Item No. 2

Staff Report

AMES CLIMATE ACTION PLAN

April 18, 2023

BACKGROUND:

The City Council, City staff, and members of a citizen steering committee have been working with Sustainability Solutions Group (SSG) for the past two years to formulate the first ever Climate Action Plan for the Ames community. On December 21, 2021, the City Council voted for a “aspirational” Green House Gas reduction target of 83% by 2030 and net-zero by 2050 as compared to the community’s 2018 carbon emission total.

On April 5, 2022, SSG introduced the path forward to achieve the City Council’s carbon reduction target which included Six Big Moves. The Big Moves include:

1. Renewable Energy Generation
2. Building Retrofits
3. Net-Zero New Construction
4. Reduction In Vehicle Emissions
5. Increase In Active Transportation And Transit Use
6. Reduction IN Waste Emissions

PROPOSED CLIMATE ACTION PLAN:

The April 18, 2023 workshop, meeting will be the first time the City Council is able to review the full text of the proposed Climate Action Plan which is attached for your review (Attachment A). You will note two changes have been made to the information presented previously to the City Council.

1. The latest modeling indicates that the proposed action steps from the Big Moves could achieve a carbon reduction target of 71% by 2030 and 94% reduction by 2050, which is slightly less than the City Council original target.

2. The latest estimate for the magnitude of the expenditures that is needed for the actions steps to achieve the above target is $3.2 billion (previously estimated to be $2.4 billion), or an average of $120 million per year for the 27-year life of the Plan. It should be emphasized that the responsibility for investing in the Climate Action Plan does not rest solely with the Ames city government. Rather, under the proposed Plan, each resident, private business, non-profit entity, and other governmental organizations within the City of Ames will be required to commit to do their part in funding the recommended action steps needed to accomplish the carbon reduction target.

In order to mitigate the costs for implementing the Plan, SSG is suggesting there will be an average savings of $50 million in reduced fuel costs, $25 million in maintenance costs, and $26 million in federal incentives (a total of $702 million in federal grants/tax credits/etc.) in each of the next 27 years of the Plan. However, even if the magnitude of offsetting revenue is achieved, because the majority of the needed expenditures are front loaded, the suggested savings will not be realized until the later years of the Plan.

Included for the first time in the Plan on Table 6 (beginning on page 80) is a more detailed Implementation Strategy reflecting a total of 47 action steps for the Six Big Moves. In addition, beginning on page 123, the Plan introduces possible indicators to monitor and evaluate progress that is being made towards reaching the Council's carbon reduction target.

SUGGESTED FIRST YEAR WORK PLAN:

While SSG has recommended that almost all of the 47 actions steps be pursued within the next two years, Staff believes it will not be possible to accomplish all of these actions steps within that timeframe. Therefore, as suggested in the Plan, an Annual Work Plan should be developed by staff and approved by the City Council. **A possible first year plan was presented to the City Council at the November 15, 2022 workshop (Attachment B).** This initial implementation work plan was influenced by Table 6 (beginning on page 80 of the Plan) which reflects the total percentage of carbon reduced as well as the cost per ton of carbon reduced by each action step. **The Staff recommended initial work plan includes the following steps:**

1. **Increase Wind and Solar Generation As Part Of The Electric Services Portfolio.** This strategy reflects a low cost per ton of carbon removed and achieves the greatest percentage of carbon removed in comparison to all other action steps. It also requires minimal administrative burden on existing staff and involves a project in which Staff has previous experience.

2. **Waste To Energy Improvements/Reducing Waste Emissions.** City staff has been working with a consultant to develop alternatives to burn our refuse in a separate boiler thereby significantly reducing the amount of natural gas that is burned in our Power Plant.

   In addition, the City Council has directed staff to explore an Organized Garbage Collection system that would facilitate the collection of organic foods, yard waste, and recyclables as well as reducing the number of truck trips and associated emissions. An update on this effort will be provided at the May 16, 2023 Council Workshop.

3. **New Construction.** The City Council could consider 1) changing our Zoning Ordinance to include specific design features of a building that supports both being net-zero ready and passive building design, 2) requiring net-zero ready and passive design as part of annexation and contract rezoning, and/or 3) implementing a new tax

abatement program to incentivize new construction to be net-zero ready and reflect passive building design.

It should be noted that the City Assessor has indicated that retrofitting existing building with more energy efficient features does not add to the assessed value. Therefore, a new tax abatement program to promote retrofitting would be an ineffective incentive.

4. **Retrofitting Existing Buildings – Pilot Program.** This step involves implementing a pilot program to incentivize retrofitting by focusing on existing smaller older homes in the Ames Electric Services Territory. We would be able to learn a lot from this initial pilot program and at the same time focus on homes that are most likely the least energy efficient and owned by lower income residents. In this way the Council's values of sustainability and inclusion can be addressed.

5. **Retrofit Municipal Buildings.** A consultant will need to be hired to do a detailed study of each building with recommendations for implementation as well as a long-range capital improvements plan for these projects.

6. **Electrify the Municipal Fleet (Non-CyRide).** When available and capable of meeting the needs of the required work, City staff will purchase electric vehicles.

   This action step excludes CyRide. Given the excessive cost of electric buses, over $1 million per vehicle, the CyRide Board has committed to purchasing 17 of the 95 buses in the fleet by 2050 but is hesitant to commit to more at this time. In is noteworthy to point out that two new Battery Electric Buses were delivered to CyRide the week of April 10th.

7. **Create a Mayor's Climate Action Plan Leadership Task Force.** This task force, comprised of primarily community leaders from the various public and private entities that are crucial to meeting the City Council's caron reduction target, should come together to share their own climate action targets to help determine what we can expect to accomplish as a community by 2030 and 2050.

PUBLIC ENGAGEMENT:

In accordance with the City Council's commitment to emphasize a robust public engagement process for major policies under consideration, the following initiatives were undertaken.

- A Climate Action Plan website was created.
- Three public input surveys were placed on the City's website, along with paper copies being available at the Ames Public Library. When available, volunteers would staff a table at the Ames Public Library to assist people who wanted to

take the survey. Each survey received hundreds of responses. The surveys focused on goal setting, the Six Big Moves, and CAP barriers to implementation.

- Six public meetings with the Supplemental Input Committee (a 27-member team appointed by the Mayor to represent different sectors of the community) were held.
- Five public workshops with the Ames City Council held.
- An in-person Town Hall Meeting and a virtual ISU Student Town Hall meeting were held.
- Questions were added to the 2022 and 2023 Resident Satisfaction Survey related to Climate Action issues.
- The project team members have responded to dozens of requests for speakers representing hundreds of residents. The team continues to provide updates and information whenever asked to present, as well as providing CAP information when representing the City of Ames at events.

NEXT STEPS:

At the April 18th Workshop, the City Council will have the opportunity to discuss the Climate Action Plan document and provide feedback to its contents, but no action will be sought at this meeting. Following the Workshop, the document will be made available publicly for feedback through May 10th. At a regular City Council meeting in late May or early June, SSG will share any feedback received and the City Council will be asked to adopt the final Climate Action Plan.

ATTACHMENT A

Every Ton Matters:

The Path to Net Zero Emissions

City of Ames Climate Action Plan

SSG

CITY OF Ames™

Disclaimer

This analysis has been undertaken to quantify energy and emissions for the City of Ames' Climate Action Plan. Reasonable skill, care, and diligence have been exercised to assess the information provided for this analysis, but no guarantees or warranties are made regarding the accuracy or completeness of this information. This document, the information it contains, the information and basis on which it relies, and factors associated with the implementation of the Climate Action Plan are subject to changes that are beyond the control of the authors. The information provided by others is believed to be accurate, but has not been verified.

This analysis includes high-level estimates of costs that should not be relied upon for design or other purposes without verification. The authors do not accept responsibility for the use of this analysis for any purpose other than that stated above and do not accept responsibility for any third-party use, in whole or in part, of the contents of this document.

This analysis applies to the City of Ames and cannot be applied to other jurisdictions without analysis. Any use by the City of Ames, project partners, sub-consultants or any third party, or any reliance on or decisions based on this document, are the responsibility of the user or third party.

Acknowledgements

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Abbreviations

BAP	Business-as-Planned scenario (formerly referred to as Business as usual (BAU)
CO2	Carbon dioxide
CO2e	Carbon dioxide equivalents
CDD	Cooling degree days
CH4	Methane
DE	District energy
GHG	Greenhouse gas
GPC	Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories
GWP	Global Warming Potential
HDD	Heating degree days
IRA	Inflation Reduction Act
LCS	Low Carbon scenario
MCA	Multi-criteria analysis
NPV	Net present value
VMT	Vehicle miles traveled

Glossary

Term	Definition
Baseline	The starting point to measure changes in the amount of emissions produced over time.
Carbon-free grid	An electricity grid where the power that is generated and distributed comes from only renewable sources.
Carbon sequestration	The process of capturing and storing carbon from the atmosphere through natural or anthropogenic methods.
Consumption-based emissions	Emissions from the volume of goods consumed by a population.
CO2e (Carbon dioxide equivalents)	A single unit of measurement that allows for the impact of releasing different greenhouse gasses into the atmosphere to be evaluated on a common basis. Carbon dioxide equivalents are calculated using Global Warming Potential factors that represent the impact of each greenhouse gas type (such as methane (CH4) and nitrous oxide (N2O) relative to that of carbon dioxide.
Decarbonize	To eliminate the release of GHGs into the atmosphere from a process or system. This includes swapping out any fossil fuel sources for renewable energy.
GHGs (Greenhouse gasses)	Compound gasses that trap heat and emit longwave radiation in the atmosphere, causing the greenhouse effect.
Heat pump	A highly efficient heating and cooling system that transfers thermal energy from the ground or air to warm a building during winter and cool it during the summer.
Low-carbon pathway	An implementation pathway that includes annual investments that result in GHG emissions reductions. This pathway is based on the modeling results in the low-carbon scenario.
MISO	Midcontinent Independent System Operator, the operator of the electricity transmission system.
Mt (Megaton)	1,000,000 metric tons.

(continued from previous table)

Term	Definition
MW	Megawatt, one million watts, or 1,000 watts. A measure of electricity output.
Net zero	A balance between the amount of greenhouse gasses released and the amount taken out of the atmosphere.
Net-zero building	A building that is highly energy efficient and produces on-site (or procures) carbon-free and/or renewable energy in an amount sufficient to offset the annual carbon emissions associated with its operations or simply eliminates carbon emissions altogether.
Person-years of employment	A person-year of employment represents the number of hours of one person working full time for one year. This could be from a single person working for a year or, for example, three people working full time for four months.
Renewable energy	A naturally occurring energy source that is not finite or exhaustible. It includes sources such as sunlight, wind, and geothermal heat.
ZEV (Zero-Emissions Vehicle)	A vehicle that does not produce tailpipe emissions or other pollutants from the onboard source of power.

Key Energy and Emissions Units

GHG emissions

1 ktCO2e = 1,000 MtCO2e

Energy

1 MMBTU = 1.055 GJ

1 MJ = 0.0001 GJ

1 TJ = 1,000 GJ

1 PJ = 1,000,000 GJ

1 GJ = 278 kWh

1 MWh = 1,000 kWh

1 GWh =1,000,000 kWh

Table of Contents

In the Numbers, for the City of Ames

- Population, 2021: 67,956[1]
- Population, 2050: 87,769[2]

- New dwellings, 2023–2050: 6,000 units
- New non-residential floor space, 2023–2050: 9.8 million ft2
- Per capita GHG emissions, 2021: 16.5 tCO2e/person
- Per capita GHG emissions in 2050 if the Low-Carbon Scenario is implemented: 0.8 tCO2e/person

- Total energy consumption, 2021: 11,848,000 MMBTU
- Total energy consumption under the Business-as-Planned Scenario, 2050: 11,897,000 MMBTU
- Total energy consumption under the Low-Carbon Scenario, 2050: 6,102,000 MMBTU

- Total expenditures on energy, 2021: $200 million
- Savings on energy expenditures under the Low-Carbon Scenario, 2023–2050: $1.3 billion

- Average energy expenditures per household in 2021 (including transportation): $3,700
- Average energy savings per household per year in 2050: $1,950

- Total investment required for the Low-Carbon Scenario, 2023–2050: $3.2 billion
- Person-years of employment[3] generated as a result of the low-carbon investments, 2023–2050: 19,000

- Total GHG emissions, 2021: 1,100,000 tCO2e
- Total GHG emissions in the absence of action, 2050: 1,177,000 tCO2e
- Total GHG emissions if the City implements the Low-Carbon Scenario, 2050: 70,600 tCO2e

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[1] This includes students enrolled at Iowa State University.

[2] Population projections from the Forward 2045: Metropolitan Transportation Plan.

[3] A person-year of employment represents the number of hours of one person working full time for one year. This could be from a single person working for a year or, for example, three people working full time for four months.

Letter From the Mayor

Greetings!

The narrative, analysis, and recommendations included in our community's first Climate Action Plan are more than just words on a page. They reflect our decades-long commitment to reducing energy use and implementing sustainable practices. In order to actualize this plan, it will require all of us working together. While Council and staff have taken the lead in the plan creation, it will require every resident and business owner to invest and participate to bring it to reality.

Change can be difficult, but it affords our community an opportunity to make a difference. Ames is a city of creative problem-solvers. This is one more opportunity for us to demonstrate how we can continue to be leaders in responding to the challenge of climate change.

Conserving natural resources is not new. Many of us remember the 1970s energy crisis and the necessary, important decisions put into motion when our energy sources were in jeopardy. In response, speed limits were reduced, minimum vehicle miles per gallon requirements were set, thermostats were seasonally raised or lowered to conserve energy, and we began recycling in earnest. More than 50 years later, we realize there is much more work to do. As you explore the Ames Climate Action Plan, please consider how you can participate in this initiative.

Finally, I want to acknowledge the commitment of our CAP Project Team, CAP Technical Team, and consultant, Sustainability Solutions Group, in completing this document. I want to thank the 27 members of the Climate Action Plan Supplemental Input Committee for their contributions representing various community sectors and providing feedback.

I also want to thank all the residents who sent emails, took a survey, attended a meeting, looked at our website, and/or shared their thoughts.

Although this plan represents countless hours of work, we are just starting the process. This is a living document that needs participation, commitment, and action to be successful. I invite each one of you to join us in implementing the plan.

Sincerely,

John A. Haila, Mayor
Ames, Iowa

E.
Executive Summary

E. Executive Summary

The City of Ames Climate Action Plan seeks to accelerate the transition to a clean energy economy, while simultaneously achieving multiple economic and social benefits. The energy system is in the midst of a profound transformation with the increasing introduction of decentralized electricity production storage, the electrification of transportation, and the advancement of policies and investments at all levels of government to mitigate GHG emissions and advance clean energy.

The transition to a cleaner energy economy requires using energy more efficiently, moving from fossil fuels to electricity wherever possible, and generating electricity with low- or zero-carbon emissions. The effort requires extensively retrofitting the existing building stock, significantly increasing the energy performance of new buildings, building new sources of zero- and low-carbon energy, and electrifying vehicles and heating systems. The result of this combination of efforts is a rapid reduction of GHG emissions with a marginal net cost to society as a whole, and these investments represent significant opportunities for the public and private sector, with many projects both generating financial returns and improving quality of life.

E.1 The Process

The development of the City of Ames CAP involved a dance between an engagement process and a technical analysis.

The technical analysis aimed to provide an investment roadmap using a detailed energy and emissions model. The analysis began by considering the drivers that determine the City's energy consumption and greenhouse gas (GHG) emissions to answer the question, "Where are we now?" Analysis of future trajectories included a Business-as-Planned (BAP) scenario, which evaluated what might happen if no additional policies or actions are put in place. A Low-Carbon scenario explored the implications of achieving GHG reductions consistent with science-based targets.[4]

Ames is projected to grow incrementally between 2023 and 2050, with the population increasing by one third over the period.

[4] For a discussion of science-based targets, see: Global Covenant of Mayors (2020). Science-Based Climate Targets: A Guide for Cities. Retrieved from: https://sciencebasedtargetsnetwork.org/wp-content/uploads/2020/11/SBTs-for-cities-guide-nov-2020.pdf

E.2 The Pathway

Reduce	Improve	Switch
Reducing or avoiding energy consumption in the first place	Improving the efficiency of the energy system (supply and consumption)	Fuel switch to zero- carbon sources
Energy use per capita	**Energy used versus lost**	**Energy source**

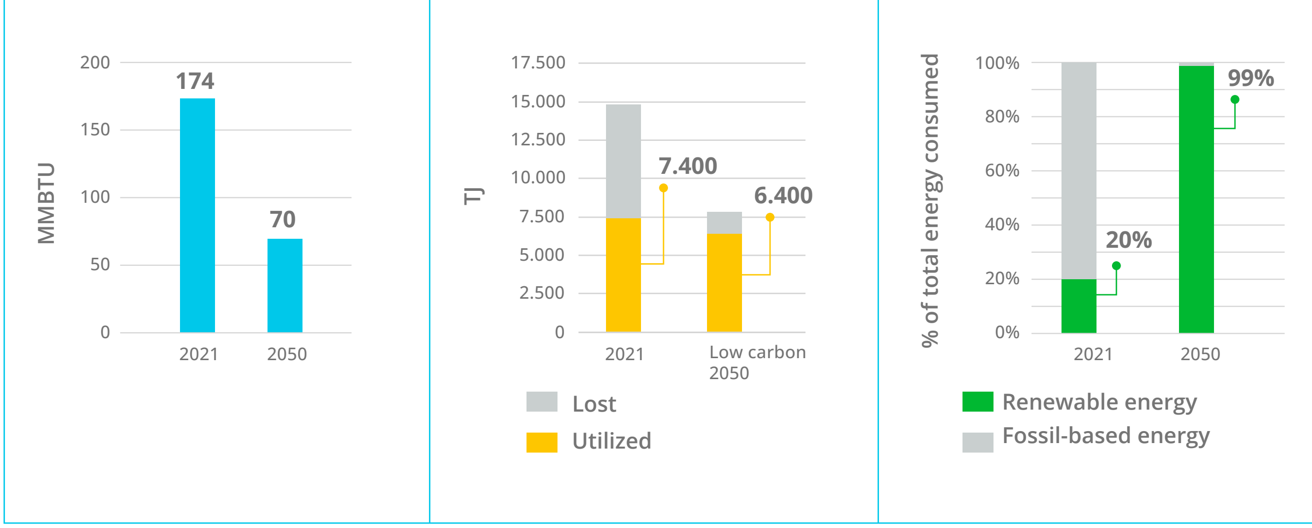

Figure 1. The transformation of Ames' energy system in three charts.

The modeling results indicate that the low-carbon pathway is technically and economically possible and logistically challenging. GHG emissions can decline from 1.1 MtCO2e in 2021 to 70 ktCO2e in 2050, a decrease of 94% over that period. The analysis relies on technologies available today and additional future technological developments will further enable GHG reductions and efficiency gains.

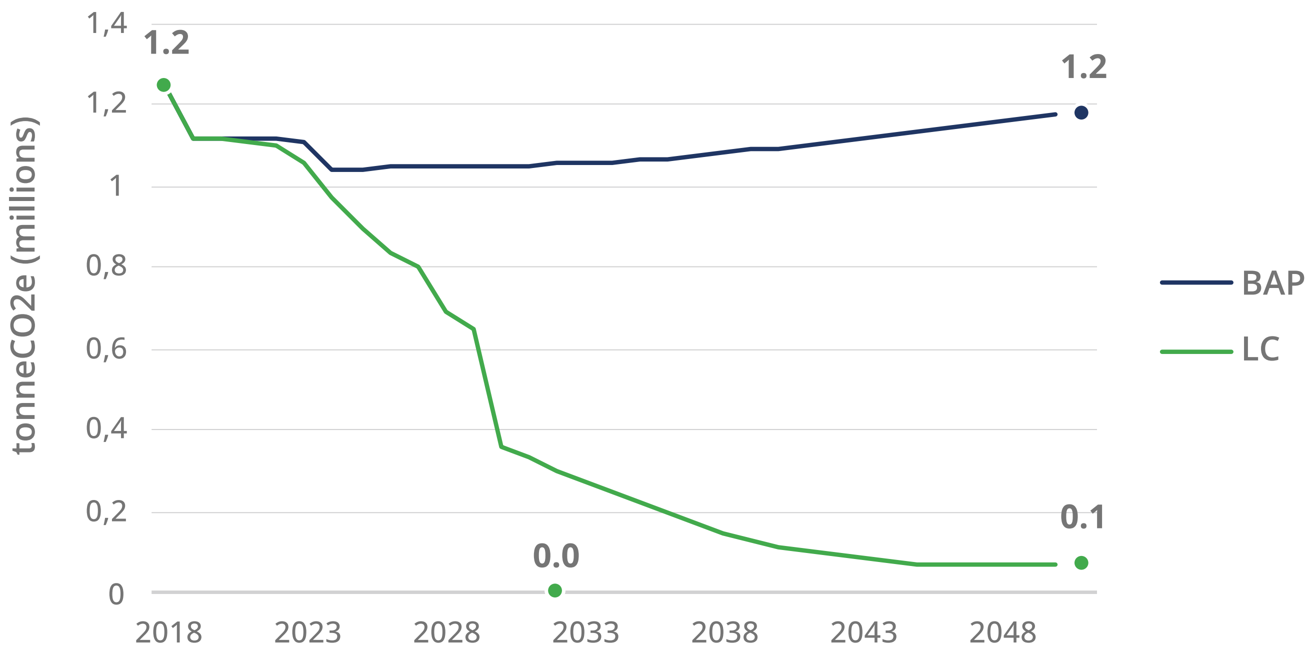

Figure 2. The Low-Carbon scenario trajectory.

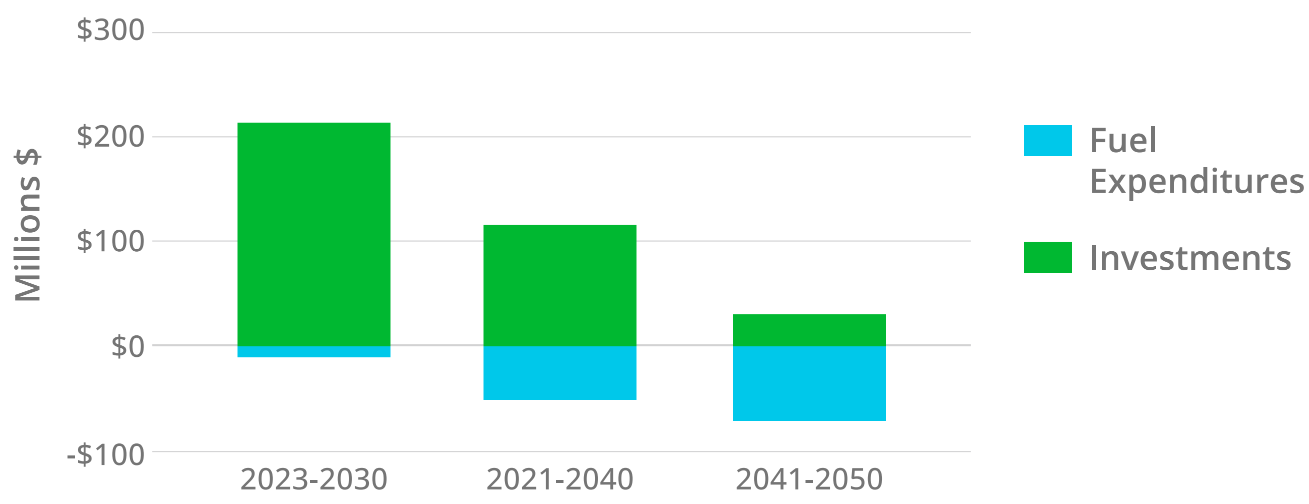

Figure 3. Average annual capital investment and fuel expenditures by decade, undiscounted.

These investments represent major opportunities for new and existing businesses, including companies providing heat pumps, building retrofits, renewable energy technologies, energy storage, electric vehicles, energy controls, etc.— a $3.2 billion opportunity, or approximately $120 million per year. Some of these investments will occur as a result of natural turnover of stocks (for example, each EV purchased represents a $5,000 incremental investment) or independent investments (each home that is retrofitted by someone making an upgrade contributes approximately $60,000 to this total investment).

On a cash basis, total expenditures in the Low-Carbon scenario are frontloaded between 2023 and 2030 before declining significantly in the subsequent decades out until 2050. Benefits increase over the same period as the impacts of the investments take effect. Costs can be better aligned with the savings by amortizing many of the investments over time.

The total investments are illustrated relative to the background rate of spending as represented by the BAP scenario in Figure 4. The Inflation Reduction Act will help to stimulate and reinforce many aspects of Ames' CAP by providing opportunities for the City to raise funds and by providing grants and incentives to individuals and businesses to support low-carbon investments.

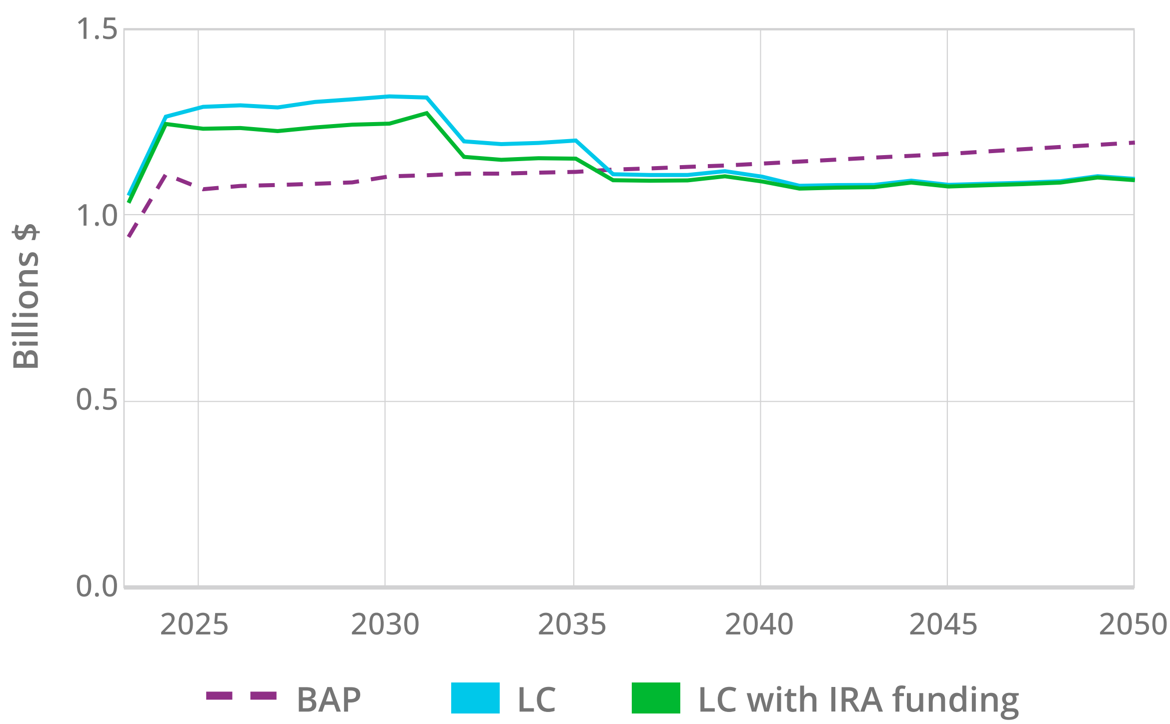

Figure 4. Total expenditures for the Low-Carbon scenario versus the BAP, with and without IRA investments.

The investments in the Low-Carbon scenario would generate new jobs in the retrofits, renewable energy, and associated sectors. Total person-years of employment are estimated to be 7,000 by 2030 and 19,000 by 2050.

E.3 Targets

During the course of this project, Ames identified the objective of achieving a target aligned with 1.5 degrees of warming, which requires a GHG reduction of 83% by 2030 and net-zero emissions by 2050. The low-carbon pathway, as modeled, achieves a reduction of 71% by 2030 over 2018 and nearly net-zero by 2050, an outcome that exceeds the federal target of 50–52% by 2030. The City's ability to achieve this 2030 target is constrained by time; for example, it is difficult to electrify the community's entire vehicle stock by 2030 because of the lifetime of vehicles. A conceivable option is to accelerate the transition to renewable electricity for the community so that electricity is 100% clean by 2030. While this level of greening electricity was not included in the low-carbon pathway because of regulatory and permitting constraints, it would result in reductions of 81% by 2030.

Specific targets have been identified to track the implementation of the Low-Carbon scenario for each decade between 2021 and 2050 to enable the City to monitor progress against the pathway.

Table 1. GHG targets.

	2018	2021	2023	2030	2040	2050	Cumulative (2023–2050)
Business as planned scenario							
Total (MtCO2e)	1,241,000	1,116,000	1,109,000	1,049,000	1,093,000	1,177,000	30,477,000
% change over 2018		-10%	-11%	-15%	-12%	-5%	
Low carbon scenario							
Total (MtCO2e)	1,241,000	1,116,000	1,053,000	358,000	110,000	71,000	9,181,000
% change over 2021		-10%	-15%	-71%	-91%	-94%	
Per capita (MtCO2e/ capita)	18.8	16.3	15.2	4.8	1.4	0.8	
% change over 2021		-13%	-19%	-74%	-93%	-96%	

E.4 Findings

The CAP envisions a transition to a low-carbon or decarbonized economy. The analysis indicates that this transition is technically and economically possible using existing technologies.

1. The transition requires reducing energy consumption in the first place through high-performance buildings and land-use planning, then improving the energy system by retrofitting existing buildings, and finally, switching to renewable energy (primarily electricity) and, to a lesser degree, renewable natural gas.
2. Energy is a major expenditure in Ames, totalling nearly $200 million per year. This is projected to increase to $250 million in the BAP scenario but would decline on average to $175 million in the Low- Carbon scenario.
3. This transition requires significant capital investments, averaging $120 million per year between 2023 and 2050, but these investments are partially offset by reduced fuel expenditures (annual savings average $50 million per year) and maintenance costs (annual savings average $25 million per year). Contributions from the Inflation Reduction Act could total $26 million per year. Note that the financial impacts are presented as averages. When represented in cash terms, investments are higher in the first decade, while savings are higher in the subsequent decades.
4. The net cost including investments and savings totals an average of $22 million per year. Factors that influence this result include the cost of technologies and the cost of fuels. For example, if the price of natural gas remains at its current price, the investments will generate savings for the community and because Ames would be powered by renewable energy, the community would be protected from future fluctuations in energy costs. The investments in the Inflation Reduction Act could also drive down technology costs, which will further improve the economic benefits of the Low-Carbon pathway.
5. The capital investment can be made by the City, households, institutions (the university), businesses, and other levels of government. The incremental capital costs of the Low-Carbon scenario are approximately 10% of the capital and operating expenditures made annually on buildings, energy, transportation, and waste in Ames.[5]
6. The investments in the energy system will generate employment in building design, retrofits, renewable energy, electric vehicle maintenance, and other sectors. Using sector-specific employment generation rates, the plan will result in a total of 19,000 person-years of employment over the period, or an average of 700 person-years of employment per year.

[5] Total expenditures on buildings, transportation, waste and energy in Ames are approximately $1 billion per year, as calculated in this analysis.

7. Thirty-one actions were identified through the engagement and technical analysis. These were bundled into six big moves. These actions have varying return on investments and risk profiles. Some investments will be more suited to the municipality, whereas others will be more appropriate for private businesses. Which action is best associated with which entity has yet to be determined, but there are many promising investment opportunities.
8. Energy and GHG gains that occur as a result of land-use planning are essentially free in that they require no investment and deliver a range of other co-benefits. The City should therefore continue to advance intensification strategies as an enabling strategy to reduce GHG emissions.
9. City interventions will be foundational in unlocking key strategies to advance the Low-Carbon scenario. Potential interventions include creating policies to support intensification, enhancing building performance, performing building retrofits, encouraging renewable energy use, and providing education and support.
10. The implementation of the actions requires a novel, coordinated approach that brings together the City, the university, and other organizations in an implementation approach that is nimble and entrepreneurial.

E.5 Implementation

An implementation program has been developed with recommended policies, initiatives, and programs that will put Ames on track to achieve the emissions reduction pathway modeled in this analysis. The program focuses on the following Big Moves:

1. Renewable Energy Generation
2. Building Retrofits
3. Net-Zero New Construction
4. Reducing Vehicle Emissions
5. Increase Active Transportation and Transit Use
6. Reduce Waste Emissions

The implementation program enables Ames to leverage key local assets such as its Electricity Department and its partnership with Iowa State University.

E.6 Conclusion

The paradigm of the climate action response has shifted from a historical emphasis on sacrifice to a paradigm of opportunity. Climate action now represents new business, new jobs, innovation, and an enhanced quality of life, and these themes are all evident in Ames' Climate Action Plan.

This plan describes a pathway to rapidly decarbonize Ames in alignment with the latest science, a process that will generate new employment, stimulate innovation, increase resilience, provide energy security, reduce household energy costs, advance equity, and improve quality of life. As a community plan, the pathway includes actions and investments by households, businesses, and the municipality. The municipality is responsible for providing policies, education, and incentives that stimulate these investments; ensuring the investments advance equity and improve the quality of life for Ames residents; coordinating partners; and tracking progress.

Ames's Climate Action Plan enables the city to address climate change, engage in the energy transition on its own terms, and future-proof the city against technological and climatic megatrends.

1. Introduction

1. Introduction

1.1 The Energy Transition

The global energy system is transitioning due to technological change and the rapid evolution of policies. Indicators of this change include the growth of clean electricity[6] and the adoption of electric vehicles[7] and heat pumps.[8] Combined with emerging technologies, these trends are disrupting every sector of society while stimulating new opportunities.

The Transformation of the Energy System

"The energy world is in the early phase of a new industrial age—the age of clean energy technology manufacturing. Industries that were in their infancy in the early 2000s, such as solar PV and wind, and the 2010s, such as EVs and batteries, have mushroomed into vast manufacturing operations today. The scale and significance of these and other key clean energy industries are set for further rapid growth. Countries around the world are stepping up efforts to expand clean energy technology manufacturing with the overlapping aims of advancing net zero transitions, strengthening energy security and competing in the new global energy economy. The current global energy crisis is a pivotal moment for clean energy transitions worldwide, driving a wave of investment that is set to flow into a range of industries over the coming years. In this context, developing secure, resilient and sustainable supply chains for clean energy is vital."

IEA (2023). Energy Technology Perspectives 2023, P. 4

[6] IRENA (2023). Record Growth in Renewables Achieved Despite Energy Crisis. Retrieved from: https://www.irena.org/News/pressreleases/2023/Mar/Record-9-point-6-Percentage-Growth-in-Renewables-Achieved-Despite-Energy-Crisis

[7] Bloomberg (2022). US Crosses the Electric-Car Tipping Point for Mass Adoption. Retrieved from: https://www.bloomberg.com/news/articles/2022-07-09/us-electric-car-sales-reach-key-milestone?leadSource=uverify%20wall

[8] IEA (2023). Global heat pump sales continue double-digit growth. Retrieved from: https://www.iea.org/commentaries/global-heat-pump-sales-continue-double-digit-growth

1.2 The Policy Context

Climate change is driving energy policy globally and this trend is highlighted by the Paris Agreement, which entered into force on November 4, 2016, under the United Nations Framework on Climate Change. The goal of the Paris Agreement is to limit global temperature rise to less than 2 degrees Celsius compared to pre-industrial levels by the end of the century. It also works to limit the increase to 1.5 degrees Celsius to minimize the impacts on oceans and reduce extreme events.[9] Each country submits a strategy to achieve that objective, called a Nationally Determined Contribution (NDC).[10] The US NDC sets a target of reducing emissions by 50%–52% below 2005 levels by 2030 net zero emissions by 2050.[11]

1.3 The City of Ames

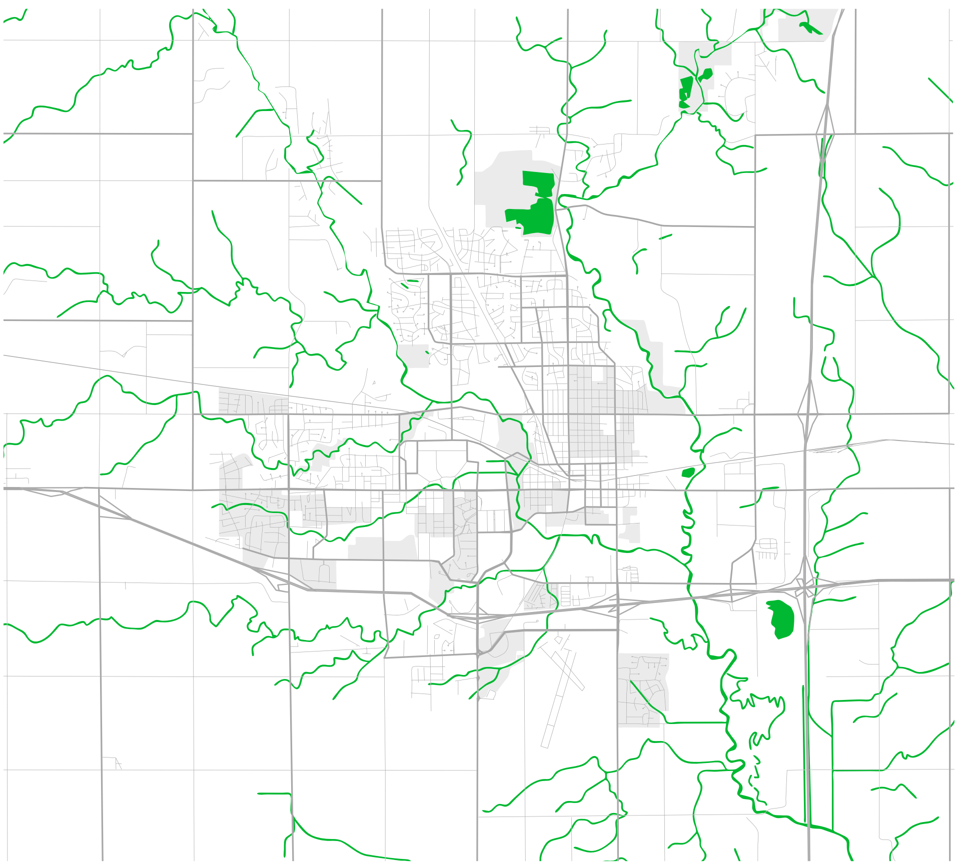

Figure 5. The City of Ames, distilled.

[9] The IPCC will be releasing a special report on 1.5 degrees in 2018. Details on this report are available here: http://ipcc.ch/report/sr15/

[10] UNFCCC (n.d.). Summary of the Paris Agreement. Retrieved, 2018 from: http://bigpicture.unfccc.int/#content-the-paris-agreement

[11] U.S. Department of State (2021a.) A Review of Sustained Climate Action through 2020 - United States 7th National Communication 3rd and 4th Biennial Report. Available at: https://unfccc.int/sites/default/files/resource/United States 7th NC 3rd 4th BR final.pdf

Located in Story County, Iowa, Ames is approximately 24.3 square miles. Iowa State University students make up just under half of the city's population.[12] Ames has a humid continental climate characterized by four distinct seasons, with cold winters, warm to hot summers, and precipitation distributed throughout the year.

Ames' economy is focused on education, agriculture, and energy. The largest employer in Ames is Iowa State University. The university is a major agriculture and energy research hub. The city hosts several major energy companies. Among these are Danfoss, a supplier of district energy equipment, and the Renewable Energy Group, America's largest producer of biomass-based diesel. The city is also home to the U.S. Department of Energy's Ames Laboratory, a major materials research and development facility, and the main offices of the Iowa Department of Transportation.

1.4 The Role of Cities in Climate Action

The transition to a low-carbon energy system deeply affects cities.[13] If cities are not built to stringent low-carbon standards, land-use planning and infrastructure investments can lock in energy and GHG-intensive patterns of development that inhibit efficient and low-carbon alternatives or make them cost prohibitive.[14] Alternatively, compact urban form increases the feasibility of district energy and the introduction or improvement of public transit. In addition, compact development reduces the financial cost and the GHG impact of providing services such as roads, water and wastewater conveyance, ambulance, fire protection, school transportation, and even provision of home-based health care.

The multiple roles of the City of Ames in addressing climate change are as follows:

- A mobilizer: Ames can engage people, municipalities, and other organizations around a vision, goals, objectives, and targets. An example is a community engagement program or a bulk purchase of renewable energy on behalf of citizens.
- An innovator: Ames can directly or indirectly support innovation by reducing risk through investments, partnerships, and/or policies that support low-carbon projects or enterprises. An example is the provision of electric vehicle infrastructure to support electric vehicles.

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[12] Iowa State University, Life in Ames FAQ (accessed June 30, 2021) online: www.stat.iastate.edu/life-ames-faq.; United States Census Bureau, Ames, Iowa (accessed June 30, 2021) online: https://data.census.gov/cedsci/profile?g=1600000US1901855.

[13] The Global Commission on the Economy and Climate. (2014). Better growth, better climate: The new climate economy report. Retrieved from http://newclimateeconomy.report/2014/wp-content/uploads/2014/08/NCE-cities-web.pdf; Seto, K. C., Dhakal, S., Bigio, A., Blanco, H., Delgado, G. C., Dewar, D., ... others. (2014). Human settlements, infrastructure and spatial planning. Retrieved from http://pure.iiasa.ac.at/11114/; International Energy Agency. (2016). Energy technology perspectives 2016: Towards sustainable urban energy systems.

[14] Erickson, P., & Tempest, K. (2015). Keeping cities green: Avoiding carbon lock-in due to urban development. Stockholm Environment Institute. Retrieved from https://www.sei-international.org/mediamanager/documents/Publications/Climate/SEI-WP-2015-11-C40-Cities-carbon-lock-in.pdf

- A collaborator: There are multiple opportunities for collaboration in the energy transition including collaboration with other levels of government, transit authorities, utilities, cities, regions, businesses, non-profit organizations, neighborhoods, and governments in other parts of the world. Collaboration can take the form of shared targets or policies or joint projects or investments.
- An investor: Ames can use its access to low-interest capital to make investments directly for building retrofits and renewable energy technologies. Alternatively, or in tandem, Ames can enable investments by third parties. An example is local improvement charges as a way to finance building retrofits.
- An implementer: Through policies and incentives, Ames can support businesses and households in the energy transition. An example is a district energy connection bylaw supporting low-carbon district energy systems.
- An incubator: Ames can cultivate the development of new technologies or applications that enable the low-carbon economy by supporting and attracting new and existing businesses and creating a hub or ecosystem in which the businesses and organizations support each other. Examples include a low-carbon business park or incentives for different levels of building performance that stimulate innovation by builders.

Key Trends

Municipalities around the world are creating innovative policies and strategies to support or engage with these trends while advancing local priorities such as reducing air pollution, stimulating economic development and new employment opportunities, increasing the livability of the community, and improving affordability.

- Renewable energy is becoming increasingly accessible: It is becoming easier for households and businesses to generate their own energy. As the cost of solar systems declines, solar PV systems will become more accessible. New financing mechanisms are also reducing barriers by reducing the requirement for upfront capital costs.
- Energy storage technologies are changing the grid: Energy storage technologies such as batteries are already available for houses and businesses and as the costs continue to decline, the number of installations will increase rapidly.
- New electric vehicle models are available every day: As the purchase price decreases and the range increases, there are compelling reasons why the number of electric vehicles on the road will increase exponentially.

- Heating systems remain a challenge, but new options are coming online: Heat pumps continue to improve in efficiency and district energy systems are gaining traction as a more efficient system for providing heating and cooling to communities with the flexibility to add or subtract technologies as required.
- Microgrids are breaking down the barriers between heating and electricity: Microgrids include electricity generation from solar or combined heat and power, converting excess power to hot water, which is then used for heating with electric batteries and other technologies.
- New financing strategies are increasing participation: Municipalities and financial institutions are offering mechanisms that reduce financial barriers to energy retrofits and renewable technologies.

