Community Climate Action Plan

CITY OF BEND

BEND COMMUNITY ENERGY SUPPLY

BACKGROUND REPORT

City Manager's Office

Prepared by:
Jon Simning, Volunteer Summer Intern
Cassie Lacy, Sustainability Coordinator
Gillian Ockner, Senior Policy Analyst
October 2018

Energy Supply and Community GHG Emissions

The types and sources of energy that we use in Bend have a large impact on the Community's overall amount of greenhouse gas (GHG) emissions. The energy supply we use determines the amount of GHG emissions generated by our building stock, which is the largest source of Bend's total greenhouse gas emissions. Residential, industrial, and commercial buildings make up 56% of the community's total greenhouse gas footprint[1].

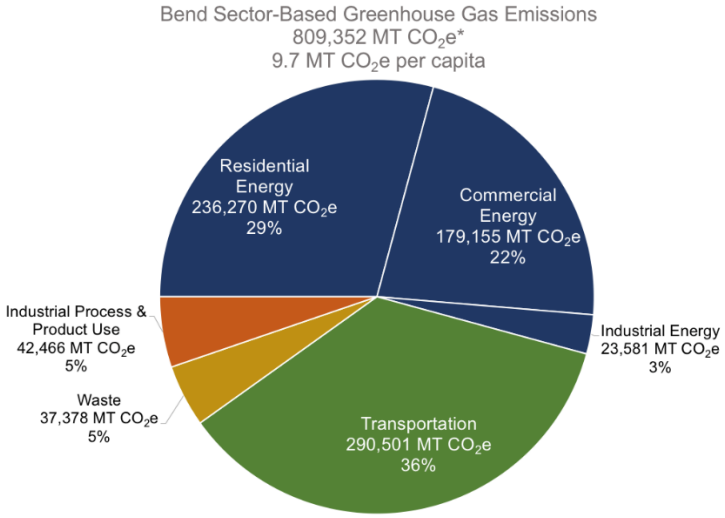


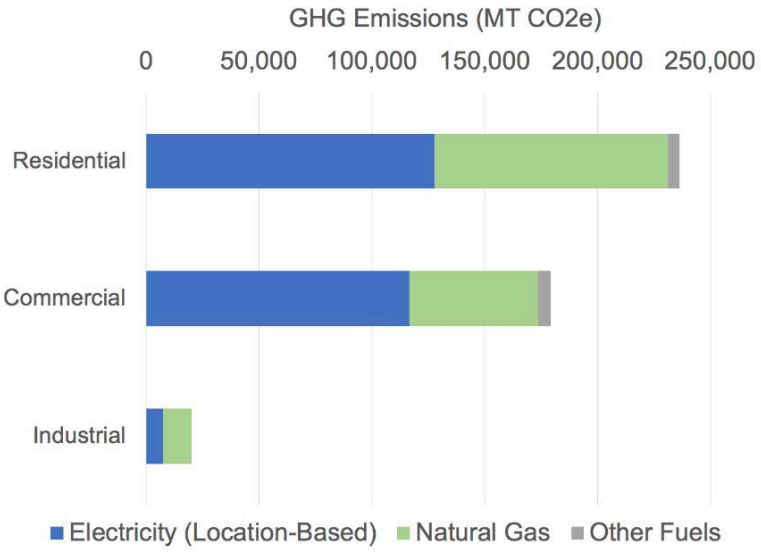
***Figure 1**. Summary of sector based greenhouse gas emissions from Bend's 2016 Community Greenhouse Gas Inventory*

These are considered stationary energy sources and GHG emissions are attributed to the combustion of fossil fuels to generate power for use in Bend. Electricity and natural gas use by the residential and commercial sectors are the largest segment of Community emissions as estimated using the Global Protocol for Community-Scale GHG Emissions (GPC). Bend residents' homes have a larger impact than commercial businesses, and industrial building energy is small by comparison. By energy type, electricity had the largest impact (58% of total building energy); followed by natural gas (40%); and other fuels (2%)[2]. Figure 2 shows stationary energy emissions broken down by sub-sector and energy type.

[1]City of Bend, 2016 Community Greenhouse Gas Inventory, Prepared by Good Company, August 2018. https://www.bendoregon.gov/Home/ShowDocument?id=38856

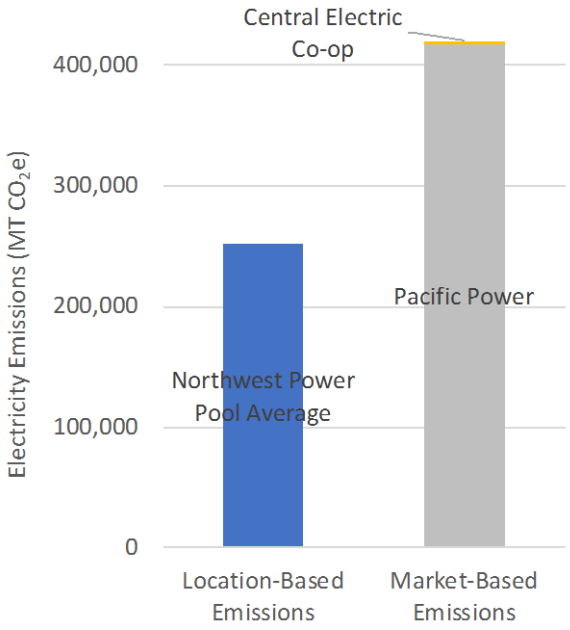
[2] Ibid.

Figure 2. Comparison of stationary energy use, by sub-sector and energy type.



GPC requires that communities' report electricity emissions using the location-based method (blue bar on Figure 3). ***Location-based emissions*** are calculated using the regional electricity grid's GHG intensity and represent the average impacts of electricity use and efficiency efforts. GPC also recommends that communities calculate ***Market-based emissions*** which are based on the GHG intensity of electricity contracts with local utilities. Bend's estimated market-based emissions are much higher than the estimated location-based emissions. Pacific Power's electricity generation from coal in 2016 is the major driver for this difference. Central Electric Cooperative (CEC) represents a very small fraction of market-based emissions as its contracts with Bonneville Power Administration are largely served by low-GHG hydroelectric and nuclear power. The market-based method also accounts for community participation in utility green power programs. In 2016, Pacific Power's customers voluntarily purchased 10% zero GHG, renewable electricity which decreases Bend's market-based emissions from what it would be otherwise.

Figure 3. Comparison of location-based and market-based electricity emissions



Energy Supply in Oregon

According to Oregon.gov, Oregon's energy mix is roughly comprised of 40% hydro, 32% coal, 16% natural gas, 6.5% wind, 3.25% nuclear, and the rest from solar, biomass, geothermal, and other small sources. Oregon has access to large quantities of renewable energy due to the Bonneville Power Administration's (BPA) dams along the Columbia River and its tributaries. Two investor-owned utilities in Oregon, Portland General Electric (PGE) and Pacific Power, account for about 70% of the electricity delivered in the state and are under the jurisdiction of the Oregon Public Utility Commission, which is chartered as a consumer protection and advocacy body. Both currently use coal in their grid mix. PGE's Boardman plant is the last remaining coal-burning power plant in Oregon, and is scheduled to end operations by 2020[3]. To meet base and peak load requirements, natural gas power plants have been recently built by Portland General Electric. Pacific Power owns a number of coal-burning plants located outside of Oregon, predominantly in the Rocky Mountain region.

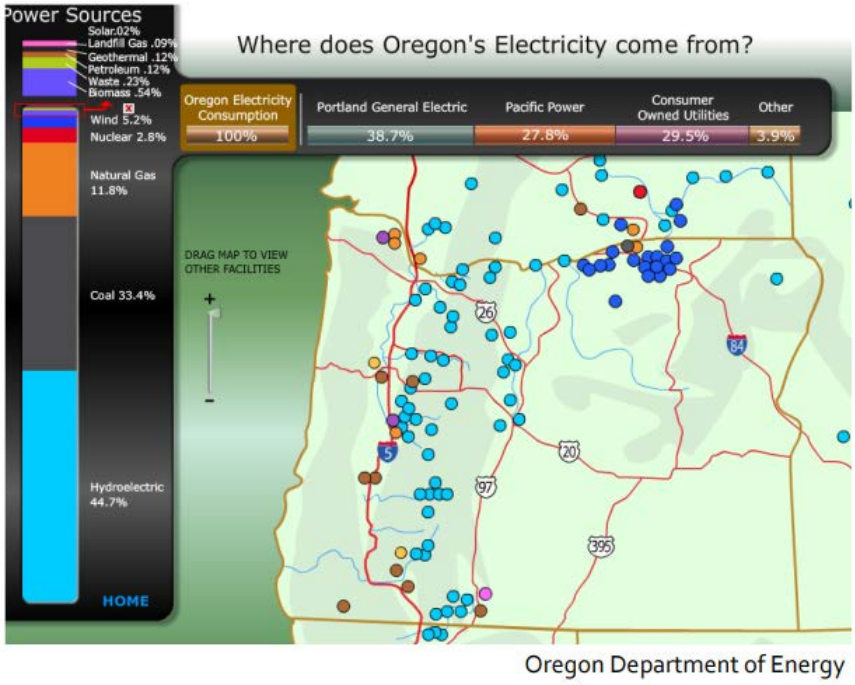


***Figure 4**. Oregon Energy Supply*

Oregon's energy supply will change significantly in the next 20 years, as recent legislation focuses on reduction in climate change, air pollution, and increasing renewables energy and sustainability.

Oregon Renewable Energy Policy

Oregon's energy mix is in a state of change as utilities meet the requirements outlined in Oregon's Renewable Portfolio Standard (RPS). Established through SB 838 in 2007 and revised with the adoption of the Clean Electricity and Coal Transition legislation in SB 1547 in 2016, the RPS mandates that by 2040, Portland General Electric, Pacific

[3] https://www.opb.org/news/article/pge-close-boardman-plant-2020/

Power, and Eugene Water & Electric Board sell 50% of their electricity from renewable energy sources. Renewable energy sources are defined as: wind energy, solar photovoltaic and solar thermal energy, wave, tidal, ocean thermal, bio-gas, small hydro power, and thermal energy. Renewable energy sources do not produce greenhouse gases, and have zero or renewable fuel sources.

Renewable sources of energy constructed prior to 1995 cannot be included as renewable electricity for the RPS. Therefore, many dams and hydro power plants (BPA dams) are excluded as sources of renewable energy sources. By excluding older hydro power plants, the RPS increases the viability and demand of other green energy sources, such as wind, biomass, and solar. By 2040 50% of Oregon's electricity will come from renewable sources, and 30-40% will be provided by BPA's dams.

Additionally, the RPS states that by 2030 no electricity produced by coal power plants can be sold to customers in Oregon. Along with the decision to close the Boardman Coal Plant, Oregon's last coal power plant by 2020, Oregon's energy supply will be coal free by 2030.

Community Solar

A community solar project means one or more solar photovoltaic energy systems that provide owners and subscribers the opportunity to share the costs and benefits associated with the generation of electricity by the solar photovoltaic energy systems. Community solar provides Oregonians who can't install solar on their homes with an option to be included in the emerging solar market. The electricity generated by the solar project is sold to the utilities, which credit owner or subscriber's electric bills as payment. These community solar programs are set to launch in 2019, per SB 1547.

The RPS established the community solar program with its mandate that "by the year 2025, at least eight percent of [Oregon's retail electrical load comes from] the aggregate electrical capacity of all electric companies that make sales of electricity to 25,000 or more retail electricity consumers, and must be composed of electricity generated by one or both of the following sources: small-scale renewable energy projects with a generating capacity of 20 megawatts or less and facilities that generate electricity using biomass that also generate thermal energy for a secondary purpose." Small-scale renewable energy projects include community solar programs, which forces utilities to increase investment in community solar projects.

Final Rules for developing a community solar project are as follows:

- The projects must be in Investor Owned Utility territory, (PGE and Pacific Power)
- Project size must be at least 25KW with 3MW maximum.

- Projects must have at least 5 customers, and no customer can subscribe to more than 40% of project capacity
- 50% of each project shall be reserved for residential or small commercial customers
- 10% of total community solar program capacity, and at least 5% per project is required to be allocated to low-income residents.
- Projects can contain more than one system, but must be located within a 5 mile radius

Air Quality

Oregon has a number of air quality programs designed to help communities improve the environment, reduce climate change, and save money. For example, Oregon legislation and the Department of Environmental Quality (DEQ) have "developed a statewide Wood Stove program to promote the use of cleaner burning wood stoves, and help homeowners burn more efficiently and with less pollution."[4] The Wood Stove program teaches owners about cleaner fuel sources, more efficient appliances, and effective methods to store fuel.

Wood stoves are one of the most significant sources of fine particulate and toxic air pollution in Oregon, which jeopardizes public health and puts communities at risk of violating federal air quality standards.[5] Incentivizing stove owners to swap from older, uncertified stoves to new Oregon DEQ or U.S. EPA certified stoves will reduce pollution and improve air quality. Since 2009, Oregon's Heat Smart program prevents any homes that are bought or sold to contain an uncertified wood stove fireplace. Homeowners must dispose of the uncertified wood stove, and notify the DEQ.

Another of Oregon's major air quality programs was passed in In April of 2018. SB 1541 authorized the "Environmental Quality Commission [to] adopt a program and rules to reduce public health risks from emissions of toxic air contaminants from individual stationary industrial and commercial air contamination sources."[6] The program established, Cleaner Air Oregon, will

> "Establish health risk based limits to protect neighbors and vulnerable people, set protective standards using the latest and best scientific evidence on health

[4] Department of Environmental Quality, Wood Stoves Webpage. https://www.oregon.gov/deq/Residential/Pages/Woodstoves.aspx

[5] Oregon Department of Environmental Quality, *Woodsmoke in Oregon: House Bill 3068 (2015) Final Report to Legislature*, (September 2016): https://www.oregon.gov/deq/FilterDocs/SB3068Report.pdf

[6] Oregon Legislature, Senate Bill 1547, (2016): https://olis.leg.state.or.us/liz/2018R1/Downloads/MeasureDocument/SB1541

effects from air toxics, and prioritize facilities with greatest risks to health and create air quality rules that allow businesses to thrive."[7]

The Department of Environmental Quality has published proposed rules, which outline Cleaner Air Oregon's purpose and jurisdiction.

Carbon Cap and Invest 2019 Proposed Legislation

Carbon cap and invest legislation which was introduced to the legislature in 2018, is designed to reduce greenhouse gas emissions, prevent climate change and ocean acidification. Emissions are based on 1990 greenhouse gas levels, with reduction goals set at 20% below 1990 levels by 2025, 45% by 2035, and 80% by 2050.

The cap and invest market would set a cap on total greenhouse gas emissions, and businesses that emit more than 25,000 metric tons of carbon dioxide equivalent would need to buy pollution permits. The capital from sold permits would be deposited into the Climate Investments Fund. Allocation of the fund's resources would be as follows: 60% for projects, programs or activities that are to benefit of or geographically located in impacted communities (communities most at risk of being disproportionately impacted by climate change), 20% for natural and working lands (lands used for farming, ranching, parks, forests, etc.), and 20% to promote anthropogenic greenhouse reduction, wherever in the state.[8]

Utilities, large manufacturers, and paper mills are some of the polluters that would need to buy permits. As reduction goals increase, the cap would reduce, and there would be fewer pollution permits available. Companies would have to reduce emissions or buy pollution credits from companies that have already made pollution reductions. Oregon's cap and invest market could sync with California and Canadian markets, allowing Oregon businesses to buy and sell pollution credits outside the state.[9]

NOTE: Oregon House Speaker, Tina Kotek, and Oregon Senate President, Peter Courtney, are joined in bringing carbon cap and invest legislation to the 2019 session. The information provided above reflects the legislation as it stood at the end of the 2018 legislation. Committee meetings since that time have informed changes to the legislation, which will be provided to the Climate Action Steering Committee as soon as it is available.

---

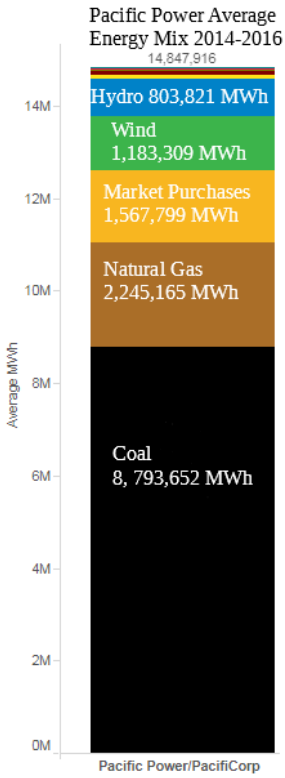
[7] Cleaner Air Oregon, Infographic, https://www.oregon.gov/deq/FilterDocs/CAOInfographic.pdf
[8] Oregon Legislature, Carbon cap and invest legislation, 2018 Regular Session https://olis.leg.state.or.us/liz/2017I1/Downloads/CommitteeMeetingDocument/139346
[9] Cassandra Profita, "Q&A: How Oreogn's Cap And Trade System Would Work," Oregon Public Broadcasting, January 10th, 2018.

Local Utility Programs

Pacific Power

One of two electric utility providers for Central Oregon, Pacific Power is the largest provider in Bend and the second largest electricity provider in Oregon. In Oregon, Pacific Power serves over 574,000 customers. As shown in Figure 5, Pacific Power currently depends heavily on coal to provide electricity to its customers. As shown in figure 2, Pacific Power's energy mix is roughly 60% coal, 15% natural gas, 10% market purchases (coal and hydro), 7% wind, and 5% hydro. The Renewable Portfolio Standard (RPS) mandates that no coal power can sold to Oregon residents by 2030. Therefore, Pacific Power plans to greatly modify the grid mix they provide to Oregon customers.

