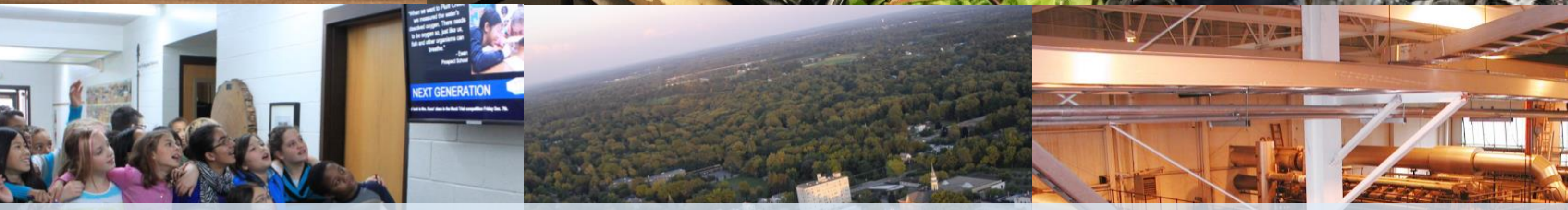
City of Oberlin Climate Action Plan



2019

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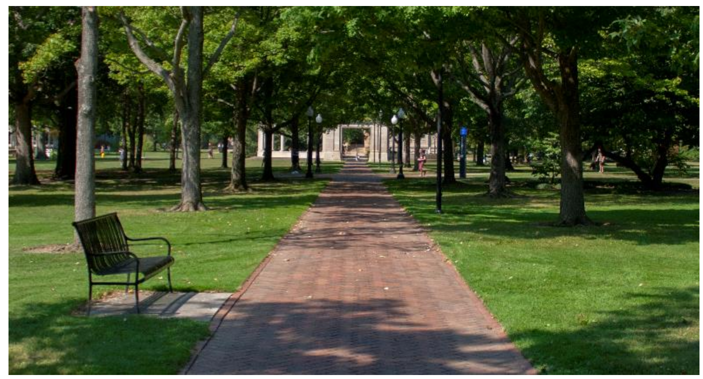
Oberlin's Vision

With a rich history of social and civil rights leadership beginning with its founding, the Oberlin community's identity as a leader has re-emerged in the context of another generation-defining challenge: climate change. The City of Oberlin has genuine concerns of global climate change and is working to address these concerns. It is committed to reducing community-wide greenhouse gas emissions below zero, while striving to balance the environmental, social, and economic interests of the Oberlin community.

With the adoption of a Sustainability Resolution in 2001, the City of Oberlin paved the way to develop a forward thinking mindset on the path toward sustainability in the community. In 2006, Oberlin College signed the American College and University Presidents Climate Commitment which committed the college to become climate neutral with the current target date being 2025. In 2007, the City became one of the first Ohio members of Local Governments for Sustainability (ICLEI), initiating a greenhouse gas inventory and developing a local climate action plan.



In 2010, the City and Oberlin College individually signed memoranda of understandings with the Clinton Foundation and the United States Green Building Council to participate in the Clinton Climate Positive Development Program. This commitment, of "reducing the City of Oberlin's GHG emissions below zero through the implementation of economically viable innovations" elevated the City and the College to the level of not only reducing GHG emissions but to becoming a climate positive community. Oberlin will become a community that will not just neutralize its emissions but would improve the environment by offsetting emissions below zero.

In accordance with membership in ICLEI and the Clinton Climate Positive Development Program agreement, the City developed and adopted a Climate Action Plan in 2011. This plan set systematic goals of reducing 2007 GHG inventory emissions by 50% in 2015, 75% by 2030 and below 100% by 2050.

The Climate Action Committee has developed this revised Climate Action Plan as a roadmap for transitioning to a climate positive community. This report represents the second update to the 2011 Climate Action Plan and outlines work to be done in the next five year period. Work by the City and the College through the use of the recommended strategies and community outreach will create not only a climate positive community but a positive community for its residents to live, learn and lead.

A Message from Oberlin City Council President

Dear Reader,

From an early age, I was taught that Oberlin has always provided leadership at the cusp of social and political advancement. We fought the injustices of slavery, segregation, and discrimination in the pursuit of justice, equality, and peace. Generations of Oberlinians have joined in the chorus of "We shall overcome" and have been moved by the significance of those words. Climate change is a different sort of challenge. It is not a wholly separate problem to be solved but instead, aggravates and compounds the social inequities we have always rallied against. Climate change has quickly become climate catastrophe and though it is a challenge we must address, I no longer believe it is one we shall overcome.

The predicament facing us is how to transform society in order to cope with the consequences of human-induced climate change and the resultant social implications. Oberlin has a responsibility to think globally but act locally. To that end, local government must ensure that every resident has safe and adequate housing, food security, transportation, and affordable access to reliable utilities. We do this with the understanding that fossil fuel use must cease and resource consumption be drastically reduced. At the same time, social equity motivates us to provide services for everyone yet focus our efforts on those most in need or most impacted. How can we responsibly address the disproportionate costs of climate change?

Oberlin voters recognized this imperative when they passed an amendment to Ordinance 07-39 in November of 2017 which specified that the revenue from selling renewable energy certificates would be used to fund Oberlin's Sustainable Reserve Program. Consequently, in the summer of 2018 City Council created the Sustainable Reserve Fund to finance Climate Action Plan initiatives with an opening transfer of $2.8 million. The document before you is a collaborative effort to provide a 5-year update of Oberlin's Climate Action Plan (CAP) and to propose expenditures furthering the stated goals of energy efficiency, energy conservation, green-house gas reductions, and renewable energy.

This is the 3rd iteration of Oberlin's Climate Action Plan and I want to offer my gratitude to the previous committees whose work provided the basis for this CAP. I also want to sincerely thank all the volunteers who contributed to this update through sub-committees and focus groups. You helped to formulate the concepts in each chapter and your enthusiasm is much appreciated. Credit for the actual drafting and editing of the CAP belongs to members of our committee widely representing the Oberlin community. A year and a half of early morning meetings in the basement of the fire station, numerous chapter group sessions, and hours spent by individuals writing and editing each chapter are evident in these pages. Thank you so much for your dedication and commitment!

I encourage City Council to swiftly implement programs in the CAP that have broad support. Be open to new ideas, seek consensus, but recognize that climate change will not pause. The sooner we act, the better off we'll be.

Sincerely,

Bryan Burgess

Bryan Burgess
President, Oberlin City Council
August 2019

Introduction

Oberlin Community and Leadership

Oberlin has demonstrated its capacity for leadership in social justice from its inception with the high standards of John Shipherd and Philo Stewart, who together founded Oberlin in 1833. Oberlin's central role in US civil rights is the foremost historical example of Oberlin's social courage and vision. Oberlin College at its founding "embraced the joint education of the sexes" which led in 1841 to the first bachelor's degrees in the nation awarded to women. Furthermore, in 1835, the College became the first institution of higher learning in the US to accept students without considering race.

Oberlin has also been credited with being the spark that ignited the Civil War. In 1858, a group of Oberlin citizens traveled to neighboring Wellington and freed John Price, an escaped slave, in defiance of the Fugitive Slave Law. The twentieth century saw Oberlin continue its leadership in civil rights through actions to end segregation and discrimination based on race, gender, and sexual orientation. One example of this was the Fair Housing Ordinance passed by City Council on November 20, 1961. This ordinance paved the way for future fair housing legislation throughout the country and affirmed Oberlin's identity as a community committed to issues of social justice.

Climate Change and Commitments to Sustainability

Oberlin has again emerged at the beginning of the twenty-first century as a leader in another generation-defining challenge: climate change (See "Climate Change" Sidebar).

Accepting the scientific consensus that climate change is here, the City and College have made commitments to address climate change consistent with their history of courageous and morally-sensitive leadership on issues of gender, labor, and race.

- 2001: the City adopted a Sustainability Resolution embracing the 1987 United Nations Commission on Environment and Development definition of sustainability: policies, decisions, and actions will meet "current needs without compromising the ability of future generations to meet their needs."
- 2004: the College created a comprehensive Environmental Policy that establishes its special obligation as an institution of higher learning to educate its students, manage its internal affairs, and interact with the broader community in ways consistent with the best environmental practices.
- 2004: the City embraced sustainability as a central theme in its 2004 Comprehensive Plan.
- 2005: the Board of Trustees of Oberlin College unanimously adopted "Move toward Environmental Sustainability" as one of the College's strategic directions in its Strategic Plan.
- 2006: the College signed the American College and University Presidents Climate Commitment (ACUPCC) committing the college to become climate neutral with the current target date being 2025.
- 2007: the City joined ICLEI's Cities of Climate Protection (CCP) program that committed the City to seriously address climate change.
- 2008: the City continued efforts to restructure its electricity portfolio toward carbon neutral sources and withdrew from participation in a 50-year contract to purchase power from a proposed coal-fired power plant.
- 2009: the City hired the energy consulting firm Black & Veatch to investigate viable low-carbon energy sources to replace the City's traditional fossil-fuel-based electricity portfolio.
- 2010: the City and College each joined the Clinton Climate Positive Development Program (CCPDP) thereby committing each to become climate positive by reducing community-wide carbon emissions below zero.
- 2011: the City completed its 2025 Strategic Plan in which environmental and economic sustainability were two of its top strategic priorities.
- 2011: the City completed the first iteration of its Climate Action Plan and then committed the City to reducing its greenhouse gas (GHG) emissions below emission levels of 2007 by 50% beginning in 2015, 75% by 2030, and 100% by 2050.
- 2013: the City completed a revision of the Climate Action Plan with greater stakeholder input.
- 2012 and 2015 Greenhouse Gas inventories completed with goal of 50% reduction in greenhouse gases met.

City Governance

Oberlin is governed under the council-manager form of governance. A seven-member City Council is elected every two years through at-large seats, and the City Council appoints the City Manager. The part-time Council members do not have physical offices but rather interact with citizens through personal contact. The City Manager is responsible for the daily operation of City departments, coordination of department heads and City staff, and is answerable to the City Council. The City Finance Director, Law Director, and Council Clerk also report directly to City Council providing independent management, operational supervision, and expert advice. More than 20 boards and commissions composed of Oberlin residents are appointed by City Council to provide advice and recommendations to city officials and City Council concerning various matters including planning, development, utility infrastructure, and various quality of life issues.

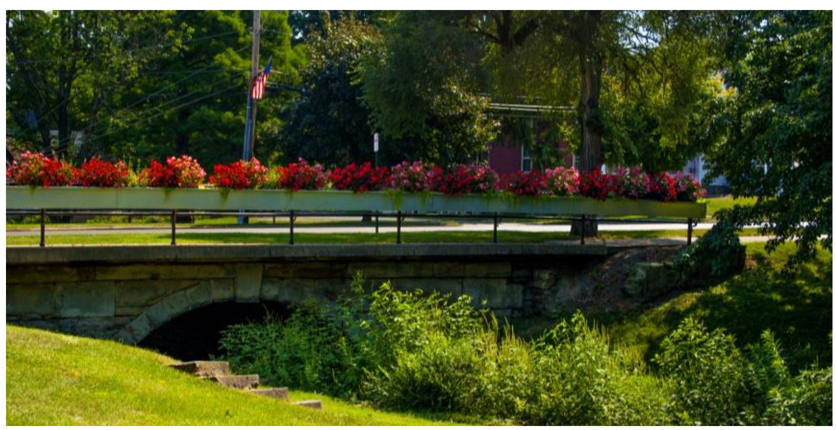
City Utilities

The City's Public Works Department has six divisions: Engineering, Administration, General Maintenance, Building and Grounds, Water, and Waste Water. Through Administration and the General Maintenance divisions, Public Works operates the City's refuse and recycling collection program as an Enterprise Fund (self-supporting). In addition to the water and wastewater utilities, the City has a community-owned, not-for-profit electric utility, Oberlin Municipal Light and Power System (OMLPS). Created in 1934, OMLPS generates, purchases, transmits and distributes electric power to over three thousand residential and commercial customers. OMLPS is overseen by an Electric Director who reports to the City Manager. See City of Oberlin website for more details on City utilities.

Oberlin College

Oberlin College is the largest employer in the City, and the student body of the College comprises approximately one third of the population of Oberlin. Oberlin College uses about 25% of the City's electricity and is responsible for about the same percentage of the City's carbon emissions. Sustainability planning at the College is led by the Committee on Environmental Sustainability (CES), a committee of the General Faculty, and by the Office of Environmental Sustainability (OES).

Since their beginning in 1833, Oberlin College and the City of Oberlin have nurtured and challenged each other to advance human well-being locally and beyond. Testimony to this relationship is provided above with the list of sustainability resolutions and commitments each has made in the past decade. By signing in 2010 individual memoranda of understanding with the CCPDP to become climate positive, the College and City will create an even stronger interdependent relationship. At the signing ceremony Bob Berkebile, an internationally renowned Kansas City architect speaking for the USGBC, foreshadowed the future this way, "This alignment of common purpose, of having to work together, will change this community in ways unimaginable and for the better."



A Model Community

As of the 2010 census, Oberlin was a city of 8,286 people and population growth was essentially flat with1% growth between 2000 and 2010. The composition of Oberlin's population is 73% white, 14.8% African American, 6.5% two or more races, and 4% Asian American. Oberlin also includes a broad range of socioeconomic backgrounds; the median household income is $47,334, and 24% of the individuals in Oberlin live at or below the poverty level. This plan was created with the premise that Oberlin is a representative community within the United States, that it is large and diverse enough to serve as a proxy for larger cities, but small enough that the community as a whole is capable of addressing many of the major sources of emissions that contribute to global warming. Oberlin strives to serve as a model that can be learned from and replicated nationally and perhaps worldwide.

About this Report:
Climate Action Plan for ICLEI Cities for Climate Protection Program

In 2007, the City of Oberlin became a member of ICLEI – Local Governments for Sustainability and committed to carry out the five milestones in ICLEI's focal program, Cities for Climate Protection (CCP) (see Figure 1). ICLEI's CCP program assists municipal officials as they pursue GHG reductions for their municipal operations and their community as a whole (see Sidebar). Having completed the first milestone of conducting the baseline inventory in 2009, the City of Oberlin completed milestones two and three with the adoption of a Climate Action Plan and establishing GHG reduction targets in 2011.

FIGURE 1: ICLEI CCP's Five Milestones

The City of Oberlin completed an emissions inventory in 2009, establishes reduction targets and adopted a Climate Action Plan in 2011.

Development and Revision of this Report

The City of Oberlin developed an initial version of the Climate Action Plan in house, led by OMLPS' Energy Services and Sustainability Initiatives Manager and a sustainability intern from Oberlin College. The initial Plan was adopted by City Council in 2011. The plan was revised in 2013 through the work of the Climate Action Committee which was comprised of members of lead entities such as Oberlin College and local non-profits and other key stake holders. The new update followed a similar strategy of involving key stakeholders and building on successes of the past few years to develop strategies for the next five years that will progress us further toward our goal of carbon neutrality. The Climate Action Committee met for nearly two years to update this plan. Oberlin City Council passed it by resolution on July 1, 2019. This revised plan includes both recommended strategies under the City's control and those that are outside of the City's direct control.

SPOTLIGHT:
ICLEI and the Cities for Climate Protection Campaign

ICLEI's CCP campaign was launched in 1993 when municipal leaders, invited by ICLEI, met at the United Nations in New York and adopted a declaration that called for the establishment of a worldwide movement of local governments to reduce GHG emissions, improve air quality, and enhance urban sustainability. The CCP campaign achieves these results by linking climate change mitigation with actions that improve local air quality, reduce local government operating costs, and improve quality of life by addressing other local concerns. The CCP campaign seeks to achieve significant reductions in U.S. greenhouse gas emissions by assisting local governments in taking action to reduce emissions.

I.C.L.E.I Local Governments for Sustainability USA

For more information on ICLEI and the five milestones, see www.icleiusa.org.

Oberlin's Emissions Inventory

The purpose of a baseline emissions inventory is to understand current patterns of GHG emissions, prioritize strategies to reduce emissions, and establish measurable reduction targets. Breaking out emissions by sector (e.g. commercial, residential) and energy supplies (e.g. natural gas, vehicle fuel, electricity) allows us to identify the best opportunities for significantly reducing emissions. An inventory is further useful for comparing emissions with other communities and tracking progress over time.

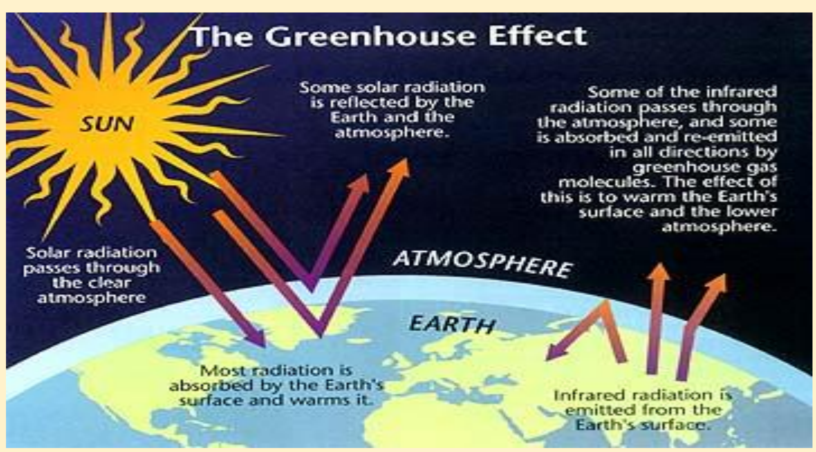
The City of Oberlin greenhouse gas emissions inventory was conducted in 2012 and again in 2015. Both a municipal and community-wide inventory were completed for these years.

SPOTLIGHT:
Climate Change

Life on Earth is possible because Earth's warm surface temperature allows water to exist in liquid form. Earth has a warm temperature in which life thrives because our atmosphere is has heat trapping gases (HTG) that act as a blanket; these HTG adsorb infrared radiation, meaning they trap heat and thereby warm the Earth's surface. Without HTG the Earth's temperature would be about 0º F instead the current average surface temperature of 59º F. Water (H_2O), carbon dioxide (CO_2), methane (CH_4), and chlorofluorocarbons are HTG with H_2O and CO_2 being the most important. Climate science has established a positive correlation between atmospheric CO_2 concentration and surface temperature. That is, in the past when CO_2 went up, temperature rose and when CO_2 went down, temperature decreased. Simply put, carbon dioxide acts like a blanket to retain infrared radiation thereby making the planet warmer than it otherwise would be.

Over the past 65 million years Earth's average temperature ranged from 50º F to 81º F while over the past 10,000 years the range was 51º F to 59º F with today's temperature being 59º F. Over the last 10,000 years agriculture and civilization arose during a period of relatively stable temperatures to which we are acclimated. Over the last 100 years human activities have increased CO_2 concentration from 310 parts per million (ppm) to 414 ppm and the temperature has risen 1.4º F, with a 1.0º F rise since 1980. Climate scientists predict that on our present course the temperature will increase from 4º F to 11º F over the next 100 years.

Although the average temperature rise of 1.4º F appears to be small, we are seeing its affects. Spring comes a week or two earlier while fall is a week or two later and the ranges of many northern hemisphere species are moving north and to higher altitudes. Result: unraveling of ecosystems and life support. Glaciers are melting almost everywhere. Greenland lost 36 to 60 cubic miles annually between 2002 and 2006 while Antarctica lost 36 cubic miles between 2002 and 2005 causing sea level rise and threatening low land populations. Oceans are more acidic from CO_2 adsorption causing coral reefs to dye.



The hottest 10 years on record have occurred in the last decade: 2009-2019. Extreme weather events are increasing: intense rainfalls, extremely high temperatures, droughts, tornados and class 4 & 5 hurricanes. If the climate were stable, then record setting low and high temperatures would be about equal. They were before 1980, but in the past two decades high records occur four times as often as low records. The climate dice are now set for extremes that will become the new norms if we persist in pumping heat trapping gases into the atmosphere. The thicker we make the heat-trapping blanket, the hotter the planet. In fact, positive feedback mechanisms now kicking-in are likely to lead to a "hothouse earth", a new state in which human habitation will be problematic.

Community-Wide Inventory Results

The community-wide inventory included GHG emitted within the municipal boundary of the City of Oberlin (the geographic scope). See [Figure 2] for information on what emissions sources were included in the inventory. The inventory determined that as a whole, the community (within city limits) emitted 174,391 tons of carbon dioxide equivalent (CO2e) in 2007. The community's per capita (2007 population was 8,344 persons) annual emissions were 20.9 tons CO2e per resident. According to the US Energy Information Administration, per capita energy-related CO_2 emissions in the US were 19.8 tons per person in 2007.

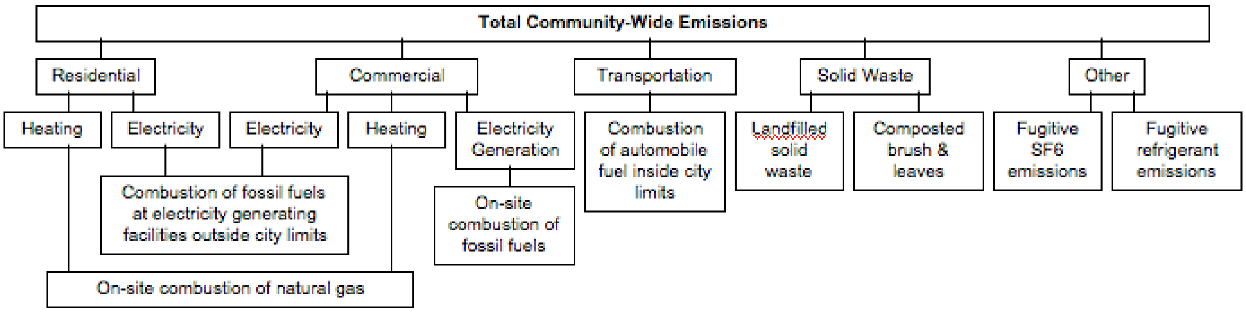
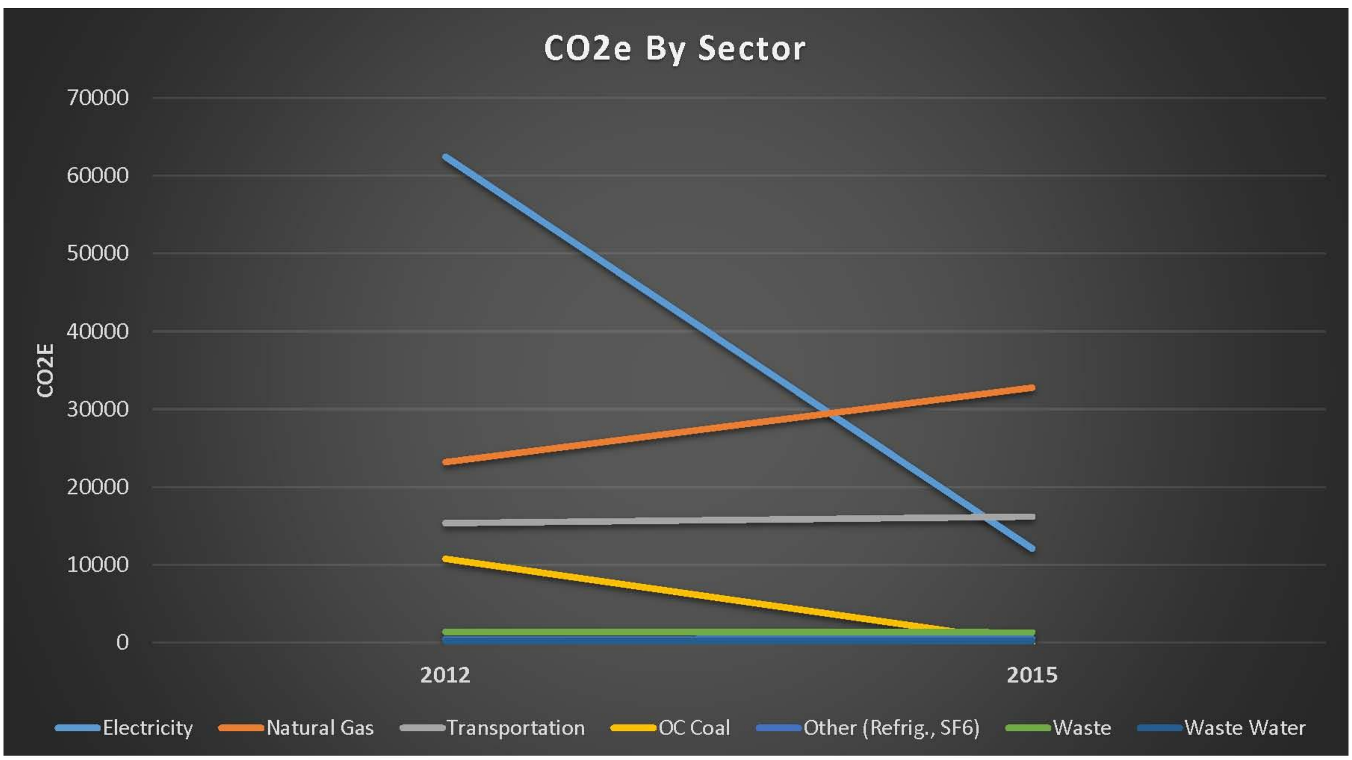
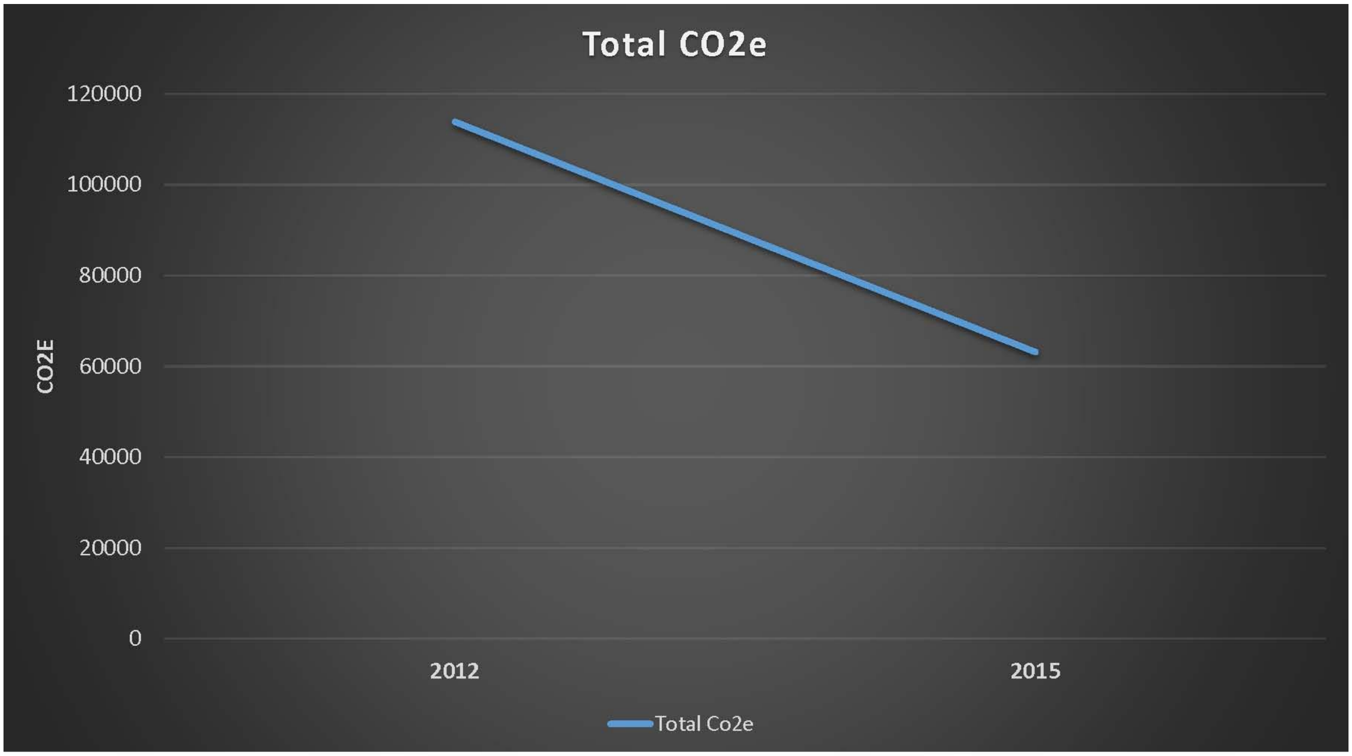


FIGURE 2: Community-Wide Emissions

Residential, commercial, transportation, solid waste, and other were broad emissions sectors included in Oberlin's community-wide inventory. Activities that produce emissions taken into account in this inventory are listed under each sector.



