Path to 80%:

A Comprehensive Roadmap to Reducing Emissions by 2050

Prepared for the City of Springfield
Prepared by the Pioneer Valley Planning Commission and Smith College's Fall 2017 Climate Change Concentration Capstone Class; (Alexandra Davis, Maggie Painter, Molly Peek, Samantha Peikes, and Meghan Suslovic); November 2017

With funding from U.S. Department of Housing and Urban Development- Community Development Block Grant National Disaster Resilience Competition

Contents

Cover Photo Credit: https://www.juggle.org/springfield-ma/

Introduction

Climate change is regarded as one of the most urgent, complex, and multifaceted environmental issues of modern times. According to the fifth assessment of the Intergovernmental Panel on Climate Change (IPCC), warming of the climate systems is unequivocal and unprecedented. Rising temperatures have caused glacial melting, sea level rise, changing habitats, and the frequency of natural disasters (IPCC, 2013). The levels of carbon dioxide have exceeded over 407 parts per million, global average temperatures have risen 1.7 degrees fahrenheit since 1880, and land ice continues to melt at 286 gigatons per year. All of these events have harmful repercussions on natural resource management, plants and wildlife, and human health. Throughout the world, small cities, regions, and countries are already experiencing the devastating impacts of climate change and are attempting to respond to them.

The creation and implementation of Climate Action Plans (CAPs), or Climate Action and Resiliency Plans (CARPs), has become a popular and empowering movement across the United States as a response to climate change. Many cities have already launched, or are in the process of creating a Climate Action Plan that addresses the needs and broader goals of their city as related to natural disaster preparedness, infrastructure improvements, protection of the most vulnerable populations, and the initiation of mitigation strategies that aim to decrease levels of greenhouse gas emissions in the growing shadow of climate change.

The City of Springfield, MA published their Climate Action and Resiliency Plan (CARP) in June of 2017, which focused not only on climate action, but also on community resilience. During this process they completed a Greenhouse Gas Emissions Inventory and established reduction goals within the framework of the action plan. This CARP lays out a roadmap for the City of Springfield to follow in order to reach their overarching goal: an 80% decrease in total greenhouse gas emissions from the city by 2050 or 974,364 metric tons CO2e out of the total 1,217,955 metric tons CO2e produced in the city.

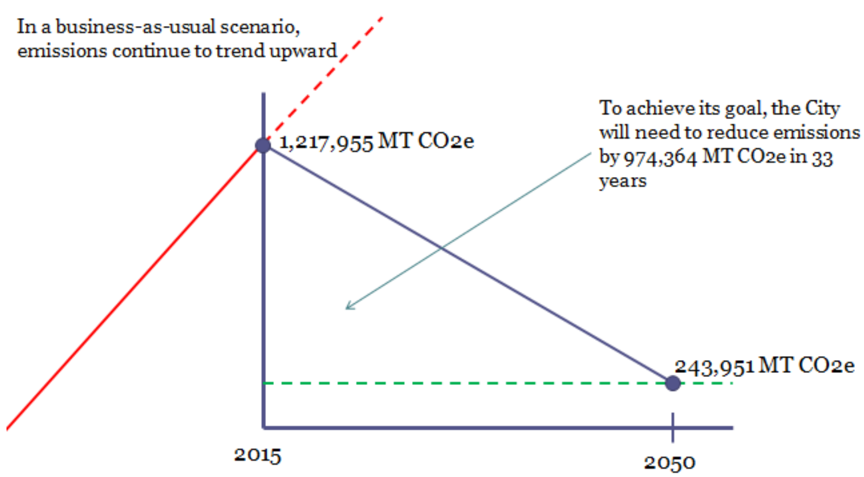


Figure 1: Understanding Springfield's goal of reducing emissions by 80% by 2050

Methodology

Quantifying Greenhouse Gas Emission Savings

The Smith College Climate Change Concentration Class of 2018 was tasked with creating a list of potential initiatives that, if taken by the City of Springfield, would allow Springfield to reach their goal of 80% reductions by 2050. This report compiles the research conducted by the class in three sectors: buildings (commercial, residential, and industrial), transportation, and waste/water. In each of these sectors, the class conducted greenhouse gas reduction calculations on a variety of initiatives, using information and methods from case studies from around the world. The greenhouse gas emission reductions of each intervention were calculated using the standard reporting unit of carbon dioxide equivalents (CO2e). It accounts for the different global warming potentials (essentially the potency) of each of the greenhouse gases and converts them into a single unit, in this case the equivalent amount of carbon dioxide. For example, if 1 kg of methane is emitted, it can be expressed as 25 kg of CO2e, which takes into account methane's ability to absorb much more heat over a shorter time span than carbon dioxide. The most common usage of CO2e is for carbon dioxide.[1]

For almost every strategy there is a conservative and an optimistic CO2e reduction calculation. This is to demonstrate the range in CO2e reductions that can be made with each intervention. The two calculations are also meant to capture the considerable level of estimation inherent in these calculations. The sum of the conservative estimates equals 643,123 MT CO2e of reductions, or 66% of Springfield's total emissions. The tally of the optimistic scenarios equals 969,570 MT CO2e, which achieves Springfield's goal of reducing emissions by 80%.

[1] Brander, M. (2012). "Greenhouse Gases CO2, CO2e, and Carbon: What Do All These Terms Mean?" *Ecometrica.* https://ecometrica.com/assets/GHGs-CO2-CO2e-and-Carbon-What-Do-These-Mean-v2.1.pdf

Strategies Overview

Introduction

The primary sources of community emissions are organized into five sectors: Buildings (Commercial, Industrial and Residential), Transportation, Solid Waste, Water/Wastewater, and Fugitive Emissions. Emissions from these five categories equal 1,217,955 metric tons of CO2e. A breakdown of emissions by sector can be found below.

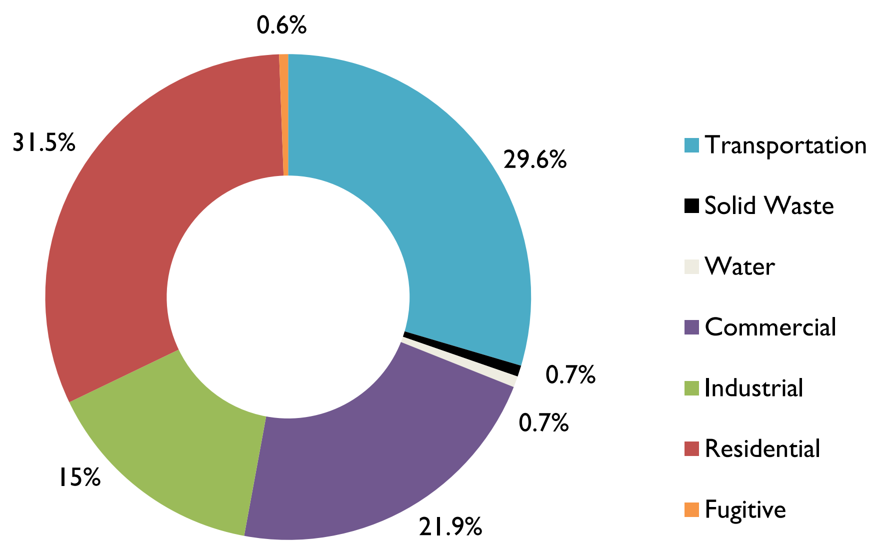


Figure 2: Community-wide Greenhouse Gas Emissions Inventory

Seventeen strategies have been proposed through this process. If implemented, these strategies—collectively—will reduce greenhouse gas emissions in the city by 969,570 MT CO2e—an 80% reduction from the 2015 baseline. Strategies of the utmost importance to pursue, because they will yield the largest reduction in greenhouse gas emissions include:

1.) The continued success of the Regional Greenhouse Gas Initiative (RGGI).

2.) The deployment of additional bike and bus lanes through the City.

3.) The installation of roof top solar photovoltaic systems on commercial buildings.

The collective savings anticipated from strategies, organized by sector, can be found below and a detailed discussion of each strategy and their calculated savings can be found in the remainder of this report.

