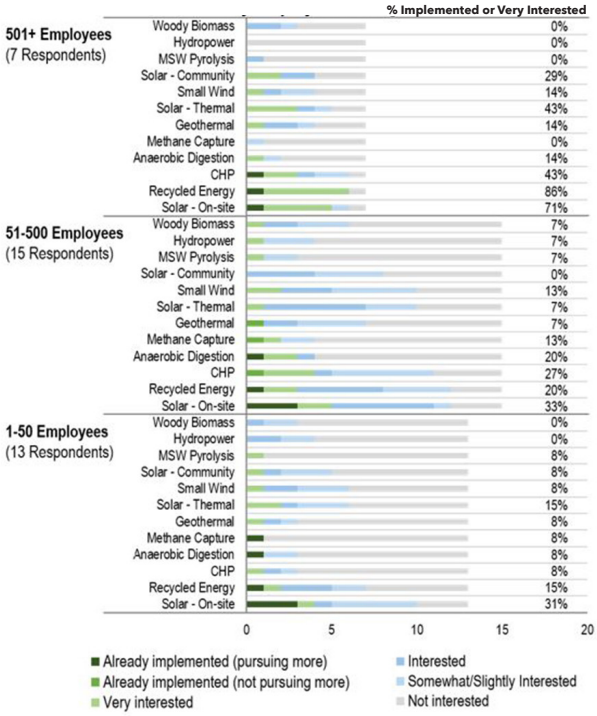
CEO RES Overview, colorado.gov/pacific/energyoffice/renewable-energy-standard

4.2.3 | On-site Energy Generation

Very few of the survey respondents have implemented on-site energy generation technologies. On-site solar electricity generation has the highest reported implementation at only 20% of the respondents. However, all of these respondents have indicated that they are pursuing more on-site solar.

Figure 4-6 breaks on-site energy generation responses down by business size. Large businesses indicated the highest levels of interest and implementation for on-site generation technologies. Follow-up conversations with large companies found that on-site generation helps them to achieve organizational energy and sustainability goals, however may only achieve cost parity with utility provided electricity. Small and medium sized companies on the other hand may have the opportunity to become net energy producers, as reported by a small plastics manufacturer with rooftop solar.

FIGURE 4-6. ON-SITE ENERGY GENERATION BY EMPLOYMENT RANGE



Many renewable technologies, such as solar, are readily available to industrial customers through now common financial mechanisms such as PPAs and a plethora of renewable electricity providers. Despite high interest, many industrial electricity consumers have not taken action. Follow-up interviews indicate that companies may be more inclined to do so if more informational resources were available or if they were more actively engaged by technical support groups or renewable energy providers. The system economics need to be evaluated on case-by-case basis and if there is a good value proposition, with low or no up-front cost to the consumer, industrial companies may be more inclined to pursue renewable electricity options.

Several of the renewable electricity options, included to align with the Colorado RES, are difficult to implement at an individual facility. Electricity from woody biomass or MSW pyrolysis could be purchased by industrial facilities, but is unlikely to be accessible or economically viable for on-site deployment. Other technologies, such as conduit hydropower, are process/industry dependent or require a suitable geographic location. Additionally, there are many requirements for renewable energy technologies to qualify for tax incentives and rebates, where those for EE may be more readily accessible to industrial customers.

Given the right process conditions, recycled energy and CHP systems offer a unique value proposition compared to the other technologies in that they can take advantage of waste heat to better utilize resources and save money. Although these technologies have only been implemented by a handful of companies there is considerable interest for these systems particularly from large and medium-sized businesses. Eight respondent companies representing 6 different industries were identified as having a steady heat source greater than 300°F or that they have deployed CHP or waste heat recovery technology. Information on these companies has been shared with the CEO Recycled Energy Program as an initial contact list. The program may increase engagement and success by reaching out to additional companies in the identified industries and applying lessons learned from previous engagements.

4.3 | Investment Barriers

Survey respondents were asked to evaluate the extent to which different factors acted as a barrier to investments in EE or DG projects. Nearly all of the suggested barriers were met with some level of disagreement from the survey respondents. The only three barriers with an average level of agreement were that they could not afford operational interruptions (agree), up-front development costs are too high (somewhat agree), and the ROI is too long (somewhat agree).

Findings indicate that the importance of a barrier varies widely depending on the amount of available resources (e.g., dedicated staff and funding for energy related projects) at industrial firms. Figure 4-7 organizes the suggested barriers by the number of employees at an organization. The results show that smaller businesses felt stronger agreement with the presented barriers compared to stronger disagreement from larger companies. This is likely reflective of the available resources of each business size.

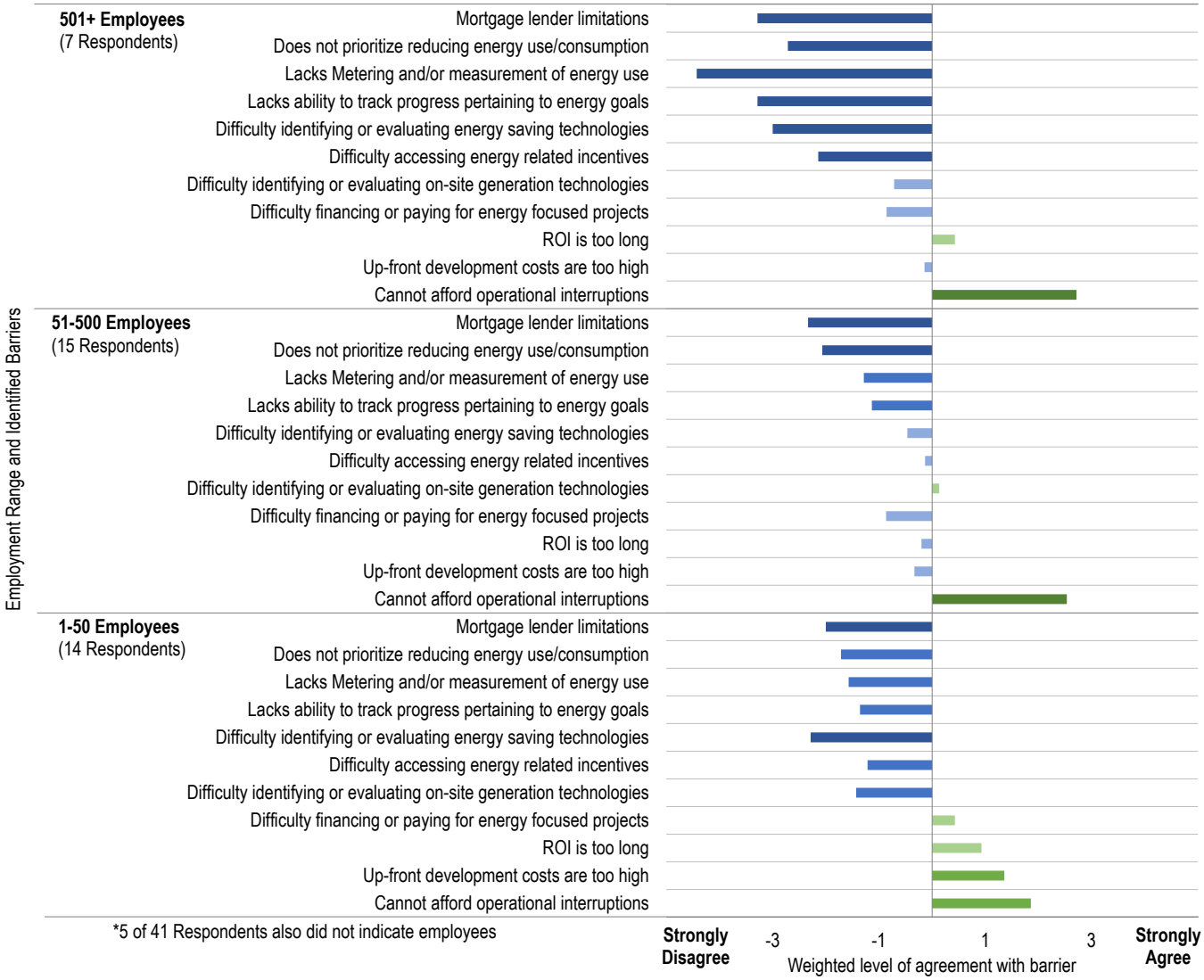
Follow-up interviews with the survey respondents shed light on the unique challenges, approaches, resources, and motivators pertaining to energy related investments at each firm. These findings are organized by business size in the following subsections.

Select Barriers to EE and DG Investments

- Organization does not prioritize reducing energy use/consumption
- Organization cannot afford operational interruptions
- Organization has difficulty identifying or evaluating energy saving technologies
- Organization has difficulty identifying or evaluating on-site generation technologies
- Organization has difficulty accessing energy related incentives
- Organization has difficulty financing or paying for energy focused projects
- Organization has mortgage lender limitations on external financing
- Return on investment is too long
- Up-front development costs are too high for my organization
- Organization does not have the ability to track progress pertaining to energy goals
- Organization lacks metering and/or measurement of energy use

Barriers based on US DOE Energy Efficiency Financing Navigator, *betterbuildingssolutioncenter.energy.gov/financing-navigator*

FIGURE 4-7. BARRIER IMPACT BY EMPLOYMENT RANGE (1-50; 51-500; 501+)



4.3.1 | Barrier Analysis – Large firms

Large firms (501+ employees) disagreed with nearly all of the proposed barriers in the survey. Follow-up interviews were very important to better understand their responses. The larger firms explained that while the proposed barriers were indeed challenges to various extents, there are several other factors that would deter or motivate them to make energy related investments.

Key Challenges:

- There is often a better ROI by expanding production or investing in other parts of the business.
- Internal funding requires multiple levels of approval throughout the organization for capital intensive projects. Simple payback is a key concern for some organizations.
- Large firms can only do so much with their available resources; time, priorities, and funding vary from year to year.
- Performance contracting needs to be well thought out and energy savings measurements must be accurate. These contracts may enable longer term investments; however industrial firms are skeptical of the terms and the complexity may be more trouble than it's worth.

Approach:

- Process optimization offers a low/no cost option for energy reduction at significant scales for large firms.
- Energy is a key consideration when replacing equipment or undergoing new construction.

- Firms commonly measure performance and ensure they have a thorough understanding of their equipment, its expected performance, and its limitations.
- Firms take advantage of normal maintenance cycles for upgrades.

Resources:

- Large firms often have dedicated staff and budgets for reducing energy consumption
- Data measurement and benchmarking are an essential part of day-to-day operations.
- Large firms have invested in internal and/or external energy management software.
- In some cases, the larger firms' utility actively engages the customer and helps them to identify and implement energy projects.
- EE goals are common for large firms and are set either at the plant or organizational level. This performance is directly monitored by senior measurement.