	2012	2015
Electricity	62,424	12,097
Natural Gas	23,211	32,769
Transportation	15,371	16,207
OC Coal	10,778	0
Other (Refrig., SF6)	450	521
Waste	1,395	1,341
Waste Water	202	201



	2012	2015
Total CO2e	113,832	63,136

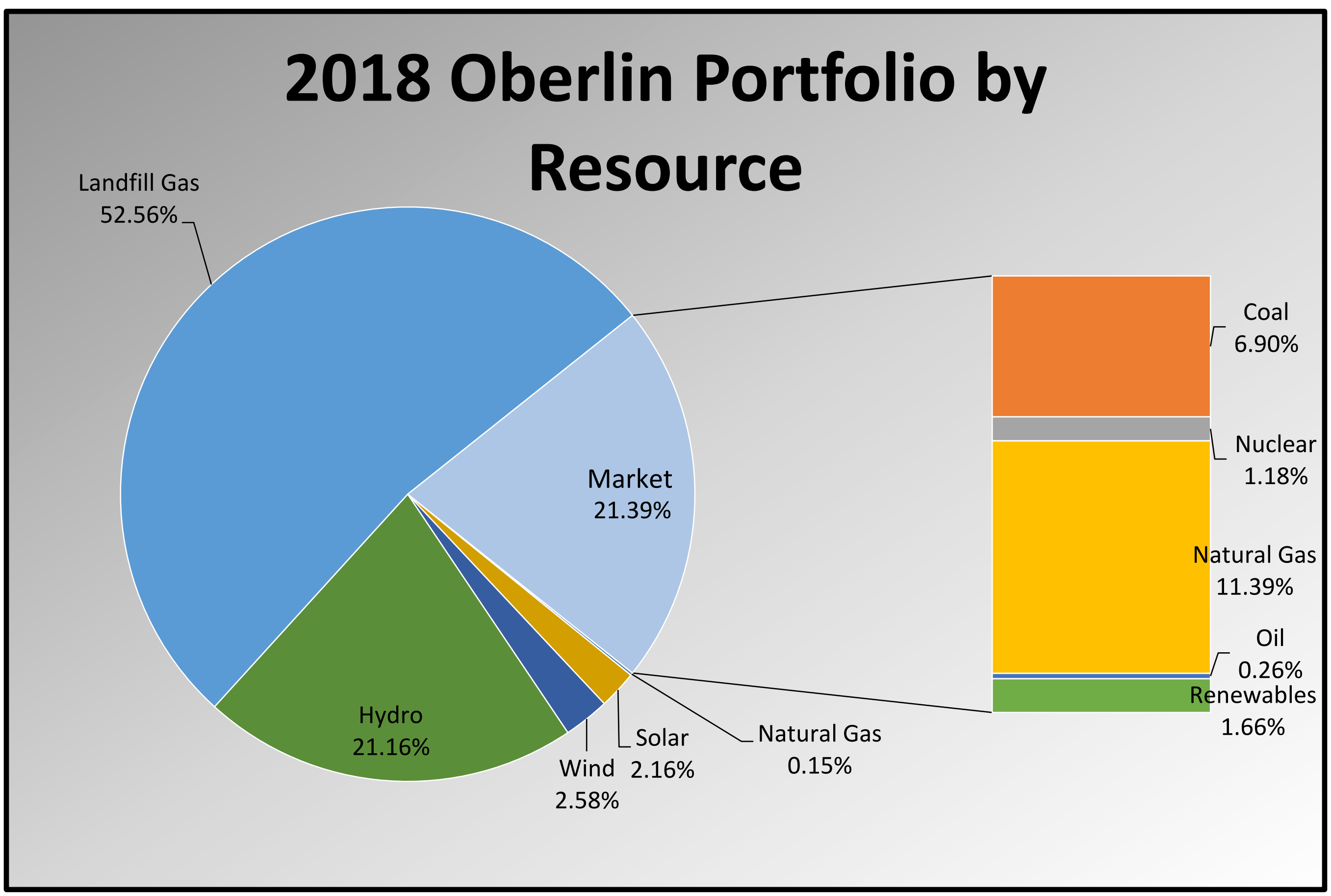


Figure 3: OMLPS' electric grid composition for 2018, broken down by resource type

Vision, Goals and Strategic Direction

The City of Oberlin is committed to reducing community-wide GHG emissions below zero, while striving to balance the environmental, social, and economic interests of the Oberlin community. This Climate Action Plan serves as a roadmap for transitioning to a climate positive community by charting specific emissions reduction strategies and establishing a plan for measurement and verification of emissions reductions. This Plan is a living document which will be reviewed on an ongoing basis and updated periodically.

Using 2007 as GHG emissions, it is recommended that the City of Oberlin set goals of reducing greenhouse gas emissions at least 50% below baseline by 2015, at least 75% below baseline by 2030, and below zero by 2050. The City will strive to achieve measurable GHG emissions reductions each year in order to ensure incremental progress toward reduction targets. Incremental goals of at least 1.5% emissions reductions every year are established in accordance with current commitments and will be measured every 5 years with an updated GHG emissions inventory.

This document was created with some important guiding principles in mind. First, in order to achieve a climate positive outcome in an environmentally and economically responsible way, we must strive to reduce our own emissions as much as possible across sectors and fuel sources highlighted in the GHG emissions inventory. However, accepting that it is impossible to reduce emissions below zero to become climate positive, it will be necessary to plan for ways of canceling remaining GHG emissions through carbon sequestration which will include offsets such as tree planting.

Second, the GHG emissions inventory highlights the sectors and fuel sources that are responsible for the majority of emissions, allowing us to identify and pursue strategies that will achieve the greatest emissions reductions first. The 2012 inventory identified electricity as the largest contributor to community-wide emissions The City has addressed these emissions through its locally owned electric utility, OMLPS, by entering into long-term contracts for landfill gas, hydro and solar power supply. See the diagram above and the Renewable Energy Section for more information on these renewable/carbon neutral resources, which provided Oberlin with 80% renewable/carbon-neutral electricity in 2018.

This plan outlines the GHG emissions reductions needed to achieve our goal of becoming climate positive; however, it does not chart how we will achieve the reduction goals while balancing, and indeed improving, the environmental, social, and economic interests of the Oberlin community. With concern for achieving economic resilience and social and environmental justice, we will need to measure success using social, physical, and economic indicators of sustainability. These metrics and financial tools which speak to economic and social aspects are currently being developed in partnership with The Oberlin Project and Oberlin College.

Renewable Energy

Introduction

When assembling a holistic approach for sustainable communities, the management of energy resources and consumption proves to be the greatest challenge. Here, energy includes electric power and thermal (heating and cooling) delivery, and its production and consumption account for close to 66% of global greenhouse gas (GHG) emissions.

In Oberlin, early changes to the production, procurement, and use of electricity have yielded significant benefits. Oberlin uses financial structures to leverage maximum community benefit, such as the City's sustainable reserve fund and the Oberlin College Student Senate Green Edge Fund. We have also implemented renewable generation projects, including a 2.27 megawatt (MW) solar array and 40 customer-owned solar installations. Energy use is affected by projects like the Oberlin Environmental Dashboard, a community-level, resource-awareness and conservation tool—which also serves as a building monitoring platform for facility operators. In the past decade, the City of Oberlin met its target of cutting 2012 greenhouse gas emissions by 50%, while simultaneously achieving approximately 85% green power for the community.[1]

Reaching and maintaining 85% renewable power is a massive accomplishment. As a community, though, we have yet to address the carbon impact of our thermal (heating and cooling) needs in a meaningful way. The largest opportunity for carbon reduction is finding solutions—especially renewable options—for heating and cooling buildings and processes throughout the City.

BACKGROUND:
THE CITY OF OBERLIN'S ELECTRIC ENERGY PORTFOLIO

Since the City maintains its own municipally operated electricity system, City leaders can make decisions on the composition of its power supply—an opportunity unavailable to most US cities. Furthermore, as a member of American Municipal Power (AMP), Oberlin is involved in a renewable/carbon-neutral joint power supply project and purchases other renewable energy. Since 2007, Oberlin has worked to systematically convert its electric energy portfolio from predominantly fossil fuels to predominantly renewable energy.

Oberlin's 2007 baseline (figure 1) renewable/carbon-neutral power supply included a mix of landfill gas (LFG), hydro, wind, and solar. Still, with the high percentage of coal resources in Oberlin's portfolio, electricity accounted for 55% of community-wide GHG emissions in 2007.

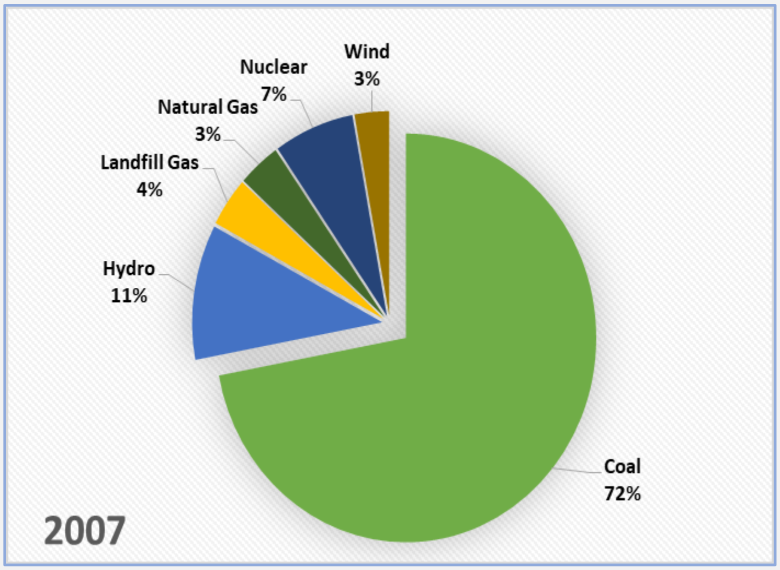


FIGURE 1: OBERLIN'S ENERGY PORTFOLIO (BASELINE 2007)

Energy used for space heating and transportation presents a different challenge, as the fossil fuel-based sources for these sectors are outside of City control. Natural gas is the major energy source for space heating and is supplied to most customers through an investor-owned utility. Transportation is heavily reliant on oil, which is sold commercially, reducing Oberlin's direct influence on these emissions. Reducing carbon dioxide equivalents (CO2e) in these sectors can be accomplished by encouraging and promoting the transition from fossil-fuel powered equipment to efficient,

[1]EPA defines green power as electricity produced from solar, wind, geothermal, biogas, eligible biomass, and low-impact small hydroelectric sources. Green power is a subset of renewable energy and represents those renewable energy resources and technologies that provide the highest environmental benefit. www.epa.gov/greenpower.

Renewable Energy Goals

The City of Oberlin is committed to developing and maintaining an electricity portfolio of renewable resources to provide residents with reliable power at reasonable prices. Specifically, the City strives to:

- Eliminate fossil fuel use for electricity generation no later than 2050; and
- Transition from fossil fuels to carbon-neutral alternatives in energy sectors for space heating and transportation, to begin as viable technologies allow, with regards to efficiencies and economics.

As recommended in the introduction of this document, a GHG inventory is to be completed every five years to monitor the CO2e reductions in Oberlin's energy use.

What is Renewable Energy?

Renewable energy resources are replenished eternally. According to the National Renewable Energy Laboratory (NREL, renewable energy sources include solar, wind, biomass, geothermal, ocean, and hydropower.

Benefits of Renewable Energy

Renewable energy creates tangible benefits for Oberlin and our region, including environmental improvement, increased fuel diversity and security, regional economic development benefits, and local revenue.

- **Environmental.** Emissions of carbon dioxide, mercury, nitrous oxide, sulfur dioxide, and particulate matter are significantly reduced. Damage associated with fuel extraction, processing, and transport is almost eliminated.
- **Fuel diversity and security.** Multiple energy assets mitigate risk from underperformance or loss of any one source. Energy sources spread across two regional transmission organizations and multiple transmission networks serves to minimize risk. Energy sources within Oberlin are effectively insulated from regional grid outage.
- **Economic benefits.** Rate stability immune to the volatile market swings of fossil fuels. Utility revenues paid to Ohio-based companies provide local jobs and circulate money through the local economy. Oberlin-based energy sources avoid transmission fees and garner capacity credits, both of which lower electricity rates. Reliable electricity with stable rates is attractive to new and existing businesses that provide jobs for the community and support a healthy tax base.
- **Local revenue.** Since 2006, the City has benefited financially from selling RECs to the College. A REC encapsulates the positive environmental attributes of electricity from a renewable source and can be sold as an asset to another entity wishing to offset the negative environmental attributes of its power source.

Challenges of Transitioning to Renewable Energy

The wind does not always blow, and the sun does not always shine. Still, we are accustomed to making use of electricity at the flip of a switch. Replacing fossil fuel generators running continuously with highly intermittent renewable energy is not a satisfactory solution. Until the technology is available to efficiently store and utilize renewable energy with low capacity factors (e.g., solar and wind power offer 10%–40% capacity factors), we have little choice but to rely upon interim sources of low-carbon or carbon-neutral power. The most promising of these energy sources is landfill gas (LFG), which is derived from the decomposition of organic matter in municipal solid waste and is widely considered a carbon-neutral energy resource. LFG, though, is a byproduct of landfills, and landfills are only replenished as long as we continue to generate and dispose of waste in the same way. While LFG is considered renewable, it will eventually be depleted if we continue to improve the rate and volume of recycling and, in turn, reduce the use of landfills. Note, too, that GHG emissions are produced in the initial construction and continuing operations and maintenance of renewable energy infrastructure—a.k.a. as the embodied carbon footprint.

OUR GOALS AND OUR MEANS TO ACHIEVE THEM

Renewable energy became a key component of the power supply of the City in 1994, when Oberlin City Council voted to join 41 other AMP communities to develop the Belleville Hydro Plant, a 42 MW hydro project on the Ohio River. This renewable project (est. 1999) now provides Oberlin with 7.1% of its annual power supply. This effort has continued with further investments in hydro, wind, and LFG resources.

The then-impending closure of AMP's Gorsuch coal-fired power plant in 2011 provided the impetus for Oberlin's quest to find a better source of affordable and reliable electricity. Oberlin commissioned a power supply study by the consulting firm Black & Veatch in 2009 to identify energy sources with an appropriate balance of cost, long-term reliability, and sustainability.

The results of that study and subsequent diligence in power-supply procurement have transformed Oberlin's energy portfolio from one heavily reliant on fossil fuels to a portfolio replete with renewable and low-carbon energy sources.

Present Strategies

Based on power supply commitments established in 2012, Oberlin's municipal electric utility had an 85% carbon-neutral portfolio of energy sources (Figure 2), reducing community-wide emissions by approximately 50%.

Oberlin's electric power supply portfolio continues to move towards the elimination of fossil fuel sources. The Spear Point 2.27 MW solar array, along with the addition of 193 kilowatts (kW) of rooftop solar, has added solar as a measurable component of the portfolio.

See the appendix for the list of our present strategies for increasing the use of renewable and carbon-neutral energy.

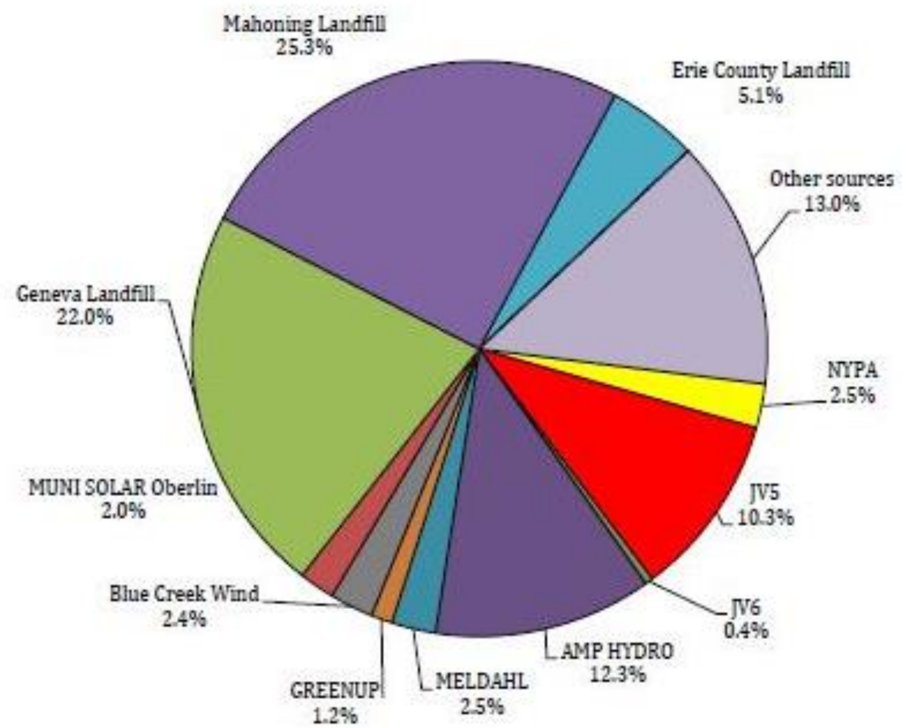


Figure 2: Oberlin's Energy Portfolio (2018)

SPOTLIGHT:

Spear Point Solar Energy 2.27 MW PV Field and Rooftop Solar

In 2012, the City and the College collaborated on the development of a 2.27 MW solar photovoltaic facility located on 11 acres of college-owned property in New Russia Township. The solar photovoltaic project was designed and constructed by SPG Solar of Novato, California, and incorporates a single-axis tracking system for solar production enhancement. The City and the College entered into an agreement to permit interconnection of the photovoltaic solar facility to the City's electric distribution network to virtually deliver the solar generation output to college properties. The College entered into a power purchase agreement with the owner, Spear Point Energy of Aspen, Colorado, to purchase the renewable solar energy. The project produces almost 3,000 megawatt hours (MWh) of renewable energy annually, which equals close to 12% of the College's power supply requirements. Additionally, the project offers benefits to the City as a renewable fuel resource and reduces wholesale power transmission and capacity costs.

Capitalize on the Market for Renewable Energy Credits

Renewable energy credits (RECs) represent the environmental benefits associated with renewable energy production in the form of tradable commodities. RECs can be sold to create a separate revenue stream to fund renewable energy projects and may be used as a regulatory compliance tool to meet mandatory renewable portfolio standards. Once a REC is sold, the environmental attributes associated with the renewable energy production can no longer be claimed. A number of OMLPS' renewable energy sources within the state have higher-value RECs than out-of-state RECs. Oberlin has successfully utilized the REC market to collect over $3,000,000 since 2006 for use in the City of Oberlin's Sustainable Reserve Program.

The Sustainable Reserve Program and the Sustainable Reserve Fund

The sustainable reserve program is managed by OMLPS and funds electric-related sustainability efforts in municipal facilities, including:

- Providing Oberlin with Efficiency Responsibly (POWER; see the chapter on energy use, conservation, and efficiency);
- The Oberlin super rebate programs for residential electrical appliances;
- Commercial light emitting diode (LED) lighting and electric home weatherization; and
- Numerous municipal electrical efficiency measures (e.g., LED street lighting).

The sustainable reserve fund is managed by the sustainability coordinator, and it funds other sustainability efforts outlined in the Oberlin Climate Action Plan, including:

- The expanded use of the sustainable reserve fund to assist environmentally positive endeavors, in terms of funding capacity and scope of allowable projects; and
- Greater funding to achieve higher targets of energy efficiency than proposed in the current Efficiency Smart program offered through AMP.

SPOTLIGHT:
Lorain Sun

In 2015, a group of Oberlin residents identified as Oberlin Peoples Energy Coalition (OPEC) came together to form a community-based solar cooperative (of sorts). The group worked with the Community Power Network (CPN), which provided technical and organizational expertise. CPN had worked with local groups to create "solar neighborhoods" in Washington DC, West Virginia, and Maryland. CPN collaborated with OPEC to provide educational forums, develop and solicit quotes from multiple solar installation companies, evaluate bids, and select the successful installer. Due to the expanding interest in solar beyond Oberlin, the organization became Lorain Sun. To date, Lorain County has completed 50 installations due to Lorain Sun influence, totaling 328.27 kW. Thirty-one of these arrays, totaling 194 kW, were installed on Oberlin businesses, churches, and homes. Following its establishment in Oberlin, the Ohio CPN has grown to over a dozen communities across the state.

Potential Strategies

Given the goal of eliminating fossil fuel use, Oberlin will continue to acquire assets of renewable energy to supply our community's electricity and other needs, as technology and opportunity allow. In turn, the City can promote transitioning to carbon-neutral electricity for sectors relying on fossil fuel, and to utilize existing opportunities in the renewable energy market to finance additional GHG reduction efforts.

Replace Natural Gas for Heating

Natural gas is widely used in Oberlin for space heating, domestic hot water (DHW), and cooking. Replacement of natural gas use with electricity or carbon-neutral energy sources should be encouraged. Both traditional insulated-tank and newer on-demand water heaters can be purchased as electric models and are an efficient method of providing DHW. Electric air-source and ground-source heat pumps have been proven to be successful for over 20 years, and their prices continue to fall as their efficiency improves. Even though equipment costs have decreased, the installation cost of space- and water-heat pump systems remains significantly higher than natural gas systems. Oberlin has implemented a successful electric efficiency incentive rebate program and should consider implementation of additional financing and rebate programs to encourage the replacement of fossil-fuel heating equipment with high efficiency electric water- and space-heating equipment with electricity supplied from the City's renewable and carbon-neutral portfolio.

Landfill Generation Waste Heat Recovery

A possibility currently under review involves Oberlin accessing high temperature hot water from the landfill generation facility located east of the city. Presently the landfill methane gas is burned in engines that generate electricity. This process creates a large amount of heat that is presently being released to the atmosphere. A project, in the conceptual design phase, is being considered that would capture this waste heat and use it to generate high-temperature hot water to heat and cool many facilities in Oberlin. An underground distribution piping system could deliver the hot water to commercial and industrial facilities, including the Oberlin City Schools, municipal facilities, churches, and college facilities. This project is expected to offset a substantial amount of natural gas usage for heating. The waste heat could also be utilized, for example, as absorption chillers for cooling in the summer months.

Replace Gasoline and Diesel Fuel

Gasoline and diesel are the common fuels utilized for motorized transport. To encourage electric vehicle use the City should consider adoption of policies that encourage electrified transport such as targeted rates for charging electric vehicles during off-peak hours or other mechanisms that ensure cost-effective and carbon-neutral vehicle charging.

Greenhouse Gas Considerations When Switching From Fossil Fuel to Electricity Use

In the near future, the City of Oberlin will have an electric supply that is largely carbon-free. Thereafter, most of the City's GHG emissions will be associated with non-electric uses of energy, including natural gas used for heating and fossil fuels for transportation.