The discourse around climate change has changed since the United Nations meetings in Paris in 2015. Climate change solutions were originally framed in terms of sacrifice in order to respond to one of the critical issues of this time. Since the Glasgow 2021 Climate Summit, climate action has focused on cost savings, risk management, economic opportunity, and job creation, based on shifts in national and international policy, reductions in technology costs and technology innovations, social movements, commitments by financial institutions, and other factors.

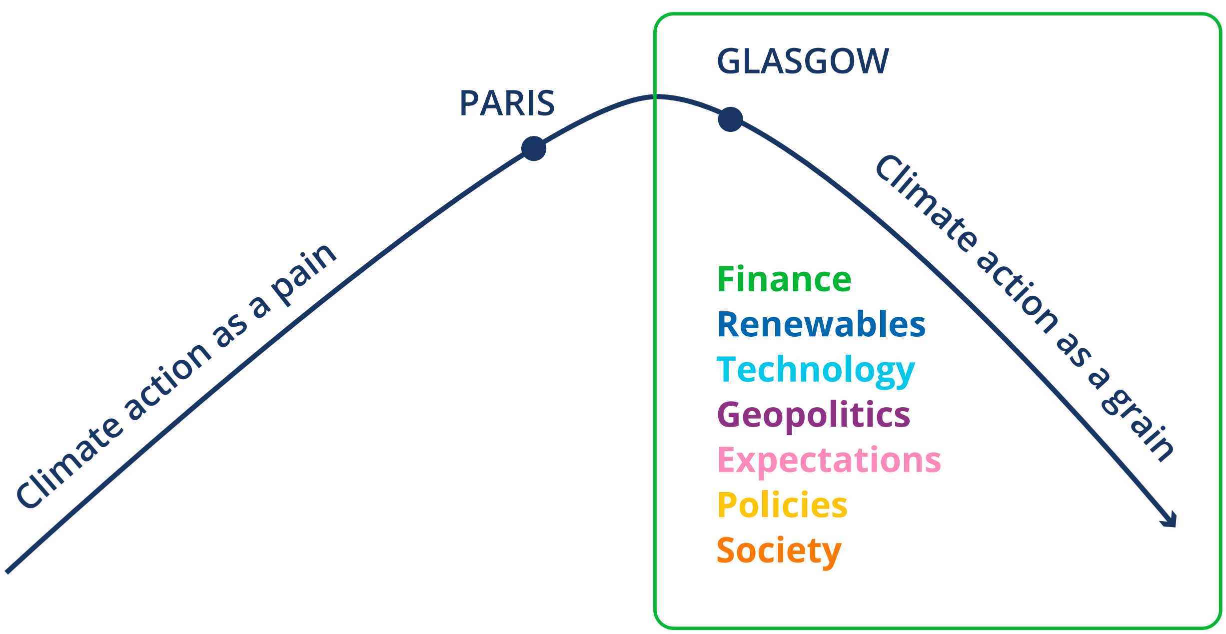

Figure 6. A shift in the paradigm of climate action.

1.5 Purpose and Objectives

The Ames' Climate Action Plan (CAP) is a comprehensive long-term, strategic plan to help Ames define its journey through the energy transition. The CAP provides a roadmap to achieve deep emissions reduction and energy savings, while improving quality of life and reducing energy costs. To identify the roadmap, the CAP explores the following questions:

- How is energy currently used in Ames?
- What factors influence patterns of energy use?
- What are the GHG emissions associated with the use of energy?
- What is the cost of energy in Ames?
- What are the opportunities for saving energy and money?
- What are the future trends of energy technologies and energy consumption?
- What is a possible pathway to decarbonize Ames?
- What are the impacts of policies or actions undertaken by Ames?
- What investments are required to support the transition to a clean energy economy?

Cities are energy systems, and how they are planned, built, and lived in largely determines the level and pattern of GHG emissions. The population requires buildings for housing and work, and these buildings consume energy. The spatial relationship between dwellings and places of work determines patterns of travel and influences the modes of travel selected by residents. Energy consumption is determined by the mode of transportation chosen and the duration and number of trips taken.

The CAP represents a comprehensive long-term approach to improve energy efficiency, reduce energy consumption and GHG emissions, foster green energy solutions, and support economic development. The CAP applies the Global Protocol for Community-Scale GHG Emissions Inventories as an accounting framework to guide the reporting on energy and emissions.[15] Sectors that were evaluated include buildings, transportation, waste management, local energy generation, and land use. Global Protocol for Cities (GPC) reports are included as an appendix.

[15] Greenhouse Gas Protocol, 2021. Global Protocol for Community-scale Greenhouse Gas Inventories. An Accounting and Reporting Standard for Cities. Version 1.1: https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

Climate Equity

Climate change impacts are not felt equally by all members of society. People living in low-income households may have reduced ability to prepare for and evacuate during emergencies, relying heavily on emergency services where available, as they may lack the financial resources for preparedness measures and may lack access to vehicles and funding to evacuate.16 Those living in low-income households are also more likely to be renters or homeowners who are "house poor", living in a home with an unaffordable mortgage.17 People living in these situations may have reduced abilities to protect their homes from climate emergencies impacts and may have difficulty recovering from the financial hardships associated with emergency or disruptive events.

People over 65 are more at risk of negative impacts and death from flooding because of physical disabilities, reduced mobility, the need for access to medicine and medical equipment, and the style of housing that allows accessibility (single-floor buildings). Additionally, studies have found that older people are less likely to respond to evacuation or public safety orders and may have physical difficulties with preparing their homes to protect against damages from flooding. After a flood, many people experience trauma or struggle with the aftermath of damages. Older people, especially those who are socially isolated, may experience stress due to the disruption, the loss of property, or the challenges associated with insurance claims and repairs.

Vulnerability to heat echoes vulnerability to other climate hazards. People over 65 and those with lower incomes are more at risk of serious consequences or death during heat events because they are more physically vulnerable and/or have reduced access to space cooling. Climate change is increasing the frequency of heat waves that put people at risk, including high daytime temperatures and warm nights.

Prioritizing those most vulnerable to climate change impacts, including people with disabilities, people living in low-income households, people with reduced mobility, and those who are experiencing social isolation, is critical to developing an equitable climate plan.

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16 Substance Abuse and Mental Health Services Administration, 2017. Greater Impact: How Disasters Affect People of Low Socioeconomic Status. Disaster Technical Assistance Center Supplemental Research Bulletin.

17 Statistics Canada. (2022). Housing Experiences in Canada: People in Poverty. Accessed: https://www150.statcan.gc.ca/n1/pub/46-28-0001/2021001/article/00017-eng.htm

1.6 Overall Process

The CAP followed a systematic approach that balanced technical analysis with an engagement process, as illustrated in Figure 7.

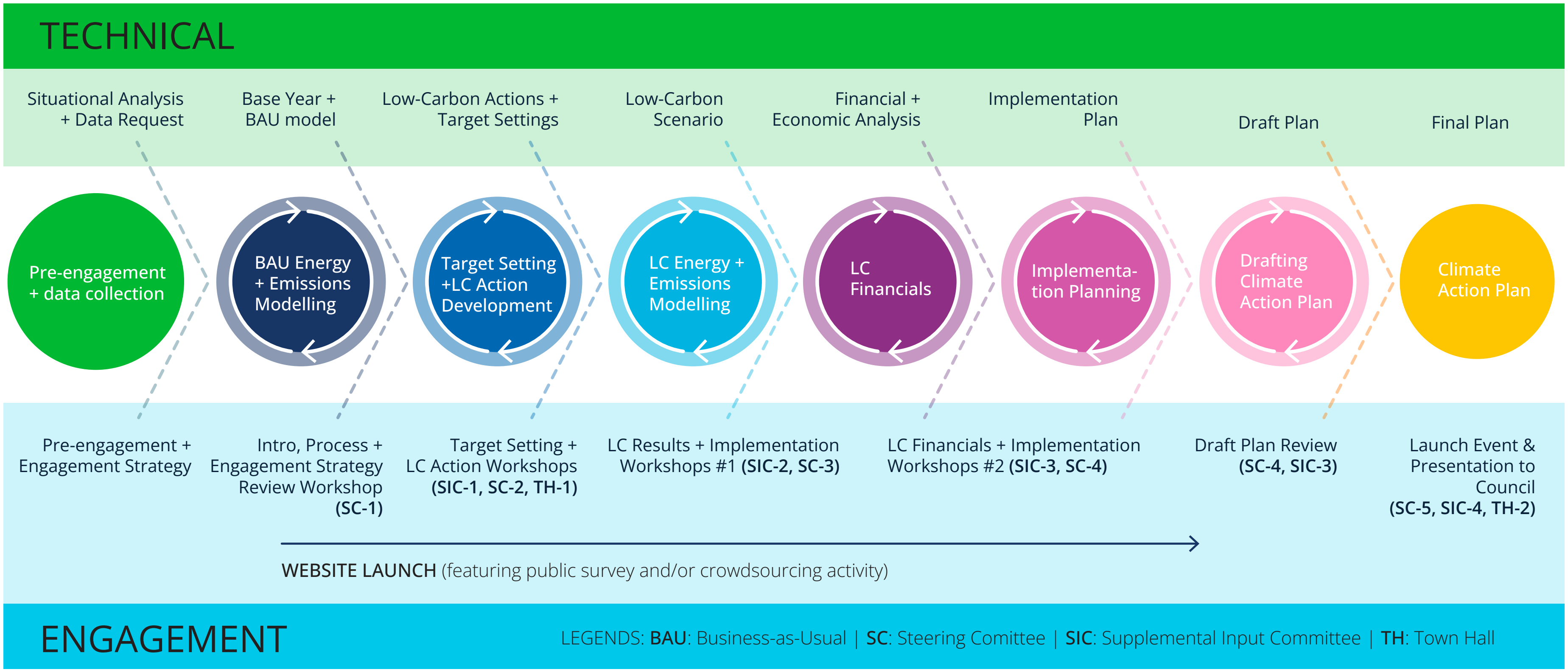


Figure 7. Schematic of the CAP development.

A Systems Dynamics Model

The relationship between land-use planning, the built environment, transportation systems, energy consumption, and GHG emissions is complex and varies from one city to the next. While there are common themes and specific actions that likely make sense in every context, in order to relate potential outcomes of actions to targets and policies—and to understand the financial implications—a model is generally required.

Our analysis applied a bottom-up, stock rollover model that projects energy demand as a result of representing the evolution of energy-consuming activities in Ames and the energy supply to address the demand.

The model estimates the changes in investments, fuel expenses, and other operating expenses of low-carbon pathways relative to a reference or Business-as-Planned scenario. The model combines changes in annualized investments, fuel costs, and operating expenses to estimate the annual net cost of a pathway.

The model incorporates the accounting framework of the Global Protocol for City-Scale GHG Emissions Inventories.

2.
Exploring a Low Carbon Future

2. Exploring a Low-Carbon Future

To explore the low-carbon future for Ames, scenarios were developed and modeled using the energy and emissions model. The modeling process involved the following steps:

1. Development of a baseline for the year 2018, calibrated against observed data from utilities and other sources. (Note that 2021 is used as a reference year for the analysis in this report).
2. Development of a Business-as-Planned (BAP) scenario.
3. Modeling of actions.
4. Creation of Low-Carbon scenarios that integrate the actions.

Figure 8 illustrates a baseline year (current emissions level), a BAP scenario (reference scenario), and GHG reductions from actions, which, combined, represent a Low-Carbon scenario. The remaining area shaded in gray is a carbon budget or carbon liability. Historically, organizations have focused on point-in-time targets such as x% reduction by 2030 or 2050, but more accurately, it is GHG emissions each year that drive climate change, in other words, the carbon liability in this graphic.

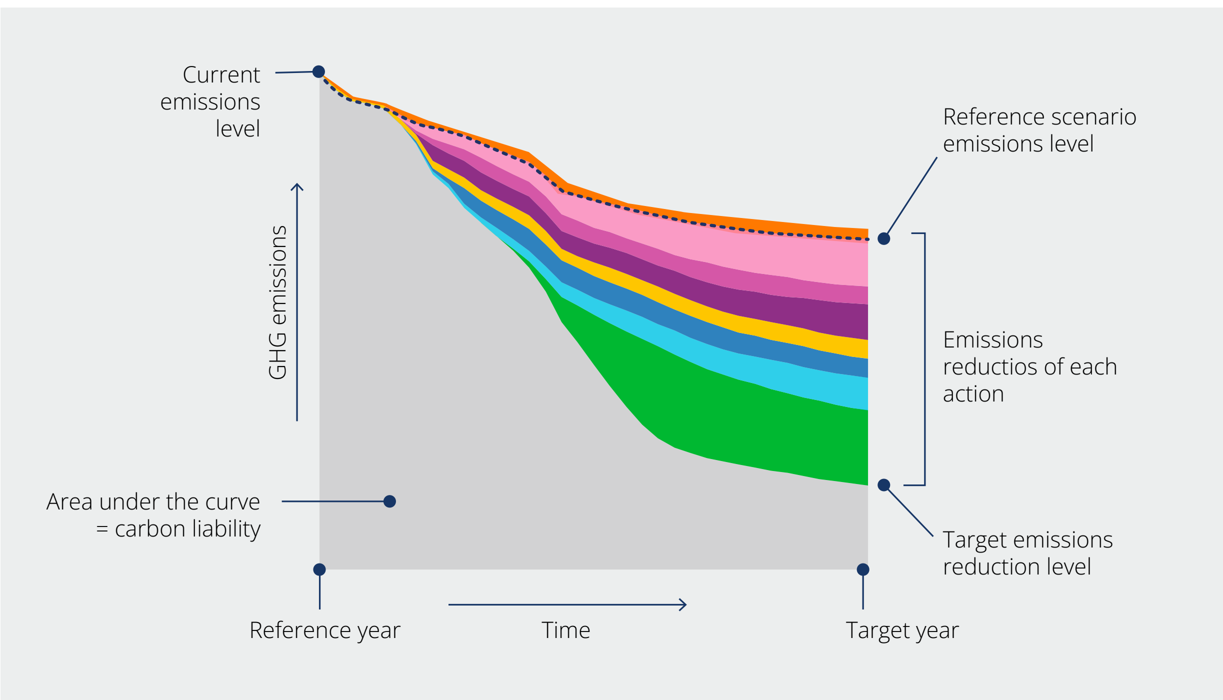


Figure 8. A conceptual representation of a Low-Carbon scenario and the insights it provides.

2.1 The Baseline Year—GHG Inventory

The year 2018 is the baseline year within the model. The modeling approach requires calibration of a base year system state (initial conditions) using as much observed data as possible to develop an internally consistent snapshot of Ames. While 2018 was used for the calibration, 2021 is the reference year used in the analysis in order to better reflect current conditions.

2.2 Identifying Actions

The first part of the actions development process involved extensive research of the Ames context, engagement with staff and community members, and best practices from other cities. An initial list of actions was reviewed by the City, and a filtering process was undertaken to identify actions that were explicitly irrelevant or inapplicable to the context of Ames or that Ames was already undertaking. This initial list of actions was completed prior to modeling the baseline and BAP and was therefore agnostic as to whether the implementation of the action would have a significant impact on emissions reduction in Ames or not.

Box: Principles of Climate Action Planning

Reduce-improve-switch: An approach of reduce, improve, and switch was used to help frame the actions. This approach, adapted from similar approaches such as the well-known Reduce-Reuse-Recycle (from the waste sector) and Avoid-Shift-Improve (from the transportation sector), looks at the energy system as a whole in all sectors. It focuses on the concept of reducing or avoiding consumption of energy in the first place, improving the efficiency of the energy system (supply and demand), and then fuel switching to low-carbon or zero-carbon renewable sources. This approach seeks to minimize the cost of the energy transition by avoiding installing capacity that is not required as a result of energy efficiency measures.

What lasts longest first: A second aspect of community energy planning involves prioritizing interventions in a hierarchy based on what lasts longest. The first priority is land-use planning and infrastructure, including density, mix of land uses, energy supply infrastructure, and transportation infrastructure. The second is major production processes; transportation modes and buildings, including industrial processes; choice of transportation modes; and building and site design. The final priority is energy-using equipment including transit vehicles, motors, appliances, and HVAC systems.

Urgency: This hierarchy explicitly concentrates the efforts on spheres of influence where there are fewer options to intervene, and it decreases the emphasis on the easier interventions, which are likely to have greater short-term returns. The World Bank defines this consideration as urgency, posing the question: Is the option associated with high economic inertia, such as a risk of costly lock-in, irreversibility, or higher costs, if action is delayed? If the answer is yes, then action is urgent; if not, it can be postponed. From this perspective, land-use planning is an urgent mitigation action.

The concepts and approaches of reduce-improve-switch, turnover inertia, and community energy planning described above guided the analysis and identification of a final list of actions for modeling, as well as the sequencing of actions in modeling. The stocks and flows logic underpinning CityInSight embeds consideration of inertia into the analysis.

2.3 The Scenarios

Following the development of the actions, two scenarios were developed.

Table 2. Descriptions of the scenarios.

Label	Title	Description
BAP	Business-as-Planned	Development follows current patterns with minimal state requirements for intensification and density. Implementation of existing and planned energy and emissions policies and programs from municipal, state, and federal governments.
LC	Low- Carbon	A scenario that implements actions to dramatically decrease GHG emissions and improve energy efficiency across all sectors. The Low-Carbon scenario includes building retrofits, electrification of most end uses, and expansion of renewable electricity generation.

Following the definition of the scenarios, modeling assumptions and parameters were developed for each action to reflect the current energy and low-carbon dimensions. Low-carbon actions were informed by literature and what other cities are undertaking. A separate modeling exercise was undertaken to identify the current development and urban intensification parameters.

2.4 The Low-Carbon Actions

Thirty-one actions were identified in the buildings, energy, and transport sectors, including enhanced energy performance in new construction, retrofits of existing buildings, additional renewable energy both on buildings and on a larger scale, electrification of vehicles, and enhanced mode shifting to walking, cycling, and transit. The actions are described in the following table.

Table 3. The Low-carbon actions.

1. Renewable Energy Generation			
Action	**Business-as-Planned Scenario**	**Low-Carbon Scenario**	**Impact**
1.1 Renewable natural gas for district energy	None	Natural gas used for District Energy is replaced by renewable natural gas by 2030.	Fuel switching
1.2 Wind generation	One wind turbine at the university (100 kW). Out of city boundary wind generation reflected in declining emissions factor for MISO.		Local energy generation
1.3 Electric boilers for district energy	None	Electric boilers added by 2024.	Fuel switching
1.4 Solar PV on roofs	Held constant at 1.1 MW.	220 MW added by 2050.	Local energy generation
1.5 Decarbonisation of the MISO grid	Emissions factors are held constant.	75% reduction in grid emissions factor for imported electricity by 2040.	
1.6 Ground mount solar	2 MW community solar farm added in 2020; (416,096 kWh of generation in June 2021).	50 MW of renewable nameplate generating capacity by 2025, 120 MW by 2030, 240 MW by 2040, 320 MW by 2050.	Local energy generation
1.7 Renewable natural gas in buildings	None	Natural gas used for buildings is replaced by renewable natural gas by 2030.	Fuel switching

2. Building Retrofits Program			
Action	Business-as-Planned Scenario	Low-Carbon Scenario	Impact
2.1 Electrification of industrial processes	Current equipment shares held constant from base year.	Electrification of industrial processes by 2040.	Fuel switching
2.2 Retrofit of municipal buildings	Existing building stock efficiency remains constant.	Municipal building retrofits begin in 2023, achieving 50% thermal savings and 10% electrical savings. All municipal buildings will be retrofitted by 2030.	Avoided/ reduced energy use
2.3 High efficiency hot water in retrofit of homes	Current equipment shares and efficiency held constant from base year.	Replace hot water heating systems with electric in line with the heat pump schedule.	Avoided/ reduced energy use
2.4 Enhanced industrial efficiency	Current efficiency held constant from base year.	30% less energy consumed by the year 2030 relative to its 2018 baseline.	Avoided/ reduced energy use
2.5 Retrofits of homes	Existing building stock efficiency remains constant.	**Pre-1981 construction:** Achieve 60% thermal savings and 15% electrical savings in 80% of buildings constructed prior to 1981 by 2030, start year 2023; 90% by 2035. **1981 and newer construction:** Achieve 60% thermal savings and 15% electrical savings in 60% of post- 1981 existing buildings by 2030, start year 2025; 90% by 2040.	Avoided/ reduced energy use

(continued from previous table)

2. Building Retrofits Program			
Action	Business-as-Planned Scenario	Low-Carbon Scenario	Impact
2.6 Retrofits of non-residential buildings	Existing building stock efficiency remains constant.	Achieve 50% thermal savings and 10% electrical savings in 80% of buildings by 2030, start year 2023; 90% by 2035.	Avoided/ reduced energy use
2.7 High-efficiency hot water in retrofits of non-residential buildings	Current equipment shares and efficiency held constant from base year.	Replace hot water heating systems with electric in line with the heat pump. schedule.	Avoided/ reduced energy use
2.8 Heat pumps in non-residential retrofits	Current equipment shares and efficiency held constant from base year.	Add air-source heat pumps for all buildings by 2040.	Fuel switching
2.9 Heat pumps in residential retrofits	Current equipment shares and efficiency held constant from base year.	Add air-source heat pumps for all buildings by 2040.	Fuel switching

3. Net-zero New Construction			
Action	**Business-as-Planned Scenario**	**Low-Carbon Scenario**	**Impact**
3.1 Heat pumps in new non-residential buildings	Current equipment shares and efficiency held constant from base year.	Add air-source heat pumps for all buildings by 2040.	Fuel switching
3.2 High-performance new homes	Current performance held constant.	All new buildings meet thermal net-zero energy standards (15 kWh/m2) by 2030, adoption increases linearly to 2030.	Avoided/ reduced energy use
3.3 High-performance new non-residential buildings	Current performance held constant.	All new buildings meet thermal net-zero energy standards (15 kWh/m2) by 2030, adoption increases linearly to 2030.	Avoided/ reduced energy use
3.4 Hot water heat pumps in new non-residential buildings	Current equipment shares and efficiency held constant from base year.	Replace hot water heating systems with electric in line with the heat pump schedule.	Avoided/ reduced energy use
3.5 High-performance new municipal buildings	Current performance held constant.	All new municipal buildings meet thermal net-zero energy standards (15 kWh/m2) by 2025, adoption increases linearly to 2025.	Avoided/ reduced energy use
3.6 Heat pumps in new homes	Current equipment shares and efficiency held constant from base year.	Add air-source heat pumps for all buildings by 2040.	Fuel switching

4. Reduce Vehicle Emissions

Action	Business-as-Planned Scenario	Low-Carbon Scenario	Impact
4.1 Electrify the municipal fleet	No change.	Replace fleet over time (based on standard vehicle and equipment replacement lifecycles) beginning in 2023 with electric (light- and medium-duty vehicles and light equipment). For heavy vehicles, begin purchasing electric in 2030. Prior to 2030, purchase vehicles running on 100% biodiesel.	Fuel switching
4.2 Electrify personal vehicles	Follow federal target: Half of all new vehicles sold in 2030 are zero-emissions vehicles.	All light- and medium-duty vehicles sold in 2030 are zero-emissions vehicles.	
4.3 Electrify commercial vehicles	Follow federal target: Half of all new vehicles sold in 2030 are zero-emissions vehicles.	All heavy-duty vehicles sold in 2030 and after are electric. Between 2023 and 2030, the proportion of biodiesel use will increase by 5% each year.	Fuel switching
4.4 Electrify transit	Add two electric buses in 2022 and three in 2023.	Replace 17 buses with electric by 2027,then replace at end of lifecycle for remaining buses.	Fuel switching
4.5 Net-zero aviation fuels for local flights	None	Starting in 2040, progressive substitution of aviation fuels for net-zero fuels, until full substitution by 2050.	Fuel switching

5. Increase Active Transportation and Transit Use			
Action	Business-as-Planned Scenario	Low-Carbon Scenario	Impact
5.1 Increased walking and cycling	No change: Mode share held constant.	By 2050, 10% of trips in the City completed using transit. By 2050, 40% of trips under 1.2 miles completed by walking, 25% of trips 1.2-3 miles completed by biking.	Avoided/ reduced energy use
5.2 Reduced driving	No change.	Car and bike share programs are available to decrease single vehicle ownership (10% reduction in VMT city-wide). Car-free zones established in the downtown core and near the university and parking fees increased (10% reduction in VMT in downtown and university zones).	Avoided/ reduced energy use

6. Reduce Waste Emissions			
Action	**Business-as-Planned Scenario**	**Low-Carbon Scenario**	**Impact**
6.1 Increased waste diversion	Total Solid Waste handled is based on the total number of households and maintaining existing volume per household and emissions factors per ton handled.	Waste decreases by 20% per household at the source by 2030; 50% per household at the source by 2050. 50% of commercial waste is diverted at source by 2030. 90% of organic/food waste is diverted by 2028. 90% of glass, metal, and paper, cardboard, and other paper products are recycled by 2027.	Avoided/ reduced energy use
6.2 New waste to energy facility	No change.	Change the permit requirement of electric burning NG with refuse derived fuel (decrease/ eliminate NG use).	Fuel switching
6.1 Increased waste diversion	Total Solid Waste handled is based on the total number of households and maintaining existing volume per household and emissions factors per ton handled.	Waste decreases by 20% per household at the source by 2030; 50% per household at the source by 2050. 50% of commercial waste is diverted at source by 2030. 90% of organic/food waste is diverted by 2028. 90% of glass, metal, and paper, cardboard, and other paper products are recycled by 2027.	Avoided/ reduced energy use

City of Ames **6 BIG MOVES** to Net-Zero

1. Renewable Energy Generation

- Ground Mount Solar and Wind Generation
- Rooftop Solar
- Grid electricity decarbonization (MISO)

2. Building Retrofits Program

- Equipment electrification
- Building Retrofits

3. Net-Zero New Construction

- Net-zero new buildings

4. Reduce Vehicle Emissions

- Electrify Personal Use and Commercial Vehicles
- Electrify Transit
- Electrify Municipal Fleet

5. Increase Active Transportation and Transit Use

- Expand transit and encourage active transportation
- Reduce personal use vehicle miles traveled

6. Reduce Waste Emissions

- Waste generation reduction and diversion
- New Waste to Energy Facility

3.
The Pathway

3. The Pathway

3.1 The Big Picture

The GHG emissions trajectory for Ames is illustrated in Figure 9 *(on next page)*. Significant emissions reductions occurred in 2019 from changes to the fuel source for the grid electricity system and when Iowa State University replaced its coal boilers with natural gas in 2020. The total reduction was 125,000 tCO2e over three years, a reduction of approximately 3.5% in emissions per year. In the Low-Carbon scenario, this rate of reduction increases over the next decade before stabilizing out towards 2050. The rapid rate of reduction, while the result of multiple actions, is primarily enabled by greening electricity, fuel switching in building, and electrifying transportation. Efficiency gains from building retrofits and from mode switching to walking, cycling, and transit make these shifts easier and less costly. The graphic illustrates a transformational departure from the Business-as-Planned scenario. It builds on existing momentum for greening electricity and the growth of electric vehicles, as well as the momentum of the Inflation Reduction Act (IRA).

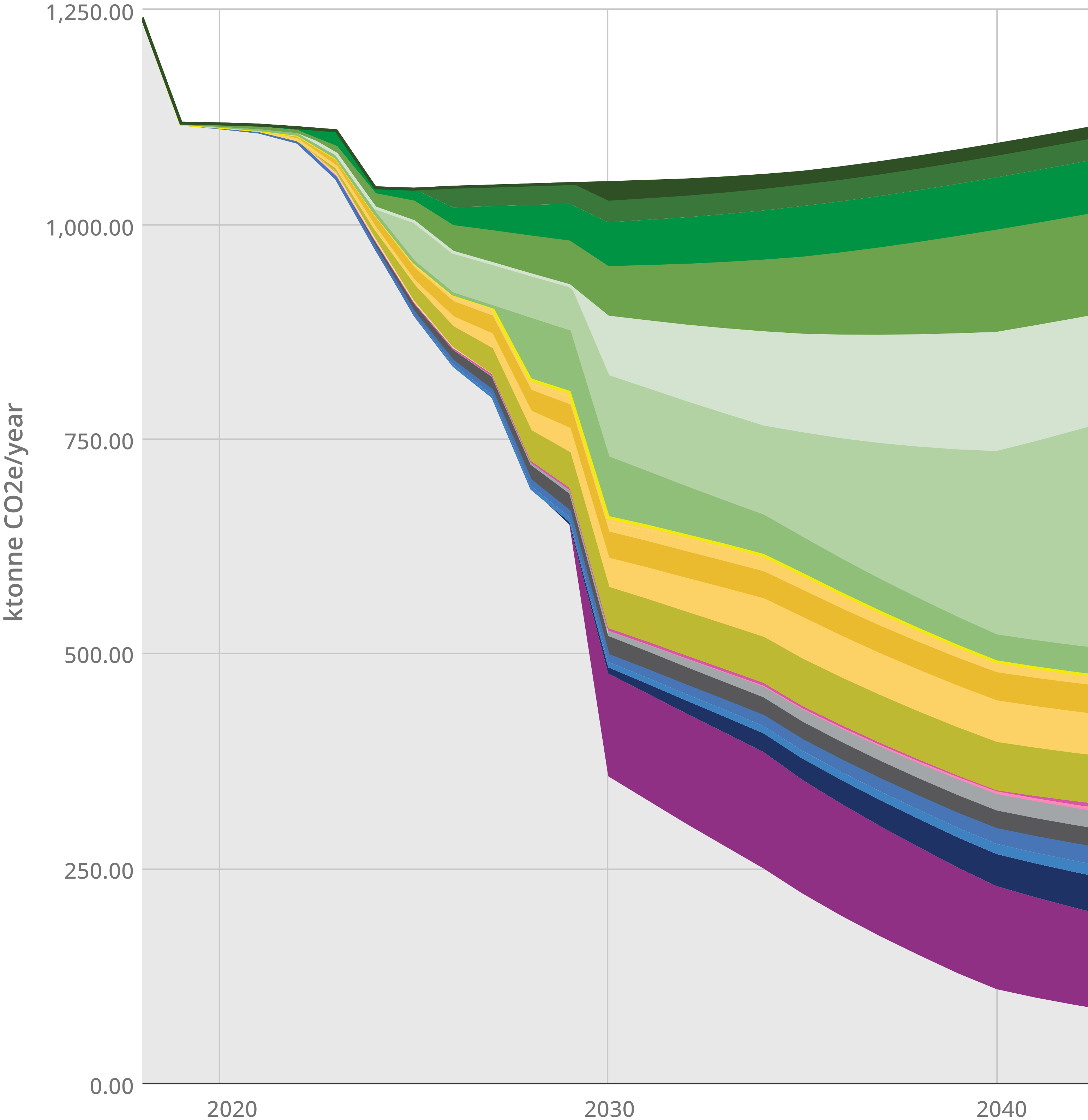


Figure 9. The Low-Carbon pathway.

Actions	BIG MOVE
1.1 Renewable natural gas for district energy 1.2 Wind generation 1.3 Electric boilers for district energy 1.4 Solar PV on roofs 1.5 Decarbonisation of the MISO grid 1.6 Ground mount solar 1.7 Renewable natural gas in buildings	**1. Renewable energy generation**
2.1 Electrification of industrial processes 2.2 Retrofit of municipal buildings 2.3 High efficiency hot water in retrofit of homes 2.4 Enhanced industrial efficiency 2.5 Retrofits of homes 2.6 Retrofits of non-residential buildings 2.7 High efficiency hot water in retrofits of non-residential buildings 2.8 Heat pumps in non-residential retrofits 2.9 Heat pumps in residential retrofits	**2. Building retrofits program**
3.1 Heat pumps in new non-residential buildings 3.2 HIgh performance new homes 3.3 High performance new non-residential buildings 3.4 Hot water heat pumps in new non-residential buildings 3.5 High performance new municipal buildings 3.6 Heat pumps in new homes	**3. Net zero new construction**
4.1 Electrify the municipal fleet 4.2 Electrify personal vehicles 4.3 Electrify commercial vehicles 4.4 Electrify transit	**4. Reduce vehicle emissions**
4.5 Net zero aviation fuels for local flights 5.1 Increased walking and cycling 5.2 Reduced driving	**5. Increase active transportation and transit use**
6.1 Increased waste diversion 6.2 New waste to energy facility	**6. Reduce waste emissions**

Carbon liability

Box: Alignment With 1.5 Degrees

Greenhouse gas emissions targets at the local government level are an important planning tool for decreasing emissions. A target also demonstrates a commitment to climate action.

Since 2018, net-zero by 2050 has been the benchmark target for all jurisdictions around the world, including national, state, and local governments, with significant discussion on the importance of interim targets and pathways to the 2050 target. Net-zero by 2050 aligns with the goals of the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement and the Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C. Achieving this target decreases the likelihood of catastrophic global climate change impacts. As of June 2021, 137 national governments around the world, including the United States, have pledged to reach net-zero emissions by 2050 or sooner. Many state and local governments have also set net-zero by 2050 targets. Some of these governments have adopted more aggressive interim targets than their national governments, recognizing that interim targets and the pathway to net-zero are as or more important than the 2050 net-zero target itself.

Different pathways result in much more or much fewer emissions being released overall between now and 2050. The amount of emissions released over the next 30 years is just as significant for staying within the 1.5 degrees Celsius to 2.0 degrees Celsius warming threshold (recommended by the IPCC and UNFCCC Paris Agreement) as reaching net-zero by 2050. Delaying action results in more emissions released over the period before the target year. It also requires a transition so rapid as the target year approaches that actions may contribute to or create undesirable social and financial impacts.

Figure 10 *(on next page)* illustrates the spatial distribution of GHG emissions from buildings in Ames. Brighter yellow represents more emissions and a darker purple represents lower levels of emissions, helping to identify “hotspots” of emissions.

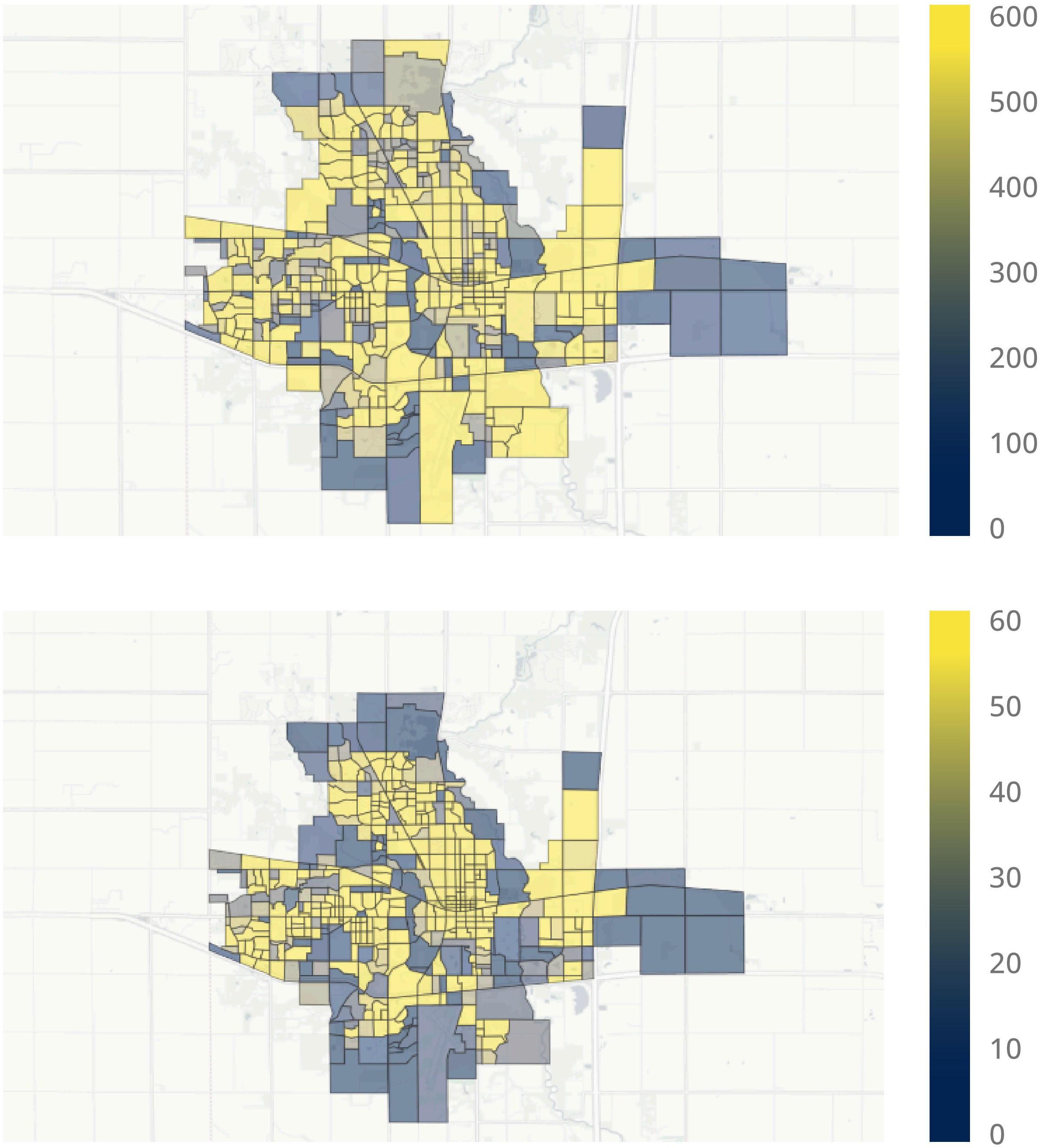


Figure 10. Spatial distribution of GHG emissions in 2020, total (top, MtCO2e) (top) and density (bottom, MtCO2e/ha).

A decarbonized Ames is a more efficient energy system, as demonstrated by the Sankey diagrams in Figure 11, which illustrate energy flows from source to end use to useful energy or conversion losses. The reduction in the share of conversion losses in 2050 indicates that more of the energy is used for its intended purposes, reducing the cost of the energy system. The Sankey diagrams highlight the magnitude of the transformation over the next 27 years from a predominantly fossil-fuel-powered system to a renewable-energy-powered system primarily from solar but which actually could come from wind or solar.

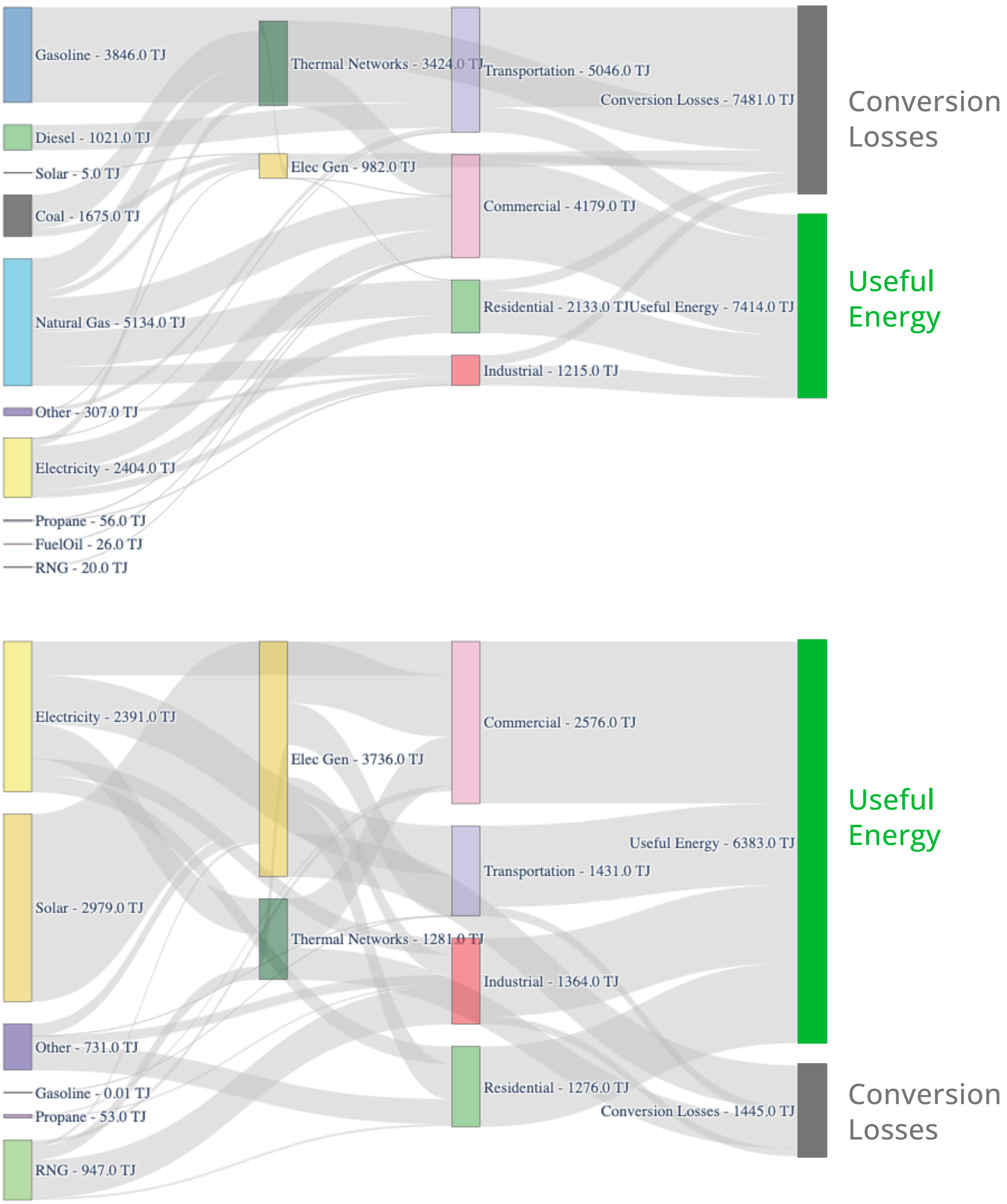


Figure 11. Sankey diagrams of energy flows in Ames in 2018 and in 2050 in the Low-Carbon scenario.


Thor

3.2 Buildings

Buildings currently account for 600,000 MtCO2e in Ames, primarily from the residential and commercial sectors, in equal measure. Space heating is the major source of emissions and half of the energy consumption. Electricity accounts for two-thirds of the emissions but half of the energy consumed, indicating that greening the electricity rapidly will be transformative.

In the Low-Carbon scenario, GHG emissions from buildings drop off rapidly around 2028 as electricity is decarbonized, heating is fuel switched to heat pumps, and building retrofits quickly ramp up simultaneously. Retrofits and heat pumps also reduce total energy consumption most significantly in the residential sector, but also in the commercial sector.

To further decrease the GHG intensity of building-related energy consumption, solar (local generation) scales up from 2030 onwards, while renewable natural gas is used to displace natural gas consumption, primarily between 2028 and 2033.