Figure 5. Pacific Power Grid Mix



Pacific Power's Integrated Resource Plan (IRP) outlines the company's plans to provide customers with reasonably priced electricity, while complying with state renewable portfolio standards. The IRP details Pacific Power's preferred portfolio, which retires coal power generation, buys renewable energy certificates, and invests in renewables.

Renewable energy certificates (RECs) signify the production of 1MWh of electricity from a renewable energy source. Renewable energy produced outside of Oregon can be bought and sold to Oregon customers by utilities. To meet RPS demands, utilities purchase thousands of RECs per year to meet the required percentage of renewable electricity in their energy mix. Pacific Power has secured enough RECs to meet the RPS goals until 2024.[10] Pacific Power will continue to purchase RECs until 2035 as they invest in renewable energy.

Figure 6 shows Pacific Power's estimate emissions trajectory as they transition away from coal in the grid mix provided to Oregon customers.

[10] Patrick Nye, "Energy Trust of Oregon REC Report," *Bonneville Environmental Foundation*, (March, 2015): 1-54.

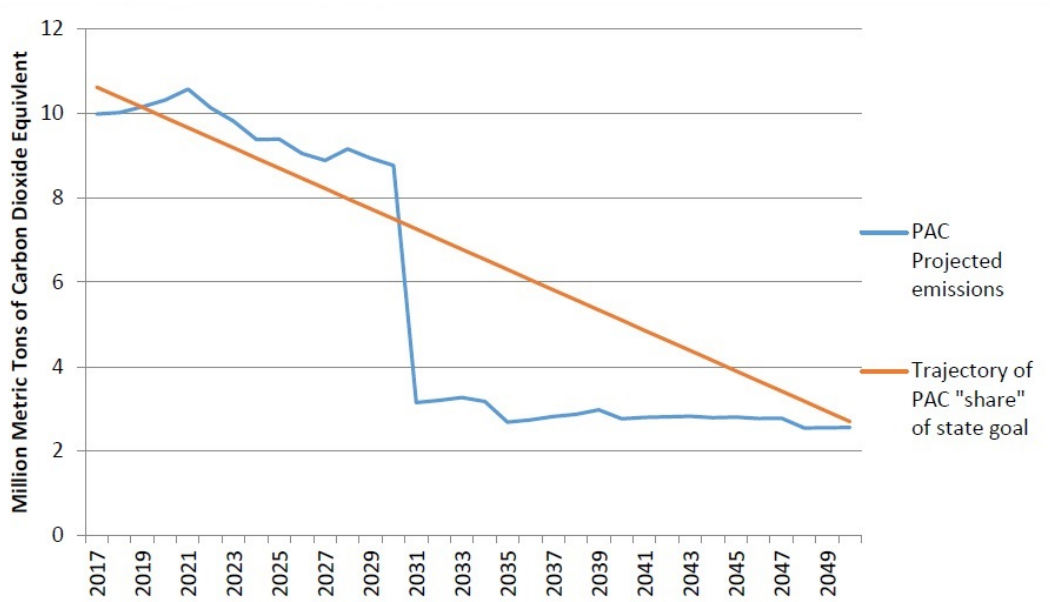


***Figure 6**. Pacific Power Emissions Chart*

Pacific Power's energy vision for 2020 includes a $3.5 billion investment in clean, reliable, and affordable energy. Most of the investment will be placed into improving and adding wind energy.

- Upgrading or "repowering" existing wind fleet with larger blades and newer technology
- Adding 1,150 megawatts of new wind resources by the end of 2020
- Building a new 140-mile Gateway West transmission segment in Wyoming to enable additional wind generation

Pacific Power also offers its customers a voluntary program which supports renewable energy. Through the Blue Sky program, customers can pay to match their electricity consumption with renewables. For homes and small businesses, the Blue Sky program has three options as shown in Figure 7.

Program Option	Description	Environmental Benefit	Extra cost
Blue Sky Block	Support renewable energy in fixed price, **100 kilowatt-hour** "blocks" of 100% western region **wind (50%) and solar (50%) energy** and help fund new, community-based renewable energy projects in your state.	It's like not driving a car more than 1,613 miles when you buy one block per month for a year	$1.95 per 100 kwh block per month
Blue Sky Usage (Oregon only)	Support a blend of 100% Pacific Northwest renewable resources from Oregon, Washington and Idaho.** The resource mix is likely to include wind (74%), biomass (8%), solar (17%) and geothermal (1%).	It's like not driving a car for each year you are enrolled	Costs $0.0105 more per kwh, about $8 extra per month*
Blue Sky Habitat (Oregon only)	Same as Blue Sky Usage and also helps restore and preserve native fish habitats in Oregon via the non-profit organization The Freshwater Trust.	It's like not driving a car for each year you are enrolled Plus habitat restoration and preservation	Costs $0.0105 more per kwh, and a $2.50 monthly donation

***Figure 7**. Pacific Power's Blue Sky Program Options*

Central Electric Cooperative

Central Electric Cooperative (CEC) is a member-owned, not-for-profit electric cooperative which serves multiple counties in Oregon, including Deschutes. The CEC's energy supply comes from the Bonneville Power Administration. In Figure 8, over a three year period from 2014-2016, hydro and nuclear power were the primary sources of electricity.

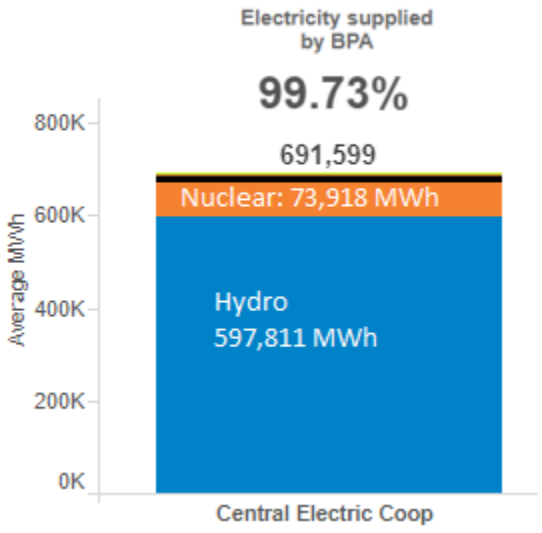


***Figure 8**. CEC's grid mix*

CEC has two renewable energy programs available to customers. Through the Green Power program, customers purchase at least one 100 kWh block per month over a 12-month contract. The price is 1.8 cents per kW more than the regular rate. The program supports the construction and operations of CEC's community solar project and Coffin Butte's gas-to-electric plant in Benton County.

Shared Solar is Central Electric's community solar program. The 200 kilowatt solar plant is located on SE 27th St. in Bend, and customers can enter into 19-year contracts to subscribe to either a quarter, half, or full panels.

Cascade Natural Gas

Cascade Natural Gas Corporation (CNGC) is Central Oregon's sole natural gas provider, and has over 282,000 customers located in the smaller cities and rural communities across Oregon and Washington.[11] In Cascade's 2018 Integrated Resource Plan, the company expects to see a load growth of 1.58% per year, or 34.6% over 20 years.[12]

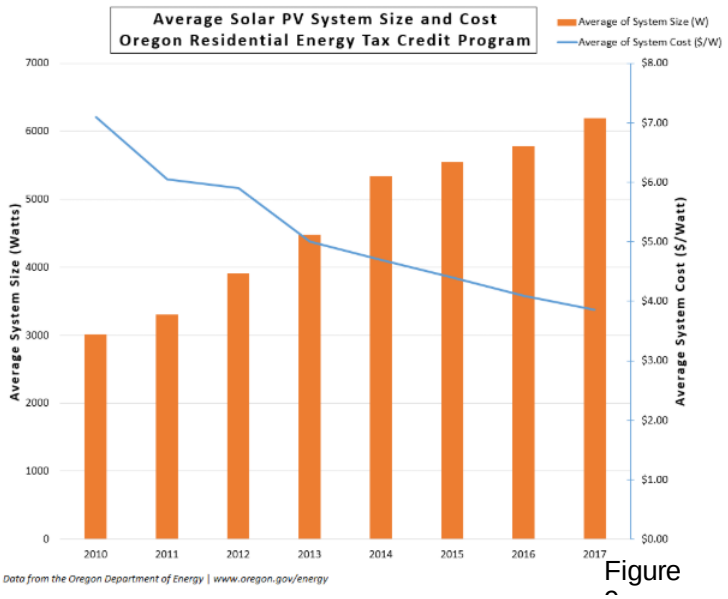
Cascade is partnered with the Energy Trust of Oregon to administer energy efficiency programs. There are programs for residential, commercial, and industrial/agricultural customers. For residential customers, weatherization, HVAC, and water heating equipment programs are available.

Current State of Leading Technologies

Utilities need to diversify their energy portfolio to ensure the RPS mandates are met. The RPS will create a marketplace for private citizens and companies who can invest in renewable energy to sell to utilities. Currently, utilities, national laboratories, and businesses are researching and developing the most cost effective and reliable forms of renewable energy.

Solar

Solar costs and installation has decreased over time while the effectiveness and reliability of the panels has increased. East of the Cascades, Oregon has high solar potential due to the amount of sunny days. Through the U.S. Department of Energy Solar Energy Technologies Office (SETO), Oregon has a federal grant called Northwest Solar Communities. The grant partners Oregon government agencies with Solar Plus Northwest, which



Figure

[11] Cascade Natural Gas Corporation, 2018 Integrated Resource Plan, (February 6, 2018): 1-2.
[12] Cascade Natural Gas Corporation, 2018 Integrated Resource Plan, (February 6, 2018): 1-2.

has a 2017-2027 Solar Plan for Oregon. The plan states "Oregon can feasibly install enough solar capacity to produce 10% of the state's electricity by 2027."[13] To reach this goal, Oregon has to enact policies to support solar development, increase the solar workforce, and examine potential future transmission issues.[14]

There will be grid integration challenges if solar development grows at rates depicted in Solar Plus Northwest's plan. Fluctuation in weather causes the reliability of solar to be far less than traditional power generation sources. Furthermore, solar peak output is during the middle of day, with no output at night. This causes grid integration difficulties as utilities must match the production of electricity with the demand.

While Oregon does not currently have enough solar generation to cause any grid integration issues, it may in the future. Potential solutions to solar integration is the Western Energy Imbalance Market (EIM). "The western Energy Imbalance Market is a real-time wholesale energy trading market that enables participants anywhere in the West to buy and sell energy when needed."[15] If production of energy is higher than demand, a utility can sell their excess power to another. This is beneficial for solar and wind power plants as the generation of their electricity may not be needed by their utility. The EIM saves hundreds of millions of dollars by allowing renewable resources to continue to produce energy even if their local utility cannot handle the load.

Wind

According to the American Wind Energy Association, "Oregon ranks eighth in the country for installed wind capacity, with a total capital investment of $6.6 billion in wind projects in the state."[16] Northeast Oregon's wind industry has developed mostly along the Columbia River Plateau in north central Oregon. 3,213 MW of wind energy has been installed across Oregon, with 201 MW under construction. A report from the National Renewable Energy Laboratory (NREL), states that the unsubsidized cost of wind energy could drop to 50% of current levels by 2030. New technology will reduce the O&M costs, and increase the efficiency of wind power plants. "The U.S. wind resource alone could supply more than 7.5 times the nation's total electricity generation in the year 2016."[17] Oregon has made great progress in utilizing wind energy, but still has large potential for growth.

---

[13] Amelia Schlusser and Jeff Bissonnette, "The Oregon Solar Plan 2017-2027," *Green Energy Institute*, (March 2017): 4.

[14] Schlusser, "The Oregon Solar Plan 2017-2027," 5.

[15] Western Energy Imbalance Market home webpage https://www.westerneim.com/pages/default.aspx

[16] American Wind Energy Association, "Wind Energy in Oregon," http://awea.files.cms-plus.com/FileDownloads/pdfs/Oregon.pdf

[17] Katherine Dykes, et al, "Enabling the SMART Wind Power Plant of the Future Through Science-Based Innovation," *National Renewable Energy Laboratory*, (August 2017): iv.

Battery Storage

Wind and solar energy may produce electricity when there is little demand. Battery storage can store excess energy to be sold later when demand is high. Usually, demand is highest in the evening, when residents are home and using air conditioning/heating. However, solar panels produce no energy without the sun, and the wind may not be blowing. Stored energy could be sold to customers when price and demand is high. Portland General Electric built a 5MW lithium-ion battery and inverter system in Salem. States like Hawaii and California which have grid integration difficulties with the massive amounts of solar generation are investing in battery storage to increase grid stability, reliability, and to reduce renewable energy curtailment.

Biomass

There are 17 biomass power facilities in Oregon, and 21 facilities that use biomass to provide space heat.[18] Currently, Mt. Bachelor Resort is conducting an economic analysis for a combined heat and power system that would displace over 10,000 gallons of propane a month.[19] Biomass has many potential fuel sources including food crops, woody plants, algae, organic waste, and fumes from landfills. While burning these sources releases the same amount of carbon dioxide as fossil fuels, it can still reduce greenhouse gas emissions.[20] Biomass plants burn carbon fuel sources which were made during our lifetime, instead of reintroducing old captured greenhouse gases by burning fossil fuels.

The Central Oregon Intergovernmental Council (COIC) received a USDA Forest Service Wood Innovation grant to support the Central Oregon Biomass Cluster Development Project in 2015. In 2016, COIC's Biomass team released a report detailing the availability of biomass for potential plants in Central Oregon. The report estimates that 181,683 bone dry tons (BDT) of biomass can be produced per year within Central Oregon. "This volume will support numerous community-scale biomass thermal projects or up to about 22 megawatts of baseload biomass power."[21]

Geothermal

Geothermal energy in Oregon has high potential, and has already seen some success. In 2012, a 22MW geothermal power plant was built in Neal Hot Springs, in Eastern

[18] Oregon Department of Energy, Bioenergy Webpage https://www.oregon.gov/energy/energy-oregon/Pages/Bioenergy.aspx
[19] United States Department of Agriculture, Woody Biomass Energy Webpage https://www.fs.usda.gov/detail/r6/communityforests/?cid=fseprd502769
[20] National Renewable Energy Laboratory, Biomass Energy Basics Webpage https://www.nrel.gov/workingwithus/re-biomass.html
[21] TSS Consultants, "Central Oregon Biomass Supply Availability Analysis," Prepared for: Central Oregon Intergovernmental Council, (June 6, 2016): 35.

Oregon near Vale. The plant entered into a power purchase agreement with U.S. Geothermal Inc. Geothermal offers consistent and reliable baseload power generation. Central Oregon has a geothermal project in development on the west side of Newberry Volcano, operated by NEWGEN. "NEWGEN is the Newberry Geothermal Energy consortium, a collaboration between Pacific Northwest National Laboratory, Oregon State University, AltaRock Energy, and StatOil. The NEWGEN consortium aims to bring cutting-edge geothermal research and development activities to Central Oregon and beyond."[22] Geothermal has high upfront costs and site location is difficult to assess, which hinders research and development.

Hydropower

Dams have been the major electricity generators for Oregon since the 1950s. The power from the Federal Columbia River Power System is marketed by the Bonneville Power Administration. All 34 consumer-owned utilities rely on BPA for the majority of their power. Hydropower is becoming less reliable due to rising temperatures, extreme weather events, reduced snowpack, and drought. Upgrading existing dams to become more efficient is one method of increasing the amount of power dams produce. The percentage in efficiency increased can be counted in the RPS, even if the dam upgraded was built before 1995.

Pumped hydro storage is a cost effective method of energy storage. Water is pumped uphill when electricity demand is low, and released to flow downhill and generate power during times of high demand. However, there are no pumped storage projects in Oregon, due to incompatibility with restrictions on flow requirements and fish protections.[23]

In-line hydro is increasingly being used within water transmission distribution systems including municipal and irrigation systems. These "micro" hydro power generation opportunities afford water systems with the ability to utilize the renewable energy created by the pressure of passing water through a pipe instead of wasting it with pressure reducing valves. An example of this is the partnership between Lucid Energy and the Portland Water Bureau that installed a series of small hydroelectric generator inside a pipe that carries drinking water to the City of Portland, Oregon.[24]

Hydrogen

While hydrogen is not a source of energy itself, it can be used to produce electricity. Electrolysis is the process of splitting water molecules into hydrogen and oxygen by

[22] Newberry Geothermal Energy FAQ Webpage http://newberrygeothermal.com/faq/

[23] Oregon Department of Energy, *Hydropower,* Webpage, (2018): https://www.oregon.gov/energy/energy-oregon/Pages/Hydropower.aspx

[24] https://www.opb.org/news/article/portland-now-generating-hydropower-in-its-water-pipes/

passing an electric current through a cathode and anode. The hydrogen is captured and stored for later use; such as fuel cells for hydrogen power vehicles, or injection into the natural gas grid. The expense of current technology prevents hydrogen from being used as a source of power. There is a growing amount of interest in this technology and its flexible applications, and future work to garner more industry attention could reduce these barriers and motivate adoption. The auto industry is developing hydrogen fuel cell technology. Hyundai is releasing a Fuel Cell Electric Vehicle in 2019.[25]

Best Practices For Climate Action Planning

One of the biggest opportunities for climate action in cities identified by C40 Cities "Focused Acceleration" study is decarbonizing the electricity grid. We cannot reach our goals without a massive expansion of renewable power generation. Best practices in this area include:

- Set decarbonization goals such as 100% net renewable energy
- Aggregate demand for renewables and reduce the cost
- Enable consumers to purchase and produce renewable energy
- Increase local production of renewable power
- Enable smart grids

Utilities and regulators must work together to assure that the overall mix of renewables is appropriately balanced at a system level and that critical components such as energy storage are in place to ensure grid reliability.