One option to reduce natural gas usage is to switch to carbon-free electric technologies for heating and transportation; however, there are a couple of important things to consider. First and foremost, switching from natural gas to carbon-free electric energy would be one way to reduce GHG emissions, if Oberlin's carbon-free electric supply were not finite and Oberlin were an energy island—i.e., not connected to the larger electric grid. Since neither of these conditions prevails, both have important GHG implications for any increase in electric load.

Should demand upon Oberlin's renewable electric supply reach maximum capacity and additional renewable power resources are not available, any additional electric load is to be supplied by market power. This market power is mostly generated by burning natural gas or coal at roughly 33% efficiency. Therefore, on average, every unit of natural gas heating energy in Oberlin that is replaced with one unit of electric energy results in the burning of three units of natural gas (or coal) at a power plant within the grid. As a result, GHG emissions (outside of Oberlin) are three times greater than they would have been in Oberlin, had natural gas been used for heating in the first place. In general, switching from natural gas to electric energy for heating results in increased GHG emissions—unless the electric technology employed for heating will use 33% as much electric energy as the alternate natural gas heating system it would replace. Some, but not all, air-to-air and ground-source heat pump systems can deliver such savings. And, an electric domestic instant-hot water system may also deliver such savings (since it does not have the standby losses of the typical hot water storage tank). This prospect depends on the details of the usage.

The City should encourage fuel switching from natural gas to electric energy, first, when the technology employed is cost-effective and, second, when such switching will result in the overall reduction in primary energy use or overall GHG emissions. As fuel switching increases electricity use in Oberlin, OMLPS will need to increase its carbon-neutral resources, customers will need to increase energy efficiency efforts to offset the increase, or both.

This CAP aims to be holistic. The relationship of energy efficiency and fuel switching needs to be a symbiotic one. Oberlin needs to establish its optimal level of consumption from the grid and then strategically balance fuel switching and energy conservation to maintain that balance.

Municipal Building Solar Expansion

Presently the fire station and the Oberlin Municipal Light and Power System (OMLPS) technical services building have solar arrays installed. These arrays have been successful in reducing purchased power for the City electrical use. The City will continue to research additional public building sites for solar array installation.

EcoSmart Choice Program

EcoSmart Choice® is a green-pricing program offered by AMP through its member municipal electric systems. Residential, commercial, and industrial customers with EcoSmart Choice are able to offset levels of monthly electric usage with renewable energy for an additional cost of 0.3 cents per kWh (i.e., $0.003/kWh) or $3.00/MWh. The current EcoSmart Choice solicitation offers participation levels of 25%, 50%, 75%, or 100%. The City will look at participating in the EcoSmart Choice program. As a participating municipality, customers can sign up for the program via the website (www.ecosmartchoice.org), phone call, a visit to the utility office, or response via US post—depending upon the local utility. Customers can join or drop out at any time, without penalty.

Municipal Renewable Energy Educational Facility

A solar array coupled with a small wind turbine and energy storage technology would provide both additional renewable power and an educational facility for the public. This interactive renewable energy facility could be located in the open area just east of the Underground Railroad Museum and McDonald's. Informational signage would be included to explain the renewable energy sources and the potential for energy storage.

Conclusion

Oberlin maintains a long-standing commitment to renewable energy and strives to eliminate carbon emissions from electricity generation no later than 2050. In 2018, Oberlin's municipal electric utility had an 80% carbon-neutral portfolio of energy resources and is projected to be at 85% renewable in 2019. Reduction of CO2e emissions from other sectors relying on oil or natural gas can be accomplished by transitioning to carbon-neutral electricity. As technology and opportunity allow, Oberlin will continue to acquire renewable energy generation to supply our community's electricity needs.

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Energy:
Use, Conservation & Efficiency

Introduction

Every activity requires the expenditure of energy. Where we source that energy and how to maximize its use are important factors to consider in the reduction of carbon emissions. The traditional goal of energy efficiency is to accomplish a given set of tasks with less energy. Energy efficiency can result from improvements in technology, better management of existing technology, or better organization of existing systems. Increasing the energy efficiency of fossil fuel-based systems will decrease costs and carbon emissions. Still, this activity will never achieve the long-term goal of becoming climate positive. Rather than using fossil fuels more efficiently, our goal is to eliminate our reliance on fossil fuels.

BACKGROUND:
Impact of Energy Efficiency on Oberlin's Greenhouse Gas Emissions

Efficient use of electricity and natural gas are both important to pursue as energy efficiency is an important way to reduce greenhouse gas (GHG) emissions. In fact, you may be surprised to know that this remains true even though Oberlin's electricity portfolio is mostly carbon neutral, due to Oberlin's connection to the nation's electric grid, which remains inefficient and carbon-intensive. As covered in the chapter on renewable energy, Oberlin's current portfolio varies from 80-85% carbon neutral and 15–20% fossil fuels. Natural gas, the major energy source for space and water heating, accounts for close to 18% of Oberlin's GHG emissions. Therefore, increasing the heating efficiency of Oberlin's building stock is an important short-term strategy for reducing GHG emissions.

A longer-term goal for achieving climate positive status will be to shift heating from natural gas to renewable resources. Because natural gas is widely used by businesses and households, maximizing GHG emission reductions through fuel switching will be labor intensive and expensive. Creating a system that motivates people to use less energy and providing homeowners and businesses with the resources they need to make informed decisions will be crucial to maximizing efficiency, improving comfort, and saving money.

Energy Efficiency Goals

The City's electric power supply commitments create a near-term baseload energy surplus: i.e., the City can accommodate additional electricity sales from our carbon-neutral portfolio. Conversely, a reduction in electricity sales would necessitate an increase in electric rates to cover the operating costs of the utility. The City must seek an appropriate balance between energy efficiency reductions and managing its load profile for the fiscal health of the utility. Therefore, the City aims coincidentally to reduce electricity demand through efficiency improvements and increase electricity demand by replacing natural gas and gasoline usage with electricity.

Present Strategies

Sustainable Reserve Program

This program offers a funding mechanism for CAP goals related to electricity use (est. 2007, reaffirmed by Oberlin voters in 2017), and allows market trading of the utility's renewable energy credits (RECs), which results in positive cash flow.

Pay-It-Forward Program in Churches

In 2016, First Church in Oberlin underwent an LED upgrade of all their lighting. The congregation decided to donate the resulting Efficiency Smart rebate money to Rust Methodist Church, to help fund their own LED upgrade. The rebate money from that project was then paid forward to help another church. Super-rebate money from the City's sustainable reserve program was combined with a grant from the College's Green Edge Fund to further advance this cascading benefit for local churches. This pay-it-forward program is successful and growing. Not only does each church facility realize lower utility bills, church members may be inspired to implement energy efficiency in their own homes.

Providing Oberlin with Efficiency Responsibly (POWER)

POWER was founded in 2008 in collaboration with Zion Community Development Corporation and Oberlin Community Services. The purpose of this non-profit, grassroots, environmental justice organization is to increase the energy efficiency of Oberlin housing and, in particular, to help modest-income residents outfit their homes with energy efficiency upgrades. Since 2008, POWER has insulated and weatherized 138 houses, resulting in reduced emissions of CO_2e. POWER estimates that 40% of the housing stock (approximately 800 homes) still require efficiency upgrades. POWER aims to facilitate efficiency retrofits of the inefficient housing stock in Oberlin through 2025.

Related Strategies

- Lighting and appliance upgrades in municipal buildings;
- Replacement of heating/cooling systems with air-source heat pumps;
- LED upgrade of municipal lighting (traffic signals, street lights, etc.);
- Electric vehicles and fleet fuel economy; and
- Efficiency Smart: commercial energy consulting

Environmental Dashboard

The dashboard provides a real-time display of electricity use, water flows, and environmental conditions across the City, in order to communicate the collective impact of individual choices. Dashboard displays are now installed in local public schools, the College, the public library, City hall, the Hotel at Oberlin, the IGA grocery store, and businesses in the downtown district. See www.environmentaldashboard.org for more information.

Near-Term Strategies

The strategies recommended below are expected to help Oberlin achieve its energy use and efficiency goals. They are based on best practices and policies identified by other electric utilities. Adoption of new technology and policies will depend on research, feasibility of implementation, and cost-benefit analyses.

Building Performance Audits and Disclosures for Residential and Commercial Properties

Consumers need better information about the energy costs of buildings when they consider buying, renting, or leasing properties. A growing practice across the country is to require sellers and landlords to share this information with prospective buyers and tenants. The City should consider either a building energy performance audit program or a voluntary rating system.

Commercial Customer Energy Advocate

The City can build on the success of POWER in the residential sector by establishing a one-stop shop for commercial energy efficiency information and assistance. This may take the form of an expanded relationship with Efficiency Smart, a new position within the City, or a contract through an energy service company. The energy advocate would promote the various energy efficiency programs offered, work with customers to identify cost-effective methods for lowering energy bills, specify and monitor the upgrades as necessary, and ensure that the rebates are processed in a timely manner. The energy advocate at POWER has been invaluable, and a similar position for commercial customers can aid our pursuit of our climate action plan (CAP) goals.

Fuel Switching

Municipal Buildings

All municipal facilities will be supplied by 100% carbon-neutral energy by 2025—where it makes financial sense.[2] The City should commit to reducing existing energy use, replacing natural-gas heating and cooling systems with heat pumps, subscribing to carbon-neutral natural gas supply, and investing in solar photovoltaics to make-up the remaining 15–20% of the energy portfolio from "carbon-positive" electricity sources. This could be done either on or off site, via a third party to take advantage of existing federal incentives, utilize unused municipal property, or in partnership with other AMP communities through a joint venture.

Water Heater Replacement

Under the sustainable reserve program, the City will establish a water heater replacement program for customers of Oberlin Municipal Light and Power System (OMLPS). Customers replacing a natural gas water heater with a high-efficiency, electric heat-pump water heater may qualify for one or more of the following: an Efficiency Smart rebate, a SRP Super Rebate, and a federal tax credit. The utility could facilitate loans, cover the remaining balance through an administered grant program, or both. Electric water heaters using carbon-neutral electricity will reduce carbon emissions and increase electricity sales for the utility.

Heating, Ventilating, and Air-Conditioning Upgrades

Under the sustainable reserve program, the City will establish incentives to encourage and assist with the installation/replacement of space heating and cooling units. New natural gas units must be Energy Star certified to qualify, and units listed as Energy Star "most efficient" should receive added incentive. In addition, efficient all-electric units such as air-source and ground-source heat pumps with a Seasonal Energy Efficiency Ratio rating of 18 or higher will qualify for substantial SRP rebates beyond the rebates offered for high-efficiency gas furnaces or boilers. Rebates for heating, ventilating, and air-conditioning (HVAC) equipment are not currently offered by Efficiency Smart, while SRP offers local rebates. All-electric HVAC equipment using the utility's carbon-neutral electricity will reduce carbon emissions and increase electricity sales.

[2]To be determined by a payback of 15 years or less or an increased cost of no more than 20% utilizing our carbon neutral electric grid.

Update OMLPS Authorization: Oberlin Codified Ordinances Chapter 913

The defining authorization for OMLPS is Oberlin Codified Ordinance Chapter 913, which received its last substantial update in 1957. Due consideration should be given to an update of chapter 913 to explicitly provide for both the provision and conservation of electricity to furnish light, power, and heat services. Based on the establishing ordinance of 1927, the purpose of the utility included electricity for heating. That purpose was reiterated in ordinance no. 119 of 1934. Interestingly, with the codification of 1954, no express purpose was attributed to the utility, although further reading of chapter 913 seems to indicate its primary purpose is the contractual provision of electric service. It also lists a cross reference to the Ohio Revised Code (ORC) 715.06, which expressly provides for a municipality to furnish its inhabitants with light, power, and heat. Based on its founding ordinances and citation of ORC 715.06 in the 1954 codification as a municipal department, OMLPS was created with and still has the authority to provide light, power, and heat services. Plain language codification would eliminate interpretive ambiguities and provide clarity to the role of the electric utility in energy conservation. Additionally, a municipal service created for the express purpose of energy conservation and efficiency, the new Office of Sustainability, will operate parallel to OMLPS and administer the sustainable reserve fund to implement the measures outlined in the CAP.

Research How to Aggregate Our Natural Gas Supply and Add Carbon Fee

In 2018, Athens, Ohio, the home of Ohio University, became the first City in the state to enact a carbon fee through a voluntary opt-out electric aggregation program. Customers realize savings through lower rates and contribute less than $2 a month toward funding a community solar program. In 2011, voters approved a ballot initiative to allow the City of Cincinnati to negotiate on behalf of its citizens and small businesses for a favorable price from suppliers of electricity and natural gas. It is the first aggregation program in the nation to offer 100% carbon-free energy for natural gas and electricity. Oberlin will investigate this possibility and consider a natural gas aggregation program with an associated carbon fee.

Future Strategies

"It's tough to make predictions, especially about the future."

Yogi Berra

The following strategies highlight future investigations that are likely outside the five-year time frame of the CAP 2019 update. It is important to note, though, that the concept of fuel-switching was not fully developed and yet received mention in the 2013 CAP.

Oberlin Municipal Light and Power System: An Energy Service Company

Municipal electric utilities such as OMLPS must transition quickly from the traditional electricity sales-based business model to an à la carte energy services provider to remain viable. Energy service companies (ESCOs) have been reducing their customers' bills via installed energy efficiency improvements for quite some time. However, utilities such as OMLPS have noticed flat or declining sales as their collective customer base purchases less electricity due in large part to these efficiency measures. Rising costs for the utility coupled with declining sales would lead to a budget crunch. So, if this energy efficiency scheme is bad for the utility, then why are we doing it?

Operating as an ESCO provides one solution to declining energy sales without raising rates to compensate. First, the utility can institute efficiency services such as weatherization, lighting, and appliances as a low-cost or at-cost offering to their customers. Second, the reduced electricity sales due to energy efficiency can be compensated through increased electricity sales attributed to fuel switching. Appliances previously utilizing natural gas such as water heaters, furnaces, or kitchen ranges could be replaced with electric appliances as part of the ESCO service. Electric vehicles which replace gasoline-powered vehicles would also qualify. Incentives offered may include reduced-rate bank financing, direct rebates, preferential electricity rates on additional customer meters, or group buy offerings. The business model for fuel switching is sound. A simultaneous reduction in carbon emissions will be achieved so long as the energy portfolio of the utility has lower carbon emissions than direct combustion of natural gas. Currently, OMLPS's portfolio is 80%-85% carbon neutral. In turn, we can work to reduce customers' bills, increase revenue for our electric utility, and reduce our overall carbon emissions.

Finally, an important source of revenue for the utility comes from outside of the traditional customer base. One longstanding source of revenue for OMLPS is capacity credits from its generation plant. Another profitable benefit of OMLPS's energy portfolio is the trading of RECs, whereby the utility benefits, first, by selling RECs to satisfy the renewable portfolio standards of adjacent states and, second, replaces them with low-cost RECs from western wind farms. A third revenue source for the utility is aggregating and monetizing unused electricity resulting from energy efficiency improvements. A fourth benefit to the utility is decreased demand charges levied by the PJM Interconnection LLC (a regional transmission organization) due to electricity generation from local behind-the-meter solar and landfill gas generators and AMP collaborative peaking projects. Opportunities for additional outside revenue must be explored: e.g., additional service offerings, public/private partnerships that may access markets and tax-related benefits not available to a traditional public utility.

Evaluate and Consider Adoption of Smart Grid Technologies for Future Real-Time Monitoring of Energy Consumption and Load Control Opportunities

Advanced Metering Infrastructure (AMI), which allows for two-way communication between the customer's meter and the utility through software and hardware upgrades, can offer opportunities for a utility to better manage its peak-load requirements and help customers understand and better manage their energy consumption. In consideration of future upgrades to its metering infrastructure, OMLPS will research the benefits and costs of AMI, including real-time monitoring, load control, and other enhanced customer services.

Conservation Goals

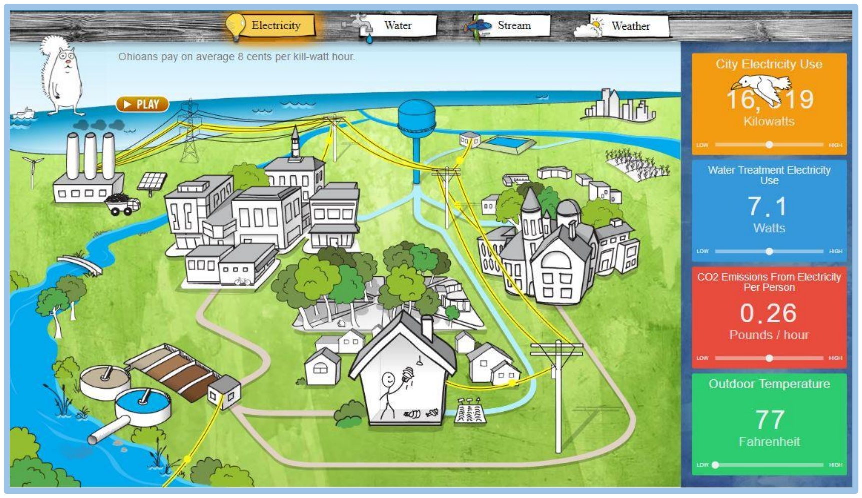
Behavior and Education

Developed by Professor John Petersen and students of Oberlin College, energy orbs make basic electricity use information visible to residents by translating a building or floor's current level of consumption into a spectrum of colors. The glowing colors display how much a building is consuming at that moment relative to normal consumption. The orb glows red if a dorm is consuming double or more of its normal electricity use. It shifts toward yellow as consumption approaches a typical rate. The color of the orb further shifts towards green as consumption approaches half of its normal electricity use. In spring 2008, energy orbs were installed in the lobbies of six residence halls at the College and, since then, controlled research has established clear reductions in energy consumption in dorms with energy orbs. Surveys found that residents viewed the orbs regularly and that the orbs motivated conservation and improved understanding, interest, and awareness of electricity use.

The environmental dashboard team went on to develop the characters "Flash" the energy squirrel and "Wally" Walleye on their website. Like the orbs, Flash and Wally's behavior reflects the relative consumption of energy. Behavior of individuals greatly impacts energy use and can exceed energy savings through efficiency measures alone. During the school year, students at the College and the Oberlin public schools compete in the Eco Olympics for bragging rights over comparative energy savings. During the competition, students often unplug vending machines, remove light bulbs, and find comparably unorthodox ways to reduce electricity use. However, these practiced behaviors tend to become habitual: post-competition energy use is consistently lower. Clearly, changes to behavior based on education and feedback can have a marked and lasting impact on energy consumption. (See, too, the chapter on education in this report.) The City should consider providing utility customers with emotional feedback on electricity consumption compared against their own long-term average and against that of their neighbors to induce behavior change through friendly competition.

Programmable Thermostats

While it may not always be cost-effective to replace HVAC systems with more efficient units, significant energy savings can be achieved for any central heating/cooling system with the use of a programmable thermostat. According to the US Department of Energy, you can save as much as 10% per year on heating and cooling by simply turning your thermostat back 7-10°F for eight hours a day from its normal setting. Smart thermostats can perform this function automatically using occupancy sensors or a phone app to maximize energy savings without sacrificing comfort. The City offers rebates for smart thermostats through Efficiency Smart and the Super Rebate program as a benefit to all customers to reduce energy consumption through conservation.



Conclusion

With the creation of the Energy Services Division of OMLPS in 1998, Oberlin took a proactive role to promote energy efficiency services and programs to residents and businesses, leading to the adoption of Efficiency Smart and POWER in 2011. Rebates and technical assistance through these programs have resulted in carbon emission reductions and millions of dollars in energy savings. Oberlin will continue to reduce its existing electrical consumption while promoting fuel switching to simultaneously increase electricity sales. POWER has weatherized 138 homes and continues to increase its weatherization and energy education efforts. Projects, programs, education, and incentives by the City, the College, and the community have brought energy efficiency to the forefront in our mission to reduce energy usage and GHG emissions. It is important to emphasize the benefits of energy efficiency and fuel-switching in order for all stakeholders to fully embrace and practice efficient use of energy.

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Transportation

Introduction

According to the Environmental Protection Agency, the US transportation sector accounts for 27% of domestic greenhouse gas (GHG) emissions. Light-duty vehicles account for 60% and medium- and heavy-duty trucks account for 23%.

The total vehicle miles traveled (VMT) in 2006 for the City of Oberlin was 40.6 million miles, a 2.5% increase from 2000. In comparison, VMT grew 10% nationally during the same period. National VMT has been on the rise for decades and is expected to grow until 2035. If this trend were to continue locally, Oberlin VMT would increase 20% above baseline by 2050. In order to reduce Oberlin's transportation-related GHG emissions, it is necessary to address the transportation needs of constituencies on multiple fronts.

Based on the 2007 CAP goals, the climate action committee set a goal of reducing emissions from the transportation sector by 1.5% annually.

The City of Oberlin will promote a more sustainable transportation system that serves the needs of the Oberlin community. Since transportation networks cross political boundaries, the City's goals will be pursued in partnership with local, county, regional, and state entities and stakeholders. Re-visioning and ultimately re-creating local and regional transportation systems will reduce GHG emissions and have numerous environmental, social, health, and economic benefits. The City of Oberlin will strive to achieve the goals noted below:

- **Reduction of the amount of fuel consumed.** Work with local and regional partners toward a more complete network of affordable, environmentally-friendly transportation choices. These improvements will provide the structure to encourage the community to travel, commute, and shop using low-carbon methods of transportation such as transit, biking, walking, ride sharing, and car sharing.
- **Reduction of the carbon content of fuel consumed.** Increase electric and alternative fuel adoption for fleets and residents. Electric-powered vehicles "filling up" in Oberlin will use renewable/carbon-neutral energy resources, and energy dollars will stay in the region.

The key strategies to achieve these goals are included in the appendices of this chapter.

The reduction of the transportation-related carbon emissions is to include:

- the promotion of the safety, convenience, and social acceptability of biking and walking;
- the improvement of the availability and reliability of no- and low-carbon fuel sources; and
- the reduction of travel demands.

These approaches must be considered in the context of the widely divergent transportation needs of the community. Continued cooperation between the City, local institutions, and regional, state, and federal entities will be necessary to rethink how to provide a more comprehensive network of no- and low-carbon transportation options. Oberlin has many assets in place that provide the foundation for achieving these goals. To meet the goal of reducing transportation-related GHG emissions, the City will need to continue to implement its Complete Streets Policy and develop new programs and policies to provide the necessary framework for progress to meet—and possibly exceed—the incremental goals.

BACKGROUND: Transportation Profile of Oberlin

Nationally, the transportation sector accounts for approximately 27% of GHG emissions. By contrast, Oberlin's transportation sector accounted in 2007 for 15% of community-wide emissions (23,887 metric tons), in part because so many Oberlin residents work locally. In fact, 53% of commuters travel less than ten minutes to work, and 53% drive to work (US average: 86%). To get from home to work, 12% of residents carpool, 32% walk, and 6% bike. 32% of Oberlin households own two motor vehicles, 51% own one car, and 13% have none – which equates to 1.5 vehicles per household (US average: 1.7 vehicles per household).

Virtually all vehicles on Oberlin's roads are powered by fossil fuels (close to 82% gasoline and 18% diesel), though hybrid-electric and all-electric vehicles are becoming more popular. In order to encourage the expansion of electric vehicles, the City and College have installed free charging stations—with the City installing two since the last CAP.

Vehicle Miles Traveled (VMT) in Oberlin

Generally, transportation-related emissions can be described as the product of the carbon content of the fuel, vehicle miles traveled, and fuel consumption of the vehicle.

Emissions $_{[Carbon]}$ = (gallons/mile) (miles traveled/vehicle) (carbon/gallon) or fuel consumption * activity * carbon content[2]

SPOTLIGHT:
Complete Streets Resolution

In May 2015, the City adopted a complete streets resolution. Oberlin was the first city in Lorain County to adopt such a policy. The Complete Streets framework is intended to ensure that the City's streetscapes are consistently designed with all users in mind—including bicyclists and pedestrians of all ages and abilities, emergency and safety service vehicles, cars and trucks and, where applicable, public transportation. The resolution demonstrates the City's commitment to maintaining, developing, and promoting a multi-modal transportation system and to serve the needs of all Oberlin residents and visitors in coordination with local, county, and regional partners. The resolution also displays the City's commitment to reducing carbon emissions. Complete Streets also helps improve the local economy, the community, and the environment and ultimately, help the City achieve its goal of becoming a climate positive community by the year 2050.

Transportation & the Reduction of the Carbon Content of Fuel

The City and its partners aim to reduce the carbon content of fuel by providing engineering solutions and education, encouragement, enforcement, and evaluation strategies that promote and incentivize the use of fuel efficient, low- and no-carbon emissions vehicles.

Performance Metrics and Status: Engineering

Progress: In 2013, the City received a grant from the state's Local Government Innovation Fund program to conduct the Oberlin Fleet and Fuels Emissions Reduction Strategy (OFFERS). Working with the Clean Energy Coalition, the City coordinated a working group of local fleet partners. Each fleet was inventoried and analyzed to develop recommendations for potential alternative fuel platforms. The final report can be viewed at:

www.Cityofoberlin.com/wp-content/uploads/2014/07/OFFERS-Final-Report-v51.pdf.

By far the most significant adaptation has been by our largest fleet partner, Republic Waste, which is presently converting its Lorain County-based fleet of refuse and recycling vehicles from diesel fuel to compressed natural gas. Their fueling station is not available to the public. The City currently has two EVs in its fleet, and the City has deployed Parker-Hannifin's hybrid hydraulic drive system on three refuse/recycling collection vehicles.