Figure 1: Estimate Emission Reductions (CO2e)

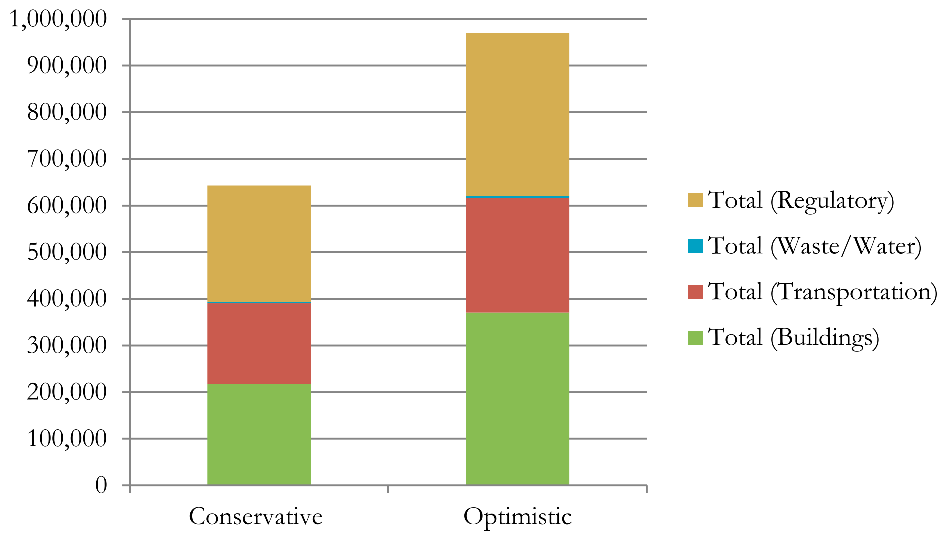
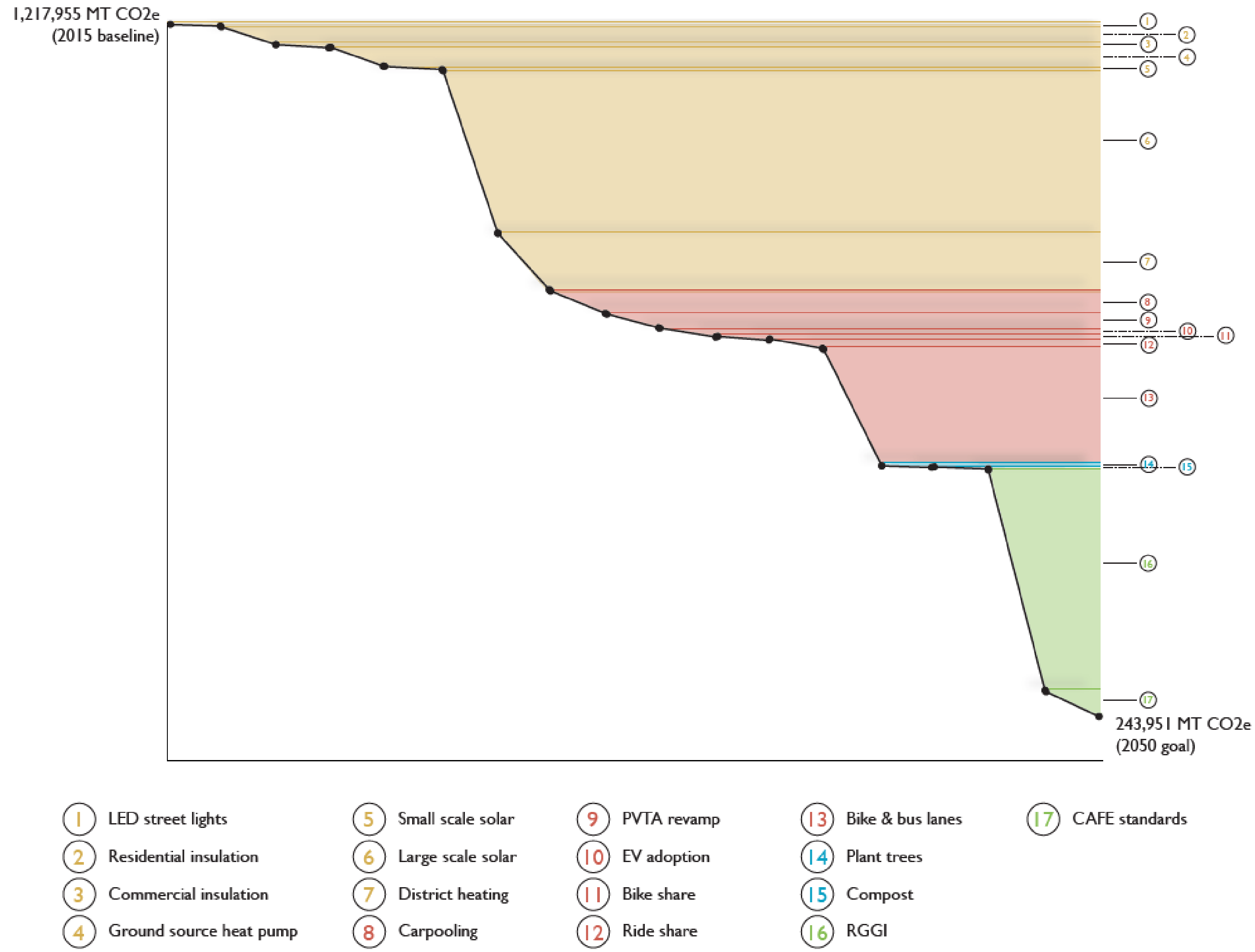


Table 1: Proposed strategies and their conservative and optimistic reductions of emissions.		
Intervention	**Conservative (MT CO2e)**	**Optimistic (MT CO2e)**
Buildings		
LED Streetlights	2,400	2,400
Residential Insulation	16,308	24,463
Commercial Insulation	3,315	4,973
Ground Source Heat Pumps	26,387	26,387
Small Scale Solar on Commercial Buildings	2,325	3,359
Large Scale Solar on Commercial Buildings	153,983	230,974
Small Scale District Heating	13,000	78,000
Regional Greenhouse Gas Initiative (RGGI)	230,585	310,000
Transportation		
Carpooling	5,373	32,250
Electric PVTA buses	18,260	18,260
Electric Car Adoption	1,217	12,168
Bike Share	1,387	5,547
Ride Share	1,222	12,218
Additional Bike/Bus Lanes	145,043	165,255
Corporate Average Fuel Economy (CAFÉ) Standards	19,357	38,714
Waste/Water		
Plant 66,000 trees	1.320	1,320
Divert food waste to anaerobic digester	1,641	3,282
Total Reductions	**643,123**	**969,570**

Figure 2: The impact each strategy will have in moving Springfield towards its 80% reduction goal. (Assuming optimistic projections are met.)



