AGENDA
SPECIAL MEETING OF THE AMES CITY COUNCIL
CITY COUNCIL CHAMBERS - CITY HALL
515 CLARK AVENUE
NOVEMBER 16, 2021

CALL TO ORDER: 6:00 p.m.

WORKSHOP ON CLIMATE ACTION PLAN:

DISPOSITION OF COMMUNICATIONS TO COUNCIL:

COUNCIL COMMENTS:

ADJOURNMENT:

Please note that this agenda may be changed up to 24 hours before the meeting time as provided by Section 21.4(2), *Code of Iowa.*

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Caring People ◆ Quality Programs ◆ Exceptional Service

MEMO

To: Mayor and City Council

From: Deb Schildroth, Assistant City Manager

Date: November 12, 2021

Subject: Objectives for the Second Climate Action Plan Steering Committee Meeting

The objectives for this CAP workshop is to inform the Steering Committee about the Business As Usual (BAU) results, engagement outputs to date, and target-setting approaches developed by SSG. While there will be no decision making required at this meeting, questions, concerns, and comments presented by the Steering Committee will be addressed.

The materials to be reviewed during this meeting include the BAU results summary, target setting briefing, and carbon budget briefing.

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www.CityofAmes.org

BUSINESS AS USUAL SUMMARY

Prepared for the Ames Climate Action Plan

CITY OF Ames

October 2021

SSG whatIf?

Disclaimer

Reasonable skill, care and diligence has been exercised to assess the information acquired during the preparation of 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 are subject to changes that are beyond the control of the author. The information provided by others are believed to be accurate but have not been verified.

This analysis includes strategic-level estimates of costs and revenues 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 does not accept responsibility to any third party for the use, in whole or in part, of the contents of this document. This analysis applies to Ames and cannot be applied to other jurisdictions without analysis. Any use by the Ames, its 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.

Contents

SECTION ONE

An Introduction to Ames

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About Ames

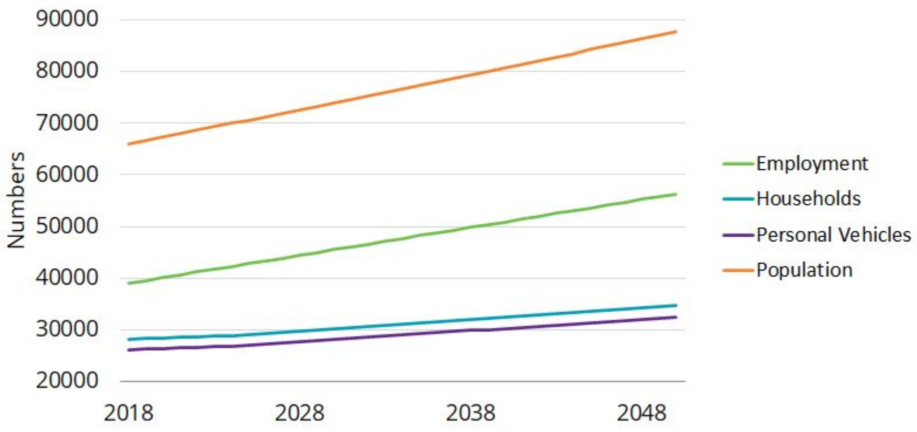
Ames is a small but growing city with a population of around 66,000 people. It is home to Iowa State University (ISU) and a student population that makes up half of the city’s population.

Unlike many small cities, the City of Ames owns its own electrical utility that supplies part of Ames’ electricity. . This has allowed the City to decrease emissions already and is an area of opportunity for future emissions reductions.

Likewise, improvements to ISU’s central heating plant will reduce emissions and is an area for future opportunity.

Local control over a significant portion of energy production and distribution is a rare circumstance and opportunity. The City of Ames and ISU are already taking advantage of their ownership of energy assets in the community to reduce emissions. Opportunities exist to build on their respective successes but this does not negate the need for other emissions reductions actions in the community.

Community Demographics



Demographics are an important consideration when thinking about future energy use and emissions.

It can be helpful to understand if energy and emissions are increasing or decreasing per capita over time and/or as a result of population and employment growth over time.

In Ames, the City expects the following growth trends between 2018 and 2050:

- 44% growth in employment
- 23% growth in the number of households
- 24% growth in the number of vehicles
- 33% growth in population

SECTION TWO

Developing a Business-as-Usual Scenario

What is a BAU?

The business-as-usual (BAU) scenario detailed in this document is a projection of energy use and GHG emissions in Ames in 2050, should the community continue on its current course of action.

The BAU assumes no additional policies, actions, or strategies are implemented by 2050 beyond those that are currently approved and funded or underway.

This document highlights major trends from the BAU results and is not a comprehensive summary of all factors that contribute to energy and emissions patterns over the timeframe.

The BAU scenario uses a 2018 baseline in line with the last census year. Aligning the baseline with a census year allows us to use the most accurate and comprehensive data available for our analysis.

Future scenarios

A scenario is an internally consistent view of what the future might turn out to be. It is not a forecast, but one possible future outcome that is based on currently available information.

Business-as-Planned Scenario

Two steps were taken to develop and quantify the BAU Scenario:

Data and Information

Data from the City & other trusted sources

Policies and plans approved and/or underway

+

Assumptions

Analysis and interpretation of data and information

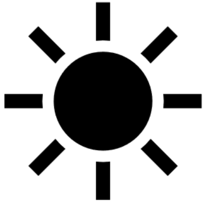
→

Projections

Projections for individual factors modeled together to forecast a future plausible scenario for community energy-use and emissions

A full Data, Methods, and Assumptions Manual for the project is available at cityofames.org/sustainability

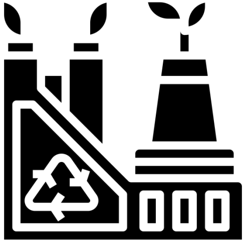
Key Assumptions in the BAU Scenario



Heating Degree Days

Declining

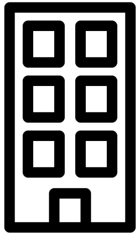
As the climate warms there will be a lesser need for home heating in Ames but a greater need for home cooling.



Grid-carbon intensity

Stable

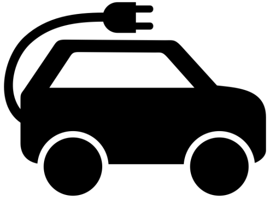
Grid-carbon intensity (emissions from grid electricity) will remain similar to current levels, except where noted in the BAU.



Building Efficiency

Increasing

As the population grows and new homes are built, a greater proportion of homes in Ames will meet current building code requirements.



Increase in EVs

Increasing

EV purchases will increase in line with federal targets, reaching 50% of vehicles sales by 2030.

SECTION THREE

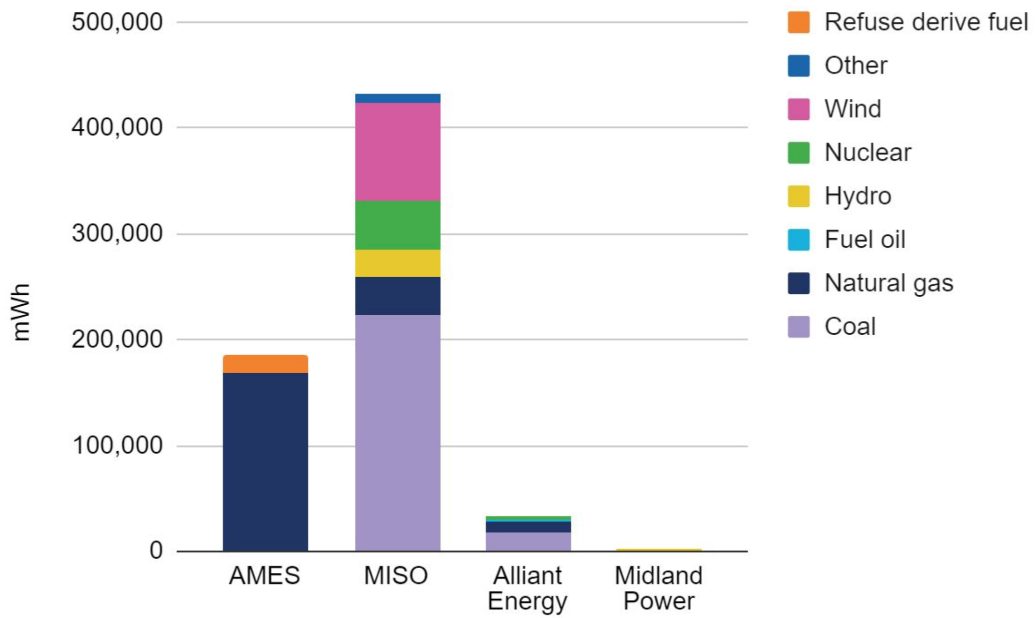
Community Energy Consumption

Energy & Emissions Source Descriptions

Legend	Description
Local energy	Solar PV
RNG	Renewable natural gas
Fuel oil, propane, natural gas	Direct to consumer (residential, commercial, industrial)
District energy	ISU combined heat and power (CHP) system
Grid electricity	From all utility providers
Fugitive	Emissions from the production and transportation of natural gas

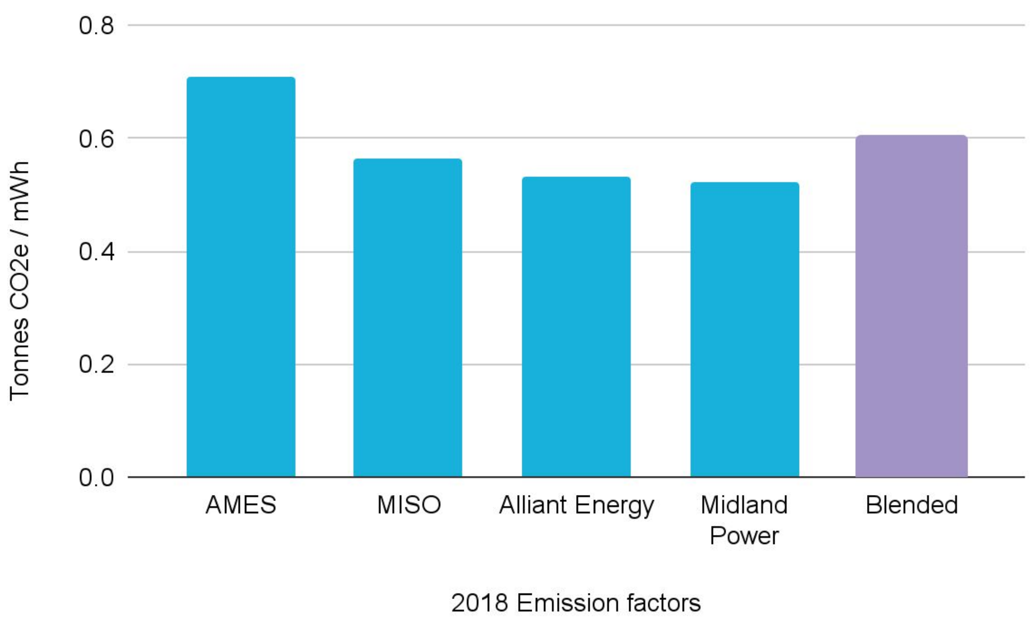
Ames has a unique combination of energy sources. Locally, energy is produced via individual solar PV installations and through ISU's district energy (combined heat and power) system. Grid electricity comes from four sources, including the City of Ames' own electrical utility.

Grid Electricity Supply by Utility & Fuel Type



There are four separate utilities that provide electricity to Ames' residents and businesses. Each of the utilities derive their electricity supply from different fuel sources.

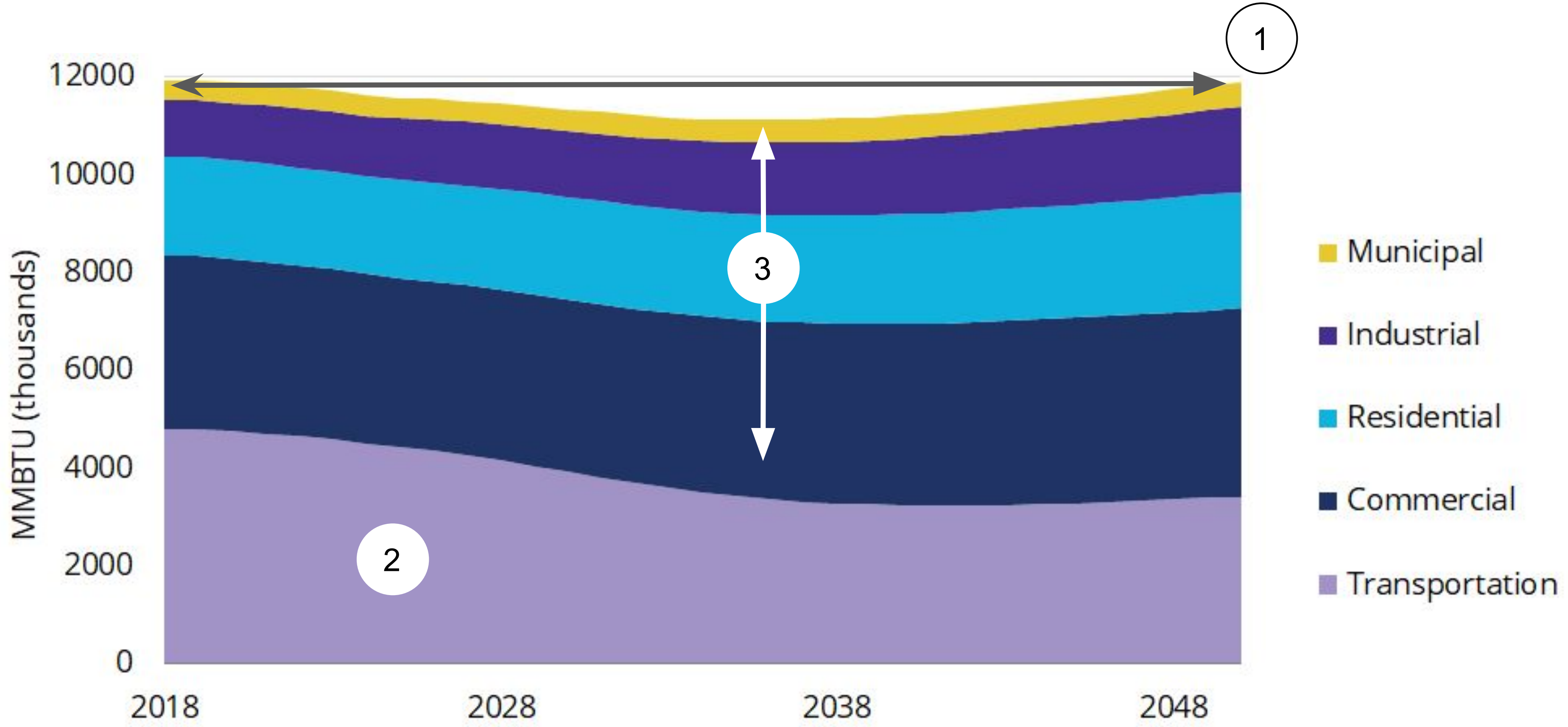
Grid Emissions Factor for Ames in 2018



The different fuel sources used by each utility results in different grid emissions factors (which represents the amount of greenhouse gas emissions emitted) for each utility. Each utility also provides a different amount of electricity to Ames. We consider both of these aspects when calculating the overall emissions factor for electricity in Ames.

Figure 1

Projected total community energy use, 2018-2050

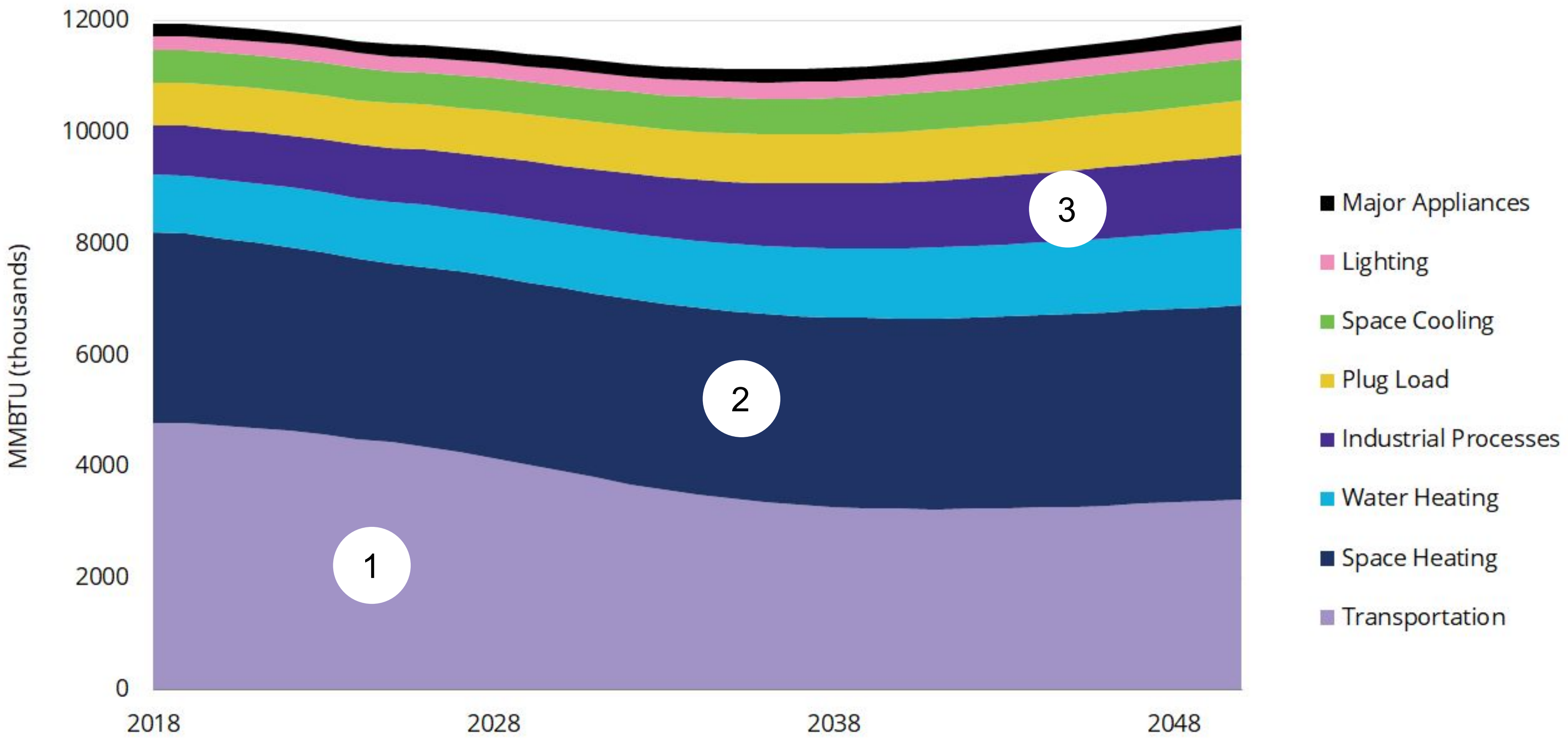

12000
10000
8000
6000
4000
2000
0
MMBTU (thousands)
2018
2028
2038
2048
1
2
3
Municipal
Industrial
Residential
Commercial
Transportation

Community Energy Use

1. **Total energy consumption in 2050 is projected to be approximately the same as in the 2018 baseline year**, at 1.2 million MMBTUs
2. **Transportation energy use will decrease** with electric vehicle sales displacing some gasoline-fueled vehicles.
3. **Energy use in all other sectors will increase** as the population grows and services and employment grow alongside population growth.

Figure 2

Projected community energy use by end use, 2018-2050


12000
10000
8000
6000
4000
2000
0
MMBTU (thousands)
2018
2028
2038
2048
1
2
3
Major Appliances
Lighting
Space Cooling
Plug Load
Industrial Processes
Water Heating
Space Heating
Transportation

Community Energy Use by End Use

1. Toward 2050, **transportation remains the most energy intensive activity** in the community despite an overall decrease in the energy consumed for this end use.

2. **Energy use for space heating and other buildings-related end uses increase** over the projection period as population and employment grow.

3. **Energy use for industrial processes increases**, reflecting employment growth in the sector.

Figure 3

Projected community energy use by fuel type, 2018-2050

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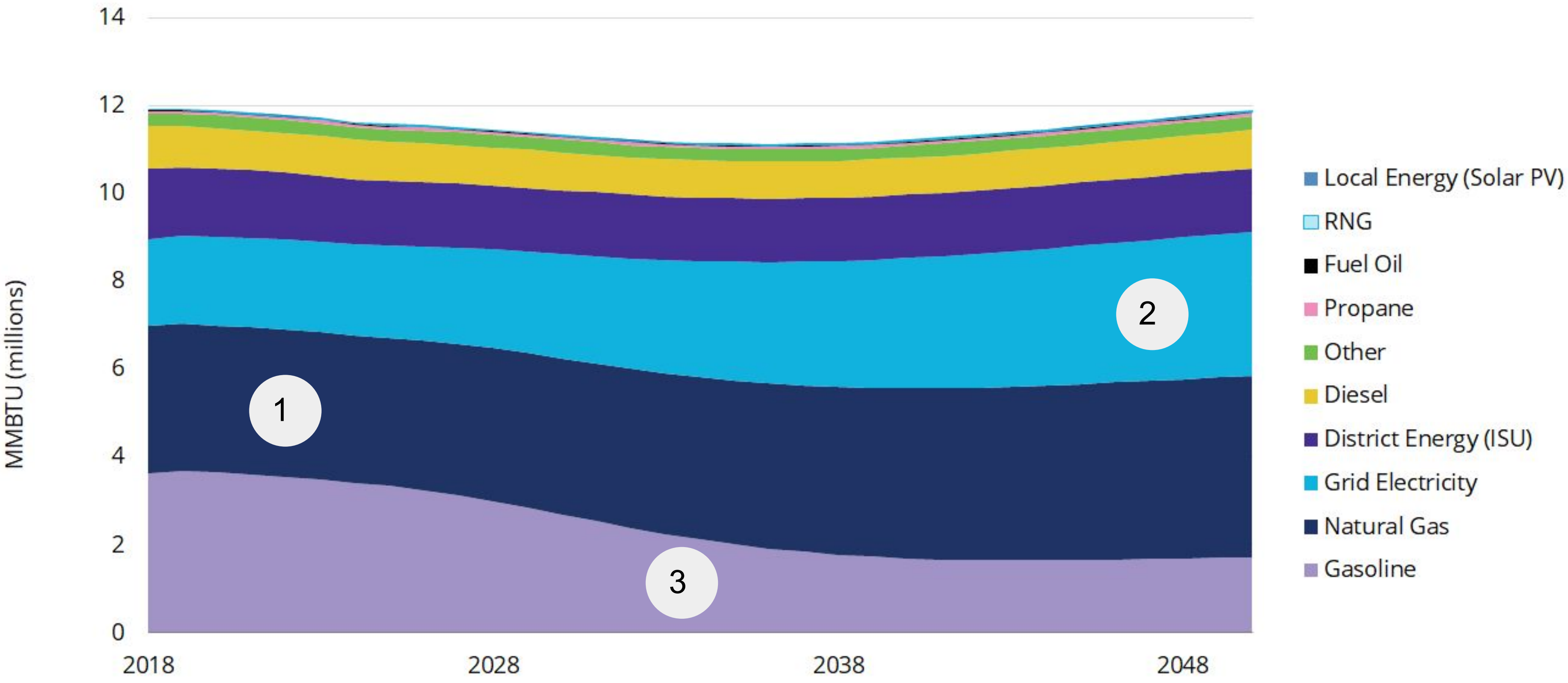

14
12
10
8
6
4
2
0
MMBTU (millions)
2018
2028
2038
2048
1
2
3
Local Energy (Solar PV)
RNG
Fuel Oil
Propane
Other
Diesel
District Energy (ISU)
Grid Electricity
Natural Gas
Gasoline

Community Energy Use by Fuel Type

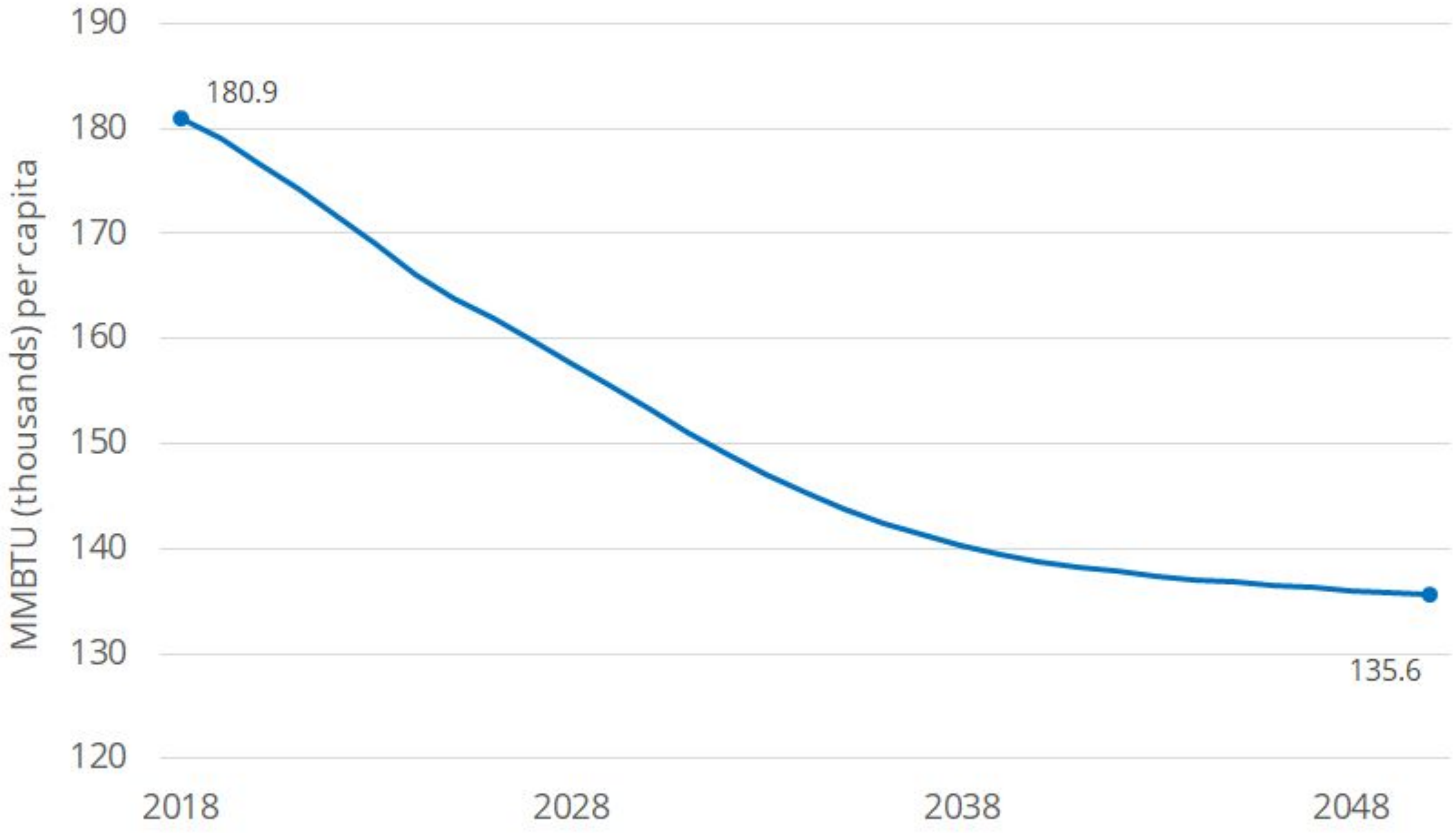
1. **Ames is powered mostly by natural gas** in 2018 and this will remain true through to 2050 due to population growth and the conversion of Iowa State University's energy system from coal to natural gas.