Plans: The City will continue to monitor the rapidly evolving hybrid, EV, and alt-fuel vehicle and equipment marketplace to make informed determinations on select vehicles and equipment.

Performance Metrics and Status: Education and Encouragement

Progress: The City currently offers two free EV charging stations. Additional charging facilities will be installed at the Oberlin Underground Railroad Center. Other locations will be evaluated for future installations. The City has adopted and disseminated an anti-idling policy for municipal drivers. This is the first step in driver education.

Plans: At this time, the City intends to continue to incentivize the use of EVs by providing free public access to charging stations. The City will continue to promote the federal incentive program and consider the development of local incentives, too. The City will encourage and potentially incentivize the incorporation of a combination of hybrid vehicles, EVs, and alt-fuel vehicles into the local rental marketplace. The City can promote a more comprehensive approach to vehicle/equipment operations by deploying training developed through OFFERS to provide strategic, tactical, and operational information to our drivers with the goals of raising awareness and reducing fuel consumption.

Performance Metrics and Status: Evaluation

Progress: The City should continue to monitor fuel and emissions reductions related to its deployment of hybrid, EV and alt-fuel vehicles. The City should meter electricity provided by its public charging stations to evaluate trends and future needs.

Plans: In order to fully evaluate and address GHG emissions from the municipal fleet specifically and the transportation sector more generally, it will be necessary to develop and maintain a more robust assessment methodology.

Why are these metrics important?

Encouraging and incentivizing the use and ownership of hybrid, EV and alt-fuel vehicles are critical to lowering the carbon content of the fuel. If vehicle miles traveled (VMT) trend were to continue under a "business as usual" scenario, Oberlin VMT would increase by 20% by 2050. Choosing to use or own a vehicle with lower carbon content will reduce transportation-related CO_2e emissions, which accounts for a large percentage of carbon emissions in Oberlin.

Transportation Services and Options

The City and its partners will endeavor to lower the amount of fuel consumed by providing engineering solutions and education, encouragement, enforcement, and evaluation strategies that promote travel by reducing carbon emissions, but also endeavor to increase health, safety, convenience, and mobility.

Performance Metrics and Status: Engineering

Progress: The City application of Complete Streets policies will benefit public transit by designing appropriate roads. Although the Oberlin Connector Transit Service is a demand-response system, Lorain County Transit (LCT) has temporarily stopped the Oberlin route. There have been designated LCT stops throughout Oberlin in anticipation of service renewal. Meanwhile, there are other services offered to various segments of Oberlin by private institutions.

The Oberlin CarShare Program features vehicles available to enrolled residents. The program started with three cars. Now it has four. Students take the greatest number of trips, but faculty, staff, and community members also utilize the vehicles. Hundreds of hours of rides are taken each month. The program has been quite a success for the community and there are plans to expand it.

Plans: The City of Oberlin Underground Railroad Center has established a park-n-ride area that allows people in cars, on bikes, or on foot to access the Oberlin Connector Transit Service and the LCT for trips to and from Oberlin.

Performance Metrics and Status: Education and Encouragement

Progress: Private organizations in Oberlin offer transportation services to their segment of the community. For example, Kendal at Oberlin provides transportation services to its residents within Lorain County.

The College has established several means of transportation with a focus on students, although most services are also available to the public. The College charters shuttle to the airport during the school semester, which also includes a shopping shuttle on Saturdays to a handful of local shopping locations.

The College also offers private transportation services for students during the academic year. Students can ride a campus shuttle to get around campus during the week. This is a free service for anyone with an Oberlin College ID. Oberlin has arranged for private shuttle services for students to and from campus to the airport and to local venues. For students that live in Chicago, Washington DC, and New York, there is a student-built mass transit service called Shuttle Home. This is a community-based transportation company that provides students with coach bus service directly from their college campus to their City during school breaks at 50% of the cost of flying.

Plans: Mobility and Opportunity for a Vibrant Economy (MOVE) Lorain County is working with various organizations and sectors throughout the county to develop a coordinated transportation plan. The purpose of locally developed, coordinated public transit is to identify community resources for transportation and mobility, understand the gaps and unmet needs within those resources, and to determine the approach to addressing those gaps and unmet needs. The MOVE organization was founded in association with residents of Oberlin, Kendal at Oberlin, and the Oberlin Project.

Performance Metrics and Status: Evaluation

Progress: The Lorain County Commissioners reduced LCT fares by over 50% in December 2017—from $4.10 to $2.00. This is important to note since the City of Oberlin contracts with the Lorain County Commissioners for the Oberlin Connector, which is a two-day-a-week service. This new fare affects riders of the Oberlin Connector, too.

The Oberlin CarShare Program remains popular, and its provider identifies the Oberlin program as exemplary.

Plans: The coordinated transportation plan under development by MOVE Lorain County encourages regular assessments of both the needs of county residents and the effectiveness of the services provided.

Why are these metrics important?

The use of public transit has been shown to assist with creating healthier lifestyles, reduce carbon emissions, while also serving as an economic driver. According to the American Public Transportation Association, “the average household spends 18 cents of every dollar on transportation, and 96% of this goes to buying, maintaining, and operating cars, the largest expenditure after housing.” In addition, mass transit users are healthier because mass transit riders get three times the physical activity than people who drive alone. Being more active lowers the risk of serious illness and diseases, including diabetes, joint/back problems, heart disease, and depression—and it reduces carbon emissions.

Transportation & the Reduction of the Carbon Content of Fuel

The City and its partners aim to reduce the carbon content of fuel by providing engineering solutions and education, encouragement, enforcement, and evaluation strategies that promote and incentivize the use of fuel efficient, low- and no-carbon emissions vehicles.

Performance Metrics and Status: Engineering

Progress: Under the broad auspices of the City's Complete Streets policy, the public works department has constructed, from 2011 to 2017, numerous cycling and walking improvements:

Cycling Related Improvements

New multi-use trail	1,877 Lane Feet (LF)
Multi-use trail maintenance	17,113 LF
New on-street bike lanes	8,140 LF
"Sharrows" (share arrows)	21,350 LF
Association of Pedestrian and Bicycle Professionals bike racks	16

Walking Related Improvements

New sidewalks	1,580 Lane Feet (LF)
Sidewalk maintenance	14,476 LF
Accessible ramps	188
Pedestrian bump-outs	3
Crosswalk markings	103

Plans: In 2018, the public works department implemented the City's Safe Routes to School Project. Eleven sidewalk infill projects, comprising nearly 7,000 linear feet, were developed. The project also included the installation of a school zone flasher system at Prospect Elementary School. The public works department has also conducted the fourth and final planned round of the City's sidewalk maintenance and repair program. The department will continue to apply complete streets principles to its capital projects. In 2019, the public works and planning departments will collaborate in the development of a walking/cycling master plan for the City.

Performance Metrics and Status: Education and Encouragement

Progress: In 2016, the Oberlin Police Department updated the City's ordinances regarding bicycle parking. The current regulations and information about how to register a bicycle in Oberlin can be found at oberlinpd.com/bike-licensing/.

The public works department inventoried available bicycle parking in the Central Business District. We found a total of 430 bicycle parking spaces—many owned and operated by the College—close to college facilities, including the Allen Memorial Art Museum. The CBD bike parking map is available at the police department link above.

Plans: Oberlin Community Services recently completed installation of a covered bike parking facility for its bicycles. The College is considering implementation of a privately managed bike share. Other education and encouragement tools to develop and implement include:

- cycling and walking education and safety programming;
- cycle- and walk-to-work (or school) promotions; and
- promotion of the "Your Move Ohio" social media campaign.

Performance Metrics and Status: Evaluation

Progress: In spring 2015, the City received a bronze rating as a bicycle friendly community from the League of American Bicyclists.

Plans: Update the City's bike friendly community application; review the 2018-2019 walking and cycling master thoroughfare plan; and evaluate and deploy cycling/walking use metrics.

Why are these metrics important?

Maintaining, improving and expanding walking/cycling infrastructure provides more active transportation choices for Oberlin residents and visitors. Choosing to walk or cycle has the dual benefits of reducing transportation-related CO2e emissions and improving public health.


High-Performance Buildings

Introduction

The high-performance building movement promotes the use of ecological principles in the creation of buildings and communities. In addition, high-performance buildings and communities can conserve resources, save money on energy and water bills, and provide a comfortable and healthy environment. High performance buildings are proving to be cost effective, more desirable, and more valuable than conventional buildings. Both new and existing structures benefit from green-building best practices, which can result in climate positive buildings.

BACKGROUND: Energy Use and Greenhouse Gas Emissions in Buildings

The operation of buildings accounts for close to 40% of the energy used in the US (residential energy: 22%; commercial buildings: 18%). In the residential sector, four areas account for 66% of the energy used: heating, 31%; cooling, 12%; hot water, 12%; and lighting, 11%. In the commercial sector, three areas account for 53% of the energy used: lighting, 26%; heating, 14%; and cooling, 13%. Electricity represents about 75% of the primary energy used in buildings. In Oberlin's 2007 GHG emissions inventory, residential buildings accounted for 16% of emissions while commercial buildings were 38%.

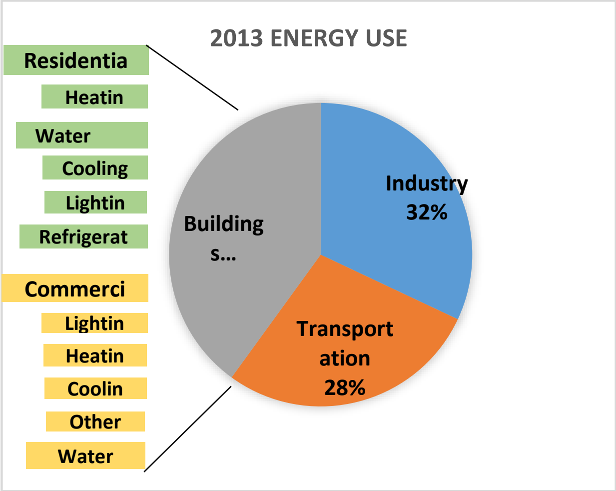

Figure 1: Energy Use in the US (2013)

From 1990 through 2013, the US Energy Information Administration identified consumption and expenditures for four end-use categories: space heating, air conditioning, water heating, and refrigeration; the remainder was aggregated as "other." As certain appliances and equipment have become more prevalent in homes, this remainder category became a larger share of residential energy consumption, especially for electricity.

In 2015, [the US International Energy Agency's (IEA) Residential Energy Consumption Survey] introduced percentages of energy consumption for an expanded list of energy end uses. For electricity, the number of end uses jumped from four to 26 by adding estimates, to begin, for dishwashers, clothes washers, clothes dryers, televisions, and lighting.

In 2015, nearly 50% of residential electricity consumption fell into the other category. Adding several new characterizations of end uses provides a better accounting of energy use in homes, and now the IEA survey attributes only 13% of residential electricity consumption to end uses not elsewhere classified.

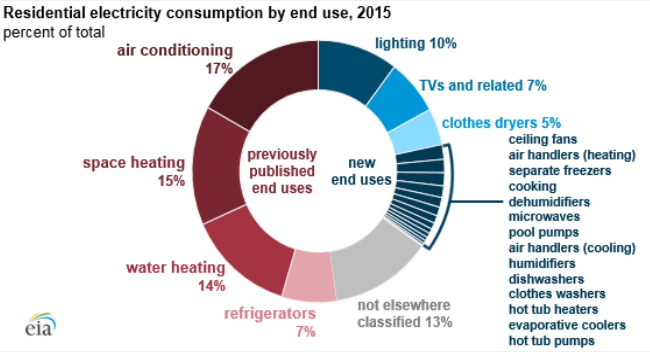

Figure 2: Residential Energy Use in the US (2015)

Since building energy use is so large and varied, it is imperative that Oberlin focus on improving the energy performance of all new and existing buildings. There must be a coordinated set of strategies to reduce the overall energy consumption of the City's building stock. These strategies should be prioritized to focus on the end-use behaviors associated with the highest levels of consumption.

What is a High-Performance Building?

A high-performance building operates on up to 70% of the average amount of energy used by a similar type of building located in the same region of the country.

Homes

In its most recent report, the Energy Information Agency tallied the average annual energy consumption for the East North Central region of the US:

- Electricity: 9,129 kilowatt hours (kWh) (Oberlin's average residential usage is 7,800 kWh);
- Natural gas: 805 centum cubic feet (ccf);
- Propane: 549 gallons;
- Fuel oil: 287 gallons.

Applying the 70% factor gives homeowners a target ceiling for higher energy performance:

- Electricity: 7,800 kWh*.7 = 5,460 kWh;
- Natural gas: 800 ccf*.7 = 560 ccf;
- Propane: 549 gallons*.7 = 384 gallons; and
- Fuel oil: 287*.7 = 201 gallons.

OMLPS reports that between 2013 and 2018, the average annual residential electricity consumption dropped from 9,000 kWh to 7,800 kWh. Each kWh of electricity generated equals 1.8 pounds of carbon dioxide released into the atmosphere. While Oberlin's energy portfolio is 85% renewable, this figure represents a reduction of 392 metric tons of CO_2 from the atmosphere each year.

Natural gas generates 1.27 pounds of carbon for every 100 cubic feet of gas burned.

If 50 homes receive retrofits per year, and they realize a 30% reduction in gas and electric consumption, the carbon reduction would equal an additional 78 metric tons each year.

For all-electric homes, a 30% reduction is a reasonable goal.

Commercial Properties

The same strategies can be applied to commercial buildings. The EIA states that commercial buildings typically consume 14 kWh per square foot and 42 cubic feet of gas per square foot.

The application of established energy conservation measures, along with greater use of renewable energy, should make the goal of higher performance achievable for all homes and businesses in our community.

SPOTLIGHT:
Smith Street House

The Smith Street House was designed and built as a high-performance home, with a modest footprint at 1,400sf.

The house is oriented with its long axis east to west to maximize sunlight in the winter. The shell of the house is very tight, which prevents air leaks. The floor is insulated at R-30, the walls at R-40, the roof at R-60, and the attic at R-84.

There are double-paned thermal windows. It is an all-electric home that has a 4.48 kilovolt photovoltaic array to provide a large portion of its electricity. All appliances are Energy Star rated.

In the first year of occupancy, the all-electric home consumed a total of 6,333 kWh, compared to the annual consumption of 7,000 kWh for the average home in Oberlin. In addition, most homes in Oberlin use gas for space and water heating. When all forms of energy are calculated, the Smith Street house uses approximately 23% of the energy of the average home.

Present Strategies

As the City strives to set the standard for sustainable practices with regards to new City buildings, the City of Oberlin's Green Building Policy may be established to provide guidelines to architects, engineers, and constructions crews for City buildings. The City needs to review the policy and determine if it's appropriate to current building standards and readily enforceable.

City of Oberlin Green Building Policy

The City of Oberlin shall incorporate green building principles and practices into the design, construction, and operations of all City facilities, City funded projects and infrastructure projects to the fullest extent possible.

All new construction exceeding 5,000 sq. ft. and major renovations exceeding 1,000 sq. ft. of municipally owned and operated facilities shall be required to meet minimally the U.S. Green Building Council's latest version of LEED Silver certification.

In addition, the City shall evaluate all land purchases for future development on the basis of reducing environmental impacts that include but are not limited to transit and bicycle accessibility, urban and brownfields redevelopment, solar access, on-site stormwater mitigation capacity and vegetation and habitat restoration.

Furthermore, the City will provide the leadership and guidance to encourage the application of green building practices in private sector development. To this end, the City shall endeavor to resolve any code or other regulatory conflicts with green building practices.

This Policy is expected to yield long-term cost savings to the City's taxpayers due to the substantial improvements in life-cycle performance and reduced lifecycle costs.

Collaborate with POWER to Implement Energy Conservation Projects in Homes and Businesses

POWER has successfully implemented and facilitated many energy conservation programs in homes, non-profits, and businesses. The services include facilitating energy audits, soliciting contracted services, and providing assistance to homeowners applying to rebate programs. In addition, POWER has provided substantial support to community churches involved in the "pay-it-forward" program and has facilitated LED lighting retrofits in small businesses. City Council has taken the initiative to provide more flexible funding for energy initiatives, and some of that funding could support POWER initiatives. POWER should collaborate with the City sustainability coordinator to identify potential projects for funding.

POWER
Providing Oberlin With Efficiency Responsibly

SPOTLIGHT:
34 South Pleasant Street House

The home of Mrs. Hattie Jones is a one-story ranch home of 1,000sf. The home has vinyl siding, forced-air, gas-furnace heating, single-pane windows. In March 2015, POWER began to add blown cellulose insulation to the home. The attic was raised to R-30 and the sloped ceiling received six inches of insulation. Additional cellulose was blown into the walls, raising the R value to 19. POWER staff also performed weather sealing and installed LED bulbs throughout the home.

Using the 2014 utilities as a base year, the home's annual gas consumption dropped from 623 hundred cubic feet to 461 hundred cubic feet: a reduction of 33%. The annual electric consumption dropped from 3,698 kWh to 2,295 kWh: a reduction of 61%.

Facilitate the Development of the City-Owned Vacant Properties in a Sustainable Manner

Sites such as the Bait Canteen and Green Acres provide the City with the opportunity, through creative design, to not only move toward a climate positive neighborhood through the application of renewable energy, but also one that has common open space and vegetable gardens, aesthetically pleasing locations and relationships among houses, and attractive landscaping created to compliment neighboring properties. There are commercial surplus properties in the industrial park area that should be developed in a sustainable manner as well.

Develop Commercial and Residential Building Performance Certification Programs

Ohio law limits the ability of cities to establish more stringent building codes than those required by the State. This restriction, however, can be overcome in at least two ways. First, the City could certify buildings as "green" if they meet green building standards established by the City, with separate criteria for commercial and residential buildings.

Second, the City could develop a residential building standard in which homes could be rated based on high performance and ecological criteria.

In establishing high-performance building performance certification programs, criteria could come from one of the established certification programs, including US Green Building Council Leadership in Energy and Environmental Design (LEED) existing buildings, LEED for homes, passive house, Living Building Challenge, Energy Star Certified New Homes, and National Association of Home Builders. Criteria would ensure that all certified houses would be high performance and potentially climate positive or positive energy. These certification programs can be paired with incentives to make such certifications attractive (see next page).

Establish Procedures and Policies that Encourage Green Building

The City should consider procedures and policies that encourage builders and homeowners to build high performance homes. . These procedures and policies should include opinion pieces and editorials in local newspapers, City Council proclamations, "green house" plaques, reduced permit fees, or other actions that will be of minimal cost to the City. Establish procedures and policies that incentivize performance improvements for existing buildings.

While much of this chapter has focused on implementing best practices relating to the construction of new buildings, we must remember that more than 90% of the buildings in Oberlin were built before the development of efficiency standards. New high-performance buildings will do nothing to offset the energy consumption of existing buildings. The City should also consider establishing similar policies and procedures for commercial building and home owners to reduce the consumption of energy in these existing buildings. Incentives such as low or no interest loans, or outright financial support for implementing recognized efficiency measures should be established. Builders and developers should be encouraged to perform lifecycle cost analyses to confirm the savings in energy costs as well as repair and replacement costs compared to conventional building practices. As with the new construction, there are several programs and incentives that could provide recognition and encouragement for improving the energy performance of an existing home or commercial building.

Promote a Lifecycle Savings Policy

The Builders Association estimates that the costs of construction represent approximately 20% of the total cost of a building with a life expectancy of 40 years. In the construction of new buildings, minimal increase in construction costs is more than offset by the lifecycle costs savings in terms of energy and maintenance. The City should consider a policy that requires builders to provide lifecycle cost analyses of new City buildings and their infrastructure. For example, the life cycle cost difference of installing LED lighting versus the most efficient fluorescent lighting should include the cost of lamp and ballast replacement, as well as the respective costs of electricity consumption. This type of analysis should be conducted for all major energy consuming equipment in the building, as well as shell components (i.e., roofing, windows, and exterior wall materials).

SPOTLIGHT:
Oberlin IGA

The Oberlin IGA is an example of an existing commercial building whose energy performance improved considerably through the application of effective energy conservation measures (ECMs). The variety of ECMs implemented include:

- installation of a highly reflective roof to reduce heat infiltration;
- LED lighting retrofit throughout the store, which reduced demand by 20% over the previous T-8 and ballast fixtures;
- replacement of all refrigeration equipment with the most energy efficient equipment available, reducing energy use by 25%;
- installation of variable frequency drives on all HVAC equipment; and
- a heat reclamation system which captures exhausted heat and is used to warm the building.

The store has realized a 22% reduction in energy consumption.

Building Envelope and Lighting Efficiency

A building's envelope—i.e., the slab, walls, and ceiling or roof—defines the movement of heat and light into and out of the building, which in turn determines the energy required to light, heat, and cool that building. For existing structures, eliminating air leaks is the most cost-efficient change for heating and cooling energy, with typical paybacks of 1-4 years. Additional insulation in attics and walls is second with paybacks of 3-6 years. Daylighting followed by lighting with linear fluorescent and LED bulbs provide the most energy efficient lighting. These efficiency measures are followed by replacement windows, which have typical paybacks of 10 years or less.

Design, Cost and Performance

When designing a new building, it is important to keep in mind the design decisions that dictate the building's lifecycle energy performance. The three most important decisions in making a high-performance building for the 21st century include:

- Size: make it as small as possible for the functions to be served;
- Envelope: make it super insulated and very tight; and
- Orientation: design it with the long axis oriented east-west to employ passive and active solar strategies.

In building rehabilitations, size and envelope decisions can often be addressed, but orientation cannot. Passive and active solar, however, should be employed whenever possible. (See Green building appendix H for reference on green building in general and passive solar in particular). It is important to understand that the conversion and renovation of existing building stock to improve performance will be a long-term effort. The obstacles include lack of motivation of building owners, cost, and lack of information. POWER's efforts to improve the energy efficiency of homes and small businesses have uncovered a variety of challenges. However, through creative programs and policies, these obstacles can be addressed successfully.

How to Calculate a Building's Energy Usage Index (EUI)

A measure of the energy consumption of a building is called the Energy Utilization Index (EUI). This measure provides a common energy measurement across different fuel and energy sources. All energy forms consumed in use of the building is converted to its British thermal unit (Btu) equivalent, a standard measure of energy.

Electricity contains 3,412 BTUs per kWh and natural gas contains 1,015 Btus per ccf.

So, to determine your home or building's EUI:

- Multiply your annual electricity consumption in kWh by 3,412;
- Divide that number by 1,000 to determine the kBtus of electricity;
- Multiply your annual total hundred ccf of gas by 103,700;
- Divide that number by 1,000 to determine the kBtus of natural gas;
- Add these two numbers together; and
- Divide this sum by the square footage of the home or building.

The resulting kBtus/sf is the annual EUI.

Top Ten Energy Efficient Measures for Home and Business

These energy efficiency steps are ranked by cost, from lowest to highest. They include the range of costs and the relative energy and cost savings. Each measure has a separate fact sheet that provides more details and information on costs and savings.

1. Install LED Light Bulbs or Fixtures

Led lamps cost between $1 and $5 and have simple payback of less than two years. On average, replacing 15 standard light bulbs with Energy Star LEDs can save about $50 per year. LED fixtures range from a few dollars to a little more than $100. They range from decorative interior fixtures to shop lights to exterior lighting. Part of the savings is in annual lamp replacement costs, since standard incandescent lamps last for 1,000 hours, compact fluorescent lamps last for 10,000 hours, and LED lamps last for 50,000 hours.

2. Replace Furnace Filters Regularly

Furnace filters cost between $3 and $5 each. The Department of Energy indicates that the average household spends about $2,200 per year on its energy bill. When you change your air filter regularly, you can save 5–15% on utility costs.

3. Insulate Your Hot Water Tank and Exposed Hot Water Pipes, and Lower Your Water Temperature Setting

Just like insulating your walls or roof, insulating your hot water tank is an easy and inexpensive way to improve energy efficiency. If you have an older hot water tank, check to see if it has insulation with an R-value of at least 24. If not, consider insulating your water tank, which could reduce standby heat losses by 25–45%, reduce water heating costs by 7–16%, and pay for itself in about a year. You can find pre-cut jackets or blankets available for $20 and can reduce water heating costs by $20–$45 each year.

Insulating your hot water pipes reduces heat loss and can raise water temperature 2°F–4°F hotter than uninsulated pipes can deliver, allowing you to lower your water temperature setting. You also won't have to wait as long for hot water when you turn on a faucet or showerhead, which helps conserve water. Polyethylene pipe insulation costs less than $1 per foot and can reduce water heating costs by $8–$12 per year.

Although some manufacturers set water heater thermostats at 140ºF, most households usually only require them to be set at 120ºF, which also slows mineral buildup and corrosion in your water heater and pipes. Water heated at 140ºF also poses a safety hazard—scalding. Savings resulting from turning down your water heater temperature are based on two components: reduced standby losses (heat lost from water heater into surrounding basement area); and consumption (from water demand or use in your home). Lowering your water temperature can save $12–$60 per year in water heating costs.

4. Install Low-Flow Shower Heads, Faucets and Aerators

You can lower your water heating costs by using and wasting less hot water in your home. Water heating is the second largest energy expense in your home (after heating and cooling). It typically accounts for about 18% of your utility bill. For maximum water efficiency, select a shower head with a flow rate of less than 2.5 gallons per minute (gpm).

New faucet flow rates can't exceed 2.5 gpm at 80 psi or 2.2 gpm at 60 psi. You can purchase a quality, low-flow fixture for $10–$20 and achieve water savings of 25%–60%.