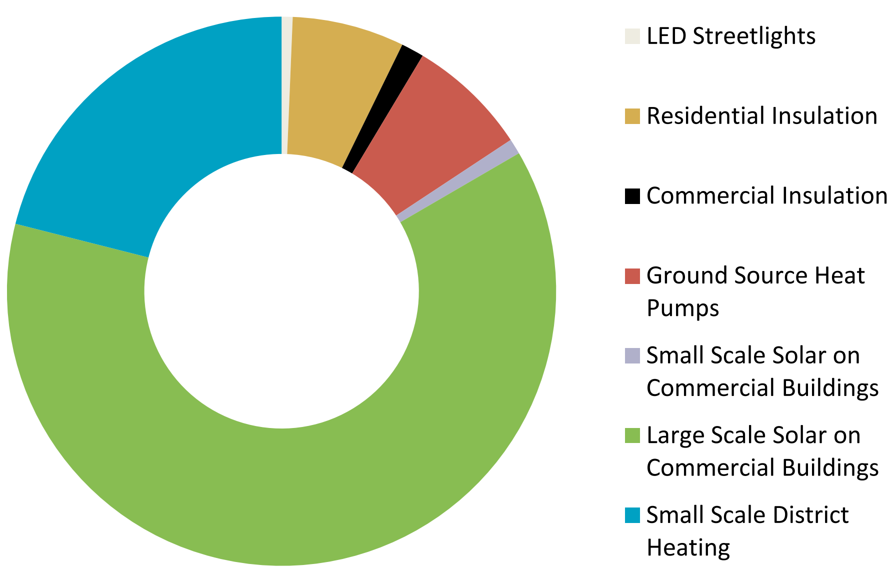
Detailed Strategies

Buildings

Collectively buildings make up the largest segment of emissions in Springfield's Community-wide inventory (approximately 68.4%). Within this segment, buildings can be distilled into three sectors: Residential, Commercial and Industrial. Residential buildings make up just over a third of Springfield's overall community emissions (31.5%) or 384,105 metric tons of CO2e. Commercial buildings account for 21.9% of Springfield's overall community emissions or 266,176 metric tons of CO2e. The two main sources of energy usage in commercial buildings captured in this audit are electricity and natural gas usage. In the near future, commercial emissions are likely to increase as the MGM casino and Union Station are finished. Industrial buildings account for 15% (182,290 metric tons of CO2e) of Springfield's overall community emissions. In the near future, industrial emissions across Springfield are likely to increase as the rail car factory comes online. Because buildings collectively make up such a large segment of Springfield's emissions, strategies that lead to a reduction in this sector will be instrumental.

Six key strategies were analyzed for reducing emissions in Springfield's building sectors. In an optimistic scenario, these strategies combined would equal 38% of Springfield's 80% reduction goal. As you can see in Figure 2 below, the implementation of small scale district heating systems, similar to the one recently installed at Baystate Medical Center, and the deployment of large scale solar on large commercial buildings are likely to generate the largest impact.

Figure 3: Estimated Optimistic Emission Reductions for strategies related to Buildings in Springfield



Strategy #1: LED Street Lights

Overview

Light Emitting Diode (LED) lighting produces light approximately 90% more efficient than traditional incandescent bulbs. With LED lighting an electrical current passes through a microchip and is illuminated by the movement of electrons in a semiconductor current. They can last for up to 50,000 hours and do not need to be changed as often as incandescent bulbs.[2]

Image 1: LED Street Lights

Source: https://www.mapc.org/our-work/expertise/clean-energy/led-streetlight-retrofits/

The reason for proposing LED street lights instead of home LED lights is because this is a large scale project that is directly controlled by the city. For large scale projects it is easier to obtain grants or financial support from organizations or utilities. LED lights last up to four times longer than traditional High Pressure Sodium (HPS) lights and installing them will save energy and maintenance costs.[3]

Co-Benefits

Some costs to consider for LED street lights are material cost of bulbs, poles, and electrical wires, labor cost of installing the light, and the cost of energy consumed by the bulb. One LED luminaire costs between $185-$240. The LED luminaire installation fee is around $170 and the total approximate cost of installing one LED street light is $4,000. Springfield should consider retrofitting its street lights instead of completely replacing them because it would be less expensive. The lifespan of an LED luminaire is approximately 7 years because they are highly efficient. This would save utility costs in the long run and prices would gradually decrease. At five hours a day, an LED bulb uses only $2.42 worth of electricity equalling roughly $13 of savings per year in electricity, which results in breaking even in less than two years.[4]

Calculations

According to the Los Angeles LED street light case study, converting just one HPS street light to an LED light reduces carbon emissions by 0.3 metric tons per bulb (we multiplied 0.3 metric tons CO2e by the number of street lights in Springfield to get approximate total CO2 equivalent reduction). It was assumed that Springfield would experience the same reductions as Los Angeles. There are approximately 14,000 street lights in Springfield (14,000) * (0.3 metric tons CO2e) = 4,200 metric tons CO2e reduced.[5]

Assumptions

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[2] Hawkin, P. (2017). *Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming.* New York.
[3] LED Street Lights. (2017). HG & E Empowering Your World. http://www.hged.com/customers/services/lighting/led-street-lights.aspx
[4] Cost Benefit Analysis of Energy Efficient Technologies Available for Use in Roadway Lighting. (2012). *Energy Management Solutions Inc.* https://www.cleanenergyresourceteams.org/sites/default/files/roadway-lighting.pdf
[5] Economic Cost-Benefit Analysis of Smart LED Street Lights. https://kb.osu.edu/dspace/bitstream/handle/1811/80699/ENRAEDE4567_StreetLights_sp2017.pdf?sequence=1

The following assumptions were made when calculating the saving attributed to this strategy:
1. All 14,000 street lights in Springfield are the same type and require the same kind of lighting fixture
2. The estimated CO_2e reductions from Los Angeles street light case study

Overall Savings

Converting the City's street lights from HPS bulbs to LED lighting will save approximately 4,200 MT CO_2e. This is a 0.3% reduction from the baseline.

Case Studies

The City of Los Angeles started a project in 2009 to retrofit 140,000 of their 209,000 street lights to LED. The program was a collaboration between the Los Angeles Bureau of Street Lighting, the Los Angeles Mayor's Office, and the Los Angeles Department of Water and Power. It was the largest LED retrofit project ever undertaken. Upon full implementation, the project will return $10 million in energy and maintenance savings per year, while reducing around 40,000 CO_2 equivalent emissions per year.[6]

Strategy #2: Spray Foam Insulation

Overview

Building insulation will keep structures warmer in winter and cooler in summer, which will reduce costs associated with heating and cooling a home. Almost 70% of the emissions from residential units in Springfield can be attributed primarily to heating homes and not to electrical usage within the home. Thus incentivizing or assisting in better insulation is likely to have a greater impact on lowering emissions[7]. While any type of insulation is helpful, spray polyurethane foam (SPF) is better than other types of insulation at reducing air leakage. With spray foam insulation, it is relatively easy to fill wall and ceiling cavities completely[8], which is why the installation of SPF in buildings was used to estimate the effect of this intervention on greenhouse gases.

Co-benefits

The average cost for spray foam insulation of a 1,600 square foot home (most homes in Springfield are between 1,500-2,000 square feet) is $1,883. Insulating a home with SPF can save around 40% on energy bills, and cost savings are around $3,500 within five years. The low end cost of insulation, on average, is $752 and the high end cost is $5,691. Closed-cell spray foam cost is between $1-$1.50 per board foot. Spray foam seals pipes, plumbing, cracks, sills and framing. It optimizes the performance of heating and cooling system when installed around the pipes, condensers, floor registers and ductwork. Reductions in extremely hot or cold climates can often offset upfront costs of buildings or additions with foam. Closed cell spray foams cost more up front, but are more durable and water/moisture resistant than open cell spray foams. This strength not only helps to insulate building and appliances, but can also strengthen the walls to which it is applied.[9]

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[6] LED Street Lighting Case Study City of Los Angeles (2009) *Clinton Climate Intiative.* https://www.dvrpc.org/energyclimate/eetrafficstreetlighting/pdf/CCI_Los_Angeles_LED_Streetlighting_Retrofit_Program_Report.pdf
[7] City of Springfield Greenhouse Gas Emissions Inventory pg. 11.
[8] Department of Energy. "Types of Insulation." https://energy.gov/energysaver/types-insulation
[9] The Differences Between Open Cell and Closed Cell Polyurethane Spray Foam. https://www.thomasnet.com/articles/plastics-rubber/closed-cell-open-cell/

Calculations

For these calculations, we used the total number of residential houses in Springfield that heat their homes with natural gas because that was what the calculator specified on insulation saver. To add to these reductions, we also decided to insulate commercial properties. We estimated the square footage below using census data from Springfield and then assumed the same categories for residential homes. The R value stands for thermal resistance and depends on the type of insulation, the thickness, and density. The higher the R value the greater the insulating effectiveness.

If you insulate a 1,600 square foot home/building with an R value of 20 using natural gas (60% use natural gas to heat their homes in Springfield) at a cost of $13.70/therm at a fuel efficiency of 80%, with a heat degree value of 6,500 you will reduce carbon emissions by 1,872 pounds annually. There are approximately 66,000 total homes in Springfield and if 60% of homeowners use natural gas to heat their homes then this comes out to 43,560 homes. There are also homes in Springfield that heat with electric, oil and wood. Insulation in these homes could also work to yield greater savings than are calculated here.