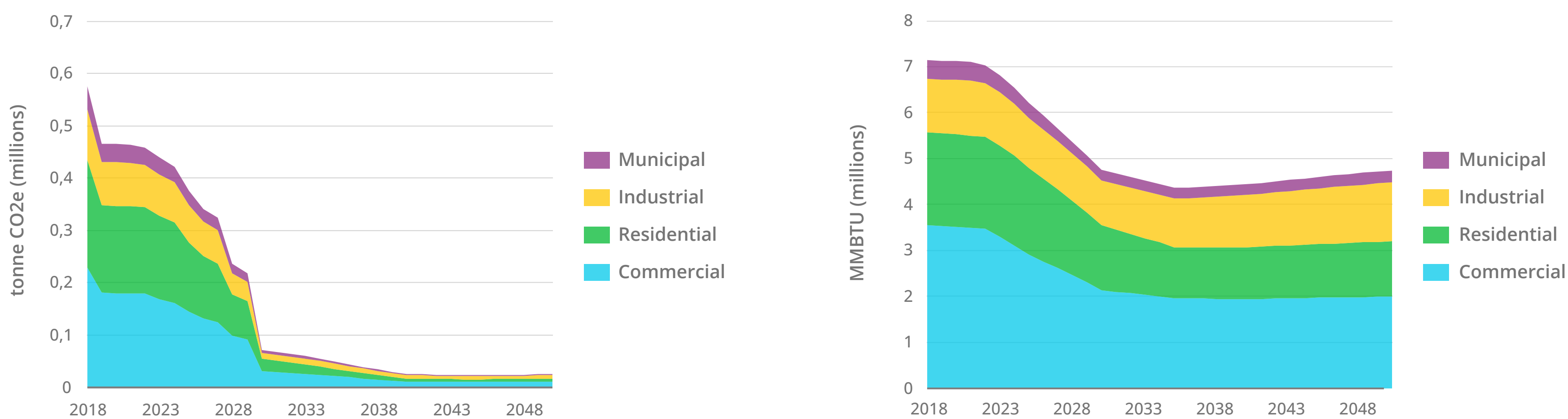
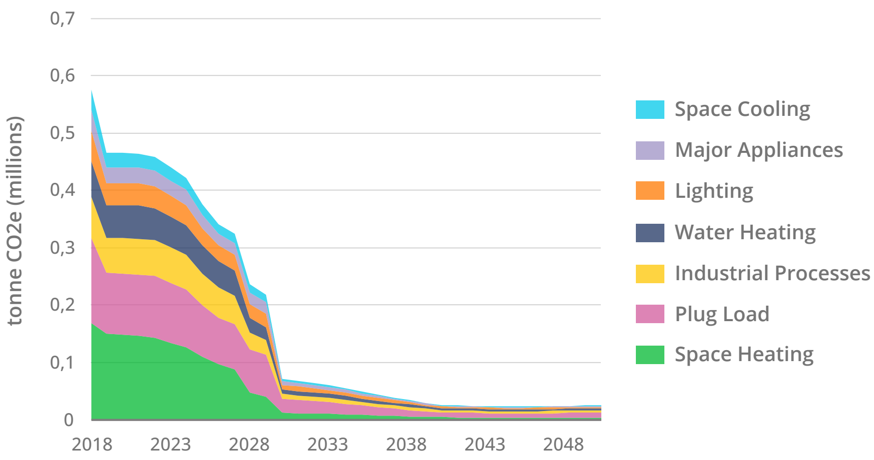


Figure 12. GHG emissions (left) and energy (right) for buildings by sector in the Low-Carbon scenario.



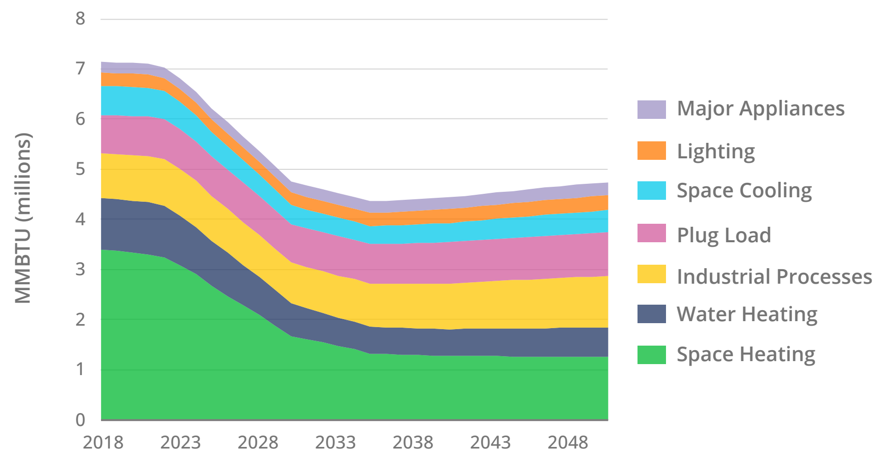
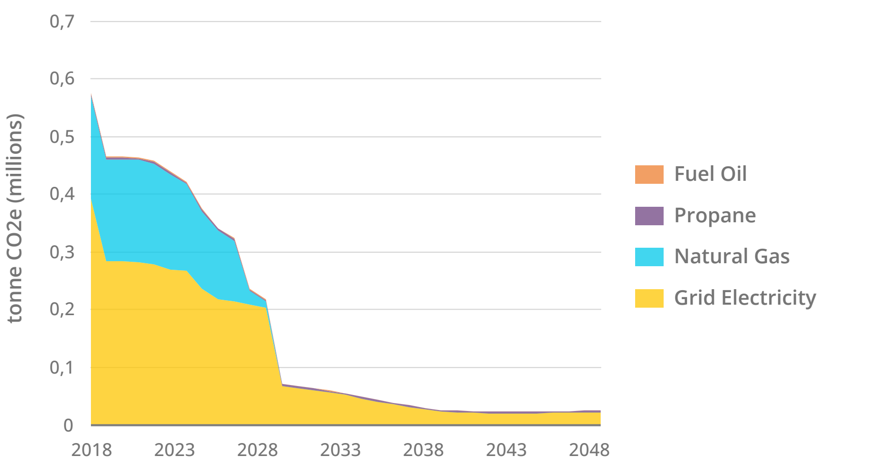


Figure 13. GHG emissions (left) and energy (right) for buildings by end use in the Low-Carbon scenario.



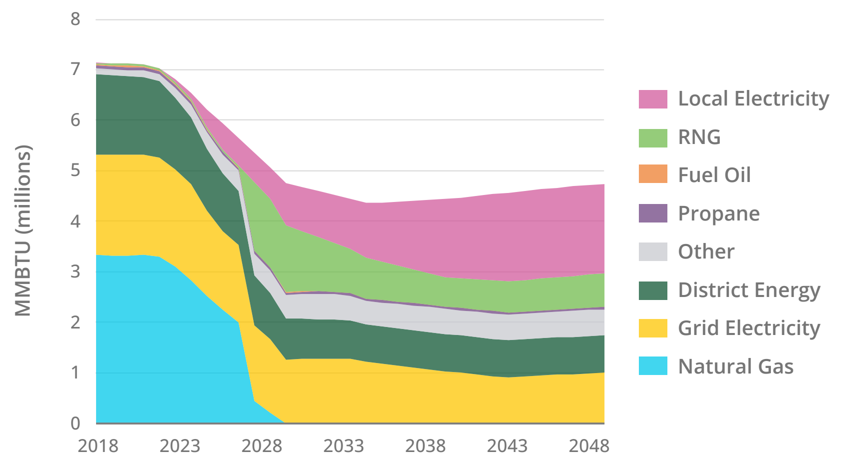
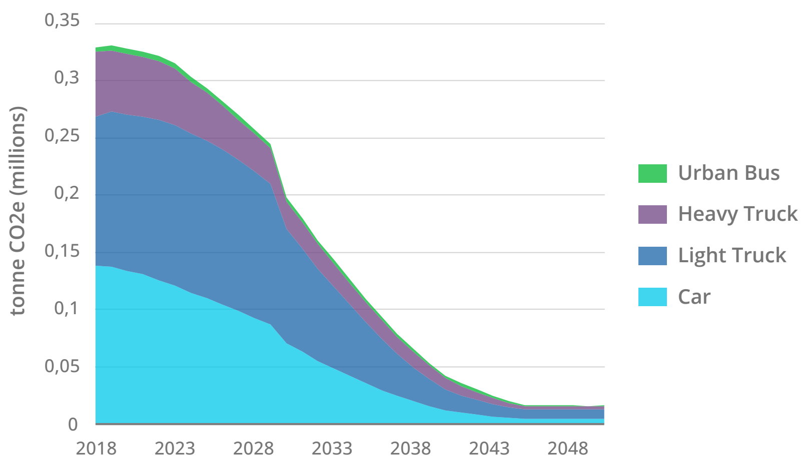


Figure 14. GHG emissions (left) and energy (right) for buildings by fuel in the Low-Carbon scenario.

3.3 Transportation

GHG emissions in transportation total 300,000 MtCO2e, the majority of which is split between cars and light trucks, with 10% from heavy trucks. Gasoline dominates as an energy source and as a source of GHG emissions. Dramatic reductions in energy consumption reflect the greater efficiency of the electric engine relative to the internal combustion engine. The combination of the efficiency gains and renewable electricity generation results in nearly eliminating GHG emissions from the transportation sector by 2050.



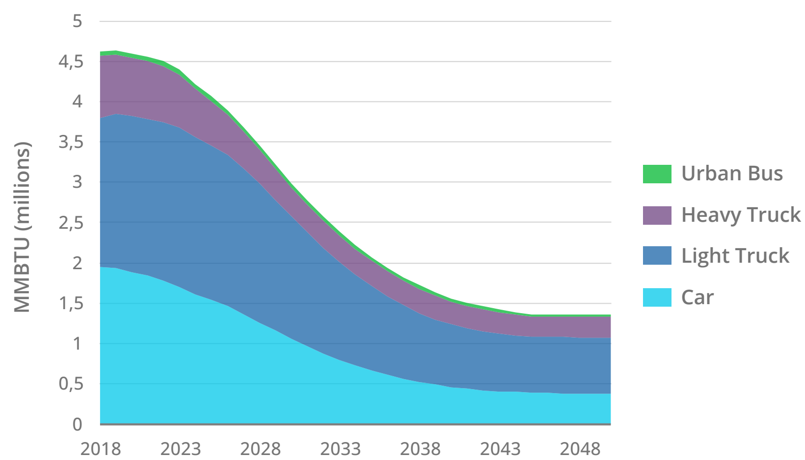


Figure 15. GHG emissions (left) and energy (right) for transportation by vehicle type in the Low-Carbon scenario.

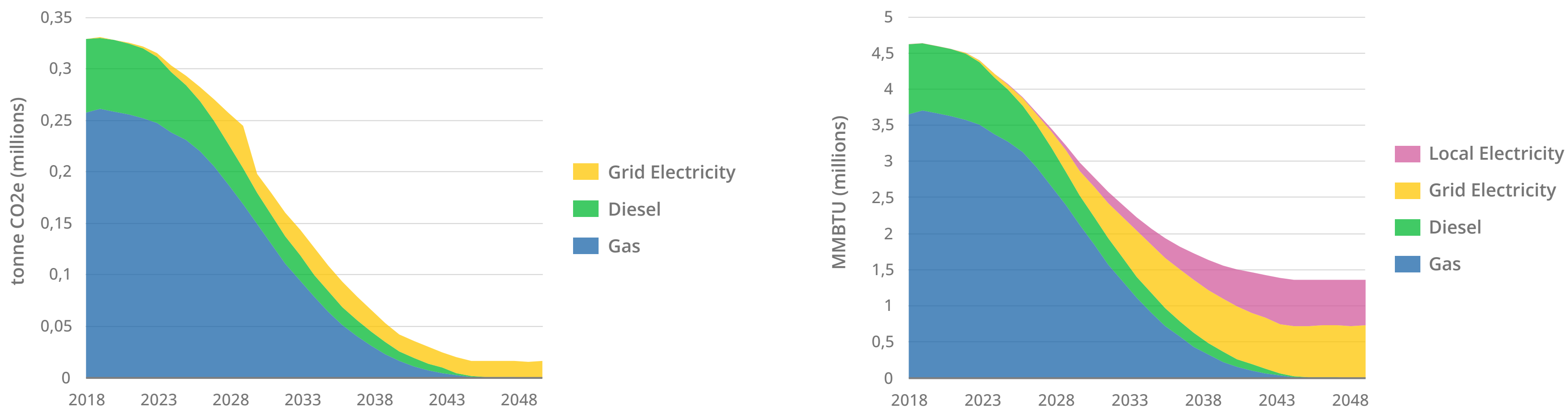


Figure 16. GHG emissions (left) and energy (right) for transportation by fuel in the Low-Carbon scenario.

This trajectory is enabled by the rapid transformation of the vehicle fleet, as illustrated in Figure 17, with accelerating adoption of electric vehicles out until 2045, with a S-curve pattern of adoption. In this scenario, 100% of new vehicle sales are electric by 2030, which is accelerated from current trends.

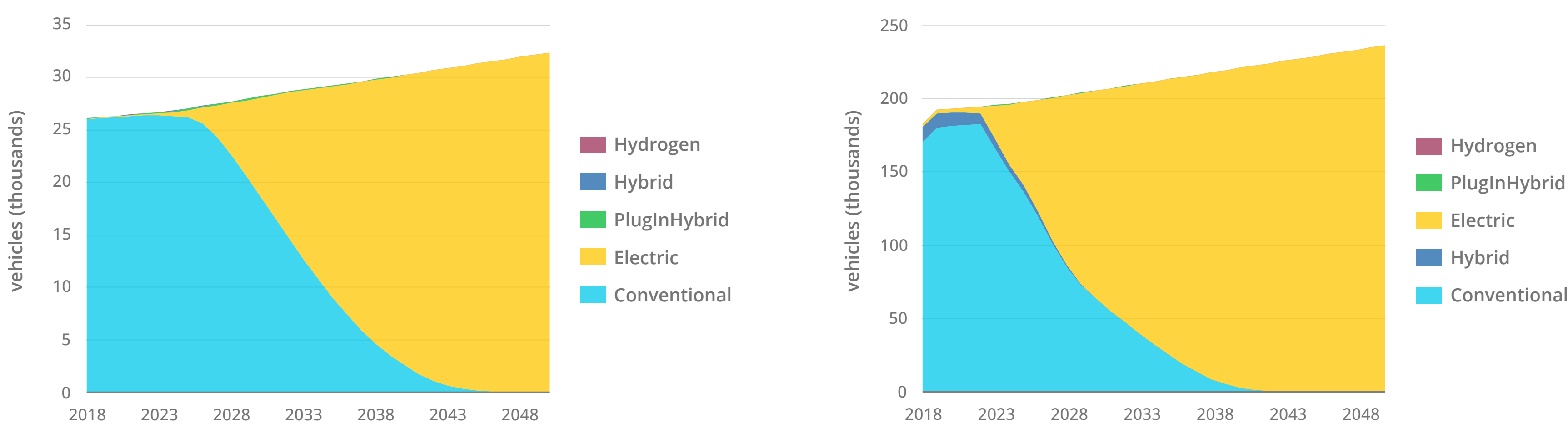


Figure 17. Vehicle share by type in the community (left) and for the City fleet (right) in the Low-Carbon scenario.

Wind in the Sails: The Growth of EVs

New technologies such as electricity, televisions, mobile phones, the internet, and LED light bulbs are adopted with a similar pattern, which is described as an S-curve. Adoption rates are initially slow, pick up speed rapidly as they go mainstream, and then gradually slow down as the last holdouts are slow to adopt. EV purchases in the US reached 5% in 2021[18], a tipping point when a technology becomes mainstream and rapid adoption will occur. There are multiple barriers to overcome to increase the rate of adoption, including cost, availability, and charging infrastructure.

3.4 Energy

As a result of efficiency gains due to electrification combined with retrofits, the energy system in Ames is more efficient, requiring just over half of the energy in 2050 that was used in 2018 as is demonstrated by the efficiency gains in transportation and heating consumption. These gains ease the effort required to decarbonize the electricity grid as less new renewable generation is required as well as fewer upgrades to transmission and distribution. The result is relatively lower household energy costs due to less upward pressure on per unit electricity costs and reduced requirements for the total units of electricity.

The transformation of the fuel mix is illustrated in Figure 20, as gasoline and diesel decline out until 2040 and are replaced primarily by electricity and to a lesser extent by renewable natural gas.

[18] Bloomberg (2023). US Crosses the Electric-Car Tipping Point for Mass Adoption. Retrieved from:https://www.bloomberg.com/news/articles/2022-07-09/us-electric-car-sales-reach-key-milestone?leadSource=uverify%20wall

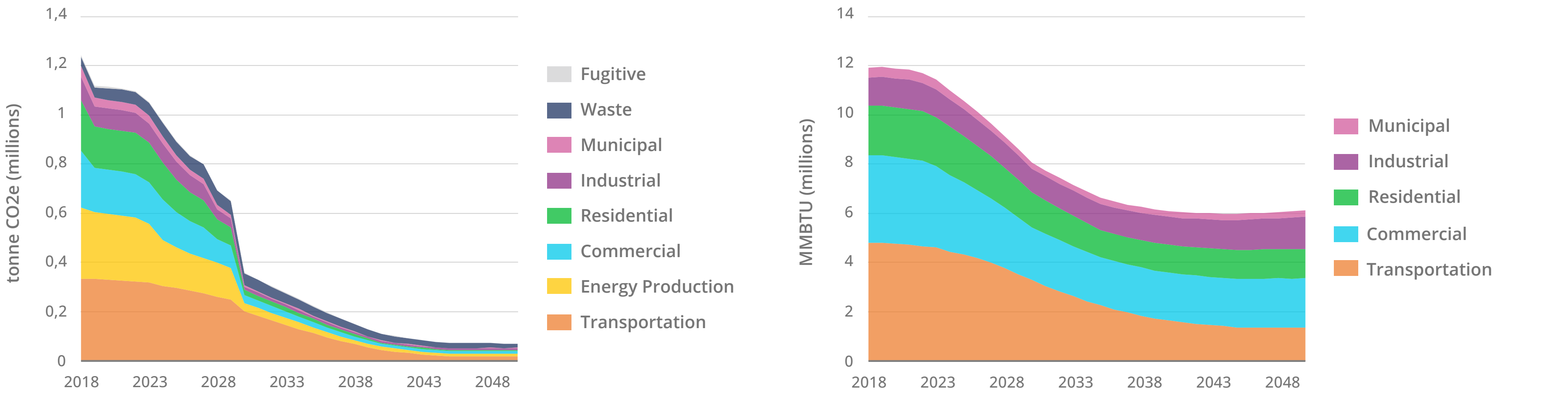


Figure 18. Total GHG emissions (left) and energy (right) by sector in the Low-Carbon scenario.

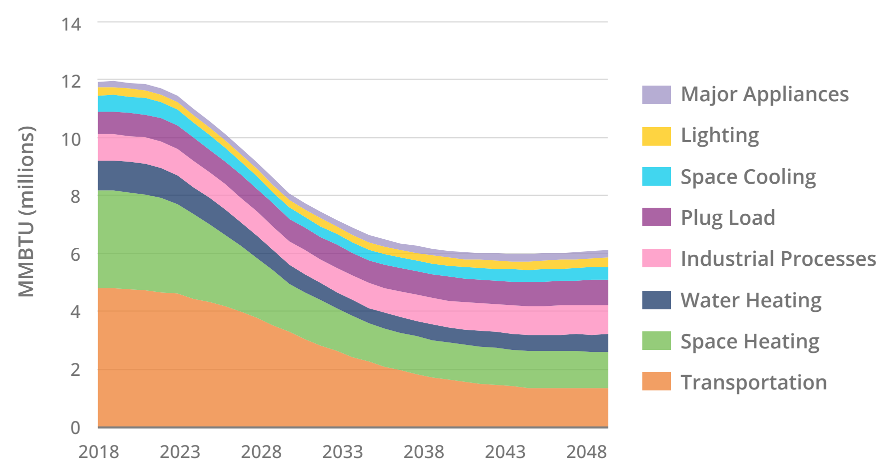
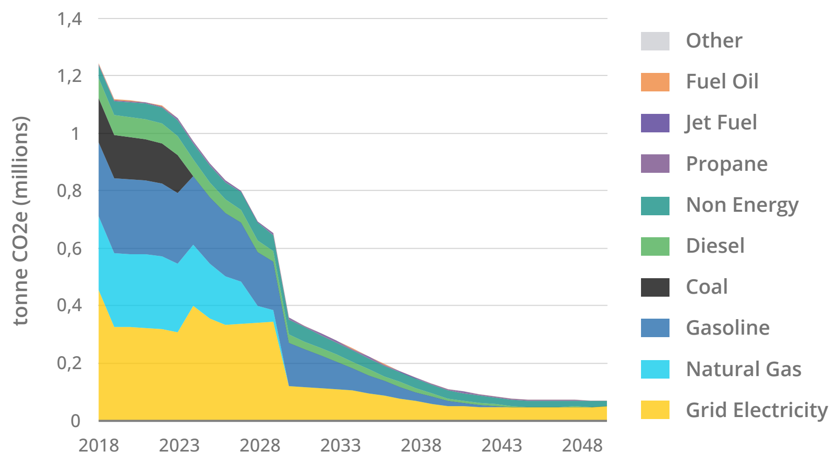


Figure 19. Total energy (right) by end use in the Low-Carbon scenario.



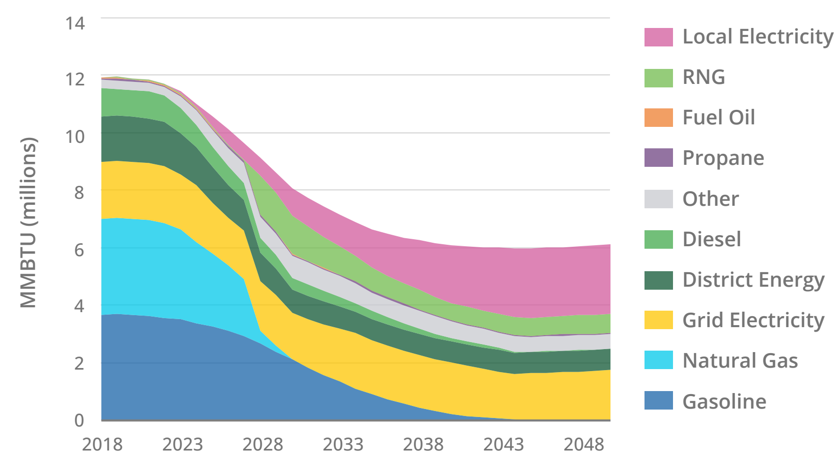


Figure 20. Total GHG emissions (left) and energy (right) by fuel in the Low-Carbon scenario.

Efficiency Gains From EVs and Heat Pumps

Heat pumps deliver three or more units of heat for every unit of electricity they consume, a ratio known as the coefficient of performance (COP). In contrast, a natural gas furnace produces 0.9 units of heat for every unit of energy consumed and electric baseboards consume one unit of heat for each unit of energy consumed. In periods of extreme cold, the COP may decline below this level, but the COP of cold weather air-source heat pumps continues to improve in cold temperatures.[19] EVs are three times more efficient than gasoline vehicles. An EV transfers about 59–62%of the electrical energy from the grid goes to turning the wheels, whereas gas combustion vehicles only convert about 17–21% of energy from burning fuel into moving the car.[20]

[19] US Department of Energy (2022). DOE Announces Breakthrough in Residential Cold Climate Heat Pump Technology. Retrieved from: https://www.energy.gov/articles/doe-announces-breakthrough-residential-cold-climate-heat-pump-technology
[20] Department of Energy (n.d.). All-electric Vehicles. https://www.fueleconomy.gov/feg/evtech.shtml

3.5 Waste

Approximately 50,000 metric tons of waste is currently produced in Ames, of which 65% is combusted and a relatively small share is shipped to a landfill. In the Low-Carbon scenario, combustion decreases in favor of composting and increased recycling. Additionally, any remaining combustion processes use minimal natural gas due to upgrades to the waste-to-energy plant. Overall GHG emissions decrease from 50,000 MtCO2e to under 20,000 MtCO2e by 2050.

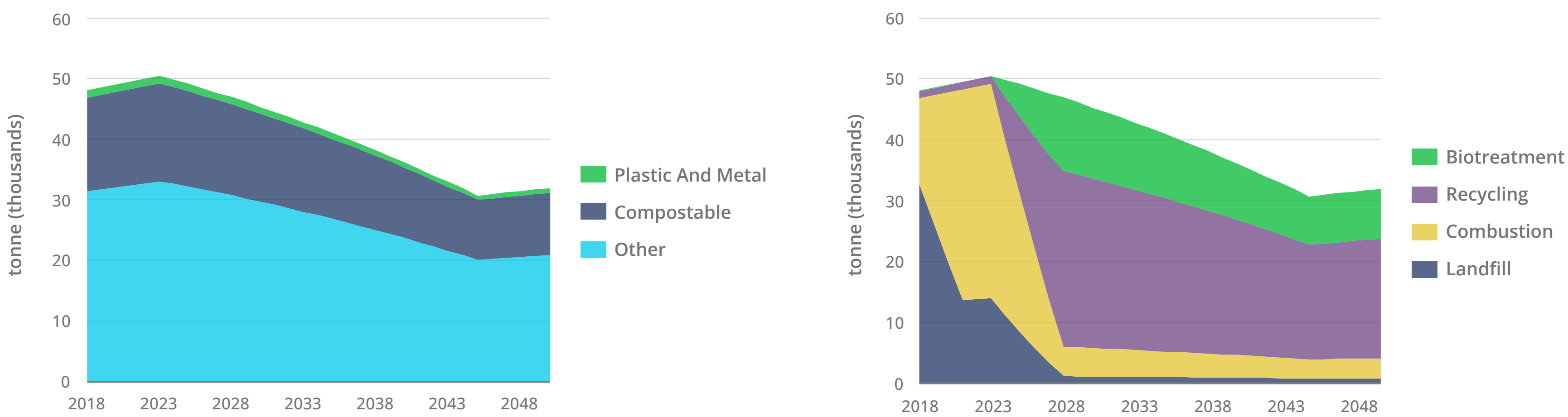


Figure 21. Waste generation by type (left) and treatment processes (right) in the Low-Carbon scenario.

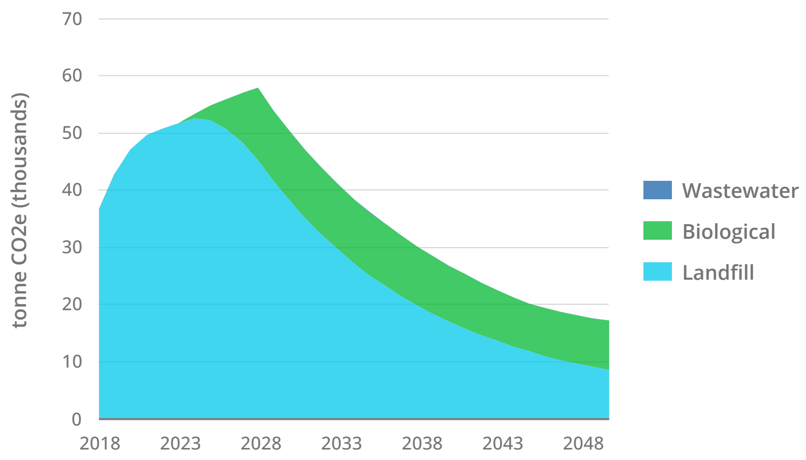
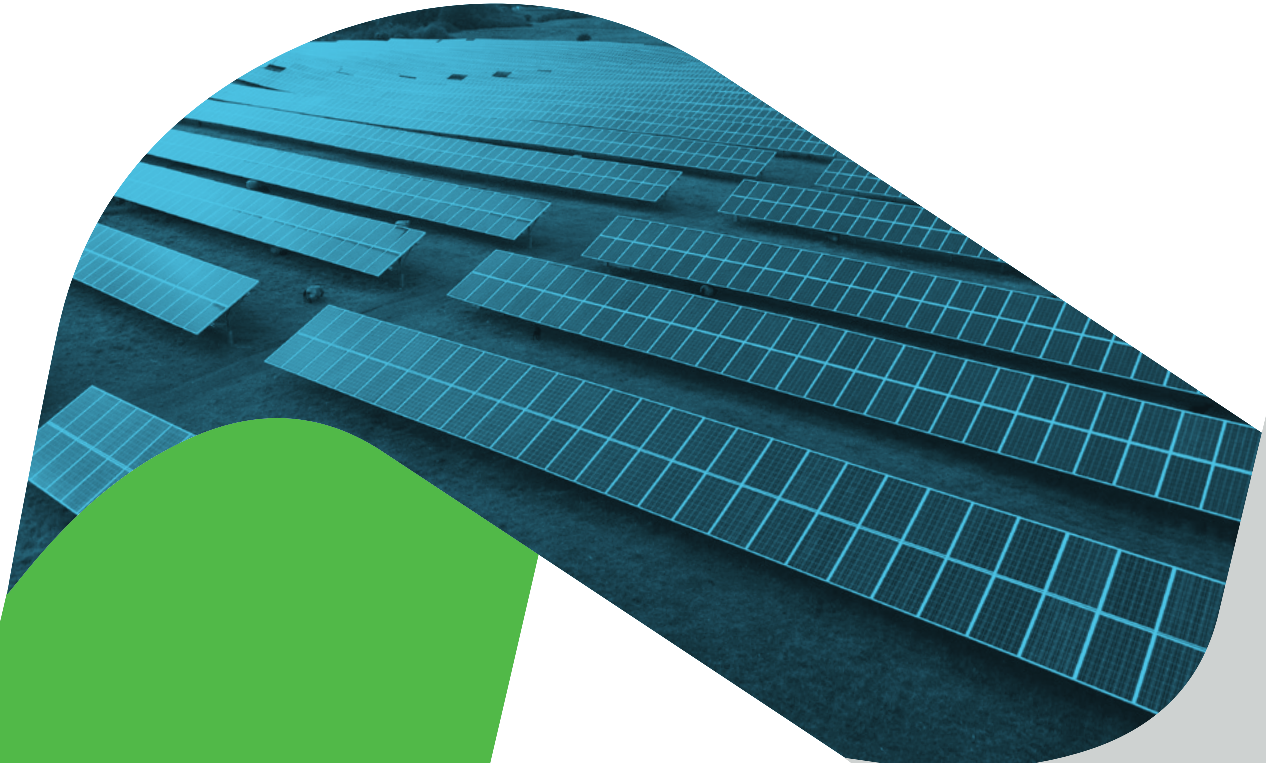


Figure 22. GHG emissions by source in the Low-Carbon scenario.



4.
The Costs and Opportunities

4. The Costs and Opportunities

Key Concepts

Key concepts that are used to analyze the financial impacts of the pathways are summarized below.[21]

Table 4. Financial concepts.

Concept	Explanation
Costs are relative to the BAP scenario	This financial analysis tracks projected costs and savings associated with low-carbon measures above and beyond the costs in the BAP scenario.
Discount Rate	The discount rate is the baseline growth value an investor places on their investment dollar. A project is considered financially beneficial by an investor if it generates a real rate of return equal to or greater than their discount rate. An investor's discount rate varies with the type of project, duration of the investment, risk, and the scarcity of capital. The social discount rate is the discount rate applied for comparing the value to society of investments made for the common good and, as such, it is inherently uncertain and difficult to determine. Some argue that a very low or even zero discount rate should be applied in the evaluation of climate change mitigation investments. In this project, we evaluate investments in a low-carbon future with a 3% discount rate.[22]

[21] Detailed financial assumptions are described in the Data, Methods and Assumptions Manual.

[22] Environment and Climate Change Canada. (2016). Technical update to Environment and Climate Change Canada's social cost of greenhouse gas estimates. Retrieved from http://ec.gc.ca/cc/BE705779-0495-4C53-BC29-6A055C7542B7/Technical%20Update%20to%20Environment%20and%20Climate%20Change%20Canadas%20Social%20Cost%20of%20Greenhouse%20Gas%20Estimates.pdf

(continued from previous table)

Concept	Explanation
Net Present Value	The net present value (NPV) of an investment is the difference between the present value of the capital investment and the present value of the future stream of savings and revenue generated by the investment. Four aggregate categories are used to track the financial performance of the low-carbon actions in this analysis: capital expenditures, energy savings (or additional costs), operations and maintenance savings, and revenue generation (associated with renewable energy production facilities and some transit actions). Administrative costs associated with implementing programs, as well as any energy system infrastructure upgrades that may be required, are excluded. Similarly, the broader social costs that are avoided from mitigating climate change, such as avoided health costs or avoided damages from climate change, are not included in this financial analysis.
Abatement Cost	The abatement cost of an action is the estimated cost for that action to reduce one metric ton of GHG emissions, calculated by dividing the action's NPV by the total GHG emissions reductions (tCO2e) resulting from the action. For example, if a project has an NPV of $1,000 and generates 10 tCO2e of savings, its abatement cost is $100 per tCO2e reduced.
Amortization	The costs of major capital investments are typically spread over a period of time (e.g. a mortgage on a house commonly has a 25-year mortgage period). Amortization refers to the process of paying off capital expenditures (debt) through regular principal and interest payments over time. In this analysis we have applied a 25-year amortization rate to all investments.[23]

[23] To manage the complexity of the analysis, a blanket amortization of 25 years was applied across all actions in order to demonstrate the impact of financing the actions.

4.1 The Big Picture: Economic Benefits

The headline finding of the economic analysis is that the Low-Carbon scenario results in a net benefit of $570 million between 2023 and 2050 and a new cost of $300 million when discounted at 3%.

Table 5. Summary of financial results, undiscounted (negative number = savings, positive number = cost) 2023–2050.

Financial Estimate	Low-Carbon Scenario (undiscounted)	Low-Carbon Scenario (3% discount rate)
Total incremental capital investment, 2023–2050	$3.2 billion	$2.4 billion
Total savings between 2023 and 2050 (energy cost savings and operations and maintenance savings)	$3 billion	$1.5 billion
IRA funding programs	$770 million	$600 million
Net cost, 2023–2050	-$570 million	$300 million
Capital cost (undiscounted) to reduce each metric ton of GHG[24]	$149	
Abatement cost (NPV) per metric ton of GHG		$14
Annual household savings on energy, 2050 over 2021	$1,950	
Average investment/person-year of employment	$43,000	

The implementation of the Low-Carbon scenario represents a total investment of $3.2 billion from 2023 to 2050, averaging $120 million annually (undiscounted). Billions of dollars in investment can seem overwhelming, but for context, the GDP of Iowa was $180 billion in 2021, so this annual investment represents less than 0.07% of the current state GDP, or just over 10% of what is spent annually in Ames on buildings, vehicles, and energy.[25]

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[24] Total reduction as a result of the Low-Carbon pathway is 21.3 MMTCO2e between 2023 and 2050.

[25] SSG calculates annual expenditures on energy-related stocks of equipment, buildings, and vehicles as part of this analysis. In 2023, the community of Ames spent $1.05 billion in these sectors.

This capital investment generates undiscounted savings of $3 billion from energy expense savings and from avoided operations and maintenance costs. This benefit transfers to the community as a whole, including households, businesses, and the municipality itself. The financial benefit would decrease if the investments are financed as a result of interest payments, while it would increase if natural gas prices increase more rapidly than electricity prices.

When the benefit of IRA (see box below) is included, the net cost decreases to $300 million from $0.9 billion.

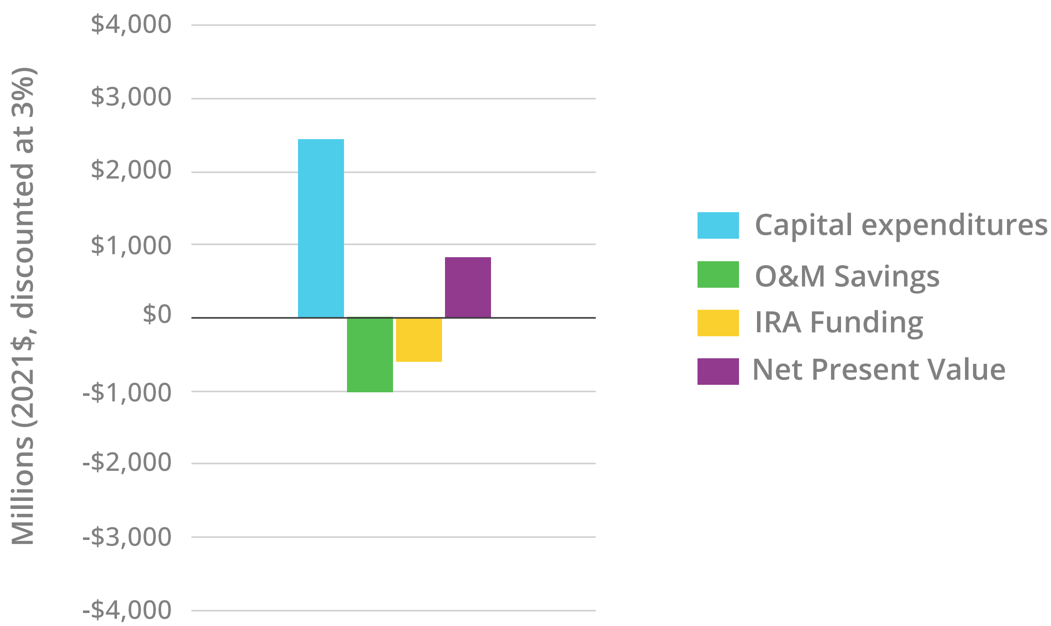


Figure 23. Present values of investments and returns for the Low-Carbon scenario, discounted at 3% (costs are positive and revenue and savings are negative), from 2023 to 2050.

4.2 Investments Unlock the Opportunities

The annual costs, savings, and revenue associated with fully implementing the actions in the Low-Carbon scenario are shown in Figure 24, with capital expenditures shown in full for the years in which they are incurred. These expenditures occur on top of the background expenditures in these sectors, which total approximately $1 billion per year. As is characteristic of low-carbon transitions, the capital expenditures in the early years of the transition are greater than the savings and revenues generated, but by 2036, the savings outweigh the costs.

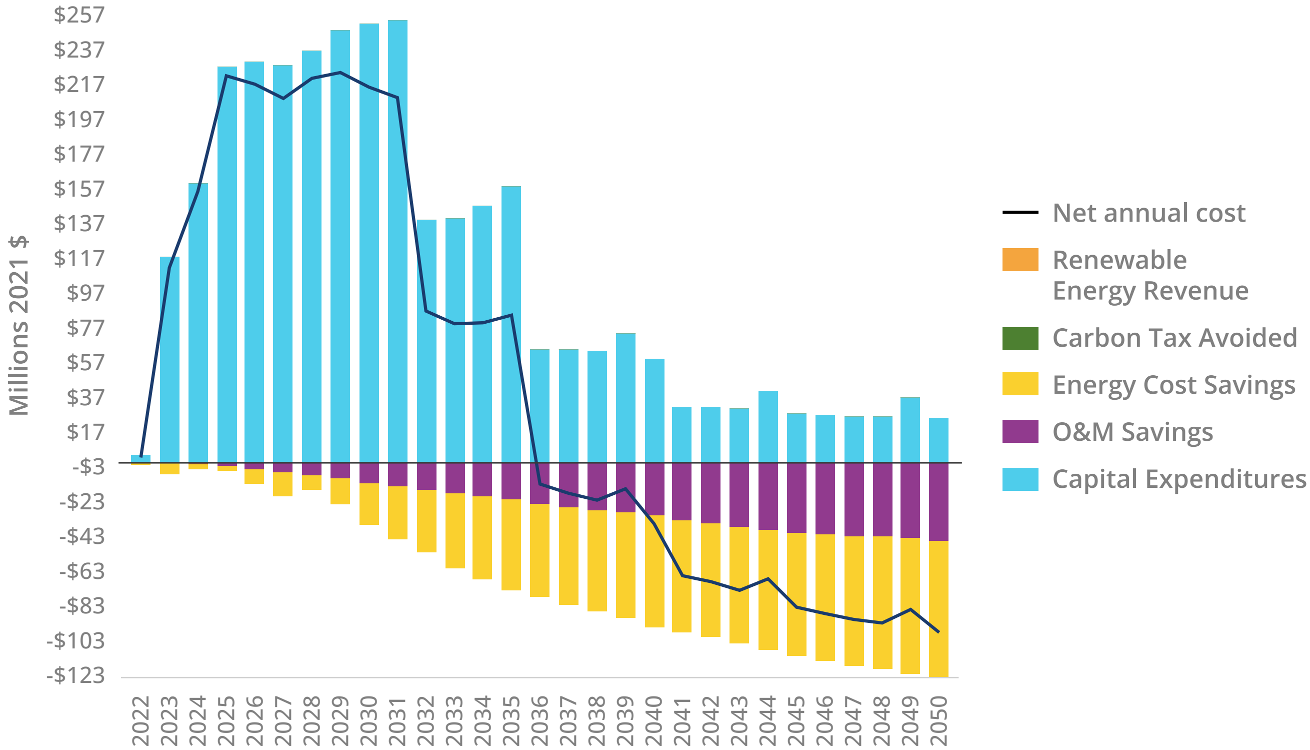
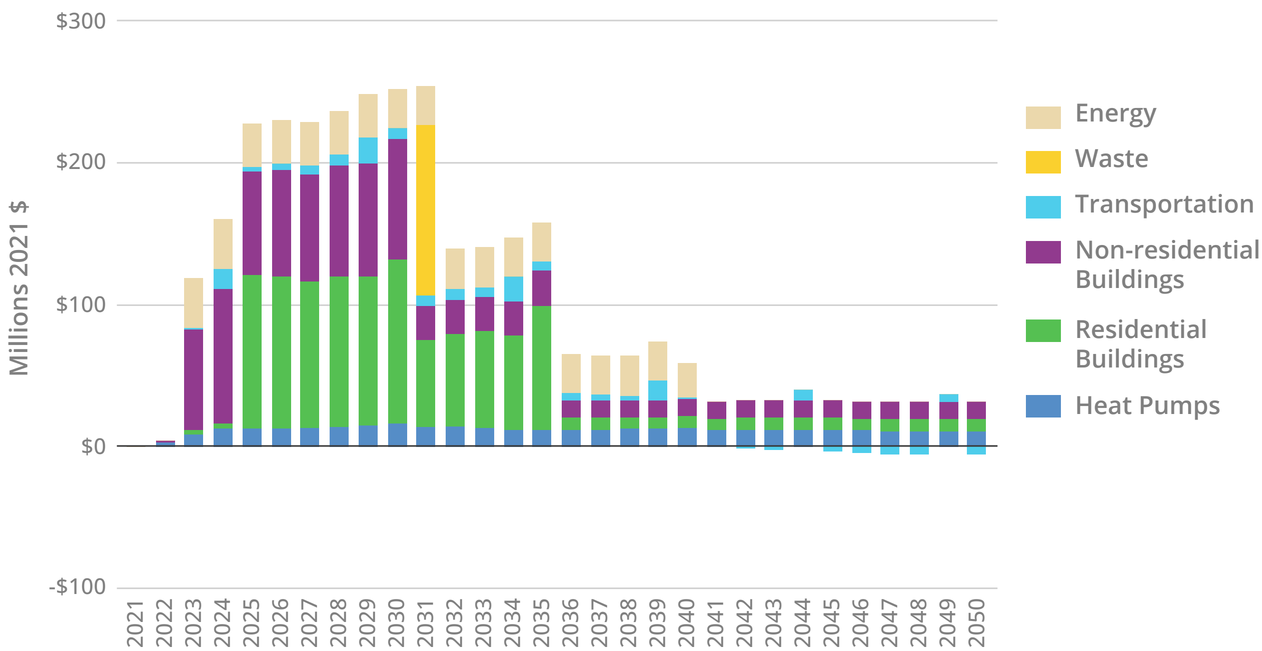


Figure 24. Year-over-year low-carbon scenario investments and returns, undiscounted. The break-even point occurs in 2036.

The majority of investments are for building retrofits. The need to retrofit existing homes dominates the investment of the Low-Carbon scenario. The incremental investment in transportation is negligible because the costs of electric vehicles are projected to reach parity with internal combustion engines as early as 2027. The reduced operational costs represent a major opportunity for cost savings going forward. Figure 25 shows the capital investments amortized over 25 years with 3% interest, resembling how the actions would likely be financed. Amortization reduces the annual capital requirements by nearly half for peak investment years, with the result of repayments decreasing to nothing beyond 2070.