Decarbonizing the electricity grid is tied to increasing energy efficiency and shifting energy consumption (particularly heat and transportation) to electricity.

[25] https://www.forbes.com/sites/samabuelsamid/2018/10/15/2019-hyundai-nexo-stands-out-as-first-truly-complete-fuel-cell-electric-vehicle/#1b2b0ef6402d

References

American Wind Energy Association, "Wind Energy in Oregon," http://awea.files.cms-plus.com/FileDownloads/pdfs/Oregon.pdf

Cascade Natural Gas Corporation, 2018 Integrated Resource Plan, (February 6, 2018): https://www.cngc.com/docs/default-source/irp-docs/2018-or-irp.pdf?sfvrsn=2

Department of Environmental Quality, Air Quality, *Cleaner Air Oregon*, webpage accessed, (2018): https://www.oregon.gov/deq/aq/cao/Pages/default.aspx

Department of Environmental Quality, Cleaner Air Oregon Proposed Rules, *Division 245 rules draft*, (2018): https://www.oregon.gov/deq/Rulemaking%20Docs/cao-pn2-Div245.pdf

Dykes, Katherine, Maureen Hand, Tyler Stehly, Paul Veers, Mike Robinson, Eric Lantz, and Richard Tusing. "Enabling the SMART Wind Power Plant of the Future Through Science-Based Innovation." *National Renewable Energy Laboratory*. (August 2017): 1-57. https://www.nrel.gov/docs/fy17osti/68123.pdf

National Renewable Energy Laboratory, *Biomass Energy Basics*, webpage accessed, (2018): https://www.nrel.gov/workingwithus/re-biomass.html

National Renewable Energy Laboratory, home webpage accessed, (2018): https://www.nrel.gov/

Newberry Geothermal Energy, *FAQ*, webpage accessed, (2018): http://newberrygeothermal.com/faq/

Nye, Patrick. "Energy Trust of Oregon REC Report," *Bonneville Environmental Foundation*, (March, 2015): 1-54, https://energytrust.org/wp-content/uploads/2016/12/REC_Report.pdf.

Oregon Department of Environmental Quality, Air Quality, *Air Quality Programs*, webpage accessed, (2018): https://www.oregon.gov/deq/aq/programs/Pages/default.aspx.

Oregon Department of Energy, *Bioenergy*, webpage accessed, (2018): https://www.oregon.gov/energy/energy-oregon/Pages/Bioenergy.aspx

Oregon Department of Energy, *Hydropower*, webpage accessed, (2018): https://www.oregon.gov/energy/energy-oregon/Pages/Hydropower.aspx

Oregon Department of Energy, Energy in Oregon, *Electricity Mix in Oregon*, webpage accessed (2018): https://www.oregon.gov/energy/energy-oregon/Pages/Electricity-Mix-in-Oregon.aspx.

Oregon Department of Energy, *R*enewable *Portfolio Standard*, webpage accessed, (2018): http://www.oregon.gov/energy/energy-oregon/Pages/Renewable-Portfolio-Standard.aspx.

Oregon Department of Environmental Quality, *Wood Stoves*, webpage accessed, (2018): https://www.oregon.gov/deq/Residential/Pages/Woodstoves.aspx

Oregon Department of Environmental Quality, *Woodsmoke in Oregon: House Bill 3068 (2015) Final Report to Legislature*, (September 2016): https://www.oregon.gov/deq/FilterDocs/SB3068Report.pdf.

Oregon Department of Environmental Quality, Wood Stoves, Buying or Selling Wood Stoves, *Oregon's Heat Smart Program*, webpage accessed, (2018): https://www.oregon.gov/deq/Residential/Pages/heatsmart.aspx.

Oregon Legislature, Carbon cap and invest legislation, 2018 Regular Session https://olis.leg.state.or.us/liz/2017I1/Downloads/CommitteeMeetingDocument/139346

Oregon Legislature, Senate Bill 1541, (2018): https://olis.leg.state.or.us/liz/2018R1/Downloads/MeasureDocument/SB1541

Oregon Legislature, Senate Bill 1547, (2016): https://olis.leg.state.or.us/liz/2016R1/Downloads/MeasureDocument/SB1547/Enrolled.

PacifiCorp. *Renewable Portfolio Standard, Oregon Implementation Plan 2017 through 2021*. https://www.pacificpower.net/content/dam/pacific_power/doc/About_Us/Rates_Regulation/Oregon/OR-UM-1754-RPS-Implementation-Plan-2017-2021_December_2015.pdf.

PacifiCorp. *Renewable Portfolio Standard, Oregon Implementation Plan 2019 through 2023*. December 28th, 2017. https://www.oregon.gov/energy/energy-oregon/Documents/2018-PAC-RPS-Implementation-Plan.pdf.

Profita, Cassandra. "Q&A: How Oregon's Cap and Trade System Would Work." *Oregon Public Broadcasting*, January 11, 2018. https://www.opb.org/news/article/qa-how-oregons-cap-and-trade-system-would-work/

Schlusser, Amelia and Jeff Bissonnette. “The Oregon Solar Plan 2017-2027.” *Oregon Solar Energy Industries Association, prepared by The Green Energy Institute*. (March 2017): 1-8.
http://solarplusnw.org/wp-content/uploads/OR-Solar-Plan.pdf

TSS Consultants, “Central Oregon Biomass Supply Availability Analysis,” Prepared for: Central Oregon Intergovernmental Council, (June 6, 2016): 1-35.
https://newcoic.files.wordpress.com/2015/12/coicbiomassavailabilityreport-final-20160606.pdf

United States Department of Agriculture, *Woody Biomass Energy*, webpage accessed, (2018): https://www.fs.usda.gov/detail/r6/communityforests/?cid=fseprd502769

Western Energy Imbalance Market, home webpage, accessed (2018): https://www.westerneim.com/pages/default.aspx

9

TRANSFORMING ENERGY SUPPLY SYSTEMS

A city's energy supply system contains two major sub-systems: electricity and thermal heating and cooling. (This Framework locates a third type of energy supply—fuels for vehicles and public transit—in the transportation system.) The energy-supply profiles and situations of cities vary considerably:

- Some cities, due to history and geography, derive much of their electricity from carbon neutral sources such as hydropower, while others rely heavily on dirty sources such as coal. This affects both their carbon reduction targets for the system and the sorts of strategies they use.
- Some cities own and operate their electricity-generating system, but most do not and are dependent on decisions by other levels of government and investor-owned utilities. Government regulatory contexts vary: some are heavily directed by government, others have been deregulated.
- Some cities have comparatively cheap electricity and this makes it difficult to spur investment in alternative, renewable sources.
- Some cities have easier opportunities to produce or access renewable energy; factors like wind and insolation levels, shade from buildings, and cost of building electricity transmission systems all make a difference.

Despite these differences, cities tend to share a set of general energy supply system conditions, a vision for what the redesigned system will look like, and common barriers to system change. They also share a strategic balancing act: how much to push for reduction of the carbon content of energy supply versus reduction in demand for energy, especially by increasing the energy efficiency of buildings. Finally, they tend to share a set of non-climate-oriented desired outcomes for the system:

The energy-supply profiles of cities vary considerably; still, cities share common barriers and a similar vision for system transformation.

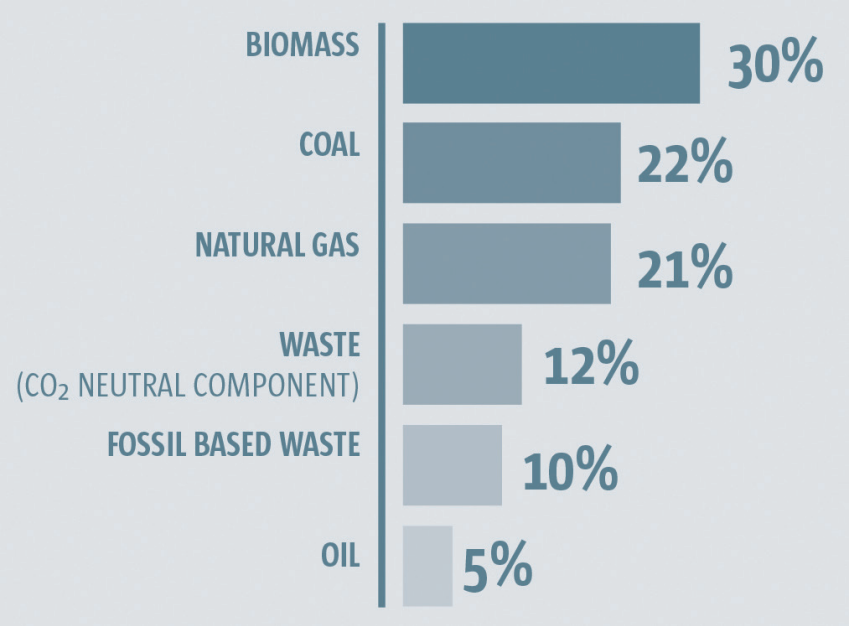
Desired Outcomes of the Energy Supply System

Clean	Reduce carbon emissions and toxic pollutants created by the system
Reliable	Minimize system downtime from outages and ensure high quality of power delivered
Affordable	Keep rates as low as possible and maintain competitiveness
Predictable	Minimize rate volatility
Transparent	Consumers can understand their power costs and what drives changes in costs
Local Control	Give residents greater control over their energy resources and energy choices
Wealth Creating	Keep more energy revenue in the local economy instead of exporting it to outside suppliers—to help drive local economic development, create new businesses and jobs
Innovative	The system spawns innovation, intellectual property creation, and entrepreneurship
Just	The system promotes "energy equity," protecting vulnerable populations from undue hardship, and promotes energy literacy

Energy Supply System Conditions

- **Centralized and Integrated.** The electricity system integrates generation, transmission, and distribution of power, typically with centralized, large-scale energy production that requires many large, long-term, sunk investments in facilities and equipment. Centralization is a system feature that is undergoing change:
- **MINNEAPOLIS:** "The current electric grid—with its large centralized power plants and miles of transmission and distribution lines—relies on many technologies that originated more than a century ago with Edison and Westinghouse. The rapidly emerging modern grid looks much more distributed and decentralized, with many actors on the system sending electricity and data back and forth."[50]
- **SYDNEY:** "Electricity used in the City of Sydney is currently provided by a remote, centralised, predominately coal-fired electricity grid. This is highly polluting and electricity used in the City of Sydney Local Government Area accounts for 80% of total greenhouse gas emissions." In addition, much of the energy produced at remote power stations is lost in the form of evaporated waste heat.[51]
- **Renewables.** These typically are only a small percentage of the electricity generated. Hydropower is a large source of power in some leading-edge cities such as **OSLO**, **VANCOUVER** and **SEATTLE**. Solar and wind much less so up to now.
- **YOKOHAMA:** Yokohama has set goals for various types of renewable energy, such as waste energy, biomass power generation (sewage treatment), solar power generation and small hydroelectric generation.
- **SEATTLE:** Seattle's electricity fuel mix includes around 89% hydropower and an additional 3.4% of wind generation. The remainder is comprised of landfill gas, nuclear, and fossil fuel purchases that the utility offsets through the purchase of renewable energy credits.
- **Private Investment.** A large portion of the capital used to build and operate energy-providing systems comes from private investors seeking returns on their investment.
- **Enormous Expenditures.** The electricity system has extensive, expensive infrastructure for transmission and distribution
- **Consumption-based Business Model.** The energy-supply business model has long been based on volume (consumption) pricing and a cost-plus rate setting model.
- **Cities Lack Control.** Except in a small number of cities that own their electricity generation and distribution utility, control of electricity system is typically at the state/province, regional, and/or national government levels.
- **Aggregated Buying Power.** Cities amount to large customers for power when you aggregate all of their individual customers.
- **Shifting Technologies.** Energy technologies are changing rapidly, and in ways that will increase the feasibility and importance of distributed, place-based design and management.
- **Emerging Capacity.** Most cities are in an early stage of developing the technical and human capacity to engage in energy systems management.
- **Heat Provided by Burning Fossil Fuels.** In many cities, heating oil is a fuel for buildings, and cities with district heating systems may incinerate fossil-fuel based plastic waste along with other waste.
    - In **COPENHAGEN**, for instance, which uses district heating to provide heat to nearly all buildings, a substantial amount of the fuel source is not renewable.

50 City of Minneapolis, "e21 Initiative Phase 1 Report," December 2014, p. 4.
51 City of Sydney, "City of Sydney Decentralised Energy Master Plan Renewable Energy," December 2013, p. 20.



Source: City of Copenhagen, "Copenhagen Solutions for Sustainable Cities," January 2014, p. 30.

- **STOCKHOLM:** Waste is "currently being used as fuel for district heating and there are plans to increase [its] share of the total energy mix. However, this fuel contains significant amounts of fossil-based plastics. If the city is to become fossil fuel-free, these plastic fractions must be separated from the waste."[52]

Vision for Redesigned Energy Supply Systems

- **Decarbonized Imported Electricity.** Any large-scale, central supply will come from renewable sources.
- **Increased Locally Produced and Community-Owned Renewable Power.** Cities maximize the amount of energy generated by distributed, smaller-scale clean supply. **SYDNEY** noted in its vision for renewables that investment and ownership of distributed, small production systems is quite different from the current model: "Community owned renewable energy is owned or partly owned by the local community. Projects are financed by the community purchasing shares in the project as members of a cooperative for which they receive dividends for the shareholding investments. Members are normally required to be active members, which mean that they must also purchase and consume the renewable energy generated directly or indirectly by the cooperative to make the project financially viable to lenders." The Sydney report noted that, "in Denmark, renewable energy developers must sell 50% of the shareholding in the project to residents

52 City of Stockholm, "Roadmap to a Fossil-Fuel Free Stockholm 2050," March 2014, p. 6

Vision for Redesigned Energy Supply Systems

- Decarbonized Imported Electricity
- Increased Local Production of Renewable Power
- Reduced Demand/Consumption of Electricity
- Elimination of Fossil-Fuel Heating Sources
- Utility of the Future Model
- Citywide Energy Management

living within 2km of the project by law." In Germany, "hundreds of thousands of people have invested in citizen's wind farms across the country representing 90% of wind farms in some states such as North Frisia." In the United Kingdom, there were "43 community owned renewable energy schemes operating." The first community owned solar farm "became operational in 2011 after raising £6 million from 1,650 members. The share issue was 50% over subscribed." And in the U.S., community wind "is one of the fastest growing markets… with 27 states having legislation that allows community renewable energy schemes."[53]

- **BERLIN:** "Solar energy offers the most promising potential of all the renewable portfolio, fitting well with the urban load curve and the urban distribution network. Berlin's 320,000 residential houses — not only the roofs, but also the facades — offer a space-efficient basis for a massive rollout of photovoltaics as well as solar heating systems. Studies find that Berlin can generate 300 times the amount of solar energy it produced in 2010."[54]
- **SYDNEY:** "Buildings, whether residential, industrial or commercial, can use onsite renewable energy technology to generate electricity and heating for the building. A small, local renewable power plant within the city could generate power for consumption within the local distribution network. Electricity produced at a great distance from cities requires major transmission and distribution infrastructure and its associated costs. These inefficiencies increase consumers' electricity bills and the amount of greenhouse gas emissions. Therefore, there is greater value in generating renewable energy close to where it will be consumed. Generating renewable electricity and replacing natural gas with renewable gases to supply a decentralised trigeneration energy network would be a significant step for decarbonising Sydney."[55]
- **PORTLAND** has piloted "community solar" to spread the use of on-site solar generation to residents who, because they are renters or own property that don't receive sufficient sunlight, are unable to tap into solar energy. "In its ideal form, community-shared solar is one larger-scale photovoltaic system that provides power or economic benefits to multiple customers." The city launched a campaign to raise funds to develop solar on schools, libraries, community centers, and other spaces.[56]
- **Reduced Demand/Consumption of Electricity.** Reduced consumption will be mostly in the building sector. Other climate-action strategies, such promoting sale and use of electric vehicles, will increase demand on the electricity grid.
- **Elimination of Fossil-Fuel Heating Sources.** Leading-edge cities seek to eliminate the use of fossil fuel-based heat for buildings, including in district heating systems.
- **Utility of the Future Model.** The underlying model for an electricity utility will be modernized.