Motivators:

- Pressure from customers is driving some companies to be more active in EE and sustainability initiatives.
- The scale of large facilities makes energy consumption a significant cost for the firm. Small EE improvements can equate to large cost savings.

4.3.2 | Barrier Analysis – Mid-size firms

Mid-sized firms (51-500 employees) indicated more agreement that they have difficulty financing projects. The mid-sized firms elaborated on the proposed barriers and other factors that would deter or motivate them to make energy related investments.

Key Challenges:

- Only 1 out of the 7 companies interviewed had established general energy or sustainability goals, but even in that case specific performance metrics were not defined. Most companies face difficulty setting energy reduction goals at the corporate or site levels and identifying measurable parameters.
- A favorable ROI is required as part of any project justification, typically 2 to 5-year payback. In many cases, energy related projects alone do not offer a favorable ROI are therefore not prioritized over other investments.
- Staff assigned to energy projects are typically facilities engineers or managers that have more responsibility than managing energy alone.
- Funding for energy projects competes with other capital projects and is a main barrier.
- No formal approach or difficulty with measuring or tracking energy use.

Approach:

- Gradually implement small-scale projects with shorter ROIs and cause no interruptions to production.
- Implement a small demonstration project to observe benefits and get buy-in for a large-scale implementation.
- With long-term planning, integrate energy projects into on-going maintenance as operating expense projects and/or plan energy considerations into new construction or production projects.
- Conduct annual look backs or utility bill analysis to measure the impact of large projects.

Resources:

- The responsibility of energy related initiatives is in part assigned to someone on-site or within the company (although they may have other job requirements).
- Energy related decision are made by a team that is representative of multiple disciplines (e.g., engineering and finance) and both corporate and on-site staff.
- Sub-metering is used where possible to track and directly measure/verify energy use consumption and savings.

Motivators:

- The main focus of energy projects is to improve production, environmental quality, or meet compliance requirements.
- Potential cost reductions are a main driver for energy related projects.

4.3.3 | Barrier Analysis – Small firms

Responses from small firms (1-50 employees) tended more towards the center, "Neither agree nor disagree" than those of the mid-sized and larger firms. This indicates that small firms are less active in pursuing EE or on-site generation opportunities. Smaller firms also have fewer resources to dedicate to energy projects than their larger counterparts.

Follow-up interviews were very important to confirm these inferences and to learn more about the factors that deter or motivate small firms to make energy related investments. The smaller firms appear more nuanced than the barriers and motivators of larger firms and this diversity is seen in the factors below. These factors may be unique to one of the interviewed firms or were endorsed by several.

Key Challenges:

- There are no established energy or sustainability objectives, goals are generally focused on cost reduction and production.
- Informal staff structure with less rigorously defined roles. No one role is clearly responsible for energy management.
- A focus on day-to-day cash flow and limitations in available capital and annual budgets create challenges in justifying non-core business investments.
- Capital projects often require a favorable ROI (less than 2 years). Companies therefore often bypass energy opportunities that do not meet the requirement or compete with priority projects for funding.
- Resources are focused on daily business, leaving little time to develop expertise beyond the essentials or identify capital energy projects or finance opportunities.
- Measuring and tracking energy use is difficult due to a lack of infrastructure such as metering.

Approach:

- Attention is directed to project areas that increase revenue, these are often production related projects not energy projects.
- Consider projects with a quick ROI, these tend to be no and low-cost EE projects.
- Where possible replacing technologies with EE options is preferred when making upgrades.

Resources:

- External publications and trade shows to stay informed on new technologies.
- Using public tools like ENERGY STAR portfolio manager to help baseline energy consumption and understand how it compares to similar facilities.
- Working with the county on energy projects when assistance is provided. This helps make energy investments affordable.

Motivators:

- Cost savings is the primary driver for energy related projects (example: one small firm is incorporating waste-heat recovery into a production-line to reduce costs).

4.4 | Access to Information

The final questions of the survey and interviews gave respondents the opportunity to assess the educational value of the survey and offer any concluding remarks regarding the resources that would be most beneficial to industrial companies in Colorado. 73% of survey respondents found the lists of incentives, programs, funding options, and technologies shown in the survey to be helpful. Nearly half of the respondents also found that the information helped to increase their awareness of the available opportunities. Only small businesses responded that the information was not helpful or cumbersome to the survey.

Eleven out of the seventeen interviewees indicated in some way that easier access to information resources would be the most beneficial resource for them in regards to EE and renewable energy investments. Respondents seemed surprised by the amount of energy related support resources available and are interested in easier access to information resources regarding: technology recommendations and best practices; how to access audits, rebates, and tax incentives; funding opportunities; and partners to support all of the above energy related activities. The respondent firms indicated that they do not fully take advantage of those opportunities because information is scattered, the opportunities seem difficult to access, and they do not have time to dig through multiple sources to find suitable opportunities.

However, simply publishing information on energy related resources, rebates, and incentives is unlikely to significantly increase utilization by industrial firms. While, easy to navigate information on opportunities is necessary, a list alone will mainly help organizations with adequate resources to investigate those opportunities on their own. Active engagement from industrial EE programs, such as one that could be developed by CEO, is needed to build relationships with industrial firms and encourage them to take advantage of available EE and DG opportunities.

The following chapter discusses several EE and DG opportunities and provides strategies for both industrial firms to more effectively finance projects and for CEO to encourage greater investment.

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5 | Opportunities to Encourage Industrial Investments

A March 2017 report by the SEE Action Network discusses case studies of industrial energy efficiency programs at large US industrial corporations and the role of ratepayer-funded support programs.[49] The SEE Action Report identifies three key requirements for successful EE programs at industrial firms: 1) Corporate Commitment; 2) "Boots on the Ground"; and 3) Efficient Project Processing Systems. These requirements align with the findings in this report and particularly with those from the industrial survey and interviews, discussed in Chapter 4. The survey and interview findings would also suggest the addition of "Access to Information Resources" as a fourth requirement that enhances the three identified in the SEE Action Report.

The four requirements are briefly discussed here and throughout this chapter. Understanding these requirements and developing the appropriate behaviors and company processes needed to adhere to them could enable industrial firms to enhance their EE and DG efforts. Committed industrial firms can take advantage technical support programs, rebates and tax incentives, and accounting strategies that available from the local to the national level. Even firms that have committed to ambitious energy and sustainability goals have the opportunity to access additional resources that can multiply their efforts at low or no cost.

Diverse financing options can help industrial firms maximize the total return of their investments. In particular, internal and external financing sources can be leveraged to support both energy and non-energy projects while remaining cash flow positive from day 1.

Additionally, industrial energy engagement programs, such as one that could be developed by the CEO, can actively engage firms that participate in its programs and those that it wants to recruit. By building trusting, multi-year relationships, an industry energy engagement program can cooperate with industrial firms to develop a strong long-term portfolio of high-impact projects. Active cooperation between industrial firms and programs can increase EE and DG investments in Colorado.

Requirements for Successful Energy Management Programs at Industrial Firms

1. Corporate Commitment Organization
2. "Boots on the Ground"
3. Efficient Project Processing Systems
4. Access to Information Resources

Requirements 1-3 based on SEE Action Network findings and validated by the industrial outreach survey and interviews discussed in this report. Requirement 4 added based on additional research findings.

Requirement 1: Corporate Commitment

"Senior management needs to signal clearly to staff that improving EE is a corporate goal that both plant managers and their staff should care about. This is best achieved by establishing clear EE-improvement targets and making plant management and staff accountable for achieving them." – SEE Action Report

This requirement is reinforced by findings from the industrial surveys and interviews. Large corporations are most likely to participate in public commitment programs such as CIEC or those run by DOE, establish corporate energy and/or sustainability goals, and hold staff accountable for energy and sustainability related initiatives. Small and mid-sized companies reported a much more passive attitude towards energy use and consumption. It is also less likely for small and mid-sized firms to have an individual or group that is expected to consider energy use as part of their normal job responsibilities, let alone the dedicated personnel or budgets found at larger firms. Without commitment and direction from senior management, energy projects are often ignored altogether or considered secondary to other priorities.

Requirement 2: "Boots on the Ground"

"Competent staff or outsourced or borrowed experts must work at the facility-level to continually identify site specific, profitable EE measures and to follow through with implementation. Although a maintenance manager may have interest in energy efficiency, it naturally ranks below other priorities of multi-tasked staff, such as keeping production lines moving. Unless someone is available who has the necessary time and competence to put EE projects together, they are not likely to be undertaken." – SEE Action Report

49 Glatt, S. Dutrow, E. "Saving Energy in Industrial Companies: Case Studies of Energy Efficiency Programs in Large US Industrial Corporations and the Role of Ratepayer-Funded Support." SEE Action Network: Industrial Energy Efficiency and Combined Heat and Power Working Group. Published March 2017. Available from, eere.energy.gov/seeaction/system/files/documents/saving_energy_industrials_0.pdf

Once senior management has established a strong corporate commitment to improving EE and DG there must be staff to execute on those commitments. Depending on a firm's available resources they may or may not be able to commit a full-time employee or team of engineers to identify EE and DG improvements, even in cases where the cost-savings of the improvements more than cover those staff's salaries. The SEE Action Report identifies several approaches industrial firms can take to ensure that have the necessary "boots on the ground" for energy initiatives including: dedicated energy engineers; outsourced experts from local utilities placed at key facilities; and a mix of roving EE engineering staff with part-time, on-site energy champions, interns, and experts supported by technical assistance programs. Additionally, third-party auditors or technical assessment personnel may be available as part of a specialty financing process, as is the case with the PACE, EPC, and ESA mechanisms.

For any energy management professional, familiarity with the equipment/process potential, and actively measuring process performance is essential to identifying savings opportunities. While not always plausible for an organization, the SEE Action Report found that a staff member with full-time responsibility for EE work can be more productive than two engineers charged with overseeing EE work part-time. Regardless of how potential EE and DG improvements are identified, at a minimum an energy champion is needed to help push projects through the myriad stages before, during, and after implementation. This champion is unlikely to emerge without the clear corporate commitment and accountability described in Requirement 1.