The aerator—the screw-on tip of the faucet—ultimately determines the maximum flow rate of a faucet. Typically, new kitchen faucets come equipped with aerators that restrict flow rates to 2.2 gpm, while new bathroom faucets restrict flow rates from 1.5 to 0.5 gpm. Aerators are inexpensive, and they can be one of the most cost-effective water conservation measures. For maximum water efficiency, purchase aerators that have flow rates of no more than 1.0 gpm. Some aerators even come with shut-off valves that allow you to stop the flow of water without affecting the temperature. When replacing an aerator, bring the one you're replacing to the store to ensure a proper fit.

5. Annual Maintenance on Your Heating and Cooling Systems

Space heating is likely the largest energy expense in your home and can account for close to 45% of your energy bills.

Every home heating system accumulates dust, dirt, and other particulates that affect performance and efficiency. This can cause your utility bills to soar. A professional heating oil furnace or boiler tune-up and cleaning eliminates the grime and ensures all components are in good working order, so when it's time to turn up the thermostat on the first chilly morning of fall, you have heat. The main benefits of a professional heating system tune-up include:

- Improved system efficiency, which means better heating performance and lower heating costs;
- Reduced risk of heating system failure—you don't want to be without heat when the temperature is sub-zero;
- Minimized possibility of needing major repair; emergency service always costs more than preventative maintenance; and
- Annual tune-ups cost $90–$200 and, if the system hasn't been tuned in the past two years, can have a payback of one year.

6. Install a Programmable Thermostat

Just as your water heater maintains a set temperature when it isn't being used, a thermostat does the same thing for the entire house. Just letting it cool off (or warm up) when there isn't anyone awake can save energy and money, too. Without sacrificing comfort, it can also be close to half of what air sealing would save you. This change usually pays for itself in about three years. Programmable thermostats cost between $100 and $300. Qualified programmable thermostats are eligible for a $25 Efficiency Smart rebate. Smart thermostats can reduce heating and cooling costs by $80 per year.

7. Seal and Caulk All Openings in the Shell of Your House

Reducing the amount of air that leaks in and out of your home is a cost-effective way to cut heating and cooling costs, improve durability, increase comfort, and create a healthier indoor environment. Caulking and weather stripping are two simple and effective air-sealing techniques that offer quick returns on investment. Heating and cooling savings can be $80–$160 per year.

8. Install Additional Insulation in Your Attic and/or Walls

Unless your home was specially constructed for energy efficiency, you can probably reduce your energy bills by adding more insulation. Many older homes have less insulation than homes built today, but even adding insulation to a newer home can pay for itself within a few years. To determine whether you should add insulation, you first need to find out how much insulation you already have. A qualified home energy auditor will include an insulation check as a routine part of a whole-house energy assessment. An energy assessment, also known as a home energy audit, will also help identify areas of your home that are in need of air sealing. (Before you insulate, you should make sure that your home is properly air sealed.)

9. Upgrade Your Appliances to Energy Star Rated Products

An Energy Star label identifies the product carrying it as more efficient than most of its peers. An Energy Star dishwasher, for example, must be 10% more efficient than the least efficient unit, while washing machines must be 37% more efficient. Replacing a pre-1994 clothes washer will save you as much as $110 per year. A new Energy Star dishwasher will save you about $25 per year.

10. Replace All Windows and Doors with Energy Star Rated Products

The installation of Energy Star qualified windows lowers energy bills and saves you money over single-pane and even new double-pane, clear-glass windows. For a typical home, choose Energy Star and save $126–$465 per year when replacing single-pane windows, or $27–$111 when replacing double-pane, clear-glass windows.

Conclusion

The City and the College have made notable strides in embracing high-performance building standards. It is important for the City and the College to use not only building certification programs and other best practice standards for new construction and renovations, but also to develop policies and mechanisms to reduce construction costs. Building performance should also be monitored over several years. Such policies can correct missteps and improve future policies.

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Waste Management

Introduction

Effective waste management to minimize CO_2e emissions entails the reduction of solid and industrial waste and the diversion of remaining waste from landfills. The present and future strategies addressed in this plan encompass residential, commercial, institutional, and industrial solid wastes—as well as residual waste products from wastewater treatment. Strategies to minimize emissions include waste reduction and diversion, recycling, composting, and methane recapture.

BACKGROUND:
Measurement of Greenhouse Gas Emissions from Waste Management

Since the City maintains its own municipally operated electricity system, City Reduction in CO_2e emissions from waste management strategies is measured in emissions from terminal waste management (i.e., landfilling, recycling, composting, etc.). Anaerobic decomposition of organic wastes in landfills or compost facilities can release significant carbon dioxide and, more importantly, methane, which has heat-trapping potential approximately 21 times that of carbon dioxide. Per the City's 2014 emissions inventory, the waste management sector accounted for 1,395 CO_2e tons, equal to 2.7% of the community's greenhouse gas (GHG) emissions. Note that CO_2e emissions associated with collection, transport, and processing of wastes are measured in the transportation and energy sectors.

Solid Waste Management

Estimated reductions in CO2e emissions for the solid waste sector are linked to waste disposal by landfilling. Reductions in the disposal quantity are attributed to the following factors: reduced consumption, improved re-use, and increases in recycling and composting. Such reductions are likely to be tied to programs and policies, as well as external factors, including local, regional, and global economic conditions and technological advancements. Measurable goals can be set to reduce solid waste disposal. These reductions can be modeled to project corresponding reductions in CO2e emissions.

In 2013, the City created its Zero Waste Plan (ZWP) as a pilot initiative sponsored by the Lorain County Solid Waste Management District. The ZWP was developed in partnership with the District and its consultant, GT Environmental; the City's Resource Conservation and Recovery Commission; and the College. The ZWP was adopted by City Council in May 2014:

> *Zero waste is the City's goal to minimize the final disposal of waste materials as completely and rapidly as possible. This reduction will be achieved using a combination of environmentally sound strategies with an emphasis on education, on source reduction and reuse and on recycling and composting (ZWP, ES-1).*

Recognizing that it may not be possible to eliminate all waste, the ZWP establishes a goal of 90% waste reduction/diversion by 2050. The City's Zero Waste Plan can be viewed at https://www.Cityofoberlin.com/wp-content/uploads/2014/07/Oberlin-ZWP-Portfolio.pdf.

Present & Potential Strategies: Solid Waste

The Zero Waste Plan is the City's framework for reducing CO_2e emissions from solid waste management activities. The ZWP provides an inventory and overview of the City's equipment and services at the time the plan was created. The ZWP evaluates various options for increasing diversion in three phases:

Phase 1: 2014–2020 **Phase 2: 2021–2030** **Phase 3: 2031–2050**

Many of the programmatic recommendations from phase I have been implemented since adoption of the ZWP. See the appendix for the list of different strategies.

The following table depicts the most recent five years of data on refuse and recycling collection service in Oberlin (all measurements in tons):

Materials Recovered	Actual 2013	Actual 2014	Actual 2015	Actual 2016	Actual 2017
Mixed recycling	803.46	247.10	841.77	883.49	962.83
Ferrous metal	22.18	3.99	6.53	38.13	8.77
Non-ferrous metal	3.09	0.73	4.42	3.84	4.88
Styrofoam	0.00	0.00	0.00	0.31	0.11
Paper and old, corrugated cardboard	411.99	181.92	93.57	80.60	117.43
Hazardous household waste	8.60	4.82	2.83	4.26	4.34
E-Scrap	12.25	6.98	7.49	8.27	6.56
Lamp/ballast	2.40	1.15	1.38	1.35	1.65
Rubber	9.80	10.01	9.58	9.63	11.45
Other HHW	1.23	3.27	6.38	7.46	8.10
Textiles	23.31	22.42	11.99	13.75	15.06
Wood	0.00	0.00	0.00	0.00	145.31
Yard waste	485.23	497.70	493.99	547.31	269.95
Food waste	0.00	0.00	55.09	65.93	69.21
Total recovery	1,783.55	980.08	1,535.02	1,664.33	1,625.64
Disposal	3,524.55	3,955.16	3,504.82	3,567.94	3,599.31
Re-Use/Source Reduction					
Total generation	5,308.10	4,935.24	5,039.84	5,232.27	5,224.95
Diversion rate	33.60%	19.86%	30.46%	31.81%	31.11%

Table 1: Refuse and Recycling Collection in Oberlin, 2013-2017

Potential Strategies

To continue the City's push towards zero waste, it will be necessary to continue to offer and to expand on phase 1 of the ZWP (2014–2020). The City has achieved the most success in its continuing management of organic wastes at its class IV composting facility, in its conversion to universal cart-based collection systems, and its ongoing partnerships with the Lorain County Solid Waste Management District to manage household hazardous waste, electronics, tires, and other special wastes. Both Kendal at Oberlin and the College have initiated pilot programs in food waste composting. For more information about food waste see the chapter on Local Food and Agriculture.

Present & Potential Strategies: Wastewater

Measuring reductions in CO2e emissions associated with wastewater are linked to biological decomposition of organic materials through treatment processes. Improving methane production, capture, and beneficial re-use may be considered a climate-positive function to offset CO2e emissions in other sectors.

Present Strategies

The City owns, operates, and maintains a class IV water environment protection facility (WEPF) that provides comprehensive wastewater treatment services. The rated capacity at the WEPF is 1.5 million gallons per day (MGD). The average daily flow is just under 1.0 MGD.

As described above, CO2e emissions associated with sanitary sewer collection and the wastewater treatment processes are primarily measured in the transportation and energy sectors. There may be, however, CO2e emissions associated with the biological decomposition of bio-solids. Solids from the primary and final settling tanks must be further treated prior to disposal. The WEPF uses both aerobic and anaerobic digestion processes. Sludge is heated in the anaerobic digester to 90°F–100°F. The methane by-product of anaerobic digestion is captured in the digester and combusted to heat the boiler that maintains digester temperature. Digested solids are sent to the sand drying beds or stored in the sludge holding lagoons. Class B bio-solids are sampled and analyzed prior to land application at agronomic rates in accordance with all applicable Ohio Environmental Protection Agency regulations.

Potential Strategies

Although the primary mission of the WEPF must be compliance with National Pollutant Discharge Elimination System requirements, the public works department will continue to support the efforts of WEPF staff to operate the plant as efficiently as possible. This will include continuing efforts to maximize energy conservation through efficiency measures and to examine opportunities to enhance resource recovery (energy and organic matter) associated with the treatment of wastewater.

Anaerobic Digestion

The City intends to evaluate its anaerobic digestion capabilities to upgrade equipment and to enhance system redundancy. We will also consider opportunities to maximize energy production, including both methane and electricity. Examples for consideration include: an enhanced or comprehensive food waste digestion system and improved treatment and recovery of the embodied energy in fats, oil, and grease. Recovered methane could be used to power a co-generation system with the electricity available for use on site and the heat from the generator recovered to maintain sludge temperatures.

Evaluation of Costs & Benefits Associated with the Production of Class A Bio-Solids

Enhanced digestion may also allow the City to produce Class A bio-solids which may be applied without restriction to farm lands, gardens and landscapes. As a more desirable soil amendment, Class A bio-solids could reduce the City's transportation costs associated with land application of Class B bio-solids.

Conclusion

Although waste management currently accounts for a small percentage of the City's GHG emissions (2.7%), this relative percentage will increase as the City makes progress towards reducing its CO2e emissions portfolio in other sectors. Ongoing tabulation of waste management GHG emissions will be necessary to evaluate progress in decreasing related emissions from the 2007 emissions inventory level of 1,395 CO2e tons.

Continuous evaluation and improvement of solid waste and wastewater management practices will also result in important related climate-positive benefits that will accrue in every other sector of the Climate Action Plan.

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Water Management

Introduction

The production and distribution of safe drinking water—along with the collection, transportation, and treatment of wastewater—have climate impacts, most notably through electricity use. This chapter explores how the City can reduce impacts through enhanced management strategies at the water treatment plant (WTP), the water environment protection facility (WEPF), storm water management, and through general water conservation opportunities in the community. Reducing water use through conservation and by minimizing water distribution system losses will save water and thereby reduce energy costs associated with the City's water systems.

Although Oberlin is considered "water rich," the City is expected to experience greater variability in weather, with regional changes expected in water quality and water resiliency. Although drought is not something Northeast Ohio communities currently face, action related to water conservation and water use are important in order to reduce regional and local impacts. Efforts to reduce the amount of water pumped and processed will reduce greenhouse gas (GHG) emissions. Although the total GHG emissions related to water pumping and treatment are a small proportion of Oberlin's total emissions, reduction in this area may provide ancillary benefits, including the development of adaptation strategies for future drought and flood episodes. Efforts should be made to reduce the amount of water treated at the WEPF by promoting water conservation by residential and commercial customers.

The WTP and WEPF are responsible for 48% of the City's electricity consumption, with waste water typically consuming twice as much as water treatment. The City should develop measurable goals to reduce water use from a set baseline with an acknowledgement that reduction in water usage corresponds with a similar reduction in revenues. Program development and implementation will need to balance these factors. The following strategies will be considered for implementation.

Potential Strategies

Climate change has increased the relative frequency of heavy rain events in Oberlin. As the climate variability increases, these events are expected to continue to increase. Opportunities to reduce inflow and infiltration to the sanitary sewer collection system can reduce the amount of water needing processing at the wastewater treatment plant. In order to minimize potential for inflow and infiltration, improved stormwater control measures for both residential and non-residential properties can be considered.

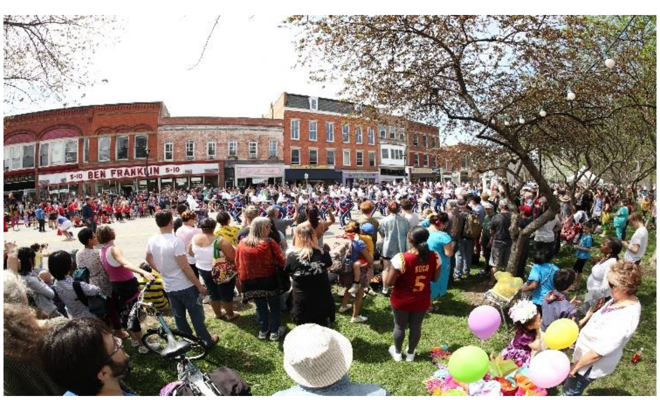
Education and Outreach

Introduction

Effective communication and education are essential to the long-term success of the Climate Action Plan (CAP). Achieving our carbon neutrality goal will require commitment, participation, and creativity from private citizens; businesses, schools, and churches; City staff; and elected leaders. It will also require that key decision makers stay well informed about evolving technologies and opportunities. The goals and strategies outlined in this chapter provide a broad strategy about the resources, knowledge base, and motivation required for widespread community support and behavior change.

The carbon-producing choices people make (what they do) are constrained by a variety of things: what they have (the physical structures around them, such as access to local food, charging stations, efficient appliances), how they think (e.g., valuing reducing carbon emissions, understanding how to reduce energy consumption), and the larger cultural context (e.g., local and federal tax rebates, networks such as Local Governments for Sustainability and supportive social norms). For the CAP to be successful, the community needs to provide the physical infrastructure, information, and motivation to enable a shift to more sustainable behaviors. We also need to leverage and promote the broader cultural context needed to support the CAP's goals. The ultimate goal of changing what people *do* (the carbon-producing choices people make) requires two key strategies:

- Provide accessible and engaging role-appropriate learning opportunities (to shape what people think); and
- Provide the necessary resources and positive incentives for all community constituencies (to provide a supportive context).



There is a considerable amount of research on how to motivate people, shift attitudes, and change behavior, particularly in the context of promoting sustainable behavior. The community-wide communications plan, incentive structures, and behavioral interventions will be informed by this research. In particular, a community-based social marketing (CBSM) approach to designing interventions will be used whenever possible. CBSM takes a systematic, empirical approach to behavior change, thereby maximizing the effectiveness of program dollars. This method has five steps:

1. Select the right behaviors: focus resources and energy on behaviors that have a large carbon impact, are easily changed, and are not already common.
2. Identify barriers and benefits: determine why people do not engage in a behavior, and what benefits they can see from doing so.
3. Develop strategies to change behaviors: design programs and campaigns that minimize the barriers to a behavior, and maximize or emphasize the benefits, drawing on strategies that empirical research has established are effective.
4. Pilot strategies and evaluate the impact: conduct pilot programs and assess the effectiveness of key strategies, make improvements as needed.
5. Broad-scale implementation and evaluation: launch programs community-wide; continually evaluate and adjust to maximize effectiveness.

BACKGROUND

The previous CAP outlined the following goals:

- Motivate residents and businesses to change their behavior to reduce carbon emissions and help the City reach its climate positive goal by 2050;

- Empower K–12 educators to create learning environments that support sustainability, and promote sustainability and environmental studies majors at higher education institutions; and

- Provide ongoing sustainability-related learning opportunities for all interested community members, institutions, and students through service learning, community events, workshops, and other educational programs.

To meet these goals, multiple strategies were implemented:

- Environmental dashboards were installed at the College, Oberlin City schools, City hall, the Oberlin Public Library, and private businesses;

- The Oberlin City schools expanded the sustainability curriculum through a partnership with Creative Change Educational Solutions, a nonprofit organization in Michigan;

- The City partnered with POWER to promote a “one-stop shop” for information and assistance with energy efficiency programs for Oberlin residents (to great success);

- Through the work of the Oberlin Project, sustainability tracking, assessment, and rating system assessments (STARS) were encouraged at all partner schools, and Oberlin College and Lorain County Community College completed STARS assessments; and

- The City created a new sustainability coordinator position that reports directly to the City manager. The sustainability coordinator is responsible for CAP implementation.

Building on our past goals we have developed a set of ambitious strategies for the next five-year period (see Appendix).

Oberlin City schools recently completed a strategic planning process and identified core values and strategies to guide decision making over the next five years. The core value of educational excellence through rigor, innovation, and challenge to the status quo aligns well with the City’s goal of achieving carbon neutrality. Similarly, the strategy focused on creating facilities that are optimized for the needs of our students and community is likewise highly consistent with the goal of creating high-performance buildings.

Work with the relevant subcommittees that emerged from the Oberlin school district’s strategic planning process, particularly:

- The educational committee to ensure that sustainability literacy is incorporated as appropriate throughout the curriculum; and

- The finance and facilities committee to ensure that the new school campus is a high-performance building that also serves as a teaching tool.

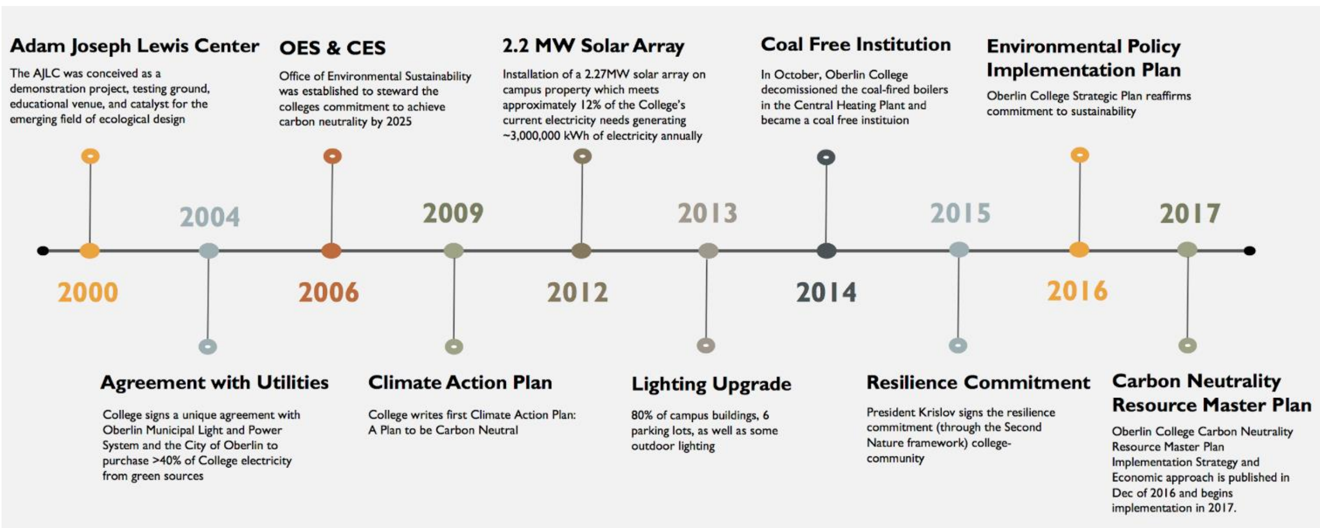
Oberlin College

Oberlin College uses close to 25% of the City's electricity and is responsible for close to 25% of the City's carbon emissions. In 2006, the College joined the Carbon Commitment—formerly the American College and University President's Climate Commitment (ACUPCC)—with a similar goal to become climate neutral. Likewise, in December 2015, the College was one of the first US colleges to sign the ACUPCC Resilience Commitment, which entails partnering with the City to explore climate adaptation and resilience planning.

Together, the concepts of carbon neutrality and climate resilience constitute a new, integrated climate commitment for the College. These commitments share common elements in their core philosophy, most notably the ability to transcend traditional campus silos of academics, operations, student life, community engagement, and administration for holistic social impact. The network of signatory institutions, of which the College is a part of, is called the Climate Leadership Network. It encourages and enforces the need for strong ties and connections to address the climate goals of the College and the City.

Managing the College energy use and water resources are the most challenging emissions issues to address. Thermal (heating and cooling) solutions present the largest impact to college greenhouse gas (GHG) accounting, just as it does with the City. The College has established an aggressive climate action plan with GHG reduction targets of 100% by 2025.

Over the past two decades, significant administrative and programmatic infrastructure investment by the College has been put in place to champion and facilitate the shared goals of the College and the City for a carbon positive community.



The College has a long history of progressive leadership on social justice issues and a shorter, but equally impressive history in environmental stewardship. The pursuit of carbon neutrality in many ways represents the ultimate liberal art. For the College to pursue its mission of education requires meeting the needs of the present without compromising its ability to educate future generations of students, too. A community that understands the dynamic interactions of species and communities over time and during changing ecological conditions is one that recognizes the interconnections between the environment, economics, equity and education. A college that embraces carbon neutrality commits itself to create new possibilities and apply ecological imaginations in any discipline or endeavor.

Since 2012 the College has implemented renewable generation projects on campus like a 2.27 megawatt (MW) solar array, as well as energy behavior-change-projects like the Oberlin Environmental Dashboard, a community-level resource awareness and conservation tool that also serves as a building monitoring platform for facility operators. The College central heating plant, which heats and cools most buildings on campus as well as a few community buildings, became a coal-free operation in March 2014. The College has also arranged financial structures to leverage maximum community benefit, such as the decision of the Oberlin College Student Senate to finance the community carbon management fund through student fees.

These efforts, in addition to others over the past 10 years, resulted in approximately 50% reduction of scope one and two GHG emissions from the College (baseline year: 2007). In December 2016, the Office of Environmental Sustainability, in conjunction with the Board of Trustees Carbon Neutrality Subcommittee of the Capital Planning Committee, presented an actionable and financially feasible plan for achieving Oberlin's commitment to carbon neutrality by 2025. *The Oberlin College Carbon Neutrality Resource Master Plan, Implementation Strategy, and Economic Approach* includes a well-elaborated community benefit component. Click here for the complete Oberlin College CAP.

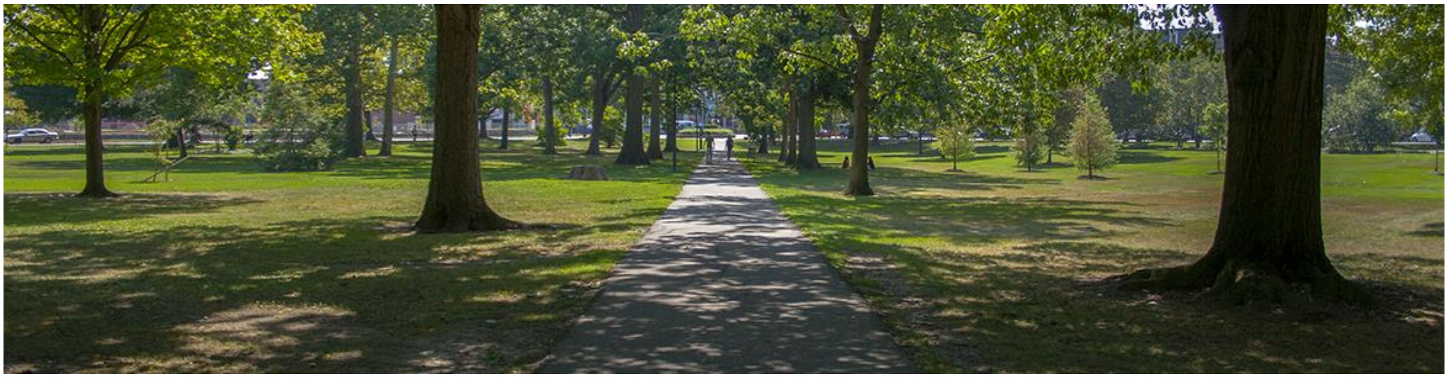
Land-Use Planning

Introduction

Land-use planning, a new topic for the Climate Action Plan, involves decisions that shape the entire community, including setting priorities for new and existing development, making zoning recommendations, guiding new commercial and neighborhood development, and defining boundaries or connections between different parts of the City. Land-use planning is extensively interconnected with transportation decisions, energy use, carbon sinks within City limits, efficient delivery of City services, health and safety, quality of life, success of businesses, and almost every other topic covered by this CAP update. In addition to addressing the general area of land-use planning, this section focuses specifically on green space planning and urban forestry as important examples of how land-use planning can address climate change adaptation, mitigation, and resilience.