Toward the "Electricity Utility of the Future"

Grid Modernization	• Smart Grids (Advanced Metering Infrastructure) • Improved grid performance (Volt/VAR Control) • Automated Demand Management • Improved Storage and Frequency Regulation
New Utility Revenue Models	• Revenue De-Coupling • Performance-Based Compensation • Fixed Cost Recovery • Minimize Stranded Assets
Other Aspects	• Reduce Peak Load Requirements • Improved Transmission Planning • Time-Variant Pricing

53 City of Sydney, "City of Sydney Decentralised Energy Master Plan Renewable Energy," December 2013, p. 28.

54 City of Berlin, "Climate-Neutrality Berlin 2050: Results of a Feasibility Study," March 2014, p. 9.

55 City of Sydney, "City of Sydney Decentralised Energy Master Plan Renewable Energy," December 2013, p. 20.

56 City of Portland, "Climate Action Plan," June 2015, p. 69.

- **Smart Grids.** Smart grids are a critical component of the utility of the future.
- In YOKOHAMA'S Yokohama Smart City Project (YSCP), the city, in cooperation with Japan's 34 leading companies in the fields of energy, electronics and construction, introduced a system to optimize the energy supply-demand balance in mixed-use residential-commercial areas. The city set individual targets for the adoption of building energy management systems (BEMS), solar installations and uptake of electric vehicles, and achieved these targets by FY2013. YSCP is now moving from the demonstration stage to the implementation stage.[57]
- SYDNEY found that "the integrated smart grid system being developed by advanced economies in Europe shows how electricity, heat and gas can be integrated to provide a 100% non-intermittent renewable energy system. Renewable gas developed from waste converted into substitute natural gas and injected into the gas grid, the use of 'power to gas' technologies for surplus renewable electricity from intermittent renewable electricity generation technologies such as solar and wind converted into renewable hydrogen or renewable gas and injected into the gas grid and heat recovered from decentralised electricity generation for supplying heating and cooling are key features of such a system."[58]
- **Citywide Energy Management.** This will be a new municipal function, with energy goals and targets; sophisticated analysis of energy systems serving the city; strategies and plans, including capital investment, to achieve goals for the system; and a capacity to manage implementation of new design and monitor progress.
- In addition, some cities — BERLIN and COPENHAGEN, for instance — project themselves as potential exporters of renewable energy.
- In BERLIN'S plans the city "will increase its total electricity production — and simultaneously decrease its import needs. This will change the image of the big city as an 'energy sink' significantly: in terms of energy accounting, Berlin can practically even out its electricity balance. If the new, system-relevant big consumers such as those from the power-to-gas/methanol technology sector were located outside Berlin, Berlin could even export an appreciable amount of electricity. However, the scenarios assume that it makes more economical and infrastructural sense to locate this production predominantly in Berlin. From a seasonal perspective, Berlin will export most of its electricity in the summer, when it produces large amounts of solar energy. In the winter, the city will need wind energy — from Brandenburg, for example — to complement its own CHP-generated power. Thus, the result pleads the case for a new division of tasks with Berlin's periphery: a high solar and cogeneration-based production of electricity will help reduce the area required for energy generation — in Berlin, but also in Brandenburg, where, at least from a Berlin perspective, lignite power plants might no longer be necessary."[59]

57 City of Yokohama, "Midterm Plan 2010 — Chapter 4: Growth Strategy," 2010, p. 127.
58 City of Sydney, "City of Sydney Decentralised Energy Master Plan Renewable Energy," December 2013, p. 32.
59 City of Berlin, "Climate-Neutrality Berlin 2050: Results of a Feasibility Study," March 2014, p. 18.

Major Barriers to Energy Supply System Change

Among the many barriers cities encounter in seeking to transform their energy supply, these are some of the most prominent:

- **Reliability** — The electricity and heating systems' reliability cannot be compromised; risks of incorporating intermittent renewable sources into the grid must be designed and managed.
- **Stranded Assets** — There is the potential for "stranded assets" in the system: devalued system components become liabilities, with financial losses and risks for private and public investors.
- **Financial Concerns** — Decision-makers may resist increased distributed production of energy and conservation because the current energy-supply business model depends on volume sales and loss of volume destabilizes financial performance.
- **Feasibility of Innovations** — The feasibility of microgrids and other distributed-generation models is not yet well established.
- **Renewable Supply Growth** — There is uncertainty about how rapidly a large-scale renewable supply can be developed and deployed.

TIMELINE FOR BOULDER'S ENERGY SUPPLY TRANSFORMATION EFFORT

2002

- City Council establishes the target of a 7% GHG reduction below 1990 levels by 2012.

2005

- City begins researching power supply options and funds a "Preliminary Municipalization Feasibility Study".

2006

- Voters approve a local carbon tax.
- Climate Action Plan approved by City Council.

2010

- Xcel franchise expires and the city decides not to renew it. Boulder voters approve a utility occupation tax to replace the franchise fee.

2011

- City Council approves Boulder Energy Future purpose, framework and goals.
- Voters pass a ballot measure to fund ($1.9 million per year) the evaluation of a municipal utility, and establish charter requirements for the utility.
- Municipal utility feasibility plan and business plan commissioned and completed.
- First Community Guide to Boulder's Energy Future and municipalization strategy is published.
- Energy localization study commissioned.

Source: City of Boulder

BOULDER is in the middle of an unusual and complex process that indicates a city's sustained desire to take control of its energy-supply future, When Boulder developed its climate action plans, the city realized that it would be almost impossible to achieve its deep decarbonization goal without an energy supplier willing to partner with the city to achieve those goals. Nearly 90 percent of electricity was generated from coal or natural gas. The City negotiated with the multi-state, investor-owned utility (Xcel) that supplied it over options for increasing renewable supplies, but was unable to reach agreement. In November 2011, Boulder voters passed a measure to fund an analysis of the feasibility of establishing a municipal utility and two years later they authorized the city to issue bonds to finance purchase of the utility's assets. A feasibility study found that a city-owned utility could immediately obtain 54 percent or more of its electricity from renewable resources. By 2015, the city was in the midst of legal maneuvering and had submitted a proposal to state regulators seeking permission to transfer the utility's assets to the city. The next step would be to file condemnation proceedings to establish the value of the assets that the city would have to compensate the utility for. The timeline is for the City to "go live" with its new municipal utility in January 2018.

2012

- White paper on potential Xcel partnership options is developed.

2013

- Detailed analysis and modeling conducted to determine if a municipal utility could meet the Charter requirements.
- City projections are validated by a third party independent review.
- City Council authorizes the filing of condemnation to acquire Xcel assets if negotiations fail.
- The Boulder-Xcel Task Force is launched and issues its report.
- After extensive negotiations, Xcel and the city decide to terminate discussions because of a lack of agreement.
- Voters approve a ballot measure to authorize city bonding to purchase Xcel assets.
- Voters defeat a ballot measure sponsored by Xcel that would prevent municipalization.
- The Colorado Public Utility Commission issues a ruling that requires CPUC approval before Boulder moves ahead on municipalization.

2014

- City Council forms a utility in the charter.
- A detailed transition plan for establishment of the utility is developed and approved by City Council.
- Voters approve a ballot measure allowing the City Council to hold private executive sessions to discuss legal advice for creation of a local utility.
- City files a condemnation petition in Boulder District Court.
- Xcel files suit to block the City condemnation petition.
- FERC affirms Boulder's right to move forward with condemnation without needing FERC approval.

2015

- City petition for condemnation is dismissed, based on a decision that the city needs to get CPUC approval first.
- Boulder files a proposal for municipalization with the PUC.
- Staff begin work on a broader Energy System Transformation Blueprint.

Levers, Strategies and Actions for Transforming Energy Supply Systems

LEVER	STRATEGIES	ACTIONS
Voluntary Action	Enable consumers to purchase and/or produce renewable energy	• Provide clean power purchasing option (e.g., allow consumers to participate in wholesale market, Community Choice Aggregation) • Assist large enterprises in implementing clean energy purchasing through PPAs and other arrangements • Ease permitting/land use regulation for on-site renewables (e.g., rooftop solar)
Price Signals	Reduce cost of renewables	• Provide financial incentives for on-site and off-site renewable generation (e.g., property tax breaks) • Provide feed-in tariffs and/or net metering incentives for excess distributed renewable generation
	Ease regulatory compliance	• Reduce regulatory barriers to Combined heat and power (CHP), microgrids, district energy, tri-generation
Public Investments	Invest in renewable supply	• Invest in large- and medium-scale distributed generation (district energy for heating and cooling, micro-grids, CHP, tri-generation districts), or in public-private partnerships • Invest in converting city-owned fossil-fuel power generating facilities • Invest in large-scale renewable production (wind, solar) facilities • Invest in "community solar" projects
	Model the behavior—Purchase and produce renewable energy	• Install distributed renewable energy generation on city facilities • Purchase clean energy
Mandates	Mandate decarbonization of central supply	• Increase renewable portfolio standards (RPS) for utilities (at state/province, regional, national scale) • Force the retirement or conversion of fossil-fuel plants (perhaps with financial support) • Implement an emissions "cap and trade" market (at state/province, regional, national scale) • Require the phasing out/conversion of buildings' fossil-fuel heating systems (and provide technical and financial assistance for owners/managers) toward waste heat, biomass or geothermal energy systems
	Mandate increased energy efficiency and conservation	• Increase efficiency and emissions requirements for fossil-fuel plants • Implement mandates to reduce energy consumption in buildings and transportation systems

Resources

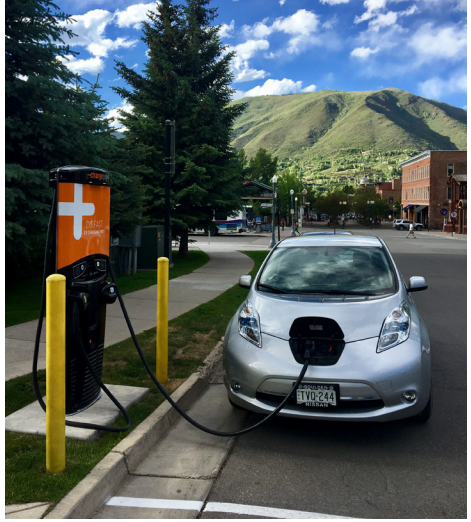
Berlin Energy Concept 2020	Berlin	Develops a future strategy for Berlin's energy supply.
Delivering London's Energy Future (2011)	London	A strategic framework that aims to protect the environment through reducing energy usage and carbon emissions in various sectors.
Minneapolis Energy Pathways: A Framework for Local Energy Action (2014)	Minneapolis	Describes the current energy system in Minneapolis, the plan to develop Minneapolis' energy vision, local utility franchise agreements and the pathway to achieve Minneapolis' energy vision.
e21 Initiative Phase 1 Report (2014)	Minneapolis	The e21 Initiative produced this report to provide Minnesota with options to decide their energy infrastructure, the production of their energy and how they want to utilize their energy.
Geothermal Systems and their Application in New York City (2015)	New York City	Explains that the use of geothermal energy can improve the efficiency of New York City's energy systems
San Francisco Mayor's Renewable Energy Task Force Recommendations Report 2012	San Francisco	Recommends specific steps to take in order to achieve San Francisco's goal to get 100% of its electricity demand with renewable power.
Stockholm Action Plan for Climate and Energy 2012-2015	Stockholm	Includes Stockholm's strategies to reduce greenhouse gas emissions and long term goals and visions to make Stockholm more sustainable.
Yokohama FutureCity Initiative (2012) and Yokohama Action Plan 2013-2017	Yokohama	Yokohama's energy strategy and strategies to tackling climate change.
Seattle Climate Action Plan (2013)	Seattle	Outlines near-term and long-term actions to achieve a carbon neutral city, including a Building Energy strategy to achieve deep energy savings in new and existing buildings and reduce the carbon content of Seattle's energy supply.

A Guide to Electricity Markets, Systems, and Policy in Massachusetts	Conservation Law Foundation	Helps stakeholders in Boston understand how regional electricity markets function in New England and Massachusetts, and to introduce some of the important choices about the design of those markets currently being discussed in the region.
Better Growth Better Climate **Charting a new path for low-carbon growth and a safer climate.**	The Global Commission on the Economy and Climate — The New Climate Economy	Commissioned in 2013 by the governments of seven countries: Colombia, Ethiopia, Indonesia, Norway, South Korea, Sweden and the United Kingdom. In chapter 4, this report examines energy trends and makes recommendations to reduce GHG emissions through changes in energy systems away from fossil fuels to renewable energy sources and minigrids.
District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy	United Nations Environment Programme	A new report from UNEP has surveyed low-carbon cities worldwide to identify the key factors underlying their success in scaling up energy efficiency and renewable energy, as well as in attaining targets for zero or low greenhouse gas emissions.
PEER: New Rating System for Sustainable Power Systems		Modeled after the U.S. Green Building Council's (USGBC) LEED green building rating system, PEER, or Performance Excellence in Electricity Renewal, evaluates power generation, transmission and distribution systems through the lens of the customer, focusing on efficiency, quality, reliability, resiliency and the environment. GBCI will serve as the independent, third party, global certification and credentialing body for PEER.
Advancing Toward a more Sustainable Urban Energy System	World Resources Institute by Rodrigo Villarroel Walker; Daniele Poponi; Benoit Lefevre	Analyses the drivers and barriers to sustainable urban energy systems.

Energy Efficiency as a Low-Cost Resource for Achieving Carbon Emissions Reductions	U.S. Environmental Protection Agency	Examines the role of energy efficiency in addressing global climate change. It summarizes research on the size, economic value, and carbon dioxide (CO2) emissions reduction impacts of efficiency resources, reviews available information on the benefits and costs of energy efficiency, discusses the factors that limit efficiency investment in today's markets, and outlines energy efficiency policy and programs in use today that can be further expanded.
Energy Efficiency in Local Government Operations	U.S. Environmental Protection Agency	Describes how local governments can lead by example and achieve multiple benefits by improving the energy efficiency of their new, existing, and renovated facilities and their day-to-day operations. It is designed to be used by facility managers, energy and environment staff, other local government agencies, and mayors and city councils.
Renewable Energy Policy in Cities: Selected Case Studies	International Renewable Energy Agency (IRENA) and International Council for Local Environmental Initiatives (ICLEI)	IRENA, in collaboration with the International Council for Local Environmental Initiatives (ICLEI), has produced a series of case studies on cities where local governments have successfully adopted measures to promote renewable energy and sustainability.
Sustainable Urban Energy Planning: A Handbook for Cities and Towns in Developing Countries	UN-Habitat, UNEP and ICLEI-Local Governments for Sustainability	The main purpose of this handbook is to assist people who are working in or with local government to develop sustainable energy and climate action plans and implementation programmes. This handbook deals with the role of urban centres and local governments in defining a sustainable development path and a new energy future in their countries.
Built-Environment Wind Turbine Roadmap	National Renewable Energy Laboratory (NREL)	The authors summarize the expertise and resources needed in understanding the built-environment wind resource and developing testing and design standards. This roadmap identifies key barriers to the development and deployment of BWTs.

Case Study, Vancouver: Reducing Carbon Emissions through District Energy	C40 Cities	District energy is a major part of Vancouver's effort to reduce its carbon emissions 33% by 2020 from a 2007 baseline, as outlined in its Greenest City Action Plan.
Cities, Towns and Renewable Energy: Yes in my front yard	International Energy Agency (IEA)	The goals of this report are to inspire city stakeholders by showing how renewable energy systems can benefit citizens and businesses, assist national governments to better appreciate the role that local municipalities might play in meeting national and international objectives, and help accelerate the necessary transition to a sustainable future.
Developing Geothermal Heat Pumps in Smart Cities and Communities	ReGeoCities: Intelligent Energy Program of European Union	Increasing the use of geothermal energy, and strengthening the geothermal industrial sector, will allow a substantial reduction of CO2 emissions, the saving of primary energy, and the creation and sustainment of a work force with many skill levels.
Grid Integration and the Carrying Capacity of the U.S. Grid to Incorporate Variable Renewable Energy	National Renewable Energy Laboratory (NREL)	Summarizes the challenges to integrating increasing amounts of variable renewable energy (RE), identifies emerging practices in power system planning and operation that can facilitate grid integration, and proposes a unifying concept-economic carrying capacity-that can provide a framework for evaluating actions to accommodate higher penetration.
Integrating Variable Renewable Energy in Electric Power Markets: Best Practices from International Experience	National Renewable Energy Laboratory (NREL)	Documents the diverse approaches to effective integration of variable renewable energy among six countries—Australia (South Australia), Denmark, Germany, Ireland, Spain, and the United States (western region-Colorado and Texas)—and summarize policy best practices to ensure that electricity markets and power systems can effectively co-evolve with variable renewable energy.

Microgrids — Benefits, Models, Barriers and Suggested Policy Initiatives for the Commonwealth of Massachusetts	Massachusetts Clean Energy Center	Focuses on the benefits of microgrids and articulates the value of microgrids, as opposed to stand-alone distributed energy resources, whose operations are not necessarily coordinated. Microgrids represent coordinated control of DERs to maximize economics, reliability and clean energy (if feasible), and to stabilize electric loads and generation while operating independently of the macrogrid.
Smart Thermal Grids	Smart Cities and Communities (EU Commission)	The scale of smart thermal grids can range from neighborhood-level systems to city-wide applications, depending on heating and cooling demand and urban context
Energy Policy Simulator	Energy Innovation	A tool that helps cities see the impacts of their energy policy decisions in relation to various outputs, including greenhouse gas emissions.



GREENHOUSE GAS REDUCTION TOOLKIT

How to Take Action in Your Community

TABLE OF CONTENTS

INTRODUCTION TO THE GREENHOUSE GAS REDUCTION TOOLKIT

The Greenhouse Gas Reduction Toolkit (Toolkit) is designed to support cities, counties, and regions as they work to advance their emissions reduction programs. It identifies best-practices, strategies and actions that reduce greenhouse gas (GHG) emissions while enhancing quality of life and helping create thriving communities.

The menu of over 250 actions from six emission sectors reflect input from a diverse group of experts. The actions are adaptable to fit the unique needs of communities and vary in terms of carbon reduction potential, feasibility, cost, associated co-benefits and more.

HIGH-IMPACT SECTORS

The Toolkit provides readers with ideas to reduce emissions stemming from the six GHG sectors common to most Colorado communities[1]:

Full descriptions of these sectors are provided in their respective chapters.