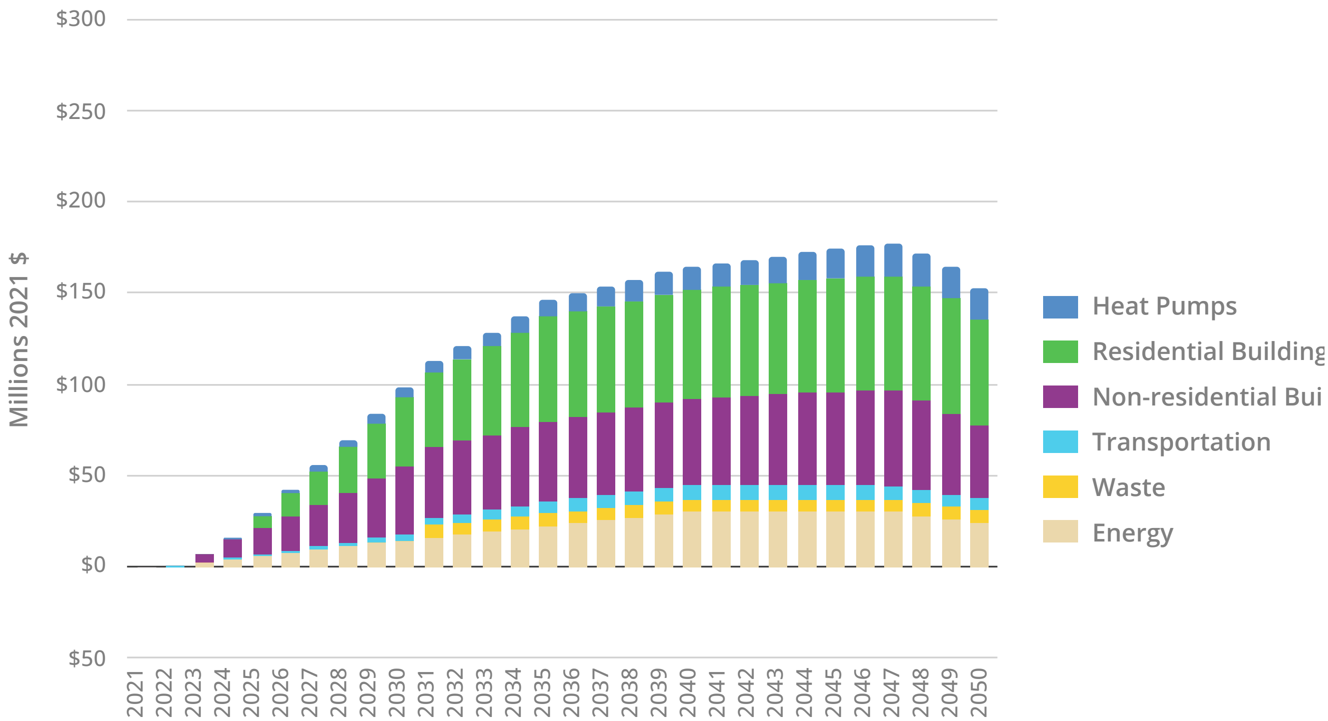


Figure 25. Two views on capital expenditures, on a cash basis and amortized.

4.3 Energy Expenditures Decrease

Figure 26 illustrates energy expenditures by sector. All sectors see financial benefits from reduced energy costs through improved energy efficiency and a reduction in total energy demand. Savings on energy are nearly $100 million annually by 2050 and continue beyond 2050, the end of the study period.

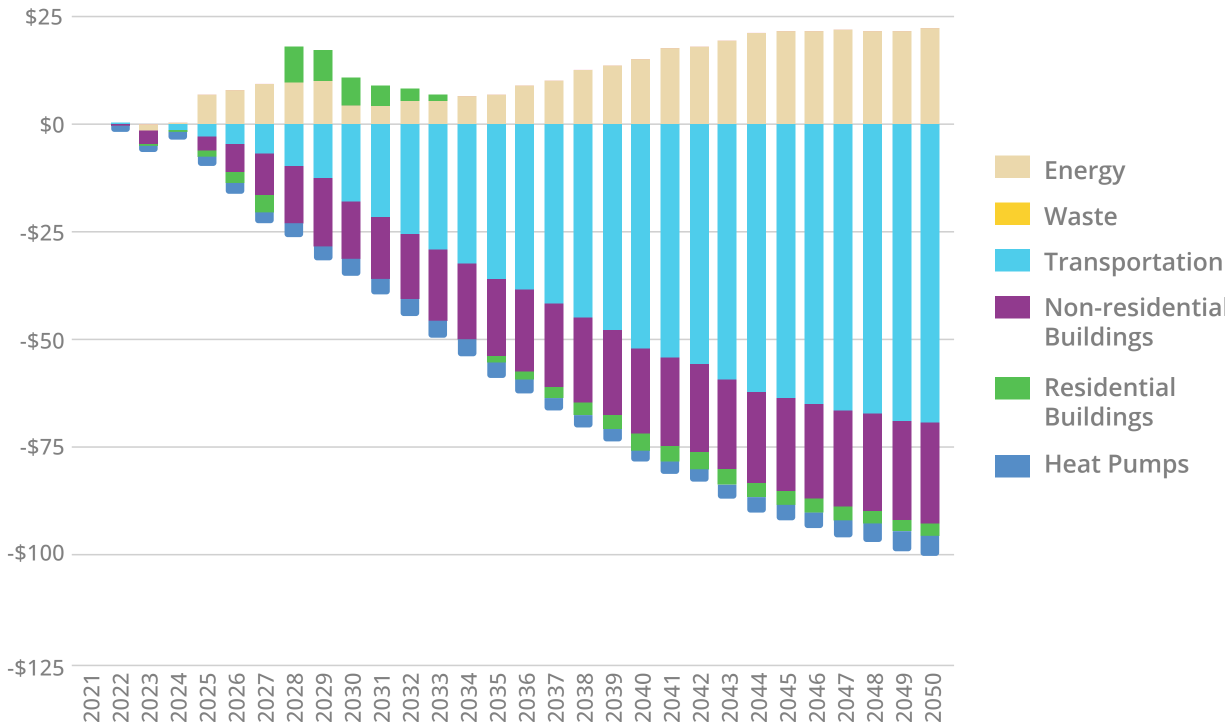


Figure 26. Financial savings from reduced energy expenditures by sector, undiscounted.

The Inflation Reduction Act

The Inflation Reduction Ac is the most extensive and ambitious piece of climate legislation in US history and is designed to transform the US economy. The IRA reinforces many aspects of Ames' CAP, by providing opportunities for the City to raise funds and by providing grants and incentives to individuals and businesses to support low-carbon investments.

Municipalities can apply directly to federal agencies for funding for a range of programs, including:[26]

- A Greenhouse Gas Reduction Fund, which will provide grants, loans, and financial and technical assistance "to enable low-income and disadvantaged communities to deploy or benefit from zero-emission technologies," including rooftop solar and other GHG reduction activities, and provide direct and indirect investment in projects, activities, or technologies;
- Climate Pollution Reduction Grants which provide grants to implement GHG pollution reductions;
- Clean Heavy-Duty Vehicles, which funds a program to cover incremental costs associated with replacing non-zero-emissions heavy-duty vehicles with zero-emissions heavy-duty vehicles, fueling and charging infrastructure, and facilitating workforce development and technical activities.
- A Low-Emissions Electricity Program, which will provide funding for technical assistance for domestic electricity generation and use;
- The Neighborhood Access and Equity Grant Program, which will provide funding for highway removal, remediation, or capping; mitigating local impacts of highways; building or improving "complete streets, multi-use trails, regional greenways, or active transportation networks"; and providing "affordable access to essential destinations, public spaces, or transportation links and hubs;
- The Environmental and Climate Justice Block Grants, which will providing funding for community-led air and other pollution monitoring, prevention, and remediation, and investments in low- and zero-emission and resilient technologies; mitigation of urban heat islands, extreme heat, wood heater emissions, and wildfires; reducing indoor air pollution; climate resilience and adaptation; and facilitating engagement of disadvantaged communities; and
- The State and Private Forestry Conservation Programs, which will support tree planting activities.

[26] Sabin Center for Climate Change Law (2022). Cities & the Inflation Reduction Act. https://blogs.law.columbia.edu/climatechange/2022/08/22/cities-the-inflation-reduction-act/

The IRA also includes tax credits and grants that go directly to consumers for vehicle and building electrification and distributed energy generation, including:

- Rebates covering 50–100% of the cost of installing new electric appliances, including super-efficient heat pumps, water heaters, clothes dryers, stoves, and ovens;
- Rebates for households to make repairs and improvements in single-family and multi-family homes to increase energy efficiency;
- Tax credits covering 30% of the costs to install solar panels and battery storage systems, make home improvements that reduce energy leakage, or upgrade heating and cooling equipment. No income limits apply;
- Tax credits covering 30% of the costs of community solar projects—owned by local businesses that sign up families to save on their electric bills—with additional bonus credits of 20% for projects at affordable housing properties and 10% for projects in low-income communities; and
- Upfront discounts of up to $7,500 for new EVs and $4,000 for used EVs, helping middle-class Americans skip the gas pump and save on fuel costs.

The impacts of IRA funding in different action categories are shown in Figure 27.

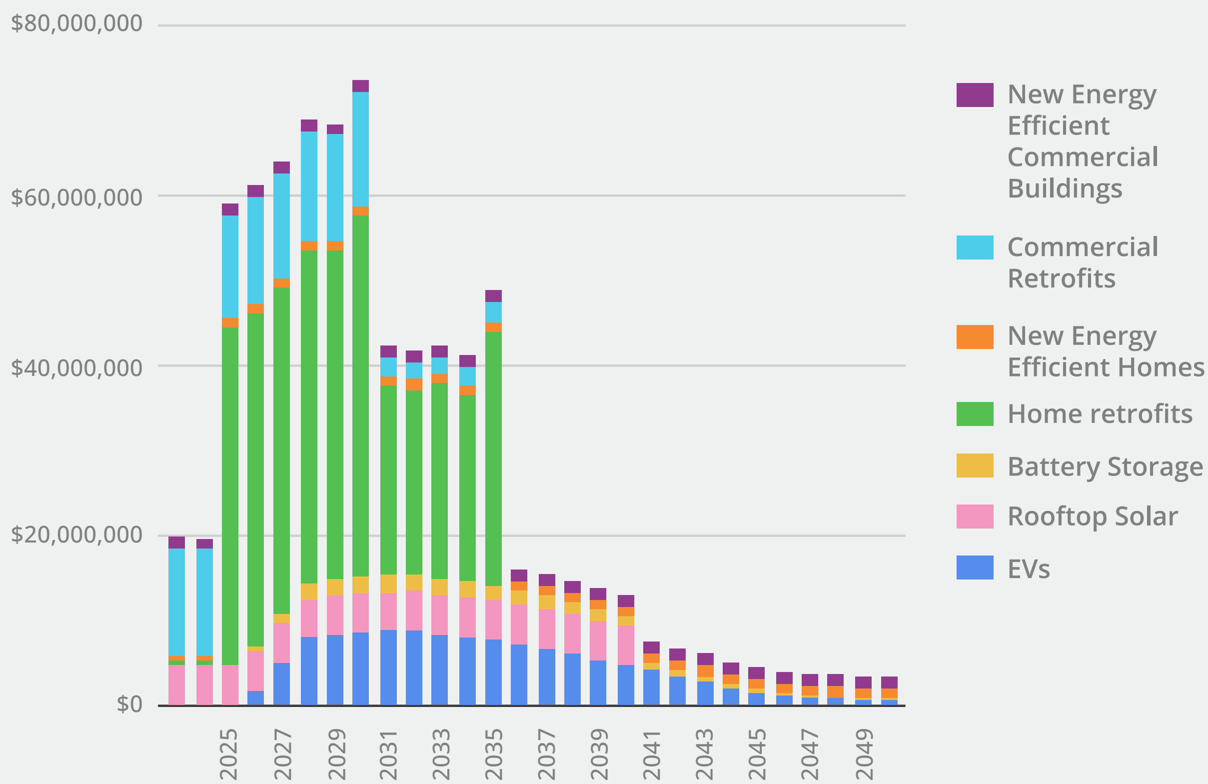


Figure 27. IRA investments by category.

4.4 Energy Savings for Households

Household energy expenditures (Figure 28)—natural gas, electricity, gasoline, and diesel—are projected to decline by 13% in the BAP, from $3,600 in 2021 to $3,150 by 2050. These savings result from more-efficient vehicles due to national fuel efficiency standards and decreased heating requirements as the climate becomes milder due to climate change. In the Low-Carbon scenario, savings are greater and household energy expenditures fall by 47% to $1675 by 2050. Depending on the business, policy, and financing strategies used to implement the actions, these savings will be partly offset by the incremental capital expenditures required.

Gasoline and diesel expenses are removed through the electrification of vehicles. Natural gas furnaces are replaced with electric heat pumps as part of the deep retrofits, which minimizes the heat required to ensure homes are comfortable in the summer and the winter.

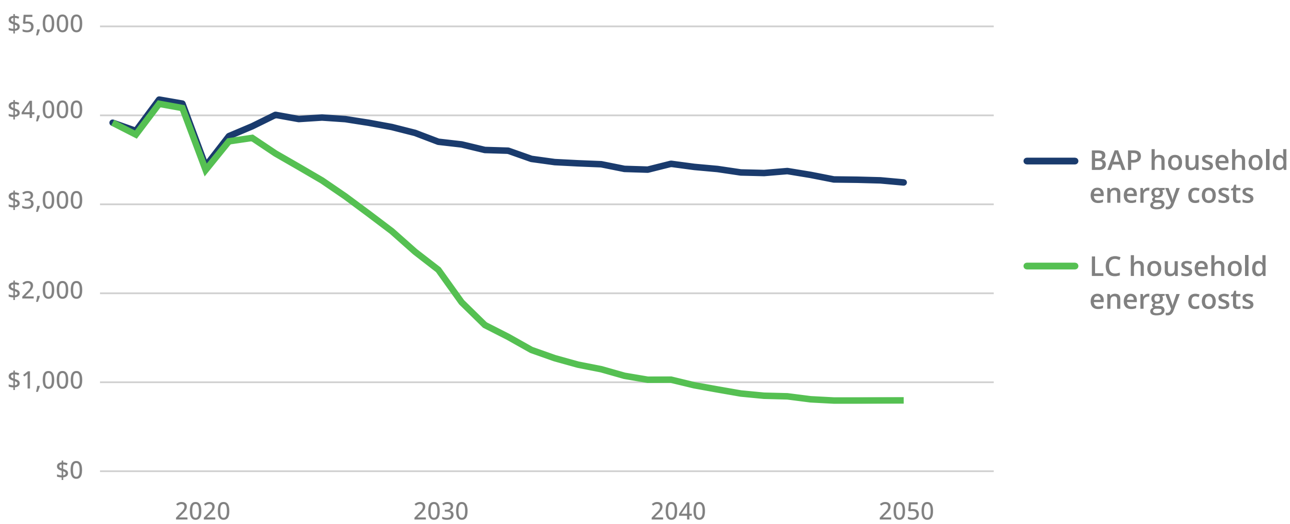


Figure 28. Household energy costs by fuel type for the Low-Carbon scenario compared to the BAP.

Household expenditures on energy can result in energy poverty, which can have a range of impacts. For example, households experiencing energy poverty or energy insecurity face challenges such as "pay the rent or feed the kids", "heat or eat", or "cool or eat".[27] In particular, energy insecurity disempowers low-income residents such as single parents, the elderly, persons with disabilities, and others with low or fixed incomes,[28] resulting in stresses such as utility-related debt, shutoffs, inefficient

[27] Cook, J. T., Frank, D. A., Casey, P. H., Rose-Jacobs, R., Black, M. M., Chilton, M., ... Cutts, D. B. (2008). A brief indicator of household energy security: Associations with food security, child health, and child development in US infants and toddlers. PEDIATRICS, 122(4), e867–e875. https://doi.org/10.1542/peds.2008-0286

[28] Hernández, D. (2013). Energy insecurity: A framework for understanding energy, the built environment, and health among vulnerable populations in the context of climate change. American Journal of Public Health, 103(4), e32–e34. https://doi.org/10.2105/AJPH.2012.301179

heating systems, antiquated appliances, and extreme home temperatures with the potential of resulting in significant health impacts.[29] Children may experience nutritional deficiencies, higher risks of burns from non-conventional heating sources, higher risks for cognitive and developmental behavior deficiencies, and increased incidences of carbon monoxide poisoning.[30]

Energy Poverty

Households facing energy poverty, or energy insecurity, face difficult choices such as "heat or eat." [31] In particular, energy insecurity disempowers low-income residents such as single parents, the elderly, persons with disabilities, and others with low or fixed incomes.[32] Energy insecurity leads to stress such as food insecurity, utility-related debt, shutoffs, inefficient heating systems, antiquated appliances, and extreme home temperatures with significant health impacts.[33] This is only exacerbated when combined with the higher expense of vehicle ownership than that of active or public transportation. In an energy poverty context, children may experience nutritional deficiencies, higher risks of burns from non-conventional heating sources, poor indoor air quality, high risks for cognitive and developmental behavior deficiencies, and increased incidences of carbon monoxide poisoning.[34] Subsequent impacts include parents being unable to work in order to look after children, missed school days, and lost productivity.

[29] Hernández, D., & Bird, S. (2010). Energy burden and the need for integrated low-income housing and energy policy. Poverty & Public Policy, 2(4), 5–25. https://doi.org/10.2202/1944-2858.1095
[30] Ibid.

[31] Cook, J. T., Frank, D. A., Casey, P. H., Rose-Jacobs, R., Black, M. M., Chilton, M., ... Cutts, D. B. (2008). A brief indicator of household energy security: Associations with food security, child health, and child development in US infants and toddlers. PEDIATRICS, 122(4), e867–e875. https://doi.org/10.1542/peds.2008-0286

[32] Hernández, D. (2013). Energy insecurity: A framework for understanding energy, the built environment, and health among vulnerable populations in the context of climate change. American Journal of Public Health, 103(4), e32–e34. https://doi.org/10.2105/AJPH.2012.301179

[33] Hernández, D., & Bird, S. (2010). Energy burden and the need for integrated low-income housing and energy policy. Poverty & Public Policy, 2(4), 5–25. https://doi.org/10.2202/1944-2858.1095
[34] Ibid.

4.5 Employment Opportunities

Transitioning to a low- or zero-carbon economy is expected to have four impact categories on labor markets: additional jobs will be created in emerging sectors, some employment will be shifted (e.g. from fossil fuels to renewables), certain jobs will be reduced or eliminated (e.g. combustion engine vehicle mechanics), and many existing jobs will be transformed and redefined. The Low-Carbon scenario adds 19,000 person-years of employment over the BAP scenario between 2023 and 2050 (Figure 29).

Building retrofits present the largest opportunity for new employment, presenting opportunities to partner with local education centers. This could include developing programs to teach the skills required to complete deep energy retrofits and install high-efficiency equipment. Developing partnerships to expand on local knowledge will help jump-start this activity.

In addition to building retrofits, improvements can simultaneously be made to the accessibility features of public buildings, buildings, and common areas.

The transportation maintenance sector shows small losses in total person-years of employment, since electric vehicles require less maintenance than internal combustion engines.

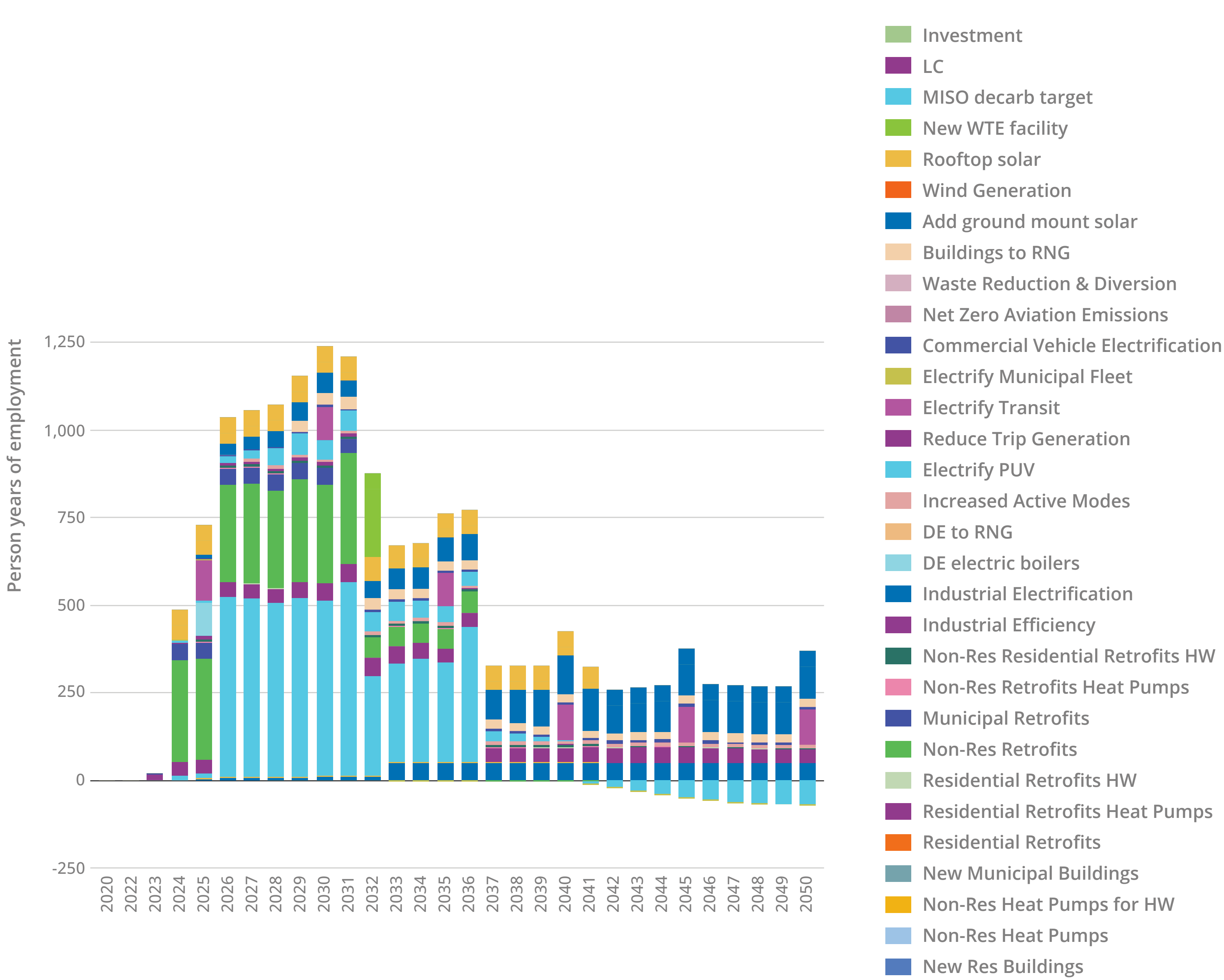


Figure 29. Annual person-years of employment generated in the Low-Carbon scenario.

4.6 Abatement Costs

The marginal abatement cost (MAC) is the incremental cost of one metric ton of GHG reductions. The lower the cost, the more affordable the action, and in some cases, the action can be profitable. It is calculated by summing the net present value of capital costs and operating costs over the lifetime of the investments divided by the metric tons of GHGs reduced.

By providing individual costs for actions, MACs can imply that the actions are a menu from which individual actions can be selected. Many of the actions are dependent on each other; for example, energy costs increase without retrofits. Another important message is that to achieve Ames' target, all the actions need to be undertaken as soon as possible.

Table 6 summarizes the marginal abatement costs for the modeled actions in Ames's low-carbon future. The actions with negative abatement costs generate financial returns over their lifetimes. A positive abatement cost requires money over the span of the project. This comparison provides one way to view the costs and benefits of the implementation of emissions-reducing actions, but should not be the only metric used to measure an action.

Table 6. Marginal abatement costs for modeled actions.

Low-Carbon Action	Cumulative Emissions Reduction (kt CO2eq)	Proportion of Total Reduction	Net present value ($1000s)	Marginal Abatement Cost ($/t CO2 eq)
Renewable energy generation				
1.1 Renewable natural gas for district energy	330	2%	59,146	$179
1.3 Electric boilers for district energy	1,477	7%	-27,718	-$19
1.4 Solar PV on roofs	2,376	11%	-37,772	-$16
1.6 Large-scale renewable electricity generation	5,120	21%	796,060	$155
1.7 Renewable natural gas in buildings	969	5%	170,467	$176
Building retrofits program				
2.2 Retrofit of municipal buildings	302	1%	22,876	$76
2.3 High efficiency hot water in retrofit of homes	415	2%	-41,995	-$101
2.4 Enhanced industrial efficiency	811	4%	-52,249	-$64
2.5 Retrofits of homes	1,046	5%	587,979	$562

(continued from previous table)

Low-Carbon Action	Cumulative Emissions Reduction (kt CO2eq)	Proportion of Total Reduction	Net present value ($1000s)	Marginal Abatement Cost ($/t CO2 eq)
2.6 Retrofits of non-residential buildings	1,268	6%	101,140	$80
2.9 Heat pumps in residential retrofits	116	1%	158,060	$1,359
Net zero new construction				
3.2 HIgh performance new homes	195	1%	55,393	$285
3.3 High performance new non-residential buildings	317	1%	134,872	$426
3.5 High performance new municipal buildings	67	0%	-10,700	-$160
3.6 Heat pumps in new homes	68	0%	7,557	$111
Reduce vehicle emissions				
4.2 Electrify personal vehicles	382	2%	-371,884	-$973
4.3 Electrify commercial vehicles	559	3%	-569,152	-$1,018
5.1 Increased walking and cycling	386	2%	-230,092	-$597
5.2 Reduced driving	277	1%	-71,440	-$258
Reduce waste emissions				
6.2 New waste to energy facility	2,513	12%	89,291	$36

Shown slightly differently, the Marginal Abatement Cost Curve (Figure 30) gives a visual representation of the financial implications and the emissions reductions associated with each action. The height of the bar indicates the size of the financial costs/savings and the width shows the potential GHG savings.

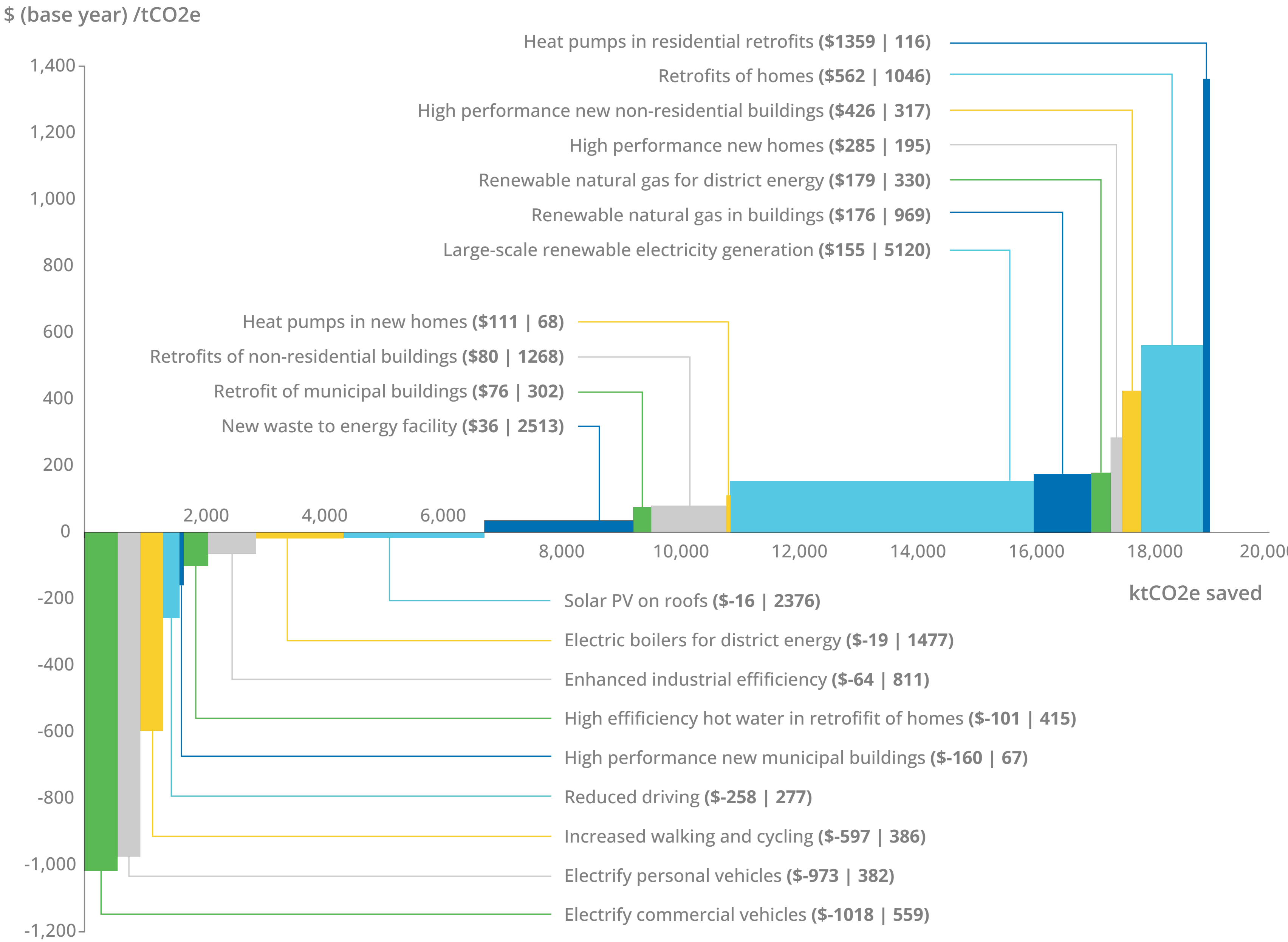


Figure 30. Marginal Abatement Cost curve.

The action with the highest cost per metric ton of CO2e reduced is residential retrofits. Residential retrofits require costly building envelope improvements and the switch to heat pumps, while maximizing efficiency and reducing GHG emissions require switching to electricity that is currently more expensive than natural gas. While these retrofits may require significant capital investment, they provide other benefits. Efficient homes are easier to heat, reduce total energy demand, and can help address energy poverty.

4.7 Business Opportunities

Investments in the Low-Carbon scenario represent opportunities for existing and new businesses in Ames. These include contractors, HVAC suppliers, renewable energy companies, auto groups, construction companies, and secondary businesses such as banks, engineering and architecture firms, and insurance companies. Figure 31 illustrates the numbers of heat pumps and electric water heaters required to decarbonize Ames. These totals essentially constitute sales targets for the HVAC industry in Ames.

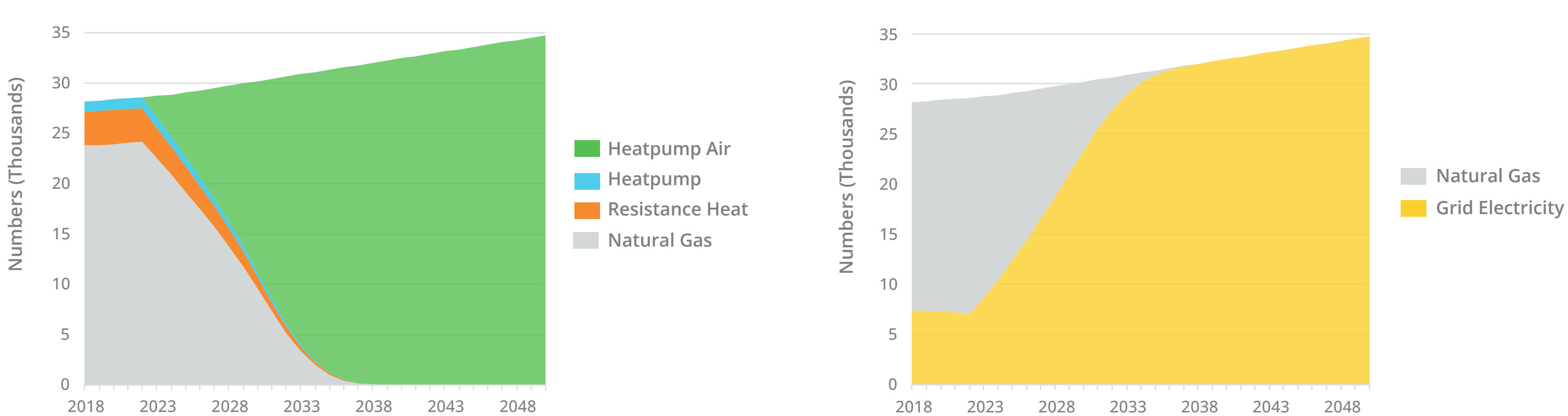


Figure 31. Shares of heat pumps and water heaters, Low-Carbon scenario.

5.
Co-Benefits

5. Co-Benefits

In many cases, actions that reduce GHG emissions correspond or directly overlap with actions that create vibrant cities and towns, improve public health outcomes, reduce municipal and state operating and capital costs, and support innovation—these are no-regrets policies.[35] Actions that reduce GHGs are synergistic with a wide range of other public goods, and these actions can be justified from the perspective of any of a number of public goods. One review of more than a dozen studies on GHG mitigation policies found that the co-benefits of reduced air pollution—a single co-benefit—often equaled or exceeded the benefit of the GHG reduction itself.[36]

Co-benefits and co-harms are effects that result from and are incidental to actions reducing GHG emissions.

Not all co-benefits or co-harms are equal. One set of criteria by which to consider the co-benefits of initiatives and actions to reduce GHG emissions is as follows:[37]

1. Synergies: Many low-carbon actions have multiple socioeconomic benefits. Examples of these types of actions include transit, improving energy efficiency, and fostering a more compact urban design.
2. Urgency: Some actions are associated with greater urgency to avoid loss of inertia on action already taken and prevent lock-in effects,[38] irreversible outcomes, or elevated costs. This may occur with road infrastructure decisions, major ecosystems displacement, and urban form. Some low-carbon actions require time to realize their effects, making immediate implementation paramount.
3. Costs: Acting early is generally less expensive than acting later. This is because delayed action often involves 'fixing' high emissions infrastructure rather than making it a low-carbon option from the beginning. Examples include buildings that are initially constructed to low energy efficiency standards and then need to be retrofitted later.
4. Longevity: Related to urgency, the longevity of planning and development decisions locks cities into their effects for decades, and sometimes centuries. For example, widening a roadway allows more vehicles to travel, encouraging more emissions for as many years as the widened roadway remains in the US.

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35 Lamia Kamal-Chaoui and Alexis Robert, "Competitive Cities and Climate Change," 2009, http://www.oecd-ilibrary.org/governance/competitive-cities-and-climate-change_218830433146.

36 Gao, J., Kovats, S., Vardoulakis, S., Wilkinson, P., Woodward, A., Li, J., ... & Liu, Q. (2018). Public health co-benefits of greenhouse gas emissions reduction: A systematic review. Science of the Total Environment, 627, 388-402.

37 Adapted from (Fay et al., 2015).

38 Lock-in effect refers to implementation of a strategy or action that improves performance of an object or activity in the short term but is prohibitive to future change. Lock-in effect can refer to building upgrades or land use, for example. As an example. where quick building retrofits are undertaken, no additional improvements in the equipment installed can be expected over the course of its lifetime without considerable additional expense. In this way, lower levels of energy reductions can be locked in for a long period.

5. **Equity Impacts:** Low-carbon actions have different impacts on different subsets of the population: Those with lower income levels may be unable to afford new heating and cooling systems in their homes; those with limited mobility may not be able to use transit as easily as the able-bodied; and those living in future generations will inherit the impacts of climate change caused by those who came before them.

Table 7 provides an assessment of the co-benefits and co-harms of implementing the Low-Carbon scenario over the BAP scenario.

Table 7. Summary of impacts.

1. Health				
Co-benefits/ co-harms	**Buildings**	**Transportation**	**Energy**	**Waste**
1.1 Co-benefit: Improved air quality	Energy-efficient buildings with low-carbon heating/ cooling systems have fewer drafts, less condensation, and less temperature variation, resulting in greater comfort and better health.	Reduced combustion of gasoline and diesel in vehicles reduces NOx and particulate matter in the air. This, in turn, reduces respiratory illnesses and flare-ups.	Reduced natural gas combustion in furnaces and industrial processes reduces NOx and particulate matter in the air. This, in turn, reduces respiratory illnesses and flare-ups.	Treating waste to reduce and capture methane reduces odor issues.
1.2 Co-benefit: Increased physical activity and health		Comprehensive, well-maintained, and safe cycling and walking infrastructure results in increased activity, better mental and physical health, lower obesity rates, and lower rates of absenteeism from work.		

(continued from previous table)

1. Health				
Co-benefits/ co-harms	**Buildings**	**Transportation**	**Energy**	**Waste**
1.3 Co-benefit: Reduction in noise pollution	Improved insulation in buildings reduces residents' exposure to exterior noise.	Switching to electric vehicles reduces total vehicle noise as EVs do not produce as much noise as combustion engines.		
1.4 Co-benefit: Improved accessibility		Transit-oriented development provides easier access to transit corridors and hubs.		

2. Economic prosperity

Co-benefits/ co-harms	Buildings	Transportation	Energy	Waste
2.1 Co-benefit: Increased employment	Retrofitting buildings and building to new higher standards will create a significant number of direct and indirect jobs annually.		Supplying, installing, and maintaining renewable and alternative energy systems, renewable fuels, and energy storage will generate a significant number of new jobs annually.	Waste mining for the circular economy, recycling, and the conversion of waste to fuel will all generate new jobs.
2.2 Co-harm: Decreased employment		The large-scale shift to EVs will result in a reduction in overall maintenance requirements for vehicles.		
2.3 Co-benefit: Increased long-term affordability	Initial capital costs for more energy-efficient buildings are more than offset with the resulting long-term savings in energy costs.	EVs have higher initial capital costs than ICE vehicles; however, in the longer-term, they save the owner more in avoided fuel and maintenance. Increased use of transit and active transportation also costs less than personal vehicle use.	Initial capital costs to replace high emissions heating and cooling technologies are more than offset with the resulting long-term savings in energy costs.	

(continued from previous table)

2. Economic prosperity				
Co-benefits/ co-harms	**Buildings**	**Transportation**	**Energy**	**Waste**
2.4 Co-benefit: Increased leadership reputation	A requirement for high-performance buildings creates a reputation for the City's developers and builders as having the skills required for innovative and sustainable building.	Less congestion, shorter commutes, more bike and walking infrastructure draw new young residents to the city's reputation of being a more livable community.	Large-scale renewable and alternative energy deployment increase the city's exposure as a climate leader and prepare the local labor force to maintain the energy systems of the future.	The city continues to enhance its reputation for innovative approaches to waste management.
2.5 Co-benefit: Increased social capital		Increased active transportation and transit use promotes more interaction among citizens, improving social cohesion.		
2.6 Co-benefit: Improved environmental capital	More-efficient buildings require less energy generation, decreasing the need for new energy generation facilities in green spaces outside the city boundary.		Energy generation within the city boundaries decreases the need to import energy (losing some in the process) and reduces the need for new generation facilities in green spaces beyond the city.	Waste managed as a valued resource results in less methane pollution.

3. Social equity				
Co-benefits/ co-harms	**Buildings**	**Transportation**	**Energy**	**Waste**
3.1 Co-benefit: Quality of life for the elderly improves	Access to naturalized spaces improves physical and mental health of all ages, especially when cool outdoor areas provide relief from extreme heat.	Low-carbon buildings are healthier for residents who are more susceptible to illness and are more comfortable.	Sidewalks and cycling infrastructure is developed to be safe for "anyone aged 8–88", improving seniors' ability to continue to move in their communities.	Heat exchange systems provide air conditioning to all residents, reducing the impacts of heat waves.
3.2 Co-benefit: Quality of life for children improves	Increased access to outdoor recreation areas and complete green streets makes it easier for children to do more outside,get to know their neighbors, and travel independently.	Low-carbon buildings are healthier, meaning the important development that occurs during childhood years takes place in cleaner spaces.	Safe, connected, well-maintained, and well-used bike paths, sidewalks and transit infrastructure make these options better for children.	
3.3 Co-benefits: Increased intergenerational equity and resilience	Low-carbon actions that begin early avoid locked-in emissions and increased costs to fix stranded assets in all of these areas. Action now also ensures changes are made before the worsening impacts of climate change begin to damage outdated infrastructure. This reduces the burden on future generations.			

6. Actions

6. Actions

6.1 The Six Big Moves

The key focus areas for Ames' CAP align with the following Six Big Moves identified through technical modeling, thorough reviews of best practices and local context, and engagement:

1. Renewable Energy Generation
2. Building Retrofits
3. Net-Zero New Construction
4. Reducing Vehicle Emissions
5. Increase Active Transportation and Transit Use
6. Reduce Waste Emissions

The Six Big Moves structure has been created to show how to organize and think about implementation, although there will be some overlap between the program, initiative, policy, and infrastructure recommendations in each sector.

Programs, initiatives, and policies are meant to support one another and are sequenced in a timeline to maximize community co-benefits, GHG reductions, and financial return. Although adaptive management will be important as technologies and conditions change, the plan will not generate the same outcome if only some actions are completed or if they are taken out of order. For example, building retrofits increase the impact of solar PV installations in terms of cost and GHG reductions, and adding solar PV can ensure there is clean electricity available for electric vehicles at homes and workplaces.

The actions included here are near-term measures that are necessary for Ames to meet it's climate targets. These actions are designed to be initiated within the next 1-3 years, and completed in the next 5 years, except where actions explicitly continue into the future. Global climate change science emphasizes the need for immediate and transformative change, and the timing of these actions aligns with the speed required to meet local and global GHG emissions targets.

Table 8. Implementation mechanisms.

Mechanism	Definition
Policy	A policy developed by the City and approved by the City Council.
Program	An ongoing effort by the City, with staff and financing to support the effort.
Initiative	A study or project undertaken by the City, private sector, not-for-profit sector, or other sectors, individually or collaboratively, with a specific focus, implemented for a set time period.
iInfrastructure	Investment in physical infrastructure by the City or private sector, not-for-profit sector, or other sectors, individually or collaboratively.
Advocacy	Any action in favor of or recommending another body (e.g. level of government, other governments, community partners) undertake an action/policy/program that influences Eemissions reductions within its jurisdictional control.
Education	A defined opportunity to target educational communications and materials to the public, community partners, and other governments related to the specific rationale and benefits of implementing Cclimate Aactions.

6.2 Renewable Energy Generation

Low-carbon energy generation refers to the production of electricity or heat using energy sources that produce low levels of greenhouse gas emissions. These include renewable energy sources such as solar, wind, hydro, tidal, geothermal, and renewable natural gas (RNG).

Renewable energy sources are considered the most sustainable and environmentally friendly option because they produce little to no emissions and do not rely on finite fossil fuel resources. Renewable energy generation significantly contributes to GHG reduction. It can take many forms, but all shifts to renewable energy require drastic changes that are challenging to scale up to meet current energy demand.

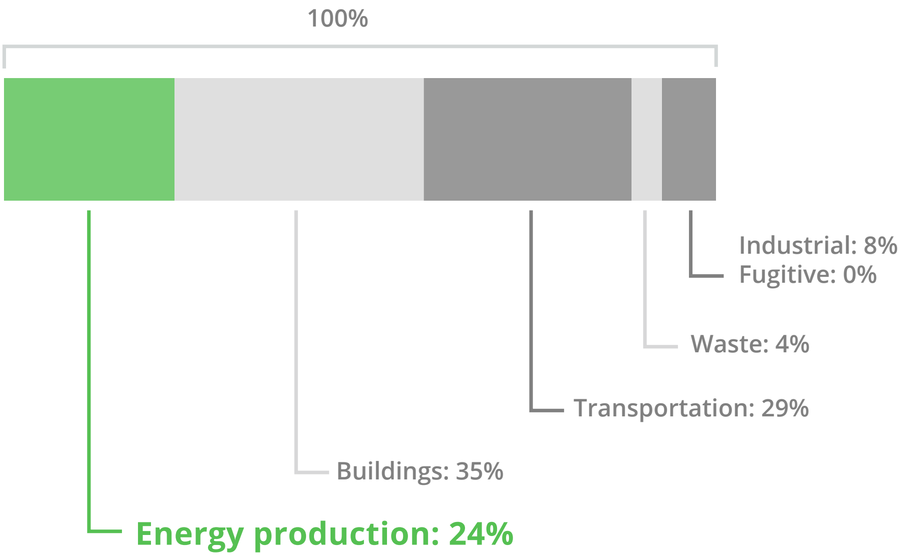


Figure 32. Share of GHG emissions from energy production in Ames.