Requirement 3: Efficient Project Processing Systems

"Effective internal systems need to be in place and smoothly operate to allocate financing for portfolios of EE measures deemed to be most attractive to the company. Project development and implementation slows when an inordinate amount of time is needed for internal processing of good EE projects, when basic energy cost saving project rationale needs to be explained over and over, and when even the best projects have uncertain outcomes." – SEE Action Report

Once a clear corporate commitment and personnel responsibility/accountability have been established, an organization needs efficient processes to ensure that EE and DG projects do not get entangled in internal bureaucracy or indecisiveness. The survey and interviews found that larger firms are able to dedicate annual budgets to EE and DG projects and have approval processes established for their energy managers to follow. Although these dedicated budgets offer greater autonomy, even energy managers with these resources cited difficulty getting some projects approved and suggested focusing on low/no cost improvement measures, such as process optimization, to avoid the need for large capital expenditure approvals when possible.

Collaboration between internal groups at larger organizations, such as between finance and engineering, may strengthen the transparency and understanding of EE/DG cost-savings benefits and increase enthusiasm for investments. At smaller organizations where fewer individuals take on multiple responsibilities, a clear set of investment criteria can help to establish guidelines for new projects. For all firms, energy criteria should be established as a factor for new construction projects and equipment purchases. Developing processes and best practices to account for energy consumption from the start of a project can lead to significant lifetime energy cost savings and fewer retroactive investments.

Requirement 4: Access to Information Resources

There is a vast array of incentives, rebates, technical support programs, financing mechanisms, and case studies available to industrial firms. The survey and interviews showed that firms have difficulty accessing external resources even in cases where there is strong corporate commitment, dedicated staff, and internal processes for identifying and investing in EE and DG projects. Many companies expressed great interest in CEO or another trustworthy entity to maintain an up-to-date website where one can access information on the various resources and partners that can help to finance, implement, and support EE/DG improvements. The companies expressed particular interest in clearly articulated eligibility requirements and benefit levels for tax incentives and rebate programs.

While simply publishing a list of available resources may not increase EE/DG investment on its own, committed industrial firms need up-to-date and accurate information available to support their personnel, accelerate their processing systems, and inform their decision-making. As discussed in Section 5.3, active engagement between company staff and technical support programs (including CEO) is needed to increase awareness and use of the available resources.

5.1 | Resources Available to Industrial Firms in Colorado

5.1.1 | Support Programs

There are numerous local, state, and federal support organizations, programs, and initiatives designed to encourage EE and DG investments. These programs range from strictly information resources to those that offer funding, free audits, or connections to financing opportunities and partners. The local programs tend to have a strong focus on rebates, financing options, and local contractors. The federal programs on the other hand position themselves more as information hubs to share best practices and help verify voluntary energy and sustainability targets.

Table 5-1 provides a brief summary of local technical support programs in Colorado. These programs are only available to industrial firms that operate in those areas. The local programs tend to provide more hands-on support than state and federal programs and may be a very useful resource for eligible industrial firms to take advantage of.

TABLE 5-1. LOCAL TECHNICAL SUPPORT

Local Technical Support Programs	
Boulder EnergySmart Commercial EE Rebate Program	
Expert energy advisors available to help businesses navigate incentives, and make appropriate energy efficient purchases for their firms. EnergySmart offers free technical support and helps businesses conduct energy assessments, prioritize projects, connect with contractors, and find and apply for incentives.	Bill Hayes, Commercial Team (303) 441-1574 bhayes@bouldercounty.org Rebate Information: (303) 786-7223 info@PACEpartners.com **Useful Links:** • Partners for a Clean Environment • EnergySmart for Business • DSIRE Overview
Boulder Small Business Development Center	
Provides business consulting services to Boulder start-ups. The Center maintains direct links with EnergySmart, ensuring members gain access to any incentives, rebates, and financing programs for EE projects.	(303) 442-1475 Request Appointment **Useful Links:** • Boulder Small Business Development Center
Certifiably Green Denver	
Free sustainability advising and certification to businesses, including industrial firms, throughout Denver County. Low-cost energy loans available through Elevations Credit Union or up to 100% financing through C-PACE for eligible projects.	Janet Burgesser, Program Manager (720) 865-5457 certifiablygreendenver@denvergov.org **Useful Links:** • Sign up now • Certifiably Green Denver • Elevations Credit, Energy Loans
Garfield Clean Energy Challenge	
Provides energy coaches to help businesses track energy use, get an on-site energy evaluation, develop an energy action plan, and access rebates and incentives. Resources available to identify contractors and learn about rebates, incentives, and financing.	Contact a Free Energy Coach (970) 704-9200 ActNow@GarfieldCleanEnergy.org **Useful Links:** • Sign up now • Garfield Clean Energy Challenge • Utility and Community Rebates
Efficiency Works – Estes Park, Ft. Collins, Longmont, and Loveland	
Offers free facility assessments, efficiency rebates, and access local Efficiency Works Providers to implement energy efficiency projects. Helps with energy action planning and support tracking energy use.	(877) 981-1888 info@efficiencyworks.co **Useful Links:** • Efficiency Works for Business • Efficiency Works Providers • Case Studies • Custom EE Rebate Guideliness

Table 5-2 provides a brief summary of statewide technical support programs in Colorado. Depending on the program, industrial firms can access purely informational resources with limited hands-on support or actively implement energy related best practices and pursue EE goals. One of these programs, the Colorado Industrial Energy Challenge (CIEC), has helped to demonstrate the value of establishing, actively pursuing, and measuring progress towards energy related goals. Firms that chose to participate in the program from 2010 to 2013 reported an average of 9.7% reduction in energy usage.

TABLE 5-2. STATEWIDE TECHNICAL SUPPORT

Statewide Technical Support Programs	
Colorado Green Building Guild	
Industrial businesses can learn about commercial EE/DG project financing and identify certified contractors that carry out projects in CO. Limited hands-on support. Website provides information about local contractors, case studies, rebates, incentives, financing, and EE rating systems.	Ann Livingston, Interim Executive Director ann@coloradogreenbuildingguild.org info@bgbg.org **Useful Links:** • Colorado Green Building Guild • Incentives & Rebates
Colorado Industrial Energy Challenge (CIEC)	
Voluntary program that challenges industrial companies in Colorado to set a five-year energy efficiency goal and to implement energy related best practices at their facilities. Provides some technical expertise and has built networking opportunities, energy audits, specialized trainings, and participant recognition into the program to help participating firms achieve their goals.	Michael Turner, Colorado Energy Office (303) 866-6665 michael.a.turner@state.co.us Neil Kolwey, Southwest Energy Efficiency Project (303) 499-0213 nkolwey@swenergy.org **Useful Links:** • CIEC - SWEEP • CIEC – US DOE
Southwest Industrial Energy Efficiency Project (SWEEP)	
Advocacy organization that focuses on energy policy and also works as a service organization with industrial firms to help implement energy efficiency and energy cost saving measures. SWEEP leads CIEC and works regularly with CEO.	Neil Kolwey, Senior Associate, Industrial Program (303) 499-0213 nkolwey@swenergy.org info@swenergy.org **Useful Links:** • SWEEP

Table 5-3 provides a brief summary of federally administered technical support programs. The technology specific programs, such as the Southwest CHP Technical Assistance Partnership, offer valuable resources and connections to hands-on support for industrial firms with waste-heat recovery opportunities. In other cases, programs such as the Better Plants Challenge and the Superior Energy Performance Program are more suitable for larger firms with significant energy footprints. These voluntary programs require a strong commitment from participating industrial firms, but due to their rigor also have a much greater energy savings potential than those resulting from other programs.

TABLE 5-3. FEDERAL TECHNICAL SUPPORT

Federal Technical Support Programs		
US DOE Southwest CHP Technical Assistance Partnership		
Offers project support for three on-site generation technologies that are applicable to industrial firms: 1) Co-generation; 2) Waste heat to power; and 3) District energy. Helps to assess the technical feasibility and economic viability of implementing the aforementioned technologies.	Gavin Dillingham, PhD SW CHP TAP Director (281) 216-7147 gdillingham@harcresearch.org **Useful Links:** • CHP TAP Project Support • CHP TAP in Colorado • EPA CHP Incentives Database	
US DOE Better Plants Challenge		
A voluntary initiative where industrial firms participate in "showcase projects" (near-term demonstrations of significant energy savings individual facilities) or develop "implementation models" (corporate best practices that overcome barriers to EE).	**Useful Links:** • Better Plants Program • Better Plants Challenge • Better Buildings 2016 Progress Report • Contact US DOE Better Buildings	
US DOE State and Local Energy Efficiency Action Network		
SEE Action is an advocacy group for best practices and policies that encourage EE projects in the industrial sector. The group shares its findings with local and national policy makers to encourage EE policies and support for industrial and manufacturing firms in the US.	Johanna Zetterberg SEE Action Network Coordinator johanna.zetterberg@ee.doe.gov **Useful Links:** • SEE Action Network	
US DOE Industrial Assessment Centers (IAC)		
Located at 28 US universities, IACS conduct free energy audits for manufacturers. Colorado currently does not have an active IAC, however the searchable IAC database provides information on 17,838 energy assessments and 135,303 recommendations.	John Smegal, IAC Coordinator (202) 287-6225 john.smegal@ee.doe.gov **Useful Links:** • US DOE - IACs • IAC Project Database • IAC Locations • IAC Top Ten EE Recommendation	
US DOE Superior Energy Performance Program (SEP)		
Provides guidance, tools, and protocols to drive deeper, more sustained savings from the ISO 50001 energy management standard. Certification has shown benefits such as 12% reduction in energy costs within 15 months of implementation, 5 to 30% improvement in energy performance over 3 yrs, and paybacks of less than 1.5 yrs.	Paul Scheihing (202) 586-7234 paul.scheihing@ee.doe.gov superiorenergyperformance@ee.doe.gov **Useful Links:** • SEP Program • SEP Business Case • Verification Bodies • 2017 Standards & Protocols • ISO 50001	

Colorado Electric Utilities, General Resources

Investor Owned Utilities

- Xcel Energy
- Black Hills Energy

Cooperative Utilities

- Colorado Rural Electric Association
- Tri-State Generation and Transmission

Public Power and Municipal Utilities

- Colorado Association of Municipal Utilities
- Platte River Power Authority
- Western Area Power Authority
- Municipal Energy Association of Nebraska
- Arkansas River Power Authority

Other Useful Links

- CEO, Electric Utilities
- Colorado Utilities Report (2010)

5.1.2 | Utility Programs and Rebates

Utilities present another opportunity for industry firms to access EE and DG cost savings. Most utilities in Colorado offer free or low-cost energy audits to help firms assess how much energy they are using and to identify ways in which energy usage can be reduced. Many utilities also offer rebates to encourage firms to buy energy efficient products, or to introduce energy efficient practices at their facilities.