If you insulate a commercial building (small retail/warehouse) that is approximately 14,399 square feet (the average size in Springfield) at a cost of $13.70/therm at a fuel efficiency of 80%, with a heat degree value of 6,500 you will reduce carbon emissions by 16,847 pounds annually.

Conservative

Assumed that 50% of the 43,560 homes and the 984 commercial properties get insulated.

*Conversion factor 1 pound CO2e=0.0004 metric tons CO2e

- (0.50) * (43,560) * (1,872 pounds CO2e reduced per building) * (0.0004 metric tons CO2e) = 16,308 metric tons CO2e reduced
- (0.50) * (984 commercial buildings) * (16,847 pounds CO2e reduced per building) * (0.0004 metric tons CO2e) = 3,315 metric tons CO2e reduced

Optimistic

Assumed that 75% of the 43,560 homes and the 984 commercial properties get insulated.

- (0.75) * (43,560) * (1,872 pounds CO2e) * (0.0004 metric tons CO2e)=24,483 metric tons CO2e
- (0.75) * (984 commercial buildings) * (16,847 pounds CO2e) * (0.0004 metric tons CO2e)=4,973 metric tons CO2e[10]

Assumptions

The following assumptions were made when calculating the savings attributed to this strategy:

[10] Insulation savings calculator. http://www.cellulose.org/HomeOwners/CalculateSavings.php

1. The calculator did not specify the type of insulation so reductions could change depending on if spray foam insulation is used
2. Costs will change depending on the square footage of the building
3. Most of the 43,560 homes will be able to get retrofitted for insulation

Overall Savings

This strategy will result in a conservative reduction of 19,623 MT CO2e and an optimistic reduction of 29,456 MT CO2e. This is a 1.6-2.4% reduction from the baseline year.

Strategy #3: Small-scale District Heating with Baystate Combined Heat and Power

Overview

A small scale district heat network allows for valuable energy that is too often wasted in power and industrial generation to be captured and supplied to businesses and households. The waste heat is distributed from a centralized location (boiler or power plant) through underground insulated pipes to residential and commercial facilities. Networks vary in size and length, distributing heat just a few hundred meters between homes to several kilometers supplying communities and industrial areas. For example, waste heat that is usually sent into the sea as a byproduct of incineration plants or combined heat and power plants is pumped through a 1,300 km network of pipes into homes. This removes the need for additional energy generation and decreases energy bills.[11]

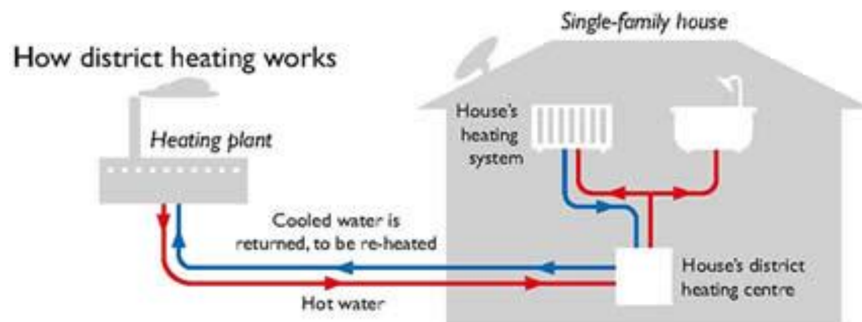

Image 2: A simplified schematic of how district heating works
Source: http://www.linn-energy.co.uk/district-energy/how-district-energy-works.html

Co-benefits

A local example of small scale district heating in Springfield is the heat generation plant for the Baystate Medical complex. Baystate hospital received approval in 2016 to construct a new $27 million 4.6 MW combined heat and power (CHP) plant that is estimated to save $2.7 million.[12] However, linking district heating networks to this facility will be extremely intensive and expensive. Small CHP plants with a 20 year lifetime, have an average electricity generation cost of 3 dollars/MWh. A district heating unit with a lifetime of 20 years will cost around 82 dollars/year for a typical house with a 15 MWh/year heat demand.[13]

[11] Dyrelund et al (2009). *The role of district heating in future renewable energy systems.* 35(3): 1381-1390. http://www.sciencedirect.com/science/article/pii/S036054420900512X
[12] Baystate Health gets OK to build $27 million power plant for cost savings, reduced gas emissions. (2016). *Masslive.* http://www.masslive.com/news/index.ssf/2016/04/baystate_health_set_to_build_2.html
[13] Dyrelund et al (2009). *The role of district heating in future renewable energy systems.* 35(3): 1381-1390. http://www.sciencedirect.com/science/article/pii/S036054420900512X

Formula for minimum cost of a district heating system:

- Cheat=Cvom+Cfuel/nheat-Velect*a+CRF*Cinv+Cfom/t

Cheat=the heat production cost of the plant
Cvom=variable operation and maintenance
Cfuel=fuel cost of the plant
Nheat=efficiency of heat production of the plant
Velect=value of produced electricity of the plant
A=electricity to heat ratio of the plant
CRF=capacity recovery factor of the plant
Cinv=specific investment cost of the plant
Cfom=annual fixed costs of the plant

Calculations

Conservative

Baystate hospital connected to three facilities would reduce carbon emissions by approximately 13,000 metric tons annually. This number was determined from an article published in 2016 titled "Baystate Public Officials Break Ground on $27 million Cogeneration Power Plant".

A study was conducted by cogeneration consultants in 2014 on the importance of cogeneration size. The smallest cogeneration plant size surveyed was 86 kw (approximately 0.086 MW) and the annual power produced on site was 729,461 KWh, the cogeneration utilization was 100%, and the heat recovery potential was 1,314,860 kWh. On the other hand, the largest cogeneration plant size surveyed was 374 kw (approximately, 0.374 MW) and the annual power produced on site was 28,379 kWh, the cogeneration utilization was 2%, and the heat recovery potential was the lowest at 42,442 kWh. In summary, the waste heat generated is a byproduct of the power generation process and heat recovery is only feasible when the generator is on load (low load for a natural gas plant is 50%). The study also found that, on average, 1 MW of electricity can supply roughly 1,000 residential homes. This means that 4.6 MW from the baystate cogeneration plant could supply up to 4,600 residential homes.[14]

Optimistic

Baystate hospital connected to six facilities would reduce carbon emissions by approximately 78,000 metric tons (13,000 metric tons * 6).

Assumptions

The following assumptions were made when calculating the savings attributed to this strategy:

1. Number of districts that the 4.6 MW cogeneration plant could supply with heat and electricity
2. Scale/size of the district
3. The length of the pipes distributing heat and electricity
4. Co-benefits equate to long-term reductions
5. Consistent heat loads/demands

Overall Savings

This strategy could result in a conservative savings of 13,000 MT CO2e and an optimistic reduction of 78,000 MT CO2e—which is between a 1.06 and 6.4% reduction.

[14] Lim, A. (2014). Cogeneration: size does matter. http://www.sustainabilitymatters.net.au/content/energy/article/cogeneration-size-does-matter-1216319359

Case Studies

The cost and primary efficiency of small scale district heating systems was analyzed in the small town of Vaxjo, Sweden (population 66,275 people). They designed a small-scale minimum cost district heating system (DHS) that produces around 100 GWh heat/year. The study found that the smaller the district heat production scale, the greater the district heat production cost and the lesser the scope for the cogeneration of district heat and electricity. Performance and investment costs may influence the selection of technology for new district heating systems. The smallest cogeneration plant surveyed was 14 MW. The investment cost for this plant was 2,310 euros/kW of heat or $2,717 and the fixed O&M cost (includes all fixed operating costs) was 44.4 euros/kW heat year or $52. With small scale district heating systems there are fewer technical options other than heat only boilers due to the high specific investment cost under the small installed capacity of non-heat only boilers. This could mean that a 4.6 MW cogeneration plant would have nearly three times the upfront investment cost.