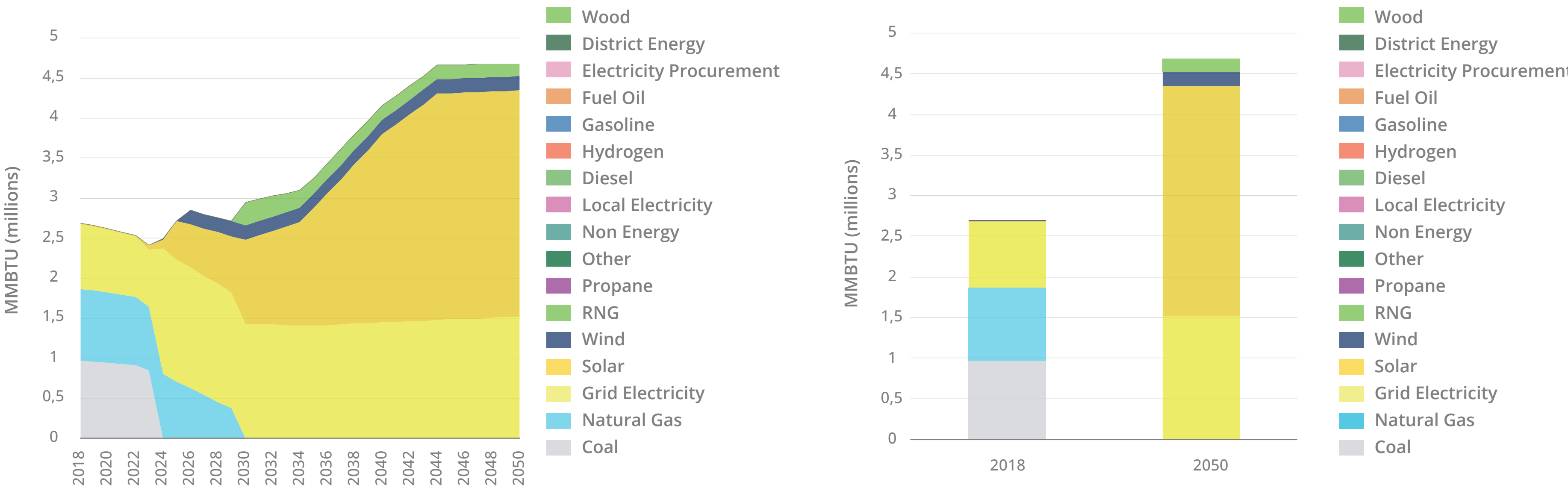


Figure 33. Local energy generation by energy type annually (left) and as a snapshot for 2018 and 2050 (right) in the Low- Carbon scenario.

Table 9. Renewable Energy Implementation Strategy. Actions marked with an asterisk (*) are actions recommended by municipal staff. Actions marked with an "e" have equity considerations.

Renewable Energy Generation	
Action Name:	**Ground Mount Solar and Wind Generation ***
Modeled Low Carbon Action:	50MW of renewable nameplate generating capacity by 2025, 120 MW by 2030, 240MW by 2040, 320MW by 2050.
GHG:	High
Metric:	MW of capacity added

(continued from previous table)

Action Name:	**Ground Mount Solar and Wind Generation ***		
Implementation Mechanism	**Description**	**Funding**	**Funding Applicant**
Initiative	Meet the 2025 target of 50 Megawatts of renewable generation capacity through power purchasing agreements (PPA).	IRA Clean Electricity Investment Tax Credit (ITC)	Municipality
Initiative	Explore the feasibility of AMES developing its own renewable electricity generation capacity, which it would own and maintain, likely through the use of PPAs.	IRA Clean Electricity Production Tax Credit (PTC)	Municipality
Initiative	AMES completes an Integrated Resource Plan (IRP), which is consistent with the CAP and includes guidance on: • Hourly demand forecasting under a high renewable generation scenario • Demand response programs to enable more control on the timing of electricity consumption in Ames • A rate increase program with an equity focus to assess and mitigate the effect of rate increases on LMI households	Municipal funding	
Education	Educate the public on plans for adding renewable energy generation and the forecasted impact on Eelectricity rates.	Municipal funding	

Renewable Energy Generation

Action Name:	**Rooftop Solar (e)**
Modeled Low Carbon Action:	Achieve a total of 220 MW of rooftop solar generating capacity by 2050.
GHG:	High
Metric:	MW of capacity added

Implementation Mechanism	**Description**	**Funding**	**Funding Applicant**
Initiative	Work with developers to provide incentives for the construction of new buildings to include solar panels or to be solar ready. Incentives can include quicker permitting for projects that meet this criteria.	New Energy Efficient Home Tax Credit (45L)	Municipality, private
Initiative	Include guidance on the following in the forthcoming Integrated Resource Plan: • Behind the meter solar dynamics of demand and demand response incentives. • Transmission infrastructure upgrades needed for net-metering. • Non-rooftop space potential for solar panels (parking lots, new building facades, etc.).	Municipal funding	
Program	Design a program that provides a financial incentive to building owners who add rooftop solar to their buildings.	Residential Clean Energy Tax Credit (25D)	Municipality, private
Program	Provide a financial incentive to building owners who add battery storage to their buildings.	Residential Clean Energy Tax Credit (25D)	Municipality, private
Initiative	Explore the possibility of a solar group buy program where one vendor provides bulk solar installations to residential and commercial building owners.	Residential Clean Energy Tax Credit (25D)	Municipality, private

Renewable Energy Generation

Action Name:	**Grid electricity decarbonization (MISO)**
Modeled Low Carbon Action:	75% reduction in grid emissions factor for imported electricity by 2040.
GHG:	High
Metric:	Grid emission factor gCO2e/kWh

Implementation Mechanism	Description	Funding	Funding Applicant
Advocacy	Advocate for MISO decarbonization.	Municipal funding	

6.3 Building Retrofits

All buildings, including homes, commercial buildings, municipal buildings, and industrial buildings undergo deep retrofits to reduce energy consumption. New buildings are built to net-zero standards, meaning they will be highly efficient and generate on-site electricity. All buildings, whether new or existing, will switch from fossil fuels to electricity for space heating, space cooling, and water heating.

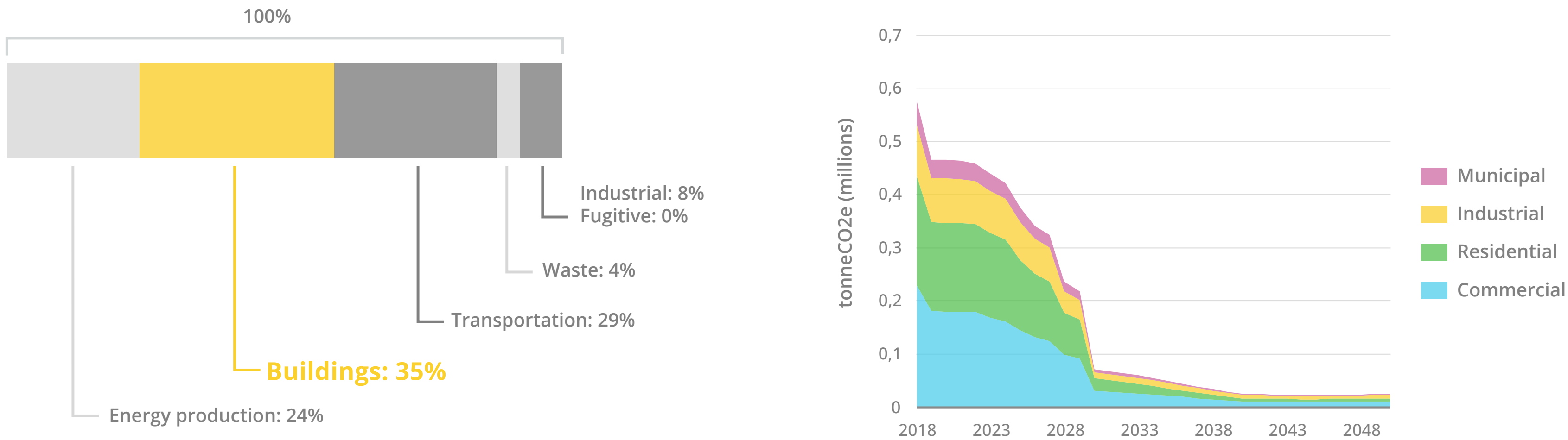
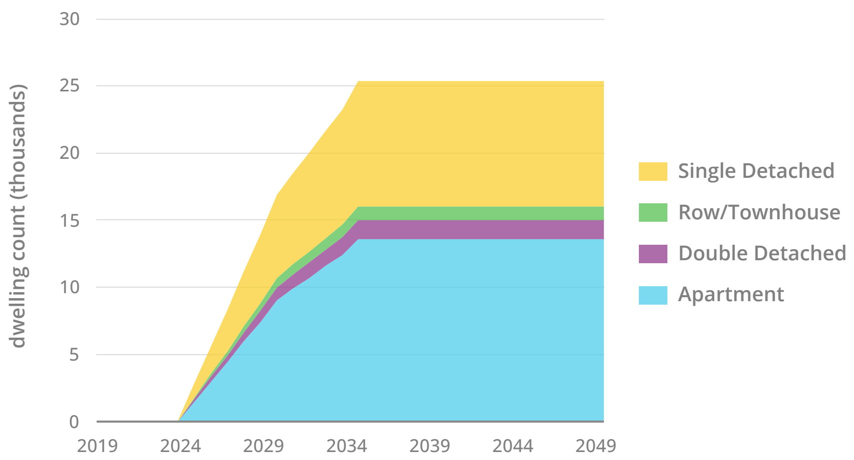


Figure 34. Share of Ames' GHG emissions from buildings in 2021 (left) and the GHG emissions reduction trajectory for buildings in the Low-Carbon scenario.



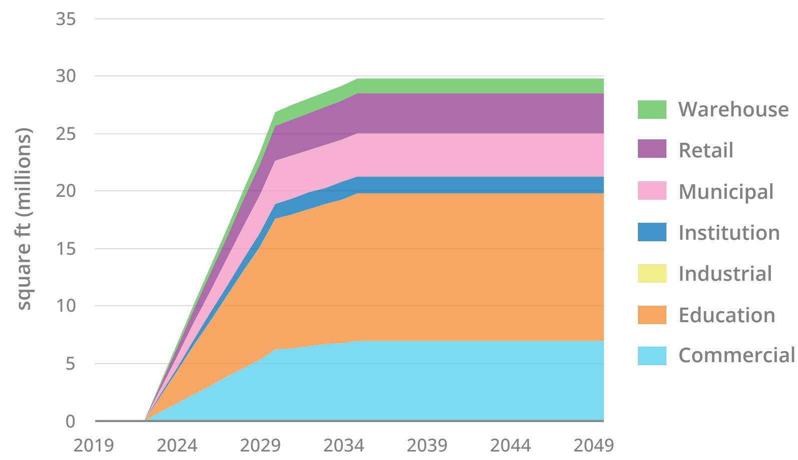


Figure 35. Number of residential units by type retrofit (left) and commercial floor area by type retrofit (right) in the Low-Carbon scenario.

What is a Deep Retrofit?

A deep retrofit is a set of actions to improve building quality and the energy efficiency of the building. Minor retrofits include draft sealing, improving the insulation, and changing out lights for LEDs. Major retrofits can include replacing windows and doors, updating heating and cooling systems, and reducing water consumption through low-flow faucets. Deep retrofits go a step further, overhauling all systems of a building. This can include reconfiguring the interior of the building, replacing the roof, rearranging windows to maximize solar gain, and replacing existing HVAC systems with electric heat pumps.

A deep retrofit can reduce a building's energy demand by up to 60%.

Table 10. Building Retrofits Implementation Strategy. Actions marked with an asterisk (*) are actions recommended by municipal staff. Actions marked with an "e" have equity considerations.

Building Retrofits Program			
Action Name:	**Equipment electrification (*,e)**		
Modeled Low Carbon Action:	Add air-source heat pumps for all buildings by 2040. Replace hot water heating systems with electric in line with the heat pump schedule.		
GHG:	Enabler		
Metric:	Number of heat pumps installed		
Implementation Mechanism	**Description**	**Funding**	**Funding Applicant**
Program	Design a program offering loans and incentives for heat pump purchase and installation.	• IRA high-efficiency electric home rebate program • IRA residential energy efficiency tax credit (25c) • IRA Improving energy or water efficiency or climate resilience of affordable housing • IRA energy efficient commercial buildings deduction (179D)	Municipality, private
Education	Create a publicly available repository of suggested heat pump vendors and installers in Ames.	Municipal funding	
Education	Provide contractor training for heat pump heaters and water heater installation. Either directly or in partnership.	Home Energy Efficiency Contractor Training (State level)	Municipality, private
Education	Gather feedback from residents who have completed or are undergoing an electrification project for their home or business about the main obstacles they encountered during their project (e.g. long wait times for energy audits, difficulty finding a trusted vendor/installer, etc.).	Municipal funding	

Building Retrofits Program

Action Name:	**Building Retrofits (*,e)**
Modeled Low Carbon Action:	**Residential:** Pre-1981 construction: Achieve 60% thermal savings and 15% electrical savings in 80% of buildings constructed prior to 1981 by 2030, start year 2023; 90% by 2035. 1981 and newer construction: Achieve 60% thermal savings and 15% electrical savings in 60% of post-1981 existing buildings by 2030, start year 2025; 90% by 2040. **Commercial:** Achieve 50% thermal savings and 10% electrical savings in 80% of buildings by 2030, start year 2023; 90% by 2035. **Municipal:** Municipal building retrofits begin in 2023. Achieve 50% thermal savings and 10% electrical savings. All municipal buildings retrofitted by 2030.
GHG:	High
Metric:	Number of buildings retrofitted

Implementation Mechanism	Description	Funding	Funding Applicant
Initiative	Launch a pilot retrofit program focusing on older homes in Ames Electrical Service territory.	IRA high-efficiency electric home rebate program IRA residential energy efficiency tax credit (25c) IRA Improving energy or water efficiency or climate resilience of affordable housing	Municipality, private
Initiative	Launch a pilot program to work with business owners to retrofit older commercial buildings.	IRA energy-efficient commercial buildings deduction (179D)	Municipality, private

(continued from previous table)

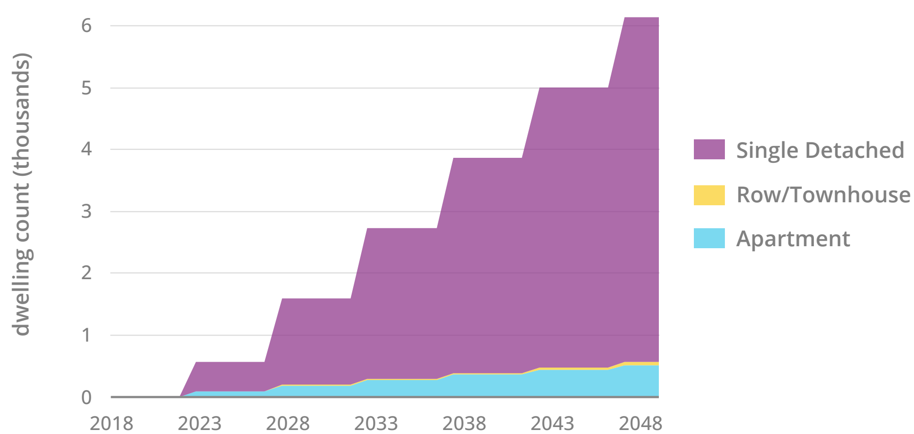
Action Name:	**Building Retrofits (*,e)**		
Implementation Mechanism	**Description**	**Funding**	**Funding Applicant**
Education	Create a publicly available repository of suggested contractors for retrofits in Ames.	Municipal funding	
Advocacy	Advocate for the State to enable Pace and C-Pace programs. Not currently available in Iowa.	Municipal funding	
Policy	Mandatory energy-use disclosure for multi-unit buildings over 20,000 sqft and commercial buildings over 50,000 sqft.	Municipal funding	
Program	Institute a revolving energy fund for municipal building retrofits (any utility cost savings resulting from energy efficiency upgrades/energy use reduction is set aside in a corporate fund to conduct additional energy projects).	Municipal funding	
Initiative	Explore partnerships with retrofit service companies (such as BlocPower).	Municipal funding	
Education	Provide contractor training for building retrofits either directly or in partnership. Offer training in heat pump installation either directly or in partnership.	Home Energy Efficiency Contractor Training (State level)	Municipality, private
Initiative	Retrofit municipal buildings in order to achieve 50% thermal savings and 10% electrical savings. All municipal buildings retrofitted by 2030.	IRA energy efficient commercial buildings deduction (179D)	Municipality, private

6.4 Net-Zero New Construction

Low-carbon new building performance refers to the ability of a new building to consume low levels of energy and generate low levels of GHG emissions throughout its lifecycle. This can be achieved through:

- Designing the building to maximize natural light and ventilation;
- Using energy-efficient materials and equipment;
- Incorporating renewable energy systems, such as solar panels or wind turbines;
- Choosing a location that is close to public transportation and other amenities; and
- Incorporating green roofs, rainwater harvesting, and greywater recycling systems.

A new low-carbon building is expected to have low energy consumption, low emissions, high indoor air quality, and thermal comfort, with a positive impact on the environment and the people that use it. As buildings and building systems are long-lasting assets, choices made today will impact emissions in the city for decades to come and will either increase or decrease the burden on future generations. Increasing the proportion of net-zero builds over time can also prepare the workforce now for changes that will impact the whole industry by 2030. Other benefits include improved air quality and lower utility bills associated with net-zero homes.



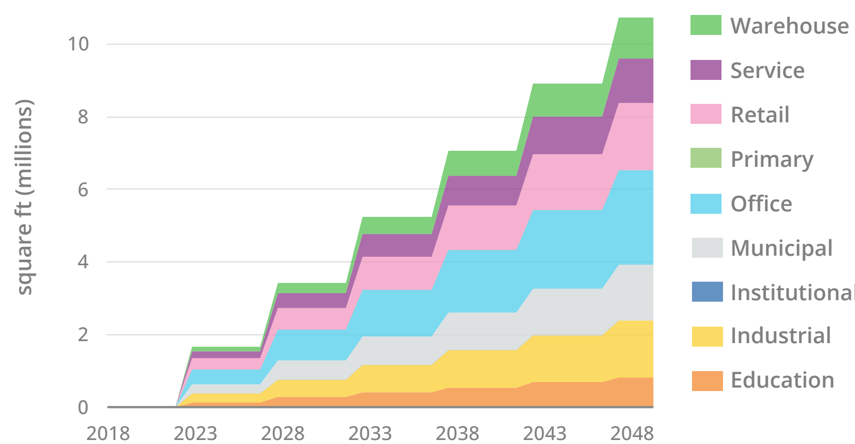


Figure 36. New dwellings by type (left)and new floorspace by type (right) in the Low-Carbon scenario.

Table 11. Net-Zero New Construction Implementation Strategy. Actions marked with an asterisk (*) are actions recommended by municipal staff. Actions marked with an "e" have equity considerations.

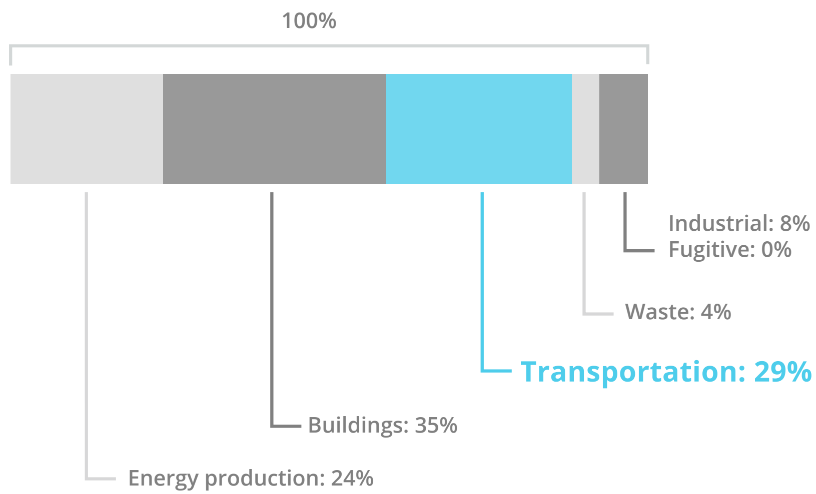
Net-Zero New Construction			
Action Name:	**Net-zero new buildings (*,e)**		
Modeled Low Carbon Action:	All new buildings meet thermal net-zero energy standards (15 kWh/m2) by 2030; adoption increases linearly to 2030. All new municipal buildings meet thermal net-zero energy standards (15 kWh/m2) by 2025, adoption increases linearly to 2025.		
GHG:	Medium		
Metric:	Number of buildings constructed to net-zero standards		
Implementation Mechanism	**Description**	**Funding**	**Funding Applicant**
Initiative	Change zoning ordinance to include specific design features of a building that support both being net-zero ready and passive building design.	Municipal funding	
Initiative	Requiring net-zero ready and passive design as part of annexation and contract rezoning.	Municipal funding	
Initiative	Implementing a new tax abatement program to incentivize new construction to be net-zero ready and reflect passive building design.	Municipal funding	
Policy	Mandatory energy-use disclosure reporting for new multi-units over 20,000 square feet.	Municipal funding	
Advocacy	Advocate for stricter energy codes at the state level.	Municipal funding	

(continued from previous table)

Action Name:	**Net-zero new buildings (*,e)**		
Implementation Mechanism	**Description**	**Funding**	**Funding Applicant**
Policy	Require that all new municipal buildings meet net-zero standards by 2025.	Municipal funding	
Education	Offer educational sessions to builders in Ames on net-zero design principles and funding opportunities.	IRA Home Energy Efficiency Contractor Training (State level) IRA New Energy Efficient Home Tax Credit (45L)	Municipality, private

6.5 Reduce Vehicle Emissions

All vehicles are zero emission, with personal vehicles leading the way. Cars, SUVs, and small trucks are electric, and heavy-duty vehicles are either electric or use a low-emissions fuel. Walking and bicycling trips increase by building and maintaining more safe trails, sidewalks, and bike lanes. Additionally, transit is expanded and decarbonized.



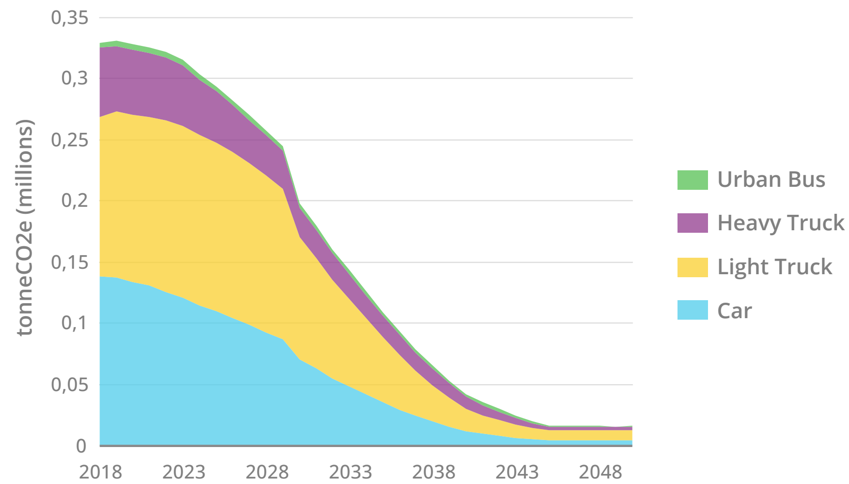


Figure 37. GHG emissions from transportation in 2021 (left) and by fuel in the Low-Carbon scenario (right).

Table 12. Reduce Vehicle Emissions Implementation Strategy. Actions marked with an asterisk (*) are actions recommended by municipal staff. Actions marked with an "e" have equity considerations.

Reduce Vehicle Emissions			
Action Name:	**Electrify personal-use and commercial vehicles**		
Modeled Low Carbon Action:	All light- and medium-duty vehicles sold in 2030 are zero- emissions vehicles. All heavy-duty vehicles sold in 2030 and after are electric. Between 2023 and 2030, the proportion of biodiesel use will increase by 5% each year.		
GHG:	Medium		
Metric:	Number of EV vehicles		
Implementation Mechanism	**Description**	**Funding**	**Funding Applicant**
Education	Raise awareness and provide information on funding opportunities for new and used clean vehicles.	IRA Clean Vehicle Tax Credit (30D) IRA Credit for previously owned clean vehicles	Municipality
Initiative	Develop EV infrastructure policies/bylaws for new MURBs, commercial buildings, and parking lots.	IRA tax credit for alternative refueling property	Municipality

Reduce Vehicle Emissions			
Action Name:	**Electrify Transit**		
Modeled Low Carbon Action:	Replace 17 buses with electric by 2027, then replace at end of lifecycle for remaining buses.		
GHG:	Low		
Metric:	Number of EV buses		
Implementation Mechanism	**Description**	**Funding**	**Funding Applicant**
Initiative	Support CyRide with their decarbonization plan. Collaborate on applying for funding opportunities.	IRA clean heavy-duty vehicles	Municipality

Reduce Vehicle Emissions			
Action Name:	**Electrify Municipal Fleet***		
Modeled Low Carbon Action:	Replace fleet over time (based on standard vehicle and equipment replacement lifecycles) beginning in 2023 with electric (light- and medium- duty vehicles and light equipment). For heavy vehicles, begin purchasing electric in 2030. Prior to 2030, purchase vehicles running on 100% biodiesel.		
GHG:	Low		
Metric:	% of zero emissions vehicles in fleet		
Implementation Mechanism	**Description**	**Funding**	**Funding Applicant**
Policy	Municipal policy for new vehicle purchases.	IRA Clean Vehicle Tax Credit (30D) IRA Credit for previously owned clean vehicles IRA clean heavy-duty vehicles	Municipality
Policy	Municipal policy for EV infrastructure at municipal facilities.	IRA tax credit for alternative refueling property	Municipality

6.6 Active Transportation and Transit Use

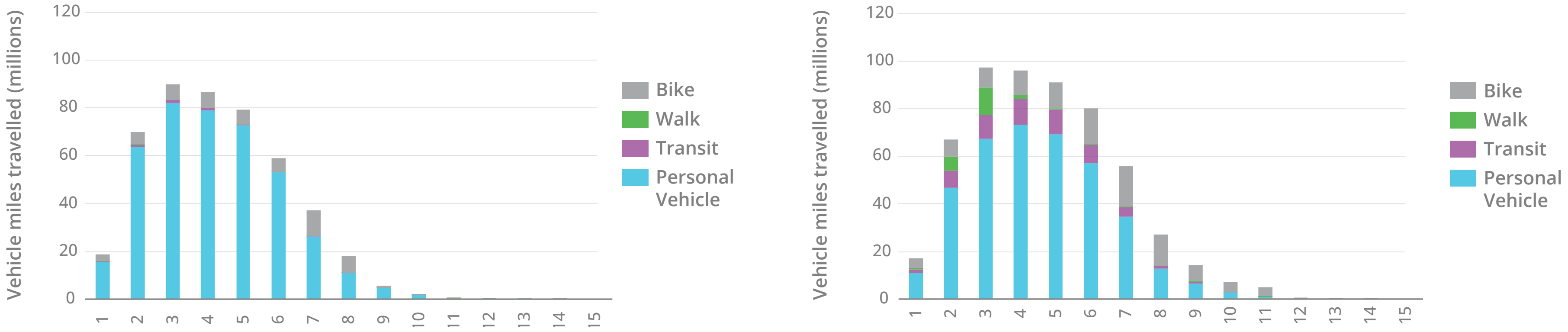


Figure 38. VMT by mode and trip distance in 2018 (left) and 2050 (right) in the Low-Carbon scenario.

Table 13. Increase Active Transportation and Transit Implementation Strategy. Actions marked with an asterisk (*) are actions recommended by municipal staff. Actions marked with an "e" have equity considerations.

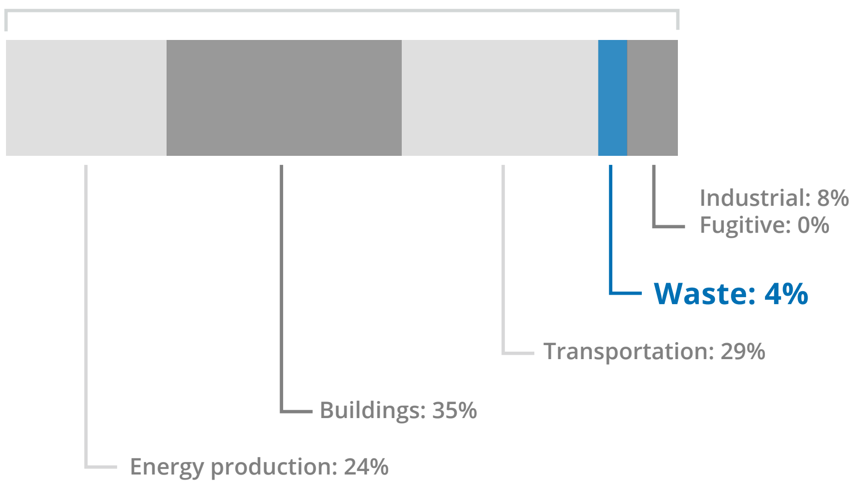
Increase Active Transportation and Transit Use			
Action Name:	**Expand transit and encourage active transportation (e)**		
Modeled Low Carbon Action:	By 2050, 10% of trips in the City completed using transit. By 2050, 40% of trips under 2 km completed by walking, 25% of trips 2 km–5 km completed by biking.		
GHG:	Medium		
Metric:	% of trips completed using transit, walking, and biking.		
Implementation Mechanism	**Description**	**Funding**	**Funding Applicant**
Initiative	Increase frequency in the downtown core and from key neighborhoods to university. Expand transit into new zones as they are developed.	IRA Neighborhood Access and Equity Grant Program	Municipality
Initiative	Active transportation infrastructure is improved and expanded.	IRA Neighborhood Access and Equity Grant Program	Municipality
Initiative	Active transportation safety features enhanced, e.g. sidewalk and trail lighting, separated bike lanes.	IRA Neighborhood Access and Equity Grant Program	Municipality
Initiative	Work with ISU to introduce a bikeshare program.	Municipal funding	Municipality, private

Increase Active Transportation and Transit Use

Action Name:	**Reduce personal- use vehicle miles traveled**
Modeled Low Carbon Action:	Car and bike share programs are available to decrease single-vehicle ownership (10% reduction in VMT city-wide). Car-free zones in the downtown core and near the university and increase in parking fees (10% reduction in VMT in downtown and university zones).
GHG:	Medium
Metric:	VMT reduction

Implementation Mechanism	Description	Funding	Funding Applicant
Advocacy	Work with local delivery companies on green last-mile delivery services.	Municipal funding	
Program	CyRide bus pass partnerships with large employers.	Municipal funding	
Policy	Car-free zones in the downtown core and near the university.	Municipal funding	

6.7 Reduce Waste Emissions



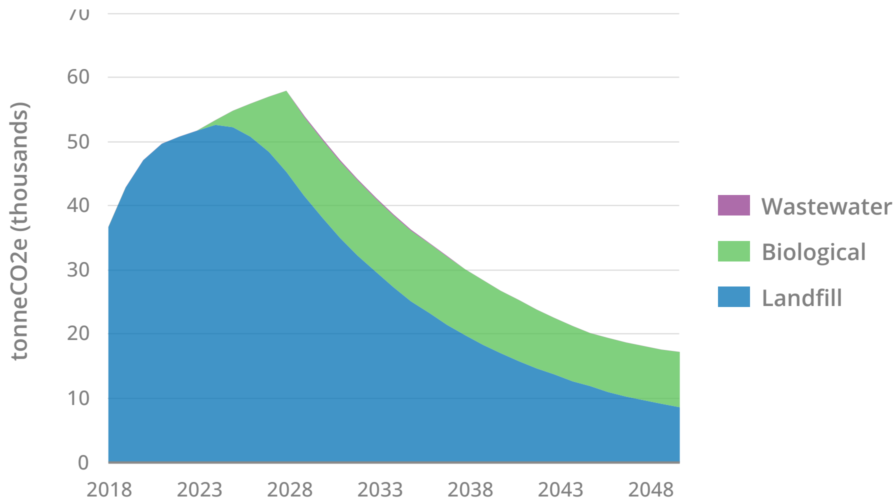


Figure 39. GHG emissions from waste and wastewater in 2021 (left) and by source in the Low-Carbon scenario (right).

Table 14. Reduce Waste Emissions Implementation Strategy. Actions marked with an asterisk (*) are actions recommended by municipal staff. Actions marked with an "e" have equity considerations.

Reduce Waste Emissions			
Action Name:	**Waste generation reduction and diversion***		
Modeled Low Carbon Action:	Waste decreases by 20% per household at the source by 2030; 50% per household at the source by 2050. 50% of commercial waste is diverted at source by 2030. 90% of organic/food waste is diverted by 2028. 90% of glass, metal, and paper, cardboard, and other paper products are recycled by 2027.		
GHG:	Medium		
Metric:	Volume of waste generated. Volume of waste diverted.		
Implementation Mechanism	**Description**	**Funding**	**Funding Applicant**
Initiative	Implement a pay-as-you-throw system to encourage waste reduction.	Municipal funding	
Education	City leads or partners with an organization to provide education to residents on composting.	Municipal funding	
Education	City leads or partners with an organization to provide education to residents on waste reduction.	Municipal funding	

Reduce Waste Emissions			
Action Name:	**New Waste to Energy Facility***		
Modeled Low Carbon Action:	Change the permit requirement of electric burning NG with refuse-derived fuel (decrease/eliminate NG use).		
GHG:	High		
Metric:	MMBTU of natural gas used for incineration.		
Implementation Mechanism	**Description**	**Funding**	**Funding Applicant**
Initiative	Implement an alternative waste-to-energy system that allows for refuse-derived fuel to be combusted in a separate boiler.	Municipal funding	

7.
The Risk of Doing Nothing

7. The Risk of Doing Nothing

If the CAP is not implemented, a BAP scenario would proceed. This status-quo scenario assumes no major changes are made to new and existing buildings, EV uptake is slower, active transportation and transit shifts are more limited, and renewable energy generation is slower. Risks are classified according to the matrix in Table 15.

Table 15. Risk classification.

Impact	Risk Classification			
Catastrophic	High	Very high	Very high	Very high
Major	Moderate	High	High	Very high
Moderate	Low	Moderate	Moderate	High
Minor	Low			Moderate
	Unlikely	Possible	Likely	Very likely
	Probability			

Table 16. The risks of doing nothing.

Risk	Description	Probability	Impact	Overall Risk
Stranded assets	Residents or the City invests in fossil-fuel-based infrastructure that must be replaced prior to the end of its useful life, either to meet its GHG reduction commitments or due to changing market conditions as a result of global Cclimate action.	Very likely	Major	Very high
Reputation is negatively impacted	The reputation of Ames is damaged because its climate efforts do not align with what science indicates is required to address climate change.	Possible	Moderate	Moderate

(continued from previous table)

Risk	Description	Probability	Impact	Overall Risk
Vulnerability to energy price shocks	The government is vulnerable to global fossil fuel prices, which will fluctuate in the future.	Very likely	Major	**Very high**
Infrastructure damage from extreme weather	The energy system, buildings, and other infrastructure is damaged from extreme weather events.	Likely	Major	**High**
Cumulative energy expenditures are greater than they would be under strategy implementation	In the long run, the BAP scenario is more costly than the Low-Carbon scenario.	Very likely	Minor	**Moderate**
GHG emissions increase or stabilize	GHG emissions will continue to increase, imposing a burden on future generations. The cost of future mitigation will also increase, requiring more expensive interventions.	Very likely	Major	**Very high**
Operational costs increase	Opportunities to reduce operational costs are missed (e.g. from EVs and heat pumps).	Very likely	Moderate	**High**

8. Monitoring and Evaluation

8. Monitoring and Evaluation

Tracking the effectiveness of the actions in the CAP helps to manage the risk and uncertainty associated with these efforts, as well as external forces, such as evolving senior government policy, and new technologies, which can disrupt the energy system. Key motivations for monitoring and evaluation include:

- Identify unanticipated outcomes;
- Adjust programs and policies based on their effectiveness;
- Manage and adapt to the uncertainty of climate change; and
- Manage and adapt to emerging technologies.

Specific activities identified to support the implementation of the CAP include an annual work plan and review, an annual indicator report, an update of the GHG inventory every two years, and an update of the CAP every five years.

Table 17. Monitoring and evaluation activities.

Activity	Purpose	Description	Frequency
1. Annual work plan and review	Review work to-date and set annual priority actions	Annual report with prioritized actions	Annual
2. Annual indicator report	Track effectiveness of actions	Annual report on set of indicators with an analysis of the results	Annual
3. Inventory	Update energy and GHG emissions profile	Recalculate the GHG emissions and energy inventory	Every 2 years
4. Update the CAP	Update the CAP to reflect changing conditions	Review each action and the progress being achieved. Identify new actions.	Every 5 years

8.1 Annual Work Plan and Review

An annual work plan will identify activities to achieve the actions and policies in the plan, as well as the responsible parties, the budget, and the schedule. The results of the previous year's work plan should be reviewed to inform the development of subsequent work plans.

8.2 Reporting Platform

The City of Ames should report annually to CDP,[39] which will enable the City to join international networks such as the Global Covenant of Mayors,[40] the UN's Race to Zero,[41] and WWF's One Planet Cities.[42] Each of these networks is a community of cities that can provide networking and profile to Ames' efforts.

8.3 GHG Inventory

Ames should complete an annual GHG inventory according to the GHG Protocol for Community-Scale GHG Inventories,[43] the standard accounting protocol for GHG emissions, which will enable the City to track its progress against targets. It will also support reporting to CDP and the annual indicator report.

8.4 Annual Indicator Report

There are two aspects involved in the application of indicators: collecting data on indicators (monitoring) and interpreting the results of those indicators (evaluation). Over time, Ames can also evaluate its effectiveness in embedding the knowledge and wisdom gained through this process into the organization.

From the perspective of the CAP, there are multiple purposes for which data is collected: to evaluate the effectiveness of the actions, to evaluate the impact of the actions on the community, and to evaluate the uptake of the lessons from the evaluation.

Ames can launch its implementation report on Earth Day each year.

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[39] The CDP platform is available here: https://www.cdp.net/en/cities

[40] Global Covenant of Mayors: https://www.globalcovenantofmayors.org/how-to-join/

[41] Race to Zero: https://www.c40knowledgehub.org/s/cities-race-to-zero?language=en_US

[42] WWF's One Planet Cities: https://wwf.panda.org/projects/one_planet_cities/

[43] WRI (2021). GHG Protocol for Community Scale GHG Inventories. Retrieved from: https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

Table 18. Types of indicators.

Indicator Category	Question
1. Effectiveness indicators	Are the actions achieving their objectives?
2. Impact indicators	What is the impact of the actions on the community?

8.5 Effectiveness Indicators

These indicators will be designed to evaluate whether or not policies or actions are having an effect. They will vary from municipality to municipality according to the specifics of the community energy and emissions plan. The results of the indicators are then compared against the assumption in the modeling to monitor whether or not the community is on track with projections. Indicators should be developed for each policy or mechanism.

8.6 Impact Indicators

Ames can develop a set of indicators that track macro trends and drivers of GHG emissions in Ames. These are designed to be reported on each year.

Table 19. Indicators.

Indicator	Trend	Data sources
Total new dwellings by type	An indication of the growth of the building stock.	Buildings permits
Average total floor area of new dwellings	An indication as to whether there is more or less additional floor space to heat or cool.	Building permits
Diversity of dwelling types	An indication of the types of dwellings and whether or not they have shared walls.	Building permits
Total new non-residential floorspace by type	An indication of the growth of the building stock.	Building permits
Total demolitions	An indication of the change in the building stock.	Demolition permits
Percentage of new dwelling units that are downtown	An indication as to whether or not residential development is occurring in areas more appropriate for walking, cycling, and transit.	Building permits and GIS analysis

(continued from previous table)

Indicator	Trend	Data sources
Percentage of non-residential floorspace that is occurring downtown	An indication as to whether or not commercial development is occurring in areas more appropriate for walking, cycling, and transit.	Building permits and GIS analysis
Number of new dwellings that are within 400 m of a transit stop	Indication of transit accessibility.	GIS layers of transit and building footprint
Annual or monthly energy price by fuel (electricity, gasoline, diesel) ($/GJ)	Energy costs are an important indicator of opportunities for energy savings and renewable energy, household, municipal, and business energy costs.	Available from Ames Electric
Total energy consumption by sector for electricity (GJ)	An indication of trends in energy use in buildings.	Available from Ames Electric
Total solar PV installs (# of installations)	An indication of the extent of decentralized renewable energy.	Available from Ames Electric
Total gasoline sales ($)	An indication of GHG emissions from vehicles.	VMT from Replica
Total transit trips	An indication of whether or not non-vehicular trips are increasing.	Ames
Length of physically separated cycling lanes	An indicator of opportunity for people of all ages to cycle.	Ames


ARMOUR

9.
Conclusion

9. Conclusion

The process for developing Ames' Climate Action Plan was rigorous, with multiple engagements and technical and staff reviews. The result is a systematic, ambitious, and transformative pathway that proactively engages in the energy transition, equips the City to take advantage of funding from the IRA, and ensures that Ames does its part to address the climate crisis.

The pathway is daunting in the breadth of investments required by residents, businesses, institutions, and the City itself, but there is wind in the sails as a result of the declining prices of key technologies such as solar and wind generation and electric vehicles combined with increasing adoption rates. Ames' efforts will build on and reinforce these efforts.

The combined ingredients of a highly engaged community and Council, the expertise and dedication of City staff, a history of innovation and pioneering environmental initiatives on which to build, the unique attribute of the City-owned electricity utility, and the partnership with the university position the City to make this journey happen.

10.
Appendices

Appendix A: Engagement Plan

August 2021

Purpose of this Document

The purpose of this Engagement Plan is to outline the objectives, desired outcomes, approach, and roles and responsibilities of the engagement portion of Ames' Climate Action Plan and Target Setting.

A1. Background

Context

The City of Ames is embarking on a process to set a community greenhouse gas emissions (GHG) reduction target and develop an associated Climate Action Plan (CAP).

Supporting Strategic Documentation

The City of Ames' strategic documents and planning initiatives were analysed in a "Situational Analysis" and provided to the City. This background research provides useful information for engagement activities such as focus groups and surveys. Drawing examples, principles, and approaches from these documents will increase the CAP's alignment with these other plans, and help to integrate all of these different but related initiatives. This in turn will improve the chances of success for all of them.

The following documentation are the primary strategic documents that will inform both the engagement and technical modelling:

- City of Ames' Promise/Vision;
- City of Ames's 2020-2021 City Council Goals, especially those related to engagement, equity, and environmental sustainability;
- The City's 2016 Resolution Reaffirming The City's Commitment to the Values of Equity, Fairness, Inclusion, and Justice;
- Ames 2040 Plan; and
- Iowa State University's Strategic Plan for Sustainability in Operations 2021-2025.

A2. What is Being Decided and How

The City of Ames wants to foster a forward-thinking, innovative, and sustainable community. An effective GHG reduction target and CAP can help achieve these goals. This will require factual information about the city's infrastructure and standards for the technical modelling, as well as an understanding of the city's context. It will also require decisions be made about an appropriate GHG reduction target and what actions the City of Ames will need to take to reduce its GHGs, on what timeline, and how those actions should be implemented. The CAP will contain the recommended answers to these questions, based on the technical modelling and engagement input.

The City of Ames expects the CAP will be ready to be recommended for approval by Council by September 2022. This plan will achieve the city's emission reduction targets, and reflect the advice, inputs, and ideas of the community.

A3. Engagement Strategy

The Engagement Strategy is the framework that will ensure internal (City) and external stakeholders are given opportunities to provide feedback that will be used to create the most effective CAP possible, and to establish a community that will support the implementation of the plan through to its completion.

Givens

Givens are facts that are outside the scope of engagement, which means they are not negotiable. The givens for this engagement will include the following:

- Climate change is real and primarily driven by human activity.
- The City of Ames will set a GHG emissions reduction target and develop a Climate Action Plan.
- This project is not an opportunity to debate ongoing flood mitigation work, or other ongoing city projects.

Stakeholders

In addition to providing broad feedback opportunities to the public, the City will engage stakeholders through three groups:

1. the Supplemental Input Committee, consisting of community stakeholders from various sectors, chosen by the City;
2. the City Steering Committee, consisting of the Mayor and Council;
3. the City Technical Advisory Committee, consisting of the Assistant City Manager, the Head of City Communications, the Iowa State University Head of Sustainability, and the Ames' Utility Energy Services Coordinator, as well as representatives from across City departments (as needed).