2. **Grid electricity use will increase significantly** between 2018 and 2050, outpacing increases in natural gas usage. This is due to population growth and a switch to electric vehicles.

3. **Gasoline use in the community is halved between 2018 and 2050** due to the uptake in electric vehicles.

GRAPH 4

Projected community energy use per capita, 2018-2050


190
180
170
160
150
140
130
120
MMBTU (thousands) per capita
180.9
135.6
2018
2028
2038
2048

Per Capita Energy Use

Per capita energy use is anticipated to decline by 33% between 2018 and 2050.

The decline in energy use is due to increasing energy efficiency over time including new vehicles and buildings being more efficient**.**

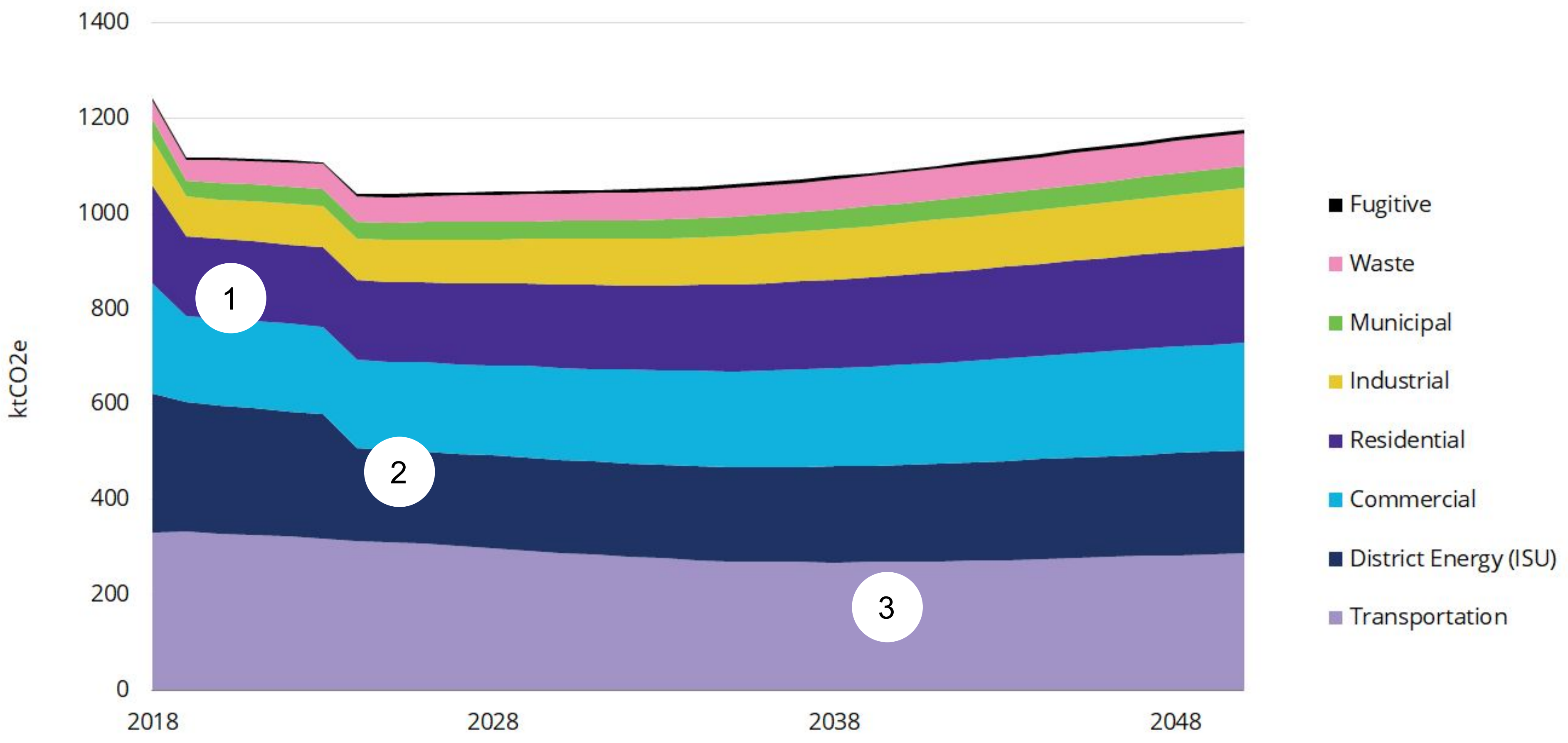
Overall community energy use will remain constant, meaning in 2050 there will be more people in Ames using the same amount of energy that was used in the community in 2018.

SECTION FOUR

Community Greenhouse Gas Emissions

GRAPH 5

Projected total community GHG emissions, 2018-2050


1400
1200
1000
800
600
400
200
0
ktCO2e
2018
2028
2038
2048
1
2
3
Fugitive
Waste
Municipal
Industrial
Residential
Commercial
District Energy (ISU)
Transportation

Community Emissions

Total annual emissions decrease slightly between 2018 and 2050, from approximately 1240 ktCO2e to 1180 ktCO2e.

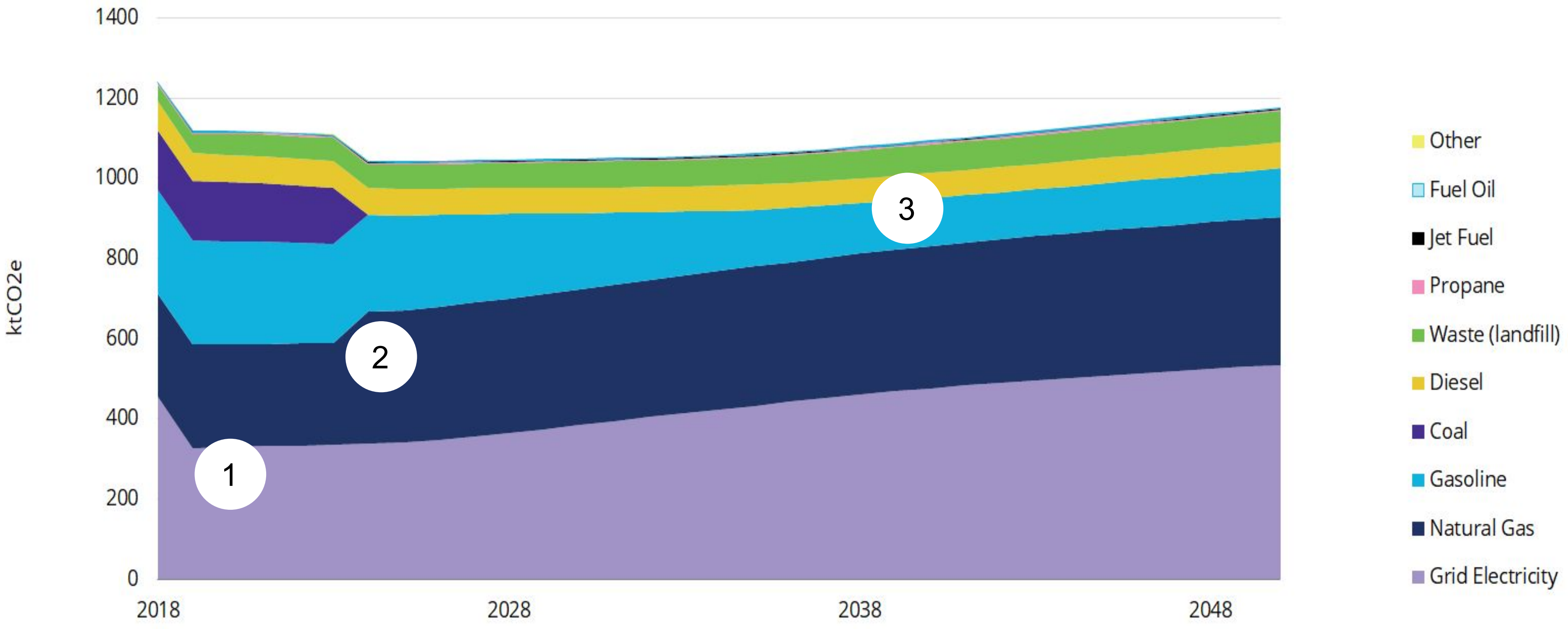
1 The **sharp decrease** in commercial and residential emissions in 2019 is due to the emissions factor of grid electricity decreasing with **Ames Electric Service using the power from their wind turbine to offset their own emissions** rather than selling renewable energy credits (RECs) to other utilities as they did in 2018.

2 The **sharp decrease** in 2024 in energy production is due to the university's energy system being converted **from coal to natural gas.**

3 **Transportation emissions decrease for a period** as gasoline use decreases and electricity use in the sector increases. Later, emissions begin to increase again as usage outpaces the emissions reductions from low emissions vehicles.

GRAPH 6

Projected community emissions by source, 2018-2050


ktCO2e
1400
1200
1000
800
600
400
200
0
2018
2028
2038
2048
1
2
3
Other
Fuel Oil
Jet Fuel
Propane
Waste (landfill)
Diesel
Coal
Gasoline
Natural Gas
Grid Electricity

Community Emissions by Source

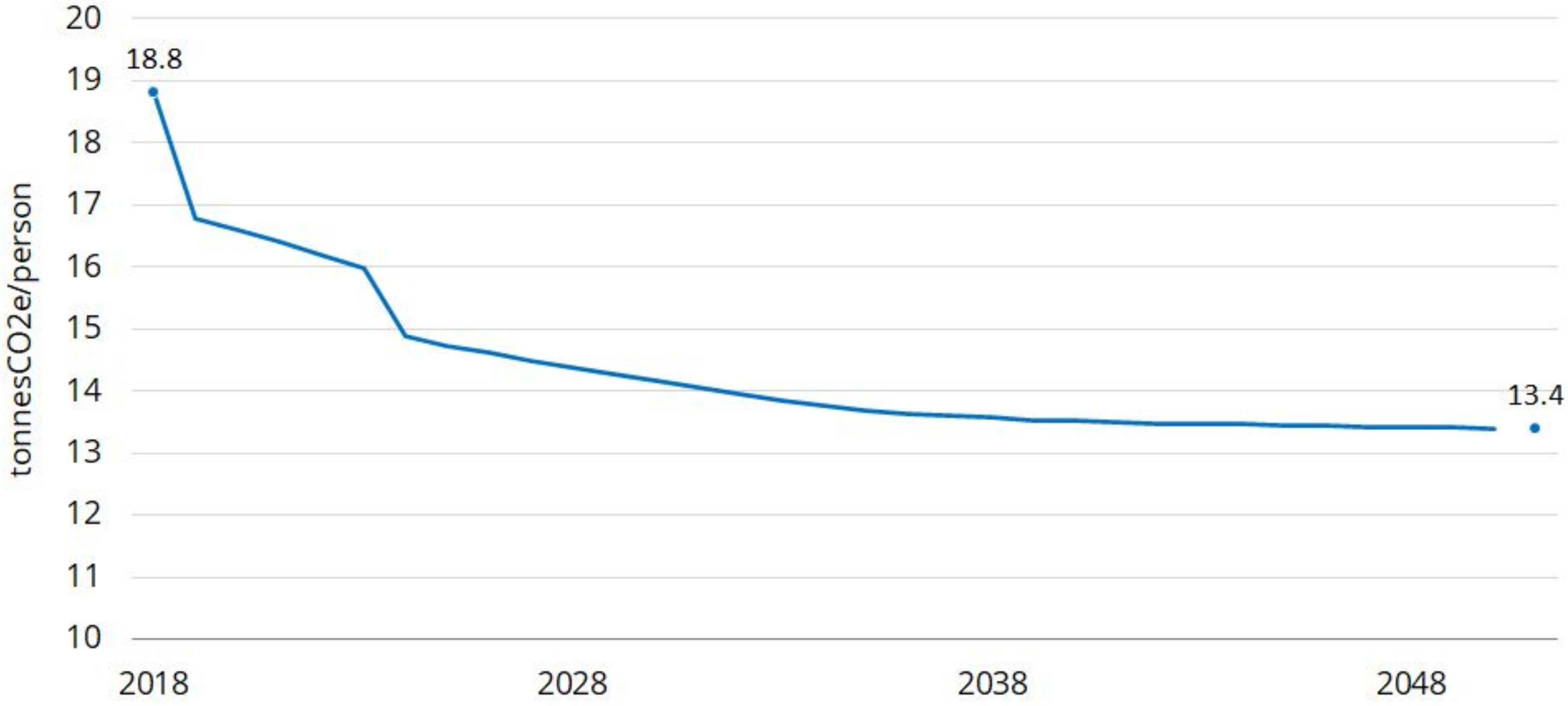
1. In 2019, the impact of REC purchases can be seen on grid electricity emissions. The **emissions from the grid begin to increase again over time as the use of electricity in Ames increases** with population growth**.**

2. Emissions from natural gas increase in 2024 as coal emissions are eliminated. **Emissions from natural gas continue to increase gradually beyond 2024 as the population grows and use increases.**

3. **Gasoline and diesel emissions decrease** while all others sources increase with population growth.

GRAPH 7

Projected community emissions per capita, 2018-2050


20
19
18
17
16
15
14
13
12
11
10
tonnesCO2e/person
18.8
13.4
2018
2028
2038
2048

Community Emission Per Capita

City	Emissions (tCO2e) in 2018
Iowa City, Iowa	13.7
Carmel, IN	13.3
Evanston, IL	12.7
Albany, NY	10.1
Medford, MA	8.2
C40 Cities	
Average	6.2
Median	5

Per capita emissions are anticipated to decline from 18.8 tonnes per person in 2018 to 13.4 tonnes per person in 2050 (-29%).

There is a wide range of per capita emissions in municipalities with fewer than 100,000 residents in the midwestern United States, as outlined in the table to the left.

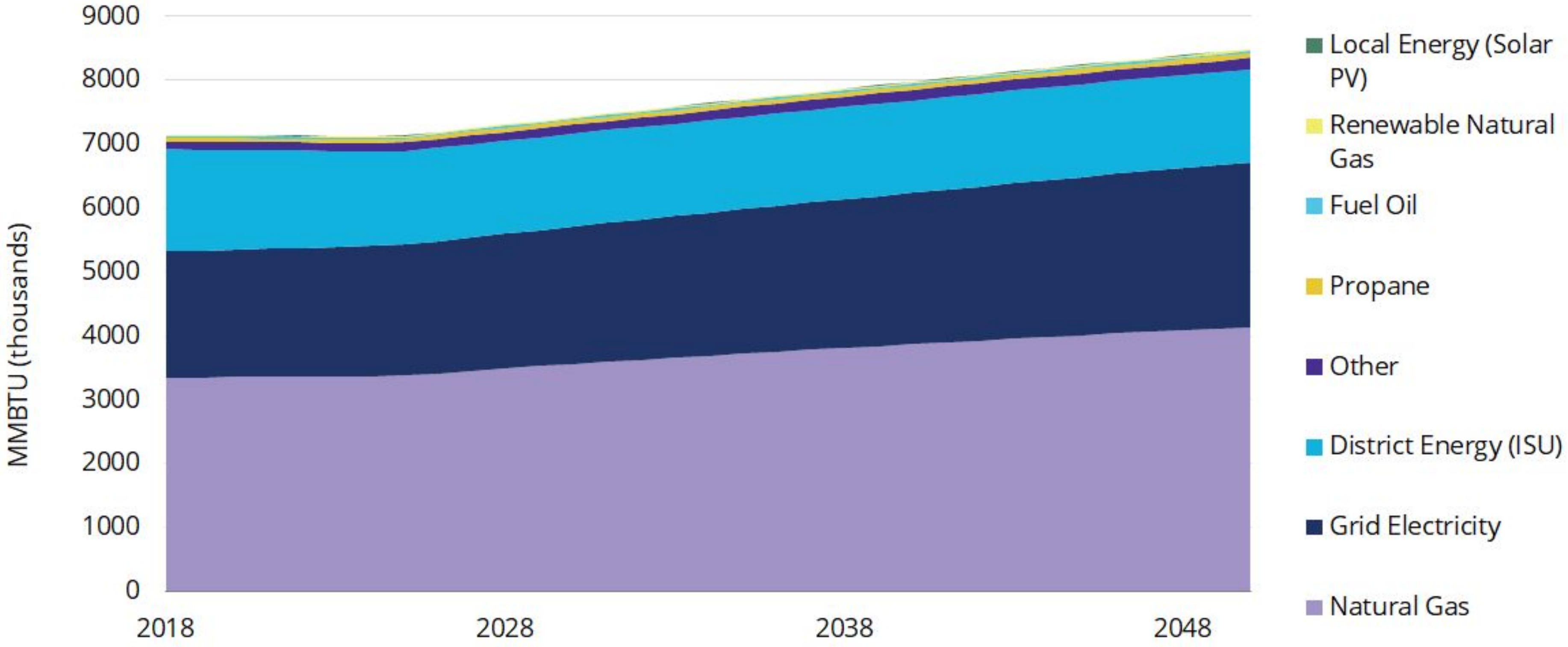
According to the latest recommendations from leading climate science organizations, per capita emissions in cities in wealthy countries should be <3 tCO2e by 2030.

SECTION FIVE

Energy and Emissions by Sector

GRAPH 8

Projected buildings energy use, 2018-2050



9000
8000
7000
6000
5000
4000
3000
2000
1000
0
MMBTU (thousands)
2018
2028
2038
2048
Local Energy (Solar PV)
Renewable Natural Gas
Fuel Oil
Propane
Other
District Energy (ISU)
Grid Electricity
Natural Gas

Buildings Energy Use by Fuel

Total energy consumption in buildings is projected to rise from around 7.1 million MMBTU per year in 2018 to around 8.5million MMBTU per year in 2050.

This 19% growth **reflects population and employment growth** that is tempered by new buildings being built more efficiently than existing buildings. In other words, the number of buildings meeting 2012 building codes, which have higher energy efficiency standards than previous codes, will increase.

Natural gas accounts for nearly half of building energy consumption throughout the period.

Electricity consumption in buildings increases by roughly 30% with increases in energy use for space cooling, lighting, major appliances, and plug load as the population increases.

GRAPH 9

Projected buildings energy use by sector, 2018-2050

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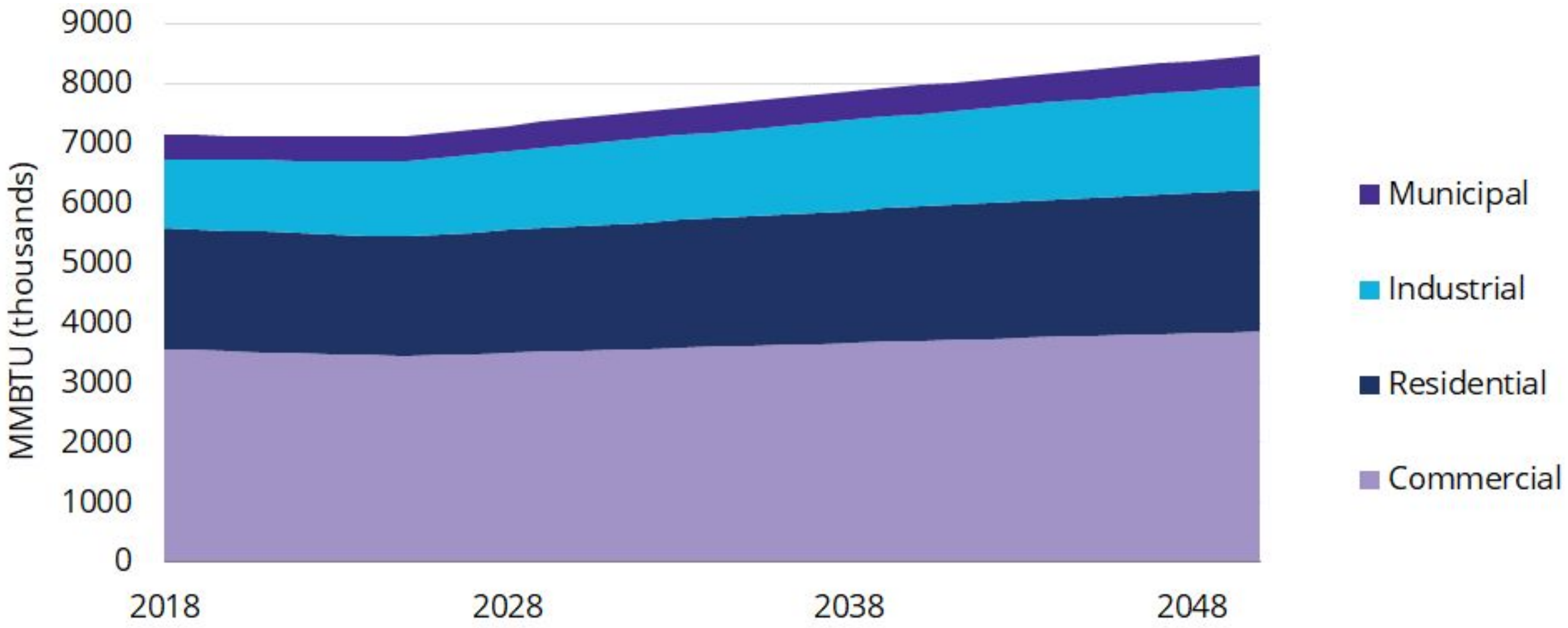


9000
8000
7000
6000
5000
4000
3000
2000
1000
0
MMBTU (thousands)
2018
2028
2038
2048
Municipal
Industrial
Residential
Commercial

Buildings Energy Use

Energy use in buildings increases for all sectors between 2018 and 2050.

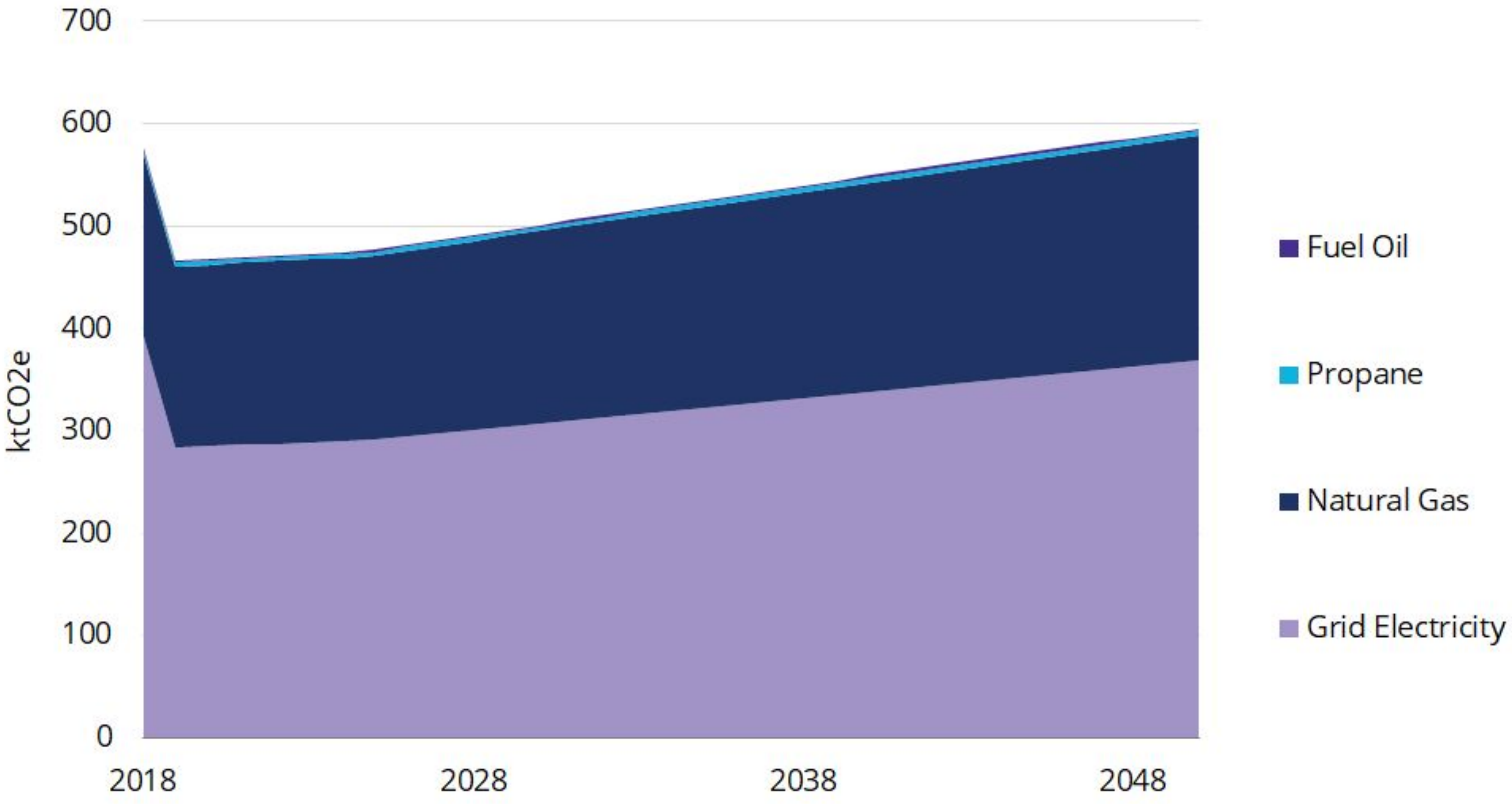
Energy use in the industrial sector increases by 50% over the timeframe due to a projected increase in industrial floorspace.