ENERGY SUPPLY

How electricity powering the community is generated

RESIDENTIAL ENERGY

How energy is used in residential buildings

COMMERCIAL ENERGY

How energy is used in commercial buildings

VEHICLES & TRANSPORTATION

The on-road movement of people, goods and services in private, transit and fleet vehicles

WASTE & LANDFILL

The solid waste generated by the community and how it is transported to the landfill

AVIATION & AIRPORT

Aircraft operations as well as energy use and transportation directly attributable to airport operations and passengers

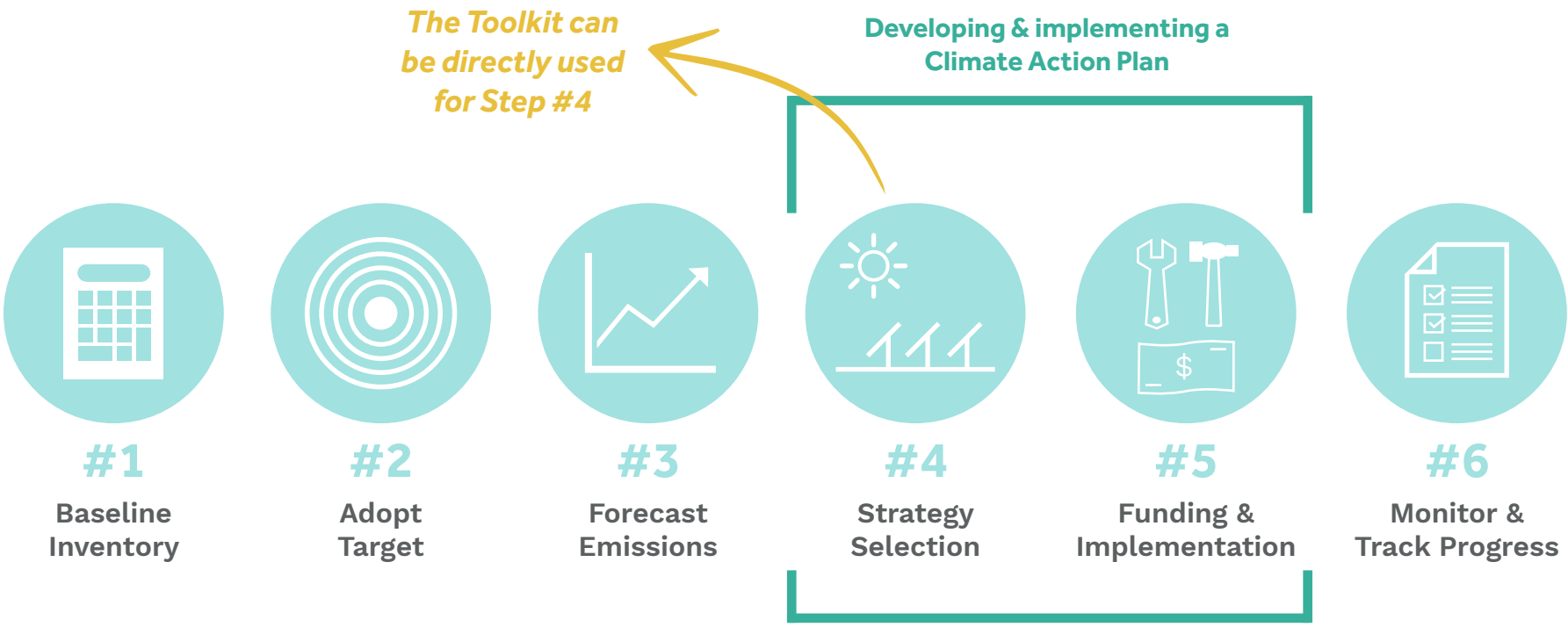
[1] These sectors also align with national and international best practices. Both the *US Community Protocol* and the *Global Protocol for Communities* suggest tracking and mitigating emissions associated with these activities.

HOW TO USE THE TOOLKIT

Fundamentally, the Toolkit is a shortcut and resource communities can use to develop climate action plans that fit their unique conditions. By listing potential actions in addition to defining the associated GHG reduction potential and co-benefits of each one, the priorities that are most important to a given community are identifiable.

The most effective way to use the Toolkit is to identify actions for implementation during the "strategy selection" phase of the climate action planning process[2]. Once actions have been selected, communities can get into the detailed deliberation necessary to move selected actions towards implementation. The Toolkit itself is a type of workbook and provides the user with space to take notes and brainstorm key considerations like implementation timeframe and partners. Since the actions detailed throughout the document are generalized, it is likely that communities will choose to modify, customize and specify Toolkit language into their own.

As actions are identified and moved towards implementation, a wide variety of considerations will likely be evaluated. Among these, it is especially beneficial to compare preferred climate actions with other strategic planning documents to identify complementary priorities. It is also especially helpful to consider opportunities for regional collaboration, given that efforts at the multijurisdictional scale can lead to efficiencies and greater impact.



[2] Detailed information and resources for completing each of these steps is available at http://www.coolcalifornia.org/local-government/toolkit and http://icleiusa.org/programs/emissions-management/5-milestones.
Page 4 figure is based on the Climate Action Resource Guide graphic on CoolCalifornia.org from the California Air Resources Board, http://www.coolcalifornia.org/local-government/toolkit.

TOOLKIT PROCESS

The Toolkit emerged as a by-product of the City of Aspen's most recent climate action planning (CAP) process. During 2016 and 2017, Aspen convened experts under the auspices of an official Advisory Committee (AC) to develop a robust strategy aimed at achieving its long-term GHG reduction goals (30% below 2004 levels by 2020 and 80% below 2004 levels by 2050). This AC is comprised mostly of leadership-level staff, specialists, and elected officials or board members[3].

The deliberative, yearlong process of GHG analysis, stakeholder meetings, and community surveys, led the leadership team to the realization that the refined yet comprehensive list of 250+ actions was far beyond the scope of a 3-5 year CAP. Further, the group realized that the list of actions could be relevant to other communities. Not wanting to limit the accessibility and impact of this impressive body of work, compiling the Toolkit became the solution to provide Aspen and others with an immediate-, mid- and long-term planning resource.

KEY RECOMMENDATIONS FOR COMMUNITY LEADERS

As community members convene to determine which actions to prioritize and refine for implementation, it is important that leaders create a supportive culture and provide resources for success. These recommendations for decision-makers will help ensure success of the overall climate planning and implementation process:

1. **Secure and prioritize the necessary organizational capacity.** This could involve assigning existing staff, hiring new staff, convening advisory commissions or otherwise.

2. Ensure that **stakeholders from all relevant sectors** are included in selecting Toolkit actions for the community's plan.

3. **Identify champions** to guide implementation when the plan is finalized.

4. **Identify and allocate funds** for plan development and implementation. This could include using existing funds, securing a new funding mechanism, or incremental multi-year budgeting. Funding is needed for projects, infrastructure, outreach, and staff capacity.

5. **Develop technical capacity** to do the work and an understanding of the linkages between climate and other local priorities. Joining the Compact of Colorado Communities[4] provides training for all levels of staff from specialists to senior leadership.

6. **Engage in state policy discussions.** Often, local priorities can be bolstered by enabling legislation at the state level. Groups such as Colorado Communities for Climate Action[5] enable municipalities to collectively represent their interests at the state capital.

7. **Collaborate across jurisdictional boundaries.** Regional collaboration in all sectors enhances efficiency and magnifies impact.

8. **Track performance, celebrate successes, and adjust course** when necessary. By measuring progress, building off what works, reevaluating when necessary, trying new things and maintaining a long-term commitment, communities are more likely to be successful in achieving their climate-related goals.

---

[3] List of Advisory Committee members provided in the Acknowledgments section of this document.
[4] http://www.compactofcoloradocommunities.org/
[5] http://cc4ca.org/

GHG REDUCTION TOOLKIT: Key & Definitions

In addition to presenting a wide range of options for reducing GHG emissions in each sector, the Toolkit presents a 'GHG reduction potential' ranking and a list of potential co-benefits of each 'Objective' and 'Action'. The schematic below explains the elements of the tables throughout the rest of the document.

OBJECTIVE:

The broad and big picture things that need to happen to make significant progress in reducing community-wide and regional GHG emissions.

ACTION:

The programs, policies and steps that help achieve each Objective.

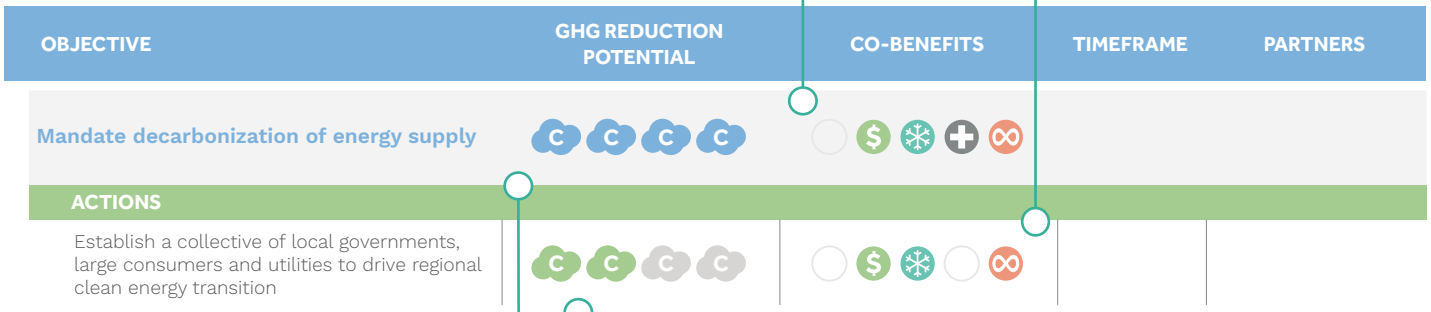
CO-BENEFITS:

Co-benefits are the additional positive benefits related to the reduction of greenhouse gases. Nearly all of the Objectives and Actions in this toolkit have co-benefits that achieve at least one of these measures:

Objective co-benefits:
The primary co-benefits of accomplishing the Objective.

Action co-benefits:
The specific co-benefits of implementing the Action.

- Promotes Equity
- Fosters Economic Sustainability
- Improves Local Environmental Quality
- Enhances Public Health & Safety
- Builds Resilience



GHG REDUCTION POTENTIAL (BLUE):

GHG reduction potential for each **Objective** represents how much it could reduce GHG emissions in the context of the sector it is a part of if fully and successfully implemented. Reduction potential was quantified using a proprietary model and simplified to a scale of 1 to 4 for presentation in the Toolkit:

Marginal

Small

Medium

Large

GHG REDUCTION POTENTIAL (GREEN):

GHG reduction potential for each **Action** represents how much it could reduce GHG emissions in the context of the Objective it is a part of. Reduction potential was approximated and is presented using a 1 to 4 scale:

Marginal

Small

Medium

Large

TIMEFRAME:

Defines whether the action is happening now or whether it should happen in the near, mid- or long-term future.

PARTNERS:

Describes which individuals, groups or organizations are leading and collaborating on implementation.

These columns have been left blank and are to be filled out by Toolkit users to help choose Actions for prioritization and implementation.

GHG REDUCTION TOOLKIT:

Energy Supply

GHG emissions in the **Energy Supply** sector are associated with purchased electricity and the use of natural gas and propane in residential and commercial buildings. The carbon intensity of a given electricity supply is the result of the resources used to generate the power; fossil resources are significantly more carbon intensive than renewable energy sources. Opportunities to reduce emissions in this sector range from fuel switching to decentralizing production. The co-benefits of successfully reducing Energy Supply sector GHGs include widespread improvements to environmental quality and the unleashing of wealth creation and employment opportunities.

GHG REDUCTION TOOLKIT: Energy Supply

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Mandate decarbonization of energy supply	C C C C	Primary Co-Benefits: $ ❄ ✚ ∞		
ACTIONS				
Participate in regional collaborative of governments, businesses, and utilities to drive clean energy transition	C C C C	$ ❄ ∞		
Establish regional market-based mechanism favoring low-carbon energy (e.g., a price on carbon or a carbon tax and fee)	C C C C	= $		
Pursue retirement, conversion or sale of fossil-fuel plants serving area	C C C C	❄ ∞		
Remove barriers to local renewable energy generation	C C C C	∞		
Establish a local renewable energy generation target	C C C C	$ ❄ ∞		
Communicate to utilities the importance of reducing the carbon content of electricity	C C C C	$ ❄ ∞		
Enable consumers to purchase and produce renewable energy	C C C C	Primary Co-Benefits: = $ ❄ ✚ ∞		
ACTIONS				
Install renewable systems on municipal facilities	C C C C	$ ❄ ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
✚ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Energy Supply

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Enable consumers to purchase and produce renewable energy				
ACTIONS				
Expand municipal renewable energy power purchasing when on-site renewables are unsuitable	C C C C	$ ❄		
Pilot microgrid infrastructure to create districts that produce the same amount of energy they consume	C C C C	$ ∞		
Enable consumers to participate in wholesale clean power market (e.g., feed-in tariffs, net metering)	C C C C	= $ ∞		
Promote access to rooftop solar for homes and businesses through code and utility policy	C C C C	= $ ∞		
Assist large entities in implementing clean energy purchasing (e.g., virtual PPAs)	C C C C	$		
Use Property Assessed Clean Energy (PACE) and other financing mechanisms to fund renewable installations	C C C C	= $ ❄ ∞		
Address the soft costs of solar energy installations such as permitting and interconnection fees	C C C C	= $ ∞		
Change land use codes to encourage regional solar development	C C C C	$ ❄ ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Energy Supply

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Reduce the cost of renewable energy	C C C C	Primary Co-Benefits: = $ ∞		
ACTIONS				
Expand Advanced Metering Infrastructure (AMI)	C C C C	= $		
Facilitate solar PV and/or solar thermal bulk purchase program	C C C C	= $ ❄ ∞		
Provide funding and incentives for residential and commercial solar projects	C C C C	= $ ❄ ∞		
Expand solar programs for low-income households (e.g., GRID Alternatives)	C C C C	= $ ❄ ∞		
Streamline and incentivize rooftop solar installation process (e.g., sales tax legislation)	C C C C	= $ ❄ ∞		
Incentivize local utility owned and operated renewable capacity	C C C C	$ ❄ ∞		
Incentivize community solar	C C C C	= $ ❄ ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Energy Supply

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Invest in renewable generation at the community and utility scales	C C C C	Primary Co-Benefits: $ ∞		
ACTIONS				
Develop goal to self-generate a given percentage of government, public, and nonprofit buildings' energy needs and install corresponding renewable capacity	C C C C	$ ∞		
Develop geothermal energy	C C C C	$ ∞		
Develop local hydropower capacity (ideally micro, pico-hydro or run of the river)	C C C C	$ ∞		
Site and develop utility-operated renewable capacity in local service area	C C C C	$ ∞		
Advance regional grid flexibility to enable a predominantly renewable electricity supply	C C C C	= $ + ∞		
Invest in energy storage to address the intermittency of wind and solar	C C C C	= $ + ∞		
Install methane digesters	C C C C	$		
Encourage customers of electric cooperatives to vote in board elections	C C C C	=		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Energy Supply

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Support relevant federal and state policies through active legislative and regulatory engagement	C C C C	Primary Co-Benefits: = $ ❄ + ∞		
ACTIONS				
Promote and share success of local climate initiatives as local narrative for broader climate action	C C C C			
Cultivate elected officials as local champions for state and federal climate and energy policy	C C C C	$ ❄ + ∞		
Track state and federal climate and energy policy and engage when appropriate	C C C C	= $ ❄ + ∞		
Advocate for grid modernization and flexibility policies	C C C C	$ ❄ ∞		
Support continuation and strengthening of Colorado's Renewable Energy Standard	C C C C	$ ❄ ∞		
Support State Energy Office	C C C C	= $ ❄ + ∞		
Become a member of Colorado Communities for Climate Action to support state climate/ energy policies	C C C C	=		

C Level of Potential GHG Reduction

= Promotes Equity

$ Fosters Economic Sustainability

❄ Improves Local Environmental Quality

+ Enhances Public Health & Safety

∞ Builds Resilience

GHG REDUCTION TOOLKIT: Energy Supply

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Support relevant federal and state policies through active legislative and regulatory engagement				
ACTIONS				
Join coalition of communities advocating for federal climate/energy policies (e.g., Mountain Pact)	C C C C	= $ ❄ + ∞		
Support state or national price on carbon	C C C C	= $ ❄ + ∞		
Help defend the Clean Air Act and continued EPA regulation of CO_2 as a pollutant	C C C C	= $ ❄ + ∞		

Notes:

C Level of Potential GHG Reduction

= Promotes Equity

$ Fosters Economic Sustainability

❄ Improves Local Environmental Quality

+ Enhances Public Health & Safety

∞ Builds Resilience

GHG emissions in the **Residential Energy** sector are associated with the use of electricity, natural gas and propane in ownership and rental units. These units vary widely in age, quality, size and occupancy, and include single-family homes, multifamily properties, mobile homes and residences in mixed use buildings. Residential units are typically served by both electric and natural gas utilities, and opportunities to reduce GHG emissions are tied to decarbonizing the supply of energy flowing to the unit and consuming less of it. The co-benefits of successfully reducing Residential Energy sector GHGs include direct consumer savings and improved dwelling comfort and safety.