Goals

- Integrate CAP’s short, medium, and long-term goals with local land use policies and practices.
- Apply placemaking strategies to stimulate sustainable reinvestment in neighborhoods where it is needed;
- Maintain and preserve existing green spaces that act as carbon sinks and encourage climate-positive recreation and transportation;
- Add additional land to Oberlin’s publicly-owned green space and add new trail connections for bicycle and pedestrian transport (where appropriate);
- Maintain Oberlin’s existing tree canopy and add additional trees where appropriate; and
- Develop metrics to assess progress and measure success.



Background

Local communities have opportunities to address climate impacts via land-use planning and, in turn, play their role in the global effort to mitigate the effects of climate change. Capital investments in "green" infrastructure that preserve natural assets or expand mobility choices in work and housing have climate positive effects. "Smart growth" strategies that link public transportation with higher density development make the built environment more energy efficient and thus reduce greenhouse gas (GHG) emissions. Communities also reduce their carbon footprint through local distributed systems of renewable energy and food production. The execution of local strategies has long term benefits, for sustainable, independent communities minimize their dependence upon global market commodities, including fossil fuels. Ongoing climate change impacts will not be completely mitigated by reduced GHG emissions, so communities can develop resilience strategies to protect vulnerable areas and communities from more frequent extreme weather events. Transfer of development rights can reserve land needed to buffer riparian systems. Land trusts can ensure that vulnerable members of a community—e.g., children, elderly citizens, and low-income families—will not be displaced when communities rebuild after natural disasters.

Local, regional, and national decision makers will need to embrace an interdisciplinary approach to establish benchmarks, collect information, and measure key conditions. Each community will need to evaluate its unique conditions and determine how to mitigate and adapt to climate change. A comprehensive land-use planning process engages the community in order to establish a consistent vision, set goals, and evaluate appropriate strategies for sustainability. The planning process becomes more relevant and accessible with real time data collection, rapid analyses, and dissemination to key decision makers and stakeholders. These planning tools can provide the same opportunities for innovations in specific places and neighborhoods. Placemaking strategies prioritize the key elements that maximize scarce resources for site-specific reinvestment. Planning tools that access multiple data sources and disciplines allow communities to gain a deeper understanding of the emerging challenges and opportunities. Oberlin will be well equipped to harness those challenges and nurture any opportunities to build a more resilient community.

Green space in Oberlin includes parks, arboretums, athletic facilities, trail corridors such as the Plum Creek Greenway, and other undeveloped land that is either publicly or privately owned. The City of Oberlin's Open Space and Visual Environment Commission of the City advises City Council on the management of Oberlin's open spaces, including its green spaces.

These spaces play an important role in climate change mitigation and resilience by sequestering carbon and encouraging climate-friendly recreation and transportation. Vegetation in cities can capture about four tons of CO2/acre (Shammin et al., 2012). Local, accessible parks can reduce greenhouse gas emissions by reducing motor vehicle use, limiting urban "heat island" effects created by paved surfaces and buildings, and sequestering carbon in trees. Bike paths, trail corridors, and greenways facilitate bicycle and pedestrian transportation options as alternatives to motor vehicle use. The permeable surface provided by parks and other undeveloped open spaces allows stormwater infiltration, which reduces stormwater runoff. Less runoff reduces the need for water treatment, which generates GHG emissions. Land-use planning that maintains and enhances Oberlin's green space will ensure that these climate positive benefits continue.

Oberlin's urban forest encompasses all trees within the City. Urban forests act as a carbon sink by capturing and storing atmospheric carbon dioxide during photosynthesis. This carbon is stored in the trees and surrounding urban soils. Maintaining the existing tree canopy and surrounding urban soils therefore helps maintain existing carbon sinks. Denser tree canopies reduce stormwater runoff and erosion of soils that store carbon dioxide. Trees also reduce the heat-island effect by providing shade, reducing *albedo* (i.e., the amount of solar radiation reflected back into the environment), and cooling air through evapotranspiration (evaporation of water from plants, which consumes heat). These effects typically reduce building energy use and, in turn, energy-related GHG emissions. Trees can also act as a wind barrier in winter, reducing heating energy and costs.[1] Finally, green spaces or any kind of vegetation can absorb pollutants from the air.[1] Shammin et al. (2012) determined that the vegetation of the average northern Midwest and Great Lakes City can absorb 1.8 grams of sulfur dioxide, 1.7 grams of nitrous dioxide, 3.9 grams of ozone, 6.0 grams of particulate matter 10, and 0.4 grams of carbon monoxide, per kg of plant biomass.

[3] H. Safford, E. Larry, E.G. McPherson, D.J. Nowak, and L.M. Westphal (August 2013). Urban Forests and Climate Change. U.S. Department of Agriculture, Forest Service, Climate Change Resource Center, https://www.fs.usda.gov/ccrc/topics/urban-forests-and-climate-change.

[4] For information on the US, see Nowak et al., 2006, and McPherson et al., 1994, and, for information on Europe see Bolund and Hunhammar, 1999.

Present Strategies

Oberlin's most recent comprehensive plan (2004; reaffirmed in the 2011 comprehensive plan update) included the following goals and strategies to incorporate sustainability in the planning process:

- Planning for interconnected streets;
- Planning for expanded walking and biking facilities;
- Promoting infill development and redevelopment of existing structures;
- Planning for preservation of natural areas, including waterways and habitat; and
- Planning for efficient infrastructure extension.

Green Space

The City has designated the Plum Creek Greenway to include parks and open space along Plum Creek. There is ongoing collaboration between the City administration, City Council, and City commissions to preserve and improve this greenway. The greenway project includes improving pedestrian and bicycle transportation, environmental education, green space and urban forest conservation, and erosion prevention components.

The Western Reserve Land Conservancy is working with the City and private property owners to preserve agricultural land and forested areas and to restore prairie habitat within the City.

The most recent comprehensive plan prioritizes preservation of green space, especially along Plum Creek, and the connection of Oberlin's open spaces for bicycle and pedestrian transport.

The City has a naturalized vegetation ordinance to allow native vegetation that can act as a more effective carbon sink than lawns and which does not require the intensive mowing which consumes fuel and generates more GHG emissions.

Urban Forestry

The Public Works Department maintains trees on public land and in public rights-of-way. The City hired an urban forestry intern in 2017 to inventory the current population of trees in the urban forest. The City also obtained a Black River Watershed Canopy Restoration Grant from the Ohio Department of Natural Resources to plant trees on public land and in the public right-of-way. The City had planted 105 new trees as of July 2017, with a total of up to 350 trees to be planted.

The open space and visual environment commission serves as the de facto tree commission, working with the department of public works to maintain Oberlin's designation as a Tree City USA from the Arbor Day Foundation, which the City has achieved for 19 years. This commission worked with City Council to expand the tree planting list for trees on public property and in the public right-of-way to include a wider range of native species. This increased focus on biodiversity is intended to maintain a healthy tree canopy that is resilient in a changing climate.

Questions Remaining for Metrics & Success

In addition to seeking public input and feedback on the potential strategies outlined above, obtaining answers to the following questions would provide important information about which strategies should be implemented.

- Which green spaces are most important to community members for recreational purposes? Transportation purposes? Are there ways in which these spaces are not serving the community as well as they could?
- What incentives or programs would encourage private property owners to preserve and increase the tree canopy on their property?

Additional data should be collected as baseline indicators and metrics for success:

- Extent and health of Oberlin's tree canopy.
- Ecological health of Oberlin's green space and evaluation of the extent to which each green space acts as a carbon sink or source.
- Use of trails and bikeways in green space for non-motorized transportation, and the resulting amount of reduction in motor vehicle use.

Local Food and Agriculture

Introduction

Local agriculture and food rescue are a vital part of the innovative vision for a post-fossil fuel community. Growing and processing food locally supports local farmers and small businesses and reduces our collective carbon footprint. Rescuing edible foods that would have added to landfill waste reduces methane in the atmosphere and provides nutritious meals to residents subject to food insecurity. The long-term goal is to work towards a more sustainable and more productive local food system that yields less waste.

The environmental effects of a local food economy are demonstrably positive when it comes to economic development, soil health, water quality, runoff, and public health. Urban agriculture sites can capture about four tons of CO_2/acre annually (Shammin et al., 2012). Urban farming reduces urban carbon footprints in a variety of ways:

- Reduced energy used by wastewater treatment plants due to avoided combined sewer overflow (CSO) volume;
- Reduced distance traveled by food from farm to plate; reduced transportation energy used by people in the community who are now able to walk to farms; and
- Reduced carbon emissions compared to food produced from large conventional farms using industrial agricultural practices.

BACKGROUND:

The City of Oberlin acknowledges the pressing issues related to food sourcing and food waste. As a community, Oberlin residents and organizations have committed to increasing the quantity of locally sourced food and to reducing the amount of food that is wasted.

Existing Conditions:

Currently the City does not collect or maintain data on local food sourcing, urban agriculture, or food rescue. However, private entities have attempted to quantify the amount of local food consumed in Oberlin. In 2012, the Oberlin Project estimated that 6-7% of produce consumed in Oberlin was grown within our “foodshed,” which comprises Lorain County and the six adjacent counties. While we have limited data on food rescue, the City of Oberlin operates its own waste collection system—which is unusual for a City this size—for effective and sustainable waste, recyclables, and yard waste collection.

Shammin et al. (2012) estimates that 0.74 tons of CO_2 emissions can be prevented per acre of urban agriculture due to reduced combined sewer overflow and associated wastewater treatment needs. While the other factors mentioned above are more difficult to quantify, it is important to recognize that the potential for significant additional reduction of greenhouse gas (GHG) emissions associated with local food production. Finally, a key aspect of building resilient communities is to develop more self-reliance with respect to critical resources, in order to foster shorter feedback loops so that the community can better adapt their practices in response to a changing climate. The environmental benefits of a strong local food economy are clearly consistent with the broad goals of this plan.

With food waste, calculations are much clearer. The US spends “$218 billion a year, or 1.3% of GDP, growing, processing, transporting and disposing of food that is never eaten.”[1] Specifically, wasted food consumes 21% of all freshwater, 19% of fertilizer, 18% of cropland, and 21% of landfill volume. Yard trimmings and food residuals together constitute 23% of the US municipal solid waste stream. Organic trash in the waste stream generates methane gas in landfills, and methane gas is 21 times more potent as a GHG than carbon dioxide. In turn, the reduction of methane gas production is key in the fight against GHG emissions. In addition, the production of fertilizer uses energy and fossil fuels. If we reduce the amount of food waste, we save water, reduce fossil fuel consumption, and reduce methane production in landfills. As a bonus, the land that is not needed for food production can be converted into areas for carbon sequestration.

Goals

As broad policy goals, the City commits to:

- Decreasing the percentage of edible food wasted;
- Increasing the percentage of food diverted from landfills through composting and rescue and donations efforts;
- Increasing the percentage of locally sourced food consumed in Oberlin;
- Increasing the percentage of land in Oberlin used for agriculture; and
- Conducting targeted research about how other cities have accomplished these goals and incentivized these activities.

[4] See the 2018 U.S. Food Waste Investment Report at https://www.refed.com/?sort=economic-value-per-ton

Accomplishments to Date

The City provides support for two significant local food and urban agriculture endeavors. Both the Oberlin Farmers Market and the Legion Field Community Garden are located on City property and supported by City administration.

In addition, the City has taken steps towards reducing waste and managing waste in a responsible and sustainable fashion. In 2013, the City completed a Zero Waste Plan, a major success solidifying the City's commitment to waste reduction. In 2016, the City of Oberlin introduced a composting incentivization program—offering full reimbursement to any private citizen who purchased a home composting bin for under $100.

Oberlin Food HUB

Private Accomplishments to Date:

Community members and organizations have made progress on waste and food sourcing. The College and Kendal collectively rescue between 200 and 300 pounds a week of leftover, edible prepared foods, freeze this product, and donate it to the Oberlin Community Services pantry and the Oberlin weekday community meals program. Oberlin Community Services is working to expand this initiative to rescue food from other entities. Lorain County Public Health sanitarians are available to address concerns about food rescue and how to safely donate extra food.

City Fresh (est. 2005) employs a community-supported agriculture model to support local farmers and deliver organic produce to the College, local restaurants, and "fresh stops" in Lorain and Cuyahoga counties. City Fresh operates at the George Jones Farm in Oberlin, pays its farmers $.81 of every shareholder dollar spent, and allows households on limited incomes to purchase shares at a reduced rate. Dozens of college students learn about sustainable agriculture and carbon sequestration on the farm every year, and efforts are underway to expand the quantity of college food waste composted at the farm.

The Oberlin Food Hub (est. 2016) serves as a central aggregation and distribution center, sourcing hyper-local agriculture products from small-to medium-sized farms in the Oberlin food shed, primarily comprised of Lorain, Cuyahoga, Ashland, Erie, Huron, Medina, and Wayne counties. The Oberlin Food Hub (OFH) provides wholesale customers access to hyper local produce from multiple farmers at a single location. The OFH is designed to strengthen the regional agricultural economy through buyer education, improve food access to all food consumers and reduce the carbon footprint of the northeast Ohio food supply chain through development of infrastructure to link producers with wholesale buyers, train food entrepreneurs, and create new markets for local foods including aesthetically imperfect but nutritionally sound produce "seconds."

Questions Remaining for Public Participation

The City acknowledges that public input and improved data collection in coming years will form the backbone of future strategies. Therefore, before formulating specific strategies, the City proposes that the following set of questions be posed to the public.

- What would it entail for Oberlin to become a zero-food-waste City?
- What are the barriers to eliminating food waste—for individual households, for restaurants, for stores, for farms?
- How can we make food waste part of a sustainable community cycle? Are there opportunities to create a closed-loop system?
- Is gleaning a viable mechanism for eliminating farm food waste? How can we organize gleaning services for farms on a City-wide scale?
- How can we assuage concerns about food donation-related liability?
- How can we incentivize composting on an individual level? What are the best metrics for success?
- For those who have backyard or kitchen space—if you knew how to compost on your own, and if the materials were provided to you, would you do it?
- For those who do not: would you compost if Oberlin provided a City-wide composting service?
- For restaurants/stores: would you donate all edible food waste if it were picked up on a regular basis by rescue groups? Would you compost your food waste if the City were to issue you a rebate based on weight of compost material?
- How can we encourage residents to value local food/growing their own food?
- How might we integrate food system education into the high school curriculum?
- What is the best way to spread information about sustainable food production? What resources for sustainable food production ought Oberlin to offer residents?
- Would you support City-organized workshops about food system matters, including planting, harvesting, building raised beds, seed saving, cooking, and canning?
- How can we source more food locally?
- How can we make local food more affordable?
- For restaurants, stores, schools: would you commit to buying a given amount of food locally if it was affordable? What percentage?
- Do we want to reserve a specific percentage of public land for agriculture? What percentage?
- How can we incentive the use of private land for agriculture?
- What are the barriers to individual/community gardening/farming?
- How do we incentivize and reward growing our own food on a community or individual scale?
- What would it look like for you to feel financially secure as a farmer/gardener?
- Would you start a home/personal garden if the City supported you with funding and materials?

In addition, data should be collected on the following indicators related to local food, local agriculture, and food waste:

- The number of existing community gardens;
- The percentage of individuals who garden
- Acreage of unused lands, public and private;
- Public lands with potential for agricultural use;
- Effective collective gardening and urban agriculture models employed in other semi-urban areas;
- Percentage of edible food wasted; and
- Percentage of wasted food that is composted on an institutional level, and, through survey data, on an individual level.

Resilience

Adaptation and Resilience

Natural disasters that affect vulnerable populations are occurring with increasing frequency and severity. During this plan update, we witnessed the most active month of any Atlantic hurricane season on record. September 2017 included Hurricane Irma (Category 5), Hurricane Maria (5), and Hurricane Jose (4). Local and national discussions about sustainability focus attention on the prevention of further climate change. However, in the face of climate disruption and extreme change resulting in multiple consequences, we recognize that adaptation needs to be more fully addressed.

The standard for adaptive strategies—behavioral, technological, and infrastructural changes—is resilience, which is the capacity of ecosystems, critical infrastructure, and the built environment to absorb varied changes without significant change in core functions. In the case of people and communities, resilience also means resisting, responding to, and recovering from shocks in ways that allow us to preserve our core values and livelihoods and, at the same time, make good use of the opportunity to make the types of changes that provide more security, equity, and happiness in the future. Creating resilient patterns of habitation that can absorb the expected variances of climate change and adaptive strategies for when resilience is overcome are concerns that are being addressed by the community through the Campus Community Resilience Task Force. The task force is also working to address adaptive approaches in the scenario our community would welcome refugees displaced from extreme climate events.

Resilience Framework

Some of the future explorations for building a more resilient community are interconnected among other sections of the CAP; and may include battery technology exploration, storm water utility, and a robust and coordinated readiness plan. The City and the College will continue in leadership roles as they strive to transform Oberlin into an even more sustainable and resilient community.

Campus Community Resilience Task Force

The Campus Community Resilience Task Force formed in 2016 to ensure alignment of the climate action plans with community goals, and to facilitate joint action regarding building a resilient campus and community. As a signatory institution to the Climate Leadership Resilience Commitment, the College supports such a joint campus-community task force by providing facilitation services to the task force and access to resilience planning tools. With its strong CAP, the City played a primary role in defining the task force focus and organization of the representative members. The following organizations hold seats on the task force: the City of Oberlin, Oberlin City School District, Oberlin Community Services, Mercy Allen Hospital, the industrial park, Kendal at Oberlin, the College, and the Oberlin faith community. The task force has one advisor, Ben Wisner, local Oberlin resident and professor at the Institute for Risk and Disaster Reduction at University College London, UK.

The task force defined resilience in the following way:

> *The capacity of our city, organizations, individuals, and systems to survive, adapt, transform, and thrive in the face of changing natural conditions and disaster. Building resiliency within our campus community is about being better prepared to withstand catastrophic events—both those triggered by natural hazards and triggered by technological failures—and able to bounce back more quickly and emerge stronger from stresses, that is, to bounce forward.*

According to *The Oxford Encyclopedia*, natural hazard governance chapter 38, by Ben Wisner,

> *Many government policies and practices influence disaster risk indirectly in areas such as housing, health, social assistance, economic development and even trade and foreign investment. However, two areas of government policy and practice bear directly on the management and possible outcomes of natural hazards, namely, mitigation and preparedness. Mitigation consists of actions taken to reduce possible losses and harm caused by a natural event or process impacting a vulnerable and exposed population and their assets. Preparedness concerns activities and decisions focused on achieving and maintaining readiness to respond to disruption, damage and injury produced by impacts of primary natural hazard events and possible cascading secondary events.*

At the core of the framework guiding national risk governance for countries and cities lie some of the most common and most effective programmatic forms of mitigation. Generally, these include:

- Government disaster relief strategies;
- Early-warning systems for floods, power outages, and biological outbreaks;
- Insurance;
- Structural mitigation, including hospital and school building codes; and
- Training and certifying of architects, engineers, contractors, and builders so that their work always meets current safety standards.

Conclusion

Creating a more sustainable community has been, and must continue to be, a community-wide effort involving the City of Oberlin, Oberlin College, residents, businesses, non-profits, the Oberlin public schools, religious leaders and congregations, and others. Good progress has been achieved with an "all hands on deck" approach towards meeting the goal of becoming a carbon-positive community by 2050.

As recent weather events in our nation and the world indicate, climate change is not just about warming. Climate change includes new wind patterns, changing rainfall levels and more potent storm systems, as well as heat waves, drought, wildfire and flooding. Climate affects nearly all aspects of our lives: the health of our City parks and surrounding agricultural land, the natural spaces for fish and wildlife, the prevalence of infectious diseases and pests that can thrive in our region, the quality of the air we breathe as affected by air pollution and allergens, as well as the quality of roads, homes and businesses. Carbon emissions from burning fossil fuels and land use changes — including deforestation — are the primary drivers for climate change today and likely into the future. Simply put, we are adding too much carbon to the atmosphere by burning fossil fuels like coal, natural gas and gasoline to heat and power our homes, businesses and industries, and to power our automobiles. The latest greenhouse gas inventory shows this to be true, even in Oberlin. According to the 2018 Intergovernmental Panel on Climate Change report, "Confidence is very high that the window of opportunity – the period when significant change can be made, for limiting climate change within tolerable boundaries – is rapidly narrowing."

The challenges ahead are many but the Oberlin community is on the path to a sustainable future. The City of Oberlin has created the Office of Sustainability and hired a Sustainability Coordinator whose primary job is to implement the Climate Action Plan (CAP). The 2019 CAP Update is the work of nearly two years and dozens of community members. This update covers a five-year period during which we will implement the strategies listed and work to track the results of our efforts. Both the City of Oberlin and Oberlin College, the community's largest stakeholder, have made commitments toward a transitioning to a carbon-free future. This 2019 Climate Action Plan Update is one more important step in that direction.

Appendix: Renewable Energy

Strategy	Lead Entity	Timeline	Benefits
AMPJV6: Bowling Green wind project	OMLPS	1999-2030	Owned asset, renewable
New York Power Authority (NYPA)	OMLPS	1999-2030	Low cost, baseload resource, renewable
Belleville Hydro Project	OMLPS	1999-2050	Owned asset, baseload resource, renewable
Customer-owned solar generation	Utility Customers	1999-Ongoing	Local assets, peaking resource, renewable
Sustainable reserve fund	OMLPS	2007-Ongoing	Provides funding for GHG reduction efforts
Ohio Renewable Energy Services, LLC; Erie County LFG	OMLPS	2010-2022	Contract capacity and ½ RECs, baseload resource, carbon-neutral
Iberdrola Renewables Blue Creek wind project	OMLPS	2012-2022	Contract capacity/RECs, renewable
Spear Point Solar One, LLC, the College solar field	Oberlin College	2012-2036	Customer-owned generation, peaking resource, renewable
Waste Management Renewable Energy, LLC; Mahoning & Geneva County LFG	OMLPS	2013-2027	Contract capacity/RECs, baseload resource, carbon-neutral
AMP hydro phase I: Cannelton, Smithland, and Willow Island	OMLPS	2013-2080	Owned asset, baseload resource, renewable
AMP hydro phase II: Meldahl and Green-up	OMLPS	2014-2080	Owned asset, baseload resource, renewable
Explore energy-storage technology	OMLPS	2018-2023	
Landfill generated distributed hot water	City & College	2020-2024	Reduces GHG from natural gas
Purchase additional RECs to offset market power purchases	OMLPS	2019-Ongoing	Keep electric costs low while reducing our carbon footprint
Join EcoSmart Choice to provide opportunities for electric customers to purchase RECs to offset their GHG emissions and research possibilities to offset natural gas through EcoSmart as well	OMLPS – AMP	2019	More GHG mitigation options for residents and businesses
Install municipally owned solar	OMLPS	2019-2024	Reduced GHG
Incentivize the replacement of gasoline and diesel fuel	City	2019-Ongoing	Educate residents
Municipal renewable energy educational facility	City	2020	Reduced use of fossil fuels
Add additional renewable energy sources to portfolio	OMLPS	2019-Ongoing	

Appendix: Energy: Use, Conservation and Efficiency

Strategy	Lead Entity	Timeline	Benefits
Building performance audits and disclosures for residential and commercial properties	City	2020	Commercial and residential buyers will be able to make informed decisions
Municipal buildings: fuel switching.	City	2019-Ongoing	All municipal facilities will be supplied by 100% carbon-neutral energy by 2025 when economically feasible
Water heater replacement program: fuel switching	City	2020	Under the sustainable reserve fund, the City will establish a water heater replacement program for OMLPS customers
HVAC upgrades incentive program	City	2020	Under the sustainable reserve fund, the City will establish incentives to encourage and assist with the installation/replacement of space heating and cooling units
Update OMLPS authorization: Oberlin codified Ordinances Chapter 913	City Council	2019	Clarify that energy conservation is part of the mandate of OMLPS
Aggregate natural gas supply and carbon fee	City	2019-Ongoing	More research required but it has the potential to reduce gas rates.

Appendix: Transportation

Strategy	Lead Entity	Timeline	Benefits
Increase cycling and walking	City and College	2019–Ongoing	Zero-carbon transportation and health benefits of exercise
Increase car sharing and ridesharing	City and College	2019–Ongoing	Carbon reduction from fewer trips
Enhance public transportation	City	2019–Ongoing	Reduce the need for private motor vehicles
Increase use of low carbon vehicles and practices	City	2019–Ongoing	Reduce the need for private motor vehicles
Improve and enhance green fleets	City	2019–Ongoing	Carbon reduction
Expand EV charging station infrastructure.	OMLPS	2019–Ongoing	Support more EV purchases
Evaluate alternative fuel options for fleet vehicles and equipment. In addition to EVs, potential options include compressed natural gas (CNG); liquid natural gas (LNG); propane and biofuels.	City	2019–Ongoing	Carbon reduction
Develop eco-driving training including enforcement of the City's (internal) anti-idling policy	City	2019–Ongoing	Carbon reduction
Develop efficient fleet standards	City	2019–Ongoing	Reductions of energy use for City fleet
Subsidize fuel switching: encourage hybrid and EV rentals	City	2019–Ongoing	Increased number of hybrids and EVs purchased

Appendix: High-Performance Buildings

Strategy	Lead Entity	Timeline	Benefits
City Green Building Policy	City	2007-ongoing	New construction/major renovations LEED Silver or equivalent
Collaborate with POWER to implement energy conservation projects in homes and businesses	City and POWER	2018–ongoing	Energy conservation projects become more accessible to home and business owners.
Facilitate the development of City-owned vacant properties in a sustainable manner	City	2018–ongoing	Development of affordable and sustainable neighborhoods.
Develop commercial and residential building performance certification programs	City	2018–ongoing	Establish certification for homes and businesses that achieve between 10% and 30% energy reductions. Recognition for achievement could encourage more participation.
Establish procedures and policies that encourage green building	City	2018–ongoing	The development of such policies could make building high-performance buildings more desirable than standard building practices.
Establish procedures and policies that incentivize performance improvements for existing buildings	City	2018–ongoing	Reduction of utility expenses and improved indoor air quality for residents.
Lifecycle savings policy	City	2018–ongoing	Long term savings over conventional building and equipment practices.