Colorado has two investor owned utilities (IOU), Xcel Energy and Black Hills Energy, along with 22 rural electric coops, and 29 municipal utilities. Links to general information on these utilities can be found in the call out box above. Industrial firms should become familiar with their electricity provider to understand what incentives and rebate options are available in their service territory. Additionally, the cost of electricity may vary from territory to territory, which may impact the return on investment for EE and DG projects at facilities in those areas.

The two IOUs, Xcel Energy and Black Hills Energy are the two largest utility providers in the state of Colorado. Summarized in Table 5-4, Xcel offers a host of rebate and energy audit programs and also help connect customers to third-party financing programs for EE and DG investments. Summarized in Table 5-5, Black Hills has several incentive and rebate programs including those for solar power, commercial energy efficiency, and natural gas technologies.

TABLE 5-4. XCEL ENERGY OFFERINGS

Xcel Energy Audits, Rebates, Loans, and Incentive Programs	
Energy Analysis Program, Audit Options	
The Xcel Energy Analysis program offers three audit options that provide information about EE/DD options and the associated costs and paybacks.	**Useful Links:** • Xcel Energy Analysis • Online Energy Assessment • On-site Audit Application Form • Engineering Assistance Form
Commercial Energy Efficiency Rebates	
Offers a variety of rebates on EE technologies. Xcel also covers 75% of recommissioning costs up to $25,000 and can connect business customers to third-part lenders if desired.	Inquire@xcelenergy.com **Useful Links:** • Equipment Rebates • DSIRE Overview
Commercial Energy Efficiency Loan Financing	
A lending referral program through HBC Energy Capital to. Rates between 4.25% to 7% for projects between $150 thousand and $1.5 million over contracts of 1 to 10 yrs.	info@hbcenergycapital.com **Useful Links:** • Xcel Commercial EE Financing • HBC EE Finance Request Form • DSIRE Overview
Solar Rewards Program	
Xcel offers both small (less than 25 kW) and medium (25-500 kW) capacity options and will purchase excess energy.	**Useful Links:** • Solar Rewards for Business • Solar Rewards Application Portal • Solar Providers
Xcel Recycled Energy Incentive	
Incentive of $500/kW of recycled energy system capacity installed paid monthly over 10 yrs at a rate of approximately $0.012/kWh. Projects must be preapproved and can be up to 10 MW.	Renewables@xcelenergy.com **Useful Links:** • Xcel Recycled Energy • Xcel Recycled Energy Fact Sheet • CEO - Recycled Energy

TABLE 5-5. BLACK HILLS ENERGY OFFERINGS

Black Hills Energy Incentives and Rebate Programs	
Solar Power Program	
Performance based incentive for solar PV systems up to 100 kW in capacity. Offers a 10 yr term and incentives of $0.05 to $0.075 per kWh depending on the size.	**Useful Links:** • Black Hills - Solar • DSIRE Overview
Commercial Energy Efficiency Rebates	
Offers both prescribed and custom rebates to commercial customers that install or upgrade to energy efficient equipment recommended by an energy evaluation. Covers 50% of equipment and labor cost up to $40,000 per facility per year.	**Useful Links:** • Black Hills - EE Rebates • DSIRE Overview
Excess is Out Rebate Program (via Colorado Natural Gas)	
Offers various natural gas related energy efficient equipment rebates. Prescriptive incentives for most of the technologies. Covers up to $50,000 for all the available technologies.	excessisout@egia.org **Useful Links:** • Excess is Out • DSIRE Overview

There are currently 22 rural electric coops serving the state of Colorado with a combined service territory that covers over two thirds of the state's land. Tri-State Energy Generation generates electricity for 18 of these entities while the remaining coops receive their energy from Xcel. Coops are mission driven, nonprofit organizations that are often highly committed to energy efficiency and distributed generation efforts. Many of the coops in Colorado have rebate programs, energy savings tips, and other incentives for on-site energy generation. Table 5-6 provides a very brief summarization of the offerings at each coop.

Colorado is home to 29 municipal utilities that serve nearly half a million people across the state. These utilities typically operate as self-supporting city divisions or authorities. Some utilities provide informational resources on their website and/or have technical support staff available as part of EE programs as in the Efficiency Works program. In another example, the Colorado Springs Utilities offers free basic and advanced energy audits to customers and provides various EE rebates. Regardless of the publicized opportunities, or lack thereof, industrial firms should contact their utility to better understand the opportunities are or can be made available to them. Table 5-7 provides a very brief summarization of the offerings at each utility.

TABLE 5-6. RURAL ELECTRIC COOPS – REBATES, PROGRAMS, AND INCENTIVES SUMMARY

Rural Electric Coop	Rebates, Programs, Incentives
Delta-Montrose Electric Assn.	Various EE rebates available
Empire Electric Association	Various EE rebates available
Grand Valley Rural Power Lines	Solar farm, on-site generation options, energy help desk
Gunnison County Electric Assn.	Energy audits available Various EE rebates available
Highline Electric Association	Energy audits available Various EE rebates available
Holy Cross Energy	Energy audits available Various EE rebates available
Intermountain Rural Electric Association	Energy audits available
K.C. Electric Association	Various EE rebates available
La Plata Electric Association	Various EE rebates available
Morgan County Rural Electric Association	Energy audits available Rebates on heat pumps
Mountain Parks Electric Inc.	Rebates on lighting and net metering
Mountain View Electric Association, Inc.	Various EE rebates available
Poudre Valley Rural Electric Association, Inc.	Various EE rebates available
San Isabel Electric Association	Rebates on heat pumps and A/C
San Luis Valley Rural Electric Cooperative, Inc.	Various EE rebates available Advanced metering options available
San Miguel Power Association	Rebates on lighting and weatherization
Sangre De Cristo Electric Association	Business energy advisor website Various EE rebates available
Southeast Colorado Power Association	Renewable Energy Credit (REC) contracts; Net metering options available
United Power, Inc.	Rebates for water heaters and heat pumps
White River Electric Association	Net metering options available Hydropower and solar options available
Yampa Valley Electric Association	Energy audits available Various EE rebates available Community solar and other initiatives
Y-W Electric Association, Inc.	Various EE rebates available

TABLE 5-7. MUNICIPAL UTILITIES – REBATES, PROGRAMS, AND INCENTIVES SUMMARY

Municipal Utilities	Rebates, Programs, Incentives
Aspen Municipal Electric System	Rebates on EE purchases up to 50% of project costs
Burlington Municipal Light & Power	None identified, contact utility
Center Municipal Gas Light & Power	None identified, contact utility
City of Fountain Utilities	None identified, contact utility
Colorado Springs Utilities	Energy audits available Various EE rebates available
Delta Municipal Light & Power	None identified, contact utility
Estes Park Light & Power	Efficiency Works Program
Fleming Electric Light Department (no website)	None identified, contact utility
Fort Collins Utilities	Efficiency Works Program
Fort Morgan Electric Light	Energy Smart Lighting Program
Frederick Municipal Light System	None identified, contact utility
Glenwood Springs Electric System	Appliance Rebates
Granada Utilities	None identified, contact utility
Gunnison Light & Water Department	None identified, contact utility
Haxtun Municipal Light & Power (no website)	None identified, contact utility
Holly Light & Power	None identified, contact utility
Holyoke Municipal Light & Power (no website)	None identified, contact utility
Julesburg Municipal Light & Power	None identified, contact utility
La Junta Municipal Utilities	None identified, contact utility
Lamar Light & Power	Business Energy Partners Program
Las Animas Municipal Light & Power	None identified, contact utility
Longmont Power & Communication	Efficiency Works Program
Loveland Water & Power	Efficiency Works Program
Lyons Municipal Light & Power	None identified, contact utility
Oak Creek Municipal Utilities	None identified, contact utility
Springfield Municipal	None identified, contact utility
Trinidad Municipal Power & Light	None identified, contact utility
Wray Light & Power	None identified, contact utility
Yuma Municipal Light & Power	Energy calculator

5.1.3 | Tax incentives

Tax incentives offer another way for industrial firms to offset costs related to EE and DG projects. There are several local, state, and federal tax incentive programs specifically designed for EE and DG projects that can provide substantial savings for investments.

Incentives may be applied as credits against a firm's tax liability, exemptions that reduce a firm's taxable income, or as refunds. Additionally, there are incentives for how equipment listed as an asset on an industrial firm's balance sheet is treated and depreciated. Tax codes are often fairly complex and qualified certified public accountants (CPA) with expertise in the application of energy incentives may help to maximize a client's savings. Table 5-8 provides a very brief summarization of tax incentives available to industrial firms in Colorado.

Investment tax credits (ITC) can help reduce the effective up-front costs for energy efficient equipment by reducing a firm's tax liability. The ITC is calculated as a percentage of the purchase price of energy efficient equipment. Also, it is a credit, as opposed to a deduction, so it is used directly to

TABLE 5-8. TAX INCENTIVE SUMMARY

Colorado EE and DG Tax Incentive Summary	
Business Energy Investment Tax Credit (BEITC) – Federal	
May be applied to various EE and DG equipment purchases and ranges from 10% to 30% depending on the technology, declining through 2022.	**Useful Links:** • Federal ITC • Federal Tax Form • DSIRE Overview
Enterprise Zone Investment Tax Credit – State	
A 3% investment tax credit may be applied to qualified EE and DG investments located in a Colorado Enterprise Zone.	**Useful Links:** • CO - EZ ITC • CO - DOR • DSIRE Overview
Modified Accelerated Cost-Recovery System (MACRS) Depreciation	
Businesses may recover investments through depreciation deductions. Certain DG technologies are classified as either 5-yr or 7-yr property and may qualify for up to 50% first year bonus depreciation.	**Useful Links:** • MACRS - IRS Bulletin • DSIRE Overview
Renewable Energy Production Tax Credit – Federal	
Inflation-adjusted per-kWh tax credit for electricity generated from qualified sources and sold to an unrelated person during the taxable year. Only wind projects are eligible for projects that commenced construction after December 31, 2016.	**Useful Links:** • IRS PTC Tax Form • IRS PTC Details • DSIRE Overview
State Sales Tax Exemption for Renewable Energy Equipment	
Colorado exempts up to 100% of the sales tax on eligible EE and DG technologies. Local taxes may still apply, although localities are encouraged to exempt.	**Useful Links:** • CO Sales Tax Exemptions • County Government Directory • Colorado Municipal League • DSIRE Overview
State Property Tax Exemption for Renewable Energy Equipment	
Counties and municipalities are authorized to offer property tax rebates or credits to property owners that install renewable energy systems on their property. Incentive varies by locality.	**Useful Links:** • DSIRE Overview • County Government Directory • Colorado Municipal League
Renewable Energy Property Tax Assessment	
DG technologies will be incorporated into a property's assessed value. The Renewable Energy Property Tax Assessment methodology attempts to minimize the amount of increase passed on to property tax bills.	**Useful Links:** • CO, DOLA - RE Property Assessment • DSIRE Overview

reduce the tax liability, and not to reduce the taxable income upon which the liability is based. Some ITCs offer carry over provisions that allow the credit to be applied in subsequent years or are refundable and pay out cash payments to firms over time.