GHG REDUCTION TOOLKIT:

Residential Energy

GHG REDUCTION TOOLKIT: Residential Energy

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Increase the efficiency of natural gas space and water heating, and convert to electric	C C C C	Primary Co-Benefits: ○ ○ ❄ ✚ ∞		
ACTIONS				
Convert natural gas heating system to electric or renewable energy	C C C C	○ $ ❄ ✚ ∞		
Convert natural gas water heating systems to electric or renewable energy	C C C C	○ $ ❄ ✚ ∞		
Heat buildings with geothermal heat pumps, air source heat pumps, or other heat exchange technology	C C C C	○ $ ❄ ○ ∞		
Integrate space and water heating equipment standards into building codes	C C C C	○ ○ ❄ ○ ∞		
Promote energy efficiency improvements such as adding insulation and pipe wrap to water heaters	C C C C	= $ ○ ✚ ○		
Offer technical assistance to determine natural gas heating alternatives	C C C C	= ○ ○ ○ ∞		
Encourage integration with air conditioning systems if future AC need is anticipated (e.g., dual ground/air-source heat pumps)	C C C C	○ ○ ○ ✚ ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
✚ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Residential Energy

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Mandate no- to low-carbon standards for new construction and major remodels	C C C C	Primary Co-Benefits: = $ ❄ + ∞		
ACTIONS				
Incentivize above-code buildings	C C C C	$ ∞		
Adopt the latest energy codes with specific local requirements to exceed minimum standards	C C C C	$ ❄ + ∞		
Adopt net zero (or similar) building and energy conservation codes	C C C C	= $ ❄ + ∞		
Require net zero (or near net zero) for all new development	C C C C	= $ ❄ + ∞		
Require net zero (or near net zero) for houses over a certain square footage	C C C C	$ ❄ ∞		
Strengthen building codes and standards to move toward net zero energy	C C C C	$ ❄ ∞		
Conduct community trainings on updated code requirements	C C C C	= +		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Residential Energy

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Improve the energy efficiency performance of existing buildings	C C C C	Primary Co-Benefits: = $ ❄ + ∞		
ACTIONS				
Retrofit buildings to meet current building codes	C C C C	= $ ❄ + ∞		
Provide incentives for energy efficiency retrofits (e.g., tax abatement, rebates, etc.)	C C C C	= $ ❄ + ∞		
Enact ordinances to drive and support deep energy retrofits and align regionally	C C C C	$ ❄ ∞		
Facilitate education and accreditation for contractors, architects and property managers	C C C C	= ∞		
Require and incentivize measurement and verification (to gauge efficacy of energy efficiency programs)	C C C C	= $ ❄ + ∞		
Mandate sleep mode technology for second homes when unoccupied	C C C C	❄ ∞		
Encourage adoption of building automation systems	C C C C	❄ +		
Conduct energy efficiency challenges and provide incentives to drive energy retrofits	C C C C	$ ∞		
Expand number of cool roofs (white coating on rooftops) to reduce cooling needs	C C C C	= $ ❄ ∞		
Expand number of green roofs (covered in soil and vegetation) to reduce heating and cooling needs	C C C C	$ ❄ ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Residential Energy

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Improve the energy efficiency performance of existing buildings				
ACTIONS				
Facilitate peer-to-peer information sharing among building owners	C	= ∞		
Improve access to Property Assessed Clean Energy (PACE) and other specialized financing mechanisms	C C	= ❄ ∞		
Provide regulatory and zoning relief for projects that meet verifiable high energy standards (e.g., LEED, Net Zero Energy Building, etc.)	C C	= $ ∞		
Provide energy consulting services	C	= $		
Support low-income households with energy upgrades and onsite renewable energy (e.g., Colorado's Affordable Residential Energy program, GRID Alternatives)	C C	= $ ❄ + ∞		
Reduce energy consumption in rentals, apartments and multifamily buildings	C C C	Primary Co-Benefits: = $ ❄ + ∞		
ACTIONS				
Encourage and incentivize energy efficiency retrofits in rental housing	C C	= $ ❄ + ∞		
Partner with seasonal housing providers to deploy large-scale energy efficiency retrofits	C C	= $ ❄ + ∞		

C Level of Potential GHG Reduction | = Promotes Equity | $ Fosters Economic Sustainability | ❄ Improves Local Environmental Quality | + Enhances Public Health & Safety | ∞ Builds Resilience

GHG REDUCTION TOOLKIT: Residential Energy

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Reduce energy consumption in rentals, apartments and multifamily buildings				
ACTIONS				
Partner with utilities to improve tenants' access to energy-usage data	C C C C	○ ○ ○ + ∞		
Implement mandatory, phased energy efficiency upgrades for rental units (e.g., SmartRegs in Boulder)	C C C C	= ○ ❄ ○ ∞		
Support building automation to optimize efficiency and effectiveness	C C C C	○ $ ○ ○ ○		
Deploy a targeted outreach strategy to engage renters	C C C C	= ○ ○ + ∞		
Adopt building energy reporting and disclosure ordinances	C C C C	○ ○ ○ ○ ○		
Require energy performance disclosure at point of lease or sale	C C C C	= $ ❄ ○ ○		
Implement sub-metering for multifamily buildings for more granular building energy data	C C C C	= ○ ○ ○ ∞		
Promote energy efficiency opportunities through outreach, workshops, and neighborhood challenges	C C C C	= ○ ○ ○ ∞		
Pilot green leasing strategies to address the landlord and tenant split incentive	C C C C	= $ ❄ + ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Residential Energy

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Anticipate and mitigate likely expansion of air conditioning use	C C C C	Primary Co-Benefits: ∞		
ACTIONS				
Avoid or delay the need for air conditioning through building design and management	C C C C	$ ∞		
Require high efficiency air conditioning systems as AC use becomes more prevalent	C C C C	$		
Coordinate with efforts to adopt high efficiency electric heating systems (e.g., dual ground/air-source heat pumps)	C C C C	+ ∞		

Notes:

C Level of Potential GHG Reduction

= Promotes Equity

$ Fosters Economic Sustainability

Improves Local Environmental Quality

\+ Enhances Public Health & Safety

∞ Builds Resilience

GHG emissions in the **Commercial Energy** sector are associated with the use of electricity, natural gas and propane in owner-occupied and tenant-occupied businesses in single occupancy and mixed-use buildings. These properties vary widely in age, quality, size, occupancy and use. All are typically served by both electric and natural gas utilities. Opportunities to reduce GHG emissions are tied to decarbonizing the supply of energy flowing to commercial properties and consuming less energy in them. The co-benefits of successfully reducing Commercial Energy sector GHGs include direct financial savings for businesses and enhancing the health, safety and comfort of the built environment.

GHG REDUCTION TOOLKIT:

Commercial Energy

GHG REDUCTION TOOLKIT: Commercial Energy

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Promote building energy benchmarking and reporting	C C C C	Primary Co-Benefits: $ ❄ + ∞		
ACTIONS				
Create commercial energy benchmarking and disclosure ordinance	C C C C	$ ❄ +		
Leverage the business license renewal process as a way to increase benchmarking participation and performance	C C C C	= + ∞		
Facilitate submetering for more granular building energy data and improve building owners' access to utility data	C C C C	$ ∞		
Provide technical support to help building owners begin benchmarking	C C C C	=		
Increase the efficiency of natural gas heating systems and appliances	C C C C	Primary Co-Benefits: $ ❄ + ∞		
ACTIONS				
Expand participation in voluntary incentive programs for upgrading old or inefficient equipment	C C C C	$ ❄ + ∞		
Identify opportunities for and implement district heating projects	C C C C	$ ❄ + ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Commercial Energy

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Replace NG heating and appliances with electric and/or renewable systems	C C C C	Primary Co-Benefits: ❄ ➕ ∞		
ACTIONS				
Eliminate natural gas connections for all new commercial developments	C C C C	➕		
Integrate geothermal heat or ground heat to offset natural gas use	C C C C	$ ❄ ➕ ∞		
Promote solar thermal for water heating	C C C C	$ ➕ ∞		
Provide rebates and incentives to replace old or inefficient boilers with electric	C C C C	= ➕		
Encourage integration with air conditioning systems if future AC need is anticipated (e.g., dual ground/air-source heat pumps)	C C C C	➕ ∞		
Enhance energy and resource efficiency in new commercial developments	C C C C	Primary Co-Benefits: = $ ❄ ➕ ∞		
ACTIONS				
Strengthen building codes to promote energy and resource efficiency in new commercial developments	C C C C	❄ ➕ ∞		
Provide above-code incentives for new commercial developments	C C C C	❄ ➕		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
➕ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Commercial Energy

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Enhance energy and resource efficiency in new commercial developments				
ACTIONS				
Require new buildings achieve LEED standards, mandating that criteria focus on energy efficiency	C C C C	○ ○ ❄ ✚ ∞		
Require new buildings meet net zero energy building (NZEB) standards	C C C C	○ ○ ❄ ✚ ∞		
Use land use planning to encourage density in development	C C C C	○ ○ ❄ ✚ ○		
Allow an outcome-based compliance path (target) to promote build/design flexibility	C C C C	○ ○ ❄ ✚ ∞		
Coordinate regional alignment of building energy codes and beyond code preferences	C C C C	= $ ○ ○ ○		
Bring all buildings up to current building codes or retrofit a majority of existing buildings	C C C C	**Primary Co-Benefits:** ○ $ ❄ ✚ ∞		
ACTIONS				
Require or incentivize remodels to meet current energy code	C C C C	○ ○ ❄ ✚ ∞		
Require commercial lighting retrofits in existing buildings	C C C C	○ $ ❄ ○ ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
✚ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Commercial Energy

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Bring all buildings up to current building codes or retrofit a majority of existing buildings				
ACTIONS				
Require or incentivize refrigeration upgrades	C C C C	$ ❄ ∞		
Ban or disincentivize open doors while heating or cooling is happening	C C C C	❄ ✚		
Conduct energy assessments	C C C C	= $ ✚ ∞		
Provide energy efficiency and renewable energy incentives for large consumers	C C C C	$ ❄ ✚ ∞		
Develop programs targeting specific commercial users (e.g., small lodges, restaurants, etc.)	C C C C	$ ❄		
Require deep energy retrofits at designated points, such as time of sale or major renovation	C C C C	= $ ❄ ✚ ∞		
Establish incremental timeline to require that all commercial buildings meet current building energy codes	C C C C	❄ ✚ ∞		
Develop and implement program for energy efficiency and renewable energy in historical buildings	C C C C	$ ❄ ✚ ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
✚ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Commercial Energy

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Model best practices through energy retrofitting of government buildings and properties	C C C C	Primary Co-Benefits: $ ❄ + ∞		
ACTIONS				
Implement energy efficiency measures on government buildings, offices and facilities	C C C C	$ ❄ + ∞		
Improve energy efficiency in affordable housing units and complexes	C C C C	= $ ❄ + ∞		
Require green capital needs assessment for renovation projects financed by local government	C C C C	$ ❄ + ∞		
Train building operators and facility managers in energy efficiency best practices	C C C C	$ +		
Ensure new government buildings achieve high performance green building standards (e.g., NEZB, LEED, etc.)	C C C C	$ ❄ + ∞		
Identify opportunities for and implement district heating in new construction, remodels and campuses	C C C C	$ ❄ + ∞		
Improve education and infrastructure; optimize utility rates	C C C C	Primary Co-Benefits: = $ ∞		
ACTIONS				
Integrate carbon sequestration practices and infrastructure into built environment	C C C C	❄ + ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Commercial Energy

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Improve education and infrastructure; optimize utility rates				
ACTIONS				
Provide contractor education programs on green building and energy efficiency upgrades	C C C C	$ + ∞		
Require certification of building operators	C C C C	$ ❄ + ∞		
Redesign utility rates to incentivize and balance current and future priorities (e.g., electric vehicles, fuel switching, time of use, peak shaving, energy efficiency, demand side management)	C C C C	= $ ❄ + ∞		
Establish a green business certification program to recognize buildings that achieve energy efficiency and sustainability thresholds	C C C C	$ ❄		
Create green business corridors	C C C C	$ ❄		
Require higher energy efficiency standards for major appliances	C C C C	❄ + ∞		
Optimize water distribution system to make it as efficient as possible	C C C C	$ + ∞		
Increase public works oversight in construction to prevent continual reconstruction due to poor initial construction quality	C C C C	= $ ∞		

C Level of Potential GHG Reduction

= Promotes Equity

$ Fosters Economic Sustainability

❄ Improves Local Environmental Quality

\+ Enhances Public Health & Safety

∞ Builds Resilience

GHG REDUCTION TOOLKIT: Commercial Energy

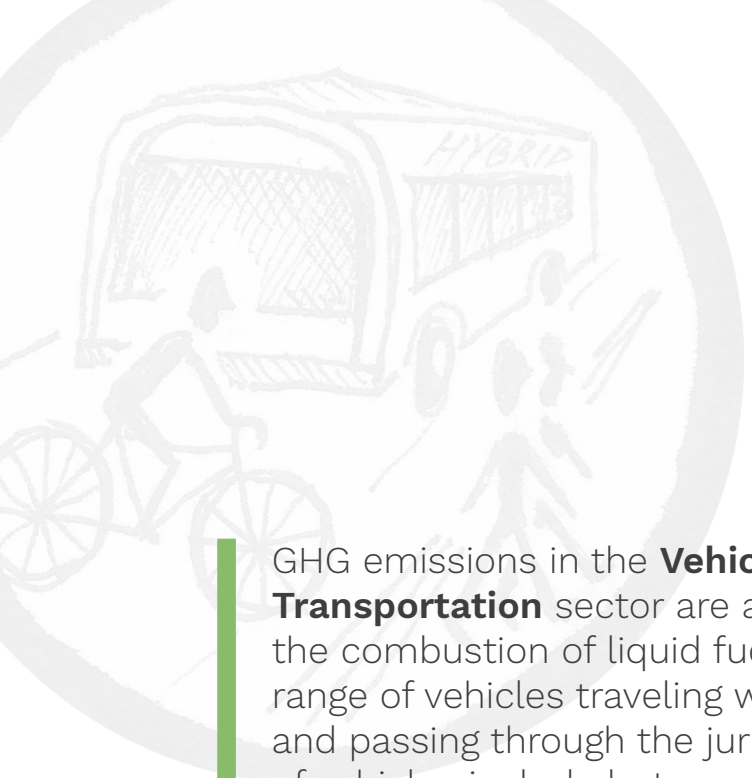
OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Improve education and infrastructure; optimize utility rates				
ACTIONS				
Promote optimal thermostat settings to couple comfort with efficiency	C C C C	=		
Expand messaging and communication on energy programs	C C C C	= $		
Anticipate and mitigate likely expansion of air conditioning use in buildings	C C C C	**Primary Co-Benefits:** $ + ∞		
ACTIONS				
Avoid or delay the need for air conditioning through building design and management	C C C C	$ ∞		
Require high efficiency air conditioning systems as AC use becomes more prevalent	C C C C	$		
Coordinate with efforts to adopt high efficiency electric heating systems (e.g., dual ground/air-source heat pumps)	C C C C	+ ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Commercial Energy

Notes:

Level of Potential GHG Reduction | Promotes Equity | Fosters Economic Sustainability | Improves Local Environmental Quality | Enhances Public Health & Safety | Builds Resilience



GHG emissions in the **Vehicles and Transportation** sector are associated with the combustion of liquid fuels in the wide range of vehicles traveling within, to, from, and passing through the jurisdiction. Types of vehicles include but are not limited to personal vehicles, light trucks, transit buses, commercial transport vehicles, heavy duty vehicles, and motorcycles. Opportunities to reduce emissions in this sector are diverse, and include shifting transportation modes away from single occupancy vehicle use and transitioning personal and commercial vehicle fleets to low or zero-emission options like electric vehicles. The co-benefits of successfully reducing Transportation sector GHGs include reduced congestion and improved air quality.