Appendix: Waste Management

Strategy	Lead Entity	Timeline	Benefits
Implement fully-automated cart collection system for refuse and recycling	City	Complete; Ongoing Nov 2014	Ease of use increases participation
Develop/implement OC waste management recommendations	City	Ongoing	Numerous internal and municipal programs in place to increase diversion
Waste audits	City, Republic Waste	2019–Ongoing	Necessary information to identify diversion/recovery opportunities
Data tracking and management	City	Ongoing	Provides necessary information to manage and enhance programming
Special wastes, electronics and HHW	City	Ongoing	Through Lorain County Solid Waste Management District Collection Center
Reuse and source reduction programs	City	2019–ongoing	Less energy expended in materials overall
Yard waste management	City	Complete/Ongoing	All yard waste diverted from landfill
Multi-family residential recycling	City	Ongoing	Increased opportunity to participate
Food waste recovery/composting pilot program	City, Private Business	Ongoing	Kendal and the College; diverts food waste from landfill
Business plan for full scale implementation of food waste recovery program	City, Schools, Non-Profits	2019–Ongoing	Food waste reduction
Implementation of food waste recovery	City, Schools, Non-Profits	2019–Ongoing	Food waste reduction
Construction and demolition materials recovery	City	2019–Ongoing	Material reuse
Municipal procurement policy	City	2019–Ongoing	Green purchasing
The development of regional facilities necessary to assist in recovery	City	2019–Ongoing	Regional promotion of materials recovery
Regulatory and financial incentives	City	2019–Ongoing	increased reuse of materials
Zero Waste Plan update	City	2019–Ongoing	Plan reflects current environment
Anaerobic digestion	City	Ongoing	Approved wastewater treatment process. Recaptured methane is used to heat the digester off-setting the purchase of natural gas.
Land application of class b bio-solids	City	Ongoing	Beneficial re-use of bio-solids in local (non-human) crop production.

Appendix: Water Management

Strategies in Water Use and Conservation

Strategy	Lead Entity	Timeline	Benefits
Reduce water use at City facilities through a variety of water conservation measures including physical changes, education, and incentives.	City	2019–Ongoing	Water conservation
Improve water efficiency through assessments and upgrades in City facilities. Require high efficiency sinks, toilets, showerheads, and other equipment in all City buildings when building new or when needing replacement.	City	2019–Ongoing	Water conservation
Install variable frequency drives (VFDs) on the high service pumps at the water treatment plant. Evaluate the cost/benefit of adding VFDs to other pumping equipment.	City	2019–Ongoing	Energy reduction
Continue to perform analysis of distribution system leaks.	City	2019–Ongoing	Water conservation
Explore offering rebates for US EPA WaterSense-labeled products to residential and commercial customers.	City	2019–Ongoing	Water conservation and cost savings
Explore the creation of a formal program to conduct water leak detection audits for residential and commercial customers.	City	2019–Ongoing	Water conservation and cost savings

Reducing Inflow and Infiltration to the Sanitary Sewer Collection System

Strategy	Lead Entity	Timeline	Benefits
Continue to identify and eliminate inflow and infiltration through inspection, maintenance, repair and replacement of sanitary sewer mains and laterals.	OMLPS	2019–ongoing	Water quality
Increase residential and commercial rainwater capture and reuse.	City	2019–ongoing	Energy use reduction and water conservation
Incorporate green infrastructure in business expansion projects to capture stormwater.	City	2019–ongoing	Energy use reduction
Install stormwater control measures on all feasible development projects.	City	2019–ongoing	Energy use reduction
Expand green roof opportunities/installations.	City	2019–ongoing	Energy use reduction
Increase residential and commercial rainwater capture and reuse.	City	2019–ongoing	Energy use reduction and water conservation

Appendix: Education and Outreach

Strategies in Education and Outreach

Strategy	Lead Entity	Timeline	Benefits
Create a Climate Action Committee (CAC)	City of Oberlin	1st Quarter 2019	An advisory group will provide support and feedback on goals and efforts
Provide regular CAP training for City employees and include their participation in annual evaluations	City of Oberlin	Scheduled annually (or more often)	City employees will have knowledge skills they need to further goals of CAP
Research, develop and enforce appropriate internal policies impacting City buildings/staff. The possibilities include: energy policy, green purchasing policy for vehicles and equipment, printing policy, green meeting policy, local purchasing policy, etc.	City of Oberlin and Climate Action Committee	2019–Ongoing	Will ensure City staff is in compliance with CAP goals; sets a model for the community
Develop education and enforcement plans for policies covered by this CAP (e.g. anti-idling)	City of Oberlin	2019–Ongoing	Provides relevant stakeholders with necessary information; makes compliance more likely
Create mechanisms of accountability for City employees tasked with implementing portions of the CAP	City of Oberlin	2019–Ongoing	Makes compliance more likely
Dashboard: Research how to monitor all City buildings so occupants and building managers can make more informed decisions about resource use	City of Oberlin and The Environmental Dashboard Group	2019	Improves decision making, saves resources

Strategies for Public Participation and Education

Strategy	Lead Entity	Timeline	Benefits
Encourage community organizations and households to create their own climate action plans.	Sustainability Coordinator, CAC, POWER, Oberlin College students, et al.	2019–Ongoing	Increases community participation, encourages citizens to contribute to overall greenhouse gas emissions
Continue shop local campaign efforts—promote buying local, farmers markets, etc.	Sustainability Coordinator and outside organizations—e.g., Oberlin Business Partnership	2019–Ongoing	Boosts local economy, reduces carbon emissions from driving to stores outside the community
Each responsible group for CAP goal to share progress with CAC on a scheduled timeline	City of Oberlin	2019–Ongoing	Improves communication and transparency; provides mechanisms for accountability and feedback
Update City website to include trackable goals related to CAP	City of Oberlin, Sustainability Coordinator	2019–Ongoing	Provides transparency and accountability
Design and hold community workshops—"e.g., develop your own climate action plan"—to encourage individual participation in positive climate action activities	Sustainability Coordinator	2019–Ongoing	Increases community participation, encourages citizens to contribute to overall greenhouse gas emissions
With local realtors, design a "welcome package" for new homeowners and business owners with information on the CAP	POWER, Sustainability Coordinator, local realtors	2019–Ongoing	Increases community participation, encourages citizens to contribute to overall greenhouse gas emissions, saves money
Revise the City's sustainable reserve program website	City of Oberlin and the Climate Action Committee	2019–Ongoing	Increases transparency and community engagement. Maximizes the chance that high-quality projects will be proposed
Expand environmental dashboard content to highlight CAP strategies, educational opportunities, and incentive programs	Environmental Studies group at Oberlin College; City representative; CAC	2019–Ongoing	Increases community awareness about CAP goals and programs.
Support POWER's efforts to raise awareness of residential energy opportunities and encourage participation in the programs offered	POWER and Climate Action Committee	2019–Ongoing	Increases community engagement, reduces energy waste, saves homeowners money, boosts the local economy
Create community and business awards to encourage participation in climate action activities	Sustainability Coordinator, outside organizations	2019–Ongoing	Increases community engagement and buy-in, highlights those who can serve as role models for others
In concert with Oberlin City schools, identify knowledge, skills, and attitudes that correspond with carbon-neutral goals, and integrate into K-12 curriculum	Sustainability Coordinator, Oberlin City School District	2019–Ongoing	Focuses environmental education efforts on most important elements, provides Oberlin youth with important skills

Appendix: Land-Use Planning

Strategy	Lead Entity	Timeline	Benefits
Incorporate smart-growth principles and Paris Agreement climate change planning guidance in comprehensive plan update	City of Oberlin Planning Department	2019	Carbon reduction guidelines of Paris agreement utilized
Preserve additional undeveloped open space in and around Oberlin, prioritizing forested open space and restoration of native vegetation	City	2019-Ongoing	Carbon sequestration
Improve existing trails and add new trails	City Council, Staff, and Commissions	2019–Ongoing	Reduction in motor vehicle use and GHG emissions. Increased community resilience (positive economic development and quality of life outcomes).
Promotion and education about the existing naturalized vegetation ordinance and consideration revision of the ordinance	City of Oberlin, Western Reserve Land Conservancy	2018–2020	Increased carbon sequestration. Increased biodiversity (important for resilience and climate change adaptation)
Addition of a new City park in west Oberlin near the western end of College Street	City Council, Staff, and Commissions	2018–2025	Reduced motor vehicle use, creation of a carbon sink, increased community resilience
Create an urban forestry ordinance with specific goals to protect healthy and significant trees and ensure planting of new trees	City Council, Staff, and Commissions	2018–2019	Increased health and biodiversity (resilience) of urban forest.
Develop and implement an urban forest management plan, focusing on public land and right of ways and incentives for private landowners	City Staff and Commissions	2018–2021	Increased health and biodiversity (resilience) of urban forest. Increased carbon sequestration, reduction in energy use and GHG emissions through decreased urban "heat island" effect.
Create a program to advise and educate private property owners about tree planting and care	City Staff, Commissions, Arborists	2018–2020	Increased health and biodiversity (resilience) of urban forest. Increased carbon sequestration, reduction in energy use and GHG emissions through decreased urban "heat island" effect.
Incorporate credits or incentives for preservation and planting of trees, or other native vegetation, or both, in the stormwater utility program	City Council, Staff, and Commissions	2018–2019	Reduction of stormwater runoff, water treatment energy use, heating/cooling energy use and GHG emissions; carbon sequestration.

Appendix: Local Food and Agriculture

Strategy	Lead Entity	Timeline	Benefits
Update the Zero Waste Plan to include food rescue and revise the community composting section	City Council, Staff, and Appropriate City Commissions	2019	Organic waste diverted from landfill; amount of methane gas produced by landfill reduced; food insecurity of community residents reduced; reduction in GHG emissions related to decreased need for food production because of rescued food.
Provide for public compost pick-up and develop a local composting facility to produce a marketable product	City Council, Staff, and Either the Rust Belt Riders, the County Solid Waste District or Both	2019–2020	Reduced amount of waste going to landfill; fertilizer/compost available for local biomass production and carbon sequestration.
Support food rescue and donation by launching an educational campaign about the Bill Emerson Good Samaritan Act, by funding rescue efforts via food waste collectors	City Council, Staff, and Appropriate City Commissions	2019	Organic waste diverted from landfill; amount of methane gas produced by landfill reduced; food insecurity of community residents reduced; reduction in GHG emissions related to decreased need for food production because of rescued food.
Food waste from the College could once again be composted and used as fertilizer	College and City and private business partnership	2019–Ongoing	Organic waste diverted from landfill
Local food use as an indicator in determinations about green restaurant certifications	City and Lorain County Public Health could partner to offer "green" restaurant certifications to promote local food	2019–2020	Increased use of local food by local restaurants; reduced GHG emissions due to reduction in food transportation costs.
Expand support for local farmers markets	City could partner with organizations involved with local farmers markets to increase local food availability	2019–2020	More local food purchased by the community; increased revenue for local food producers.
Reduce barriers related to the availability and cost of local food	City could form a local task force of local food stakeholders to develop solutions to reducing the cost and increasing the availability of local food to all citizens in Oberlin	2019–2020	More local food purchased and consumed by the community; reduction in food insecurity for local residents; possible increased public health as more local produce is consumed by the community.
Establish a strong farm-to-school program to increase local food and nutrition education in school meals	Oberlin City Schools, local food producers	2018–2020	Increase in amount of local food consumed by school children; increased awareness in school children of local food and nutrition; possible increase in health of local children
Adopt an urban agriculture policy through changes to the zoning code	City Planning Director	June 2019	Increased opportunities in the City for local food production; elimination of barriers to urban agriculture.
Increase the number of private individual and collective gardens	Sustainability Coordinator	2019–Ongoing	Increased number of local gardens; increased local food production; reduced GHG emissions due to local food production and increased carbon sequestration in local biomass; greater awareness about gardening.
Establish guidelines about the percentage of public land used for agriculture	City Council and Staff could research this issue and, with public input, develop these guidelines	2019–2023	Public land available for local food production; increased community resilience around food production.
Update the Zero Waste Plan to include food rescue and revise the community composting section	City Council, Staff, and Appropriate City Commissions	2019	Organic waste diverted from landfill; amount of methane gas produced by landfill reduced; food insecurity of community residents reduced; reduction in GHG emissions related to decreased need for food production because of rescued food.

Appendix: Resilience

Strategy	Lead Entity	Timeline	Benefits
Reconvene task force meetings	City manager	2019–Ongoing	Representation and input from all the major entities in the community
Incorporation of resilience into policy-level planning process and documents	Task force	2019–Ongoing	Social equality and governance
Community communication system created	Task force	2019–Ongoing	More community resilience via emergency preparedness trainings, workshops, or both
Build agreements to share assets	Task force	2019–Ongoing	Build agreements among organizations within the community populations to access facilities and/or assets in the event of major climate disruption and displacement (e.g., Splash Zone has an agreement to act as a refugee site in the case of large population relocation)

Appendix: Trajectories of the Earth System in the Anthropocene

Original article and references: https://www.pnas.org/content/115/33/8252

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We explore the risk that self-reinforcing feedbacks could push the Earth System toward a planetary threshold that, if crossed, could prevent stabilization of the climate at intermediate temperature rises and cause continued warming on a "Hothouse Earth" pathway even as human emissions are reduced. Crossing the threshold would lead to a much higher global average temperature than any interglacial in the past 1.2 million years and to sea levels significantly higher than at any time in the Holocene. We examine the evidence that such a threshold might exist and where it might be. If the threshold is crossed, the resulting trajectory would likely cause serious disruptions to ecosystems, society, and economies. Collective human action is required to steer the Earth System away from a potential threshold and stabilize it in a habitable interglacial-like state. Such action entails stewardship of the entire Earth System—biosphere, climate, and societies—and could include decarbonization of the global economy, enhancement of biosphere carbon sinks, behavioral changes, technological innovations, new governance arrangements, and transformed social values.

The Anthropocene is a proposed new geological epoch based on the observation that human impacts on essential planetary processes have become so profound that they have driven the Earth out of the Holocene epoch in which agriculture, sedentary communities, and eventually, socially and technologically complex human societies developed. The formalization of the Anthropocene as a new geological epoch is being considered by the stratigraphic community, but regardless of the outcome of that process, it is becoming apparent that Anthropocene conditions transgress Holocene conditions in several respects. The knowledge that human activity now rivals geological forces in influencing the trajectory of the Earth System has important implications for both Earth System science and societal decision making. While have contributed differently and unequally to pressures on the Earth System and will have varied capabilities to alter future trajectories (4), the sum total of human impacts on the system needs to be taken into account for analyzing future trajectories of the Earth System.

Here, we explore potential future trajectories of the Earth System by addressing the following questions.

> Is there a planetary threshold in the trajectory of the Earth System that, if crossed, could prevent stabilization in a range of intermediate temperature rises?
>
> Given our understanding of geophysical and biosphere feedbacks intrinsic to the Earth System, where might such a threshold be?
>
> If a threshold is crossed, what are the implications, especially for the wellbeing of human societies?
>
> What human actions could create a pathway that would steer the Earth System away from the potential threshold and toward the maintenance of interglacial-like conditions?

Addressing these questions requires a deep integration of knowledge from biogeophysical Earth System science with that from the social sciences and humanities on the development and functioning of human societies (5). Integrating the requisite knowledge can be difficult, especially in light of the formidable range of timescales involved. Increasingly, concepts from complex systems analysis provide a framework that unites the diverse fields of inquiry relevant to the Anthropocene (6). Earth System dynamics can be described, studied, and understood in terms of trajectories between alternate states separated by thresholds that are controlled by nonlinear processes, interactions, and feedbacks. Based on this framework, we argue that social and technological trends and decisions occurring over the next decade or two could significantly influence the trajectory of the Earth System for tens to hundreds of thousands of years and potentially lead to conditions that resemble planetary states that were last seen several millions of years ago, conditions that would be inhospitable to current human societies and to many other contemporary species.

Risk of a Hothouse Earth Pathway

Limit Cycles and Planetary Thresholds. The trajectory of the Earth System through the Late Quaternary, particularly the Holocene, provides the context for exploring the human-driven changes of the Anthropocene and the future trajectories of the system. Fig. 1 shows a simplified representation of complex Earth System dynamics, where the physical climate system is subjected to the effects of slow changes in Earth's orbit and inclination. Over the Late Quaternary (past 1.2 million years), the system has remained bounded between glacial and interglacial extremes. Not every glacial–interglacial cycle of the past million years follows precisely the same trajectory (7), but the cycles follow the same overall pathway (a term that we use to refer to a family of broadly similar trajectories). The full glacial and interglacial states and the ca. 100,000-years oscillations between them in the Late Quaternary loosely constitute limit cycles (technically, the asymptotic dynamics of ice ages are best modeled as pullback attractors in a nonautonomous dynamical system). This limit cycle is shown in a schematic fashion in blue in Fig. 1, Lower Left using temperature and sea level as the axes. The Holocene is represented by the top of the limit cycle loop near the label A.

The current position of the Earth System in the Anthropocene is shown in Fig. 1, Upper Right by the small ball on the pathway that leads away from the glacial–interglacial limit cycle. In Fig. 2, a stability landscape, the current position of the Earth System is represented by the globe at the end of the solid arrow in the deepening Anthropocene basin of attraction.

The Anthropocene represents the beginning of a very rapid human-driven trajectory of the Earth System away from the glacial–interglacial limit cycle toward new, hotter climatic conditions and a profoundly different biosphere. The current position, at over 1 °C above a preindustrial baseline (10), is nearing the upper envelope of interglacial conditions over the past 1.2 million years. More importantly, the rapid trajectory of the climate system over the past half century along with technological lock in and socioeconomic inertia in human systems commit the climate system to conditions beyond the envelope of past interglacial conditions. We, therefore, suggest that the Earth System may already have passed one "fork in the road" of potential pathways, a bifurcation (near A in Fig. 1) taking the Earth System out of the next glaciation cycle.

In the future, the Earth System could potentially follow many trajectories (12, 13), often represented by the large range of global temperature rises simulated by climate models (14). In most analyses, these trajectories are largely driven by the amount of greenhouse gases that human activities have already emitted and will continue to emit into the atmosphere over the rest of this century and beyond—with a presumed quasilinear relationship between cumulative carbon dioxide emissions and global temperature rise (14). However, here we suggest that biogeophysical feedback processes within the Earth System coupled with direct human degradation of the biosphere may play a more important role than normally assumed, limiting the range of potential future trajectories and potentially eliminating the possibility of the intermediate trajectories. We argue that there is a significant risk that these internal dynamics, especially strong nonlinearities in feedback processes, could become an important or perhaps, even dominant factor in steering the trajectory that the Earth System actually follows over coming centuries.

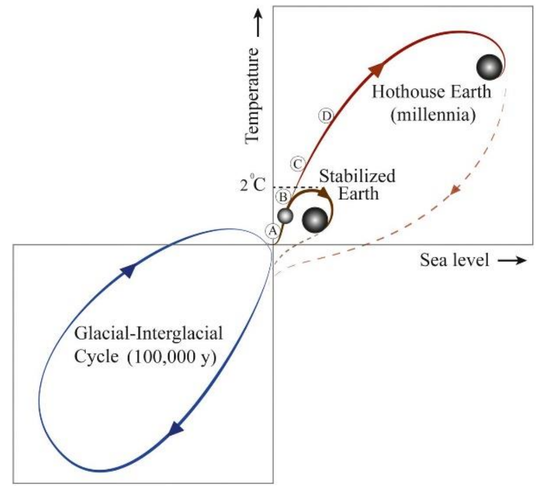

Figure 1: A schematic illustration of possible future pathways of the climate against the background of the typical glacial–interglacial cycles (Lower Left). The interglacial state of the Earth System is at the top of the glacial–interglacial cycle, while the glacial state is at the bottom. Sea level follows temperature change relatively slowly through thermal expansion and the melting of glaciers and ice caps. The horizontal line in the middle of the figure represents the preindustrial temperature level, and the current position of the Earth System is shown by the small sphere on the red line close to the divergence between the Stabilized Earth and Hothouse Earth pathways. The proposed planetary threshold at ∼2 °C above the preindustrial level is also shown. The letters along the Stabilized Earth/Hothouse Earth pathways represent four time periods in Earth's recent past that may give insights into positions along these pathways: A, Mid-Holocene; B, Eemian; C, Mid-Pliocene; and D, Mid-Miocene. Their positions on the pathway are approximate only. Their temperature ranges relative to preindustrial are given in SI Appendix, Table S1.

This risk is represented in Figs. 1 and 2 by a planetary threshold (horizontal broken line in Fig. 1 on the Hothouse Earth pathway around 2°C above preindustrial temperature). Beyond this threshold, intrinsic biogeophysical feedbacks in the Earth System (Biogeophysical Feedbacks) could become the dominant processes controlling the system's trajectory. Precisely where a potential planetary threshold might be is uncertain. We suggest 2°C because of the risk that a 2°C warming could activate important tipping elements, raising the temperature further to activate other tipping elements in a domino-like cascade that could take the Earth System to even higher temperatures (Tipping Cascades). Such cascades comprise, in essence, the dynamical process that leads to thresholds in complex systems.

This analysis implies that, even if the Paris Accord target of a 1.5 °C to 2.0 °C rise in temperature is met, we cannot exclude the risk that a cascade of feedbacks could push the Earth System irreversibly onto a "Hothouse Earth" pathway. The

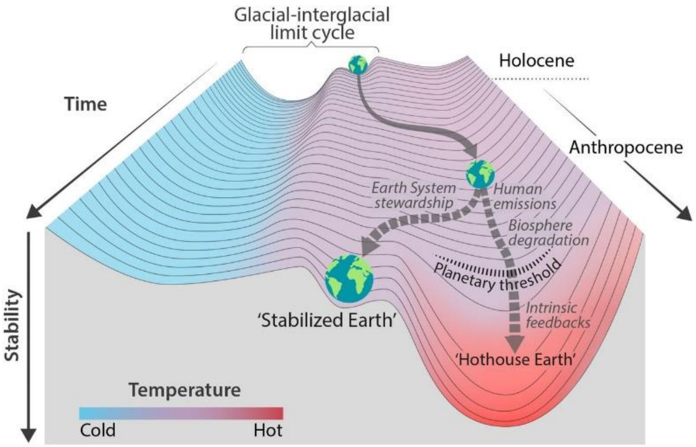

Figure 2: Stability landscape showing the pathway of the Earth System out of the Holocene and thus, out of the glacial–interglacial limit cycle to its present position in the hotter Anthropocene. The fork in the road in Fig. 1 is shown here as the two divergent pathways of the Earth System in the future (broken arrows). Currently, the Earth System is on a Hothouse Earth pathway driven by human emissions of greenhouse gases and biosphere degradation toward a planetary threshold at ∼2 °C (horizontal broken line at 2 °C in Fig. 1), beyond which the system follows an essentially irreversible pathway driven by intrinsic biogeophysical feedbacks. The other pathway leads to Stabilized Earth, a pathway of Earth System stewardship guided by human-created feedbacks to a quasistable, human-maintained basin of attraction. "Stability" (vertical axis) is defined here as the inverse of the potential energy of the system. Systems in a highly stable state (deep valley) have low potential energy, and considerable energy is required to move them out of this stable state. Systems in an unstable state (top of a hill) have high potential energy, and they require only a little additional energy to push them off the hill and down toward a valley of lower potential energy.

challenge that humanity faces is to create a "Stabilized Earth" pathway that steers the Earth System away from its current trajectory toward the threshold beyond which is Hothouse Earth (Fig. 2). The human created Stabilized Earth pathway leads to a basin of attraction that is not likely to exist in the Earth System's stability landscape without human stewardship to create and maintain it. Creating such a pathway and basin of attraction requires a fundamental change in the role of humans on the planet. This stewardship role requires deliberate and sustained action to become an integral, adaptive part of Earth System dynamics, creating feedbacks that keep the system on a Stabilized Earth pathway (Alternative Stabilized Earth Pathway).

We now explore this critical question in more detail by considering the relevant biogeophysical feedbacks (Biogeophysical Feedbacks) and the risk of tipping cascades (Tipping Cascades).

Biogeophysical Feedbacks. The trajectory of the Earth System is influenced by biogeophysical feedbacks within the system that can maintain it in a given state (negative feedbacks) and those that can amplify a perturbation and drive a transition to a different state (positive feedbacks). Some of the key negative feedbacks that could maintain the Earth System in Holocene-like conditions— notably, carbon uptake by land and ocean systems—are weakening relative to human forcing, increasing the risk that positive feedbacks could play an important role in determining the Earth System's trajectory. Table 1 summarizes carbon cycle feedbacks that could accelerate warming, while SI Appendix, Table S2 describes in detail a more complete set of biogeophysical feedbacks that can be triggered by forcing levels likely to be reached within the rest of the century.

Most of the feedbacks can show both continuous responses and tipping point behavior in which the feedback process becomes self-perpetuating after a critical threshold is crossed; subsystems exhibiting this behavior are often called "tipping elements". The type of behavior—continuous response or tipping point/abrupt change—can depend on the magnitude or the rate of forcing, or both. Many feedbacks will show some gradual change before the tipping point is reached.