Strategy #4: Deployment of Solar PV on Commercial Buildings

Overview

According to the Springfield Climate Action and Resilience Plan, the City aims to increase community scale solar generation to comprise 50% of the total energy consumption by 2050.[15] One way to work towards achieving this goal is to encourage commercial business to install solar on their buildings. Encouraging the deployment of solar in the commercial sector is favorable because commercial buildings are often characterized by large flat roofs and vast parking lots—both of which are suitable for in the installation of solar panels. In addition, business owners have a direct interest in lowering their expenses.

Image 3: Solar PV Canopies over a large parking lot similar to the system at Smith and Wesson's Springfield factory. This is one way that large commercial users can install solar on their properties.

Source: https://www.solarworld-usa.com/commercial-and-government/commercial-solar-project-gallery?category=Commercial

Co-benefits

Besides providing clean air and lessening air pollution, installing a solar PV system can also significantly decrease business operating expenses to the point where the savings can eventually pay for the solar PV system. According to EnergySage marketplace data, the average commercial property owner paid $1,950 in monthly electricity bills before going installing solar. After, these expenses were reduced by 75% to around $500, which resulted in monthly savings of $1,400. These savings are all made possible through net metering, which is where businesses with solar PV systems receive credits for generating their own electricity from solar power and return the excess electricity that they don't use back to the grid. The upfront cost of installing a commercial solar system has decreased over the years and is now approximately

[15] Springfield Climate Action and Resilience Plan (2017). Pg. 47.

\$2.95/watt. The expected price range of a 250 kw solar array is between \$397,250 and \$635,250, while the expected price range of a 25 kw solar array is between \$39,725 and \$63,525.[16]

Calculations

According to the Solar Mango calculator, a 1 kW solar array results in 0.73 metric tons CO_2 (means that 1 MW array of solar reduces carbon by 730 metric tons) being reduced.[17] Data from City of Springfield's Assessor's Office was used to categorize buildings that could support either 470 kW arrays or 30 kW arrays. Because of their size, commercial buildings were estimated to support 470 kW solar arrays, while small-scale retail buildings were assumed to support 30 kW solar arrays. The total number of commercial properties in Springfield is 1,122, while the total number of retail properties in Springfield is 236.

Optimistic

The optimistic factor assumes that 60% of the commercial and retail properties install solar panels.

(1,122 commercial properties) * (470kw) * (730 metric tons CO_2e)=384,958,200 metric tons CO_2/1,000=(384,958 metric tons CO_2e) * (0.60)=230,974 metric tons CO_2e reduced

(236 retail properties) * (30kw) * (730 metric tons CO_2e)=5,168,400 metric tons CO_2/1,000=(5,168 metric tons CO_2e) * (0.60)=3,101 metric tons CO_2e reduced

Conservative

The conservative factor assumes that 25% of the commercial and retail properties install solar panels.

(384,958 metric tons CO_2e) * (0.25)=96,239 metric tons CO_2e reduced
(5,168 metric tons CO_2e) * (0.25)=1,292 metric tons CO_2e reduced

Assumptions

1. The calculator settings on Solar Mango (see footnote 18)
2. The 1,122 commercial properties was a combination of warehouses and other large facilities with the "commercial" tab on the Springfield census data. Therefore, we do not know if all of these properties can be categorized as commercial. It seems like an overestimate.
3. We also do not know commercial roof characteristics which is highly important to consider when installing solar because the panels must be facing north south to receive optimum sunlight.

Overall Savings

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[16] Solar Panels for Business: Does Commercial Solar Make Sense? https://news.energysage.com/commercial-solar-benefits-for-business/
[17] Solar Mango. "CO2 Emission Reduction With Solar." http://www.solarmango.com/in/tools/solar-carbon-emission-reduction

This strategy could result in a conservative savings of 156,308 MT CO2e and an optimistic reduction of 234,369 MT CO2e—which is between a 12.8 and 19.2% reduction.

Strategy #5: Ground Source Heat Pumps

Overview

Ground Source Heat Pumps (GSHP), use geothermal energy from beneath Earth's surface to heat and cool homes. The temperature beneath the Earth's surface is relatively constant, which leads to more efficient heating, while significantly reducing carbon emissions. GSHP are able to heat, cool, and supply homes with hot water and can deliver three or four times as much heat as is used in electrical heat energy generation. There are five types of GSHP:

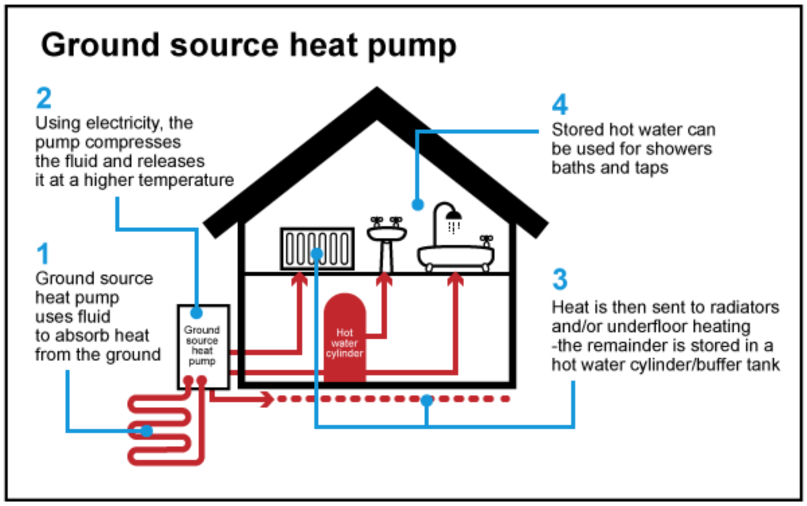

Image 4: A diagram of how ground source heat pumps work.
Source: https://www.clarityheating.com/products-and-services/renewables/ground-source-heating-in-your-home-or-office/

1. horizontal loop system (closed system), which is typically low in cost, but requires a large ground area,
2. spiral loop system, which requires less ground area, but more total pipe length,
3. vertical loop system, which requires less total pipe length, but costs more because of increased drilling equipment,
4. submerged loops, which requires the least total pipe length, but needs a large body of water to operate, and
5. open loop systems, which have lower drilling requirements, simple design, low upfront and operating costs, but are subject to various state and federal clean water codes.[18]

Co-benefits

A geothermal system in an average home of 2,500 square feet with a heating load of 60,000 BTU and a cooling load of 60,000 BTU will cost between $20,000 to $25,000 to install. While there is a high upfront cost, it can reduce utility bills by 50% and the system's lifespan is about 25 years--almost double conventional systems. A GSHP can save up to 40% of the electricity used for heating.

GHG savings = HL * (FI/AFUE * 1000kg/ton-EI/COP * 3600 sec/hr). HL = seasonal heat load, FI = emission intensity of fuel, AFUE = furnace efficiency, COP = heat pump coefficient of performance, EI = emission intensity of electricity.[19]

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[18] Bayer et al, (2012). *Greenhouse gas emission savings of ground source heat pumps in Europe: A Review.* 16(2): 1256-1267. https://www.sciencedirect.com/science/article/pii/S1364032111004771

Additionally programs like MassCEC offer awards to nonprofit and government facilities that install GSHP. Small-scale systems (up to 120,000 BTU/hr) can receive rewards up to $25,000 and commercial-scale systems (over 120,000 BTU/hr) are eligible for up to $250,000. Awards are available for project sites that receive electrical services from National Grid and Eversource, which means that Springfield is eligible for these grants.[20]

Calculations

The calculations for carbon reductions were obtained from the Climate Action Plan (CAP) of Ann Arbor Michigan. In this plan, strategies were listed on the left (pp. 39-48) and on the right were estimated annual CO2 reductions. We have used Ann Arbor's calculations for these calculations.

Assumptions

1. We were unable to identify the source of the calculations from the Ann Arbor CAP but in referencing the total metric tons of carbon reduced we are referring to the savings associated with constructing one ground source heat pump system.
2. We do not know what the cost savings of a home between 1,000-2,000 square feet
3. The size of the GSHP pipes
4. The kind of GSHP system that would be best for Springfield

Overall Savings

Implementing a ground source heat pump will save approximately 26,387 MT CO2e—a 2.1% reduction from the baseline.