Interviewees from the pre-engagement process suggested the plan incorporate feedback from the broader community. To maximize resources, the Supplemental Input Committee, which will be deeply engaged in the CAP development and target setting process, will be tasked with:

- providing representative feedback from their sectors,
- looking for opportunities to educate their networks, and
- sharing concerns from their networks.

Guiding Principles

The following principles, derived primarily from the Pre-Engagement Report and the project Proposal, will guide the design and execution of all engagement activities,

A commitment to:

- Informing the public about complexity before and during the active engagement period, in order to raise the general level of understanding of global warming and climate action planning;
- Involving stakeholders via a Supplemental Input Committee in information collection to demonstrate process integrity and build credibility for recommendations;
- Communicating background information and engagement opportunities (times, dates, online venues) in a reasonable time prior to engagement;
- Providing stakeholders with various opportunities to provide input throughout the active engagement period; and
- Although decision-making will be focused on building consensus, the decision-making body is the Steering Committee, which is composed of the Ames City Council. The Council will consider the advice received during the engagements as much as possible in making the required decisions.

A4. Objectives

The following are the main objectives of this Engagement Plan described according to the IAP2 (International Association of Public Participation) Spectrum of Engagement (i.e., inform, consult, involve, or collaborate), **which is included at the end of this document**. As with the Guiding Principles, these Objectives are based on information available in the project proposal, the Pre-Engagement Report, as well as City Technical Advisory Committee input to date. The **outputs** (i.e. tangible things) and **outcomes** (i.e. intangible things) that will help achieve each objective are also described below.

The outputs and outcomes drive the techniques selected to achieve these objectives. The techniques selected are described in the **Engagement Technique** section, further below.

Objective 1

To inform and educate the community of the specific targets and actions required to create meaningful and feasible greenhouse gas emission reductions, while engendering a sense of responsibility for continuing this work through to its long-term completion.

Outputs:

- A community-based input committee, with internal (i.e., City) and external members, is established.
- Communications materials are created to educate and inform stakeholders about the strategy process and opportunities for input.

Outcomes:

- Stakeholders understand the process of science-based GHG reduction target setting, and best practices from other communities.
- Stakeholders understand the level of action and investment required from a climate action plan in order to meet their chosen GHG reduction target, and best practices from other communities.
- Stakeholders understand the increasing costs of inaction, and the benefits of action.

Objective 2

To involve stakeholders in the development of the engagement process and facilitate inclusive conversations among stakeholders in order to document community concerns and aspirations.

Outputs:

- Interviews with key stakeholders form the pre-engagement process, which results in a pre-engagement report containing a set of engagement plan recommendations.
- An interactive website serves as a place for members of the public to learn about ways to provide feedback and learn more about relevant background information.

Outcomes:

- Stakeholders say they have been meaningfully involved in the development of the engagement plan for the CAP.
- Community participants know how to get engaged, are motivated to identify opportunities, and become partners in the realization of the CAP.

Objective 3

To involve the community and City staff in gathering feedback that will inform: 1) the community's GHG reduction target, 2) the selected low-carbon actions, and 3) the CAP's near term implementation strategy.

Outputs:

- A series of assumptions to be used in the creation of low-carbon scenarios.
- City Steering Committee and Supplemental Community Input Committee sessions on:
  - Target-setting and climate action planning 101;
  - BAU and low-carbon scenario results; and
  - CAP implementation planning.
- Regular updates (e.g., bi-monthly) to the website on project progress.
- Community-wide feedback on effective CAP implementation planning.
- A draft implementation plan.
- Contact lists of stakeholders who wish to continue the dialogue on CAP implementation.

Outcomes:

- A revised list of low-carbon actions, adjusted based on City and stakeholder feedback.
- The City of Ames identifies and collaborates with its implementation partners to maximize the impact of the CAP and to benefit all participants justly and equitably.

Objective 4

To inform stakeholders of how their involvement shaped the plan.

Outputs:

- The City of Ames will provide regular and clear information on the progress of the CAP on the project's interactive website (during the course of the CAP development) and then on the City of Ames' website. These updates will summarize input received and how it influenced plan decisions.
- Final presentation to the City Council.

Outcomes:

- Community-members can see they have impacted decision-making.
- Community-members will understand the impact of their participation in shaping the CAP, and in acting as champions for the implementation of the plan.

A5. Communications

Comprehensive communications and education efforts are critical to the engagement's overall success. Stakeholders will need to see that sustained efforts are necessary in order to implement the low-carbon transition over the long-term. Working with the City of Ames' communications staff and the project team, we will communicate the following key messages through the channels outlined below.

A6. Key Messages

The following key messages have been developed for the project, which have been informed by the pre-engagement interview process:

- The City of Ames is committed to creating a climate-friendly future by partnering with the community.
- The City of Ames is prepared to pursue policy changes that encourage and require carbon reduction behaviors.
- Investment in climate action contributes to Ames' economic development, in addition to generating co-benefits related to health, improved environment, equity, and economic growth.

A7. Timeline

The timeline of engagement will be integrated with the project's technical modelling activities. Between the stages of modelling, engagement input will be gathered; and when the modelled results are completed, results will be presented.

The engagement will feed into the overall Plan completion as shown in the image below.

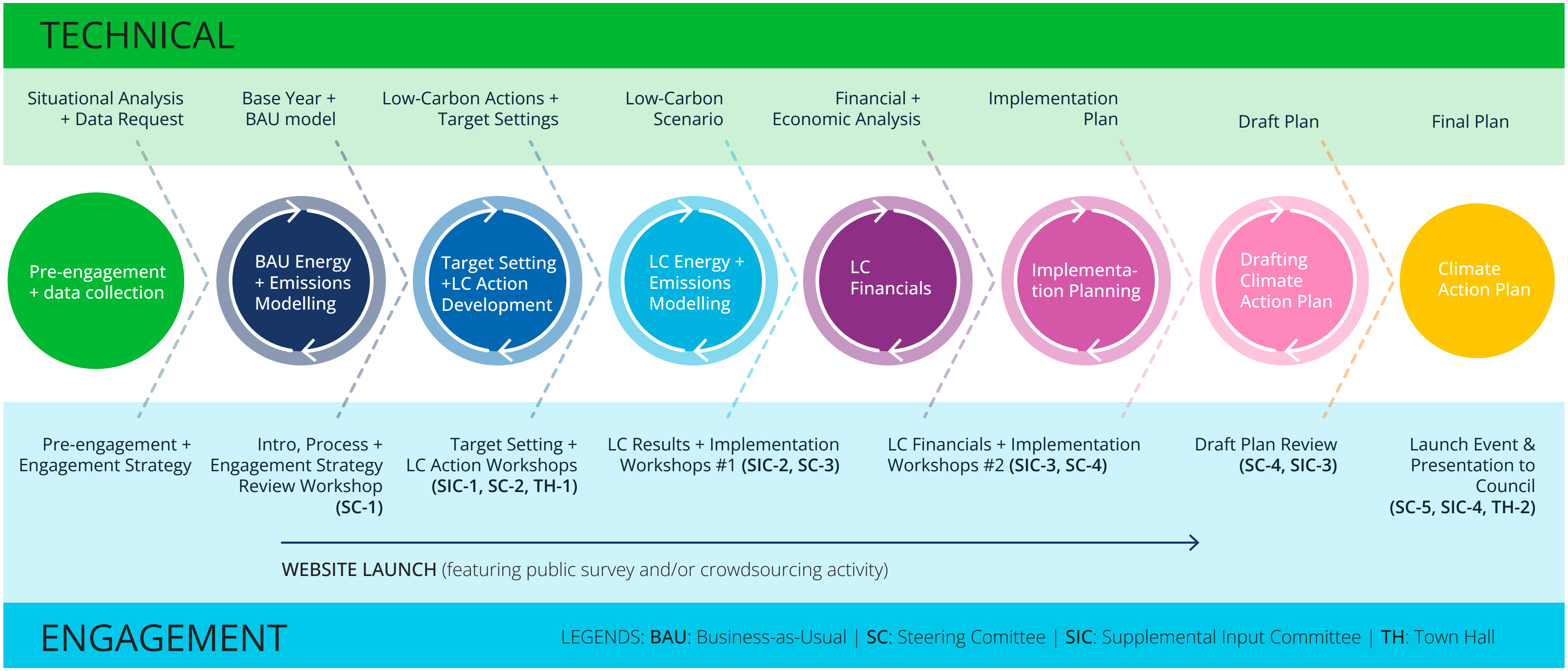


Figure 1. Energy and emissions modelling with data and engagement milestones.

A.8 Engagement Techniques

Phase 1: Pre-engagement Interviews + Engagement Design

Project initiation - September 2021

Activity	SSG role	City role	Objectives	Timeframe
Pre-Engagement Interviews and Summary Report	Conduct interviews of individuals identified by city (30-minute to 1-hour phone or video call. Analyze interviews.	Identify participant pool and advise them about being contacted to gather engagement data.	Objective 1	June - July
Engagement Plan design	Draft Engagement Plan.	Refine and approve	All	August-September

Phase 2: Active Engagement Period (prior to plan completion)

July 2021 - July 2022

Activity	IAP2 Spectrum Level	SSG role	City role	Objectives	Timeframe
Focus groups with key stakeholders As identified by the Technical Advisory Committee, hold discussions with stakeholders to discuss the city's current energy and emissions profile, potential low-carbon actions, and implementatieplan design	**Involve.** Although decision-making will be focused on building consensus, the decision-making body is the Steering Committee, which is composed of the Ames City Council. The Council will consider the advice received during the engagements as much as possible in making the required decisions.	• Lead discussion, provide key background material, and take notes • Incorporate key information into CAP	Support in coordinating meeting timing and hosting.	All	July 2021 - July 2022
CAP interactive website	**Inform.** Promise to the public: We will provide you with resources and opportunities to stay informed.	• Design website and draft content that ensures the public is informed about: — engagement opportunities, — key background information, and — how their feedback is used to shape the final CAP. • Website will host the community survey described	Provide support and guidance.	Objectives 1, 3, 4	Ongoing

Activity	IAP2 Spectrum Level	SSG role	City role	Objectives	Timeframe
City Steering Committee (CSC) Workshop 1: The Process Steering Committee members will become acquainted with the project goals and process, including the scenario modelling method. Target setting and climate action planning best practices will be introduced and discussed. Finally, the project's engagement strategy will be reviewed and discussed. In particular, the process for seeking and integrating community and CSC input into the CAP and in setting the community GHG target will be reviewed, and feedback sought from the CSC.	**Involve.** Although decision-making will be focused on building consensus, the decision-making body is the Steering Committee, which is composed of the Ames City Council. The Council will consider the advice received during the engagements as much as possible in making the required decisions.	• Prepare an energy and emissions planning and target setting 101 presentation. • Prepare an overview of the project process and milestones. • Prepare an overview of the engagement plan.	• Coordinate meeting timing and hosting. • Review presentation materials prior to the workshop. • Respond to questions about the City's role, jurisdiction.	All	August/ September

Activity	IAP2 Spectrum Level	SSG role	City role	Objectives	Timeframe
Supplemental Input Committee (SIC) **Workshop 1:** **Base Year and BAU Results and Target-Setting Workshop** SIC members will become acquainted with each other and the project goals and process. SiC members will be asked to watch the CSC workshop as preparation for the workshop. Base year energy and emissions inventory data and business as usual (BAU) scenario modelling results will be reviewed. Emissions reduction challenges and opportunities will be discussed Participatory workshop exercises will be hosted to build relationships and develop a CAP vision. Varying emissions reduction targets will be debated, and preferred targets will be documented.	**Involve.** Although decision-making will be focused on building consensus, the decision-making body is the Steering Committee, which is composed of the Ames City Council. The Council will consider the advice received during the engagements as much as possible in making the required decisions.	• Prepare an energy and emissions planning and target setting 101 presentation. • Prepare an overview of the project process and milestones. • Provide digital framework/ exercise tools. • Prepare a take-home survey or worksheets after the workshop. To finalize ideas.	• Recruit committee members. • Coordinate meeting timing and hosting. • Provide presentation background material on the CAP, indicating how it fits with other City plans/ strategies. • Review presentation materials prior to the workshop. • Respond to questions about the City's role, jurisdiction.	Objectives 1, 3, 4	September/ October

Activity	IAP2 Spectrum Level	SSG role	City role	Objectives	Timeframe
Launch Event: Town Hall - CAP Inventory and BAU: The first public event, the Town Hall will introduce the community to the CAP process, share information about public input opportunities, and enable participants to share their vision for Ames' future.	**Involve.** Although decision-making will be focused on building consensus, the decision-making body is the Steering Committee, which is composed of the Ames City Council. The Council will consider the advice received during the engagements as much as possible in making the required decisions.	• Assist with the logistics and coordination of the event. • Prepare an energy and emissions planning and target setting 101 presentation. • Prepare a presentation on community GHG inventory, BAU modelling results, and public input opportunities. • Design an activity to allow participants to express their vision for Ames' low-carbon future. • Co-host, if required.	• Set the program/ agenda. • Advise on guest speakers. • Provide a host for the event. • Invite the Mayor and/or Council to give some brief remarks.	Objectives 1, 3, 4	October
SIC Workshop 2: Low-Carbon Action Workshop Ames's energy and emissions outlook will be presented to provide the scale of the emissions reductions challenge. The SIC will identify emissions areas on which to focus and present emissions reduction opportunities in each emissions sector for consideration in CAP development.	**Involve.** Although decision-making will be focused on building consensus, the decision-making body is the Steering Committee, which is composed of the Ames City Council. The Council will consider the advice received during the engagements as much as possible in making the required decisions.	• Lead the workshop, prepare and provide materials. • Provide digital framework/ exercise tools. • Prepare a list of low-carbon actions. • Prepare a take-home survey or worksheets after the workshop. To finalize ideas.	• Review presentation materials prior to the workshop. • Coordinate meeting timing and hosting.	Objectives 1, 3, 4	November

Activity	IAP2 Spectrum Level	SSG role	City role	Objectives	Timeframe
CSC Workshop 2: Review of feedback to date on target setting and low-carbon actions, and low-carbon action workshop. For context, base year energy and emissions inventory data and business as usual (BAU) scenario modelling results will be reviewed. Emissions reduction challenges and opportunities will be discussed with regard to City powers. Inputs for the workshop will come from SSG's technical analysis and the SiC. **Proposed Attendees:** Directors or senior representatives from building approvals, community planning/short-term planning, transportation, environmental services	**Involve.** Although decision-making will be focused on building consensus, the decision-making body is the Steering Committee, which is composed of the Ames City Council. The Council will consider the advice received during the engagements as much as possible in making the required decisions.	• Provide modelling outputs presentation materials. • Prepare a summary of what we've heard to date. • Prepare discussion topics and exercises. • Prepare a preliminary list of low-carbon actions. • Lead workshop.	• Identify and convene group members • Review presentation materials prior to the workshop. • Coordinate meeting timing and hosting.	Objectives 1, 3, 4	December

Activity	IAP2 Spectrum Level	SSG role	City role	Objectives	Timeframe
CSC & SIC Workshops : Low-carbon scenario modelling results & introduction to implementation Low-carbon scenario modelling results **Proposed Attendees:** Directors or senior representatives from building approvals, community planning/short-term planning, transportation, environmental services	**Involve.** Although decision-making will be focused on building consensus, the decision-making body is the Steering Committee, which is composed of the Ames City Council. The Council will consider the advice received during the engagements as much as possible in making the required decisions.	• Provide modelling outputs presentation materials. • Prepare discussion topics and exercises. • Lead workshop. • Provide digital framework/ exercise tools.	• Review presentation materials prior to the workshop. • Coordinate meeting timing and hosting	Objective 4	February
Community survey: Online survey to give community members a chance to provide their input on the CAP implementation plan.	**Consult.** Promise to the public: We will seek your advice on the variety of options presented.	• Draft survey. • Set survey up on selected online platform. • Analyze feedback.	• Review draft survey. • Promote to the community. • Logistical support.	Objectives 1,3, 4	March-June

Activity	IAP2 Spectrum Level	SSG role	City role	Objectives	Timeframe
CSC & SIC Workshops: Low-carbon financial results & implementation part 2 Low-carbon financial modelling results **Proposed Attendees:** Directors or senior representatives from building approvals, community planning/short-term planning, transportation, environmental services	**Involve.** Although decision-making will be focused on building consensus, the decision-making body is the Steering Committee, which is composed of the Ames City Council. The Council will consider the advice received during the engagements as much as possible in making the required decisions.	• Provide modelling outputs presentation materials. • Prepare discussion topics and exercises. • Lead workshop. • Provide digital framework/ exercise tools.	• Review presentation materials prior to the workshop. • Coordinate meeting timing and hosting	Objective 4	March/April
Online Implementation Plan review: CSC + SIC	**Consult.** Promise to the public: We will seek your advice on the variety of options presented.	• Prepare draft. • Set up a feedback mechanism to gather input.	• Provide logistical support.	Objectives 1, 3, 7	May-June

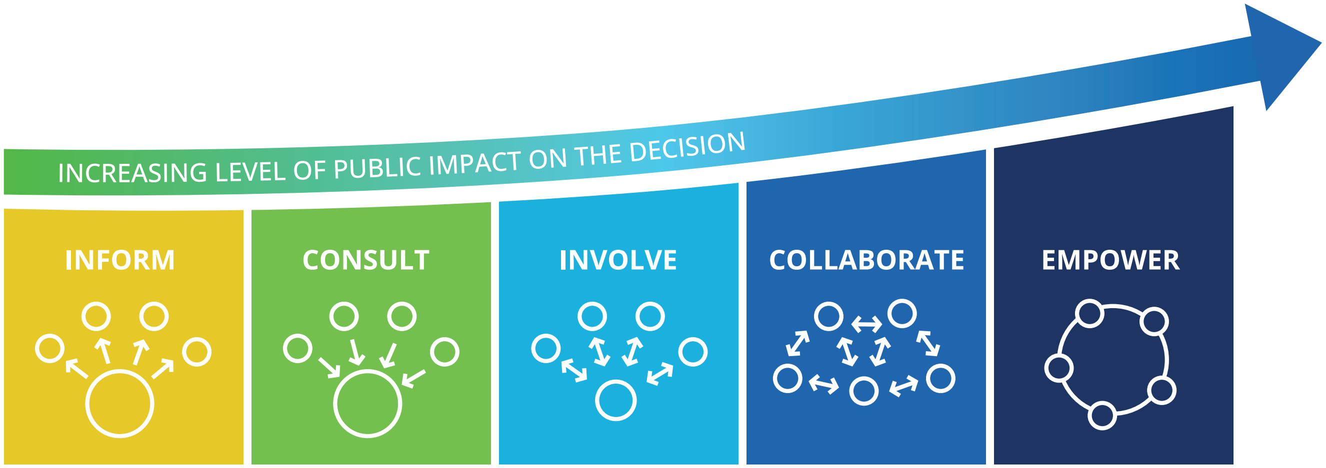
Activity	IAP2 Spectrum Level	SSG role	City role	Objectives	Timeframe
Town Hall + Kitchen Workbook The team will prepare guided workbooks that households can work through around the kitchen table to review the draft CAP and explore how they can contribute to the CAP in their household and place of work, and identify how the City and other stakeholders can be a resource.	**Consult.** Promise to the public: We will seek your advice on the variety of options presented.	• Prepare workbook • Co-host if required • Analyze results	• Set the program/ agenda. • Advise on guest speakers. • Provide a host for the event. • Invite the Mayor and/or Council to give some brief remarks. Promote to the community. • Provide logistical support.	Objectives 3, 4	June - July
Online Draft CAP review (TAC +CSC)	**Consult.** Promise to the public: We will seek your advice on the variety of options presented.	• Prepare and deliver a presentation on an updated version of the CAP. • Gather and analyze feedback.	• Provide logistical support.	Objectives 1, 3, 7	July - August

Phase 3: Final Report + Presentation

By September 2022

Activity	SSG role	City role	Objectives	Timeframe
Presentation to Council	• Draft presentation • Deliver presentation to Council and answer questions.	• Edit presentation. • Co-deliver presentation.	Objective 4	September 2022

Sub-Appendix A: IAP2 Public Participation Spectrum



	INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
PUBLIC PARTICIPATION GOAL	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision making in the hands of the public.
PROMISE TO THE PUBLIC	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

Figure 2. IAP2 Spectrum of Public Participation © IAP2 International Federation 2018

Appendix B: GPC Reporting

Green rows = Sources required for GPC BASIC inventory
Blue rows = Sources required GPC BASIC+ inventory
Yellow rows = Sources required for territorial total but not for BASIC/BASIC+ reporting

Exclusion Rationale Legend

N/A	Not Applicable or not included in scope
ID	Insufficient Data
NR	No Relevance or limited activities identified
Other	Reason provided in other comments

					in tonnes			
GPC ref No.	Scope	GHG Emissions Source	Inclusion	Reason for exclusion (if applicable)	CO2	CH4	N2O	Total CO2e
I	STATIONARY ENERGY SOURCES							
I.1	Residential buildings							
I.1.1	1	Emissions from fuel combustion within the city boundary	Yes		71,357	0	0	71,357
I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes		122,845	0	0	122,845
I.1.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes		11,572	0	0	11,572
I.2	Commercial and institutional buildings/facilities							
I.2.1	1	Emissions from fuel combustion within the city boundary	Yes		71,583	5	9	71,597
I.2.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes		183,546	0	0	183,546
I.2.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes		17,291	0	0	17,291
I.3	Manufacturing industry and construction							
I.3.1	1	Emissions from fuel combustion within the city boundary	Yes		39,52	3	5	39,528
I.3.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes		52,636	0	0	52,636
I.3.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes		4,959	0	0	4,959

					in tonnes			
GPC ref No.	Scope	GHG Emissions Source	Inclusion	Reason for exclusion (if applicable)	CO2	CH4	N2O	Total CO2e
I.4	**Energy industries**							
I.4.1	1	Emissions from energy used in power plant auxiliary operations within the city boundary	No	NR	229,48	388	1,702	231,571
I.4.2	2	Emissions from grid-supplied energy consumed in power plant auxiliary operations within the city boundary	No	NR	55,465	0	0	55,465
I.4.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption in power plant auxiliary operations	No	NR	5,225	0	0	5,225
I.4.4	1	Emissions from energy generation supplied to the grid	No	NR	0	0	0	0
I.5	**Agriculture, forestry and fishing activities**							
I.5.1	1	Emissions from fuel combustion within the city boundary	No	NR	0	0	0	0
I.5.2	2	Emissions from grid-supplied energy consumed within the city boundary	No	NR	0	0	0	0
I.5.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	No	NR	0	0	0	0

					in tonnes			
GPC ref No.	Scope	GHG Emissions Source	Inclusion	Reason for exclusion (if applicable)	CO2	CH4	N2O	Total CO2e
I.6	**Non-specified sources**							
I.6.1	1	Emissions from fuel combustion within the city boundary	No	NR	0	0	0	0
I.6.2	2	Emissions from grid-supplied energy consumed within the city boundary	No	NR	0	0	0	0
I.6.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	No	NR	0	0	0	0
I.7	**Fugitive emissions from mining, processing, storage, and transportation of coal**							
I.7.1	1	Emissions from fugitive emissions within the city boundary	No	NR	0	0	0	0
I.8	**Fugitive emissions from oil and natural gas systems**							
I.8.1	1	Emissions from fugitive emissions within the city boundary	Yes		7	5,017	0	5,024

					in tonnes			
GPC ref No.	Scope	GHG Emissions Source	Inclusion	Reason for exclusion (if applicable)	CO2	CH4	N2O	Total CO2e
II	**TRANSPORTATION**							
II.1	**On-road transportation**							
II.1.1	1	Emissions from fuel combustion for on-road transportation occurring within the city boundary	Yes		252,289	368	662	253,32
II.1.2	2	Emissions from grid-supplied energy consumed within the city boundary for on-road transportation	Yes		183	0	0	183
II.1.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	Yes		75,335	112	206	75,653
II.2	**Railways**							
II.2.1	1	Emissions from fuel combustion for railway transportation occurring within the city boundary	No	NR	0	0	0	0
II.2.2	2	Emissions from grid-supplied energy consumed within the city boundary for railways	No	NR	0	0	0	0

II.2.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	No	NR	0	0	0	0
					in tonnes			
GPC ref No.	Scope	GHG Emissions Source	Inclusion	Reason for exclusion (if applicable)	CO2	CH4	N2O	Total CO2e
II.3	**Water-borne navigation**							
II.3.1	1	Emissions from fuel combustion for waterborne navigation occurring within the city boundary	No	N/A	0	0	0	0
II.3.2	2	Emissions from grid-supplied energy consumed within the city boundary for waterborne navigation	No	N/A	0	0	0	0
II.3.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	No	N/A	0	0	0	0
II.4	**Aviation**							
II.4.1	1	Emissions from fuel combustion for aviation occurring within the city boundary	No	N/A	0	0	0	0
II.4.2	2	Emissions from grid-supplied energy consumed within the city boundary for aviation	No	N/A	0	0	0	0

GPC ref No.	Scope	GHG Emissions Source	Inclusion	Reason for exclusion (if applicable)	CO2	CH4	N2O	Total CO2e
II.4.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	No	N/A	0	0	0	0
					in tonnes			
GPC ref No.	Scope	GHG Emissions Source	Inclusion	Reason for exclusion (if applicable)	CO2	CH4	N2O	Total CO2e
II.5	**Off-road**							
II.5.1	1	Emissions from fuel combustion for off-road transportation occurring within the city boundary	No	NR	0	0	0	0
II.5.2	2	Emissions from grid-supplied energy consumed within the city boundary for off-road transportation	No	NR	0	0	0	0
III	**WASTE**							
III.1	**Solid waste disposal**							
III.1.1	1	Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps within the city boundary	Yes		0	0	0	0

III.1.2	3	Emissions from solid waste generated within the city boundary but disposed in landfills or open dumps outside the city boundary	Yes		0	36,681	0	36,681
III.1.3	1	Emissions from waste generated outside the city boundary and disposed in landfills or open dumps within the city boundary	No	N/A	0	0	0	0
					in tonnes			
GPC ref No.	Scope	GHG Emissions Source	Inclusion	Reason for exclusion (if applicable)	CO2	CH4	N2O	Total CO2e
III.2	**Biological treatment of waste**							
III.2.1	1	Emissions from solid waste generated within the city boundary that is treated biologically within the city boundary	Yes		0	0	0	0
III.2.2	3	Emissions from solid waste generated within the city boundary but treated biologically outside of the city boundary	No	N/A	0	1	4	5
III.2.3	1	Emissions from waste generated outside the city boundary but treated biologically within the city boundary	No	N/A	0	0	0	0
III.3	**Incineration and open burning**							
III.3.1	1	Emissions from solid waste generated and treated within the city boundary	No	N/A	0	0	0	0

III.3.2	3	Emissions from solid waste generated within the city boundary but treated outside of the city boundary	No	N/A	0	0	0	0
III.3.3	1	Emissions from waste generated outside the city boundary but treated within the city boundary	No	N/A	0	0	0	0
					in tonnes			
GPC ref No.	Scope	GHG Emissions Source	Inclusion	Reason for exclusion (if applicable)	CO2	CH4	N2O	Total CO2e
III.4	**Wastewater treatment and discharge**							
III.4.1	1	Emissions from wastewater generated and treated within the city boundary	Yes		0	0	0	0
III.4.2	3	Emissions from wastewater generated within the city boundary but treated outside of the city boundary	No	NR	0	0	3	3
III.4.3	1	Emissions from wastewater generated outside the city boundary	No	N/A	0	0	0	0
IV	**INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)**							
IV.1	1	Emissions from industrial processes occurring within the city boundary	No	ID	0	0	0	0
IV.2	1	Emissions from product use occurring within the city boundary	No	ID	0	0	0	0

					in tonnes			
GPC ref No.	Scope	GHG Emissions Source	Inclusion	Reason for exclusion (if applicable)	CO2	CH4	N2O	Total CO2e
V	**AGRICULTURE, FORESTRY AND LAND USE (AFOLU)**							
V.1	1	Emissions from livestock within the city boundary	No	NR	0	0	0	0
V.2	1	Emissions from land within the city boundary	No	NR	0	0	0	0
V.3	1	Emissions from aggregate sources and non-CO2 emission sources on land within the city boundary	No	NR	0	0	0	0
VI	**OTHER SCOPE 3**							
VI.1	3	Other Scope 3	No	N/A	0	0	0	0
							TOTAL	**1,240,536**

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Appendix C: Data, Methods, and Assumptions (DMA) Manual

July 2021

Purpose of this Document

This Data, Methods, and Assumptions (DMA) manual details the modeling approach used to provide community energy and emissions benchmarks and projections while providing a summary of the data and assumptions used in scenario modeling. The DMA makes the modeling elements fully transparent and illustrates the scope of data required for future modeling efforts.

Glossary

BAU	Business as usual
CBECS	Commercial Buildings Energy Consumption Survey
CHP	Combined heat and power
DMA	Data, methods, and assumptions manual
GHG	Greenhouse gases
GIS	Geographic information systems
GPC	Global Protocol on Community-Scale GHG Emissions Inventories
IPCC	Intergovernmental Panel on Climate Change
VMT	Vehicle Miles Travelled

C1 Accounting and Reporting Principles

The municipal greenhouse gas (GHG) inventory base year development and scenario modeling approach correlate with the Global Protocol for Community-Scale GHG Emissions Inventories (GPC).[1] The GPC provides a fair and true account of emissions via the following principles:

Relevance: The reported GHG emissions appropriately reflect emissions occurring as a result of activities and consumption within the City boundary. The inventory will also serve the decision-making needs of the City, taking into consideration relevant local, state, and national regulations. Relevance applies when selecting data sources and determining and prioritizing data collection improvements.

Completeness: All emissions sources within the inventory boundary shall be accounted for and any exclusions of sources shall be justified and explained.

Consistency: Emissions calculations shall be consistent in approach, boundary, and methodology.

Transparency: Activity data, emissions sources, emissions factors and accounting methodologies require adequate documentation and disclosure to enable verification.

Accuracy: The calculation of GHG emissions should not systematically overstate or understate actual GHG emissions. Accuracy should be enough to give decision makers and the public reasonable assurance of the integrity of the reported information. Uncertainties in the quantification process should be reduced to the extent possible and practical.

[1] WRI, C40 and ICLEI (2014). Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories. Retrieved from: https://ghgprotocol.org/sites/default/files/standards/GHGP_GPC_0.pdf.

C.2 Scope

Geographic Boundary

Energy and emissions inventories and modeling for the project will be completed for the City of Ames' current boundary (Figure 1) and new growth areas as identified in the Ames Plan 2040 draft (Figure 2). The land-use and density targets modeled will be in line with what is identified in the 2040 plan.

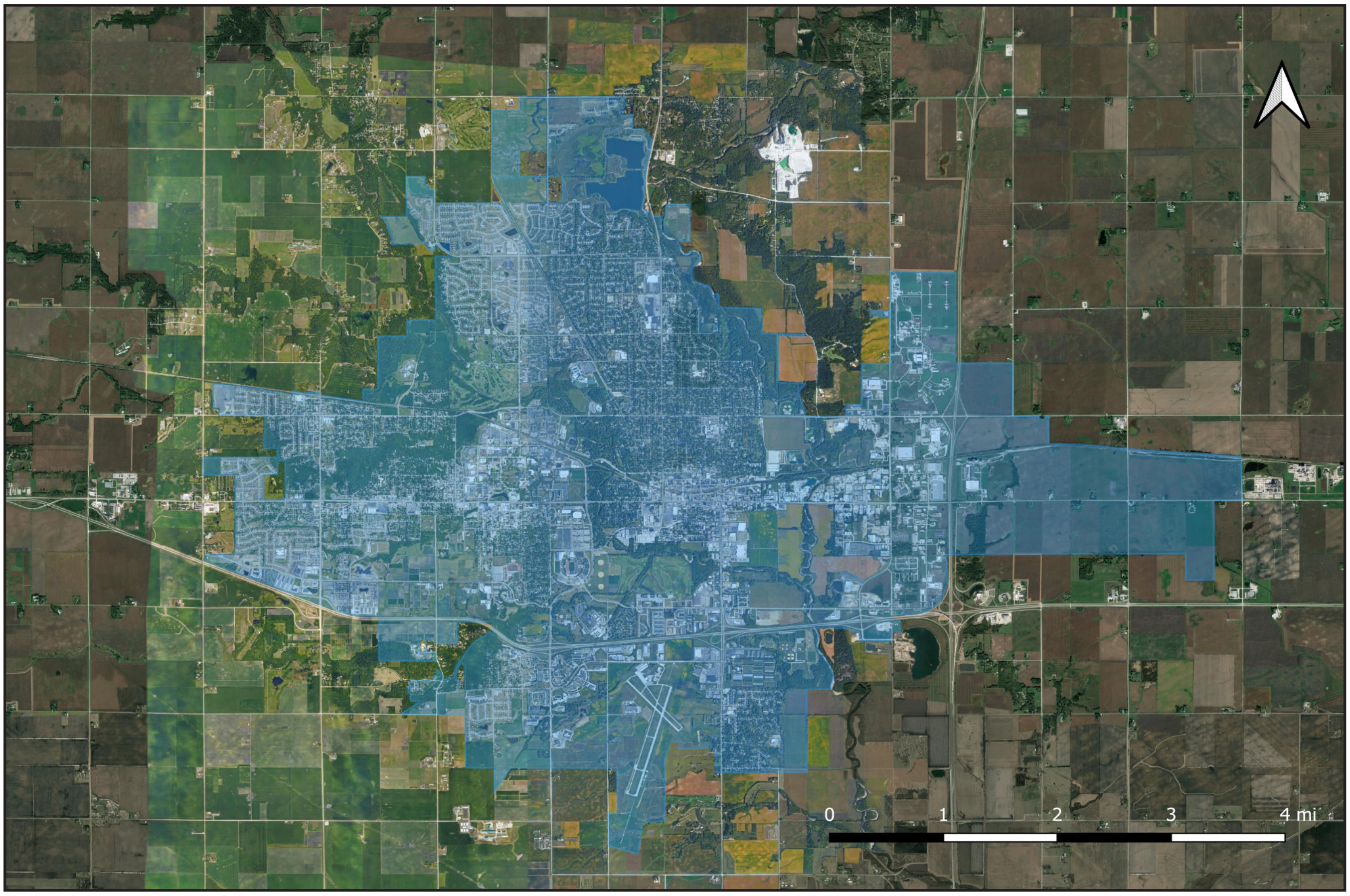


Figure 1. Current geographical boundary for Ames

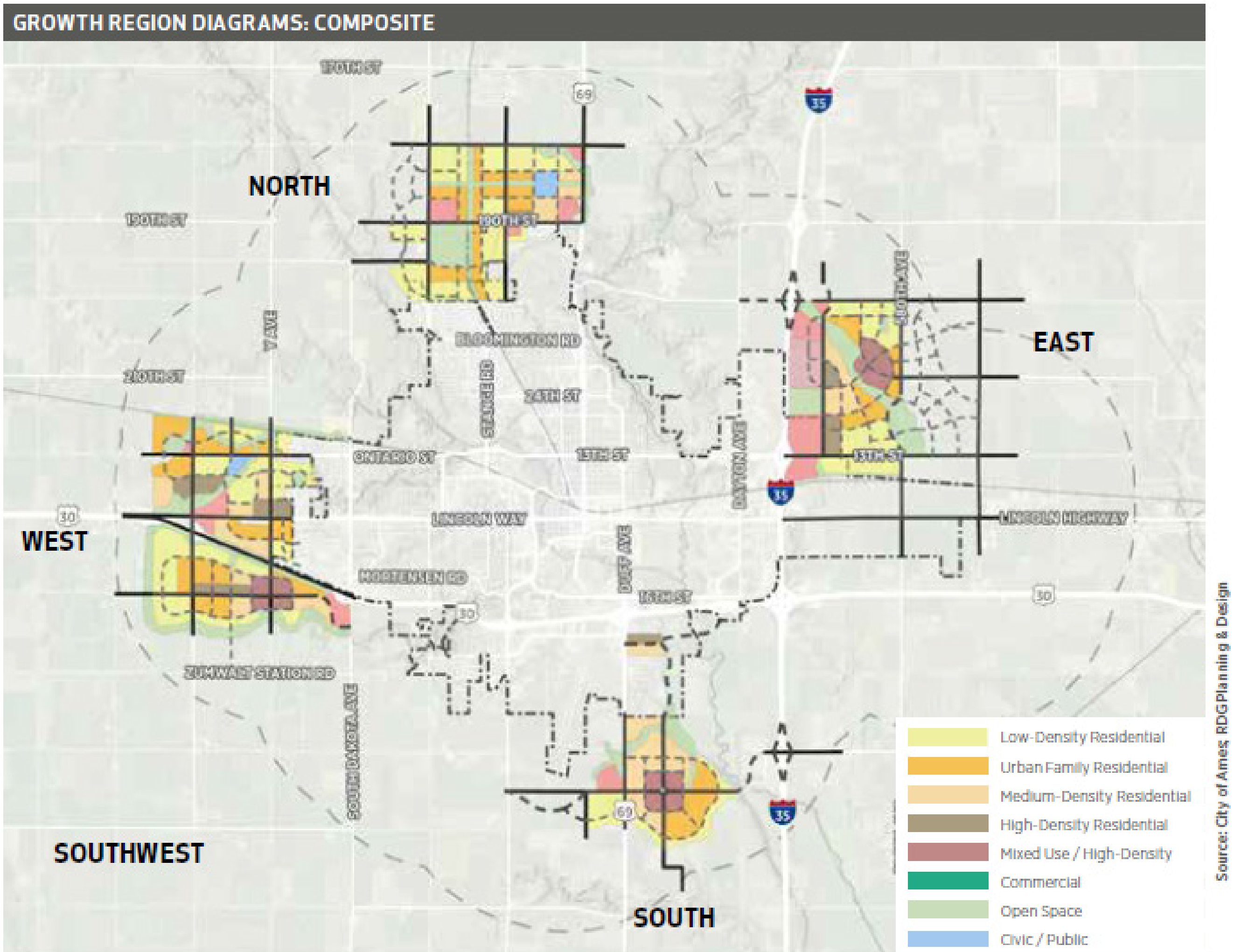


Figure 2. Future geographical boundary for Ames and land-use types in growth areas.

C.3 Time Frame of Assessment

The modeling time frame will include years 2018-2050. The year 2018 will be used as the base year since it aligns with the City's existing inventory and the latest census, and 2050 is the relevant target year. Model calibration for the base year uses as much locally observed data as possible.

C.4 Energy and Emissions Structure

The total energy for a community is defined as the sum of the energy from each of the following aspects:

$$Energy_{City} = Energy_{transport} + Energy_{buildings} + Energy_{waste\&wastewater}$$

Where:

$Energy_{transport}$ is the movement of goods and people.

$Energy_{buildings}$ is the generation of heating, cooling, and electricity.

$Energy_{wastegen}$ is energy generated from waste.

The total GHG emissions for a community is defined as the sum from all in-scope emissions sources:

$$GHG_{landuse} = GHG_{transport} + GHG_{energygen} + GHG_{waste\&wastewater} + GHG_{agriculture} + GHG_{forest} + GHG_{landconvert}$$

Where:

$GHG_{transport}$ is emissions generated by the movement of goods and people.

$GHG_{energygen}$ is emissions generated by the generation of heat and electricity.

$GHG_{waste\&wastewater}$ is emissions generated by solid and liquid waste produced.

$GHG_{agriculture}$ is emissions generated by food production.

GHG_{forest} is emissions generated by forested land.

$GHG_{landconvert}$ is emissions generated by the lands converted from natural to modified conditions.

C.5 Emissions Scope

The inventory will include emissions Scopes 1 and 2, and some aspects of Scope 3, as defined by GPC (Table 1 and Figure 2). Refer to Appendix 1 of this DMA for a list of included GHG emissions sources by scope.

Table 1. GPC scope definitions.

Scope	Definition
1	All GHG emissions from sources located within the municipal boundary.
2	All GHG emissions occurring from the use of grid-supplied electricity, heat, steam, and/or cooling within the municipal boundary.
3	All other GHG emissions that occur outside the municipal boundary as a result of activities taking place within the boundary.

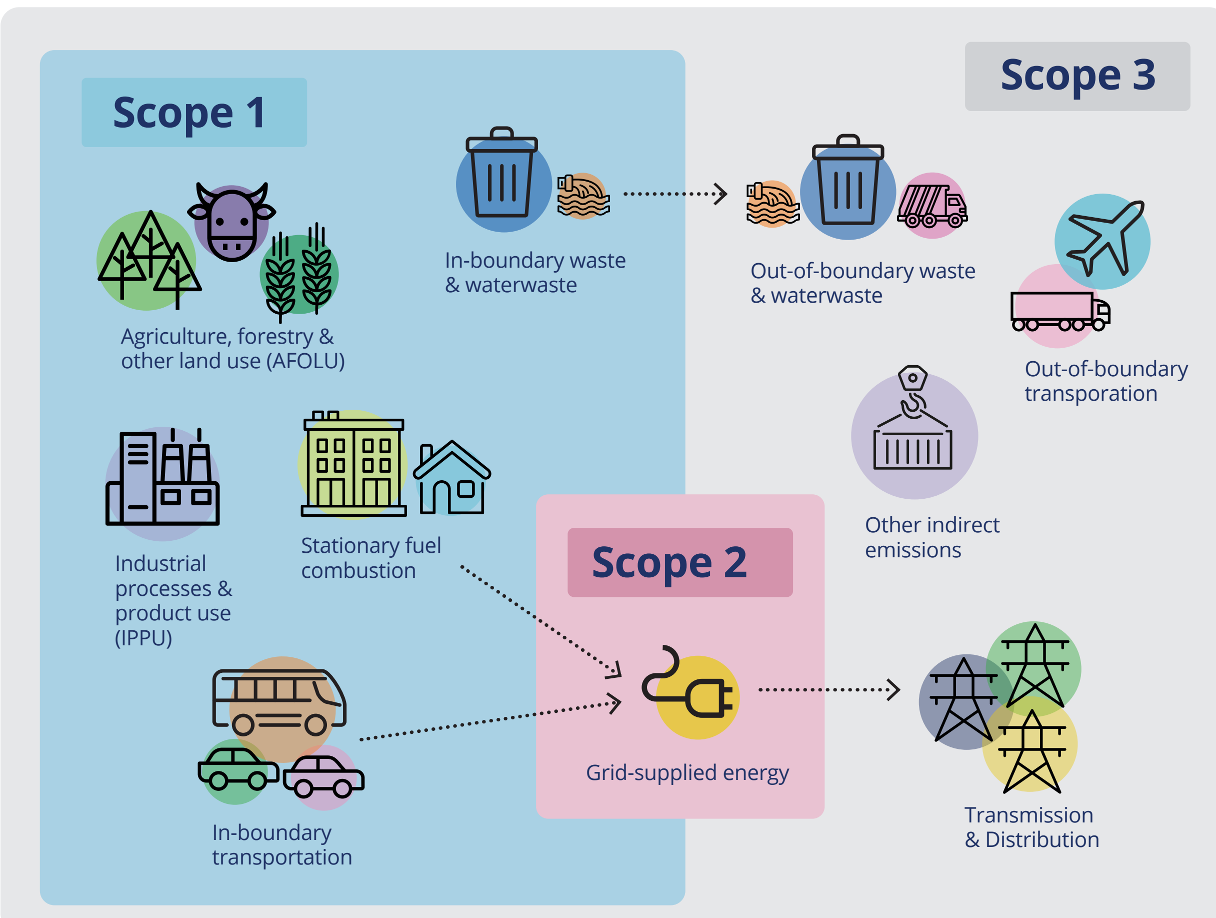


Figure 2. Diagram of GPC emissions scopes.