The Federal Renewable Energy Production Tax Credit (PTC) is primarily designed to encourage utility-scale renewable energy investments and electricity generated from qualified sources must be sold to an unrelated person during the taxable year to qualify. Industrial firms interested in consuming the electricity they generate on-site may be more interested in the Federal energy ITC.

Industrial firms should be aware of local policy when considering Colorado state sales tax and property tax exemptions. Although the state exempts up to 100% of sales tax on eligible EE and DG technologies, Colorado counties and cities must choose to adhere to this incentive as well. Likewise, property tax rebates and credits are offered locally and may vary.

Another important consideration for tax incentives is equipment ownership. If an industrial firm finances an EE or DG project and is the outright equipment owner they may claim any local, state, or federal incentives. Those incentives may go to the financer if the project is being financed through a third-party, however this typically enables the financer to offer a more competitive rate.

5.1.4 | Financing Options for DG and EE

There are many ways to finance EE and DG projects. These financial products, shown in Figure 5-1, include traditional funding methods, such as: internal funding, equipment leases, and commercial bank loans; newer specialized financing approaches, such as: power purchase agreements (PPA), on-bill financing and repayment (OBF/OBR), Commercial Property Assessed Clean Energy (C-PACE), Energy Performance Contracts (EPC), and Energy Services Agreements (ESA/MESA); and government loan and grant programs. Each funding approach has advantages and disadvantages and should be evaluated on case by case basis. This section briefly discusses the various funding options, however Chapter 5.2 provides more strategic recommendations to successfully achieve EE and DG projects.

FIGURE 5-1. ENERGY EFFICIENCY FINANCING LANDSCAPE (US DOE FINANCING NAVIGATOR)

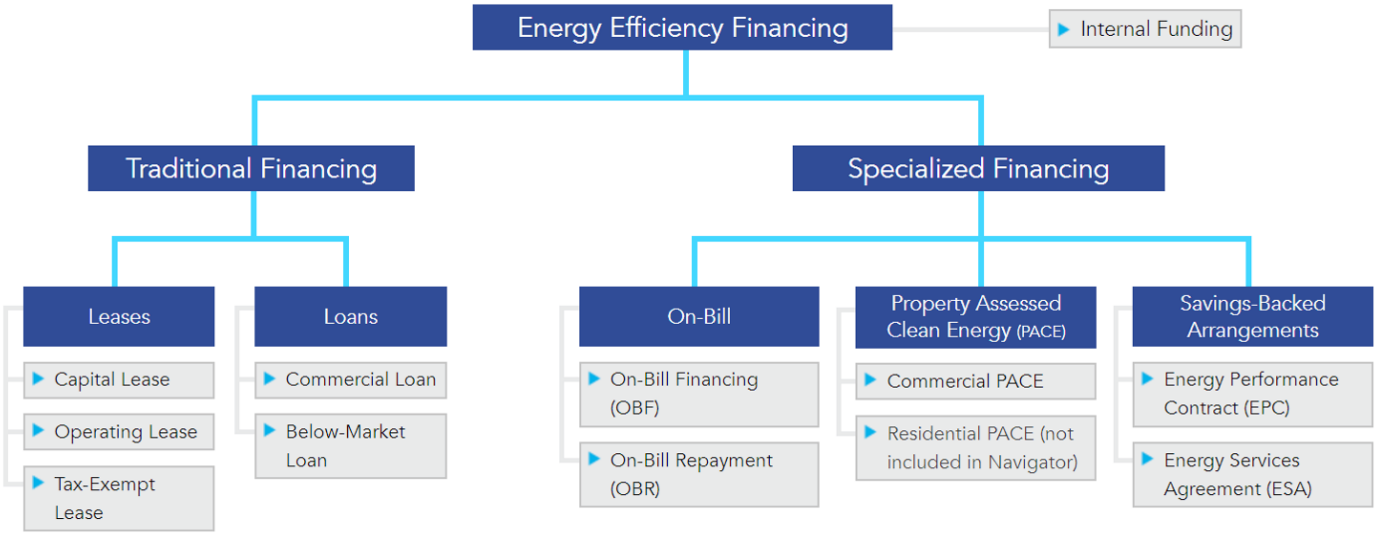


Figure from betterbuildingssolutioncenter.energy.gov/financing-navigator/explore

The traditional funding approaches require available capital resources up-front and/or the ability to pay off leases or loans over time. Conversely the specialized financing approaches may enable an organization to avoid capital expenditures all-together, however the cost reductions from energy savings must be shared with the funding provider over the duration of the agreement.

Internal funding offers the quickest and simplest option for industrial firms to finance EE/DG projects at their facilities. Internal financing allows the organization to capture the full cost-savings of energy efficiency rather than paying a portion to a financing provider. Unfortunately, not all organizations have sufficient resources to dedicate staff time and budgets towards energy related initiatives and in these cases external funding and third-party support may be necessary to enable projects. Additionally, organizations may find benefits in external financing options on low-complexity projects with easily verifiable energy savings to free internal capital for use on competing business priorities.

Traditional financing sources include banks and credit unions who issue loans and lines of credit, as well as leasing companies, or manufacturers, who provide lease options to their customers. A benefit of traditional sources is the ease with which these programs may be accessed.

In addition to the traditional financing options that are used to fund a variety of goods and services, there are specialized financing options that are specifically designed for EE and DG projects. These products come in various forms designed to mitigate or address barriers specific to energy investments. In particular, some specialized products guarantee energy savings, can be cash flow positive from day one, can be administered off a firm's balance-sheet, can be transferable, or offer longer repayment terms than traditional options. However, the specialized mechanisms often take longer to put in place because they are more complex and less familiar to industrial companies and financial institutions than traditional funding options. Additionally, the process complexity and multiple variables that may influence energy consumption at an industrial facility can make it extremely difficult to agree upon a methodology through which energy savings can be accurately quantified and attributed toward an "energy savings guarantee". Therefore, while specialized financing products have significant benefits that may expand access to capital for energy related investments, projects should be evaluated on a case-by-case basis to minimize complexity and find the most suitable financing option.

PPAs (not shown in the figure) allow electricity customers to avoid up-front capital expenses for renewable energy systems by agreeing to pay a fixed price for each kWh produced over a contract term (10-25 years) to an independent power producer or electric utility. PPAs are most commonly associated with roof based solar arrays in which a developer will retain ownership to the equipment and sell the power back directly to the customer or utility. PPAs are the most common form of distributed generation undertaken by industrial firms in Colorado and are useful for firms of all sizes to help offset electricity consumption.

On-bill financing (OBF) and On-Bill repayment (OBR) are financing options in which a utility or private lender finances an EE project and is repaid through regular payments on an existing utility bill. On-bill programs typically offer attractive terms such as low-to-zero interest rates, flexible repayment terms ranging from 2 to 15 years, is suitable for customers in leased space, and can be transferrable. Several states have enacted legislation to create on-bill pilot programs or to require utilities to offer on-bill options to their customers, however this has not occurred in Colorado. Utilities have the right to introduce OBF/OBR options for their customers and industrial firms interested in OBF/OBR should contact their utility to determine what options may be available.

Commercial property-assessed clean energy, or C-PACE, enables owners of Eligible Commercial & Industrial Buildings to finance up to 100% of energy efficiency, renewable energy and water conservation eligible improvements. Financing is provided by private capital providers at competitive rates with repayment terms up to 20 years. Repayment is facilitated through the county property tax assessment process and in most cases the annual energy cost savings will exceed the annual assessment payment, thereby enabling capital intensive equipment upgrades. The C-PACE program is relatively new to Colorado with 15 counties currently participating and 7 counties in-discussion to join as of May 4, 2017. C-Pace financing may be highly suitable for complex, difficult-to-measure, projects when internal funds are not available because although it does not guarantee energy savings, it also does not require the firm to share a fixed portion of those savings with the financing provider.

An Energy Performance Contract (EPC), is a type of agreement in which an energy service company (ESCO) coordinates installation and maintenance of efficiency equipment in a customer's facilities and is paid from the associated energy savings. Although EPCs can help to increase the amount of funding attributed towards energy related initiatives and have become common in the commercial building space, industrial firms have been hesitant to enter into agreements due to the long contract terms and skepticism of the arrangements for M&V of energy savings and payment structure. Additionally, EPCs require some internal capital or third-party financing to cover up-front costs.

An Energy Services Agreement (ESA) is a pay-for-performance, off-balance-sheet financing option with no up-front capital expenditure. In an ESA, the provider will obtain financing to acquire the equipment and pay for and manage a contractor for installation, maintenance, and M&V of actual energy savings compared to baseline energy use throughout the contract period. Due to contract complexity, close times can take 9-12 months and providers focus on large projects ($1M+). However, ESAs can be a highly valuable, and practical, option for financing common building upgrades or equipment improvements that are easily measurable and of a sufficient scale.

Government programs represent a unique alternative to the private market and can offer highly competitive loan rates or simply will provide grants to fund projects of interest. These funding streams often requires an ability to deal with government bureaucracies and long timelines for contracts, funding, and approvals. Additionally, these programs have highly specific requirements that may only be relevant to a small portion of industrial firms in CO.

There are two hydropower loan programs in Colorado. The Colorado Water Conservation Board (CWCB) administers the Water Project Loan Program and the Colorado Water Resources & Power Development Authority (CWRPDA) administers the Small Hydropower Loan Program. The CWCB program is applicable to both private and public entities, whereas the CWRPDA program may only be industrially relevant for Colorado government owned wastewater treatment facilities. Each program finances a broad array of water related technologies, however the most applicable technology is likely for conduit hydropower projects. Conduit hydropower fits electric generating technology in pipelines that carry water.