Case Studies

A study conducted by *Renewable and Sustainable Energy Reviews* provided an analysis of GSHP technology, with a specific emphasis on loops, ground systems, applications, and cost benefits. As far as cost savings go, the results showed that an open loop GSHP system may cost around $10,000 upfront, while a closed loop system may cost around $20,000 upfront. However, the operating costs of the systems is only around $800, which is considerably lower than conventional heating and cooling systems (usually around $2,000). These costs will likely fluctuate with heating and cooling demand through the seasons. Overall, improved use of hydrothermal resources, limitation of upfront costs, and increased ground heat extraction are keys to a stable development of conventional geothermal energy.[21]

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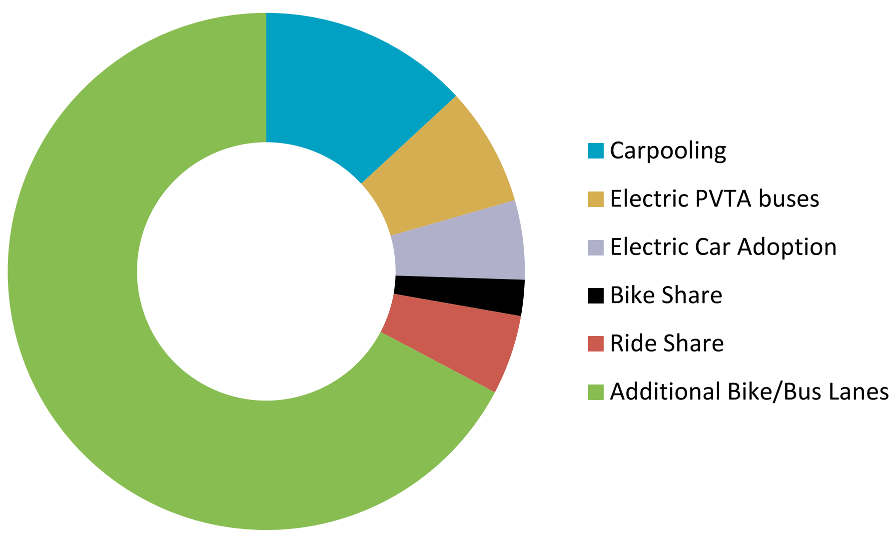
[19] *Ibid., pg. 1261*
[20] Clean Energy Center. "Ground Source Heat Pump Massachusetts." http://www.masscec.com/ground-source-heat-pumps
[21] Omer, A. (2008). *Ground source heat pumps systems and applications.* 12(2): 344-371. http://www.sciencedirect.com/science/article/pii/S1364032106001249

Transportation

Transportation accounts for approximately 29.5% of Springfield's total community emissions—the second largest source of emissions when considering emissions from each building sector separately. This includes on-road vehicles, public transportation and passenger and freight rail. Ninety-nine percent of the emissions from the transportation sector come from on-road vehicles. This includes heavy trucks, light trucks, motorcycles and passenger vehicles. It is assumed that 791, 385,408 miles are driven annually within Springfield's boundaries. These miles driven equate to approximately 351,793 metric tons of CO_2e annually based on the fleet mix and relevant emissions factors. A reduction in vehicle miles driven each year, either by taking transit, walking or bicycling, would result in a direct drop in emissions from the transportation sector. Strategies that make active transportation and public transportation easier and more desirable will be integral to decreasing emissions from on-road vehicles.

Six key strategies were analyzed for reducing emissions in Springfield's transportation sector. In an optimistic scenario, these strategies combined would equal 25% of Springfield's 80% reduction goal. As you can see in Figure 3 below, the implementation of bus and bike lanes and the encouragement of carpooling are likely to generate the largest impact.

Figure 4: Estimated optimistic emission reductions for strategies related to transportation in Springfield



Strategy #1: Electric Vehicle Incentives

Overview

Emissions from the transportation sector account for almost 30% of Springfield's total annual CO_2 emissions. On-road vehicles account for 99% of transportation-sector emissions, so large cuts must be made in this area. One way to do this is to encourage the use of electric vehicles (EVs), as they have far lower lifetime emissions than conventional combustion engine cars. Incentivizing the use of electric vehicles through free and reserved parking, widely available charging stations, and High Occupancy Vehicles (HOV)/Electric Vehicle (EV) car lanes inside and outside the city center can make driving EVs more attractive and increase the number of EV drivers. These changes could result in at least 1,200 MT of CO_2e (conservative) and up to 12,000 MT of CO_2e reductions (optimistic).

Image 5: Prioritized parking for owners of electric vehicles is one type of incentive that could be offered by the city.
Source: https://www.greencarreports.com/news/1099264_illinois-bill-to-fine-car-owners-who-park-in-electric-car-charging-spaces-waits-for-governors-signature

The efficiency of electric vehicles is likely to increase rapidly in the future, as is their range, making them more attractive to consumers and more efficient with electricity. Changes in electricity source towards more renewable energy will also improve the efficiency of vehicles. Solar charging stations can also improve the efficiency of EVs and can make them virtually emission-free.[22]

Co-benefits

Electric vehicles have significantly lower lifetime and operational CO_2 emissions, and also offer a host of other benefits. Electric vehicles are much quieter than conventional combustion engine vehicles, and their lack of emissions means that they do not contribute to air pollution. With an increase in electric vehicle usage in the city, there will also be an increase in air quality and pollution control and generally quieter streets.

Assumptions

- Estimated that 58,656 people are commuting in Springfield every day, 75% by single-occupancy vehicles.[23] Therefore, the number of people driving alone to work is 43,992.
- Average commute time: 21.2 minutes[24]

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[22] http://www.envisionsolar.com/ev-arc/
[23] Springfield Climate Action and Resilience Plan. 2017.
[24] Data USA. https://datausa.io/profile/geo/springfield-ma/. 2015.

- Assume each commute trip is 12 miles in the commute time (average speed of about 34 mph). Round trip commute is estimated to be 24 miles/day
- Assume that every electric vehicle incentivized/increased is one fewer gasoline car driving the commute
- Assume that there are 260 workdays in a year[25]
- Assume charging emissions from a Nissan Leaf, a median-range EV
- Assume car is used only for commuting 24 miles/ day--car only needs charging once every 2 days and only for the 260 work days per year

Calculations

The purpose of this calculation is to estimate the effect of increased electric car use on greenhouse gas production in the city. To make this calculation, the distance and the number days driven need to be estimated for each electric car.

Number of electric vehicle commute miles per year =
(# electric cars) * (number of daily commute miles) * (number of workdays per year)

Estimated MT CO2 reduced =
(#miles) * (emissions factor 0.3916 kg/mile) * (0.001)

Table 2. CO2 reductions scenarios for increased electric vehicle usage in Springfield.

Number of electric vehicles increased	Number of conventional car miles decreased	MT CO2 reduced per year	MT CO2 reduced after charging emissions are counted (MT)
250	1,560,000	611	608
500 (Conservative)	3,120,000	1,222	1,217
1000	6,240,000	2,444	2,434
5000 (Optimistic)	31,200,000	12,218	12,167

Table 2 shows that reductions in CO2e emissions from the transportation sector decrease as the adoption of electric vehicles increases. While CO2e reductions in EV usage can be lessened from emissions related to charging the vehicles, this is minimal, and EV use still results in significant CO2e emissions reductions. Calculations for the emissions related to charging electric vehicles are shown in Table 3.

Electric vehicle emissions per charge =(Emissions per mile) * (range of vehicle)

[25] U.S. Office of Personnel Management. https://www.opm.gov/policy-data-oversight/pay-leave/pay-administration/fact-sheets/computing-hourly-rates-of-pay-using-the-2087-hour-divisor/

Table 3. EV Charging emissions for electric vehicles		
kWh required for full charge	Emissions per mile (g CO2e)	Total emission per full charge
Nissan LEAF 2017-- 30	96[26]	10,272g (0.010 MT)
Tesla Model S 75D-- 32	102[4]	28,050g (0.028 MT)
Chevrolet Bolt-- 28 kWh	89[27]	21,182g (0.021 MT)

This table shows the emissions related to charging three of the most popular EVs on the market today, charged through non-renewably sourced electricity. These emissions are quite small, especially when compared to the overall reductions of CO2 when EVs are used instead of traditional combustion-engine vehicles.