The increases in energy use in municipal (26%), residential (18%) and commercial (8%) buildings can be attributed to **population and employment growth and growth in associated community services** without additional policies and programs beyond those currently in place to encourage building efficiencies.

Across all buildings, growth in energy use for space heating is low (2%) and growth in energy use for space cooling is much higher (29%) due to milder winters and hotter summers.

GRAPH 10

Projected emissions from buildings, 2018-2050


700
600
500
400
300
200
100
0
ktCO2e
2018
2028
2038
2048
Fuel Oil
Propane
Natural Gas
Grid Electricity

Building Emissions

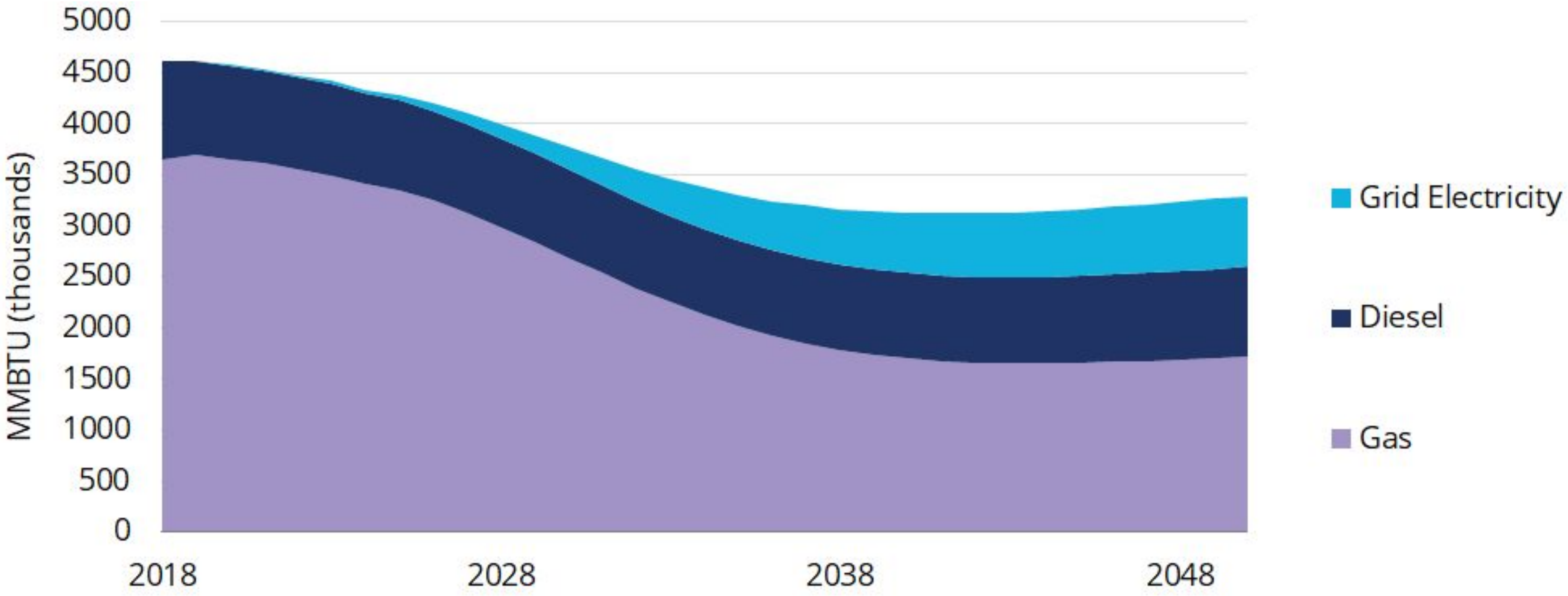
Emissions from buildings are projected to increase from around 5.6 to 5.9 MtCO2e per year by 2050.

Initially emissions from buildings decrease due to the drop in the grid emissions factor for electricity in 2019.

This efficiency gain is soon overtaken by increased energy demand in buildings across all sectors and fuel types.

GRAPH 11

Projected transportation energy use, 2018-2050



MMBTU (thousands)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
2018
2028
2038
2048
Grid Electricity
Diesel
Gas

Transportation Energy Use

Overall **energy use in transportation is projected to decrease by 29%** during the period.

Gas consumption decreases by 53% between 2018 and 2050, reflecting Ames meeting the federal goal of 50% of vehicles sales being electric by 2030.*

Diesel use decreases by 9% from 2018 levels, reflecting diesel efficiency standards and the displacement of some diesel vehicles with electric.

Electricity used for transportation increases from near 0% to 21% of the energy consumption in the sector as electric vehicles become more common.

**Note that the federal standard, if achieved, does not reflect what will happen in each individual community across the country. Electric vehicle sales may make up 70% of vehicle sales in some communities and 30% in others. This highlights the need for continued local action to reach this target.*

GRAPH 12

Projected community transportation emissions, 2018-2050

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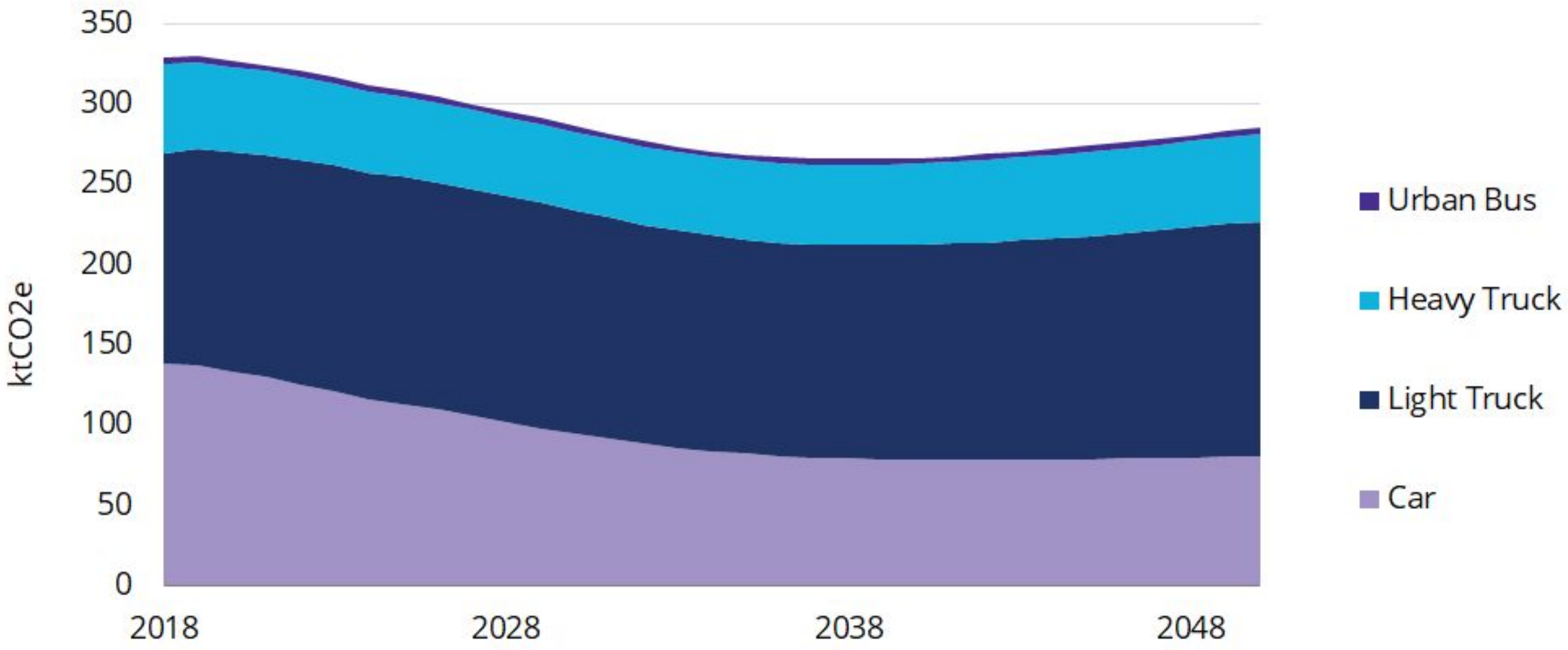

350
300
250
200
150
100
50
0
ktCO2e
2018
2028
2038
2048
Urban Bus
Heavy Truck
Light Truck
Car

Transportation Emissions

Emissions in the transportation sector are projected to decrease by 13% between 2018 and 2050

As electric vehicle sales in the car and light duty truck categories increase over time, **emissions decrease between 2025 and 2040**.

As the population increase and vehicle kilometers travelled per person increases**, emissions begin to climb again around 2040.** This increase also reflects the expectation that there will still be emissions from grid electricity in 2040.

GRAPH 13

Projected emissions from waste, 2018-2050

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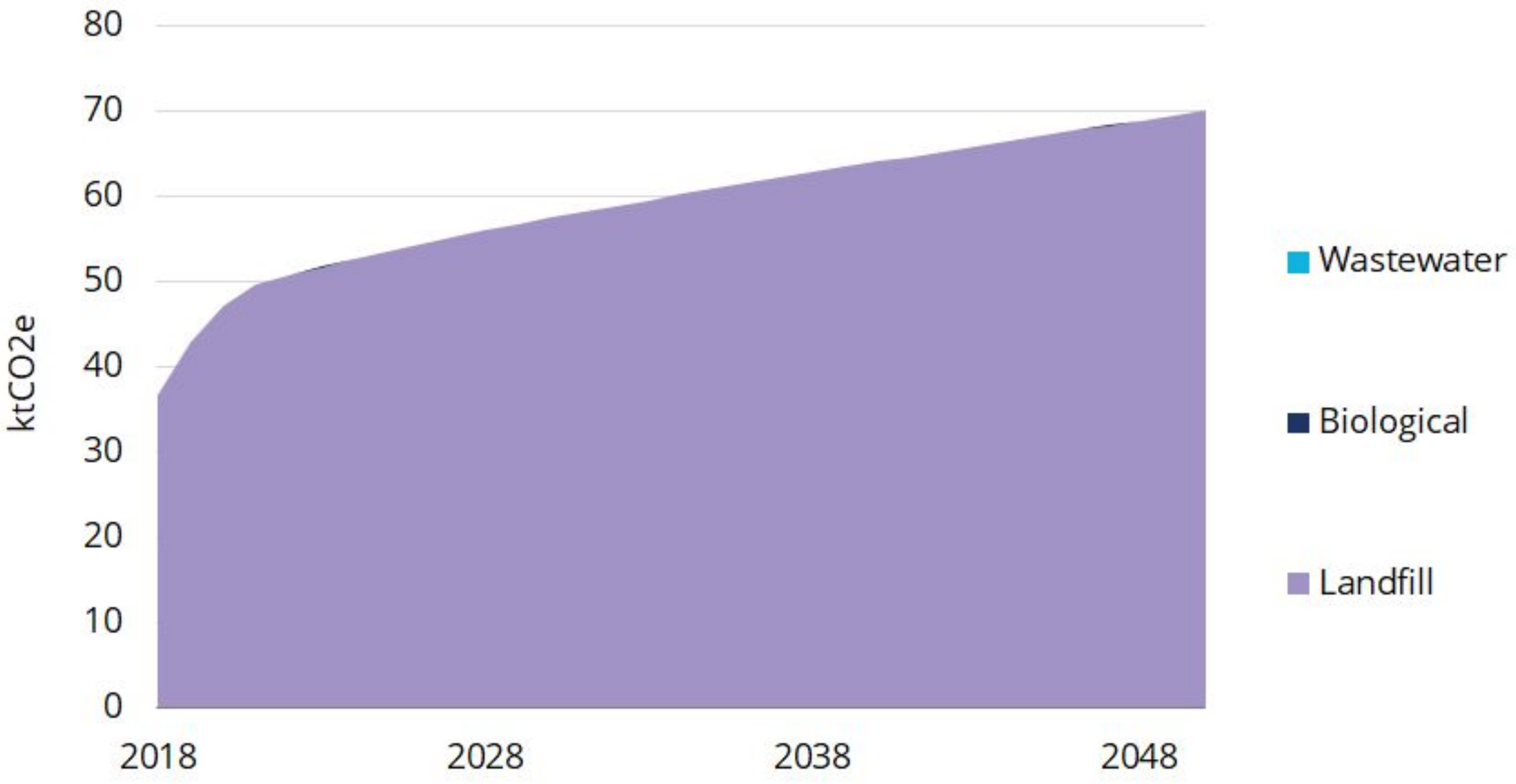
80
70
60
50
40
30
20
10
0
ktCO2e
2018
2028
2038
2048
Wastewater
Biological
Landfill

Waste Emissions

The model uses a first order decay model for waste meaning that it accounts for methane release from waste over time rather than during the year it was deposited.

In 2018 the Waste to Energy facility underwent a repair and only 30% of waste was combusted in 2018, ramping back up to 73% by 2021. During this period more waste was brought to the landfill, resulting in an increase in emissions as that waste decays over time.*

Emissions from waste are anticipated to grow by 91%. **as a result of a growing community without additional plans for increasing diversion rates.**

Wastewater emissions are negligible due to a methane capture system in place at the wastewater treatment facility.

*Emissions from the Waste to Energy facility are captured in the grid electricity emissions factor rather than under the waste emissions category.

SECTION SIX

BAU Summary & Trend Analysis

Population and employment growth will influence energy and emissions use in Ames

The City's of Ames projects significant ongoing population growth, reaching over 87,000 by 2050,a 33% increase over the 2018 population. This growth requires rethinking energy systems to accommodate growth while decreasing emissions.

The BAU projections for Ames indicate that emissions will decrease slightly from around 1240 ktCO2e in the 2018 baseline year to around 1176 ktCO2e in 2050. This reflects a period of anticipated employment and population growth that is offset by the phase-out of coal, growth of electrification in the transportation sector, and more efficient buildings.

Out of all fuel sources, grid electricity remains the most significant source of emissions. This highlights an opportunity for the grid to be further decarbonized through the addition of grid-tied and community- scale renewable energy. The City of Ames' electric utility has already demonstrated the benefit of this action with the addition of wind-source energy that has decreased the emissions factor of the utility's electricity.

Natural gas use also makes up a significant proportion of Ames' emissions. Efforts to decarbonize this source or fuel-switch to electricity, which can be decarbonized through an increase in renewables, are key to reducing emissions.

Grid-tied renewable energy is an opportunity in Ames, given the City has direct control over one third of the community's electricity supply through its own utility.

Amongst sectors, transportation is the largest source of emissions between 2018 and 2050 even as emissions in the sector decrease by 13% over the period. This calculation considers federal targets of 50% electric car sales by 2030.

Energy production is also a significant source of emissions although emissions from this source decrease during the projection period. This accounts for the central heating plant at the university and highlights the significant role the university plays in addressing energy and emissions reductions in the community due to its size.

Significant emissions from residential and commercial sectors highlight, once again, the need for renewables at the grid level and fuel-switching.

Ames' emissions come from several sectors that pose unique opportunities and challenges for reducing emissions.

Emissions from waste are captured in two different portions of the BAU. The combustion of waste associated with the waste to energy system is included in the grid emissions factor. Emissions from landfill waste is included in the waste emissions sector.

Solid waste reduction and increased diversion from the landfill are necessary to meaningfully reduce GHG emissions from this growing emissions sector.

A closer look at the waste to energy facility as technology evolves may uncover more efficient processes for waste disposal.

Best practices and technologies addressing waste and emissions from waste are evolving at a rapid pace but reducing waste will remain a top priority.

Reducing emissions between now and 2050 will require systems level changes in energy production, distribution, and use.

Ames is in the process of setting a target for reducing greenhouse gas emissions. Based on the BAU, Ames would need to shift away from non-renewable natural gas, invest heavily in clean electrification and renewables, shift away from gasoline fueled vehicles, and undertake deep energy efficiency improvements in buildings to realize significant reductions in its current emissions. These changes will require changes in policies, regulations, and programs, the participation of residents and business-owners, and partnership and ongoing coordination with other levels of government, industry, and other emitters.

APPENDIX A

Business as Usual Technical Background

Developing a BAU

Two steps were taken to develop and quantify the BAU Scenario:

Data collection: A data request was produced and data was collected with assistance and input from the City. Assumptions were identified to supplement any gaps in available data. A data, methods, and assumptions manual was produced to ensure transparency about the data and assumptions used.

Model calibration and baseline: The model is custom built for the local context and includes data for: population, population assignment to dwellings, jobs assignment to buildings, a surface model of buildings, transportation, waste, industry, and land-use. The baseline energy and emissions inventory year is 2018. The modeling process involves regular validation of observed data against broader state averages at each modeling stage.

Units of Measurement in this Analysis

GHG emissions	Energy
1 ktCO2e = 1,000 tCO2e	**1 MMBTU = 1 thousand BTUs**
One kilotonne (kt) of carbon dioxide equivalents (CO2e) is equal to one thousand tonnes of CO2e.	One thousand metric millions of British Thermal Units (MMBTU) is equal to one billion BTUs.

Emissions are characterized as kilotonnes of carbon dioxide equivalent (ktCO_2e). To compare fuels on an equivalent basis, all energy is reported as units of energy content primarily as thousands of Metric Million British Thermal Units (MMBTU). These measures can be characterized as follows:

- A 1500 square foot house uses about 500 MMBTUs of energy in a year
- One gallon of gasoline provides about 0.12 MMBTU
- One gallon of diesel or heating oil provides about 0.14 MMBTU
- A terawatt-hour is about 3.4 MMBTU

*Data provided by United States Environmental Protection Agency

APPENDIX B

Energy and Emissions Tables

Community Demographics

	2018	2050	% change 2018-2050
Employment	38,995	56,318	44%
Households	28,164	34,752	23%
Personal Vehicles	26,088	32,367	24%
Population	65,993	87,770	33%

Total GHG emissions by sector (ktCO2e)

Sector	2018	2018 Share	2050	2050 Share	% change 2018-2050
Commercial	229.0	18%	225.9	19%	-1%
District Energy (ISU)	292.3	24%	216.2	18%	-26%
Fugitive	5.0	0%	7.2	1%	43%
Industrial	97.1	8%	122.0	10%	26%
Municipal	43.6	4%	45.4	4%	4%
Residential	205.8	17%	201.6	17%	-2%
Transportation	331.2	27%	287.9	24%	-13%
Waste	36.7	3%	70.1	6%	91%
TOTAL	**1240.7**	**100%**	**1176.3**	**100%**	**-5%**

Total GHG emissions by fuel type (ktCO2e)

Fuel Type	2018	2018 Share	2050	2050 Share	% change 2018-2050
Coal	150.9	12%	0.0	0%	-100%
Diesel	71.8	6%	65.2	6%	-9%
Fuel Oil	2.0	0%	2.3	0%	18%
Gasoline	257.1	21%	121.3	10%	-53%
Grid Electricity	453.6	37%	533.9	45%	18%
Jet Fuel	2.1	0%	2.7	0%	32%
Natural Gas	258.2	21%	369.0	31%	43%
Non Energy	41.7	3%	77.3	7%	85%
Propane	3.3	0%	4.6	0%	40%
TOTAL	**1240.7**	**100%**	**1176.3**	**100%**	**-5%**

Total GHG emissions per capita (tCO2e)

2016	2050	% change, 2016-2050
18.8	13.4	-29%

Total energy consumption by sector (MMBTU, thousands)

Sector	2018	2018 Share	2050	2050 Share	% change 2018-2050
Commercial	3,563.2	30%	3,857.3	32%	8%
Industrial	1,151.9	10%	1,739.7	15%	51%
Municipal	406.5	3%	514.0	4%	26%
Residential	2,022.1	17%	2,377.1	20%	18%
Transportation	4,784.2	40%	3,413.7	29%	-29%
Total	**11927.9**	**100%**	**11901.8**	**100%**	**0%**

Total energy consumption by fuel type (MMBTU, thousands)

Fuel Type	2018	2018 Share	2050	2050 Share	% change 2018-2050
Diesel	967.6	8%	877.6	7%	-9%
District Energy (ISU)	1,597.4	13%	1,443.3	12%	-10%
Fuel Oil	26.4	0%	31.1	0%	18%
Gasoline	3,646.3	31%	1,720.9	14%	-53%
Grid Electricity	1,973.5	17%	3,279.1	28%	66%
Local Energy (Solar PV)	2.4	0%	4.3	0%	81%
Natural Gas	3,351.1	28%	4,136.8	35%	23%
Other	290.6	2%	306.4	3%	5%
Propane	53.9	0%	75.3	1%	40%
RNG	18.7	0%	27.0	0%	44%
Total	**11927.9**	**100%**	**11901.8**	**100%**	**0%**

Total energy consumption by end use (MMBTU, thousands)

End use	2018	2018 Share	2050	2050 Share	% change 2018-2050
Industrial Processes	883.9	7%	1,330.2	11%	50%
Lighting	250.9	2%	334.1	3%	33%
Major Appliances	209.3	2%	258.3	2%	23%
Plug Load	768.3	6%	965.2	8%	26%
Space Cooling	587.4	5%	755.9	6%	29%
Space Heating	3,416.8	29%	3,478.9	29%	2%
Transportation	4,784.2	40%	3,413.7	29%	-29%
Water Heating	1,027.1	9%	1,365.6	11%	33%
Total	**11927.9**	**100%**	**11901.8**	**100%**	**0%**

Total Energy Use Per Capita (MMBTU, thousands)

2018	2050	% change, 2018-2050
180.9	135.6	-33%

Sector Summary: Buildings Energy Use (MMBTU, thousands)

By End Use	2016	2016 Share	2050	2050 Share	% change 2016-2050
Industrial Processes	883.9	12%	1,330.2	16%	50%
Lighting	250.9	4%	334.1	4%	33%
Major Appliances	209.3	3%	258.3	3%	23%
Plug Load	768.3	11%	965.2	11%	26%
Space Cooling	587.4	8%	755.9	9%	29%
Space Heating	3,416.8	48%	3,478.9	41%	2%
Water Heating	1,027.1	14%	1,365.6	16%	33%
Total	**7,143.7**	**100%**	**8,488.1**	**100%**	**19%**

Sector Summary: Buildings Energy Use (MMBTU, thousands)

By Fuel Type	2018	2018 Share	2050	2050 Share	% change 2018-2050
District Energy (ISU)	1,597.4	22%	1,443.3	17%	-10%
Fuel Oil	26.4	0%	31.1	0%	18%
Grid Electricity	1,972.5	28%	2,587.1	30%	31%
Local Energy (Solar PV)	2.4	0%	4.3	0%	81%
Natural Gas	3,351.1	47%	4,136.8	49%	23%
Other	121.4	2%	183.3	2%	51%
Propane	53.9	1%	75.3	1%	40%
RNG	18.7	0%	27.0	0%	44%
Total	**7,143.7**	**100%**	**8,488.1**	**100%**	**19%**

Sector Summary: Buildings Energy Use (MMBTU, thousands)

By Sector	2018	2018 Share	2050	2050 Share	% change 2018-2050
Commercial	3,563.2	50%	3,857.3	45%	8%
Industrial	1,151.9	16%	1,739.7	20%	51%
Municipal	406.5	6%	514.0	6%	26%
Residential	2,022.1	28%	2,377.1	28%	18%
Total	**7,143.7**	**100%**	**8,488.1**	**100%**	**19%**

Sector Summary: Buildings Emissions (ktCO2e)

By End Use	2018	2018 Share	2050	2050 Share	% change 2018-2050
Industrial Processes	72.0	13%	89.3	15%	24%
Lighting	49.9	9%	47.6	8%	-5%
Major Appliances	38.2	7%	34.2	6%	-11%
Plug Load	146.4	25%	132.5	22%	-9%
Space Cooling	35.4	6%	41.1	7%	16%
Space Heating	170.8	30%	172.2	29%	1%
Water Heating	62.9	11%	78.0	13%	24%
Total	**576**	**100%**	**595**	**100%**	**3%**

Sector Summary: Buildings Emissions (ktCO2e)

By Fuel Type	2016	2016 Share	2050	2050 Share	% change 2016-2050
Fuel Oil	2.0	0%	2.3	0%	18%
Grid Electricity	392.7	68%	368.8	62%	-6%
Natural Gas	177.6	31%	219.2	37%	23%
Propane	3.3	1%	4.6	1%	40%
Total	**576**	**100%**	**595**	**100%**	**3%**

Sector Summary: Buildings Emissions (ktCO2e)

By Sector	2016	2016 Share	2050	2050 Share	% change 2016-2050
Commercial	229.0	40%	225.9	38%	-1%
Industrial	97.1	17%	122.0	21%	26%
Municipal	43.6	8%	45.4	8%	4%
Residential	205.8	36%	201.6	34%	-2%
Total	**575.5**	**100%**	**595.0**	**100%**	**3%**

Sector Summary: Transportation Energy Use (MMBTU, thousands)

By Vehicle Type	2018	2018 Share	2050	2050 Share	% change 2018-2050
Car	1,947.9	42%	891.1	27%	-54%
Heavy Truck	767.1	17%	736.9	22%	-4%
Light Truck	1,848.5	40%	1,611.2	49%	-13%
Urban Bus	51.4	1%	51.4	2%	0%
Total	**4,614.9**	**100%**	**3,290.6**	**100%**	**-29%**

Sector Summary: Transportation Energy Use (MMBTU, thousands)

By Fuel Type	2018	2018 Share	2050	2050 Share	% change 2018-2050
Diesel	967.6	21%	877.6	27%	-9%
Gas	3,646.3	79%	1,720.9	52%	-53%
Grid Electricity	1.0	0%	692.1	21%	68711%
Total	**4,614.9**	**100%**	**3,290.6**	**100%**	**-29%**

Sector Summary: Transportation Emissions (ktCO2e)

	2018	2018 Share	2050	2050 Share	% change 2018-2050
Car	137.8	42%	80.4	28%	-42%
Heavy Truck	56.6	17%	54.4	19%	-4%
Light Truck	130.8	40%	146.5	51%	12%
Urban Bus	3.8	1%	3.8	1%	0%
Total	**329.1**	**100%**	**285.2**	**100%**	**-13%**

Sector Summary: Transportation Emissions (ktCO2e)

	2018	2018 Share	2050	2050 Share	% change 2018-2050
Diesel	71.8	22%	65.2	23%	-9%
Gas	257.1	78%	121.3	43%	-53%
Grid Electricity	0.2	0%	98.7	35%	49176%
Total	**329.1**	**100%**	**285.2**	**100%**	**-13%**

Sector Summary: Waste GHG Emissions (ktCO2e)

	2018	2018 Share	2050	2050 Share	% change 2018-2050
Biological	0.0	0%	0.0	0%	33%
Landfill	36.7	100%	70.1	100%	91%
Wastewater	0.0	0%	0.0	0%	33%
Total	**36.7**	**100%**	**70.1**	**100%**	**191%**

SUSTAINABILITY SOLUTIONS GROUP

Ames Climate Action Plan and Target Setting

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.