A few of the changes associated with the feedbacks are reversible on short timeframes of 50–100 years (e.g., change in Arctic sea ice extent with a warming or cooling of the climate; Antarctic sea ice may be less reversible because of heat accumulation in the Southern Ocean), but most changes are largely irreversible on timeframes that matter to contemporary societies (e.g., loss of permafrost carbon). A few of the feedbacks do not have apparent thresholds (e.g., change in the land and ocean physiological carbon sinks, such as increasing carbon uptake due to the CO2 fertilization effect or decreasing uptake due to a decrease in rainfall). For some of the tipping elements, crossing the tipping point could trigger an abrupt, nonlinear response (e.g., conversion of large areas of the Amazon rainforest to a savanna or seasonally dry forest), while for others, crossing the tipping point would lead to a more gradual but self-perpetuating response (large-scale loss of permafrost). There could also be considerable lags after the crossing of a threshold, particularly for those tipping elements that involve the melting of large masses of ice. However, in some cases, ice loss can be very rapid when occurring as massive iceberg outbreaks (e.g., Heinrich Events).

For some feedback processes, the magnitude—and even the direction—depend on the rate of climate change. If the rate of climate change is small, the shift in biomes can track the change in temperature/moisture, and the biomes may shift gradually, potentially taking up carbon from the atmosphere as the climate warms and atmosphericCO_2 concentration increases. However, if the rate of climate change is too large or too fast, a tipping point can be crossed, and a rapid biome shift may occur via extensive disturbances (e.g., wildfires, insect attacks, droughts) that can abruptly remove an existing biome. In some terrestrial cases, such as widespread wildfires, there could be a pulse of carbon to the atmosphere, which if

Table 1.
Carbon cycle feedbacks in the Earth System that could accelerate global warming

Feedback	Strength of feedback by 2100,* °C	Refs. (*SI Appendix*, Table S2 has more details)
Permafrost thawing	0.09 (0.04–0.16)	20–23
Relative weakening of land and ocean physiological C sinks	0.25 (0.13–0.37)	24
Increased bacterial respiration in the ocean	0.02	25, 26
Amazon forest dieback	0.05 (0.03–0.11)	27
Boreal forest dieback	0.06 (0.02–0.10)	28
Total	0.47 (0.24–0.66)	

- The strength of the feedback is estimated at 2100 for an ~2 °C warming.
- * The additional temperature rise (degrees Celsius) by 2100 arising from the feedback.

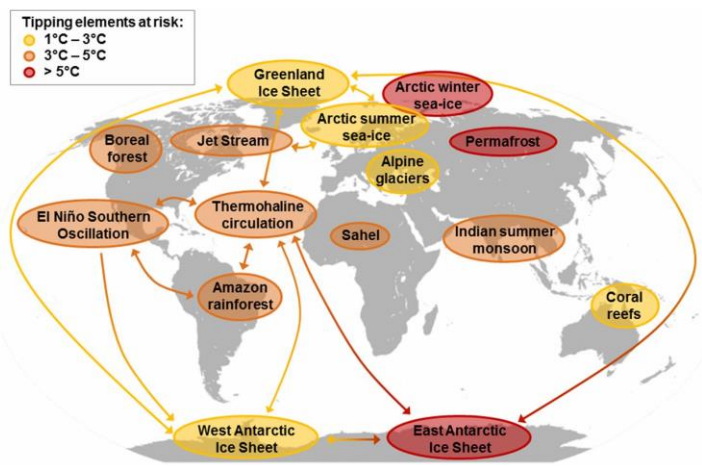

Figure 3: Global map of potential tipping cascades. The individual tipping elements are color- coded according to estimated thresholds in global average surface temperature (tipping points). Arrows show the potential interactions among the tipping elements based on expert elicitation that could generate cascades. Note that, although the risk for tipping (loss of) the East Antarctic Ice Sheet is proposed at >5 °C, some marine-based sectors in East Antarctica may be vulnerable at lower temperatures.

large enough, could influence the trajectory of the Earth System.

Varying response rates to a changing climate could lead to complex biosphere dynamics with implications for feedback processes. For example, delays in permafrost thawing would most likely delay the projected northward migration of boreal forests, while warming of the southern areas of these forests could result in their conversion to steppe grasslands of significantly lower carbon storage capacity. The overall result would be a positive feedback to the climate system.

The so-called "greening" of the planet, caused by enhanced plant growth due to increasing atmospheric CO2 concentration, has increased the land carbon sink in recent decades. However, increasing atmospheric CO2 raises temperature, and hotter leaves photosynthesize less well. Other feedbacks are also involved—for instance, warming the soil increases microbial respiration, releasing CO2 back into the atmosphere.

Our analysis focuses on the strength of the feedback between now and 2100. However, several of the feedbacks that show negligible or very small magnitude by 2100 could nevertheless be triggered well before then, and they could eventually generate significant feedback strength over longer timeframes—centuries and even millennia—and thus, influence the long-term trajectory of the Earth System. These feedback processes include permafrost thawing, decomposition of ocean methane hydrates, increased marine bacterial respiration, and loss of polar ice sheets accompanied by a rise in sea levels and potential amplification of temperature rise through changes in ocean circulation.

Tipping Cascades. Fig. 3 shows a global map of some potential tipping cascades. The tipping elements fall into three clusters based on their estimated threshold temperature. Cascades could be formed when a rise in global temperature reaches the level of the lower-temperature cluster, activating tipping elements, such as loss of the Greenland Ice Sheet or Arctic sea ice. These tipping elements, along with some of the non-tipping element feedbacks (e.g., gradual weakening of land and ocean physiological carbon sinks), could push the global average temperature even higher, inducing tipping in mid- and higher temperature clusters. For example, tipping (loss) of the

Greenland Ice Sheet could trigger a critical transition in the Atlantic Meridional Ocean Circulation (AMOC), which could together, by causing sea-level rise and Southern Ocean heat accumulation, accelerate ice loss from the East Antarctic Ice Sheet on timescales of centuries.

Observations of past behavior support an important contribution of changes in ocean circulation to such feedback cascades. During previous glaciations, the climate system flickered between two states that seem to reflect changes in convective activity in the Nordic seas and changes in the activity of the AMOC. These variations caused typical temperature response patterns called the “bipolar seesaw”. During extremely cold conditions in the north, heat accumulated in the Southern Ocean, and Antarctica warmed. Eventually, the heat made its way north and generated subsurface warming that may have been instrumental in destabilizing the edges of the Northern Hemisphere ice sheets.

If Greenland and the West Antarctic Ice Sheet melt in the future, the freshening and cooling of nearby surface waters will have significant effects on the ocean circulation. While the probability of significant circulation changes is difficult to quantify, climate model simulations suggest that freshwater inputs compatible with current rates of Greenland melting are sufficient to have measurable effects on ocean temperature and circulation. Sustained warming of the northern high latitudes as a result of this process could accelerate feedbacks or activate tipping elements in that region, such as permafrost degradation, loss of Arctic sea ice, and boreal forest dieback.

While this may seem to be an extreme scenario, it illustrates that a warming into the range of even the lower-temperature cluster (i.e., the Paris targets) could lead to tipping in the mid- and higher-temperature clusters via cascade effects. Based on this analysis of tipping cascades and taking a risk-averse approach, we suggest that a potential planetary threshold could occur at a temperature rise as low as ∼2.0 °C above preindustrial (Fig. 1).

Alternative Stabilized Earth Pathway

If the world’s societies want to avoid crossing a potential threshold that locks the Earth System into the Hothouse Earth pathway, then it is critical that they make deliberate decisions to avoid this risk and maintain the Earth System in Holocene-like conditions. This human-created pathway is represented in Figs. 1 and 2 by what we call Stabilized Earth (small loop at the bottom of Fig. 1, Upper Right), in which the Earth System is maintained in a state with a temperature rise no greater than 2 °C above preindustrial (a “super-Holocene” state). Stabilized Earth would require deep cuts in greenhouse gas emissions, protection and enhancement of biosphere carbon sinks, efforts to remove CO2 from the atmosphere, possibly solar radiation management, and adaptation to unavoidable impacts of the warming already occurring. The short broken red line beyond Stabilized Earth in Fig. 1, Upper Right represents a potential return to interglacial-like conditions in the longer term.

In essence, the Stabilized Earth pathway could be conceptualized as a regime of the Earth System in which humanity plays an active planetary stewardship role in maintaining a state intermediate between the glacial–interglacial limit cycle of the Late Quaternary and a Hothouse Earth (Fig. 2). We emphasize that Stabilized Earth is not an intrinsic state of the Earth System but rather, one in which humanity commits to a pathway of ongoing management of its relationship with the rest of the Earth System.

A critical issue is that, if a planetary threshold is crossed toward the Hothouse Earth pathway, accessing the Stabilized Earth pathway would become very difficult no matter what actions human societies might take. Beyond the threshold, positive (reinforcing) feedbacks within the Earth System—outside of human influence or control—could become the dominant driver of the system’s pathway, as individual tipping elements create linked cascades through time and with rising temperature (Fig. 3). In other words, after the Earth System is committed to the Hothouse Earth pathway, the alternative Stabilized Earth pathway would very likely become inaccessible as illustrated in Fig. 2.

What Is at Stake? Hothouse Earth is likely to be uncontrollable and dangerous to many, particularly if we transition into it in only a century or two, and it poses severe risks for health, economies, political stability (especially for the most climate vulnerable), and ultimately, the habitability of the planet for humans.

Insights into the risks posed by the rapid climatic changes emerging in the Anthropocene can be obtained not only from contemporary observations but also, from interactions in the past between human societies and regional and seasonal hydroclimate variability. This variability was often much more pronounced than global, longer-term Holocene variability (SI Appendix). Agricultural production and water supplies are especially vulnerable to changes in the hydroclimate, leading to hot/dry or cool/wet extremes. Societal declines, collapses, migrations/resettlements, reorganizations, and cultural changes were often associated with severe regional droughts and with the global mega-drought at 4.2–3.9 thousand years before present, all occurring within the relative stability of the narrow global Holocene temperature range of approximately ±1 °C.

SI Appendix, Table S4 summarizes biomes and regional biosphere–physical climate subsystems critical for human wellbeing and the resultant risks if the Earth System follows a Hothouse Earth pathway. While most of these biomes or regional systems may be retained in a Stabilized Earth pathway, most or all of them would likely be substantially changed or degraded in a Hothouse Earth pathway, with serious challenges for the viability of human societies.

For example, agricultural systems are particularly vulnerable, because they are spatially organized around the relatively stable Holocene patterns of terrestrial primary productivity, which depend on a well-established and predictable spatial distribution of temperature and precipitation in relation to the location of fertile soils as well as on a particular atmospheric CO_2 concentration. Current understanding suggests that, while a Stabilized Earth pathway could result in an approximate balance between increases and decreases in regional production as human systems adapt, a Hothouse Earth trajectory will likely exceed the limits of adaptation and result in a substantial overall decrease in agricultural production, increased prices, and even more disparity between wealthy and poor countries.

The world's coastal zones, especially low-lying deltas and the adjacent coastal seas and ecosystems, are particularly important for human wellbeing. These areas are home to much of the world's population, most of the emerging megacities, and a significant amount of infrastructure vital for both national economies and international trade. A Hothouse Earth trajectory would almost certainly flood deltaic environments, increase the risk of damage from coastal storms, and eliminate coral reefs (and all of the benefits that they provide for societies) by the end of this century or earlier.

Human Feedbacks in the Earth System. In the dominant climate change narrative, humans are an external force driving change to the Earth System in a largely linear, deterministic way; the higher the forcing in terms of anthropogenic greenhouse gas emissions, the higher the global average temperature. However, our analysis argues that human societies and our activities need to be recast as an integral, interacting component of a complex, adaptive Earth System. This framing puts the focus not only on human system dynamics that reduce greenhouse gas emissions but also, on those that create or enhance negative feedbacks that reduce the risk that the Earth System will cross a planetary threshold and lock into a Hothouse Earth pathway.

Humanity's challenge then is to influence the dynamical properties of the Earth System in such a way that the emerging unstable conditions in the zone between the Holocene and a very hot state become a de facto stable intermediate state (Stabilized Earth) (Fig. 2). This requires that humans take deliberate, integral, and adaptive steps to reduce dangerous impacts on the Earth System, effectively monitoring and changing behavior to form feedback loops that stabilize this intermediate state.

There is much uncertainty and debate about how this can be done—technically, ethically, equitably, and economically—and there is no doubt that the normative, policy, and institutional aspects are highly challenging. However, societies could take a wide range of actions that constitute negative feedbacks, summarized in SI Appendix, Table S5, to steer the Earth System toward Stabilized Earth. Some of these actions are already altering emission trajectories. The negative feedback actions fall into three broad categories: (i) reducing greenhouse gas emissions, (ii) enhancing or creating carbon sinks (e.g., protecting and enhancing biosphere carbon sinks and creating new types of sinks), and (iii) modifying Earth's energy balance (for example, via solar radiation management, although that particular feedback entails very large risks of destabilization or degradation of several key processes in the Earth System). While reducing emissions is a priority, much more could be done to reduce direct human pressures on critical biomes that contribute to the regulation of the state of the Earth System through carbon sinks and moisture feedbacks, such as the Amazon and boreal forests (Table 1), and to build much more effective stewardship of the marine and terrestrial biospheres in general.

The present dominant socioeconomic system, however, is based on high-carbon economic growth and exploitative resource use. Attempts to modify this system have met with some success locally but little success globally in reducing greenhouse gas emissions or building more effective stewardship of the biosphere. Incremental linear changes to the present socioeconomic system are not enough to stabilize the Earth System. Widespread, rapid, and fundamental transformations will likely be required to reduce the risk of crossing the threshold and locking in the Hothouse Earth pathway; these include changes in behavior, technology and innovation, governance, and values.

International efforts to reduce human impacts on the Earth System while improving wellbeing include the United Nations Sustainable Development Goals and the commitment in the Paris agreement to keep warming below 2°C. These international governance initiatives are matched by carbon reduction commitments by countries, cities, businesses, and individuals, but as yet, these are not enough to meet the Paris target. Enhanced ambition will need new collectively shared values, principles, and frameworks as well as education to support such changes. In essence, effective Earth System stewardship is an essential precondition for the prosperous development of human societies in a Stabilized Earth pathway.

In addition to institutional and social innovation at the global governance level, changes in demographics, consumption, behavior, attitudes, education, institutions, and socially embedded technologies are all important to maximize the chances of achieving a Stabilized Earth pathway. Many of the needed shifts may take decades to have a globally aggregated impact (SI Appendix, Table S5), but there are indications that society may be reaching some important societal tipping points. For example, there has been relatively rapid progress toward slowing or reversing population growth through declining fertility resulting from the empowerment of women, access to birth control technologies, expansion of educational opportunities, and rising income levels. These demographic changes must be complemented by sustainable per capita consumption patterns, especially among the higher per capita consumers. Some changes in consumer behavior have been observed, and opportunities for consequent major transitions in social norms over broad scales may arise. Technological innovation is contributing to more rapid decarbonization and the possibility for removing CO_2 from the atmosphere.

Ultimately, the transformations necessary to achieve the Stabilized Earth pathway require a fundamental reorientation and restructuring of national and international institutions toward more effective governance at the Earth System level, with a much stronger emphasis on planetary concerns in economic governance, global trade, investments and finance, and technological development.

Building Resilience in a Rapidly Changing Earth System. Even if a Stabilized Earth pathway is achieved, humanity will face a turbulent road of rapid and profound changes and uncertainties on route to it—politically, socially, and environmentally—that challenge the resilience of human societies. Stabilized Earth will likely be warmer than any other time over the last 800,000 years at least (that is, warmer than at any other time in which fully modern humans have existed).

In addition, the Stabilized Earth trajectory will almost surely be characterized by the activation of some tipping elements (Tipping Cascades and Fig. 3) and by nonlinear dynamics and abrupt shifts at the level of critical biomes that support humanity (SI Appendix, Table S4). Current rates of change of important features of the Earth System already match or exceed those of abrupt geophysical events in the past (SI Appendix). With these trends likely to continue for the next several decades at least, the contemporary way of guiding development founded on theories, tools, and beliefs of gradual or incremental change, with a focus on economy efficiency, will likely not be adequate to cope with this trajectory. Thus, in addition to adaptation, increasing resilience will become a key strategy for navigating the future.

Generic resilience-building strategies include developing insurance, buffers, redundancy, diversity, and other features of resilience that are critical for transforming human systems in the face of warming and possible surprise associated with tipping points. Features of such a strategy include (i) maintenance of diversity, modularity, and redundancy; (ii) management of connectivity, openness, slow variables, and feedbacks; (iii) understanding social–ecological systems as complex adaptive systems, especially at the level of the Earth System as a whole; (iv) encouraging learning and experimentation; and (v) broadening of participation and building of trust to promote polycentric governance systems.

Conclusions

Our systems approach, focusing on feedbacks, tipping points, and nonlinear dynamics, has addressed the four questions posed in the Introduction.

Our analysis suggests that the Earth System may be approaching a planetary threshold that could lock in a continuing rapid pathway toward much hotter conditions—Hothouse Earth. This pathway would be propelled by strong, intrinsic, biogeophysical feedbacks difficult to influence by human actions, a pathway that could not be reversed, steered, or substantially slowed.

Where such a threshold might be is uncertain, but it could be only decades ahead at a temperature rise of ∼2.0°C above preindustrial, and thus, it could be within the range of the Paris Accord temperature targets.

The impacts of a Hothouse Earth pathway on human societies would likely be massive, sometimes abrupt, and undoubtedly disruptive.

Avoiding this threshold by creating a Stabilized Earth pathway can only be achieved and maintained by a coordinated, deliberate effort by human societies to manage our relationship with the rest of the Earth System, recognizing that humanity is an integral, interacting component of the system. Humanity is now facing the need for critical decisions and actions that could influence our future for centuries, if not millennia.

How credible is this analysis? There is significant evidence from a number of sources that the risk of a planetary threshold and thus, the need to create a divergent pathway should be taken seriously:

First, the complex system behavior of the Earth System in the Late Quaternary is well-documented and understood. The two bounding states of the system—glacial and interglacial—are reasonably well-defined, the ca. 100,000-years periodicity of the limit cycle is established, and internal (carbon cycle and ice albedo feedbacks) and external (changes in insolation caused by changes in Earth's orbital parameters) driving processes are generally well known. Furthermore, we know with high confidence that the progressive disintegration of ice sheets and the transgression of other tipping elements are difficult to reverse after critical levels of warming are reached.

Second, insights from Earth's recent geological past (SI Appendix) suggest that conditions consistent with the Hothouse Earth pathway are accessible with levels of atmospheric CO_2 concentration and temperature rise either already realized or projected for this century (SI Appendix, Table S1).

Third, the tipping elements and feedback processes that operated over Quaternary glacial–interglacial cycles are the same as several of those proposed as critical for the future trajectory of the Earth System (Biogeophysical Feedbacks, Tipping Cascades, Fig. 3, Table 1, and SI Appendix, Table S2).

Fourth, contemporary observations (29, 38) (SI Appendix) of tipping element behavior at an observed temperature anomaly of about 1°C above preindustrial suggest that some of these elements are vulnerable to tipping within just a 1°C to 3°C increase in global temperature, with many more of them vulnerable at higher temperatures (Biogeophysical

Feedbacks and Tipping Cascades). This suggests that the risk of tipping cascades could be significant at a 2°C temperature rise and could increase sharply beyond that point. We argue that a planetary threshold in the Earth System could exist at a temperature rise as low as 2°C above preindustrial.

The Stabilized Earth trajectory requires deliberate management of humanity's relationship with the rest of the Earth System if the world is to avoid crossing a planetary threshold. We suggest that a deep transformation based on a fundamental reorientation of human values, equity, behavior, institutions, economies, and technologies is required. Even so, the pathway toward Stabilized Earth will involve considerable changes to the structure and functioning of the Earth System, suggesting that resilience-building strategies be given much higher priority than at present in decision making. Some signs are emerging that societies are initiating some of the necessary transformations. However, these transformations are still in initial stages, and the social/political tipping points that definitively move the current trajectory away from Hothouse Earth have not yet been crossed, while the door to the Stabilized Earth pathway may be rapidly closing.

Our initial analysis here needs to be underpinned by more in depth, quantitative Earth System analysis and modeling studies to address three critical questions. (i) Is humanity at risk for pushing the system across a planetary threshold and irreversibly down a Hothouse Earth pathway? (ii) What other pathways might be possible in the complex stability landscape of the Earth System, and what risks might they entail? (iii) What planetary stewardship strategies are required to maintain the Earth System in a manageable Stabilized Earth state?

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Abbreviations

AJLC – Adam Joseph Lewis Center for Environmental Studies

CAP - Climate Action Plan

CFL – Compact Fluorescent Light

CHIP – Community Housing Improvement Program

CNT - Center for Neighborhood Technology

CPDP – Climate Positive Development Program

EV – Electric Vehicle

GHG - Greenhouse Gas

HTG – Heat Trapping Gas

kW – Kilowatt

kWh – Kilowatt hour

LCCC - Lorain County Community College

LCJVS - Lorain County Joint Vocational School

LED – Light Emitting Diode

LEED – Leadership in Energy and Environmental Design

LGIF – Local Government Innovation Fund

NEOSCC – Northeast Ohio Sustainable Communities Consortium

NOACA – Northeast Ohio Areawide Coordinating Agency

OAQDA – Ohio Air Quality Development Authority

OC - Oberlin College

OCSD - Oberlin City School District

ODOT – Ohio Department of Transportation

OMLPS - Oberlin Municipal Light and Power System

POWER - Providing Oberlin with Efficiency Responsibly

PV – Photovoltaic

RCRC - Resource Conservation and Recovery Commission

REC – Renewable Energy Credit

STARS - Sustainability Tracking, Assessment and Rating System

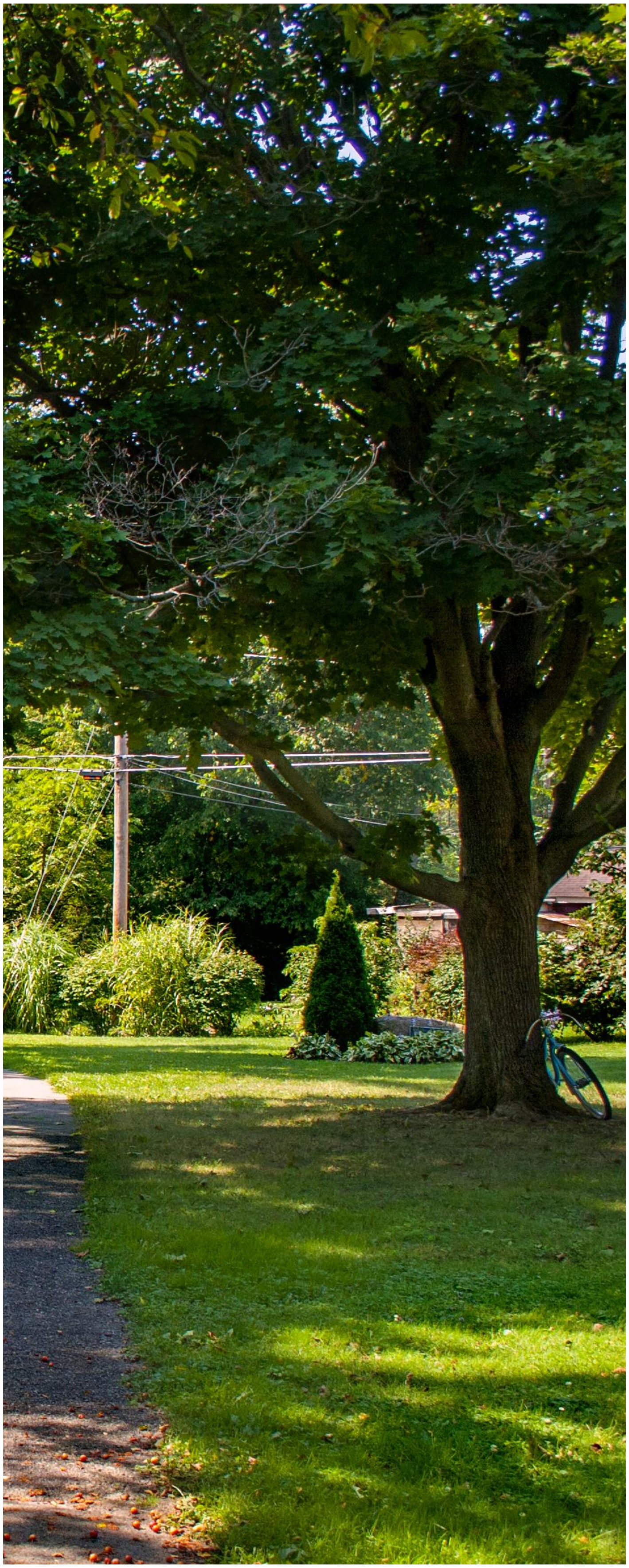
SVO – Straight Vegetable Oil

TLCI – Transportation for Livable Communities Initiative

USGBC – United States Green Building Council.

VMT – Vehicle Miles Traveled

VOC – Volatile Organic Compound



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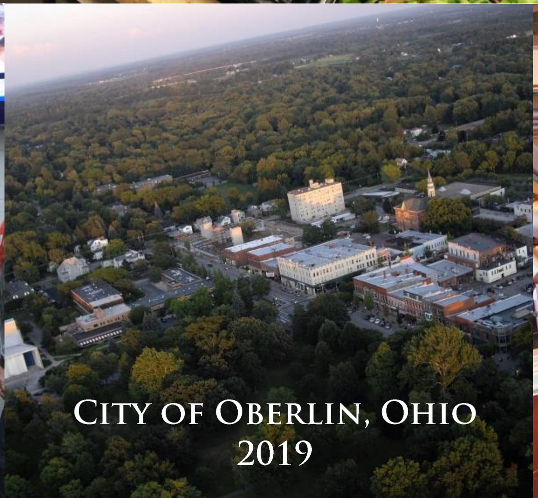

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