<u>Overall Savings</u>

This strategy could result in a conservative savings of 1,217 MT CO2e and an optimistic reduction of 12,168 MT CO2e—which is between a 0.09 and 0.99% reduction from the baseline year.

<u>Case Studies</u>

The country of Norway has successfully used electric car incentives to quickly increase the number of EV owners in the country. The main incentives used in Norway were monetary. The government exempted EVs from import and value-added taxes, making them much more affordable, and also began programs that opened HOV lanes and cleared toll charges for electric vehicles. These measures have almost doubled the amount of electric vehicles registered in Norway every year since 2010, and the country now has the greatest number of electric vehicles per capita in the world.[28] While these programs were largely effective in encouraging EV usage and lowering GHG emissions, they also resulted in a loss of government revenue by lowering the number of people paying tolls and parking fees.

Strategy #2: PVTA Revamp

<u>Overview</u>

The Pioneer Valley Transportation Authority (PVTA) is the only public transportation system operating in Springfield, and Springfield has the highest rider density for the entire PVTA system, filling the system to capacity on almost all Springfield routes. Still, with improvements to the PVTA system within Springfield, and route and frequency expansions, ridership could be increased. Increased ridership would lead to fewer cars on the road and decrease the amount of combustion-engine emissions in Springfield. Suggested improvements include replacing the current diesel fleet with electric buses, increasing the amount of bus

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[26] Plug in America. 2014. https://pluginamerica.org/how-much-does-it-cost-charge-electric-car/

[27] Union of Concerned Scientists. http://www.ucsusa.org/clean-vehicles/electric-vehicles/ev-emissions-tool#z/01199/2017/Chevrolet/Bolt

[28] Aasness and Odeck. *The increase of electric vehicle usage in Norway-- incentives and adverse effects.* 2015.

shelters, and increasing the amount of night routes and service to low-income neighborhoods throughout the day and night. These improvements could reduce CO2 emissions from buses by 18, 260 MT. Additionally, there could be savings between 5,753 and 32,250 MT CO2e from increase choice ridership (those electing to take the bus instead of driving). Combined these could save between 24,013 MT CO2e (conservative) and 50,510 MT CO2e (optimistic). A large portion of these reductions come from the implementation of electric buses.

Image 6: PVTA currently operates a Proterra bus on a line that travels from Holyoke to Springfield.
Source: https://www.proterra.com/our-story/our-customers/

Co-benefits

Improving the bus system comes along with many co-benefits. Decreasing the amount of drivers on the road improves air quality and decrease noise and traffic in the city. Implementing electric buses also helps to improve air quality and noise, as electric buses have zero engine emissions. Electric buses also save money over time, as they have lower lifetime maintenance costs and can last, on average, six years longer than conventional diesel buses. Electric buses may also help increase bus ridership on their own, as they offer quieter, more pleasant rides that can attract new riders.

Calculations

Replacing old buses with electric vehicles on their current replacement time schedule:

Emissions reductions for one 40’ bus: 243,980 lbs/year[29]

[29] https://www.proterra.com/

Table 4: Replacement schedule for PVTA vehicles and CO_2 reductions associated with electric bus replacements.		
Fiscal Year	**Number of buses to be replaced**	**Total amount of CO_2 reduction (MT) per year**
2018	0	0
2019	**11(35'), 15 (40'),** 5 (60')	2877
2020	**5 (40'),** 8 (60')	553
2021	**10 (40'),** 4 (shuttle vans)	1106
2022	**15 (35'), 5 (40')**	2213
2023	**6 (40')**	664
2024	**16 (35'), 15 (40')**	3430
2025	**6 (35'), 22 (40')**	3098
2026	**11 (40')**	1217
2027	**8 (40'),** 4 (60')	885
2028	**10 (35'), 10 (40')**	2213
Total	**165 buses**	**18,260 Metric Tons reduced in the year 2028**

** the bolded numbers are counted to be replaced with an electric bus. Only 35' and 40' buses are calculated because those are the models that Proterra makes.

Table 5: CO_2 reductions from increased bus ridership and associated decreases in commuter cars		
Single drivers switching to public transportation (%)	**Number of car commuters reduced per day**	**MT of CO_2 reduced per year**
5	2,199	5,373
10	4,399	10,749
20	8,798	21,499
30	13,198	32,250

Assumptions

- Assumed that if we decrease single-passenger commutes by 5% by 2022, by 10% by 2030, by 20% by 2050, that bus ridership will increase by the same amount of people
- Current bus ridership: 5.2% of 58,626 commuting residents= **3,048 people per workday**[30]
- Current number of people driving alone to work: **43,992**
    - -5% = 41,792.4 people
    - -10% = 39,592.8 people
    - -20% = 35,193.6 people
    - Assumptions: 58,656 people commuting every day, 75% by single-rider cars
- Assumed that a decrease in single-passenger commutes by 5% by 2022, by 10% by 2030, and by 20% 2050, would produce a corresponding increase in bus ridership Current bus ridership: 5.2% of 58,656 commuting residents= **3048 people per workday**
- Increasing PVTA ridership may, at some point, require an investment in a larger fleet to service the area. A larger fleet would increase the amount of emissions related to public transportation. However, even if the investments were made with conventional diesel buses, carbon emissions would be lower than carbon contribution from the equivalent number of single drivers.

Overall Savings

It is expected that replacing all of the PVTA buses to electric buses will result in an 18,260 MT CO2e reduction. Additionally, it is assumed that those who do not ride the bus may be enticed to after these upgrades. This shift is projected to conservatively reduce CO2e emissions by 5,753 MT and will optimistically reduce CO2e emission by 32,250 MT. This strategy could yield a 1.9 - 4.1% reduction in emissions from the baseline year.

Case Studies

Studies on electric bus implementation in Putrajaya, Malaysia, concluded that electric bus operation outperforms that of conventional buses, but the most desired ridership and CO2 reduction scenarios are achieved through thoughtful route design, and with fast charging stations.[31] In Cleveland, Ohio, the installation of a rapid transit lane for buses along the main commuter route in the city increased bus ridership by 67% in 5 years along the route. Although uncalculated, this dramatic increase in commuter bus usage has certainly lowered CO2 emissions from commuter cars in the City and helped to improve air quality. The addition of a bus rapid transit (BRT) lane shortened commute time from 40 to 28 minutes, which no doubt continued to attract new bus riders and reduced car miles driven in the city. As Cleveland has continued to implement new rapid transit lanes, these trends have held steady, and the city has seen significant ridership increases along rapid transit corridors.[32]

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[30] Springfield Climate Action and Resilience Plan. 2017.
[31] Teoh, et. al. Scenario-based electric bus operation: A case study of Putrajaya, Malaysia. 2017.
[32] Environment Massachusetts. *100% Renewable Boston.* 2017.

Strategy #3: Carpooling and trip-chaining

Overview

About 75% of daily commuters into Springfield drive alone in cars.[33] Encouraging people to participate in carpooling and trip-chaining programs would reduce the amount of commuter cars on the road and contribute to emissions reductions. We suggest that Springfield implement a city-wide carpooling program connected to a website and smartphone application, and implement and publicize park-and-ride areas outside of the city. Partnering with local businesses in Springfield will be key to encouraging the use of these programs. The City should encourage local businesses to help their employees find carpooling opportunities within and between companies, and provide incentives such as reduced parking rates for carpooling vehicles. With the successful implementation of such programs, we estimate that between 1,200 MT (conservative) and 12,000 MT (optimistic) of CO2e can be reduced per year by reducing the amount of cars on the road.

Co-benefits

Increasing carpooling and trip-chaining with the aim to reduce the number of cars on the road can also help to improve air quality and limit car traffic as well as reduce the pressure on parking areas. These initiatives also create opportunities for community building between individuals, businesses, and neighborhoods.