GHG REDUCTION TOOLKIT:

Vehicles & Transportation

GHG REDUCTION TOOLKIT: Vehicles & Transportation

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Reduce VMT by promoting alternatives to single-occupancy vehicles	C C C C	Primary Co-Benefits: = $ ❄ + ∞		
ACTIONS				
Encourage employers to subsidize bus passes for employees	C C C C	= ❄ +		
Create funding mechanism for free regional bus ridership	C C C C	= $ ❄ +		
Promote and incentivize carpooling	C C C C	= $ ❄ + ∞		
Strengthen enforcement of high occupancy vehicle (HOV) and transit lanes	C C C C	❄ +		
Boost public transit reliability	C C C C	=		
Promote teleworking as an alternative to commuting	C C C C	$ ❄		
Make transit more convenient, affordable and fun than driving (e.g., optimized schedules, dedicated bus lanes, comfortable seats, free wi-fi, etc.)	C C C C	= $ ❄ + ∞		
Increase the number and quality of safe routes and transit options to schools	C C C C	= ❄ + ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Vehicles & Transportation

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Reduce VMT by promoting alternatives to single-occupancy vehicles				
ACTIONS				
Evaluate high-speed rail to optimize transit coverage and efficiency	C C C C	= $ ❄ + ∞		
Enable growth of on-demand mobility services (i.e., ride-sharing, e-hailing, bike-sharing, car-sharing etc.)	C C C C	$ ❄ +		
Place 'air pollution disclosure' labels on gas pumps (similar to Surgeon General's warning on cigarettes)	C C C C			
Enhance first and last mile connectivity to transit	C C C C	**Primary Co-Benefits:** = $ ❄ + ∞		
ACTIONS				
Expand feeder transit network to primary bus stops (e.g., circulators, 'mobility as a service')	C C C C	= $ ❄ + ∞		
Expand bike share network to better connect neighborhoods and work centers to public transit	C C C C	= $ ❄ + ∞		
Expand rideshare network to better connect people traveling to similar destinations	C C C C	= $ ❄ + ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Vehicles & Transportation

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Enhance first and last mile connectivity to transit				
ACTIONS				
Promote zero-emission and driverless technologies for expanded mobility services	C C C C	$ +		
Expand bicycle network to better connect neighborhoods and work centers to public transit	C C C C	= $ ❄ + ∞		
Expand pedestrian infrastructure to better connect neighborhoods and work centers to public transit	C C C C	= $ ❄ + ∞		
Promote adoption of alternate fuel vehicles for individuals and fleets	C C C C	Primary Co-Benefits: $ ❄ + ∞		
ACTIONS				
Provide free parking for zero-emissions vehicles in areas that typically charge parking fees	C C C C	❄ +		
Increase the proportion of EVs in fleets (e.g., car share, municipal, rental cars, hotel shuttles, etc.)	C C C C	= ❄ +		
Create EV charging hubs for taxis or other fleets	C C C C	❄ + ∞		
Increase EV charging stations in visible, accessible locations	C C C C	= $ ❄ + ∞		

C Level of Potential GHG Reduction | = Promotes Equity | $ Fosters Economic Sustainability | ❄ Improves Local Environmental Quality | + Enhances Public Health & Safety | ∞ Builds Resilience

GHG REDUCTION TOOLKIT: Vehicles & Transportation

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Promote adoption of alternate fuel vehicles for individuals and fleets				
ACTIONS				
Encourage off-peak EV charging through electricity rate structure	C C C C	$ ❄ + ∞		
Require EV charging stations (or EV readiness) in all new commercial developments	C C C C	$ ❄ + ∞		
Require EV charging stations (or EV readiness) in all new multifamily developments	C C C C	= $ ❄ + ∞		
Require all new single-family construction to be EV ready	C C C C	$ ❄ + ∞		
Provide incentives to tie PV (and storage battery) installation to EV purchases	C C C C	$ ❄ + ∞		
Provide free public EV charging stations	C C C C	= $ ❄ + ∞		
Support the full spectrum of low emission vehicle technologies, in addition to EVs	C C C C	= $ ❄ +		
Convert transit and government fleets to low-carbon fuel vehicles (e.g., electric buses)	C C C C	❄ + ∞		
Provide financial incentives to convert fleets to low-carbon fuel vehicles	C C C C	= $ ❄ +		
Make transportation fuels at landfill using methane capture	C C C C	$ ❄ ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Vehicles & Transportation

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Promote the adoption of alternate fuel vehicles for individuals and fleets				
ACTIONS				
Deploy public outreach campaign and give the public opportunities to drive an EV	C C C C	=		
Facilitate EV bulk purchase program	C C C C	$ ❄ + ∞		
Redesign urban form and population density to reduce vehicle use	C C C C	**Primary Co-Benefits:** ❄ + ∞		
ACTIONS				
Use zoning and transit-oriented development to site new development near jobs and transit	C C C C	= $ ❄ + ∞		
Enable a greater percentage of the workforce to live near work and transit	C C C C	= $ ❄ + ∞		
Improve winter bike and pedestrian options	C C C C	= $ ❄ + ∞		
Improve and expand pedestrian infrastructure (e.g., pedestrian malls, fast walk signals, sidewalks)	C C C C	= $ ❄ + ∞		
Create or expand no car zones	C C C C	$ ❄ + ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Vehicles & Transportation

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Redesign urban form and population density to reduce vehicle use				
ACTIONS				
Improve and expand bicycle infrastructure (e.g., well-placed bike lanes, find solutions for conflict/hazard areas, etc.)	C C C C	= $ ❄ + ∞		
Build bike racks in strategic locations; consider covered or winter bike racks	C C C C	= $ ❄ + ∞		
Support local food production and sale at scale	C C C C	$ ❄ + ∞		
Change codes to include EV service equipment installations as acceptable transportation demand management (TDM) option	C C C C	❄ ∞		
Limit parking and drop-off permits at schools	C C C C	❄ +		
Eliminate minimum parking requirements for development; instead, require transit and mobility services	C C C C	= + ∞		
Support relevant federal, state and local policy through active legislative and regulatory engagement	C C C C	**Primary Co-Benefits:** = $ ❄ + ∞		
ACTIONS				
Support local, state and federal incentives, policies and programs to grow EV adoption and infrastructure	C C C C	= ❄ +		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Vehicles & Transportation

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Support relevant federal, state and local policy through active legislative and regulatory engagement				
ACTIONS				
Actively support Colorado transit grants	C C C C	= $ ❄ + ∞		
Support EPA greenhouse gas emissions standards and fuel efficiency standards for medium- and heavy-duty engines and vehicles	C C C C	❄ +		
Promote state fuel economy standards, such as California's standards	C C C C	❄ +		
Advocate for a strengthening of the CAFE standards (the national fuel economy targets)	C C C C	= ❄ +		
Promote new mobility technologies and business models	C C C C	Primary Co-Benefits: $		
ACTIONS				
Integrate a multi-modal mobility system at the regional or state scale	C C C C	= $ ❄ + ∞		
Pilot on-demand bus and/or van share	C C C C	= $ ❄ +		
Implement peak demand service for strategic transit routes	C C C C	= $ ❄ + ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Vehicles & Transportation

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Promote new mobility technologies and business models				
ACTIONS				
Address regulatory barriers to shared-use mobility and driverless vehicles	C C C C	= $ ❄ + ∞		
Support on-demand parking apps to reduce vehicle circulation and congestion	C C C C	$ ❄		
Deploy real-time public transit data to provide up-to-the-minute information (e.g., bus arrival information, parking availability, etc.)	C C C C	❄ +		
Increase the cost of using fossil-fuel vehicles	C C C C	**Primary Co-Benefits:** ❄ +		
ACTIONS				
Establish CO_2 fees on fossil-fuel vehicles at purchase or registration	C C C C	❄ +		
Establish congestion fees on fossil-fuel vehicles in designated areas or for driving during high-use times	C C C C	❄ +		
Tax gasoline sales locally or regionally	C C C C	$ ❄ +		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Vehicles & Transportation

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Increase the cost of driving in certain places	C C C C	Primary Co-Benefits: ○ ○ ❄ ✚ ○		
ACTIONS				
Institute new parking pricing models (e.g., performance-based parking, off-street parking tax, dynamic pricing, etc.)	C C C C	○ ○ ❄ ○ ○		
Establish regional road pricing (e.g., toll roads, dynamic pricing)	C C C C	○ ○ ❄ ○ ○		

Notes:

C Level of Potential GHG Reduction

= Promotes Equity

$ Fosters Economic Sustainability

❄ Improves Local Environmental Quality

✚ Enhances Public Health & Safety

∞ Builds Resilience

GHG emissions in the **Waste and Landfill** sector come from waste generated within the jurisdiction, then transported to, and processed at the landfill. Organic components within the waste stream generate methane as they decompose. Organic components vary but predominantly include food waste and construction and demolition (C&D) waste. Heavy duty vehicles hauling waste to the landfill and processing it on site consume liquid fuels. Opportunities to reduce emissions in this sector include diverting or salvaging organic components of the waste stream and increasing the efficiency of hauling and processing. The co-benefits of successfully reducing Landfill sector GHGs include extending the life of local landfills and improving local environmental quality.

GHG REDUCTION TOOLKIT:

Waste & Landfill

GHG REDUCTION TOOLKIT: Waste & Landfill

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Increase rates of and participation in composting and recycling	C C C C	Primary Co-Benefits: $ ❄ ∞		
ACTIONS				
Require composting through codes or regulations	C C C C	= $ ❄ + ∞		
Create convenient, accessible neighborhood compost drop-off locations	C C C C	= ❄ ∞		
Equip an entity like the landfill with resources to turn organic waste into a safe and usable compost product	C C C C	$ ❄ + ∞		
Make finished compost product accessible to gardeners and landscapers	C C C C	$ ❄ ∞		
Require waste haulers to offer compost pickup	C C C C	$ ❄ + ∞		
Require waste haulers to offer recycling pickup	C C C C	= ❄		
Run ongoing public education campaigns to promote composting	C C C C	=		
Ensure buildings have adequate space for composting and recycling collection and storage (e.g., equal space ordinance)	C C C C	❄ +		
Create (or strengthen, if existing) yard waste composting ordinances	C C C C	❄ +		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Waste & Landfill

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Increase rates of and participation in composting and recycling				
ACTIONS				
Create (or enforce, if existing) ban on burying yard waste in landfill	C C C C	○ ○ ❄ ✚ ○		
Create composting program and infrastructure for multifamily complexes	C C C C	= $ ❄ ✚ ○		
Supply local food waste to agricultural operations (e.g., animal feed)	C C C C	○ $ ❄ ○ ∞		
Provide resources and support for property managers to increase recycling and composting	C C C C	= $ ❄ ✚ ○		
Charge more for trash service and reduce trash pickup days	C C C C	○ $ ❄ ○ ○		
Implement a single-stream recycling policy	C C C C	○ ○ ❄ ○ ○		
Expand public recycling and composting infrastructure	C C C C	= ○ ❄ ✚ ○		
Expand businesses' participation in compost collection services	C C C C	○ ○ ❄ ○ ○		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
✚ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Waste & Landfill

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Maximize diversion of construction and demolition (C&D) waste	C C C C	Primary Co-Benefits: $ ❄ ∞		
ACTIONS				
Create a system for moving C&D waste to markets	C C C C	$ ∞		
Make demolition more expensive than deconstruction	C C C C	$ ❄ ✚ ∞		
Mandate deconstruction	C C C C	$ ❄ ✚ ∞		
Update building codes to ensure deconstruction of buildings is prioritized over demolition	C C C C	$ ❄ ✚ ∞		
Charge a lot more for C&D loads	C C C C	$ ❄ ✚ ∞		
Adopt and enforce C&D waste ordinance	C C C C	$ ❄ ✚ ∞		
Create a salvage yard for deconstructed building materials	C C C C	= $ ❄ ✚ ∞		
Establish reuse center for building materials	C C C C	= $ ❄ ✚ ∞		
Facilitate markets for resale businesses to pre-resell materials	C C C C	$ ❄ ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
✚ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Waste & Landfill

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Maximize diversion of construction and demolition (C&D) waste				
ACTIONS				
Offer incentives to encourage reuse of existing structures	C C C C	❄ ✚		
Introduce onboard technology to sort C&D waste at landfill	C C C C	= $ ❄ ✚ ∞		
Provide technical support to contractors to reduce C&D waste	C C C C	= ✚		
Increase community compliance with waste diversion ordinances	C C C C	**Primary Co-Benefits:** = ❄ ✚		
ACTIONS				
Impose tickets and fines for not recycling or for contaminating recycling loads	C C C C			
Provide consistent education across relevant target audiences	C C C C	=		
Create and enforce zero-waste event requirements	C C C C	= ❄ ∞		
Require recycling and compost bins at public events	C C C C	= ❄ ✚ ∞		
Align city, county and regional waste policies and codes	C C C C	=		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
✚ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Waste & Landfill

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Increase community compliance with waste diversion ordinances				
ACTIONS				
Perform compliance spot-checks (similar to health code inspections at restaurants)	C C C C	=		
Host community-wide waste collection events to support proper disposal of hard-to-recycle items (e.g., electronics, tires, batteries, etc.)	C C C C	= $ ❄ + ∞		
Consume fewer products and resources	C C C C	Primary Co-Benefits: ❄ ∞		
ACTIONS				
Conduct “buy local” and “consume local” campaigns	C C C C	$ ∞		
Promote reusable mugs and water bottles	C C C C	$ ❄		
Develop and adopt local Styrofoam ban	C C C C	❄ +		
Tax or ban plastic water bottles	C C C C	❄ +		
Develop programs to reduce use of plastic foodservice packaging	C C C C	❄ +		
Incentivize the use of reusable containers over disposable	C C C C	❄ +		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Waste & Landfill

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Consume fewer products and resources				
ACTIONS				
Promote government and corporate purchasing policies favoring low waste	C C C C	$ ❄ ∞		
Redesign organizational purchasing rules to favor sustainable consumption	C C C C	$ ❄ ∞		
Require improved materials management by businesses and government	C C C C	$ ❄ + ∞		
Increase oversight by public works departments to reduce the need to reconstruct poorly built projects	C C C C	❄ + ∞		
Support food waste reduction programs	C C C C	= $ ❄ + ∞		
Change state regulations to allow food rescue (e.g., food pantry)	C C C C	= $ ❄ + ∞		
Facilitate donation of excess or unused food (e.g., Uber-style app to connect restaurants and private chefs to organizations that feed the hungry)	C C C C	= $ ❄ + ∞		
Require use of recycled asphalt in streets	C C C C	❄ + ∞		
Ban plastic bags	C C C C	❄ +		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Waste & Landfill

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Consume fewer products and resources				
ACTIONS				
Impose fees on paper bags	C C C C	= ❄		
Promote thrift stores, reuse programs, fix-it clinics and community share programs	C C C C	= $ ❄ ∞		
Increase the cost of waste disposal for MSW and C&D	C C C C	Primary Co-Benefits: ❄ ∞		
ACTIONS				
Implement tiered 'Pay As You Throw' rates to all jurisdictions served by a particular landfill	C C C C	= ❄ +		
Expand and improve existing waste hauling practices	C C C C	Primary Co-Benefits: $ ❄ +		
ACTIONS				
Combine yard waste and food waste for pickup service	C C C C	$ ❄ +		
Re-route haulers to increase operating efficiency	C C C C	$ ❄ +		
Require haulers use cleaner vehicles	C C C C	❄ +		

C Level of Potential GHG Reduction | = Promotes Equity | $ Fosters Economic Sustainability | ❄ Improves Local Environmental Quality | + Enhances Public Health & Safety | ∞ Builds Resilience

GHG REDUCTION TOOLKIT: Waste & Landfill

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Pilot new technologies	C C C C	Primary Co-Benefits: ∞		
ACTIONS				
Develop waste-to-energy technologies at regional landfills	C C C C	= $ ❄ + ∞		
Pilot small-scale anaerobic digestion facilities for organic waste	C C C C	$ ❄ + ∞		
Assess feasibility of FastOx Gasification (waste becomes energy via hydrogen, syngas)	C C C C	$ ❄ ∞		
Combine small-scale plasma gasification with district heating	C C C C	$ ❄ ∞		

Notes:

C Level of Potential GHG Reduction

= Promotes Equity

$ Fosters Economic Sustainability

❄ Improves Local Environmental Quality

+ Enhances Public Health & Safety

∞ Builds Resilience

GHG emissions in the **Aviation and Airport** sector are associated with aircraft operations, airport ground support equipment, on road vehicle use and energy consumed in airport buildings. Aircraft operations include landings and takeoffs. Opportunities to reduce emissions in this sector include increasing the operating efficiency of aircraft, electrifying ground support equipment and ground access vehicles and maximizing the energy efficiency and production of airport buildings. The co-benefits of successfully reducing Airport sector GHGs include improvements to both public health and environmental quality.