CONTENTS

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

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.

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.

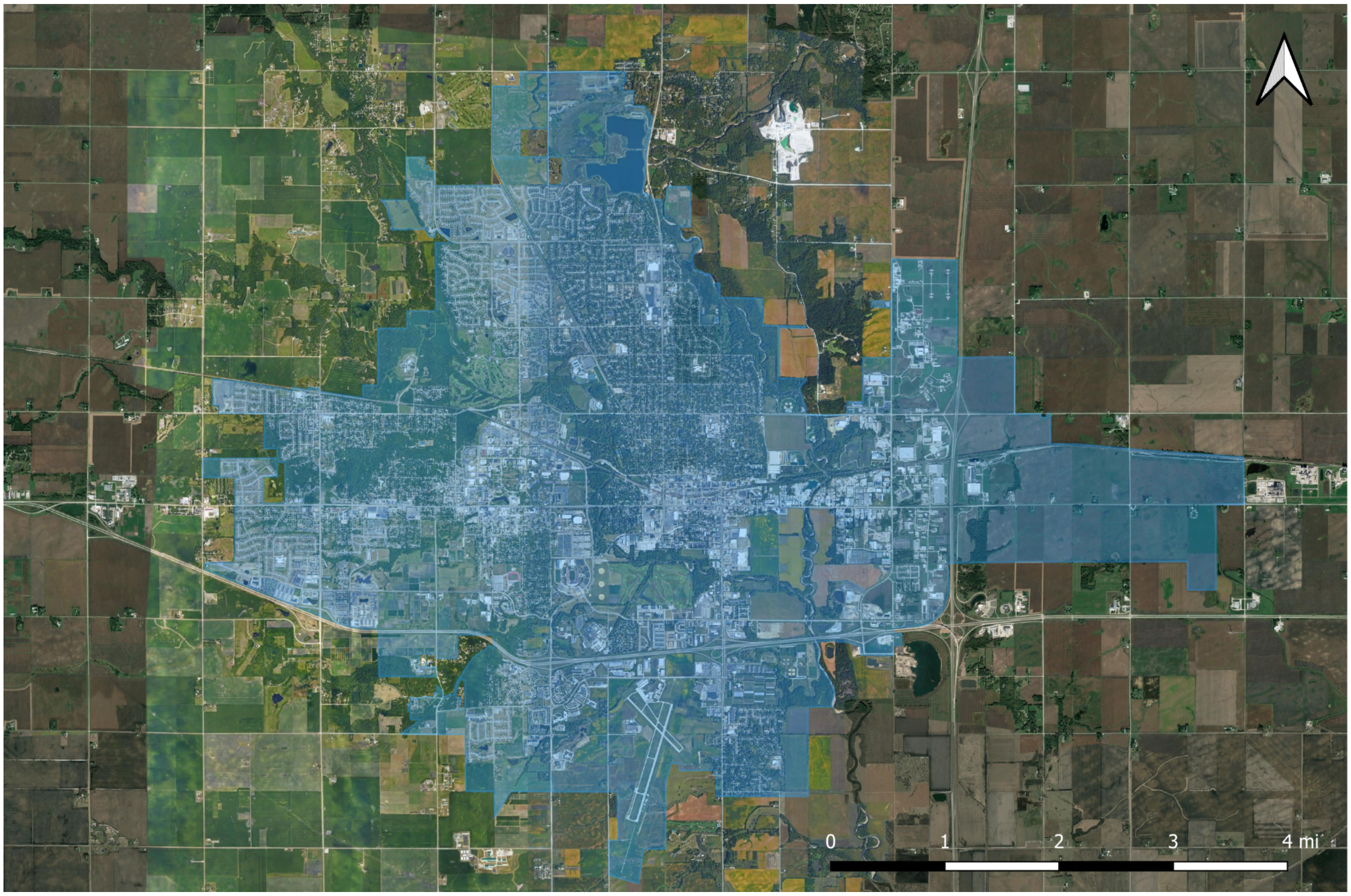

Figure 1. Current geographical boundary for Ames

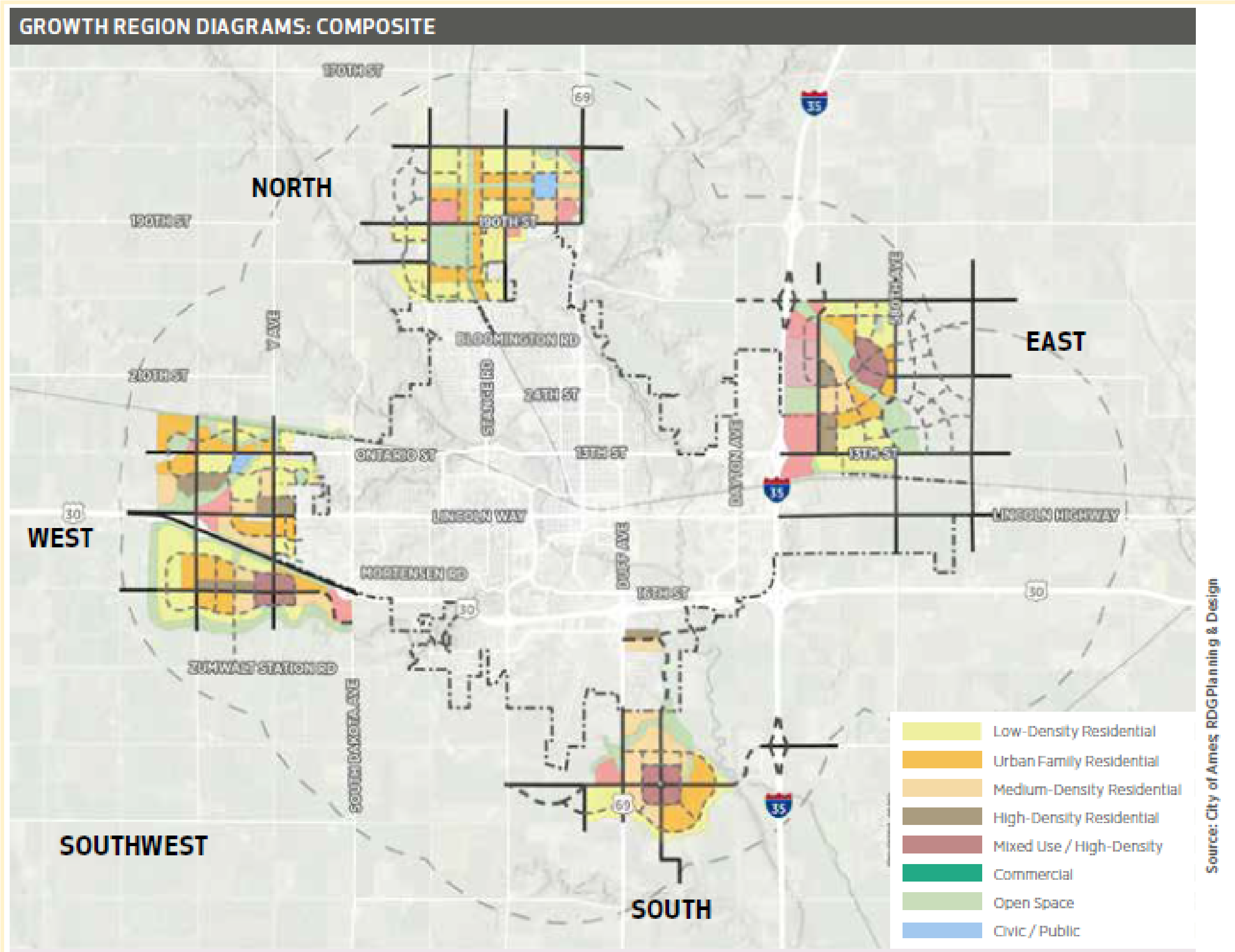

Figure 2. Future geographical boundary for Ames and land-use types in growth areas.

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.

Energy and Emissions Structure

The total energy for a community is defined as the sum of the energy from each of the 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.

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.

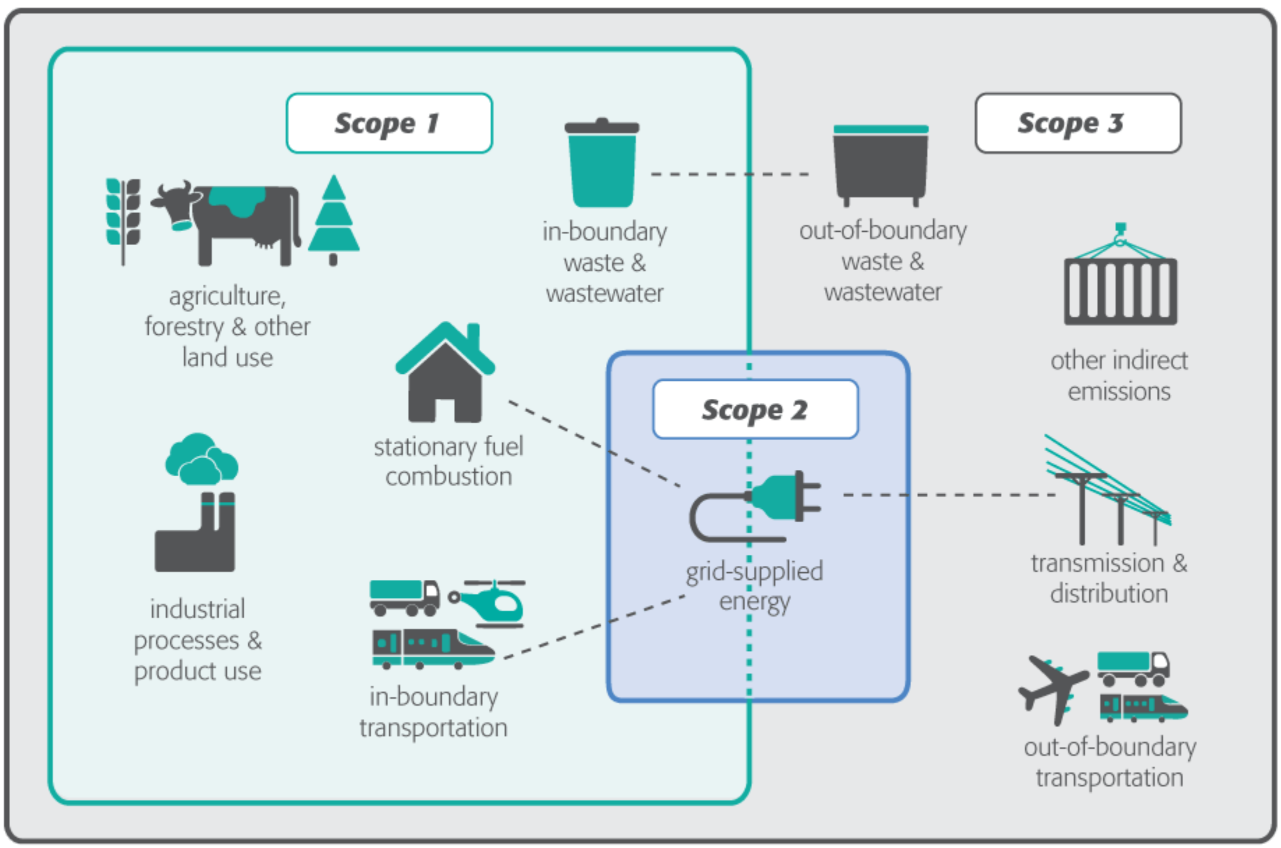

Figure 2. Diagram of GPC emissions scopes.

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, 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 technology 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 to 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 modelled 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.
GPC-compliant	The model is designed to report emissions according to the GHG Protocol for Cities (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.

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).

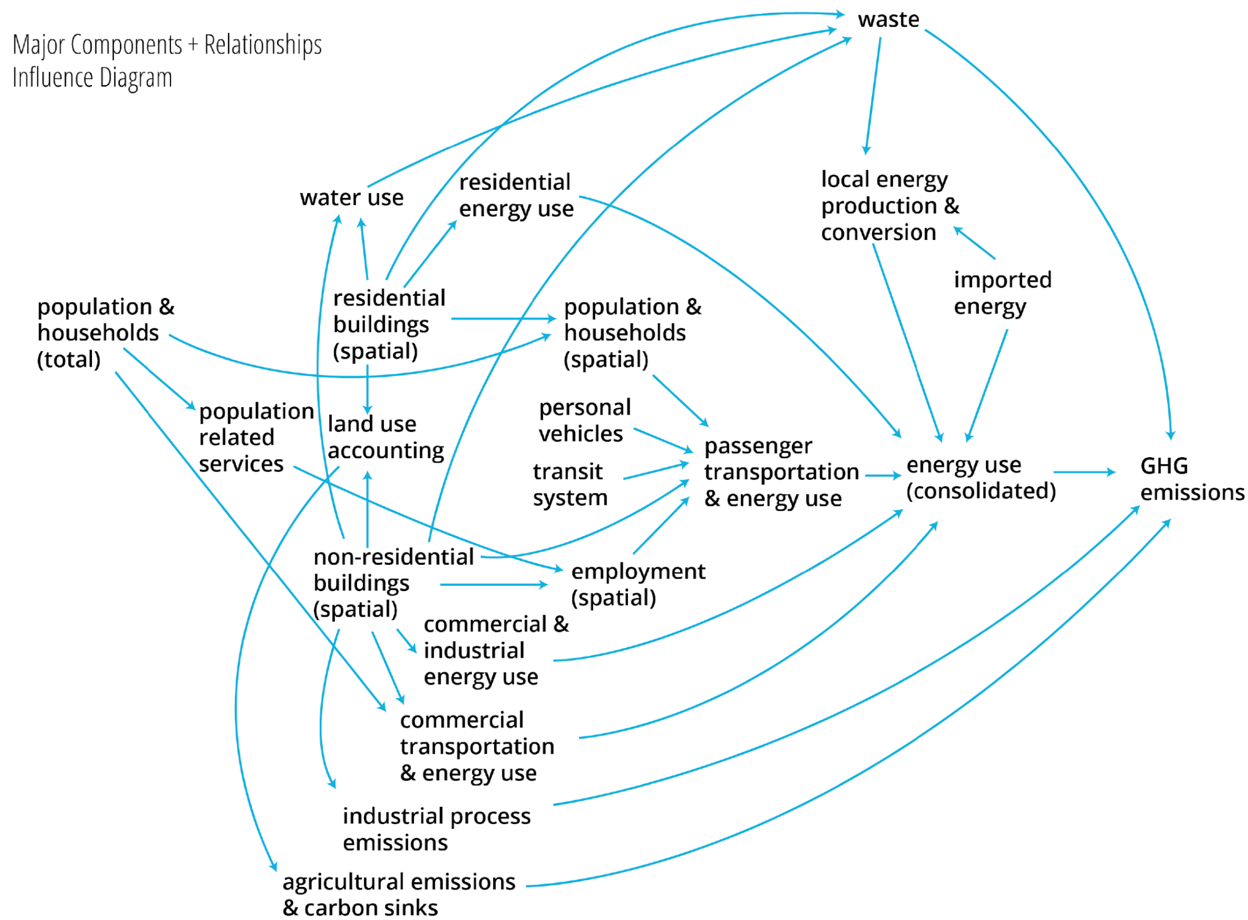

Figure 3. Representation of the CiS model structure.

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 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 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.

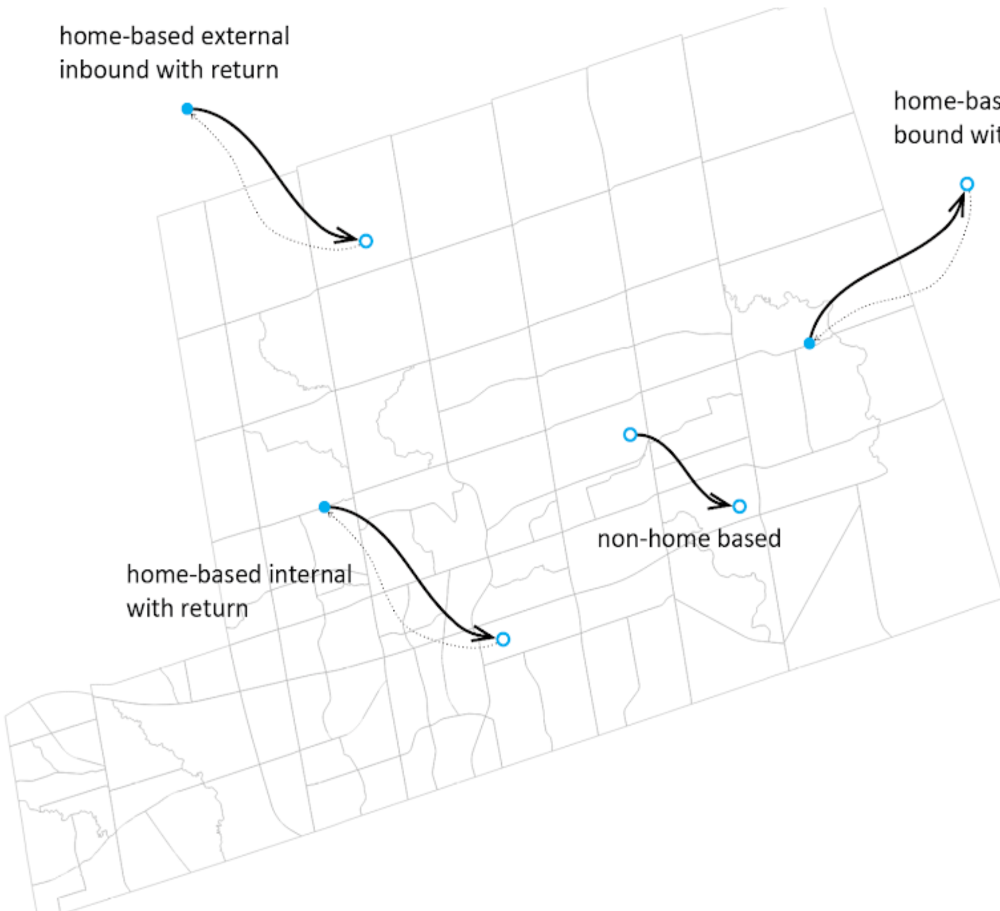

Figure 4. Conceptual diagram of trip categories.

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.

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.

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.

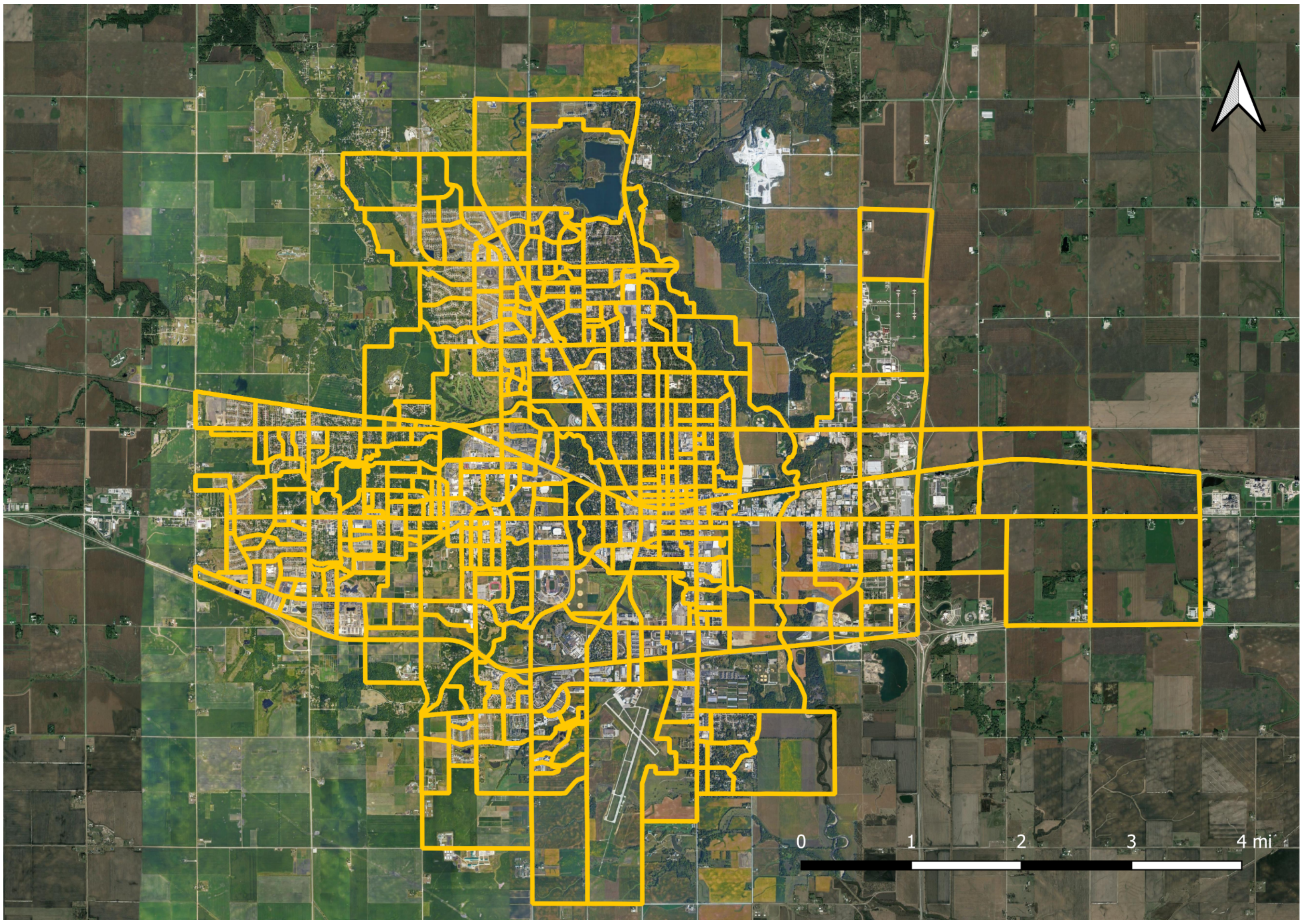

Figure 5. Zone system used in modelling.

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.

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 through:
    - 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; and
8. Develop a marginal abatement cost curve for the low-carbon scenario.

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 the use of '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 enabling policy-makers to understand the uncertainty intrinsic in a model.

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

Appendix 1: GPC Emissions Scope Table for Detailed Model

Green rows = Sources required for GPC BASIC inventory

Blue rows = Sources required GPC BASIC+ inventory

Red 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	
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
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
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.1.3	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 of 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 of 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 of 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	
TOTAL				

Appendix 2: Building Types in the model

Residential Building Types	Non-residential Building Types	
Single_detached_1Storey_tiny	college_university	commercial_retail
Single_detached_2Storey_tiny	school	commercial
Single_detached_3Storey_tiny	retirement_or_nursing_home	commercial_residential
Single_detached_1Storey_small	special_care_home	retail_residential
Single_detached_2Storey_small	hospital	warehouse_commercial
Single_detached_3Storey_small	municipal_building	warehouse
Single_detached_1Storey_medium	fire_station	religious_institution
Single_detached_2Storey_medium	penal_institution	surface_infrastructure
Single_detached_3Storey_medium	police_station	energy_utility
Single_detached_1Storey_large	military_base_or_camp	water_pumping_or_treatment_station
Single_detached_2Storey_large	transit_terminal_or_station	industrial_generic
Single_detached_3Storey_large	airport	food_processing_plants
Double_detached_1Storey_small	parking	textile_manufacturing_plants
Double_detached_2Storey_small	hotel_motel_inn	furniture_manufacturing_plants
Double_detached_3Storey_small	greenhouse	refineries_all_types
Double_detached_1Storey_large	greenspace	chemical_manufacturing_plants
Double_detached_2Storey_large	recreation	printing_and_publishing_plants
Double_detached_3Storey_large	community_centre	fabricated_metal_product_plants
Row_house_1Storey_small	golf_course	manufacturing_plants_miscellaneous
Row_house_2Storey_small	museums_art_gallery	_processing_plants
Row_house_3Storey_small	retail	asphalt_manufacturing_plants
Row_house_1Storey_large	vehicle_and_heavy_equiptment_service	concrete_manufacturing_plants
Row_house_2Storey_large	warehouse_retail	industrial_farm
Row_house_3Storey_large	restaurant	barn
Apartment_1To4Storey_small		
Apartment_1To4Storey_large		
Apartment_5To14Storey_small		
Apartment_5To14Storey_large		
Apartment_15To24Storey_small		
Apartment_15To24Storey_large		
Apartment_25AndUpStorey_small		
Apartment_25AndUpStorey_large		
inMultiUseBldg		

Appendix 3: 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 CO2e: 1,098 lbs CO2e 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
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 emissions: IPCC Guidelines Vol 5. Ch 3, Equation 3.1

	landfill methane and waste composition.	
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.