C.6 The Model

The model is an energy, emissions, and finance tool developed by Sustainability Solutions Group and whatIf? Technologies. The model integrates fuels, sectors, and land use in order to enable bottom-up accounting for energy supply and demand, including:

- renewable resources;
- conventional fuels;
- energy consuming technology stocks (e.g. vehicles, appliances, dwellings, and buildings); and
- all intermediate energy flows (e.g. electricity and heat).

Energy and GHG emissions values are derived from a series of connected stock and flow models, evolving based on current and future geographic and technologic decisions/assumptions (e.g. EV uptake rates). The model accounts for physical flows (e.g. energy use, new vehicles by technology, VMT) as determined by stocks (buildings, vehicles, heating equipment, etc.).

The model applies a system dynamics approach. For any given year, the model traces the flows and transformations of energy from sources through energy currencies (e.g. gasoline, electricity, hydrogen) to end uses (e.g. personal vehicle use, space heating) to energy costs and GHG emissions. An energy balance is achieved by accounting for efficiencies, technology conversion, and trade and losses at each stage in the journey from source to end use.

Table 2. Model characteristics.

Characteristic	Rationale
Integrated	The tool models and accounts for all city-scale energy and emissions in relevant sectors and captures relationships between sectors. The demand for energy services is modeled independently of the fuels and technologies that provide the energy services. This decoupling enables exploration of fuel-switching scenarios. Feasible scenarios are established when energy demand and supply are balanced.
Scenario-based	Once calibrated with historical data, the model enables the creation of dozens of scenarios to explore different possible futures. Each scenario can consist of either one or a combination of policies, actions, and strategies. Historical calibration ensures that scenario projections are rooted in observed data.
Spatial	Built environment configuration determines walkability and cyclability, accessibility to transit, feasibility of district energy, and other aspects. The model therefore includes spatial dimensions that can include as many zones (the smallest areas of geographic analysis) as deemed appropriate. The spatial components can be integrated with GIS systems, land-use projections, and transportation modeling.

Characteristic	Rationale
GPC-compliant	The model is designed to report emissions according to the Global Protocol for Community-Scale GHG Emissions Inventories (GPC) framework and principles.
Economic impacts	The model incorporates a high-level financial analysis of costs related to energy (expenditures on energy) and emissions (carbon pricing, social cost of carbon), as well as operating and capital costs for policies, strategies, and actions. This allows for the generation of marginal abatement costs.

C.7 Model Structure

The major components of the model and the first level of their modelled relationships (influences) are represented by the blue arrows in Figure 3. Additional relationships may be modelled by modifying inputs and assumptions—specified directly by users, or in an automated fashion by code or scripts running "on top of" the base model structure. Feedback relationships are also possible, such as increasing the adoption rate of non-emitting vehicles in order to meet a GHG emissions constraint.

The model is spatially explicit. All buildings, transportation, and land-use data are tracked within the model through a GIS platform, and by varying degrees of spatial resolution. A zone type system is applied to divide the City into smaller configurations, based on the City's existing traffic zones (or another agreeable zone system). This enables consideration of the impact of land-use patterns and urban form on energy use and emissions production from a base year to future dates using GIS-based platforms. The model's GIS outputs will be integrated with the City's mapping systems.

For any given year various factors shape the picture of energy and emissions flows, including: the population and the energy services it requires; commercial floorspace; energy production and trade; the deployed technologies which deliver energy services (service technologies); and the deployed technologies which transform energy sources to currencies (harvesting technologies). The model is based on an explicit mathematical relationship between these factors—some contextual and some part of the energy consuming or producing infrastructure—and the energy flow picture.

Some factors are modelled as stocks—counts of similar things, classified by various properties. For example, population is modelled as a stock of people classified by age and gender. Population change over time is projected by accounting for: the natural aging process, inflows (births, immigration), and outflows (deaths, emigration). The fleet of personal use vehicles, an example of a service technology, is modelled as a stock of vehicles classified by size, engine type and model year, with a similarly classified fuel consumption intensity. As with population, projecting change in the vehicle stock involves aging vehicles and accounting for major inflows (new vehicle sales) and major outflows (vehicle discards). This stock-turnover approach is applied to other service technologies (e.g., furnaces, water heaters) and harvesting technologies (e.g., electricity generating capacity).

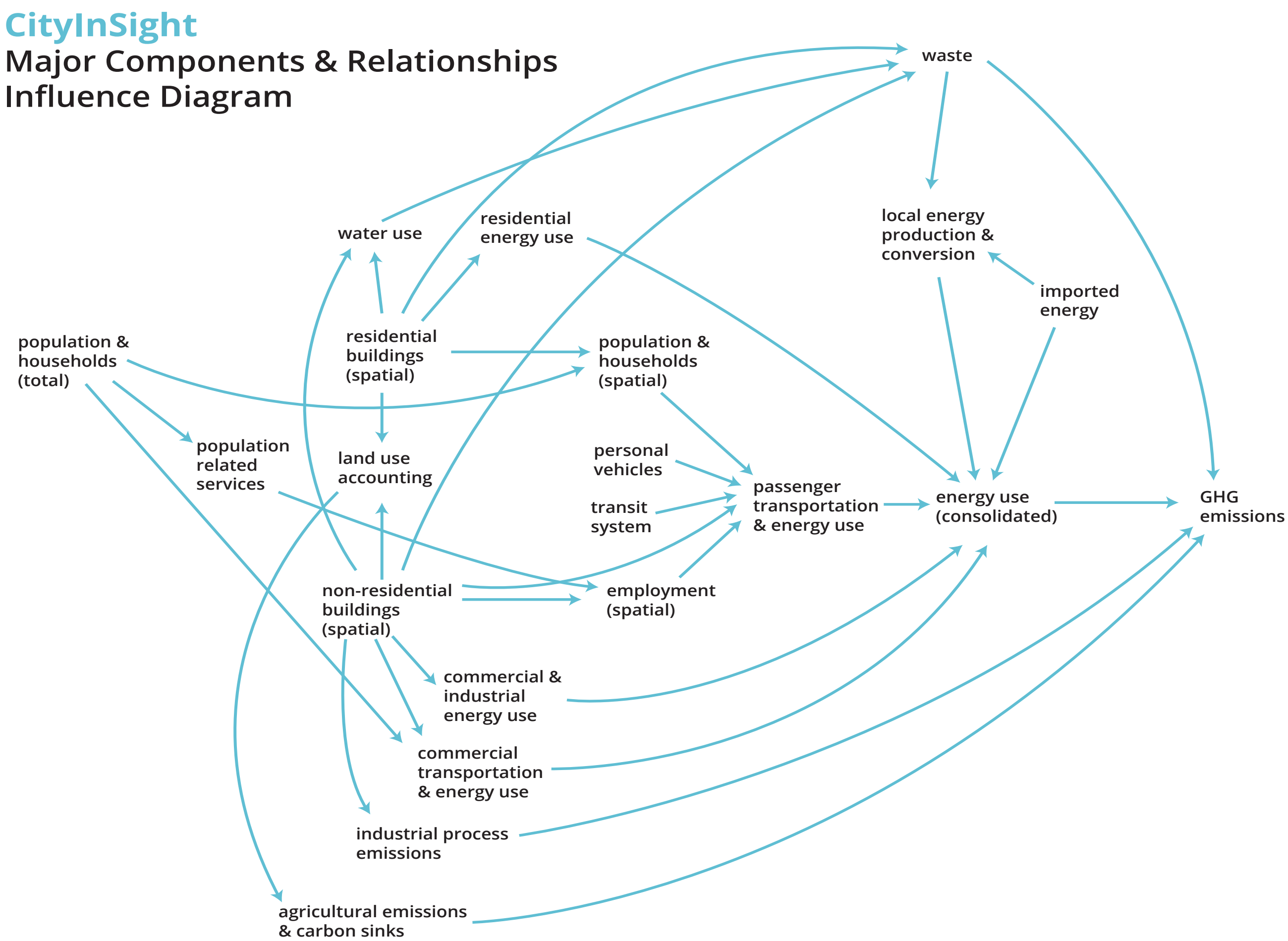


Figure 3. Representation of the CiS model structure.

C.8 Sub-Models

Population and Demographics

City-wide population is modelled using the standard population cohort-survival method, disaggregated by single year of age and gender. It accounts for typical components of change: births, deaths, immigration and emigration. The age-structured population is important for analysis of demographic trends, generational differences and implications for shifting energy use patterns. These numbers are calibrated against existing projections.

Residential Buildings

Residential buildings are spatially located and classified using a detailed set of 30+ building archetypes capturing footprint, height and type (single, double, row, apt. high, apt. low), and year of construction. This enables a “box” model of buildings that helps to estimate the surface area, and model energy use and simulate the impact of energy efficiency measures based on what we know about the characteristics of the building. Coupled with thermal envelope performance and degree-days the model calculates space conditioning energy demand independent of any space heating or cooling technology and fuel. Energy service demand then drives stock levels of key service technologies including heating systems, air conditioners, water heaters. These stocks are modelled with a stock-turnover approach capturing equipment age, retirements, and additions—exposing opportunities for efficiency gains and fuel switching, but also showing the rate limits to new technology adoption and the effects of lock-in (obligation to use equipment/infrastructure/fuel type due to longevity of system implemented). Residential building archetypes are also characterized by the number of contained dwelling units, allowing the model to capture the energy effects of shared walls but also the urban form and transportation implications of population density.

Non-Residential Buildings

These are spatially located and classified by a detailed use/purpose-based set of 50+ archetypes. The floorspace of these archetypes can vary by location. Non-residential floorspace produces waste and demand for energy and water, and provides an anchor point for locating employment of various types.

Spatial Population and Employment

City-wide population is made spatial through allocation to dwellings, using assumptions about persons-per-unit by dwelling type. Spatial employment is projected via two separate mechanisms:

- population-related services and employment, which is allocated to corresponding building floorspace (e.g., teachers to school floorspace), and
- floorspace-driven employment (e.g., retail employees per square foot).

Passenger Transportation

The model includes a spatially explicit passenger transportation sub-model that responds to changes in land-use, transit infrastructure, vehicle technology, travel behavior change, and other factors. Trips are divided into four types (home-work, home-school, home-other, and non-home-based), each produced and attracted by different combinations of spatial drivers (population, employment, classrooms, non-residential floorspace). Trips are distributed and trip volumes are specified for each zone of origin and zone of destination pair. For each origin-destination pair, trips are shared over walk/bike (for trips within the walkable distance threshold), public transit (for trips whose origin and destination are serviced by transit), and automobile. A projection of total personal vehicles miles travelled (VMT) and a network distance matrix are produced following the mode share calculation. The energy use and emissions associated with personal vehicles is calculated by assigning VMT to a stock-turnover personal vehicle model. The induced approach is used to track emissions. All internal trips (trips within the boundary) are accounted for, as well as half of the trips that terminate or originate within the municipal boundary. Figure 4 displays trip destination matrix conceptualization.

Figure 4. Conceptual diagram of trip categories.

Waste and Wastewater

Households and non-residential buildings generate solid waste and wastewater. The model traces various pathways to disposal, compost, and sludge including those which capture energy from incineration and recovered gas. Emissions accounting is performed throughout the waste sub-model.

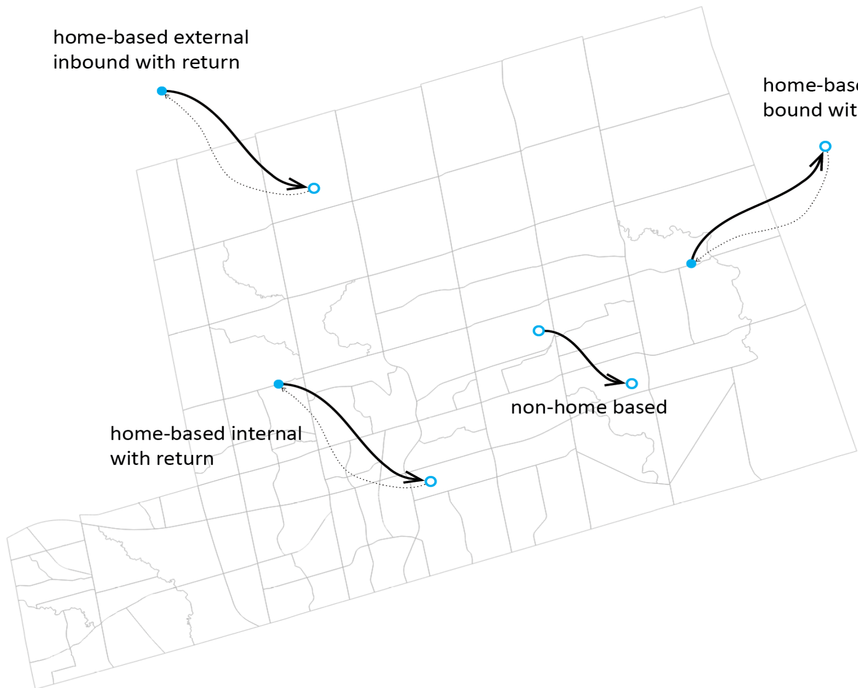


Figure 4. Conceptual diagram of trip categories.

Energy Flow and Local Energy Production

Energy produced from primary sources (e.g., solar, wind) is modelled alongside energy converted from imported fuels (e.g., electricity generation, district energy, CHP). As with the transportation sub-model, the district energy supply model has an explicit spatial dimension and can represent areas served by district energy networks.

Finance and Employment

Energy related financial flows and employment impacts are captured through an additional layer of model logic (not shown explicitly in Figure 2). Calculated financial flows include the capital, operating, and maintenance cost of energy consuming stocks and energy producing stocks, including fuel costs. Employment related to the construction of new buildings, retrofit activities and energy infrastructure is modelled. The financial impact on businesses and households of implementing the strategies is assessed. Local economic multipliers are also applied to investments.

Consumption Emissions

Emissions attributable to the production of some items produced outside, but consumed in, Ames are estimated and included in the emissions inventory and modeling (e.g., those for electronics, food, and clothing). These are estimated based on the number of households and a weighted average consumption per household across all income levels. A total base year emissions value is derived by multiplying the weighted average emissions per household intensity by number of households. This methodology enables accurate comparison to previous Ames inventories.

C.9 Model Calibration for Local Context

Data Request and Collection

Local data was supplied by the municipality. Assumptions were identified to supplement any gaps in observed data. The data and assumptions were applied in modeling per the process described below.

Zone System

The model is spatially explicit: population, employment, residential, and non-residential floorspace are allocated and tracked spatially within the City's zone system (see Figure 5). These elements drive stationary energy demand. The passenger transportation sub-model, which drives transportation energy demand, also operates within the same zone system.

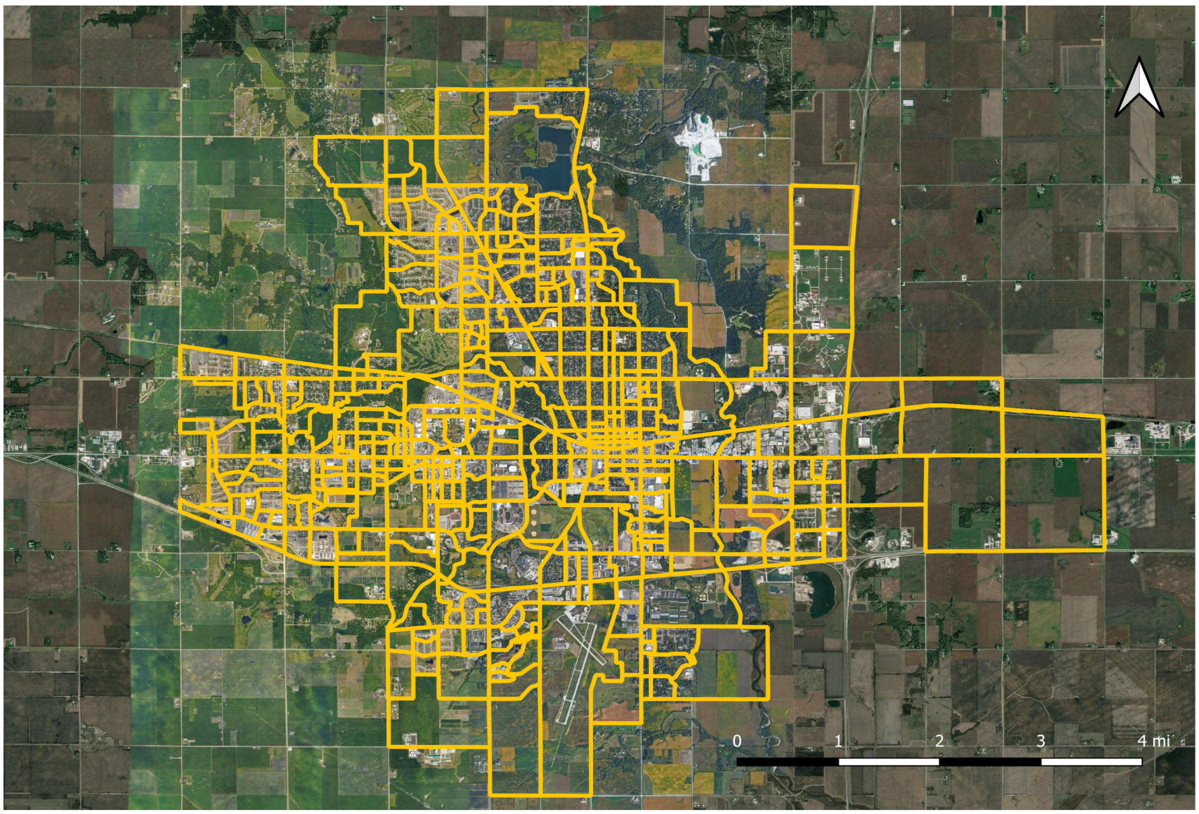


Figure 5. Zone system used in modelling.

Buildings

Buildings data, including building type, building footprint area, number of stories, total floorspace area, number of units, and year built was sourced from City property assessment data. Buildings were allocated to specific zones using their spatial attributes, based on the zone system. Buildings are classified using a detailed set of building archetypes (see Appendix 2). These archetypes capture footprint, height and type (e.g., single-family home, semi-attached home, etc.), enabling the creation of a "box" model of buildings, and an estimation of surface area for all buildings.

Residential Buildings

The model multiplies the residential building surface area by an estimated thermal conductance (heat flow per unit surface area per degree day) and the number of degree days (heating and cooling) to derive the energy transferred out of the building during winter months and into the building during summer months. The energy transferred through the building envelope, the solar gain through the building windows, and the heat gains from equipment inside the building constitute the space conditioning load to be provided by the heat systems and the air conditioning. The initial thermal conductance estimate is a regional average by dwelling type from a North American energy system simulator, calibrated for the Midwest. This initial estimate is adjusted through the calibration process as the modelled energy consumption from the market profile in the 2015 Residential Energy Consumption Survey (RECS) and City property assessment data.

Non-Residential Buildings

The model calculates the space conditioning load as it does for residential buildings with two distinctions: the thermal conductance parameter for non-residential buildings is based on floor space area instead of surface area, and incorporates data from Ames.

Starting values for output energy intensities and equipment efficiencies for non-residential end uses are taken from the 2012 Commercial Buildings Energy Consumption Survey (CBECS). All parameter estimates are further adjusted during the calibration process. The calibration target for non-residential building energy use is the observed commercial and industrial fuel consumption in the base year.

Using assumptions for thermal envelope performance for each building type, the model calculates total energy demand for all buildings, independent of any space heating or cooling technology and fuel.

Population and Employment

Federal census population and employment data was spatially allocated to residential (population) and non-residential (employment) buildings. This enables indicators to be derived from the model, such as emissions per household, and drives the BAU energy and emissions projections for buildings, transportation, waste.

Population for 2018 was spatially allocated to residential buildings using initial assumptions about persons-per-unit (PPU) by dwelling type. These initial PPUs are then adjusted so that the total population in the model (which is driven by the number of residential units by type multiplied by PPU by type) matches the total population from census/regional data.

Employment for 2018 was spatially allocated to non-residential buildings using initial assumptions for two main categories: population-related services and employment, allocated to corresponding building floorspace (e.g., teachers to school floorspace); and floorspace-driven employment (e.g., retail employees per square foot). Like population, these initial ratios are adjusted within the model so that the total employment derived by the model matches total employment from census/regional data.

Transportation

The model includes a spatially explicit passenger transportation sub-model that responds to changes in land-use, transit infrastructure, vehicle technology, travel behaviour change, and other factors. Trips are divided into four types (home-work, home-school, home-other, and non-home-based), each produced and attracted by a different combination of spatial drivers (population, employment, classrooms, non-residential floorspace). Trip volumes are distributed as pairs for each zone of origin and zone of destination. For each origin-destination pair, trips are shared over walk/bike (for trips within the walkable distance threshold), public transit (for trips whose origin and destination are serviced by transit), and automobile. Total personal vehicle miles travelled (VMT) is produced when modeling mode shares and distances. The energy use and emissions associated with personal vehicles is calculated by assigning VMT to model personal vehicle ownership.

The passenger transportation model is anchored with origin-destination trip matrices by trip mode and purpose, generated by the City's transportation department. The results are cross-checked against indicators such as average annual VMT per vehicle. For medium-heavy duty commercial vehicle transportation, the ratio of local retail diesel fuel sales to State retail diesel fuel sales was applied to estimate non-retail diesel use.

The modelled stock of personal vehicles by size, fuel type, efficiency, and vintage was informed by regional vehicle registration statistics. The total number of personal-use and corporate vehicles is proportional to the projected number of households in the BAU.

The GPC induced activity approach is used to account for emissions. Using this approach, all internal trips (within boundary) as well as half of the trips that terminate or originate within the municipal boundary are accounted for. This approach allows the municipality to understand its transportation impacts on its peripheries and the region.

Transit VMT and fuel consumption was modelled based on data provided by Ames in the 2018 emissions inventory data.

Waste

Solid waste stream composition and routing data (landfill, composting, recycling) was sourced from local data sources. The base carbon content in the landfill was estimated based on historical waste production data. Total methane emissions were estimated for landfills using the first order decay model, with the methane generation constant and methane correction factor set to default, as recommended by, and based on values from, IPCC Guidelines for landfill emissions. Data on methane removed via recovery was provided by the landfills.

C.10 Data and Assumptions

Scenario Development

The model supports the use of scenarios as a mechanism to evaluate potential futures for communities. A scenario is an internally consistent view of what the future might turn out to be—not a forecast, but one possible future outcome. Scenarios must represent serious considerations defined by planning staff and community members. They are generated by identifying population projections into the future, identifying how many additional households are required, and then applying those additional households according to existing land-use plans and/or alternative scenarios. A simplified transportation model evaluates the impact of the new development on transportation behaviour, building types, agricultural and forest land, and other variables.

Business-As-Usual Scenario

The Business-As-Usual (BAU) scenario estimates energy use and emissions volumes from the base year (2018) to the target year (2050). It assumes an absence of substantially different policy measures from those currently in place.

Methodology

1. Calibrate model and develop 2018 base year using observed data and filling in gaps with assumptions where necessary.
2. Input existing projected quantitative data to 2050 where available:
    - Population, employment, and housing projections by transport zone
    - Build out (buildings) projections by transport zone
    - Transportation modeling from the municipality
3. Where quantitative projections are not carried through to 2050, extrapolate the projected trend to 2050.
4. Where specific quantitative projections are not available, develop projections by:
    - Analyzing current on-the-ground action (reviewing action plans, engagement with staff, etc.), and where possible, quantifying the action.
    - Analyzing existing policy that has potential impact and, where possible, quantifying the potential impact.

Low-Carbon Scenario

The model projects how energy flow and emissions profiles will change in the long-term by modeling potential changes in the context (e.g., population, development patterns), projecting energy services demand intensities, waste production and diversion rates, industrial processes, and projecting the composition of energy system infrastructure.

Policies, Actions, and Strategies

Alternative behaviours of various energy system actors (e.g., households, various levels of government, industry, etc.) can be mimicked in the model by changing the values of the model's user input variables. Varying their values creates "what if" type scenarios, enabling a flexible mix-and-match approach to behavioral models which connect to the physical model. The model can explore a wide variety of policies, actions and strategies via these variables. The resolution of the model enables the user to apply scenarios to specific neighbourhoods, technologies, building or vehicle types or eras, and configurations of the built environment.

Methodology

1. Develop a list of potential actions and strategies.
2. Identify the technological potential of each action or group of actions to reduce energy and emissions by quantifying the actions:
    a. If the action or strategy specifically incorporates a projection or target; or,
    b. If there is a stated intention or goal, review best practices and literature to quantify that goal; and
    c. Identify any actions that are overlapping and/or include dependencies on other actions.
3. Translate the actions into quantified assumptions over time.
4. Apply the assumptions to relevant sectors in the model to develop a low-carbon scenario (i.e. apply the technological potential of the actions to the model).
5. Analyze results of the low-carbon scenario against the overall target.
6. If the target is not achieved, identify variables to scale up and provide a rationale for doing so.
7. Iteratively adjust variables to identify a pathway to the target.
8. Develop a marginal abatement cost curve for the low-carbon scenario.

C.11 Addressing Uncertainty

There is extensive discussion of the uncertainty in models and modeling results. The assumptions underlying a model can be from other locations or large data sets and do not reflect local conditions or behaviours, and even if they did accurately reflect local conditions, it is exceptionally difficult to predict how those conditions and behaviours will respond to broader societal changes and what those broader societal changes will be.

The WhatIf?/SSG modeling approach uses four strategies for managing uncertainty applicable to community energy and emissions modeling:

1. **Sensitivity analysis:** One of the most basic ways of studying complex models is sensitivity analysis, which helps quantify uncertainty in a model's output. To perform this assessment, each of the model's input parameters is drawn from a statistical distribution in order to capture the uncertainty in the parameter's true value (Keirstead, Jennings, & Sivakumar, 2012).

   Approach: Selected variables are modified by ±10–20% to illustrate the impact that an error of that magnitude has on the overall total.

2. **Calibration:** One way to challenge untested assumptions is to use 'back-casting' to ensure the model can 'forecast the past' accurately. The model can then be calibrated to generate historical outcomes, calibrating the model to better replicate observed data.

   Approach: Variables are calibrated in the model using two independent sources of data. For example, the model calibrates building energy use (derived from buildings data) against actual electricity data from the electricity distributor.

3. **Scenario analysis:** Scenarios are used to demonstrate that a range of future outcomes are possible given the current conditions and that no one scenario is more likely than another.

   Approach: The model will develop a reference scenario.

4. **Transparency:** The provision of detailed sources for all assumptions is critical to ensuring policy-makers understand the uncertainty intrinsic in a model.

   Approach: Modeling assumptions and inputs are presented in this document.

Sub-Appendix C1: GPC Emissions Scope Table for Detailed Model

Green rows = Sources required for GPC BASIC inventory
Blue rows = Sources required GPC BASIC+ inventory
Yellow rows = Sources required for territorial total but not for BASIC/BASIC+ reporting

Exclusion Rationale Legend

N/A	Not Applicable or not included in scope
ID	Insufficient Data
NR	No Relevance or limited activities identified
Other	Reason provided in other comments

GPC ref No.	Scope	GHG Emissions Source	Inclusion	Exclusion rationale
I	**STATIONARY ENERGY SOURCES**			
I.1	**Residential buildings**			
I.1.1	1	Emissions from fuel combustion within the city boundary	Yes	
I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes	
I.1.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes	
I.2	**Commercial and institutional buildings/facilities**			
I.2.1	1	Emissions from fuel combustion within the city boundary	Yes	
I.2.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes	
I.2.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes	

GPC ref No.	Scope	GHG Emissions Source	Inclusion	Exclusion rationale
I.3	**Manufacturing industry and construction**			
I.3.1	1	Emissions from fuel combustion within the city boundary	Yes	
I.3.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes	
I.3.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes	
I.4	**Energy industries**			
I.4.1	1	Emissions from energy used in power plant auxiliary operations within the city boundary	Yes	
I.4.2	2	Emissions from grid-supplied energy consumed in power plant auxiliary operations within the city boundary	Yes	
I.4.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption in power plant auxiliary operations	Yes	
I.4.4	1	Emissions from energy generation supplied to the grid	No	NR
I.5	**Agriculture, forestry, and fishing activities**			
I.5.1	1	Emissions from fuel combustion within the city boundary	Yes	
I.5.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes	
I.5.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes	
I.6	**Non-specified sources**			
I.6.1	1	Emissions from fuel combustion within the city boundary	No	NR
I.6.2	2	Emissions from grid-supplied energy consumed within the city boundary	No	NR
I.6.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	No	NR
I.7	**Fugitive emissions from mining, processing, storage, and transportation of coal**			
I.7.1	1	Emissions from fugitive emissions within the city boundary	No	NR

GPC ref No.	Scope	GHG Emissions Source	Inclusion	Exclusion rationale
I.8	**Fugitive emissions from oil and natural gas systems**			
I.8.1	1	Emissions from fugitive emissions within the city boundary	Yes	
II	**TRANSPORTATION**			
II.1	**On-road transportation**			
II.1.1	1	Emissions from fuel combustion for on-road transportation occurring within the city boundary	Yes	
II.1.2	2	Emissions from grid-supplied energy consumed within the city boundary for on-road transportation	Yes	
II.1.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary and transmission and distribution losses from grid-supplied energy consumption	Yes	
II.2	**Railways**			
II.2.1	1	Emissions from fuel combustion for railway transportation occurring within the city boundary	No	N/A
II.2.2	2	Emissions from grid-supplied energy consumed within the city boundary for railways	No	N/A
II.2.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary and transmission and distribution losses from grid-supplied energy consumption	No	N/A
II.3	**Water-borne navigation**			
II.3.1	1	Emissions from fuel combustion for waterborne navigation occurring within the city boundary	No	NR
II.3.2	2	Emissions from grid-supplied energy consumed within the city boundary for waterborne navigation	No	NR
II.3.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary and transmission and distribution losses from grid-supplied energy consumption	No	NR

GPC ref No.	Scope	GHG Emissions Source	Inclusion	Exclusion rationale
II.4	**Aviation**			
II.4.1	1	Emissions from fuel combustion for aviation occurring within the city boundary	Yes	
II.4.2	2	Emissions from grid-supplied energy consumed within the city boundary for aviation	Yes	
II.4.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary and transmission and distribution losses from grid-supplied energy consumption	No	ID
II.5	**Off-road**			
II.5.1	1	Emissions from fuel combustion for off-road transportation occurring within the city boundary	Yes	
II.5.2	2	Emissions from grid-supplied energy consumed within the city boundary for off-road transportation	No	ID
III	**WASTE**			
III.1	**Solid waste disposal**			
III.1.1	1	Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps within the city boundary	No	NR
III.1.2	3	Emissions from solid waste generated within the city boundary but disposed in landfills or open dumps outside the city boundary	Yes	
III.1	**Solid waste disposal**			
III.1.3	1	Emissions from waste generated outside the city boundary and disposed in landfills or open dumps within the city boundary	No	N/A
III.2	**Biological treatment of waste**			
III.2.1	1	Emissions from solid waste generated within the city boundary that is treated biologically within the city boundary	Yes	
III.2.2	3	Emissions from solid waste generated within the city boundary but treated biologically outside the city boundary	No	ID
III.2.3	1	Emissions from waste generated outside the city boundary but treated biologically within the city boundary	No	N/A

III.3	**Incineration and open burning**			
III.3.1	1	Emissions from solid waste generated and treated within the city boundary	Yes	
III.3.2	3	Emissions from solid waste generated within the city boundary but treated outside the city boundary	No	N/A
III.3.3	1	Emissions from waste generated outside the city boundary but treated within the city boundary	No	N/A
III.4	**Wastewater treatment and discharge**			
III.4.1	1	Emissions from wastewater generated and treated within the city boundary	Yes	
III.4.2	3	Emissions from wastewater generated within the city boundary but treated outside the city boundary	No	NR
III.4.3	1	Emissions from wastewater generated outside the city boundary	No	N/A
IV	**INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)**			
IV.1	1	Emissions from industrial processes occurring within the city boundary	No	ID
IV.2	1	Emissions from product use occurring within the city boundary	No	ID
V	**AGRICULTURE, FORESTRY, AND LAND USE (AFOLU)**			
V.1	1	Emissions from livestock within the city boundary	Yes	
V.2	1	Emissions from land within the city boundary	No	NR
V.3	1	Emissions from aggregate sources and non-CO2 emission sources on land within the city boundary	No	ID
VI	**OTHER SCOPE 3**			
VI.1	3	Other Scope 3	Yes	

Sub-Appendix C2: Building Types in the model

Residential Building Types	Non-residential Building Types	
Single_detached_small	college_university	religious_institution
Single_detached_medium	school	surface_infrastructure
Single_detached_large	retirement_or_nursing_home	energy_utility
Double_detached_small	special_care_home	municipal_office
Double_detached_large	hospital	municipal_fire_station
Row_house_small	penal_institution	municipal_police_station
Row_house_large	police_station	municipal_culture
Apt_1To3Storey	military_base_or_camp	municipal_entertainment
Apt_4To6Storey	transit_terminal_or_station	municiipal_recreation
Apt_7To12Storey	airport	municipal_community_centre
Apt_13AndUpStorey	parking	municipal_arena_pool
inMultiUseBldg	hotel_motel_inn	municipal_yards_ maintenance
	greenhouse	municipal_other
	greenspace	municipal_retirement_home
	recreation	water_pumping_or_ treatment_station
	community_centre	industrial_generic
	golf_course	pulp_paper
	museums_art_gallery	cement
	retail	chemicals
	vehicle_and_heavy_ equiptment_service	iron_steel_aluminum
	restaurant	mining
	commercial_retail	agriculture
	commercial	industrial_farm
	warehouse_commercial	barn
	warehouse	

Sub-Appendix C3: Emissions Factors Used

Category	Value	Comment
Natural gas	CO_2: 53.02 kg/MMBtu CH_4: 0.005 kg/MMBtu N_2O: 0.0001kg/MMBtu	ICLEI–Local Governments for Sustainability USA. "US community protocol for accounting and reporting of greenhouse gas emissions." (2012).
Electricity	2018 CO_2e: 1,098 lbs CO_2e per MWh	MROW average emissions factor per US EPA eGRID (www.epa.gov/egrid/data-explorer)
Gasoline	CO_2: 0.07024 MT/MMBtu CH_4: 0.000000017343 MT/mile N_2O: 0.000000009825 MT/mile	ICLEI–Local Governments for Sustainability USA. "US community protocol for accounting and reporting of greenhouse gas emissions." (2012).
Diesel	CO_2: 0.073934483 MT/MMBtu CH_4: 0.000000001 MT/vehicle mile N_2O: 0.0000000015 MT/vehicle mile	ICLEI–Local Governments for Sustainability USA. "US community protocol for accounting and reporting of greenhouse gas emissions." (2012).
Fuel oil	CO_2: 73.9 kg per mmBtu CH_4: 0.003 kg per mmBtu N_2O: 0.0006 kg per mmBtu	Environmental Protection Agency. "Emission factors for greenhouse gas inventories." Stationary Combustion Emission Factors," US Environmental Protection Agency2014, Available: https://www.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf (2014). Table 1 Stationary Combustion Emission Factor, Fuel Oil No. 2
Wood	CO_2: 93.80 kg per mmBtu CH_4: 0.0072 kg per mmBtu N_2O: 0.0036 kg per mmBtu	Environmental Protection Agency. "Emission factors for greenhouse gas inventories." Stationary Combustion Emission Factors," US Environmental Protection Agency2014, Available: https://www.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf (2014). Table 1 Stationary Combustion Emission Factor, Biomass fuels: Wood and Wood Residuals

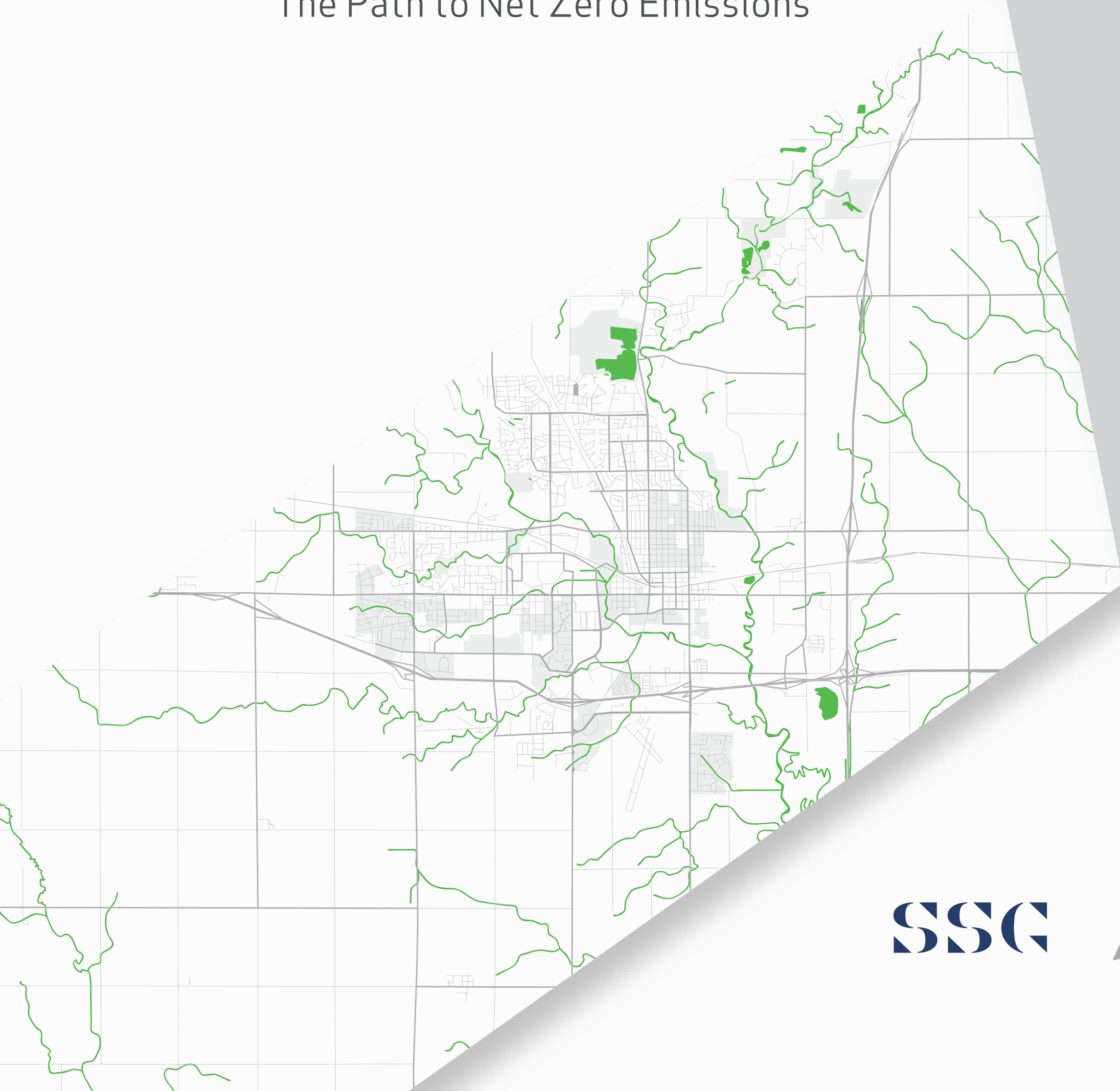
(continued from previous table)

Category	Value	Comment
Propane	CO_2: 62.87 kg per mmBtu CH_4 : 0.003 kg per mmBtu N_2O: 0.0006 kg per mmBtu For mobile combustion: CO_2: 5.7 kg per gallon	Environmental Protection Agency. "Emission factors for greenhouse gas inventories." Stationary Combustion Emission Factors," US Environmental Protection Agency2014, Available: https://www.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf (2014). Table 1 Stationary Combustion Emission Factor, Petroleum Products: Propane Table 2 Mobile Combustion CO2 Emission Factors: Propane
Waste	Landfill emissions are calculated from first order decay of degradable organic carbon deposited in landfill. Derived emission factor in 2018 to be determined based on % recovery of landfill methane and waste composition.	Landfill emissions: IPCC Guidelines Vol 5. Ch 3, Equation 3.1
Wastewater	CH_4: 0.48 kg CH_4/kg BOD N_2O: 3.2 g / (person * year) from advanced treatment 0.005 g /g N from wastewater discharge	CH_4 wastewater: IPCC Guidelines Vol 5. Ch 6, Tables 6.2 and 6.3; MCF value for anaerobic digester N_2O from advanced treatment: IPCC Guidelines Vol 5. Ch 6, Box 6.1 N_2O from wastewater discharge: IPCC Guidelines Vol 5. Ch 6, Section 6.3.1.2
Greenhouse gases	Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N20) are included. Global Warming Potential CO_2 = 1 CH_4 = 34 N_2O = 298	Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3) are not included.

Every Ton Matters:

City of Ames Climate Action Plan

The Path to Net Zero Emissions



SSG

CITY OF Ames™

ATTACHMENT B

Staff Report

ANALYSIS OF PROPOSED SIX BIG MOVES AND ASSOCIATED ACTION STEPS FOR THE CLIMATE ACTION PLAN

November 15, 2022

BACKGROUND:

The City Council has placed a high value on promoting environmental sustainability. To address this goal and to decrease Ames' carbon footprint, the City Council approved issuing a Request for Proposal in December of 2020 seeking a consultant to develop a Climate Action Plan (CAP). That plan included two phases: 1) Establishing a community carbon reduction goal, and 2) Developing a relevant, achievable, and cost-effective strategy, timeline, and metrics to track progress toward achieving the goal.

Due the importance of the CAP and its potential impact on the community, the project structure included naming the Ames City Council as the CAP Steering Committee and appointing 27 residents as sector representatives to provide feedback through the CAP Supplemental Input Committee.

Sustainability Solutions Group (SSG), a climate action consulting firm with offices throughout North and South America, was hired by the City Council on April 27, 2021. The consultant began meeting with the City project and technical teams, the Steering Committee/City Council, and the Supplemental Input Committee. As part of the robust public input requirement of the contract, SSG developed a CAP website, created public input surveys, and facilitated the first Town Hall Meeting on Oct. 25, 2021.

Based on emissions identified in the Greenhouse Gas Inventory, which had been completed in 2020 as the first step in creating a CAP, SSG presented the CAP Steering Committee with several options for carbon reduction targets ranging from a 1) 83% reduction by 2030 and net-zero by 2050; 2) Net-zero by 2050, 3) 45% Reduction by 2030 and net-zero by 2050, and 4) No Predetermined 2030 target until after modeling was complete (Evidence-Based). **On Dec. 21, 2021, the City Council voted for the target to reduce emissions by 83% by 2030 over 2018 levels and to reach net-zero by 2050.**

This net-zero target by 2050 is in line with global best practices for reducing emissions, so communities do not significantly contribute to exceeding a 1.5 degree Celsius increase in global temperature. The 2050 target also accounts for global inequality, based on the acceptance that communities in wealthier countries have a greater capacity than those in less wealthy countries to address climate change, and they have a responsibility to aggressively address emissions because they have benefited from greenhouse gas emitting actions in the past.

With the City Council's goal decided, SSG analyzed the Greenhouse Gas Inventory, met with City staff and Iowa State University officials, and identified the path needed

to achieve the goal of reducing the carbon emissions in our community by 83% by 2030 as well as net-zero by 2050. With such an aspirational target, the path to achieving carbon reduction in the timeframe identified requires bold moves, substantial investment, and significant policy changes. SSG outlined the path forward in a document entitled the "Six Big Moves," which separated carbon reduction into six concentration areas with 29 carbon reduction action steps.

Attachment A reflects the net cost, amount of carbon emission reduction, and the dollar cost for every ton of carbon reduced for each of the 29 action steps.

Attachment B condenses this same information in accordance with each of the six Big Moves.

The following table provides the grand totals for the carbon reduction targets for 2030 and 2050 as they relate to the community and city projects.