GHG REDUCTION TOOLKIT:

Aviation & Airport

GHG REDUCTION TOOLKIT: Aviation & Airport

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Reduce airport-controlled GHGs	C C C C	Primary Co-Benefits: ❄ ✚		
ACTIONS				
Require EVs and/or cleaner fuels for ground support vehicles and ground support equipment (GSE)	C C C C	❄		
Build onsite PV or PV canopies to power EV service vehicles and EV GSE	C C C C	$ ❄ ∞		
Install alternative fueling sources (would need to be regionally based) at airports to enable airlines to convert ground support equipment to cleaner, lower emission vehicles	C C C C	❄ ✚ ∞		
Maximize the energy efficiency and energy performance of airport buildings	C C C C	$ ❄ ✚ ∞		
Integrate ground heat or geothermal heating into existing buildings and facilities	C C C C	$ ❄ ∞		
Replace airfield lighting with LED lighting	C C C C	$ ❄ ∞		
Increase the efficiency of the airport curbside to reduce vehicle trip lengths and idling	C C C C	❄ ✚		
Prohibit vehicle idling in pickup/drop-off and waiting zones	C C C C	❄ ✚		
Install ground power and preconditioned air systems at gates to reduce the use of the auxiliary power units on aircraft	C C C C	❄		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
✚ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Aviation & Airport

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Reduce airport-controlled GHGs				
ACTIONS				
Optimize waste diversion practices and rates at airport facilities and terminal	C C C C	❄ ✚ ∞		
Require taxi and airport shuttles to meet a clean-fuels or MPGe standard for onsite agreements	C C C C	❄		
Reduce aircraft- and aviation-related GHGs	C C C C	Primary Co-Benefits: ❄ ✚		
ACTIONS				
Modernize Air Traffic Control System (NextGen – FAA controlled)	C C C C	$ ❄ ✚ ∞		
Encourage continuous descent approaches (CDAs) if possible	C C C C	❄		
Financially incentivize the use of more efficient aircraft serving airport (e.g., through takeoff/ landing fees)	C C C C	❄ ✚		
Incentivize the use of aviation biofuels in aircraft servicing local airport (would require local supply, regional approach or partnership with DIA)	C C C C	$ ❄ ✚ ∞		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
✚ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Aviation & Airport

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Reduce aircraft- and aviation-related GHGs				
ACTIONS				
Offer targeted offsets through partnerships with industry leaders and airlines serving local airport	C			
Encourage and support Bustang to DIA	C C	❄		
Reduce the need for air travel via state/regional high-speed rail	C C	❄		
Pressure local airlines to implement their aspirational International GHG goals	C C C	Primary Co-Benefits: ❄ ✚ ∞		
ACTIONS				
Inform airlines of local GHG reduction targets, and provide operational incentives connected with facilitating attainment	C C	❄ ✚		
Educate passengers about 'greener' flying and becoming consumer advocates via airline promotional material	C	❄		
Encourage airlines to continue developing improved Engine and Airframe Technology	C	❄ ✚		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
✚ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Aviation & Airport

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
If a new terminal is developed, ensure that it represents the pinnacle of energy efficiency and sustainability	C C C C	Primary Co-Benefits: $ ❄ + ∞		
ACTIONS				
Require any new terminal or airport building to be net-zero	C C C C	$ ❄ + ∞		
Mandate 'zero construction waste' and 'sustainable construction' plans for any new terminal or airport facilities	C C C C	❄ +		
Integrate ground heat or geothermal heating into new buildings and facilities	C C C C	$ ❄ ∞		
Plan for and install PV at airport and adjacent areas (e.g., PV parking canopies)	C C C C	$ ❄ ∞		
Ensure terminal encourages next-generation mobility by providing EV and 'mobility as a service' infrastructure	C C C C	= $ ❄		
Encourage passengers to use transit and mobility services to access airport	C C C C	Primary Co-Benefits: = $ ❄		
ACTIONS				
Deploy combined marketing outreach with chamber and lodges regarding transit and mobility options	C C C C			
Provide luggage delivery to hotels or residences so passengers can use the transit and mobility options of their choice	C C C C	= $ ❄		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Aviation & Airport

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
(Cont.) Encourage passengers to use transit and mobility services to access airport				
ACTIONS				
Require rental car companies to have EV options (and require that EVs are a certain percentage of rental fleet); also require an MPGe standard for rental car fleet	C C C C	= $ ❄		
Partner with airport rental car companies to include info card about local mobility options (including option of zero-emissions rental cars)	C C C C			
Provide a dedicated ground transit route with local service into terminal drop-off	C C C C	= ❄ +		
Establish an easy-to-use link from terminal to transit	C C C C	= ❄ +		
Create a luxury bus system to carry people and luggage to and from airport to their accommodations	C C C C	❄		
Install signage and wayfinding from terminal to existing transit	C C C C	+		
Install light rail from airport to city	C C C C	$ ❄ +		
Provide appropriate amount of remote airport parking (including at Park and Rides)	C C C C	= ❄		

C Level of Potential GHG Reduction
= Promotes Equity
$ Fosters Economic Sustainability
❄ Improves Local Environmental Quality
+ Enhances Public Health & Safety
∞ Builds Resilience

GHG REDUCTION TOOLKIT: Aviation & Airport

OBJECTIVE	GHG REDUCTION POTENTIAL	CO-BENEFITS	TIMEFRAME	PARTNERS
Support relevant federal and state policies through active legislative and regulatory engagement	C C C C	Primary Co-Benefits: $ ❄		
ACTIONS				
Push for federal air quality standards to reduce GHGs associated with jet fuel	C C C C	❄		
Establish an active local government voice in federal aviation policy	C C C C	$ ❄		
Encourage or facilitate the adoption of 'sustainable aviation fuels,' such as biofuels	C C C C	$ ❄ + ∞		
Support federal carbon tax that includes aircraft operations	C C C C	= $ ❄ + ∞		

Notes:

C Level of Potential GHG Reduction

= Promotes Equity

$ Fosters Economic Sustainability

❄ Improves Local Environmental Quality

+ Enhances Public Health & Safety

∞ Builds Resilience

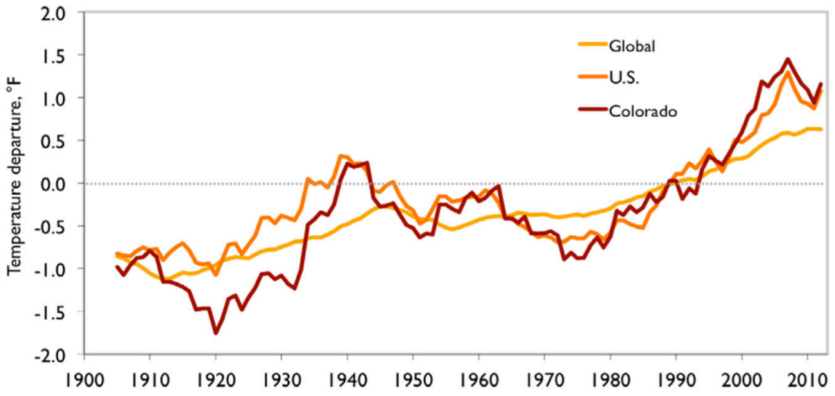
APPENDIX: Notable climate change info for your CAP

While questions remain about the exact specifics of future climate conditions, the basic facts of climate science and solutions are well understood, and more relevant and accessible to local communities than they ever have been. The following insights have been compiled to provide Toolkit users with accessible climate change information that can be drawn for use in their own climate action plans.

Our climate is changing, and more rapidly than at any point on record[i].

- "Every single year since 1977 has been warmer than the 20th century average, with 16 of the 17 warmest years on record occurring since 2001, and 2016 being the warmest year on recorded history."[ii]
- Global temperatures have risen by 1.5°F since 1880[iii] and national temperatures have increased 2°F since 1978[iv].
- In Colorado, average temperatures have risen by 2.5°F since the 1950s[v].
- In Western Colorado, there are 23 fewer frost free than there were before the 1980s and annual snowfall has declined by 10 inches[vi].

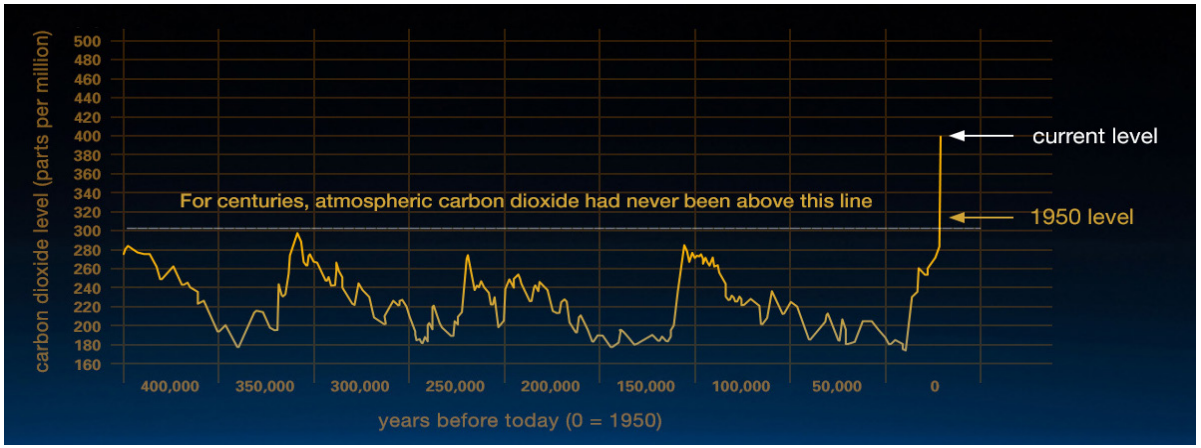
Figure 1. Observational record of annual mean temperature: Global, U.S. and Colorado (Aspen Global Change Institute[v])



Human activity is driving most of this change.

- 97% of climate scientists agree that the warming over the past century is due to human activity. Most leading scientific organizations worldwide have issued public statements affirming this[vii].
- Atmospheric concentrations of CO_2 have risen 40% since the industrial revolution[viii].

Figure 2. Evidence that atmospheric CO_2 has increased since the Industrial Revolution (NASA[vii])



APPENDIX: Notable climate change info for your CAP

The severity of future climate change is directly linked to GHG emissions.

- GHG emissions are the single most significant factor in determining the amount of future global temperature change[ix].
- Currently, the world is on a high emissions trajectory. Unless GHG emissions are mitigated, this could lead to a 9.7°F increase in Western Colorado by 2100[x].
- The best available science indicates that the world, Colorado and communities should reduce GHG emissions 45% below 2005 levels by 2030 and 90% below 2005 levels by 2050, to limit warming to 1.5 to 2°C above preindustrial levels[xi].

We know how to solve it.

- Robust and effective climate solutions are developed and ready for implementation at the international, national, state and local level[xii].

Acting now is less expensive than inaction and can create healthy, thriving communities.

- Dramatically reducing GHG emissions is much less expensive than the anticipated costs of dealing with the impacts of unchecked climate change[xiii] [xiv].
- Effectively addressing climate change at the scale necessary to solve the problem could be the largest wealth creation opportunity of our time[xv].
- In communities, climate action typically creates numerous co-benefits such as increased resilience and economic activity, healthier citizens and improved environmental quality. This Toolkit defines some of the co-benefits that are associated with various actions.
- Climate action is frequently complementary to existing priorities for communities and regions.

Local action matters.

- While future climate will be determined by global GHG emissions, the cumulative impact of local action is significant and meaningful.
- 78% of energy globally is consumed in cities[xvi]. Collectively, local action can significantly accelerate a transition away from fossil fuels.
- Local governments in the US currently have some of the most ambitious climate action commitments. More than 350 US mayors have signed a pledge to uphold the Paris Climate Agreement through local action and necessary policy at the state, federal and international levels[xvii].

---

[i] American Meteorological Society, 2017. State of the Climate in 2016, https://www.ametsoc.org/ams/index.cfm/publications/bulletin-of-the-american-meteorological-society-bams/state-of-the-climate/.
[ii] NASA, 2017. Release 17-006. https://www.nasa.gov/press-release/nasa-noaa-data-show-2016-warmest-year-on-record-globally.
Quotation from Union of Concerned Scientists: http://www.ucsusa.org/global_warming/science_and_impacts/science/human-contribution-to-gw-faq.html#.WdvDKmhSzxU.
[iii] IPCC, 2013. Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution 12 of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.
[iv] Aspen Global Change Institute, 2014. Climate Change and Aspen 2014, p. 28.
[v] Aspen Global Change Institute, 2014. Climate Change and Aspen 2014. p. 29.
[vi] Ibid p. 14.
[vii] NASA, 2017. Climate change: How do we know? https://climate.nasa.gov/evidence/.
[viii] NOAA, 2014. Global Warming FAQ. https://www.climate.gov/news-features/understanding-climate/global-warming-frequently-asked-questions#hide7.
[ix] Aspen Global Change Institute, 2014. Climate Change and Aspen 2014. p. 43.
[x] Ibid p. 44.
[xi] Western Resource Advocates, 2017. Colorado's Climate Blueprint. https://westernresourceadvocates.org/publications/colorados-climate-blueprint/.
[xii] Hawken, P., 2017. Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming. http://www.drawdown.org/.
[xiii] Universal Ecological Fund, 2017. The Economic Case for Climate Action in the US. https://feu-us.org/case-for-climate-action-us2/.
[xiv] American Security Project. http://www.americansecurityproject.org/resources/pnpl/Colorado%20FINAL.pdf.
[xv] Shah, J., 2013. Creating Climate Wealth: Unlocking the Impact Economy.
[xvi] CDP Cities, 2015. Report infographic.
[xvii] https://www.wearestillin.com/cities-counties/initiatives/.

ACKNOWLEDGMENTS

The GHG Reduction Toolkit was prepared by the City of Aspen and the Community Office for Resource Efficiency (CORE) with extensive direction from expert stakeholders representing all GHG emission sectors. It would not be possible without the expertise, time, and dedication of this Advisory Committee. We would like to express our thanks to the following individuals and the organizations they represent for developing and refining this comprehensive menu of actions for reducing greenhouse gas emissions at the community and regional scales.

Advisory Committee (AC):

Person	Title	Organization
Adam McCurdy	Forest Programs Director	Aspen Center for Environmental Studies
Ashley Perl	Director of Canary Initiative	City of Aspen
Auden Schendler	Vice President of Sustainability	Aspen Skiing Company
Bert Myrin	Council Member	City of Aspen
Chris Hildred	Power Supply & Special Projects Supervisor	Holy Cross Energy
Chris Lane	Chief Executive Officer	Aspen Center for Environmental Studies
Chris Menges	Data Research and Project Planner	City of Aspen
Cindy Houben	Director of Community Development	Pitkin County
Claire Sacco	Member Services Coordinator	Aspen Chamber Resort Association
Clem Kopf	Board Member	Holy Cross Energy
David Hornbacher	Director of Utilities and Environmental Initiatives	City of Aspen
Ellen Sassano	Long Range Planner	Pitkin County
Jack Johnson	Executive Director	Aspen Zero Impact
Jamie Mandel	Prinicipal	Rocky Mountain Institute
Jamie Werner	Forest Programs Director (former)	Aspen Center for Environmental Studies
Jane Wilch	Climate Outreach Coordinator	City of Aspen
Jannette Whitcomb	Sr. Environmental Health Specialist – Air Quality	City of Aspen
Jed Miller	Operations Foreman	Pitkin County Landfill
Jen Wolchansky	Project Manager	Mead & Hunt
Jesse Morris	Principal	Rocky Mountain Institute
Jessica Garrow	Community Development Director	City of Aspen
John Katzenberger	Executive Director	Aspen Global Change Institute
John Kinney	Director of Aviation	Aspen/Pitkin County Airport
John Krueger	Director of Transportation	City of Aspen
Kate Andrus	Project Manager, Aviation Services	Mead & Hunt
Laura Armstrong	Climate and Sustainability Programs Associate	City of Aspen
Liz Chapman	Sr. Environmental Health Specialist – Waste	City of Aspen
Mary Vigilante	President	Synergy Consultants LLC

ACKNOWLEDGMENTS

(Cont.) Advisory Committee (AC):

Person	Title	Organization
Matt Hamilton	Sustainability Director	Aspen Skiing Company
Matthew Shmigelsky	Energy Consultant	Clean Energy Economy for the Region
Michael Miracle	Director of Community Engagement	Aspen Skiing Company
Mirte Mallory	Executive Director	We-Cycle
Mona Newton	Executive Director	Community Office for Resource Efficiency
Phillip Supino	Long Range Planner	City of Aspen
Randy Ready	Assistant City Manager (former)	City of Aspen
Richard Heede	Director	Climate Accountability Institute
Robert Gardner	Board Member	Holy Cross Energy
Ruth Brown	Co-chair	Aspen Chapter, Citizens Climate Lobby
Ryk Dunkelberg	Vice President of Aviation Services	Mead & Hunt
Ryland French	Utilities Efficiency Specialist	City of Aspen
Sara Ott	Assistant City Manager	City of Aspen
Sarah Gruen	Community Sustainability Coordinator	Community Office for Resource Efficiency
Stephen Kanipe	Chief Building Official	City of Aspen
Steve Child	Commissioner	Pitkin County

Facilitation and meeting assistance:

Person	Title	Organization
CJ Oliver	Director of Environmental Health and Sustainability	City of Aspen
Julia Farwell	Sustainability Intern – Waste Reduction	City of Aspen
Larissa Read	Principal Owner	Common Ground Environmental Consulting
Missy Stults	Program Officer	Climate Resilience Fund
Mitzi Rapkin	Community Relations Director	City of Aspen

Project leads and contact information:

Author, Toolkit project manager: Chris Menges, Data Research and Project Planner, City of Aspen. chris.menges@cityofaspen.com

Contributing author, Toolkit community liaison: Sarah Gruen, Community Energy Coordinator, CORE. sarah@aspencore.org

Meeting facilitator: Larissa Read, Common Ground Environmental Consulting. larissa@commongroundenv.com

Graphic design and layout: Kate Lohnes and Claire Lukens, Lilja Communications. kate@lilja.com, claire@lilja.com

Cover illustration: Ellie Barber, Aspen Global Change Institute. ebarber@agci.org

THE CITY OF ASPEN

CORE
Community Office for Resource Efficiency

PARTNERS

ACES Aspen Center for Environmental Studies
ASPEN CHAMBER RESORT ASSOCIATION
ASPEN GLOBAL CHANGE INSTITUTE
ASPEN/PITKIN COUNTY AIRPORT
ASPEN SNOWMASS. ASPEN SKIING COMPANY
ASPEN ZERO IMPACT
Citizens' Climate Lobby
CLEER
CLIMATE ACCOUNTABILITY INSTITUTE
Mead & Hunt
PITKIN COUNTY
SYNERGY CONSULTANTS, INC.

NOVEMBER 2017

City of Aspen

130 South Galena Street
Aspen, Colorado 81611
(970) 429-1798
Canary@CityofAspen.com
www.CityofAspen.com

The City of Aspen strives to be an environmental leader and to promote environmental stewardship throughout the Roaring Fork Valley, across the state of Colorado, and around the globe. We recognize Aspen's dependence on climate and natural resources for a thriving economy, healthy ecosystems, and exceptional quality of life. In an effort to do our part to reduce the threat of climate change, Aspen's City Council adopted the Canary Action Plan in 2007, which commits to reducing community-wide emissions 30% by 2020 and 80% by 2050, below 2004 levels.

Community Office for Resource Efficiency (CORE)

111 Airport Business Center, Suite M
Aspen, Colorado 81611
(970) 925-9775
Energy@AspenCORE.org
www.AspenCORE.org

The Community Office for Resource Efficiency (CORE) works cooperatively with businesses, individuals, utilities, and government entities to create measurable improvements in energy and water efficiency in order to benefit the environment and develop a more sustainable economy. The non-profit has been serving the Roaring Fork Valley since 1994.