City of Ames Climate Action Plan (CAP) and Target-Setting

Briefing note: GHG reduction targets for consideration

November 2021

Issue

The City Steering Committee needs to establish a target for the Climate Action Plan to be developed. The first step in establishing this target is for the Steering Committee (SC) to understand the different target options and their implications in order to establish a target that best meets the needs of the Ames community.

Context

The City of Ames is responding to the climate emergency by setting a greenhouse gas (GHG) emissions reduction target and developing a Climate Action Plan (CAP). The CAP will provide a framework including a recommended pathway and set of doable actions for reaching Ames' greenhouse gas reduction target, once it has been set.

The process is both technical and community-based. The CAP planning process provides the opportunity for the community to rethink how homes and businesses are built and heated, how to move around the city, and how to reduce and manage waste. Input from stakeholders, including the public, is being sought as technical analysis is being conducted to understand Ames' current situation and opportunities to forge a new pathway.

At this point in the project, SSG, the consultant assisting the City in developing the CAP, has developed a business-as-usual (BAU) scenario. The BAU outlines a plausible scenario of energy use and greenhouse gas emissions in the community out to 2050 if new climate actions are not pursued. In this scenario, emissions in Ames are similar in 2018 and 2050.

With the BAU established, SSG has been tasked with proposing GHG emissions reduction targets for the City Steering Committee to consider. The targets proposed in this briefing draw on insights from best practices nationally and globally, the science-based guidance from the Global Covenant of Mayors, and targets from other similar-sized cities in the mid-west, from state governments, and from the federal government. Potential benefits and challenges relating to each target are in line with case studies and SSG's direct experience in other communities and. They also consider the results of the BAU scenario.

The targets are being shared with the SC at this time for consideration, and to provide an opportunity for questions. Following the project plan, the SC is scheduled to decide on a target after consultation with the Supplemental Input Committee and the public has occurred and the results from the engagements have been presented.

Background

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 around 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[1]. Many state and local governments have also set net-zero by 2050 targets, some with 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.

Discussion

This briefing explains net-zero by 2050 as a standard goal, and its alignment with the U.S. federal target, the UNFCCC Paris Agreement, and IPCC recommendations. It also details four pathways to reach net-zero.

The pathways to an emissions target can vary greatly (Figure 1) and the appropriate pathway for Ames is the subject of consideration for the SC. Different pathways result in much more (right figure) or much fewer (left figure) emissions being released overall between now and 2050. The amount of emissions released over the next thirty years is just as significant for staying within the 1.5°C to 2.0°C 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. At the same time, it is important for each local government to carefully consider the rate at which it can transition to a low carbon economy given the constraints in which it operates.

[1] Energy & Climate Intelligence Unit | Net Zero Tracker (eciu.net)

Figure 1. Emissions reductions pathways are associated with the timing of actions and setting interim targets.

This briefing proposes four potential pathways to net-zero for the Ames community. The pathways explored include:

- A science-based target (general)
- A science-based target using a carbon budge and fair share approach
- A target aligning with the United Sates' federal target
- An evidence-based target

This briefing discusses the associated 2050 and 2030 emissions reductions for each target, the source of the target, the background behind the target being described, and a brief analysis of the target from SSG's perspective with supporting evidence from other sources. This briefing also compares the targets, and their respective benefits and challenges.

Science-Based Target (General)

Target: 45% minimum reduction in greenhouse emissions from 2005 levels by 2030, and net-zero emissions by 2050.

Target Source: The Intergovernmental Panel on Climate Change (IPCC), in their 2018 report *Global Warming of 1.5°C, "*an IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global GHG emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty[2]."

Background: In 2018, the IPCC released a report with analysis showing that in order for the world to meet the targets set out in the UNFCCC Paris Agreement, every jurisdiction in the world would need to decrease greenhouse gas emissions by 45% over 2005 levels by 2030, and be at net-zero emissions at or before 2050. This is based on earlier IPCC work that states that the world must stay within 1.5°C to 2°C of warming above pre-industrial levels to avoid the most catastrophic global impacts of climate change. The earlier work of the IPCC is referenced in the Paris Agreement, which calls for signatory nations to create plans that will reach net-zero emissions by 2050 and limit global warming to 1.5°C to 2°C by calculating a nationally determined contribution (NDC) to identify the country's interim (2030) emissions reduction target.

Analysis: This target is ambitious and the minimum the IPCC calls for in order to, with moderate confidence, keep global warming within the threshold of 1.5°C above pre-industrial levels. As more recent research points out, however, this method does not account for global equity concerns including the responsibility of wealthier nations and their local governments to act faster to decrease emissions, allowing developing nations more time to develop and build the capacity to decarbonize. More recent reports also raise concerns that emissions need to begin to trend downward now to reach the 1.5°C rather than putting off action to reach the interim and end goals just in time.

It must be made clear though that even a 45% reduction, between now and 2030 will require transformational and systems-level change in the way that local government, businesses, community members, institutions, other levels of government, and energy suppliers make decisions and behave.

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[2] IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global GHG emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia,

Science-Based Target: Carbon Budget & Fair Share Approach

Target: 83% reduction in greenhouse emissions from 2018 levels by 2030, and net-zero emissions by 2050.

Target Source: The C40 Cities Climate Leadership Group, made up of 97 cities around the world that represents one-twelfth of the world's population and one-quarter of the global economy and focused on addressing climate change through urban action[3].

Background: The C40 Cities Climate Leadership Group has developed the methodology used for setting the carbon budget. Along with general emissions per capita information, the methodology takes into consideration factors such as how much GHG emissions should be allocated to countries with high levels of poverty versus wealthy countries. This is referred to as a 'fair-share approach'. In order to achieve a fair-share science-based target, cities are encouraged to create a carbon budget outlining the fair share of carbon emissions they can emit before they hit net-zero emissions and the amount they can emit each year before hitting their target. Cities can then plan for the actions that will help them achieve their carbon budget.

According to the Science-Based Targets Network, "Equity is a consideration in all recommended methodologies when calculating a city's carbon budget. Carbon budgets are a simplified measurement of the additional emissions that a city or country can still emit if the world is to limit global heating to 1.5 °C. The carbon budget of a city or country will vary based on the following factors:

1. **Responsibility:** GHG emissions, particularly CO2 emissions, accumulate in the atmosphere over time. Many industrialized countries have been the source of dangerous carbon emissions for the past 200 years. These past emissions are termed historical emissions. Other countries are still developing their economies and are permitted to peak their emissions later. These are called late emissions. Carbon budgets take into account historical emissions and late emissions, tasking those countries and cities who are most responsible for global CO2 accumulation with reducing their emissions.
2. **Capacity:** it is acknowledged that different cities and countries have varied capacities to respond to the challenge of climate change based on their respective levels of socio-economic development.
3. **Inter-generational justice**: present generations have certain duties towards future generations, in terms of decreasing climate change risks, increasing the availability of natural resources and the health of the planet's ecosystems.[4]"

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[3] C40

[4] Science Based Targets Network. November 2020. Science-Based Climate Targets: A Guide for Cities, 15p.

Analysis: Science-based targets using a carbon budget and equity approach are considered the current best practice for target setting and are now recommended by the world's leading climate organizations, including C40, CDP, Global Covenant of Mayors, ICLEI, World Wildlife Fund, and the World Resources Institute. These targets are also among the most aggressive emissions reductions targets. If every jurisdiction across the world were to adopt this target and implement it, the world has the best chance of staying within the 1.5 °C threshold while, arguably, realizing equity and co-benefits to climate action. Implementation requires swift action including capital investments, coordination at multiple levels of government and with other stakeholders, and social and behavioral changes at multiple scales, making this target very challenging to achieve.

Alignment with Federal Target

Target: 50-52% reduction in greenhouse emissions from 2005 levels by 2030, and net-zero emissions by 2050.

Target Source: This target is in line with the United States' federal emissions reduction target announced in April 2021. The target is based on the United States' Nationally Determined Contribution in line with Article 4 of the Paris Agreement.

Background: Nationally Determined Contributions (NDCs) are non-binding national plans that communicate a nation's intended climate target and the climate policies and actions the government intends to implement to reach their stated target. An NDC is established independently by the contributing country and must be based on:

- Climate neutrality by 2050
- Limiting global warming to well below 2 °C and pursuing efforts to limit it to 1.5 °C
- Reducing emissions of greenhouse gases (GHGs) from an established baseline
- Increasing adaptation to the harmful effects of climate change
- Adjusting financial flows to align with reducing GHG emissions

The United States only recently rejoined the Paris Agreement and developed a new NDC. Policies and actions the current administration has outlined to reach their target include:

- 100% carbon-free electricity by 2035
- Supporting energy efficiency upgrades and electrification in buildings
  - A job-creating retrofit program
  - Sustainable affordable housing
  - Wider use of heat pumps and induction stoves
  - Adoption of modern building codes for buildings
- Reducing carbon pollution from the transportation sector
  - 50% of personal and light-duty vehicles sales are electric by 2035
- Industry decarbonization
  - Research, development, demonstration, commercialization, and deployment of very low-carbon and zero-carbon industrial processes and products.
  - Incentivizing carbon capture
  - Incentivizing new sources of hydrogen produced from renewable energy, nuclear energy, or waste
- Agriculture decarbonization and land management
  - Supporting scaling of climate-smart agricultural practices including reforestation, rotational grazing, and nutrient management practices
  - Investing in forest protection and forest management
  - Supporting nature-based solutions and sequestration in waterways through blue carbon

Analysis: Aligning with the federal target requires a 5%-7% greater decrease in emissions by 2030 compared to a general science-based target and signifies an increase in effort at the local level. However, if the measures identified at the federal level are implemented this should ease the burden on local government to act, regardless of the interim target chosen at the local level. In fact, policies identified at the federal level to achieve the United States' NDC, including 100% carbon-free electricity by 2030 could significantly decrease the burden on all local governments. As we have seen in the past, however, not all targets are achieved at the national level and changes in administration can disrupt climate action, so it is critical that local governments continue to pursue action at the local level and collaborate with higher orders of government and other local governments.

According to an analysis of the new federal target, full implementation would see emissions in the United States drop to a level that limits global warming to 2 °C (if all countries were to adopt a similar goal) but would not reach the ideal 1.5 °C limit. The U.S. target does not take into account a fair share target[5].

[5] USA | Climate Action Tracker

Evidence-Based Target

Target: Greenhouse emissions reductions by 2030 to be determined through modeling using a bottom-up approach, and net-zero emissions by 2050.

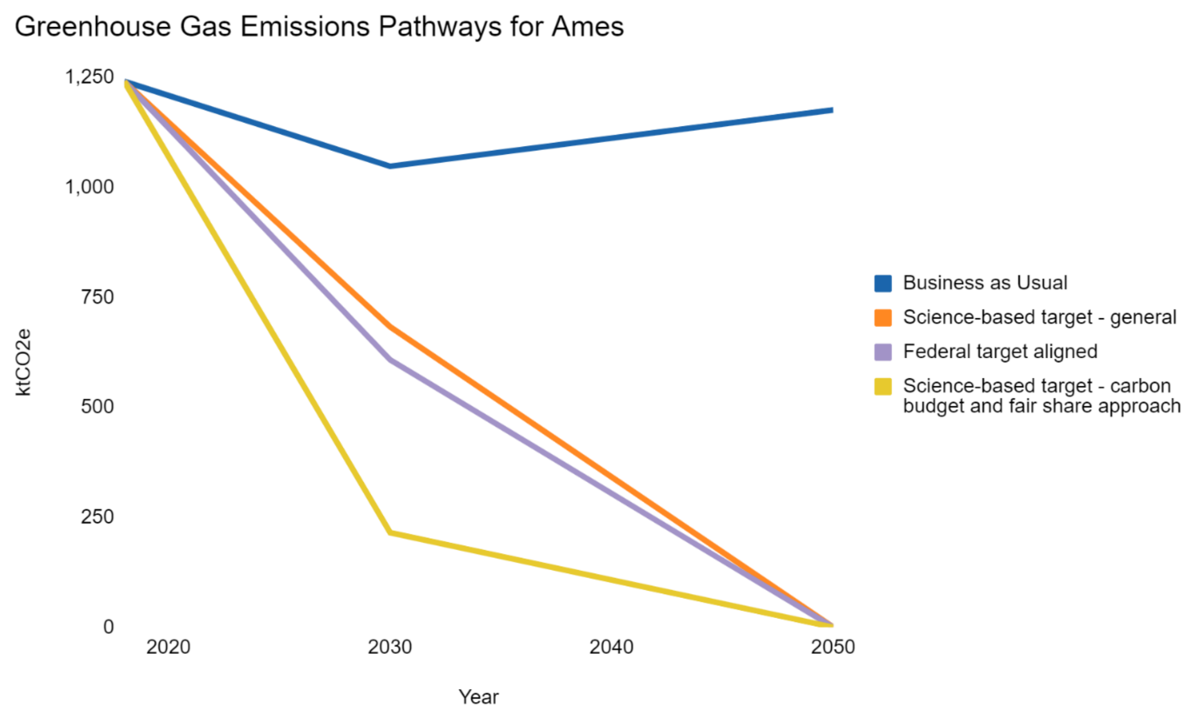
Target Source: This target is a hybrid of a science-based target approach and a bottom-up approach to identifying a target.

Background: Evidence-based targets are sometimes used when a community recognizes the need to implement a science-based approach based on best practices (option two in this briefing) but has legitimate concerns about its ability to reach the target due to the local conditions and constraints the community faces. Local conditions and constraints that cause significant concern around reaching an interim target may include the financial and economic situation of the City, significant industry presence in the community which the City and its residents have little agency to influence, and/or a lack of commitment from higher orders of government that control energy assets used by the community. During the modeling process, the consulting team may find additional constraints relating to the feasibility of decarbonization in all sectors. In this situation, a community may choose to recognize the need for a science-based target while stating what is within their agency to achieve, and committing to working towards changing conditions to realize a science-based target or get closer to it.

Analysis: This approach likely does not meet the threshold for a science-based target as defined by the IPCC, the Science-Based Reporting Network, or emissions reporting bodies, including the Global Covenant of Mayors. It is a pragmatic and conservative approach rooted in the realities of local constraints, and can still include aggressive and transformative action at the local level. Setting this target should still recognize the need to work towards changing conditions and best practices. A community establishing an evidence-based target should be prepared to exercise adaptive management and reassess the target over time as conditions change. In other words, a community choosing this type of target should still put actions in motion and identify a pathway to get as much done as quickly as possible but set the race to the carbon budget and science-based target aside while it works on addressing systemic constraints, rather than simply waiting for changes by others.

Comparing Target Approaches

Other than continuing with the business-as-usual scenario, all targets outlined result in net-zero emissions by 2050. As presented in the table below, the pathways to get there can differ greatly. A general science-based target and aligning with the federal target have similar trajectories, with emissions in the 600-700 ktCo2e range by 2030. Note that the 2030 reductions for the general science-based target and aligning with the federal target are currently based on reductions from 2018, and SSG would conduct a comprehensive analysis of the 2030 target based on the 2005 baseline if one of these targets is selected. The current projections should be treated as estimates. The science-based target using a carbon budget and fair share approach reduces emissions much sooner, to around 215 ktCO2e by 2030. An evidence-based trajectory is not included in the chart because a trajectory is not clear until the scenario is built from the bottom-up.



Each of the targets and pathways is also subject to some benefits and challenges. The table below summarizes some of these but the lists are not exhaustive.

	Benefits	Challenges
Science-based target	• Aligned with the UNFCCC Paris Agreement • Aligned with the 2018 IPCC recommendations • Similar target to many other jurisdictions (local and national) which may create synergies, peer exchange, and reduce legislative issues and resistance • Avoids some costly infrastructure lock-in • Has potential to realize co-benefits at a local level- clean air, connected community	• Does not address global equity concerns • Does not align with the most recent evidence for requirements for staying within the 1.5°C threshold • Challenging systems-level changes required • Extensive behavior change required • Ongoing political will required • Some costly infrastructure lock-in will occur • Significant up-front capital costs
Science-based target using a carbon budget and fair-share approach	• Aligned with the UNFCCC Paris Agreement • Aligned with the 2018 IPCC recommendations for limiting warming to 1.5 °C • Aligns with the Science-Based Target Network's recommendations for cities • Avoids costly infrastructure lock-in • Maximizes co-benefits - equity, cleaner air, more connected communities • Has potential to realize co-benefits at a local level sooner	• Significant up-front capital costs • Challenging systems-level changes required • Extensive behavior change required • Ongoing political will required • Potential for resistance due to quick, transformative changes
Aligning with the United Sates' federal target	• Aligned with the UNFCCC Paris Agreement • Aligned with the 2018 IPCC recommendations • Similar target to many other jurisdictions (local and national) which may create synergies, peer exchange, and reduce	• Does not address global equity concerns • Does not align with the most recent evidence for requirements for staying within the 1.5°C threshold • Challenging systems-level changes required • Extensive behavior change required

	legislative issues and resistance ● Avoids some costly infrastructure lock-in	● Ongoing political will required ● Some costly infrastructure lock-in will occur ● Significant up-front capital costs
Evidence-based approach	● Provides the local government with the ability to focus on what it controls rather than spending time and energy on levers it cannot control ● The plan may be viewed as more localized and decrease resistance or skepticism	● May not meet the threshold for the UNFCCC Paris agreement ● May not be science-aligned ● Does not address global equity concerns ● Does not align with the most recent evidence for requirements for staying within the 1.5°C threshold ● Challenging systems-level changes required ● Extensive behavior change required ● Ongoing political will required ● Some costly infrastructure lock-in will occur ● Can create a discourse of changes being someone else's problem

Summary and Next Steps

The City Steering Committee has been presented with four targets options to consider. The recommendation on the City project team and the consulting team is for stakeholder engagement on the targets with the Supplemental Input Committee and the public to continue as planned, and for the SC to hear a summary of the stakeholder feedback before selecting a target during the next SC meeting on December 21st, 2021.

SUSTAINABILITY SOLUTIONS GROUP

City of Ames Climate Action Plan and Target-Setting

Backgrounder: Carbon budgets

November 2021

Introduction

In order to prevent dangerous levels of climate change, scientists have quantified the total greenhouse gas emissions that can be emitted in order to limit the temperature increases.

In 2017, C40 published a report titled *Deadline 2020: How cities will get the job done*. The report assessed the contribution of the C40 cities to COP21 Paris Agreement's aspirations of limiting climate change to 1.5°C and 2°C degrees respectively. Specific greenhouse gas (GHG) emissions reduction trajectories were identified for each of the C40 cities, as well as potential actions to achieve those trajectories. The report concluded that the next four years will determine whether or not the world's megacities can achieve the reductions required to be consistent with the Paris Agreement. Since that report, other cities around the world have adopted C40's approach to determining a carbon budget to determine their emissions reduction trajectories required to limit warming to 1.5°C.

Carbon budget Overview

A carbon budget can be defined as the maximum amount of greenhouse gases that can be emitted worldwide without increasing the global average temperature by more than 1.5° Celsius. Using carbon budgets as a decision-making tool for managing greenhouse gas (GHG) emissions was pioneered by the City of Oslo[1] It has some key features worth noting:

[1] City of Oslo, "Climate Budget 2019," 2019 [Online]. Available: https://www.klimaoslo.no/wp-content/uploads/sites/88/2019/03/Climate-Budget-2019.pdf. [Accessed: 17-Apr-2019]

- Annual targets can be derived from the pathway identified by the carbon budget for five- or ten-year periods.
- Like a financial budget, the carbon budget provides an accountability framework for achieving the organization's objectives
- A carbon budget provides an overarching framework for GHG emissions management, extending over multiple years and over all aspects of community social and economic activity.
- When combined with effective emissions monitoring, the carbon budget also provides a framework for reporting progress on a consistent basis from year-to-year, while ensuring transparency and the feedback needed to make periodic adjustments to the budget.

The latest science indicates that in order to restrict warming to less than 2°C, total CO2 emissions from all anthropogenic sources since 1870 likely need to be limited to about 2,900 GtCO2, and approximately 1,900 GtCO2 had been emitted by 2011, leaving approximately 1,000 GtCO2, assuming a 66% degree of confidence.[2] Restricting GHG emissions to 1.5° implies an even more strict budget of 400 GtCO2 as of 2016.[3] With emissions since 2016, this puts the carbon budget under 200 GtCO2 in 2021.

C40's Approach to Carbon Budgeting

C40 is a group of the largest cities in the world that recognize their influence over a large portion of the world's population and economies. They share their practices widely and aspire to influence the remaining cities and national governments across the world. The approach used to calculate a carbon budget is applicable to any city and can place the community on an aggressive pathway to limiting climate change.

In its *Deadline 2020* report, C40 used a three-step approach to identify carbon budgets for its targeted cities:

1. Determine the global carbon budget for safe levels of warming of below 1.5°C and 2°C;
2. Identify an approach to allocate a fair portion of this budget to the C40 cities with global equity concerns taken into consideration; and

[2] Allen, M. R., Barros, V. R., Broome, J., Cramer, W., Christ, R., Church, J. A., ... & Edenhofer, O. (2014). IPCC fifth assessment synthesis report-climate change 2014 synthesis report.
[3] Carbon countdown (2016). Carbon Brief. Analysis: Only five years left before 1.5C carbon budget is blown. Retrieved from: https://www.carbonbrief.org/analysis-only-five-years-left-before-one-point-five-c-budget-is-blown

3. Calculate the resulting total C40 carbon budget using the chosen approach in step 2 and the relevant carbon budgets in step 1.

Under step 1, member cities in C40 were allocated a collective budget of 22 GtCO2e to meet the 1.5 degree Celsius limit and 67 GtCO2e for the 2 degree Celsius between 2016 and 2100. All other cities were given a limit of 307 GtCO2e in the 2 degree scenario, and 97 GtCO2e in the 1.5 degree scenario as shown in figure 2 below. C40 used the global carbon budgets with a 66% degree of confidence of limiting global temperature rises to 1.5 and 2 degrees Celsius respectively.

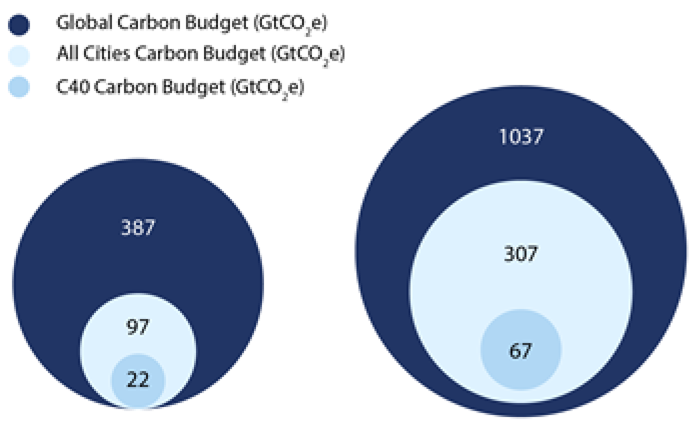


Figure 30: Global Carbon Budgets under the 1.5 degrees Celsius Scenario (Left) and 2 degrees Celsius scenario (Right)[4]

For step 2, C40 selected the year of 2030 where member cities need to achieve 2.9 tonnes of carbon dioxide equivalent (tCO2e) per capita, to be consistent with a 1.5 degrees Celsius pathway.[5] By 2050, the selected cities are required to reach 0.9 tCO2e.

This same methodology can be extrapolated to determine the carbon budget for other cities.

[4] Deadline 2020 (2017) C40 Cities. Retrieved from: https://www.c40.org/researches/deadline-2020

[5] For the selected C40 cities, 3.2 tCO2e per capita is approximately half of the current global per capita emissions.

City of Ames

Climate Action Plan + Target Setting

City Steering Committee: Target Setting Overview

Nov. 16, 2021—6:00-8:00 PM

Meeting Objectives

- **To inform** Steering Committee members about:
  - Business-as-usual (BAU) results;
  - Engagement outputs to date; and
  - Target options developed by SSG.
- **To consult** Steering Committee members about their questions, comments, and concerns today regarding the BAU results, engagement outputs, and target options.