	Net Cost (using discounted rates and recognition of savings)	Total Amount of Emissions Reduction	$/Ton of Carbon Reduction (Average)
Year 2030			
City	$ 142,247,923	314,000 Tons	$453
Community	$1,283,420,711	2,601,000 Tons	$493
Total	$1,425,668,634	2,915,000 Tons	
Year 2050			
City	$58,275,920	2,859,000 Tons	$20
Community	$838,957,455	18,468,000 Tons	$45
Total	$897,233,375	21,327,000 Tons	
GRAND TOTAL	**$2,322,902,009**	**24,242,000 Tons**	

This report summarizes City Staffs' analysis of the consultants' recommended Six Big Moves and carbon reduction action steps through eight criteria. Staff utilized data from the financial dictionary developed by SSG as well as City records and resources.

Since it might not be feasible to accomplish all of the 29 action steps suggested by the consultants, it is hoped that the Staff analysis will assist the City Council in identifying the highest priority action steps for an implementation plan.

ANALYSIS OF THE PROPOSED SIX BIG MOVES AND ASSOCIATED ACTION STEPS

The "Six Big Moves" are:

1. BUILDING RETROFITS
2. NET-ZERO NEW CONSTRUCTION
3. RENEWABLE ENERGY GENERATION

4. REDUCING VEHICLE EMISSIONS
5. INCREASE ACTIVE TRANSPORTATION AND TRANSIT USE
6. REDUCE WASTE EMISSIONS

The eight criteria offered by the Staff for this analysis are:

1. Cost – cost of investment; gain on investment; marginalized abatement cost
2. Amount of Administrative Effort Needed
3. Feasibility of Achievement
4. Legal Feasibility
5. Funding Sources
6. Impact on Residents in Terms of Property Taxes, Utility Rates, etc.
7. Impact on Inclusion
8. Cost Compared to the Tonnage of Carbon Reduced

BIG MOVE 1 – BUILDING RETROFITS

A building retrofit can include replacing windows, doors, adding additional insulation to walls, attic, and the building's exterior. Retrofits also include the replacement of heating and cooling systems with more efficient systems. It can also include reconfiguring the building's interior or the placement of windows and doors to maximize the use of sunlight, airflow, and thermal comfort.

Included in this move are retrofits related to residential homes, industrial, commercial, institutional, and municipal buildings. The exact retrofits for a home or individual building may vary depending on current building conditions and needs.

ACTION STEPS

- 90% or 15,621 of residential buildings retrofitted by 2035
- 90% or 1,067 of industrial, commercial, and institutional buildings retrofit by 2035
- 30% energy savings below Business As Usual scenario through process efficiency in industrial buildings by 2030
- All 17 municipal buildings retrofit by 2030
- Add 26,691 air-source heat pumps for all buildings by 2040
- Replace 19,338 hot water heating systems with electric by 2040

Amount of Administrative Effort Needed:

The retrofit process for residential, industrial, commercial, and institutional buildings including the action steps of adding air-source heat pumps and hot water heaters will require an additional four FTE's in the Inspections Division at approximately $360,000 per year. These employees will be responsible for program oversight and tasks include clerical, data entry, marketing, enforcement, and inspections. Inspections' existing software and materials should be able to handle the process, though additional space may be needed for the expansion of staff.

For the municipal building retrofits, a consultant will need to be hired to do a detailed study of each building with recommendations for implementation. These recommendations will then have to be designed, bid, and constructed with oversight from the current staff.

Feasibility of Achievement:

The Inspections Division can manage the retrofit process with the additional FTE's. Existing software and materials are anticipated to be able to handle the process, but additional space may be needed for the employees. This could pose a problem as we are running out of available space in our existing city buildings and it will be costly and inefficient to decentralize staff in a rented facility.

For municipal buildings, the time needed for a study, design, and construction for all municipal buildings is extensive and will take time beyond the 2030 target. Additionally, construction costs continue to rise which could exceed the projected costs in the consultant's analysis.

Legal Feasibility:

Currently state law requires municipalities to follow state building codes, therefore, the City could not legally mandate retrofits in residential, industrial, commercial, and institutional buildings. Conversely, the City can determine retrofit requirements for the municipal buildings it owns and operates.

Funding Sources:

Funding for retrofits could come from issuing General Corporate Purpose bonds that will require a 60% voter approval referendum or by increasing our General Levy up to the $8.10 tax rate. Increasing the General Levy to $8.10 would generate an additional $8,791,471 annually based on our current tax rate and valuation and a result in 26% increase in property taxes. The City could also consider funding the total retrofit action step with utility backed revenue bonds. However, the electric utility rate increase required to repay the bonds is projected to be 356%.

In terms of adding air-source heat pumps and hot water heaters, the City of Ames Electric Services can play a supporting role by offering rebates and possibly rate incentives. Customers will be more likely consider a replacement of their furnace or hot water heater at the time of failure, not when everything is functioning fine. With the typical appliance life of 15 years, it will take a 15 year cycle for nearly all customers to have a "moment" when they must consider replacement.

These incentives could be included in Electric Services Demand Side Management budget at $250,000 per year and increase if there is a desire to increase saturation.

For municipal buildings, most expenses are charged to a department's operating budget of a department or division. Funding would then be up to each department to program within their budget. Of the 17 municipal buildings, eight, plus a portion of City Hall, are funded through the General Fund. The estimated increase to the General Fund would be $2,362,500.

Impact on Residents in Terms of Property Taxes, Utility Rates, etc.:

Increases in property taxes and utility rates to fund residential and non-residential retrofits would be significant and would impact residents and businesses.

If heat pumps and hot water heaters are installed at the time of current appliance failure, this is for the most part "fuel switching." Customers' natural gas bills for water heating and building heating will go down while electric usage will go up. There will be a reduction in summer electric load as air conditioning through a heat pump is more efficient than a standard air conditioner. Additionally, utility benefits can be achieved by adding electric water heaters to the Prime Time Power program where Electric Services can take steps to provide economical off-peak electric rates to shift the electric load.

Impact on Inclusion:

Low- and middle-income residents would be significantly impacted by the rate increases required to fund the retrofit project. There is a concern that most of these residents will not be able to pay the rate increases required and may be forced to move or look for more affordable methods of heating and lighting homes such as portable generators, wood or corn stove, or movable kerosene heaters.

Offering rebates and incentives on replacement hot water heaters and air-source heat pumps will assist residents with making these purchases. The impact of electric rates will be dependent on how much in the way of incentives that the City Council wishes to offer for retrofits.

The increases in utility rates and related expenses for retrofitting municipal buildings would be passed down to residents in the form of user fees, rental fees, and program fees for City services.

Big Move 2 – Net-Zero New Construction

Net-zero new construction is described as creating ultra-efficient residential, commercial, and municipal buildings by utilizing integrated design and building techniques that generate on-site energy, using clean renewable energy resources in a quantity equal to or greater than the needs of the buildings. Net-zero new construction would not utilize natural gas as a fuel source for any activity. The result is a decrease in energy costs to the building owner and a reduction in greenhouse gas emissions.

Net-zero can be thought of as setting an electric budget for a home based upon what level of renewable energy could be generated on site to offset its usage, but the renewable energy source is not installed at the time of construction. Passive building design is specific rigorous design approach for a whole systems approach of design and energy efficiency sets a maximum usage per sq. ft. for a building.

Net-zero energy ready buildings are designed to be ultra-efficient with the goal of being net zero energy at some point in the future.

ACTION STEPS

- All buildings constructed in 2026 and after will be net-zero ready
- Linear increase 2023-2026
- Passive house standard by 2030 in residential and commercial buildings
- All new municipally-owned buildings to be net-zero energy ready beginning in 2023 and passive building by 2025

Amount of Administrative Effort Needed:

The review of a house or other structure would go through the same review process as currently exists and would not add to the work of the existing staff as it is already part of the review process.

If the City were to create an incentive program or a training program there would be some additional staff time needed, but without a scope of program it is hard to estimate staff time needs. Additionally, it would be assumed administration of this program and the retrofit program would have some synergy. For example, the Inspections Division noted the need to add 4 FTEs to help administer a retrofit program. These additional positions could also service the new construction action step.

Feasibility of Achievement:

Currently there is a lack of expertise in the community for implementing this type of standard. The steps to adopt a standard would be relatively easy but ensuring there is a contracting community available with expertise to meet the standards is unknown. Hopefully, as trends for construction change based upon experiences in other markets, those techniques will filter to Ames and become more commonplace.

This action step might require the City of Ames to institute or support a training program to building a knowledge base, but that does not ensure that those that are trained would be available or do work in Ames.

Legal Feasibility:

Legal feasibility has multiple facets. Locally adopted buildings codes are unlikely to be able to require net-zero ready homes or passives homes if they are viewed as exceeding the requirements of the State's adopted energy code.

Iowa Code prohibits local governments from prohibiting the sale or use of natural gas. Additionally, outright limitations on the use of natural has are not permissible under Iowa law.

However, this action step differs from the retrofit feasibility, because it addresses new development and the City may be able to employ other measures beyond building code standards. For example, the City could negotiate with developers at the time of annexation or through contract rezoning a commitment to net-zero readiness and passive home design. In addition, the City could establish new zoning standards for specific design features of a building that support both being net zero ready and passive building design.

Funding Sources:

There is no funding anticipated to be needed as costs would likely be included with current fees. The promotion of training sessions and working with trade groups could be done at minimal costs and possibly with the assistance of outside resources.

Impact on Residents in Terms of Property Taxes, Utility Rates, etc.:

Increases in property taxes would be no different on a net-zero home than that of a conventionally built home. Utility rates are not impacted, but the actual monthly bill would be a savings for the resident.

Impact on Inclusion:

For single family home construction there are no new homes constructed at a price point that is considered affordable to low-income households. Reduced monthly energy bills would be beneficial, but it is unknown if rent or mortgage payments would be higher and offset the saving on energy bills.

BIG MOVE 3 – RENEWABLE ENERGY GENERATION

Ames Electric Services serves 90% of the electric load within the City limits and is powered from a mix of renewable and non-renewable sources. Adding additional renewable energy such as wind and solar can significantly decrease emissions in the community. Investing in individual and community wind and solar power will decrease emissions from homes, businesses, electric vehicles, etc.

Adding home scale battery storage can help the system in two ways.

- First, if there is an overabundant amount of solar/wind energy being produced during the day, then this excessive renewable energy can be used at night when there is no solar and wind may be low. The key with this operation is there will need to be control signals sent to each of the battery systems to insure they are storing energy "when" it's available. Failure to do so could create new strains on the system.

- Second, the battery could be used to charge at night when the energy cost is at its cheapest. Then when the energy is its most expensive, the homeowner could pull energy from the battery. This can be encouraged with a proper rate design.

- In addition a battery storage system can help customers during power outages.

The key is to create the right level of rate incentives/disincentives together with some form of utility control to achieve the best balance of customer needs and utility needs.

ACTION STEPS

- **Max out rooftop solar potential** (220 MW)
- **Add 50 MW solar farm by 2025, additional 50 MW by 2030, and an additional 200 MW between 2035-2045**
- **Add 20 MW wind farm by 2026**
- **Add Tesla power walls or other home scale battery storage to every home when an electric vehicle is acquired**
- **Local production moved to electric 2024 and renewable natural gas 2030 (NOTE: Due to technology not being readily available, this action step is to be determined at a later date.)**

Amount of Administrative Effort Needed:

Rooftop Solar

Like the building retrofitting action step, implementation of a more extensive rooftop solar program on private property will be labor intensive. With the increased workload, it is estimated that at least one new position totaling $100,000 annually will be needed to work with customers through the interconnection agreement process, to spend time with equipment manufacturers on equipment setting, and to monitor final system acceptance testing. Along with the new position in Electric Services, additional FTEs might be required in the Inspections Division and Planning and Housing Department to administer a more robust rooftop solar program. It should be pointed out that none of these additional personnel costs were factored into the consultant's analysis.

Additional Solar and Wind Generation

In addition to being one of the most cost-effective action steps to reduce carbon, it poses the least impact on staffing requirements if the primary strategy involves a Request for Proposal process resulting in a Power Purchase Agreement(s) for energy from a private entity. If this is the case, it is anticipated that the existing staffing levels from the City Attorney's Office, the Purchasing Division, and Electric Services Engineering Division will be sufficient to accomplish this action step.

With the recent signing of the federal Inflation Reduction Act, ownership by the City now might prove to be a cost-effective option. The bill allows municipals to gain the same credits that previously have been afforded to taxable entities. However, if the City wishes to be an owner of any new generation facilities, staff support will increase significantly in order to operate and maintain a city owned facility.

Tesla power wall or other home scale battery storage

Assuming this is a rebate program, no additional staff would be required. However, if a City incentive is offered for this action step, it is important that there is a requirement that the power wall is charged during off-peak periods.

Feasibility of Achievement:

Rooftop Solar

One of solar generation's greatest needs is space. Making use of our customers' roofs will provide needed space with minimal impact to the surrounding area. Currently, Electric Services does provide incentives in the form of a rebate ($300 per kW at time of system peak) and a net metering program for private rooftop solar systems. There are 165 approved systems, with 11 proposed projects in-the-queue. Since the program's inception in 2010, Ames' customers have added 1.2 MW through rooftop installations.

Staff believe that by increasing the installation incentive to $1,200 kW, the average cost to a homeowner for rooftop installation of $30,000 can be mitigated. The City incentive would cover $12,000, and with a $10,000 federal tax credit, the homeowner would only be responsible for $8,000.

While increasing the installation incentive should prove more enticing to a building owner, Staff believes it is highly probable we will not be able to achieve this action step of 220 MWs of rooftop solar systems because of the lack of the needed amount of solar panels, a lack of needed private installers, and the lack of available rooftop square footage to accomplish the goal.

Additional Solar and Wind Generation

The action step to add a 50 MW of wind or solar farm by 2025, an additional 50 MW by 2030, an additional 200 MW between 2035-2045, and an additional 20 MW of wind by 2026 is relatively straight forward in concept. The intent is to build renewable generation to replace energy which would have otherwise been produced from fossil-fuel generation.

As you know, the Staff has experience with this type of action step and have successfully entered into Purchase Power Agreements for wind and electric energy. Therefore, assuming there are private vendors willing to develop these renewable resources at the magnitude suggested by our consultants, the Staff will be able accomplish this action step to a level that the Council is willing to raise electric rates to finance.

Tesla Power Wall or battery storage

The feasibility of achievement of this action steps will depend upon the financial level of rebates the City is willing to offer and the number of electric vehicles our residents ultimately purchase.

Legal Feasibility:

Rooftop Solar

There are no legal impediments to the City continuing the current voluntary rooftop solar program.

Additional Wind and Solar Generation

The two entities that have the most control over the accomplishment of installing this much renewables are the Iowa Utilities Board and MISO. A generating plant, greater that 25 MW, must be submitted to MISO for interconnection review and transmission overload studies. Otherwise, there does not appear to be any legal impediments to pursuing these action steps under the Renewable Energy Generation Big Move.

Tesla power wall or other home scale battery storage

There are no legal impediments to offering a rebate program for this action step.

Cost:

Rooftop Solar

If the City funds all of this on 100% of the rooftops, the estimated cost of $432 million or an average of $17 million annually. This additional $17 million represents a 28% increase in Electric Services budget for this action step alone. In addition while the individual customers will see savings on electric bills, Electric Services will lose revenue from the reduction in the sale of energy. In order to make up the loss in revenue to pay for debt incurred to pay for rooftop installations, electric rates will need to be increased accordingly.

Additional Generation

It is difficult to determine the projected cost for adding more renewables until it is determined through a competitive bidding process. In the recent past, 20 year contracts were being signed in the $20-30 per MWh range for wind and $42-55 per MWh range for solar. The City is seeing current contracts inflated by 10-50% due to supply chain issues.

Tesla power wall or other home scale battery storage
Home scale battery storage units can range in cost between $10,000 - $20,000 depending on type and size. It is estimated that a Tesla Power Wall costs $12,000 per home.

Funding Sources:

Rooftop Solar
This program is currently funded through electric utility rates. As noted in the Cost analysis, an average of $17 million annually would be needed to fund 100% of the rooftops. This additional cost represents a 28% increase in electric rates to fully cover the lost revenue.

Wind and Solar Generation
The funding for the Purchase Power Agreement(s) would come from user revenues generated from electric user fees (Energy Cost Adjustment).

Tesla power wall or other home scale battery storage
A rebate program for these battery storage units would be funded through the electric utility's Demand Side Management program which is funded though electric rates.

Impact on Residents in Terms of Property Taxes, Utility Rates, etc.:

In general, for every 50 MW of wind or solar installed, staff believes that customer rates will go up approximately 5% from today's rates. Keep in mind that solar is nearly twice as expensive as wind, but you only receive half the energy for the same amount of generation built. Therefore, the additional 320 MW would require a 32% increase in today's rates. (NOTE: This projected rate increase is in addition to any other rate increase needed to finance the operating and capital improvement budgets.)

For the home scale battery storage, the increase in electric utility rates will be dependent upon the size of the incentive, number of rebates offered, and the number of electric vehicles purchased. A rebate program would benefit the electric vehicle owner the most, but the cost of such a program would be spread amongst all customers through the electric utility rates.

Impact on Inclusion:

Any utility rate increases will have a disproportionally higher impact on low to moderate income residents.

BIG MOVE 4 – REDUCING VEHICLE EMISSIONS

Under this area there would be a shift from gasoline and diesel fueled vehicles toward alternatives such as electric vehicles and additional uses of biodiesel. In addition, car share and pooling programs can help decrease overall vehicle miles traveled.

ACTION STEPS

- All light and medium duty vehicles sold in 2030 are zero emissions vehicles
- All heavy duty vehicles sold in 2030 and after are electric
- Between 2023 and 2030 proportion of biodiesel use increasing by 5% each year
- Transit Electrification

Amount of Administrative Effort Needed:

There is no additional staffing or administrative effort needed to purchase new all-electric vehicles and increase the use of biodiesel fuel.

Feasibility of Achievement:

Currently most all-electric vehicles have demand higher than production, so the feasibility achievement will be hampered by the availability of vehicles. For example, it appears larger vehicles like trucks, fire trucks, etc. needed for our work might not be available for a number of years.

In the first year of the B100 biodiesel pilot project, the City used approximately 10,500 gallons of B100. In year two with additional vehicles, we used approximately 23,000 gallons. This means that we would need to use an additional 675 gallons in the following year and increasing from there. Currently we are projecting that we will meet that increase without additional vehicles.

In 2021 the City installed systems on 7 more snowplow trucks that will use B100. This will be a significant step in the amount of B100 used. Staff is also exploring more heavy trucks in the fleet for possible use of B100.

Feasibility would be impacted by being able to install systems on heavy duty or transit vehicles that allow for the use of B100. Recently the City went from 5 to 12 snowplow trucks that can use B100. Fleet staff also works with departments to use a blend of B100 in vehicles that don't have a system installed in the summer when there is not a chance of issues from cold weather.

Legal Feasibility:

There are no legal obstacles with the City's pursuit of all-electric vehicles and increased usage of biodiesel fuel.

Cost:

City staff worked on estimating the cost of having each vehicle in the fleet go to an all-electric option based on the remaining lifecycle. This estimate only includes the vehicles, not construction equipment. The cost of sedans were estimated with the current cost of the Chevy Bolt. Light duty vehicles were estimated to be 30% more, medium duty 40% more and heavy duty was estimated to be 50% more. An assumption was made that current technology would be the basis for future replacements. This means in areas of snow removal, utility work, and Police that extra vehicles would be required to provide twenty-four-hour coverage as needed. **These costs would be placed in the yearly escrow for replacement at an increase of $705,000 annually.** This includes the cost for additional vehicles for snow plowing, utility work and Police.

There would also be additional infrastructure costs for electric vehicle charging. Estimated costs for chargers, assuming 2022 costs, is approximately $3,450,000. This includes Level II chargers for regular use City vehicles and Level III (fast chargers) for City vehicles used 24 hours such as snowplows and Police vehicles. **There would be an additional $600,000 needed to upgrade electrical services at several of the City buildings in order to accommodate these additional chargers.**

Funding Sources:

Currently for vehicles, escrow is charged to the department budget depending on how they distribute the cost of the vehicle. This means that department budgets would need to assume the cost of the increase. This would have a larger effect on departments that have heavy trucks and would need additional vehicles.

Impact on Residents in Terms of Property Taxes, Utility Rates, etc.:

This action step will lead to an increase in property taxes and utility rates to cover the increased costs.

Impact on Inclusion:

Increases in property taxes and utility rates would adversely impact limited income households

BIG MOVE 5 – INCREASING ACTIVE TRANSPORTATION AND TRANSIT USE

Active transportation refers to more sustainable modes of transport including walking, cycling, carpooling, and public transit. Reducing car usage in favor of active transport and public can decrease traffic congestion, promote active and healthy lifestyles, and complement mixed-use developments while decreasing emissions.

ACTION STEPS

- By 2050 10% of trips in the city completed using transit
- 17 buses replaced with electric by 2027; then replace at end of lifecycle for remaining buses
- By 2050 40% of trips under 1.25 miles completed by walking, 25% of trips 1.25 miles – 3 miles completed by bicycling - **The City is currently underway with a Bicycle and Pedestrian Master Plan. The outcomes of that plan will be used to develop and implement safety mechanisms, path connectivity, and improved wayfinding**.
- Car and bicycle share programs – **These programs in conjunction with exploring micromobility options will be considered and developed based on outcomes from the City's Bicycle and Pedestrian Master Plan**
- Reduction in vehicle miles traveled

Amount of Administrative Effort Needed:

Completed City Trips Using Transit
To effectively manage this, many FTE's would need to be added across all CyRide divisions, along with an expansion in buses and facilities. Once CyRide operates 100 or more buses at peak times, federal oversight increases significantly, requiring further administrative FTE's to ensure the organization is fully compliant with appropriate regulations.

Bus Replacement
Moving to all Battery Electric Buses (BEBs) is costly and not achievable under the current funding through the State of Iowa bus replacement program. CyRide staff would need one additional FTE to apply for Federal discretionary grants, as indicated under "Cost" below.

Completed Trips by Walking/Bicycling and Car/Bicycle Share Programs
The City is currently underway with a Bicycle and Pedestrian Master Plan. The outcomes of that plan will be used to develop and implement safety mechanisms, path connectivity, and improved wayfinding.

<u>Feasibility of Achievement:</u>

<u>Completed City Trips Using Transit</u>
To achieve 10% of trips using transit in the city by 2050, CyRide ridership would need to rise to about 20 million trips per year, a five-fold increase over current levels. It's important to note that approximately 95% of CyRide's ridership is Iowa State University students.

<u>Bus Replacement</u>
A previous consultant analysis concluded that the transit system could effectively operate up to 17 battery electric buses, given the existing route configuration and facility infrastructure constraints. CyRide has Transit Board approval to fund eight BEBs, aiming to ultimately operate seventeen of these buses by 2050. This plan has been developed to allow the vehicles to operate allow for the buses to be purchased gradually as supplemental funding sources become available.

<u>Legal Feasibility:</u>

The Transit Board is responsible for overseeing CyRide operations and there are no known legal impediments with the Completed Trips and Bus Replacement action steps.

<u>Cost:</u>

<u>Completed City Trips Using Transit</u>
This type of growth will require heavy investments in multiple areas of the organization, including additional and expanded bus routes, higher frequency service, rolling stock purchases, additional facilities, and increased FTE's to operate and administer the service.

<u>Bus Replacement</u>
The BEB buses are approaching $1 million per vehicle when configured to CyRide's specifications (almost twice the cost of a traditional diesel 40' bus), and they also require specialized charging infrastructure.

CyRide will likely need to recharge more than once a day for up to several hours, depending on how much battery life is left in the vehicle. CyRide would need to explore installing charging stations and on-route charging stops. **These stations can cost upwards of $50,000, not including the added utility costs of the electricity they would use.**

<u>Building Expansion</u>
All of the ridership growth needed to meet the City Council's goal would require an expansion in facilities to house, maintain, and manage the enlarged transit fleet. The cost for this expansion is projected to be $60,000,000 in today's dollars.

Funding Sources:

Completed City Trips Using Transit
In Iowa, the primary source of transit funding is a local property tax levy, which is capped by statute at .95 cents per $1,000 dollars of assessed value. As of FY 2022/23, Ames residents pay about .60 cents per $1,000 dollars, which provides about $2 million in local funding for CyRide. **Even at its cap, this funding source would not be sufficient to support the extensive expansion. Additionally, there are limitations in the state and federal funding allowed for transit, which may also add challenges in finding alternative sources beyond the existing funding partners agreement.**

Bus Replacement
Federal and state sources help CyRide procure buses with about 80% or more of the purchase price supported through grant funding. The local funding partners bear the remaining cost. It is hoped that the price disparity between conventional buses and BEBs will decrease over time as availability increases and technology improves. Additionally, there are challenges with purchasing BEBs due to the structure of the State of Iowa bus purchasing program. This system only permits purchasing standard 40' heavy-duty diesel buses. If CyRide were to stop purchasing diesel vehicles, this major source of capital revenue would become unavailable.

High-performance batteries are running between $250,000 and $400,000. Vendors are expecting battery replacement to be needed about every six years. The useful life of a bus is around 12 years, but CyRide historically operates its buses for much longer than that. If trends continue, it may be necessary for CyRide to replace batteries at least twice during the lifetime of a bus, posing additional expenses to the budget with some offset in other maintenance costs.

Impact on Residents in Terms of Property Taxes, Utility Rates, etc.:

Completed City Trips Using Transit
Given the above funding source, there is expected to be a significant impact on property tax rates. There would also be direct operational costs to replace lost farebox revenue and expand service to support a zero-fare transit system. Assuming cost-sharing levels between the funding partners are consistent, staff expects a need to significantly increase the transit tax levy to support these projects.

Bus Replacement
There are significant costs associated with a rapid fleet transition to BEBs. Assuming cost-sharing levels between the funding partners are consistent, City staff expects a need to increase the transit tax levy to support these efforts.

Impact on Inclusion:

Depending on the type of incentives offered to encourage utilization of the transit system, there could be significant benefits for inclusion, but this could be offset by any increases in property taxes that are required from property owners or indirectly from renters to subsidize CyRide to a greater level.

BIG MOVE 6 – REDUCING WASTE EMISSIONS

Reducing waste at the source, such as purchasing less, can play a significant role in reducing emissions as will enhanced recycling and composting programs that will divert waste away from the landfill and waste-to-energy system.

ACTION STEPS

- Waste decrease by 20% per household at the source by 2030; 50% per household at the source by 2050 below Business As Usual scenario
- 50% of commercial waste is diverted at the source by 2030 below the Business As Usual scenario
- 90% of organic/food waste is diverted by 2028
- 90% of glass, metal, and paper, cardboard, and other paper products are recycled by 2028
- New Waste To Energy System

Amount of Administrative Effort Needed:

Staff estimates adding 1.5 FTEs for education and awareness programing as well as contract oversight for the action steps included under this big move.

Feasibility of Achievement:

Waste Decrease by Household and Commercial Waste Diversion
The feasibility of achieving this action step is based on the acceptance and participation of the residential and commercial communities in making changes their buying, consumption, and disposal habits.

Organic and Food Waste Diversion
This extremely aggressive goal. Story County currently generates approximately 52,000 tons of waste per year of which 20% is organics, so the volume of organics to meet this goal is 9,360 tons per year or 180 tons per week. To achieve this action step, organics diversion would depend on the acceptance by the residential and commercial community to change their handling of organic waste and the level of incentives that the City is willing to provide. Furthermore, currently in Iowa, there are less than a handful of vendors handling commercial food waste composting, and none that have the capacity to handle an additional 180 tons per week.

The more organics that are composted in households' backyards reduces the amount that would need to be collected and transported to a compost facility. The EPA reported in January 2022 that 6.3% food waste generated was composted in 2017 the most recent reporting year. The action step of 90% diversion would be challenging to meet based on national trends and lack of statewide infrastructure to handle the volume of organics generated.

Recycling
Recycling is a widely recognized program and has support within both the residential and commercial communities. The national average for recycling reported by EPA for 2018 is 23.6%. The more that post-consumer recycled material is used in products, the more consistent and sustainable the markets should be.

Legal Feasibility:

While the City government has the legal authority to take certain actions to incentivize or financially penalize to assure our residents help achieve this action step, we do not the legal authority to control waste collections throughout Story County.

Cost:

The estimated cost of the additional FTE's and supporting material is $160,000. Since there is currently no vendor in Iowa that could handle this quantity of organic waste, it is difficult to assign cost to this. Utilizing a recycling type system to model for collection and processing of organics the anticipated price would be $15 to $20 per household per month if there was a compost site in central Iowa. In terms of recycling, there would be an anticipated price of $10.50 per household per month if a recycling vendor is used in central Iowa. For both services, commercial accounts would be charged by the vendor for the volume that is collected.

Funding Sources:

Funding for *w*aste decrease by household, commercial waste diversion, organic food waste diversion, and recycling would come from increases in the per capita property tax subsidy from our residents or from the tipping fees charged to the haulers which will be passed on to their customers.

Impact on Residents in Terms of Property Taxes, Utility Rates, etc.:

Waste Decrease by Household and Commercial Waste Diversion
An increase of approximately 6% in tipping fees would be needed to cover the additional costs. And as the amount of waste tonnage decreases, the fee would have to be raised an additional 6% to offset the 50% reduction in waste volume. This would be approximately a 12% increase in tipping fees at current rates without any inflation increase.

Organic and Food Waste Diversion
An increase of approximately 5% in tipping fees would be needed to cover the additional costs. There would be a decrease in the amount of tonnage so that fee would have to be raised to 9% to offset the 90% reduction of the organics in the waste volume. This would be approximately a 14% increase in tipping fees at current rates without any inflation increase.

Recycling
There would be an increase of approximately 2.5% in tipping fees to cover additional costs. As the amount of tonnage decreases due to increase recycling of materials, the fee would have to be raised to 5% to offset the 90% reduction of the recycling in the waste volume. This would be approximately a 7.5% increase in tipping fees at current rates without any inflation increase.

Impact on Inclusion:

All of these fee increases will place a burden on our low income families.
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STAFF SUMMARY COMMENTS

A Community Climate Action Plan
It should be emphasized that the Climate Action Plan is a carbon reduction strategy for the total community, and not just for the City organization. As such, the City is not expected to fund every action step, but rather also provide support to achieve the actions in other forms such as education and guidance.

Incentives
The total net cost reflected in consultant's analysis is $1,425,668,634 to achieve an 83% carbon reduction by 2030 and an additional $897,233,375 to achieve net-zero by 2050, for a total of $2,322,902,009, does not indicate who will pay for the action steps related to the "community."

Therefore, the City Council will need to decide what level of incentives, if any, should be paid by the City. The less incentives that are offered, the greater the savings that will be realized by the City. However, the more incentives that are provided by the City, the greater are the chances for voluntary participation in our carbon reduction action steps.

For example, if the cost to retrofit a single-family home is estimated to be $60,000; should the City offer grants of $15,000 (25%), $30,000 (50%), or $45,000 (75%) in order to attract the property owners to participate in the action steps?

You will remember that a question on SSG's public engagement on-line survey addressed this issue. The results from this self-selected survey revealed that approximately 47% of the respondents would need "partial" financial support and approximately 26% of the respondents would need "full" in order to entice them to make the necessary changes to their homes. Unfortunately, we did not clarify what "partial" meant.

Rooftop Solar On Private Property
Our current program to encourage rooftop solar systems on private properties, involves an incentive of $300 per kW for installation. In addition, Electric Services purchases the excess energy at a rate of $.075/kwh under a net metering program. **It is important to note that the rooftop solar program prevents the utility from collecting enough**

revenue to pay for the fixed costs of serving the customer such as for transmission, transformers, distribution, and labor. Therefore, the remaining customer base is subsidizing the property owners who install rooftop solar systems.

Rather than providing the $0.075/kWh net metering incentive, the City Council could consider increasing the $300/kW rebate to $1,200/kW (or some other amount) from the Electric Service's Demand Side Management budget and eliminate the net metering incentive. This change will allow the property owner to realize savings much earlier and, therefore, hopefully incentivize more installations.

New Construction

In regards to new building construction, the State legislature has negated the City's ability to establish requirements that exceed the State's adopted Energy Code or prohibiting the sale or use of natural gas. However, for new construction, the City could negotiate with developers at the time of annexation or through contract rezoning a commitment to net-zero readiness and passive home design. In addition, the City could establish new zoning standards for specific design features of a building that support both being net zero ready and passive building design.

Along with grants or forgivable loans in some pre-determined percentage as suggested with retrofit action steps, the City could create a new tax abatement program to incentivize the owners to install the needed carbon reduction improvements with new construction projects.

Increasing Solar and Wind Generation Owned By The City

Adding more ground mounted solar and/or wind generation to our Electric Services portfolio is the least complicated, least labor intensive as it relates to staffing needs, and least cost in terms of effectiveness in carbon reduction. Furthermore, the Staff has previous experience successfully negotiating Purchase Power Agreements for wind and solar energy.

The consultant's analysis indicates it will take 320 MW of these renewable energy sources to meet the 2030 and 2050 goals. When reviewing this action, the following must be considered:

- It should be remembered that renewable generation from wind and solar is produced when the "fuel source" is available. Oftentimes, this does not match up with how the City's electric customers use the energy. One alternative would be to install battery storage capacity of sufficient size to store the energy, which is not included in this analysis. Current battery storage costs are approximately $1 million per MW.

- While renewable generation produces the clean energy needed, it does not replace the generation "capacity" required. The existing installed generation Ames has today must be maintained to meet its capacity obligation within MISO.

- Depending on the amount of generation and the location, siting and operating the generation will be subject to MISO rules.

- Given the significant amount of acreage that will be needed for these renewable systems, it should be understood that they might have to be sited outside of Story County or outside of Iowa.

Electric Utility Rates

Many of the action steps suggested in the SSG's analysis will rely of revenues from the Electric Services to pay for incentives to accomplish improvements to private or other governmental entities, or to finance improvements to Electric Services infrastructure.

As the City Council considers an implementation plan, a general rule would be that for every $500,000 in additional expenditures in the electric utility, a 1% electric rate increase will be needed.

Community Participation

Absent any government mandates, the key to success will be through voluntary participation from the "community." For purposes of this report, community includes other electric utilities within the Ames city limits; other local, state, and federal entities within the Ames city limits; and private homes, commercial buildings, and industrial buildings. Approximately 91% of the net costs needed to meet the City Council's climate action goals are associated with these community entities.

An important next step will be for the Mayor to create a Community Climate Action Task Force with leaders from the primary "community" groups in an effort to reach agreement regarding how each entity will commit to reaching the City Council's goals.

Inclusion

The City Council has expressed two important values; environmental sustainability and inclusion. It is clear that the addition of financial incentives for community entities, expenditures for Electric Services infrastructure, and improvements to the Municipal buildings and fleet will result in significant increases in electric rates and property taxes. While these increases will have the greatest impact on our lower income residents, these costs will affect all of our residents. Therefore, as we piece together the implementation strategy for our Climate Action Plan, it is important that the City Council attempts to balance their two values. If we are unable to find this balance, the cost of living in Ames could become prohibitive.

Priorities For The Initial Implementation Plan

After considering the $2.3 billion estimated price tag, the lack of adequate technology needed for some of the action steps, and the legal obstacles that impact our ability to pursue all of the 29 action steps at this time; it would seem prudent to develop a more relevant, achievable, and cost effective carbon reduction strategy to initially implement our Climate Action Plan.

After reviewing data provided by SSG in Attachment A and the Staff's additional analysis based on the 8 evaluation criteria, the City Council might want to consider an initial implementation plan that includes:

1) **Increased Wind and Solar Generation As Part Of Electric Services Portfolio**

   This step reflects a low cost per ton of carbon removed, achieves the greatest percentage of carbon removed from all of the proposed action steps, requires a minimal administrative burden on the existing staff, and involves a project in which the Staff has previous experience.

2) **Waste to Energy Improvements/Reducing Waste Emissions**

   The Staff is already working with a consultant to develop alternatives to burn our refuse in a separate boiler thereby significantly reducing the amount of gas that must burned in our Power Plant. Options will be presented to the City Council in December 20, 2022.

   In addition, the City Council has directed staff to explore an Organized Garbage Collection system that would facilitate the collection of organic foods, yard waste, and recyclables as well as reducing the number of truck trips and associated emissions.

3) **New Construction**

   The City Council could consider 1) changing our Zoning Ordinance to include specific design features of a building that support both being net-zero ready and passive building design, 2) requiring net-zero ready and passive design as part of annexation and contract rezoning, and/or 3) implementing a new tax abatement program to incentivize new construction to be net-zero ready and reflect passive building design.

   It should be noted that the City Assessor has indicated that retrofitting existing buildings with more energy efficient features does not add to the assessed value. Therefore, a new tax abatement program to promote retrofitting would be an ineffective incentive.

4) **Retrofitting Existing Buildings – Pilot Program**

   SSG's analysis indicates that the action steps related to retrofitting existing buildings actually generates a net saving because the improvements will reduce the energy consumption for the individual property owners. However, assuming that Electric Services will have to borrow funds to incentivize property owners to participate in this action step, the electric utility might have to increase its rates further to pay off the debt.

   While this remains an important action step, it might be prudent to move slowly until it is determined how much of an incentive is needed to attract voluntary participation. **One possible initial action step would be to implement a pilot**

program to incentivize retrofitting existing buildings by focusing on smaller older homes in Ames Electric Services territory. We will be able to learn a lot from this initial pilot program and at the same time focus on homes that are most likely the least energy efficient and owned by lower income residents. In this way the Council's values of sustainability and inclusion can be addressed.

5) **Retrofit Municipal Buildings**

For the municipal building retrofits, a consultant will need to be hired to do a detailed study of each building with recommendations for implementation as well as a long-range capital improvements plan for these projects.

6) **Electrify the Municipal Fleet (Non-CyRide)**

When available and capable of meeting the needs of the required work, the staff will purchase electric vehicles. However, this action step excludes CyRide. Given the excessive cost of electric buses, over $1 million vehicle, the CyRide Board has committed to purchasing 17 of the 95 buses in the fleet by 2050 but is hesitant to commit to more at this time.

7) **Create a Mayor's Climate Action Plan Leadership Task Force**

This task force, comprised of primary "community" leaders from the various public and private entities that are crucial to meeting the City Council's carbon reduction goals, should come together to share their own climate action goals to calculate what we can expect to accomplish as a community by 2030 and 2050.

ATTACHMENT A

		To change discount rates for indivual actions, go to the Discount Rate Log						
QA'd	**Note:** All totals on this document (e.g. column C, H-AN) are NPV out to 2050, assuming a discount rate of 3% (see Yearly Investments tab)	Low-Carbon Action	Cumulative Emissions Reduction (kt CO2eq)	Proportion of Total Reduction	Net present value	Marginal Abatement Cost ($ / t CO2 eq)	Cost of Investment	Gain of Investment
	Reference							
####	Res Heat Pumps	Res Heat Pumps	68	0.32%	$7,557,398	$111	$17,428,065	-$9,870,667
####	New Res Buildings	New Res Buildings	195	0.91%	$55,393,083	$285	$93,718,132	-$38,325,049
####	Non-Res Heat Pumps	Non-Res Heat Pumps	-201	-0.94%	$36,636,437	$0	$36,636,437	$0
####	Non-Res Heat Pumps for HW	Non-Res Heat Pumps for HW	-56	-0.26%	$14,771,691	$0	$14,771,691	$0
####	New Non-Res Buildings	New Non-Res Buildings	317	1.48%	$134,872,272	$426	$191,464,696	-$56,592,424
####	New Municipal Buildings	New Municipal Buildings	67	0.31%	-$10,699,504	-$160	$722,756	-$11,422,260
####	Residential Retrofits	Residential Retrofits	1,046	4.90%	$587,978,777	$562	$752,822,728	-$164,843,951
####	Residential Retrofits Heat Pumps	Residential Retrofits Heat Pumps	116	0.55%	$158,059,783	$1,359	$167,502,534	-$9,442,751
####	Residential Retrofits HW	Residential Retrofits HW	415	1.95%	-$41,994,759	-$101	$13,077,356	-$55,072,115
####	Non-Res Retrofits	Non-Res Retrofits	1,268	5.95%	$101,139,516	$80	$446,759,760	-$345,620,244
####	Municipal Retrofits	Municipal Retrofits	302	1.41%	$22,875,858	$76	$64,949,071	-$42,073,213
####	Non-Res Retrofits Heat Pumps	Non-Res Retrofits Heat Pumps	-129	-0.61%	$24,587,482	$0	$24,587,482	$0
####	Non-Res Residential Retrofits HW	Non-Res Residential Retrofits HW	-163	-0.76%	$40,496,239	$0	$40,496,239	$0
####	Industrial Efficiency	Industrial Efficiency	811	3.80%	-$52,248,574	-$64	$14,769,254	-$67,017,829
####	Industrial Electrification	Industrial Electrification	-337	-1.58%	$27,126,323	$0	$27,126,323	$0
####	DE electric boilers	DE electric boilers	1,477	6.93%	-$27,717,605	-$19	$21,661,933	-$49,379,538
####	DE to RNG	DE to RNG	330	1.55%	$59,145,581	$179	$59,145,581	$0
####	Increased Active Modes	Increased Active Modes	386	1.81%	-$230,091,805	-$597	$20,770,850	-$250,862,655
####	Electrify PUV	Electrify PUV	382	1.79%	-$371,884,291	-$973	$135,029,854	-$506,914,145
####	Reduce Trip Generation	Reduce Trip Generation	277	1.30%	-$71,440,051	-$258	$0	-$71,440,051
####	Electrify Transit	Electrify Transit	0	0.00%	$26,966,876	$1,318,803	$44,332,427	-$17,365,552
####	Electrify Municipal Fleet	Electrify Municipal Fleet	-23	-0.11%	-$43,191,704	$0	$0	-$43,191,704
####	Commercial Vehicle Electrification	Commercial Vehicle Electrification	559	2.62%	-$569,151,641	-$1,018	$11,216,840	-$580,368,481
####	Net Zero Aviation Emissions	Net Zero Aviation Emissions	15	0.07%	$0	$0	$0	$0
####	Waste Reduction & Diversion	Waste Reduction & Diversion	726	3.40%	$0	$0	$0	$0
####	Buildings to RNG	Buildings to RNG	969	4.55%	$170,467,256	$176	$170,467,256	$0
####	Add ground mount solar	Add ground mount solar	4,536	21.27%	$796,059,702	$176	$796,059,702	$0
####	Wind Generation	Wind Generation	584	2.74%	$0	$0	$0	$0
####	Rooftop solar	Rooftop solar	2,376	11.14%	-$37,772,237	-$16	$431,966,846	-$469,739,083
####	New WTE facility	New WTE facility	2,513	11.78%	$89,291,270	$36	$89,291,270	$0
####	MISO decarb target	MISO decarb target	2,502	11.73%	$0	$0	$0	$0
####	LC	LC	0.00	0.00%	$0	$0		
		TOTAL	21,326.52		$897,233,375	$42	$3,686,775,084	-$2,789,541,709
						Annual Avg Number	$131,670,539	-$99,626,490
0%		Buildings		0.34%		Return on $ invested	-$0.76	
				0.34%		Total MACC	$42	
						Annual Avg Number	$131,670,539	-$99,626,490

ATTACHMENT B

	Cumulative Emissions Reduction (kt CO2eq)	Proportion of Total Reduction	Net Spending	Marginal Abatement Cost ($ / t CO2 eq)	Cost of Investment	Gain of Investment	Notes
Building Retrofits	3,141	15%	926,986,172	295	1,620,926,941	-693,940,769	
Net-Zero New Construction	578	3%	179,565,851	311	285,905,584	-106,339,733	
Renewable Energy Generation	10,009	47%	847,578,735	85	1,317,317,818	-469,739,083	
Reducing Vehicle Emissions	933	4%	-957,260,759	-1,027	190,579,122	-1,147,839,881	
Increase Active Transportation and Transit Use	662	3%	-301,531,856	-455	20,770,850	-322,302,706	
Reduce Waste Emissions	726	3%	0	0	0	0	No costs were included for waste reduction or diversion
Non Big Six:							
Low Carbon DE system at ISU	1,807	8%	31,427,976	17	80,807,514	-49,379,538	
MISO grid decarbonization plans	2,502	12%	0	0	0	0	
Replacing Building Natural Gas Use With Renewable Natural Gas	969	5%	170,467,256	176	170,467,256	0	