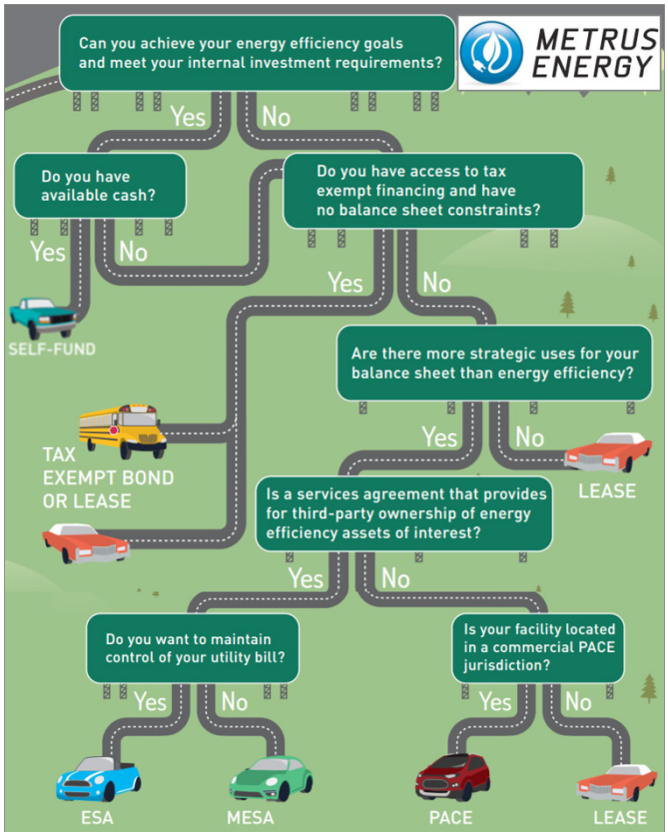
There are also three federal programs that may be relevant to select industrial firms in Colorado. The US DOE Loan Guarantee Program has funding available primarily to businesses that are willing to be early adopters of cutting edge technologies that may reduce air pollution and greenhouse gas emissions. The USDA Biorefinery Assistance Loan Guarantee Program is highly specific for the development, construction and retrofitting of biorefineries. The USDA also offers the Repowering Assistance Program that provides cost reimbursement grants for biorefineries to install renewable biomass systems for heating and power at their facilities to replace fossil fuels.

5.2 | Strategies for Industrial Firms to Increase EE and DG Investments

5.2.1 | Choosing a Financing Option

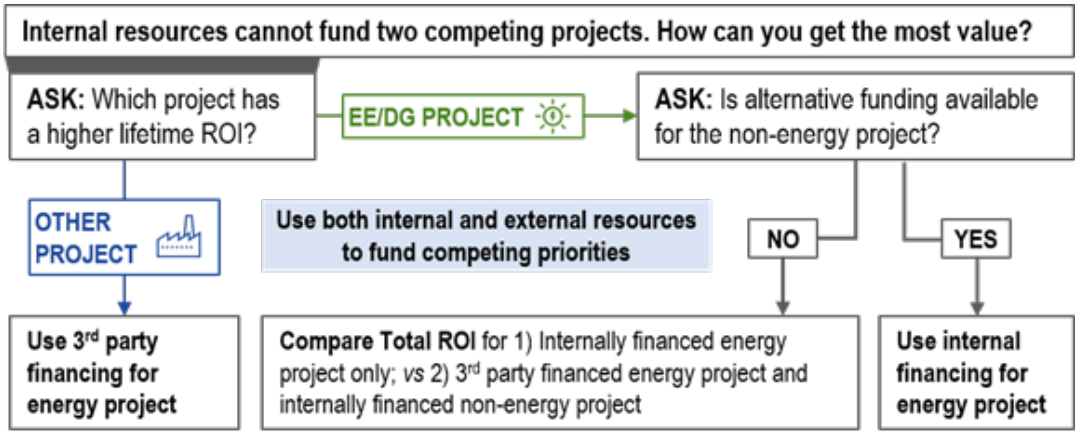
As discussed in the previous section, there are numerous financing options along with incentives, rebates, and other resources that industrial firms must consider when deciding how to finance and implement a project. This is often a difficult process to navigate due to the nuances of each approach and the attributes that may make one option more favorable then another. Metrus Energy has visualized this decision process in the simplified infographic shown in Figure 5-2.

FIGURE 5-2. ROAD TO ENERGY EFFICIENCY (METRUS ENERGY)



Complete infographic available from, metrusenergy.com/wp-content/uploads/2013/04/metrusinfographicfinal.pdf

FIGURE 5-3. SIMPLIFIED APPROACH TO USE INTERNAL AND EXTERNAL RESOURCES TO FUND COMPETING PRIORITIES



There is an important caveat to the infographic regarding self-funding that is particularly applicable to the industrial sector. It is true that self-funding a project will allow an organization to obtain the highest return on investment (ROI) for an energy project because the firm will not owe interest on any equipment or have to share savings with an ESA or EPC provider. However, industrial companies often have competing priorities for internal capital and may be able to achieve a higher ROI from another investment (e.g., expanding production capacity, developing new products, etc.). In these situations, third-party financing presents a valuable opportunity to derive some cost savings and value from energy savings initiatives without limiting the ability to spend internal capital on other high value initiatives. Although the energy cost savings will be less than that of a fully-funded project, they will still provide a positive return on investment that could be cash flow positive from day one. Figure 5-3 provides a simplified approach that may help industrial firms to increase funding energy initiatives when they are faced with competing investment priorities.

Third-party financing can be a very attractive, but confusing, way to pursue an energy related project if a firm does not have sufficient internal resources or there are competing investment opportunities that warrant external support. Table 5-9 provides a high-level comparison of the third-party financing mechanisms described earlier.

All of the mechanisms enhance a firm's access to capital, but with different conditions or strings-attached. A firm's decision to use a certain financing mechanism may be influenced by factors including: reducing or eliminating up-front costs; being cash-flow positive from day one; shifting performance risk to a third-party; obtaining low or no-cost 3rd party technical support via audits, recommendations, and support; contract complexity and duration; repayment terms; transferability; and potential geographic or utility specific restrictions. These attributes may greatly influence internal decision making and approvals at industrial organizations and must be considered when deciding how to approach a project.

PACE, OBF, and ESA contracts are of particular interest because they can provide up to 100% of funding for a project and can be cash flow positive from day 1. These three mechanisms each offer different options regarding typical project size, balance-sheet treatment, contract duration, transferability, and repayment.

Industrial processes can be highly complex with multiple factors that influence energy consumption that may make it very difficult to negotiate and agree upon a methodology to calculate energy savings. In these situations with complex processes and difficult to quantify savings, PACE and OBF may be preferred because they do not require an industrial firm to share a fixed portion of the energy savings. OBF, however is not wide-spread in Colorado and industrial firms should talk to their utility if it is a financing option of interest. Alternatively, the performance guarantees and third-party project management of an ESA may be preferable for common building upgrades or equipment improvements that are easily measurable and of a sufficient scale.

Due to the nuances of each funding approach all available options should be reviewed on a case-by-case basis to determine the best fit for a given project.

TABLE 5-9. THIRD-PARTY FINANCING COMPARISON

	Leases/Loans	On-bill (OBF)	PACE	EPC	ESA
Access to Capital	● Fast, but requires down-payment	● Up to 100%	● Up to 100%	▲ Requires financing	● Up to 100%
Cash flow positive	▲ Depends on contract terms	● Day 1. Depends on contract terms	● Day 1. Savings exceed payments	▲ Depends on contract terms	● Day 1. No up-front costs
Project size limitations	● Any, depends on lender	▲ Smaller projects ($5k - $350k)	● No	▲ Large projects ($1M or $5M+)	▲ Large projects ($1M+)
Balance-sheet treatment	● Both options available	● Paid via utility bill	● Paid via annual property tax	▲ Asset, on-balance-sheet	● Off-balance-sheet
Interest rates & repayment	▲ Market rates	● Low-to-zero	▲ Higher than commercial rates	▲ Cost savings go to EPC provider	▲ Cost savings go to ESA provider
Contract duration	● Flexible (3-5 yrs common)	● Flexible, 2-15 years	▲ Up to 20 years	▲ 10-20 years	▲ 5-15 years
Transferability	▲ No, tied to customer	● Yes, tied to utility meter	● Yes, tied to property	▲ Cannot exceed lease duration	▲ Cannot exceed lease duration
3rd party technical involvement	▲ No	▲ Utility administrated	● Initial assessment and M&V	● Audits & project management	● Audits & project management
M&V of energy savings	▲ No	▲ Not provided	● Not required, but M&V provided	▲ Required, savings shared	▲ Required, savings shared
Performance guarantees	▲ No	▲ No	▲ No, but high confidence	● Yes	● Yes
Other	● Simple/familiar contracts	▲ Utility specific Not required in CO	▲ Geographically limited	▲ Contractually complex	▲ Contractually complex

Legend: ▲ Partly or not addressed by mechanism ● Favorably addressed by mechanism

For more information visit the US DOE Better Buildings Financing Navigator (betterbuildingssolutioncenter.energy.gov/financing-navigator) and the Colorado Commercial PACE website (copace.com/).

5.2.2 | EE/DG Investment Considerations Based on Firm Size and Resources

The size, and more specifically the amount of resources, available to an industrial firm present yet another factor that can influence EE and DG investments. Industrial firms, and the organizations that work with them, should strive to understand how the amount of resources available to different sized firms impacts the ability to effectively identify savings opportunities, access support services, and finance investments. Industrial firms must recognize their abilities and limitations so that they can take appropriate actions to operate as efficiently as possible, while support organizations must understand the firms they are attempting to work with so that they can offer prudent and actionable advice.

Table 5-10 compares large (501+ employees) and small to mid-sized firms (0-500 employees) across their available resources, interest, and activity in EE/DG investments including for the four requirements described at the start of Chapter 5. The larger firms that responded to the industrial outreach survey and interviews have more alignment with the four primary requirements for successful EE programs than do the small and mid-sized firms.

Firms with more resources can pursue corporate commitments using dedicated staff and investments from dedicated budgets. The larger firms typically have energy managers who devote their time and effort to EE improvements in their plants. Additionally, large businesses are more likely to focus not just on absolute dollars, but recognize other justifiable attributes of EE/DG investments, such as meeting energy and/or sustainability goals.

Conversely, small to mid-sized firms instead rely on engineers and/or plant managers who have a host of competing duties. These firms may have informal staff structures with no clear responsibility for energy management nor encouragement to pursue EE. The small to mid-sized firms tend to focus on cash flow and meeting their day-to-day obligations and without support may only implement EE/DG projects opportunistically in efforts to cut costs, improve production, and comply with regulatory requirements.