Reminder

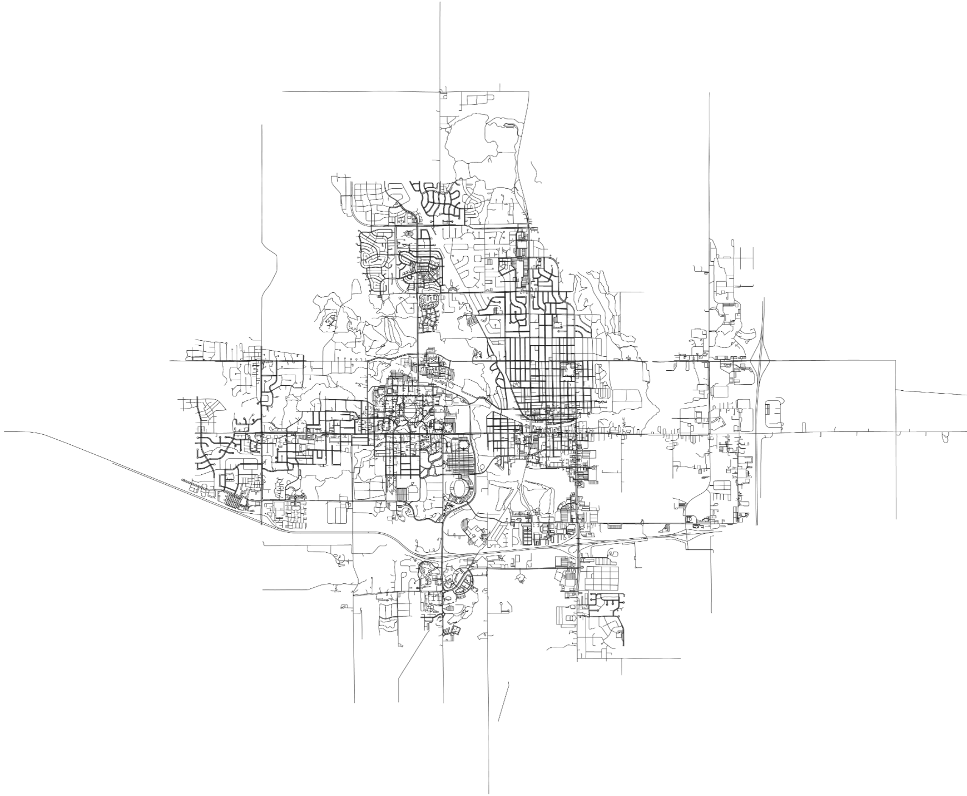
- This evening is about sharing information, asking questions and providing feedback

- We will share how we would like to engage the community between this evening and the next SC meeting

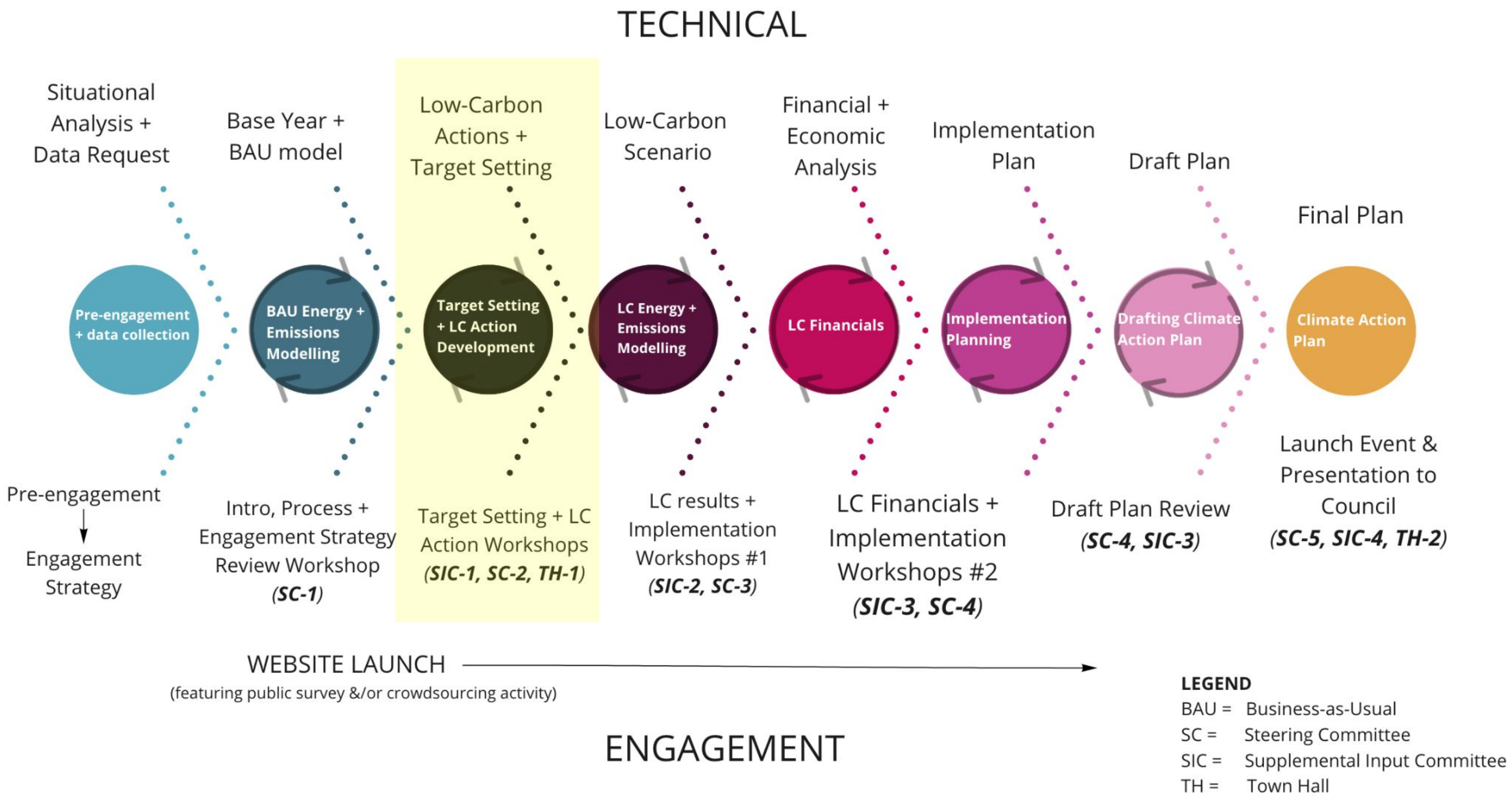
- At the next SC meeting, we encourage you to set a target

Meeting Agenda

- Introduction
- Engagement Update + Q&A
- Business-as-usual results + Q&A
- Target Setting Overview + Q&A
- Wrap-Up & Next Steps



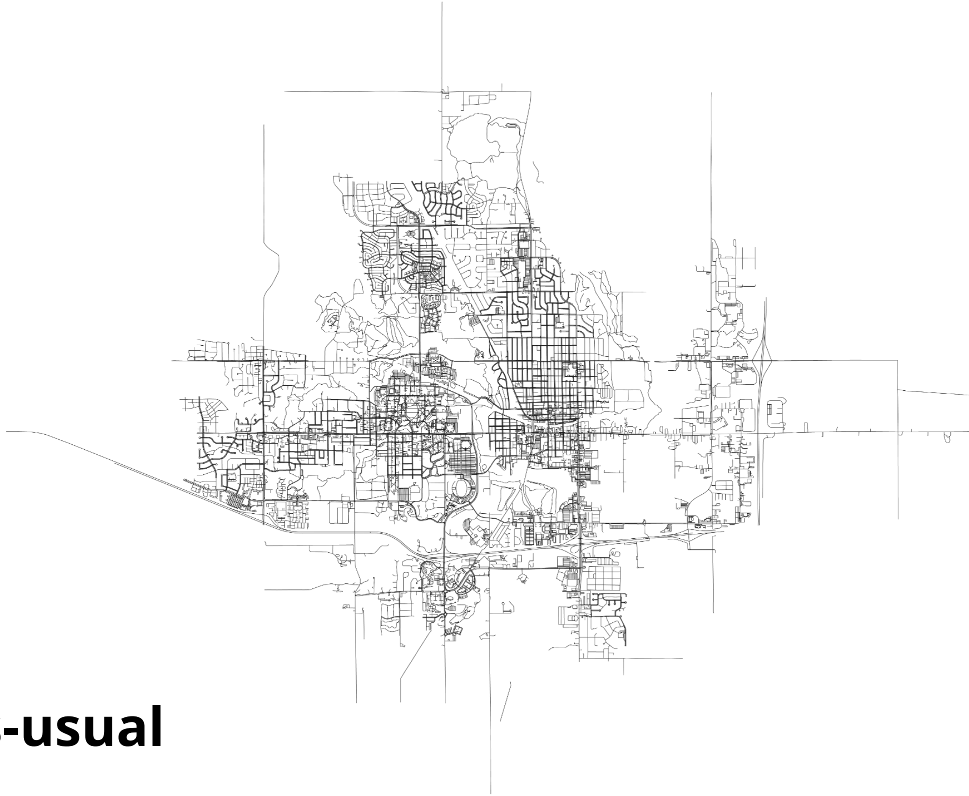
Project Overview



Engagement Update

Engagement Summary to Date

- Website launched
- Community visioning exercise
- Supplemental Input Committee
- Town Hall



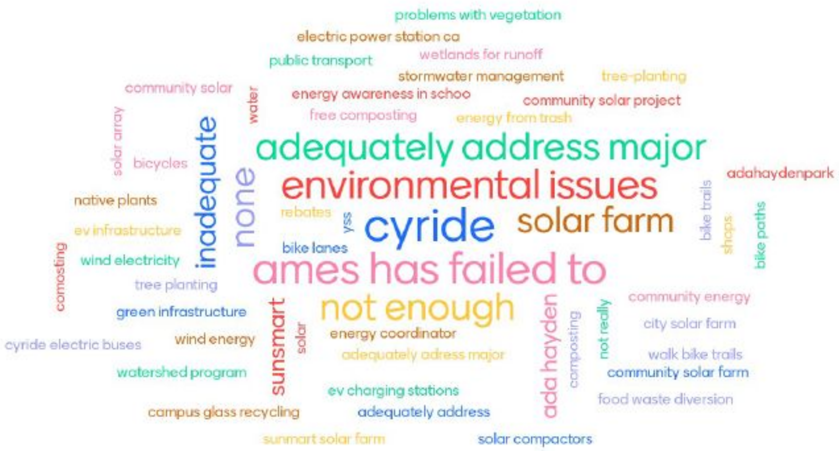
Project launch and business-as-usual phase (information-sharing)

What makes Ames a great place to live?

1. Sense of community
2. Parks & nature
3. Services
4. Safety
5. ISU + education

Are there any environmental initiatives in Ames that you think have been really successful?

1. Renewables
2. Transit
3. Parks, trees & nature
4. Waste diversion
5. Not enough



Are there other problem-solving examples in Ames that have been really effective?

1. Renewables
2. EV infrastructure
3. Transit
4. Food at First
5. Parks (Miracle Park, Ada Hayden)

Are there climate action examples in other jurisdictions that you find inspirational?

1. Iowa City
2. Des Moines
3. Illinois
4. Boulder, CO
5. Europe

Copenhagen 100% carbon neutral by 2025Amsterdam prioritizes pedestrians over cars

Iowa City climate action

California citiesOberlin

Boston- include climate adaption plans ar neighborhood level

Illinois - nation's leading climate bill (is shutting down working coal plants)

There are goals but very few have implemented effective policy to support infrastructure. Ames is living in the dark ages compared to many places in and outside the US

IL, DSM, Boulder CO, CA, GA, AZ, TX, GWU, Rockford IL, rural electric coops

IL, DSM, Boulder CO, CA, GA, AZ, TX, GWU, Rockford IL, rural electric coops

Boulder Colorado

Decorah, IowaAnn Arbor, MIFort Collins, COBoulder, CODuluth, MN

Rural Iowa, gardening increasing in Iowa communities,

Austin tx

Iowa city

Other countries , Europe, norway

IL, DSM, Boulder CO, CA, GA, AZ, TX, George Washington University, Rockford IL, & rural co-ops

This isn't necessarily climate action, more water quality focused, but the whole Des Moines area has great watershed scale projects that involve a lot of innovative partnerships and new ways to get conservation on the ground.

IL, DSM, BOULDER, CA, GA, ROCKFORD

Decorah

In considering opportunities to transition to a low carbon future, what gives Ames a unique advantage in tackling this issue?

1. Expertise & education
2. Community involvement
3. Students & young people
4. Availability of clean energy
5. ISU

Nearby wind energy, solar farm opportunities. Established transportation network.

Our public power system, university expertise

Lots of renewable resources in the form of solar and wind

Local expertise at ISU

Education. Relatively wealthy.

Renewable energylocal expertiseISU research

NREL

We have many highly educated and concerned people

Research and expertise from ISU

Open minded population, educated

If there were no constraints, what is the first thing you would want to see happen in Ames to tackle the issues of climate change?

1. Increase renewables
2. Lower transportation emissions
3. Increase waste diversion
4. Net-zero by 2030
5. City design and zoning

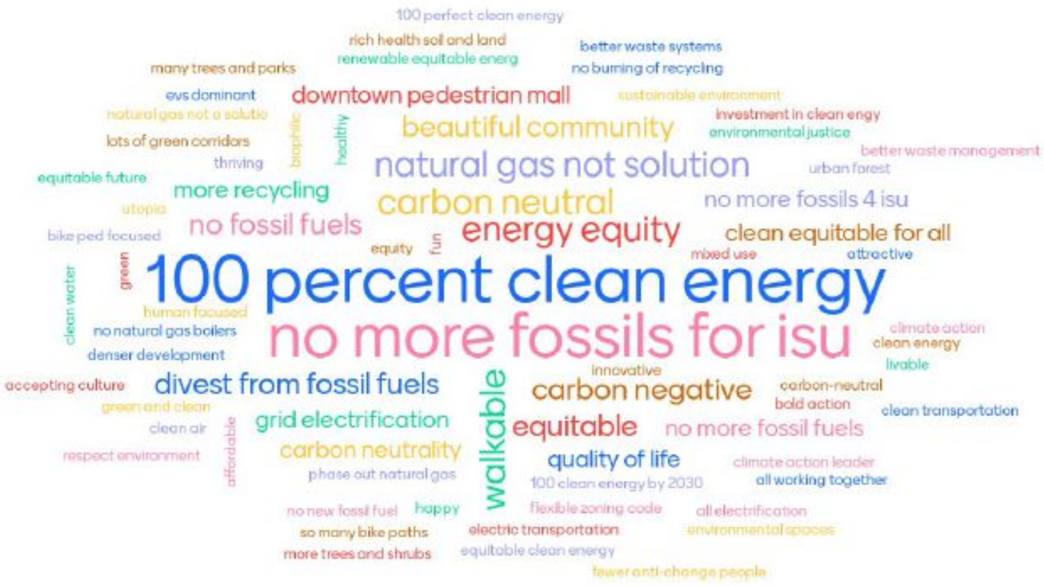
What are your desired outcomes from this plan?

1. 100% clean energy
2. Net-zero by 2030
3. Implementation

- 100% clean energy and carbon neutrality by 2030
- 100% clean energy by 2030, carbon neutrality as soon as possible
- huge drop in emissions
- Long-term sustainability for the City; net zero GHG emissions.
- 100 percent clean energy by 2030
- 100 percent clean energy by 2030 & electrified public transit
- 100% renewable energy by 2030. Stop the transition from coal to natural gas at isu
- Carbon neutrality by 2030, 100% renewal by 2030
- Quality of life. Carbon negative.
- 100% renewable and net carbon neutral by 2030
- Vibrant, attractive, resilient, inclusive, equitable, healthy and thriving community.
- 100 clean energy 2030 , carbon negative, fossil fuel divestment, renewable energy
- An aggressive plan that takes advantage of the advantages that Ames has: Wind power, solar, innovation, biofuels, parklands: 100% clean by 2030.
- 100 percent clean energy by 2030
- An equitable transition to 100% renewable energy and divestment from fossil fuels. Electrification using renewables.
- The city of Ames embarks on an ambitious plan for clean energy. 100% clean by 2030.
- Both to achieve 100% clean energy by 2030 and to inspire other communities to do the same.
- that we are a clean energy example for the state and world by 2030

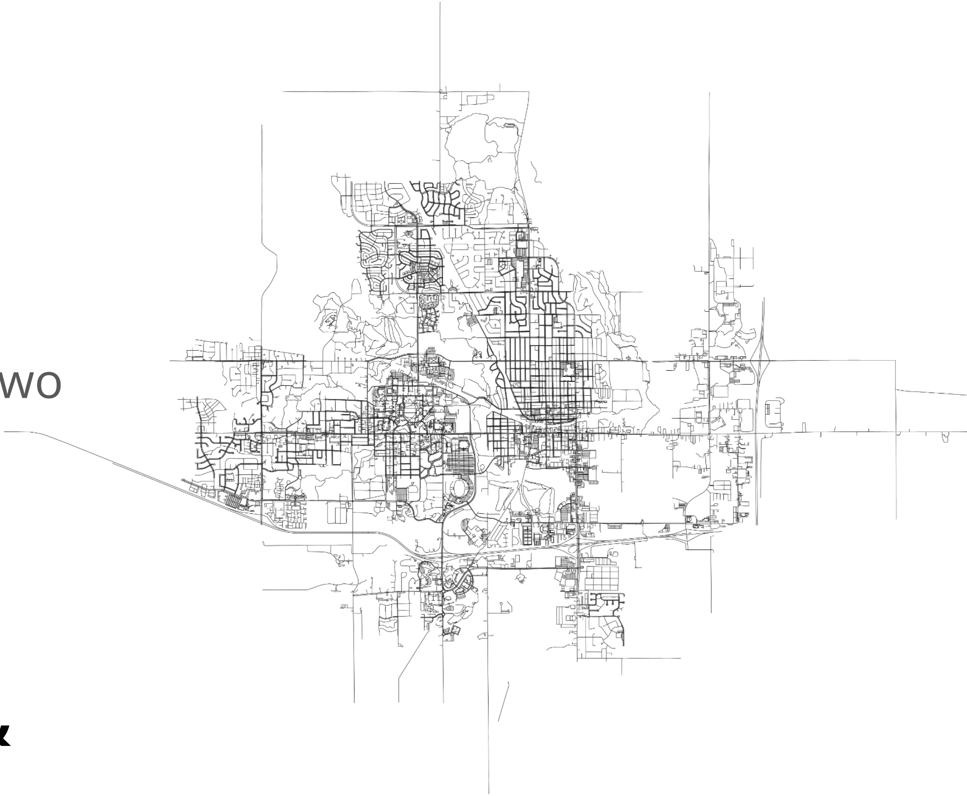
When the plan is complete what do you want the community to look like?

1. Sustainable
2. Green
3. Equitable



Upcoming Engagement

- Community survey
- Supplemental Input Committee outreach support
- Supplemental Input Committee Two
- Ongoing website updates



Target-setting phase (consult & involve)

Engagement

Q+A

Business-as-Usual Results

Business-as-Usual Scenario

Data and Information

Data from city and other trusted sources

Policies and plans approved and/or underway

+

Assumptions

Analysis and interpretation of data and information

→

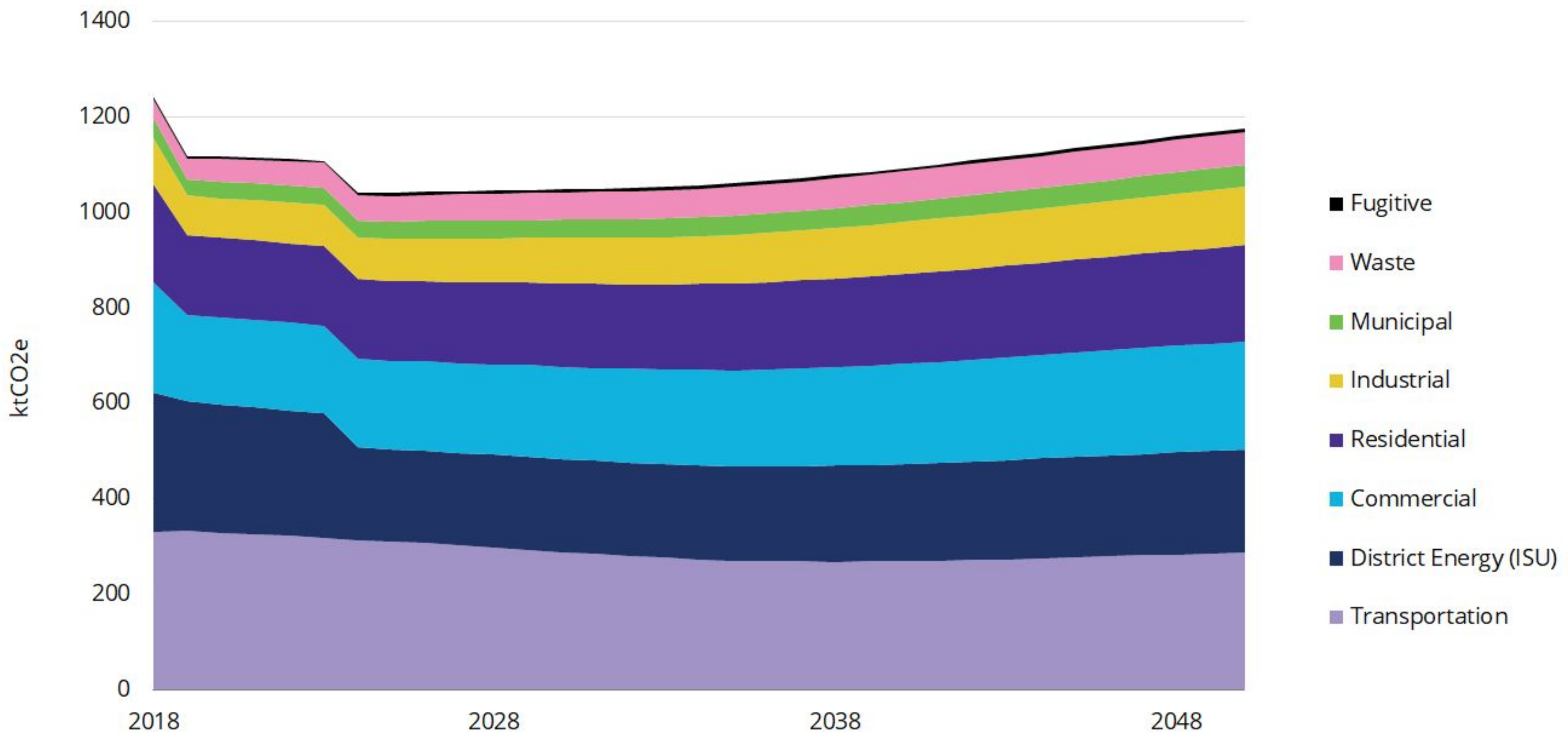
Projections

Projections for individual factors modelled together to create a future scenario for community energy-use and emissions

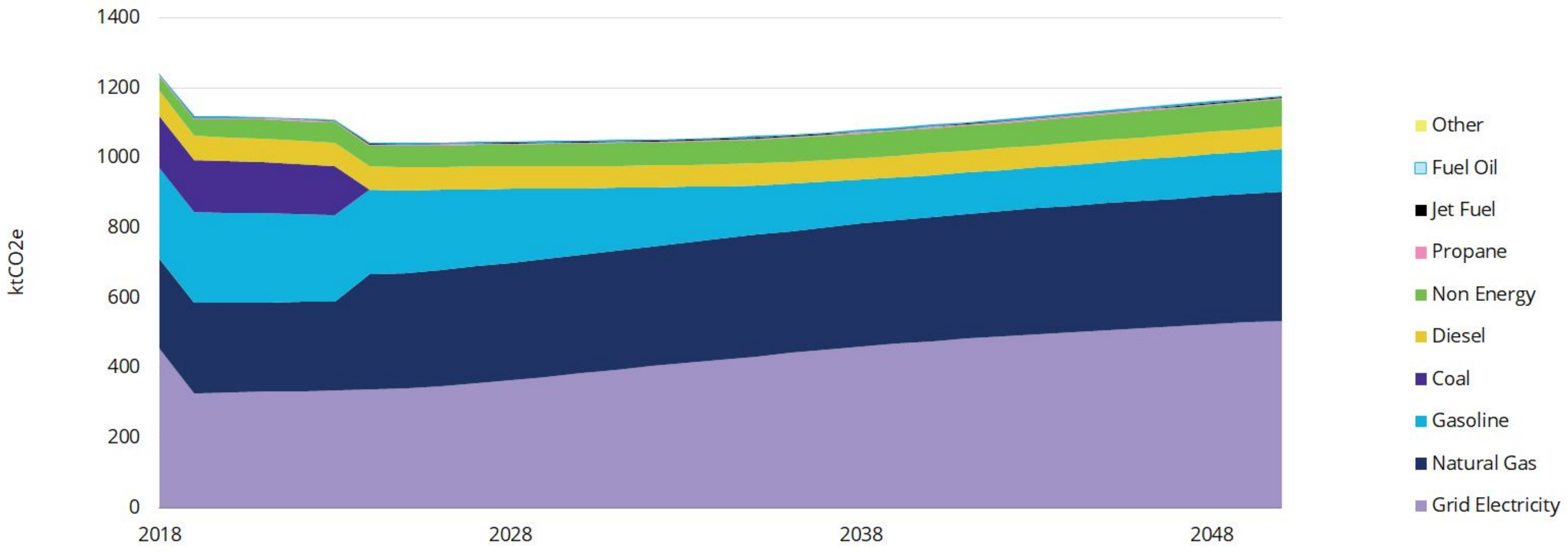
About Scenarios

A scenario is an internally consistent view of what the future might turn out to be - not a forecast, but one possible future outcome; one of many possible views of the future.

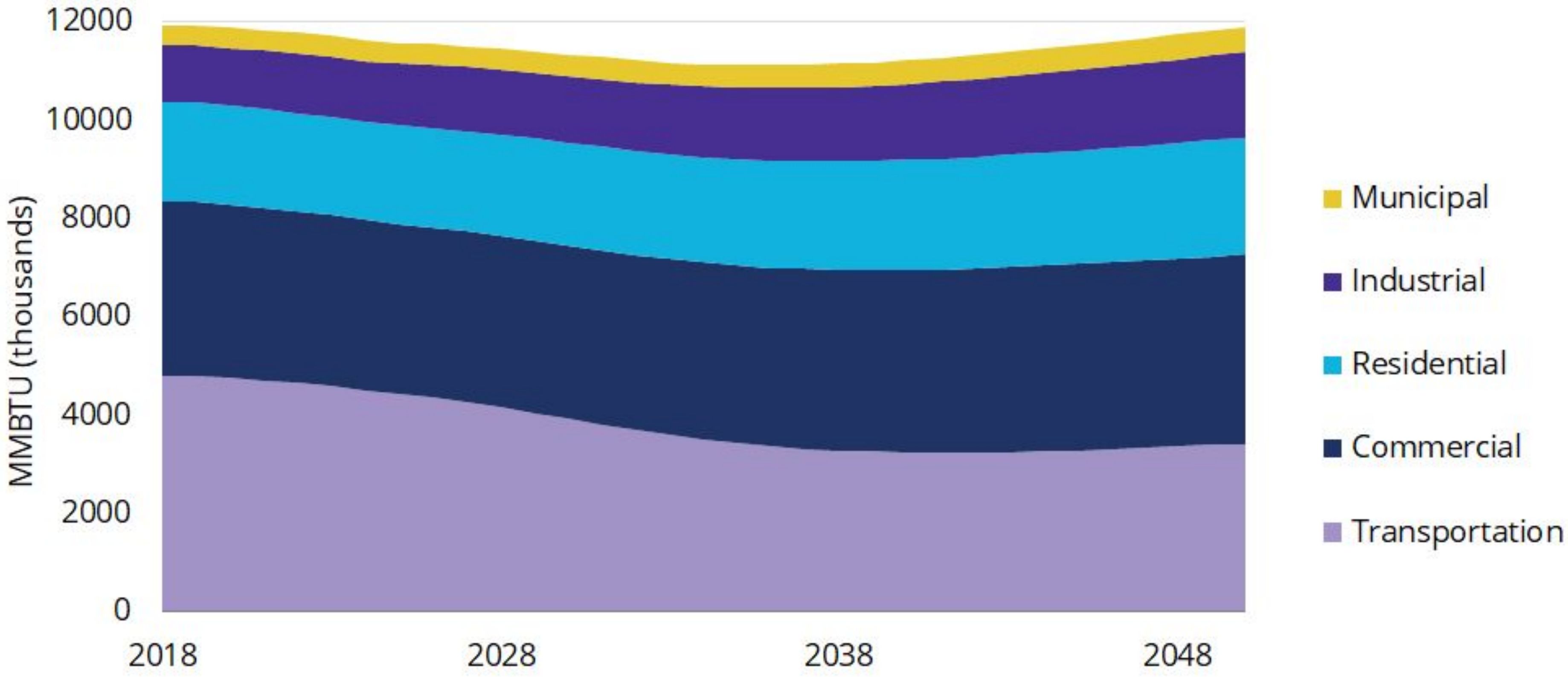
Total GHG Emissions by Sector



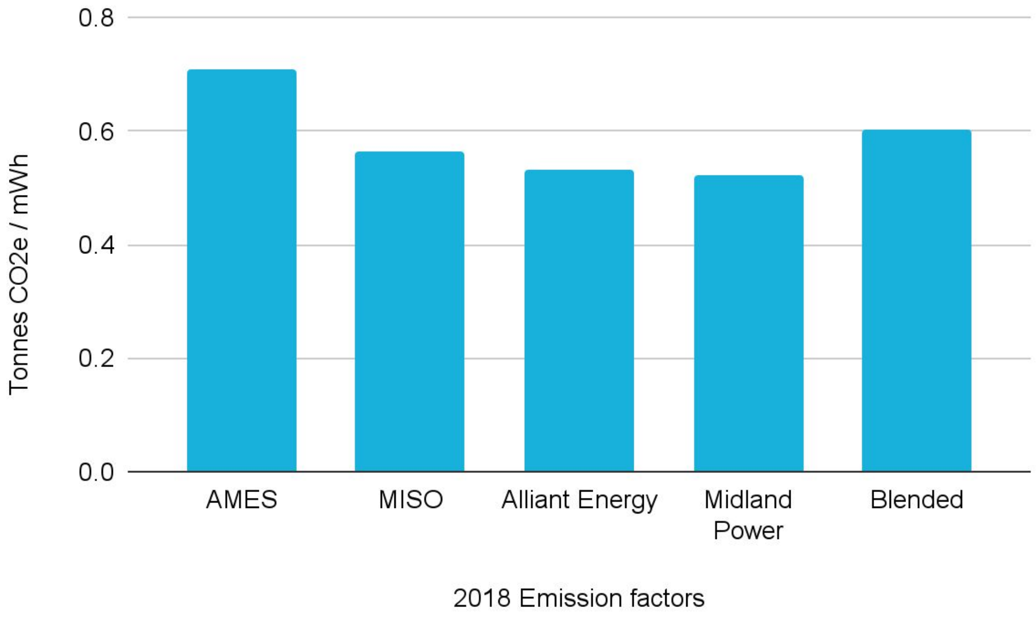
Total Emissions by Fuel

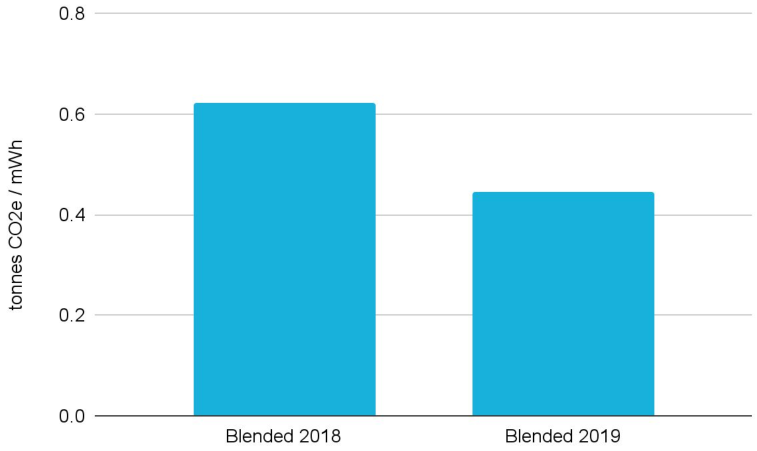


Total Energy Use by Sector

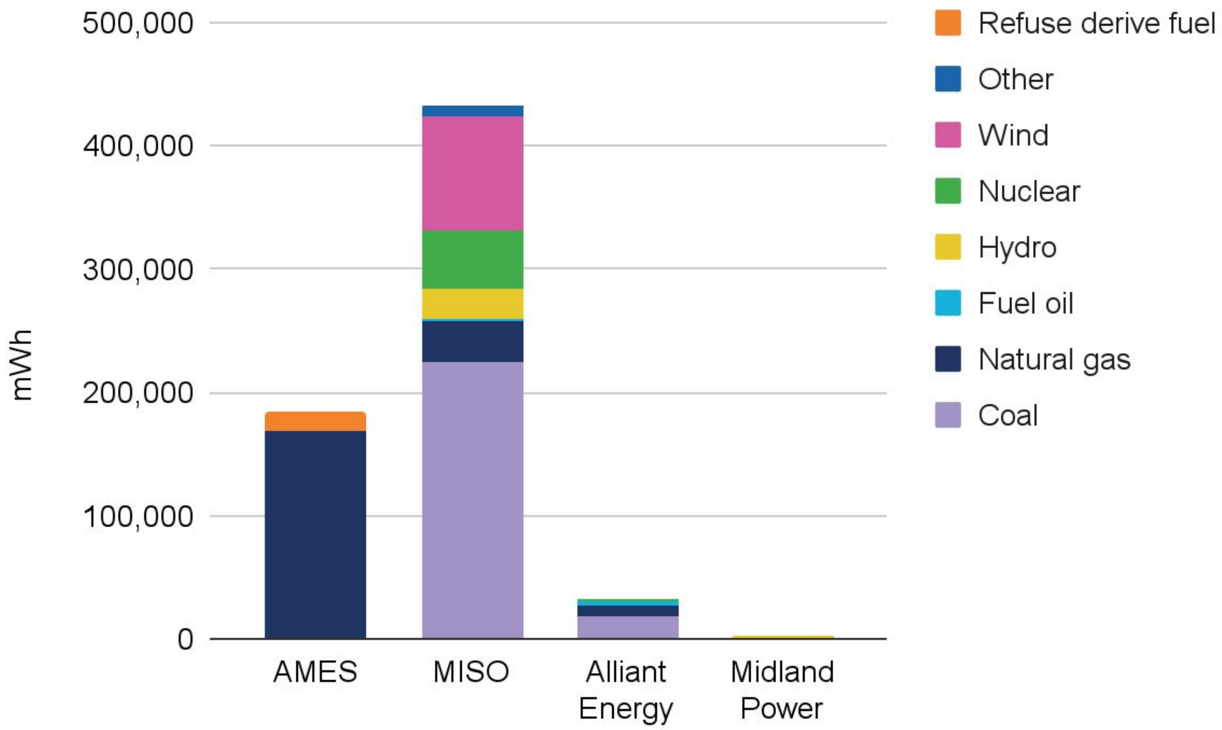


Electricity supply emission factors





Electricity supply 2018



Energy & Emissions Source Descriptions

Legend	Description
Local energy	Solar PV
RNG	Renewable natural gas
Fuel oil, propane, natural gas	Direct to consumer (residential, commercial, industrial)
District energy	ISU combined heat and power (CHP) system
Grid electricity	From all utility providers
Fugitive	Emissions from the production and transportation of natural gas

Business-as-usual

Q+A

Target Setting Overview

Target-setting Review

The Process

Present the four options to the City Steering Committee

A. Target-setting briefing
B. Tonight's presentation and opportunity for questions and comments

Present the four options to the Supplemental Input Committee

A. Target-setting briefing
B. Workshop on December 1st (to inform and to involve)

Present the four options to the public

A. Via the website, social media, press release and their access to this presentation (to inform)
B. Via a community survey (to consult)

City Steering Committee sets the target

A. Meeting on December 21st
B. With engagement outputs available for consideration

The Target Options

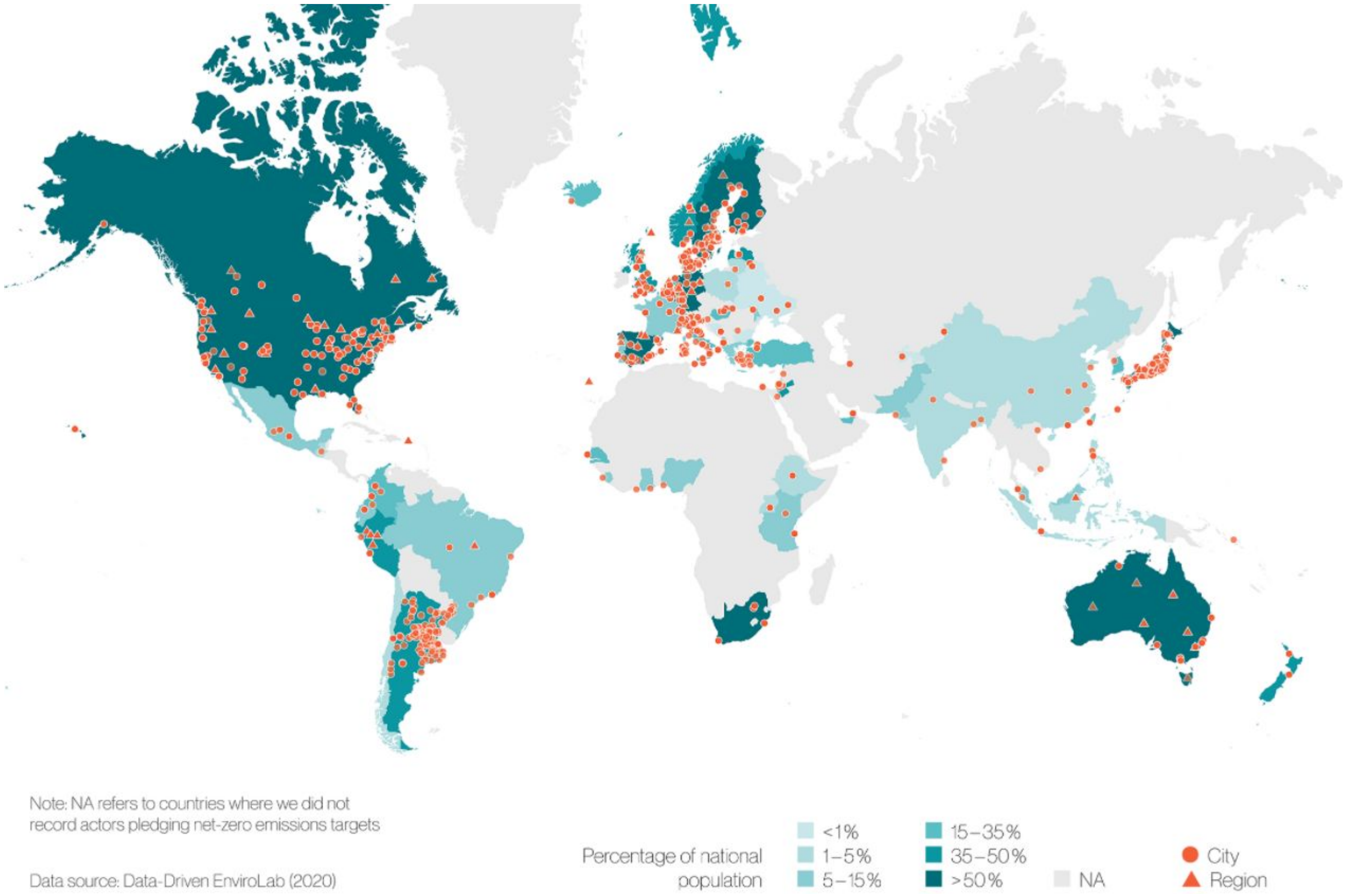
Science-based (general)

Aligned with Federal Target

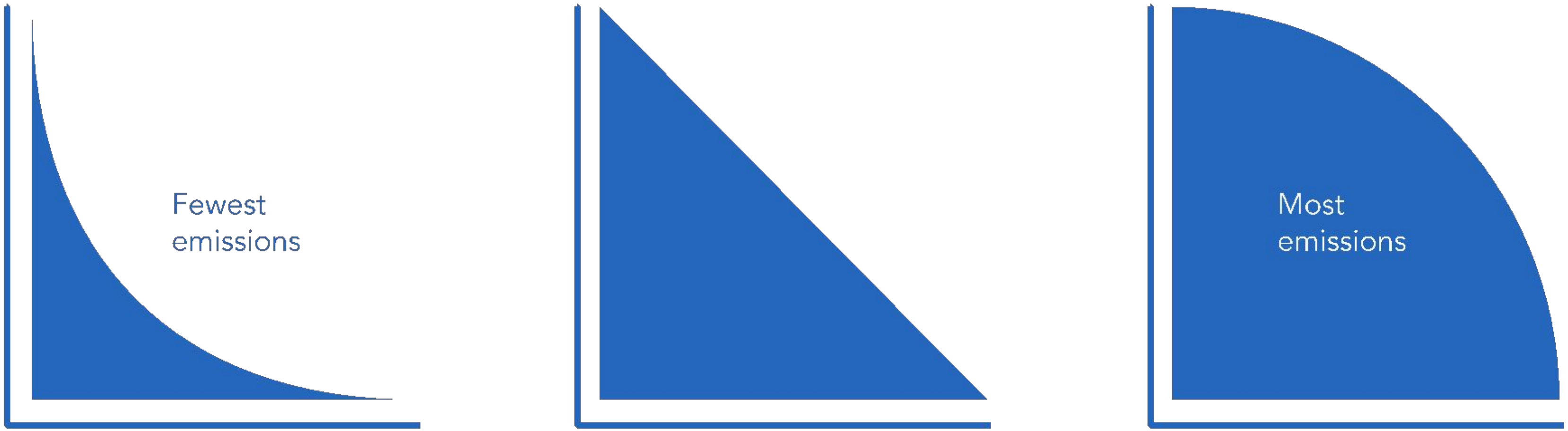
Evidence-based

Science-based (Fair-share)

Net-zero 2050 commitments



Not all targets are created equal



Science-based Target (General)

SSG

CITY OF Ames

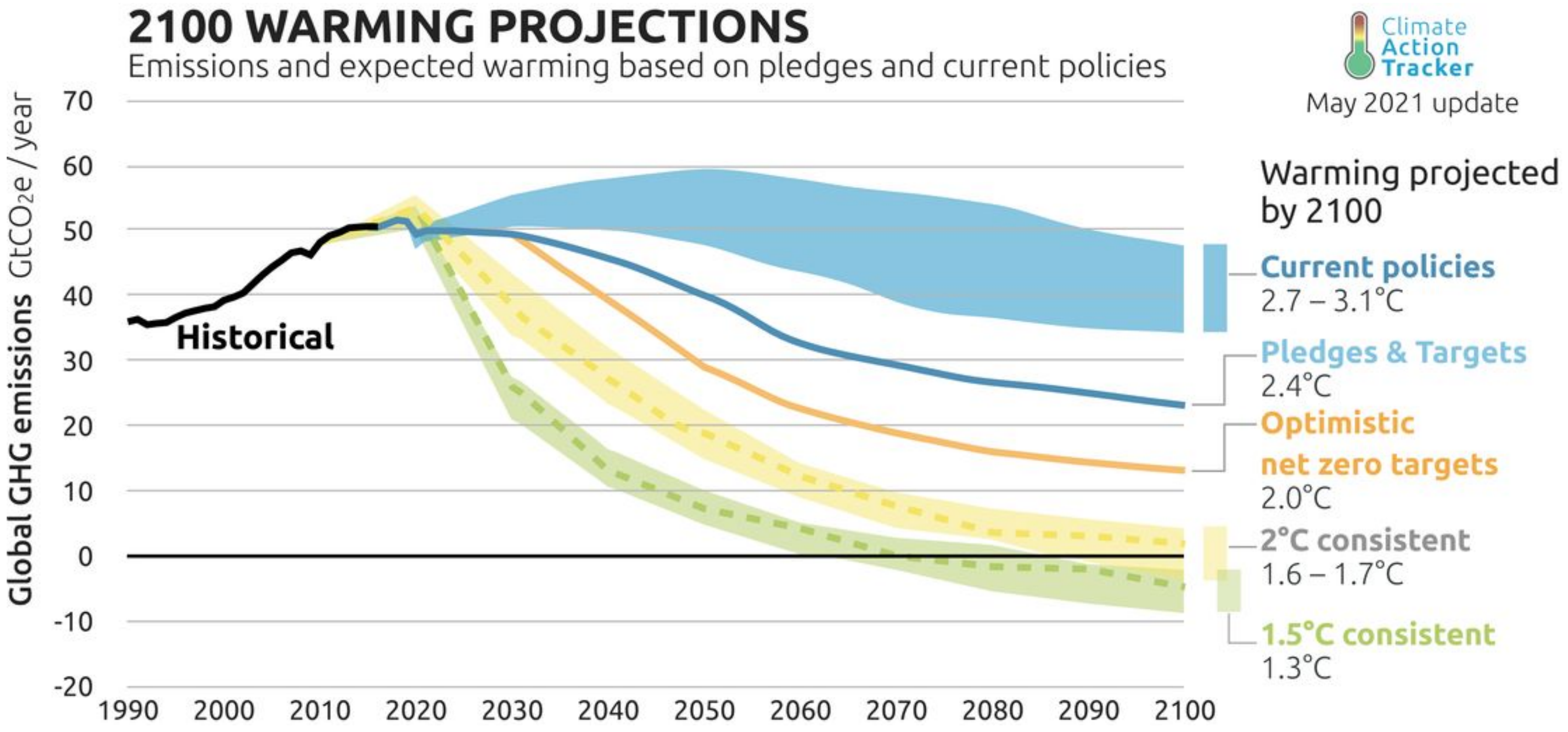
Science-based Target (general)

- 45% reduction in greenhouse emissions from 2005 levels by 2030, and net-zero emissions by 2050.

- In line Paris Agreement and the 2018 recommendation from the Intergovernmental Panel on Climate Change

- Based on staying below 2°C and ideally 1.5°C in warming above pre-industrial level.

The World is **not on track**



Science-based Target (general)

Benefits

- Aligned with:
  - UNFCCC Paris Agreement
  - 2018 IPCC recommendations
- Similar target to many other jurisdictions
- Avoids some costly infrastructure lock-in
- Has potential to realize co-benefits at a local level- clean air, connected community

Challenges

- Does not address global equity
- Does not align with the most recent evidence for staying within 1.5°C
- Challenging systems-level changes required
- Extensive behavior change required
- Ongoing political will required
- Some costly infrastructure lock-in will occur
- Up-front capital costs
- Impacts of climate change

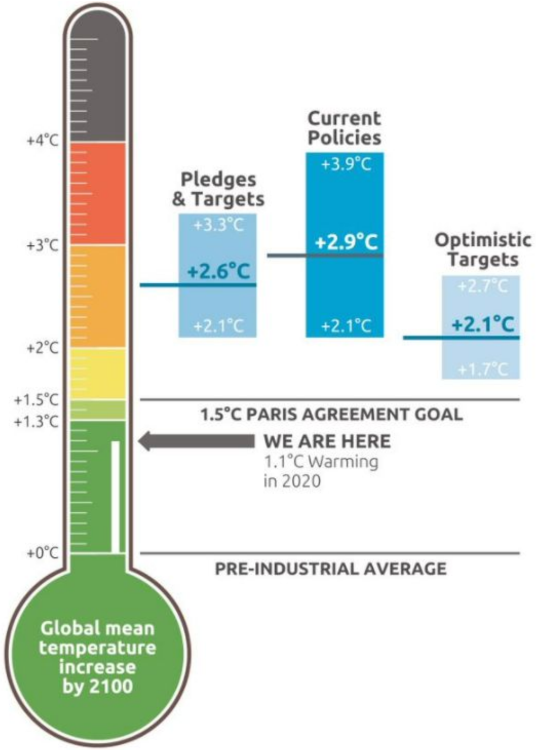
Aligned with Federal Target

Aligned with Federal Target

- 50-52% reduction in greenhouse emissions from 2005 levels by 2030, and net-zero emissions by 2050.
- In line with the federal emissions reduction target announced in April 2021.
- Based on the United States' Nationally Determined Contribution in line with Article 4 of the Paris Agreement.

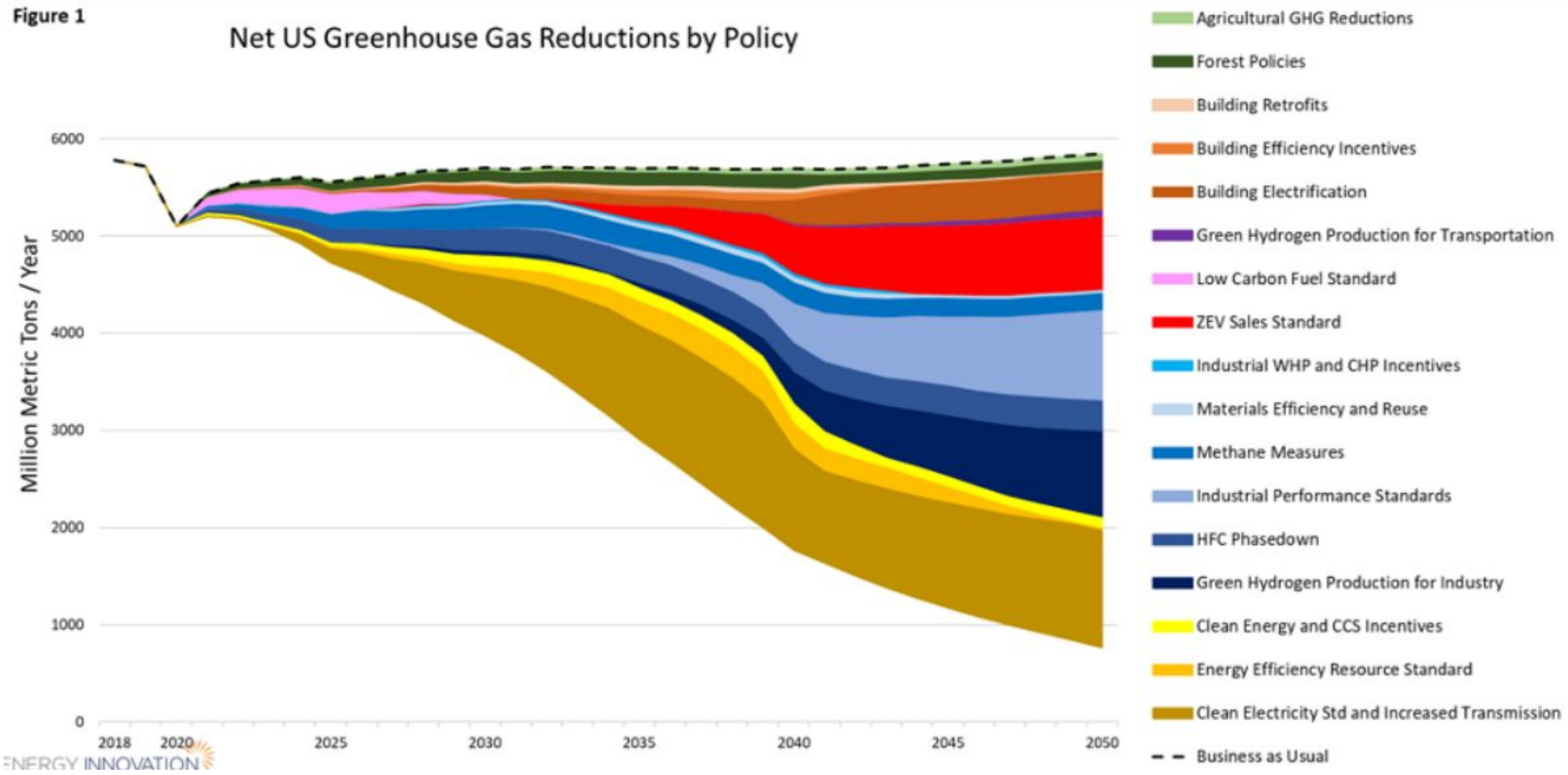
Nationally Determined Contributions

- Non-binding
- Self-imposed
- Climate neutrality by 2050
- Minimum 2°C aligned
- Based on a baseline figure
- Adaptation considerations
- Adjusting financial flows to align with reducing GHG emissions



Federal Commitments

- 100% carbon-free electricity by 2035
- Supporting energy efficiency upgrades and electrification in buildings
- Reducing carbon pollution from the transportation sector
- Industry decarbonization
- Agriculture decarbonization and land management



Source: United States | Energy Policy Solutions

Federal Target

Benefits

- Aligned with:
  - UNFCCC Paris Agreement
  - 2018 IPCC recommendations
- Similar target to many other jurisdictions (local and national)
- Avoids some costly infrastructure lock-in
- Has potential to realize some co-benefits at a local level (e.g. clean air)

Challenges

- Does not address global equity
- Does not align with the most recent evidence for staying within 1.5°C
- Challenging systems-level changes required
- Extensive behavior change required
- Ongoing political will required
- Some costly infrastructure lock-in will occur
- Up-front capital costs
- Impacts of climate change

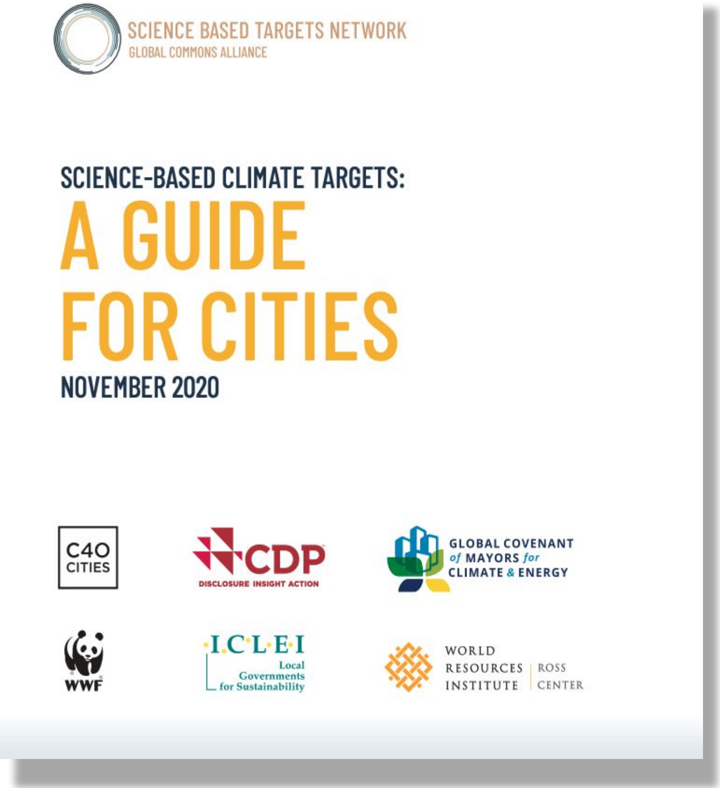
Science-based Target: Carbon Budget + Equity

Science-based Target (Carbon Budget + Equity)

- 83% reduction in greenhouse emissions from by 2030, and net-zero emissions by 2050.
- In line with the Science-Based Targets Network & C40 Climate Leadership recommendations
- Based on staying within 1.5° C in warming while considering equity.