TABLE 5-10. INTEREST AND ACTIVITY COMPARISON FOR EE/DG INVESTMENTS BY FIRM SIZE

	Large firms (501+ employees)	Small to mid-sized firms (0-500 employees)
Primary Requirements for Successful EE Programs		
Corporate Commitment	**High** (common to have energy/sustainability goals)	**Moderate-low** (uncommon to have energy goals)
"Boots on the Ground"	**High** (dedicated energy managers and efficiency engineers)	**Low** (staff stretched thin with multiple responsibilities)
Efficient Project Processing Systems	**Moderate-High** (common to have established approval processes)	**Low** (no established processes)
Access to Information Resources	**Moderate** (scattered information, but dedicated personnel)	**Low** (scattered information and no responsible personnel)
Other Notable Attributes, Behaviors, and Resources		
Available resources	**High** (dedicated EE budgets and personnel)	**Low** (little to no dedicated funds or personnel)
EE/DG investment activity	**High** (annual budgets, but competition for capital)	**Low** (no budgets and competition for capital)
Typical financing approach	**Internal funding** (avoid long-paybacks and 3rd party commitments)	**Internal funding** (as available, mostly opportunistic)
Attitude towards specialty financing products	**Skeptical** (particularly of M&V of savings, but would consider)	**Interested** (need active engagement and support to access)
Participation in technical support programs	**Case by case** (those that engage seek all possible opportunities)	**Case by case** (high interest but require active/direct engagement)
Use of rebates	**Moderate** (will access when readily available)	**Low** (will access when brought to them)
Use of tax incentives	**Low** (change frequently and often do not qualify)	**Low** (no dedicated staff to pursue)

The outreach survey and interviews found that industrial firms have not yet seriously pursued specialty financing products. Additionally, a 2014 Colorado Energy Office research report on EPC's found that large industrial firms would take advantage of the EPC process to obtain a reduced-price investment quality audit from a pre-qualified ESCO and then move forward with self-implementation of the identified facility improvement measures.[50] This reluctance is largely because firms are unfamiliar with the specialty financing products and the associated contractual complexities. Specifically, firms reported that the process of quantifying and reimbursing a third-party for energy savings has a lot of potential pitfalls that can lead to opposing viewpoints and conflict. Manufacturing companies, understandably, do not trust an EPC or ESA provider to estimate how equipment changes will affect the energy profile of their processes.

Process alterations and technology upgrades may be better suited towards PACE or OBF financing to avoid complex M&V negotiations and energy cost-savings sharing agreements. Specialty financing options with performance guarantees (i.e., EPC and ESA) instead should be targeted towards common technologies with easily measurable energy savings and consistent energy baselines, such as building technologies. By working together on easy to measure projects industrial firms and specialty financing providers may develop a positive and trusting relationship that could be expanded to more complicated investments later on.

Industrial firms also often have competing priorities for capital that may enable greater returns if spent elsewhere in the organization and have traditionally sought payback periods of 2-years or less. Specialty financing options could potentially address both of these issues. Companies can invest in competing priorities by leveraging both internal and external (specialty finance) capital to maximize their total ROI and can structure contracts to be off the balance sheet and require no up-front costs to the industrial firm.

Lastly, firms of all sizes indicated that they desire easier access to information on the various resources and partners that can help to finance, implement, and support EE/DG improvements. Even larger firms with dedicated staff underutilize rebates and incentives if they must spend time digging up information opportunity. Industrial firms most commonly take advantage of support resources when approached by an organization that will help walk them through the opportunity. Industrial firms could therefore seek to develop better relationships with their utility account managers and local, state, and federal technical support programs to help reduce the administrative burden needed to track and access all of the available rebates, incentives, and other support resources.

50 Paluzzi, J. "Colorado's Venture into the Private Sector with Energy Performance Contracting: Considerations for a State Energy Office Program Offering." Colorado Energy Office Final Report to the US Department of Energy. March 31, 2015. Available from, colorado.gov/pacific/energyoffice/private-energy-performance-contracting

TABLE 5-11. SUMMARIZED EE/DG FINANCING RECOMMENDATIONS BY FIRM SIZE

EE/DG Financing Recommendations for Industrial Firms	
Large firms (501+ employees)	**Small to mid-sized firms (0-500 employees)**
• **Leverage internal and external financing to support both energy and non-energy projects** Compare the total ROI of energy and non-energy projects. 3rd party financed energy projects can still provide a cash flow positive ROI and while freeing internal funds for other investments. • **Consider ESA for simple, large scale projects** The performance guarantees and third-party project management of an ESA may be preferable for common building upgrades or easily measurable equipment improvements over $1M • **Consider PACE and OBF for complex projects** Although PACE and OBF do not guarantee energy savings, they also do not require the firm to share a fixed portion of those savings with the provider and, if available, may be more suitable for complex, difficult-to-measure, projects than an ESA. • **Avoid operational interruptions** Target low/no cost process optimization, plan improvements into maintenance cycles, replace equipment with high efficiency technology, plan energy into new facility constructions, and pilot efficiency strategies before expanding company-wide.	• **Consider PACE financing if in a supported county** PACE does not require the same large scale as ESAs, but offer similar 3rd party technical resources to help identify opportunities and M&V savings. The energy savings from these agreements typically pay for themselves with no cost to the customer. • **Access technical support programs where available** If available, local programs (e.g., Denver, Boulder, Ft. Collins, etc.) as well as some utility programs (e.g., Xcel, Black Hills, etc.) will help organizations identify opportunities and access EE/DG rebates. • **Plan EE and DG into equipment and facility decisions** Every operational advantage matters and prioritizing efficient, state-of-the-art equipment and facilities can help to optimize production, realize significant lifetime energy cost savings, and minimize the need to identify and implement retroactive investments. • **Establish energy use and consumption as a priority** There will not be any projects to worry about financing if there is not a strong corporate commitment and staff recognition that energy is a priority. An energy champion is needed to identify, assess, manage, implement, monitor, and document EE/DG projects.

Table 5-11 summarizes the aforementioned findings into high-level recommendations for EE/DG financing at large and small to mid-sized industrial firms.

5.3 | Opportunities for an Industrial Energy Program in Colorado

There is an ancient proverb that states,

"Give a man a fish and you feed him for a day; teach a man to fish and you feed him for a lifetime."

The same concept can be applied to energy management. An industrial energy program will make a much more significant impact by helping industrial firms to learn and adopt productive behavioral changes that make energy related data measurement, benchmarking, and improvement an essential part of their day-to-day operations rather than simply paying for the occasional upgrade.

Technical support programs that require an active commitment from participants, such as the Colorado Industrial Energy Challenge, the US DOE Better Plants Challenge, and the US DOE Superior Energy Performance Program (all discussed in section 5.1.1) are able to routinely claim that their participants improve their energy performance by 10 to 30% over a three-year period. Yet it can be very difficult to encourage industrial firms to participate in such programs despite these success stories and program administrators must decide how best to allocate program resources to make the largest possible impact.

Numerous case-studies and analyses of ratepayer-funded energy efficiency programs and industrial strategic energy management identify recommendations for industrial energy engagement programs to achieve the best partnership results with firms of all sizes:

- SEE Action Network, Case Studies of EE Programs in Large US Industrial Firms and Ratepayer-Funded Support;[51]
- SEE Action Network, Designing Effective State Programs for the Industrial Sector;[52]
- SEE Action Network, Sustained Energy Savings through Industrial Customer Interaction with Ratepayer Programs;[53]
- Consortium for Energy Efficiency, Industrial Strategic Energy Management Initiative;[54]

Table 5-12 summarizes recommendations from the various reports.

51 Glatt, S. Dutrow, E. "Saving Energy in Industrial Companies: Case Studies of Energy Efficiency Programs in Large US Industrial Corporations and the Role of Ratepayer-Funded Support." SEE Action Network: Industrial Energy Efficiency and CHP Working Group. Published March 2017. Available from, eere.energy.gov/seeaction/system/files/documents/saving_energy_industrials_0.pdf

52 A. Goldberg, R.P. Taylor, and B. Hedman, Industrial Energy Efficiency: Designing Effective State Programs for the Industrial Sector, SEE Action Network, Industrial Energy Efficiency and CHP Working Group. 2014. Available from, energy.gov/sites/prod/files/2014/03/f13/industrial_energy_efficiency.pdf

53 Glatt, S. Dutrow, E. "Sustained Energy Savings Achieved through Successful Industrial Customer Interaction with Ratepayer Programs: Case Studies." SEE Action Network: Industrial Energy Efficiency and CHP Working Group. Published October 2015. Available from, eere.energy.gov/seeaction/system/files/documents/IEE%20Case%20Studies_1002.pdf

54 Burgess, J. "CEE Industrial Strategic Energy Management Initiative." Consortium for Energy Efficiency. Published January 17, 2014. Available from, library.cee1.org/system/files/library/11282/Industrial_SEM_Initiative.pdf

TABLE 5-12. SUMMARIZED RECOMMENDATIONS FOR INDUSTRIAL ENERGY ENGAGEMENT PROGRAMS

Recommendations for Industrial Energy Engagement Programs	
Universal Recommendations	**Specific Recommendations for Engaging Larger Firms**
• **Multi-year relationships** Develop relationships between program administrators and industrial company staff in a steadily evolving program of support to identify and implement multiple projects over time. • **Dedicated, Competent Support Staff** Assign dedicated, technically competent program staff or trusted contractors to work as account managers with key clients, maintaining medium-term staff continuity as much as possible. • **Flexible Program Offerings** Include both custom project incentives and prescriptive incentives, with flexibility to best accommodate the budgeting, processing, and implementation needs of industrial customers. • **Active outreach and engagement** Programs should make it easy to participate in the program and save energy. Work with industrial customers to tailor solutions to specific needs rather than offering a catalog of incentives.	• **Partner participation and recognition programs** (can provide companies with reputational and service benefits) • Understand specific technical assistance needs (be flexible to support the needs of different firms) • **Consider pilot and rollout programs for locating or financing support staff or EE engineers at facility sites** (attempts to address requirement 2, "boots on the ground") • **Understand project development, approval, and implementation procedures within key industrial clients** (cater assistance to match and support these procedures) • **Strive for maximum flexibility when structuring incentives** (overcome corporate hurdles, such as simple payback periods) • **Consider facility SEM and/or behavioral energy savings program support where clients wish to pilot such efforts** (cohort initiatives with meetings for training, peer exchange, and experience sharing can be successful for large and small firms) • **Consider incremental financial incentives for new equipment purchases with above business-as-usual EE performance** (must not delay project time lines or procurement activities)

The recommendations presented in Table 5-12 are intended for industrial energy programs to be as effective as possible at proverbially "teaching industrial firms to fish." Yes, the industrial sector is a broad descriptor for many highly unique industries and processes. However, there are best practices, behaviors, and mind-sets that can produce significant results if embraced by the industrial firms that learn them.