Carbon Budget + Equity Principles

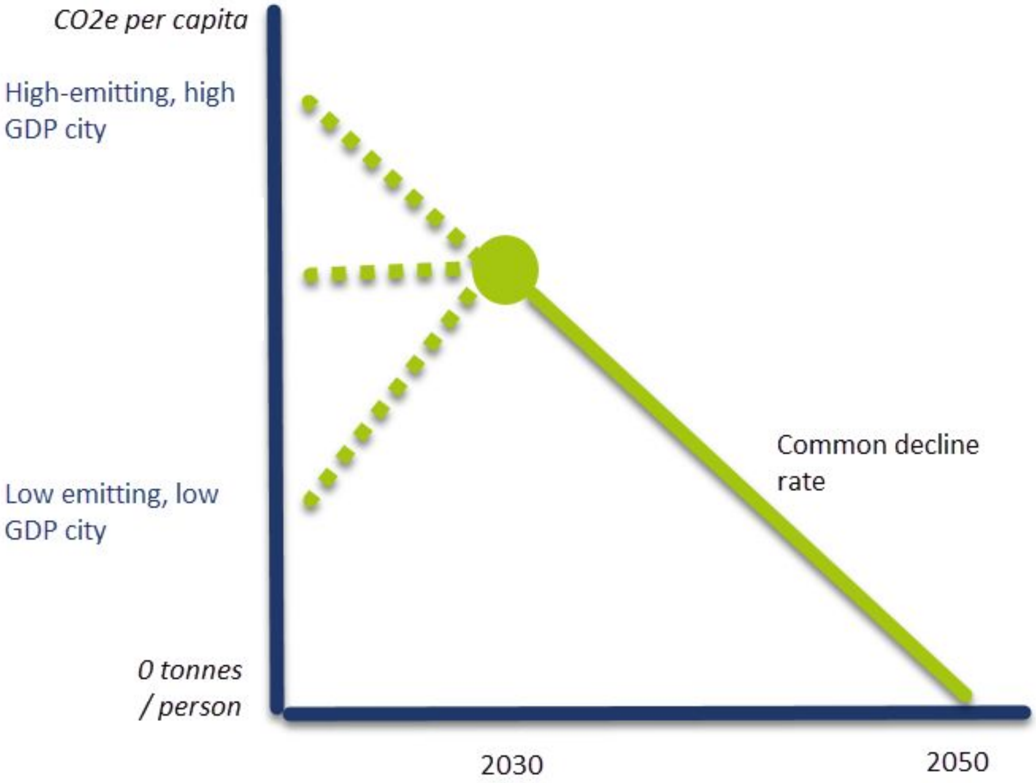
1. Responsibility
2. Capacity
3. Intergenerational justice


SCIENCE BASED TARGETS NETWORK
GLOBAL COMMONS ALLIANCE

SCIENCE-BASED CLIMATE TARGETS:
A GUIDE FOR CITIES
NOVEMBER 2020

C40 CITIES
CDP DISCLOSURE INSIGHT ACTION
GLOBAL COVENANT of MAYORS for CLIMATE & ENERGY
WWF
ICLEI Local Governments for Sustainability
WORLD RESOURCES INSTITUTE | ROSS CENTER

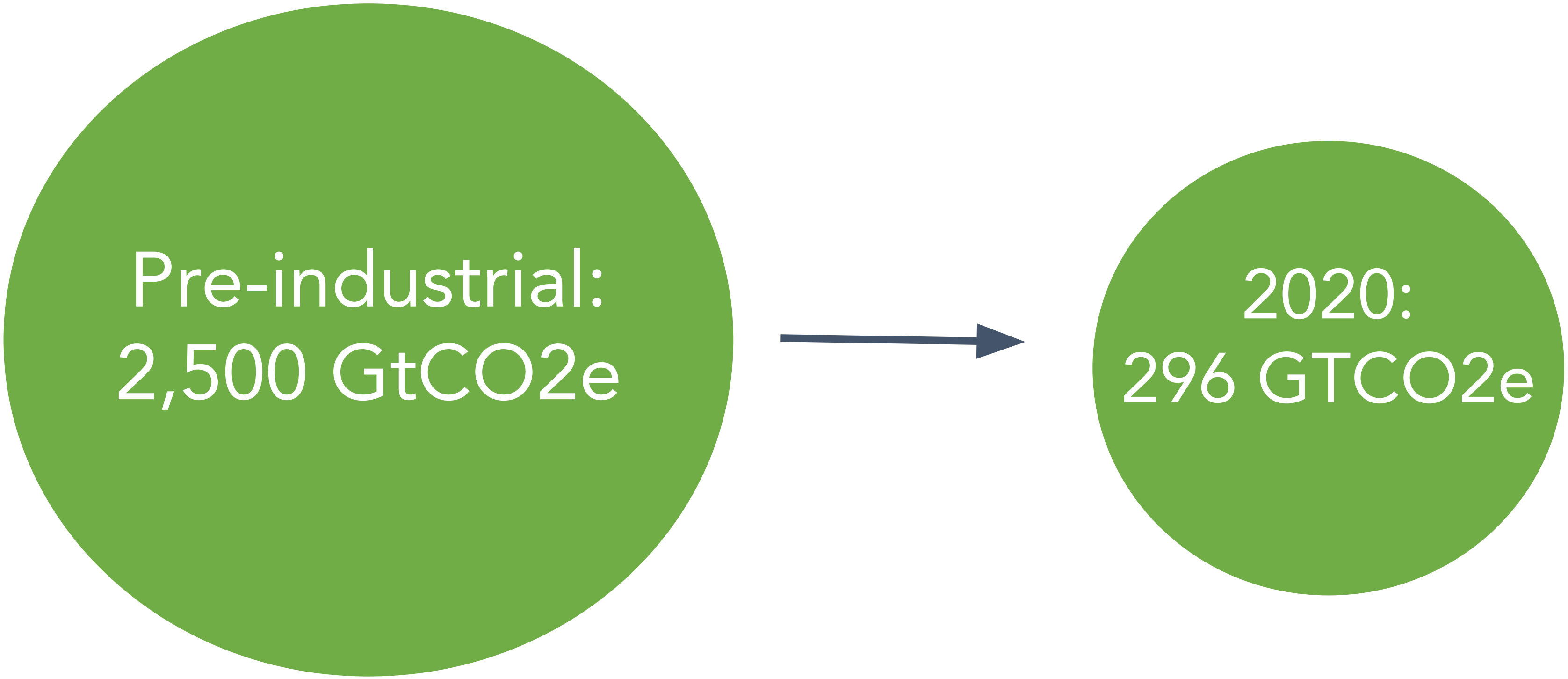
Equitable distribution



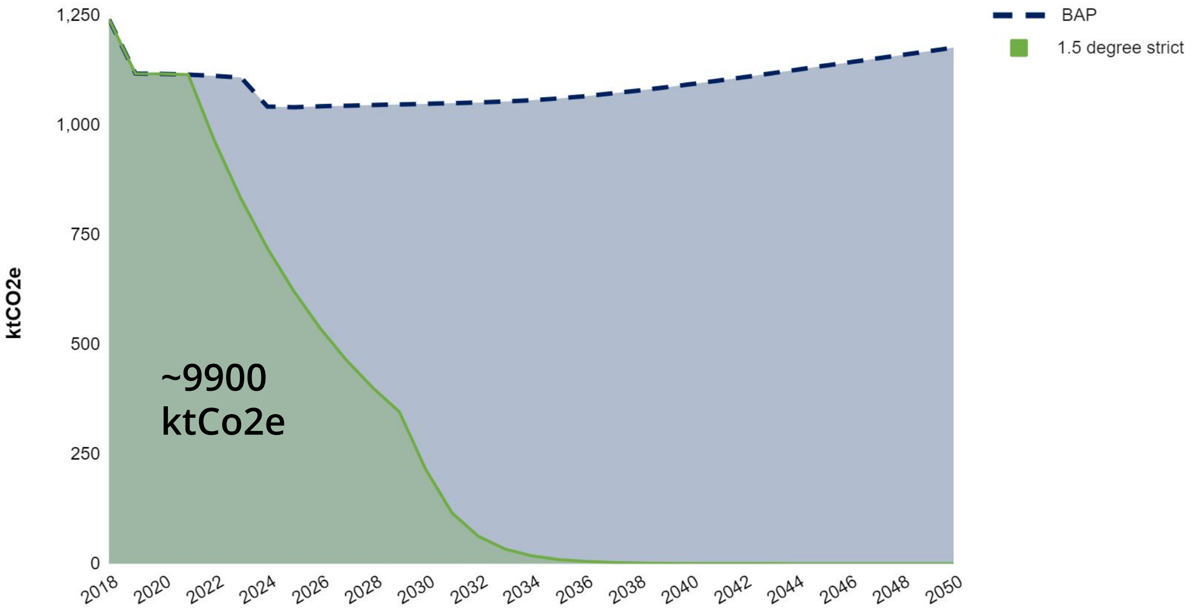
Carbon Budget

The maximum amount of greenhouse gases that can be emitted world-wide without increasing the global average temperature more than 1.5° Celsius.

How much is the global carbon budget?

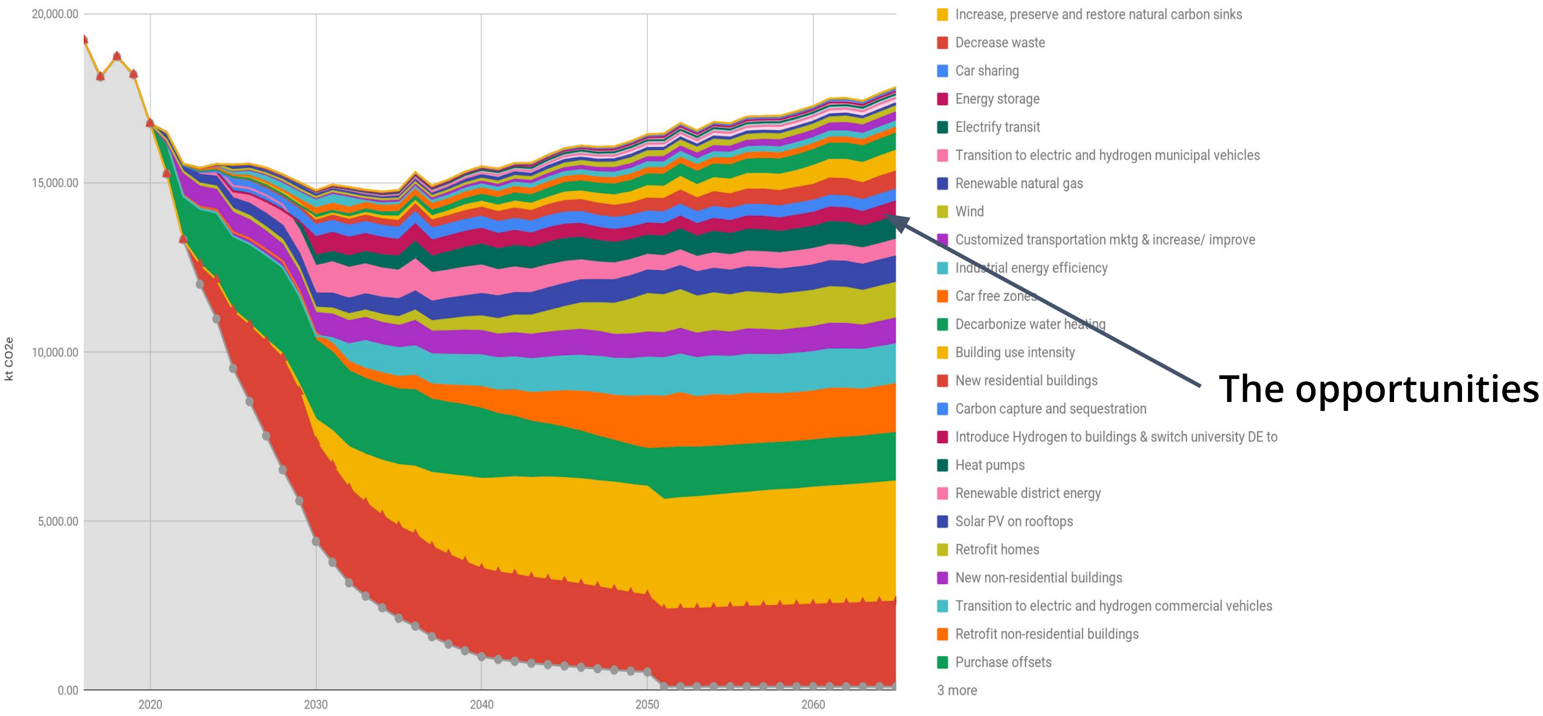


Carbon Budget - Ames (2018)



The carbon deficit (aka "the opportunities")

Carbon Budget Opportunities Example



This chart is an example and does not represent Ames

Science-based Target (Carbon Budget + Equity)

Benefits

- Aligned with:
  - UNFCCC Paris Agreement
  - 2018 IPCC recommendations
  - Science-based Target Network
- Avoids costly infrastructure lock-in
- Maximizes co-benefits - equity, cleaner air, more connected communities
- Has potential to realize co-benefits at a local level sooner

Challenges

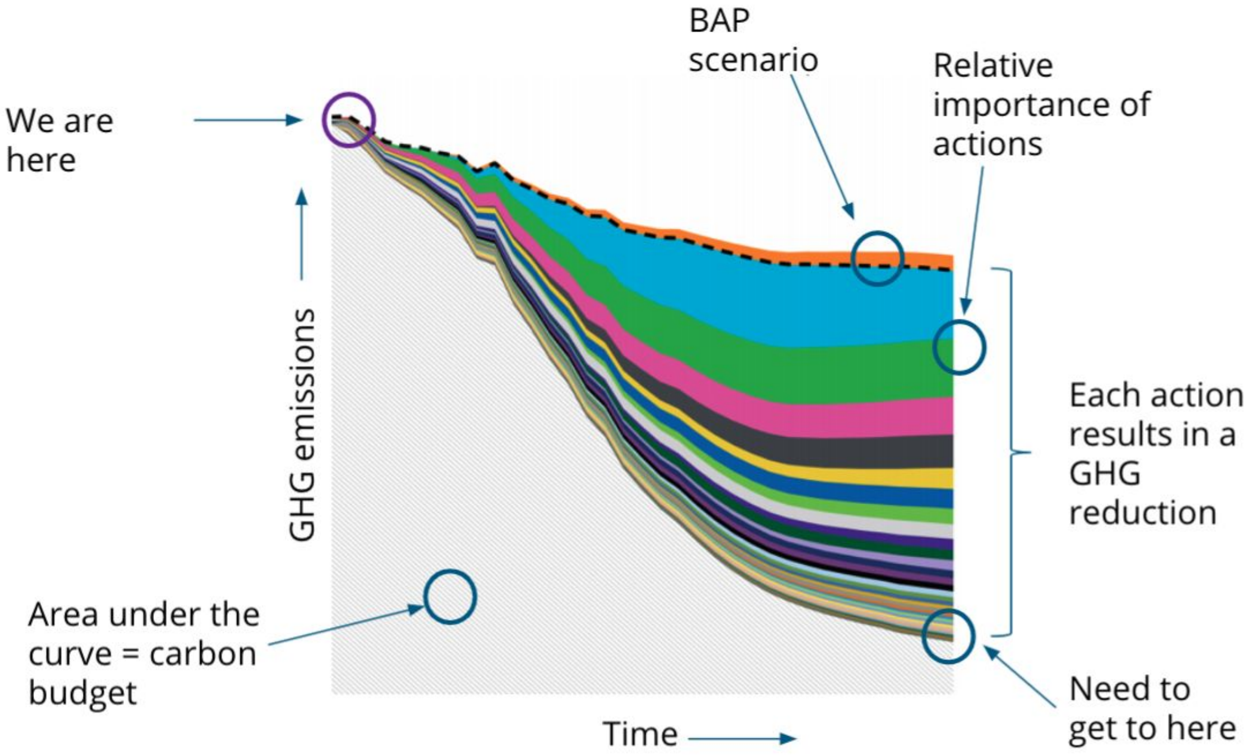
- Up-front capital costs
- Challenging systems-level changes required
- Extensive behavior change required
- Ongoing political will required
- Potential for resistance due to quick, transformative changes

Evidence-based Target

Evidence-based Target

- 45% reduction in greenhouse emissions from 2005 levels by 2030, and net-zero emissions by 2050.
- In line Paris Agreement and 2018 pathway identified by the Intergovernmental Panel on Climate Change
- Based on staying below 2°C and ideally 1.5°C in warming above pre-industrial level.

Evidence-based Target Example



Evidence-based Target

Benefits

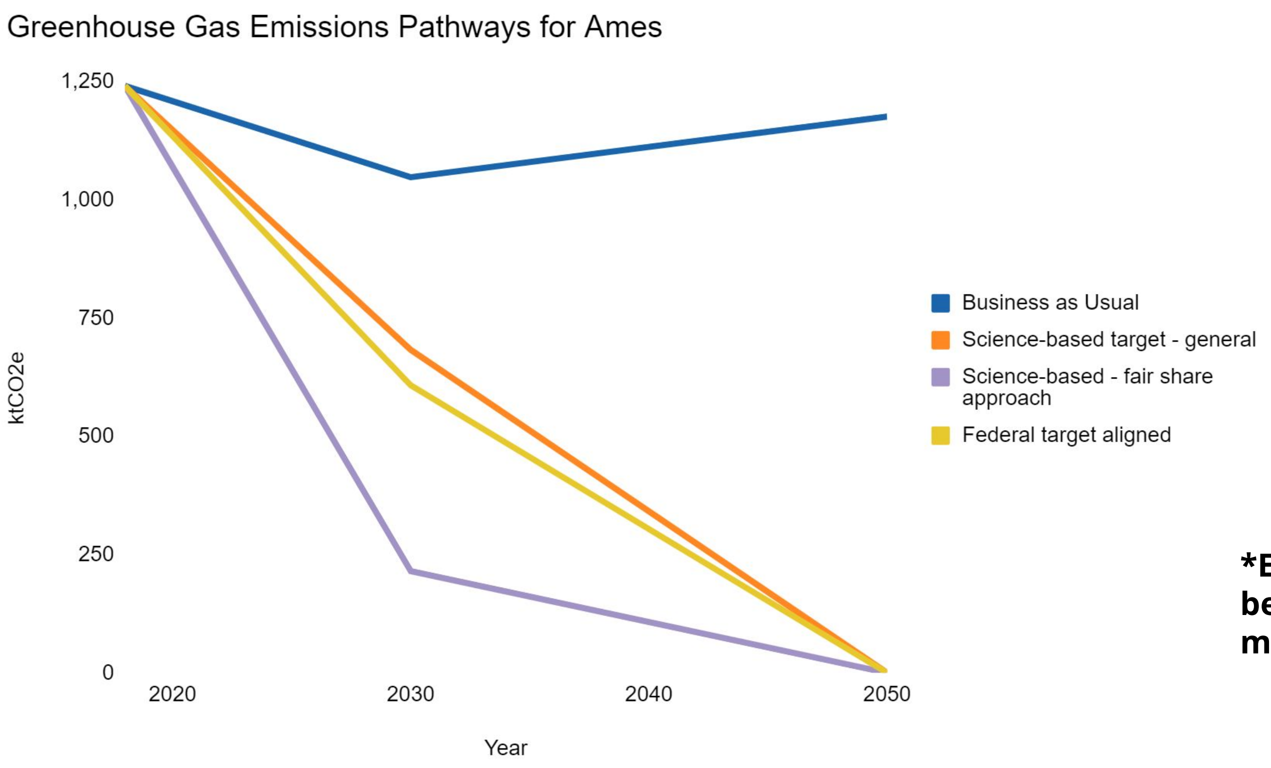
- Provides the local government with the ability to focus on what it controls rather than spending time and energy on levers it cannot control
- Change may be accepted because it was ‘locally-built’
- May avoid costly infrastructure lock-in
- Has potential to realize co-benefits

Challenges

- May not meet the threshold for the UNFCCC Paris agreement
- May not be science-aligned
- Does not address global equity
- Challenging systems-level changes required
- Extensive behavior change required
- Ongoing political will required
- Some costly infrastructure lock-in will occur
- Can create a discourse of changes being someone else’s problem

Targets Summary

Targets Compared

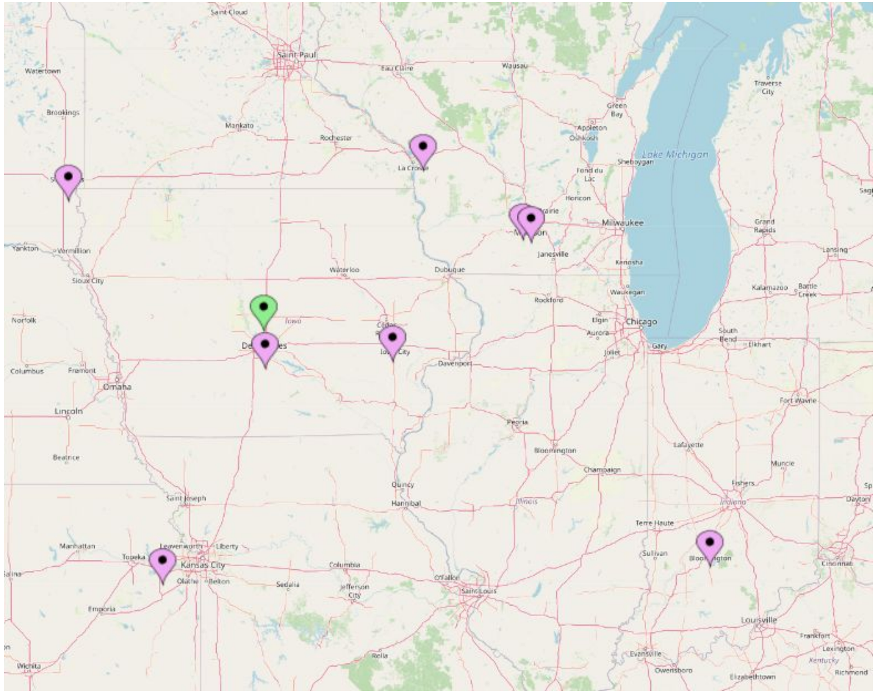


***Evidence-based not shown because it needs to be modeled first**

Your Neighbors

Net-Zero by 2050 Goals

Des Moines, IA
Iowa City, IA **(approaching net-zero)**
Sioux Fall, SD
Bloomington, IN
Lawrence, KS **(100% renewable by 2050)**
Madison, WI
LaCrosse, WI
Middleton, WI



Target Setting

Q+A

Wrap Up + Next Steps

Thank You!

CITY OF Ames

SSG SUSTAINABILITY SOLUTIONS GROUP