One of the fundamental building blocks of a successful industrial energy program is active engagement on the part of the program. While having information on potential opportunities resources is necessary, simply publishing a list of basic incentives for EE measures, waiting for companies to approach the program, and then processed incentive requests slowly will not help industrial firms to achieve impactful energy reductions and best practices. Additionally, firms that currently lack interest in EE, lack staff to find EE projects, or lack a clear path to internal co-financing of projects are unlikely to benefit from relatively passive energy programs.

Of course, to be truly successful requires an industrial firm to reciprocate the active engagement in a relationship and be willing to show corporate commitment (requirement 1) and put boots on the ground (requirement 2). This is where the time and effort to engage and develop long-term relationships with industrial firms is needed.

There is a continuum of responsibility at industrial firms to identify potential energy projects, summarize the technical and financial feasibility of the project, present the opportunity to financial and management teams for approval, manage and implement the project, and then monitor project operations and make adjustments to maximize energy savings. While outside auditors may be valuable to identifying low-hanging fruit and simple projects that are common across industries and buildings, these outsiders are unlikely to be effective for more complicated projects. Dedicated staff and internal resources are most effective at championing projects forward through each stage of responsibility. EE tasks are often neglected when personnel are not specifically tasked with the responsibility as was found in the survey and interview results. Technical support programs or EE initiatives that take a more active role in partnering with their industrial customers, and require at least some form of active commitment in return, can be effective in helping obtain benefits from EE.

Implementing energy related best practices, changing individual behavior, and shifting corporate culture are not trivial tasks. Industrial firms will be more likely to continue improving their practices if they know they have dedicated, highly competent, support staff available to help them along the way.

Cooperation between technical support programs, technical professionals with relevant experience to the opportunity, and industrial company personal can help to increase access to the various forms of assistance available for energy related projects. Each of the identified opportunities takes time and resources to obtain and industrial firms are unlikely to fully access the available benefits without adequate commitment, encouragement, and support through the process.

Each opportunity may also require specific knowledge or a trained professional to access, such as an experienced CPA to access tax incentives. Firms will only become more familiar with the available offerings and how to access them if they build relationships with the professionals that administer the opportunities or have experience navigating the process. Ultimately, energy incentives and financing energy-related projects could become an invaluable part of operations for firms of all-sizes as organizations pursue more projects and realize actual savings to their bottom-line's.

CEO should remain mindful of the available resources and motivations of the firms they are attempting to work with as they consider possible programmatic efforts to encourage and aid industrial customers in EE and DG decision making. Any approach will need to be flexible to accommodate the needs and resources of different industrial firms. Lastly, the core an industrial energy program should be for the industrial firms to learn and adopt energy management practices and EE/DG investment strategies an essential part of their day-to-day operations.

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Appendix A | Major Employers in Colorado

Table A-1 summarizes public resources made available by the Colorado Office of Economic Development & International Trade (OEDIT). The Choose Colorado website provides numerous factsheets that profile key industries in Colorado, the major employers in those industries, and locations of those employers.

TABLE A-1. MAIN SOURCES REFERENCED IN IDENTIFYING THE MAJOR EMPLOYERS, INDUSTRIES AND COMPANY STATISTICS IN COLORADO

Source	Use	Notes
Choose Colorado – Doing Business	Major employers (statewide); industry; city; number of employees. Table A-2	Identifies Colorado's industries with the highest number of employees as well as their locations
	Available from, *choosecolorado.com/doing-business/major-employers/*	
Choose Colorado – Key Industries	Major employers (industry specific); number of companies; total output; total workforce; annual payroll. Table A-3 and Table A-4.	Identifies the presence of 14 key industries in Colorado as of the year 2013; factsheets were referenced for each of the key industries
	Available from, *choosecolorado.com/key-industries/*	

Table A-2 identifies the top 14 employers in Colorado. These employers predominantly operate within the aviation, healthcare, and telecommunications industries. The Denver metropolitan area accommodates approximately 59% of the total employment among the main employers in Colorado.

TABLE A-2. MAIN EMPLOYERS IN COLORADO BY INDUSTRY, LOCATION AND NUMBER OF EMPLOYEES (FROM CHOOSE CO - DOING BUSINESS)

Employer	Industry	City	Number of Employees
Denver International Airport	Aviation	Denver	35,000
HealthONE Corporation	Healthcare	Denver	11,050
Lockheed Martin	Aviation/Aerospace	Littleton	14,000
Centura Health	Healthcare	Englewood	8,310
SCL Health Systems	Healthcare	Denver	8,270
Century Link	Telecommunications	Denver	6,500
Kaiser Permanente	Healthcare	Denver	6,280
Liberty Tax Service	Financial Services	Grand Junction	6,000
Western Union Co	Financial Services	Englewood	6,000
Comcast Corporation	Telecommunications	Englewood	8,000
University of Colorado Health	Healthcare, Research	Aurora	5,860
Children's Hospital Colorado	Healthcare	Aurora	5,740
United Airlines	Aviation	Denver	4,900
Wells Fargo	Financial Services	Denver	4,450

Table A-3 compares the fourteen key industries in Colorado as identified by Choose Colorado/OEDIT. The key industries in Colorado accounted for approximately 1,884,200 employees by the end of 2013, with an annual payroll of approximately $123.3 billion. The electronics industry accounted for 16% of the total manufacturing employment in Colorado.

TABLE A-3. MAJOR EMPLOYERS IN KEY INDUSTRIES BY TOTAL PRESENCE, OUTPUT, WORKFORCE AND ANNUAL PAYROLL AS OF THE END OF 2013 (SOURCE: CHOOSE COLORADO - KEY INDUSTRIES)

Key Industries	Number of Companies	Average Annual Employment	Total Output (%)	Total Workforce (%)	Annual Payroll (billion dollars)
Advanced Manufacturing	5,900	150,700	7.5	4.5	$ 10.9
Aerospace	140	25,100	n/a	n/a	$ 3.2
Bioscience	1,700	27,900	n/a	n/a	$ 2.8
Creative Industries	9,000	164,500	n/a	n/a	$ 9.1
Defense & Homeland Security	5	55,100	n/a	n/a	$ 2.8
Electronics	1,400	28,100	n/a	n/a	$ 3.2
Energy & Natural Resources	6,000	123,200	n/a	n/a	$ 9.9
Financial Services	10,300	219,800	n/a	n/a	$ 15.4
Food & Agriculture	4,400	115,600	n/a	n/a	$ 5.0
Heath & Wellness	16,400	315,000	n/a	n/a	$ 16.5
Infrastructure Engineering	9,800	137,200	n/a	n/a	$ 9.9
Technology & Information	10,900	146,800	n/a	n/a	$ 15.2
Tourism & Outdoor Recreation	7,800	177,700	n/a	n/a	$ 6.0
Transportation & Logistics	16,700	197,500	n/a	n/a	$ 13.4

Table A-4 lists up 16 major employers for each of the fourteen key industries in Colorado as identified by Choose Colorado/ OEDIT. In some instances, employers are listed in multiple industries if they have cross-cutting applicability. Overall there are 89 unique companies identified as major employers in Colorado.

TABLE A-4. MAJOR EMPLOYERS BY INDUSTRY

Key Industries	Major employers by industry (from individual summary pages at choosecolorado.com/key-industries/)		
Advanced Manufacturing	• Ball Aerospace & Technologies Corp. • Cargill • Covidien • IBM Corporation	• JBS USA • Lockheed Martin • MillerCoors Brewing Company • Northrop Grumman	• Raytheon Company • Terumo BCT, Inc. • United Launch Alliance • Vestas
Aerospace	• Ball Aerospace & Technologies • The Boeing Company • DigitalGlobe, Inc. • Exelis	• Honeywell Technology Solutions • Lockheed Martin • Northrop Grumman • Raytheon Company	• Sierra Nevada Corporation • United Launch Alliance
Bioscience	• Agrium Inc. • Amgen Inc. • Baxter Corporation • Cochlear Americas • Covidien	• Hach Company • Johnson & Johnson • DePuy Synthes • Medtronic • Quest Diagnostics	• Sandoz, Inc. • Spectranetics • Terumo BCT, Inc. • TOLMAR, Inc.
Creative Industries	• Comcast Corporation • The Denver Post • DISH Network	• Starz • Denver Art Museum • Fentress Architects	• High Noon Entertainment • Rocky Mountain PBS
US Defense & Security	• Buckley Air Force Base • Peterson Air Force Base	• Cheyenne Mountain Air Force Station • Schriever Air Force Base	• Fort Carson • The US Air Force Academy
Electronics	• Arrow Electronics • Ball Aerospace & Technologies Corp. • The Boeing Company • Integrated Defense Systems	• Hewlett Packard • IBM Corporation • Lockheed Martin • Northrop Grumman	• Oracle Corporation • Raytheon Company • Seagate Technology
Energy & Natural Resources	• Agilent Technologies • Amtel Corporation • Anadarko Petroleum • Colorado Springs Utilities	• Encana Corporation • Halliburton • Noble Energy • Vestas	• Woodward • Xcel Energy
Financial Services	• Anthem Blue Cross and Blue Shield • Charles Schwab • FirstBank Holding Company • Great-West Financial	• JP Morgan Chase & Co. • State Farm Insurance • TIAA-CREF • US Bank	• Urban Lending Solutions • VISA Debit Processing Services • Wells Fargo
Food & Agriculture	• Anheuser-Busch • Beverage Distributors Co. • Cargill • JBS USA	• Leprino Foods Company • MillerCoors Brewing Company • Navajo Express • PepsiCo Bottling Company	• Shamrock Foods • Steven Roberts Original Desserts
Heath & Wellness	• Banner Health • Centura Health • Children's Hospital Colorado • Denver Health and Hospital Authority	• HCA-HealthONE LLC • Kaiser Permanente Colorado • SCL Health System • University of Colorado Anschutz	• Medical Campus • University of Colorado Health • US Department of Veterans Affairs
Infrastructure Engineering	• CH2M Hill • Jacobs Engineering Group Inc. • Johns Manville • Kiewit Corporation	• M.A. Mortenson Company • MWH Global • SAIC • Tetra Tech	• URS Corporation • Wagner Equipment
Technology & Information	• AT&T Corporation • CenturyLink • Comcast Corporation • DISH Network	• Hewlett Packard • IBM Corporation • Level 3 Communications • Oracle Corporation	• Sprint Corporation • Verizon
Tourism & Outdoor Rec.	• Aspen Ski Company • South Suburban Parks and Rec.	• Steamboat Ski and Resort Company • The Broadmoor	• Vail Resorts • Winter Park Resort
Transportation & Logistics	• Arrow Electronics • Denver International Airport • FedEx Corporation • Frontier Airlines	• Oracle Corporation • Regional Transportation District • SkyWest Airlines • Southwest Airlines	• United Airlines • United Parcel Service

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