Calculations

Number of single driver commute miles decreased per year =

(# single car drivers) * (number of daily commute miles) * (number of workdays per year)

Number of MT CO2 emitted from miles driven =

(#miles) * (emissions factor 0.3916 kg/mile) * (0.001)

Table 6: Emissions reductions from decreasing the number of single-car drivers			
Number of single car drivers decreased	Number of single driver commute miles decreased	CO2e reduced per year (MT)	Total CO2e output per year (MT)
250	1,560,000	611	351,182
500	3,120,000	1,222	350,571
1,000	6,240,000	2,444	349,349
5,000	31,200,000	12,218	339,575

[33] Springfield Climate Action and Resilience Plan. 2017.

Assumptions

- Average commute time: 21.2 minutes[34]
- Assume they drive 12 miles in that time (average speed of about 34 mph), assumed that is a one-way trip-- round trip commute is estimated 24 miles/day
- Assumptions: 58,656 people commuting every day, 75% by single-rider cars
- Assume that there are 260 workdays in a year[35]
- Assume and emissions factor of 0.3916 kg/mile

Overall Savings

This strategy could result in a conservative savings of 1,222 MT CO2e and an optimistic reduction of 12,218 MT CO2e—which is between a 0.1 and 1% reduction from the baseline year.

Case Studies

The City of Stockholm, Sweden was one of the first cities to introduce carpooling and car sharing initiatives in an effort to cut down on traffic in the city and limit CO2 emissions. The city implemented car sharing clubs in and around the city, and granted access to bus lanes for cars with three or more passengers. This helped to increase the amount of commuter cars carrying 3 or more passengers in the first years of the program by 6%.

Strategy #4: Bike-Sharing

Overview

A new bike-sharing program will be launched in the City of Springfield in April 2018, bringing 500 pedal-assist bikes into the city. Bike-share memberships will be available for purchase. With this strategy, we suggest that the number of pedal-assist bikes be increased in the future to further amplify the emission-decreasing effect of bike-sharing systems. The conservative estimate provided above reflects the use of the pedal-assist bikes (approximately 500 estimated daily trips) already coming to Springfield, while the optimistic estimate calculates the carbon emission equivalents savings for bikes used for 2,000 daily trips within the boundaries of Springfield.

Image 7: Valley Bike Share is set to launch in Spring of 2018, with pedal assist bikes in Springfield and other towns across the Pioneer Valley.
Source: http://www.richmond.com/news/local/city-of-richmond/city-signs-deal-with-bike-share-vendor-hopes-to-open/article_e2eb1dbc-a351-5c73-a05a-cce15ad5ba20.html

Co-benefits

[34] Data USA. 2015. https://datausa.io/profile/geo/springfield-ma/
[35] U.S. Office of Personnel Management. https://www.opm.gov/policy-data-oversight/pay-leave/pay-administration/fact-sheets/computing-hourly-rates-of-pay-using-the-2087-hour-divisor/

A bike-sharing system would decrease the number of cars on the road, therefore improving traffic conditions. Less traffic will result in better air quality in the city, as well as decrease noise pollution. This intervention will also free up parking demand and ease traffic associated with searching parking spaces.

Additionally, the implementation of a bike-sharing system would bring with it a host of health benefits to the community. Encouraging Springfield's citizens to bike to work will provide a source of cardiovascular exercise, improving health and fitness among the population. We also suggest the implementation of incentives by local companies and business, who could provide passes to their employees for free if they were to bike instead of drive to work.

Calculations

- 21,665 people commuting within city = 36.95% of commuters (out of 58,626)
    - 75% driving alone = 16,249 people
    - 0.03% biking = 650 people
- 791,385,408 miles driven within boundaries of Springfield every year, 351,793 MT CO2e
    - Each mile = approx. 0.0004445 MT CO2e
    -

Table 7: MT CO2e reduced by people switching to biking commutes, based on mileage				
People Switched to Biking (from 16,249 people who are driving alone to commute within city)	**Mileage Saved by Biking (assuming 24 mi/day average commute w/i city)**	**MT CO2e Reduced (mileage x 0.0004445 MT/mi)**	**¾ Mileage Saved by Biking (no biking in winter)**	**MT CO2e Reduced (for ¾ mileage)**
200	1,248,000	554	936000	416
500	3,120,000	1,386	2340000	1,040
1,000	6,240,000	2,773	4680000	2,080
2,000	12,480,000	5,547	9360000	4,160

Assumptions

- Average commute time: 21.2 minutes[36] and that a commute round trip averages 24 miles each day (average speed of about 34 mph). Assume they drive 12 miles in that time, assumed that is a one-way trip-- round trip commute is estimated 24 miles/day
- Assumptions: 58,656 people commuting every day, 75% by single-rider cars
- Assumes 260 workdays in a year[37]
- Assumes an emissions factor of 0.3916 kg/mile

[36] Data USA. https://datausa.io/profile/geo/springfield-ma/
[37] U.S. Office of Personnel Management. https://www.opm.gov/policy-data-oversight/pay-leave/pay-administration/fact-sheets/computing-hourly-rates-of-pay-using-the-2087-hour-divisor/

Overall Savings

This strategy could result in a conservative savings of 1,387 MT CO2e and an optimistic reduction of 5,5547 MT CO2e—which is between a 0.11 and 0.45% reduction from the baseline year.

Case Studies

The City of Portland, Oregon created a Climate Action Plan addressing their greenhouse gas emissions, and featured the role of bike/bus lanes and bike-share systems in their central goals. The Portland CAP connected these expansions to the establishment of "complete communities": communities where all the necessities for living (i.e. food, health care, schools, etc.) are within walking or biking distance for all residents, reducing the need for cars in order to live satisfactory lives.[38]

A study done in Helsinki also concluded the importance of bike-share systems to decrease greenhouse gas emissions. This study developed a hypothetical bike-sharing system in the greater Helsinki area, and from this model predicts its effect on travel times for different modes public transportation. Researchers concluded that by pairing a bike-share system with traditional modes of public transportation, sustainable methods of transportation (biking, walking, etc.) would become more attractive in urban settings.[39]

Lastly, a study done on the impacts of bike-share systems insists that bike-share programs are most successful when accompanied by pro-cycling, pro-sustainable mobility.[40] As the bike-share program is implemented and expanded in Springfield, it's important that the City keep in mind additional factors that contribute to the success of an initiative.

Strategy #5: Bike/Bus Lanes

Overview

Most Springfield citizens live within biking distance of their place of work, but choose not to bike due to significant safety concerns.[41] Crowded streets and exhaust-heavy traffic deter people from using their bikes to get to work. A number of studies (cited below) show that the establishment of bike and bus lanes in cities encourages people to use the bus or ride their bike to work. Bike/bus lanes are an expensive investment, but provide long term benefits by magnifying the effects of other interventions, including bike-share systems. Springfield currently has 2.5 miles of bus lanes, and has already set a goal of reaching 10 miles by 2020.[42] The conservative estimate above provides the number of metric tons of CO2e reduced if 20 miles of

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[38] Portland Climate Action Plan. https://moodle.smith.edu/pluginfile.php/419221/mod_resource/content/1/Portland%20OR%202015%20Climate%20Action%20Plan.pdf

[39] Jäppinen, Sakari, Tuuli Toivonen, and Maria Salonen. "Modelling the Potential Effect of Shared Bicycles on Public Transport Travel Times in Greater Helsinki: An Open Data Approach." *Applied Geography*.

[40] Ricci, Miriam. "Bike Sharing: A Review of Evidence on Impacts and Processes of Implementation and Operation." *Research in Transportation Business & Management*.

[41] Institute for Transportation and Development Policy. https://www.itdp.org/a-global-high-shift-cycling-scenario/

[42] Resilient Springfield. http://resilientspringfield.org/bike-lanes/

bike/bus lanes were to be established in Springfield, while the optimistic estimate reflects 30 new miles of bike/bus lanes.

Co-benefits

Providing designated lanes for buses and bikes helps to keep buses running on time - therefore encouraging people to ride the bus - and will additionally ease traffic in the city. Fewer cars on the street will improve air quality. This intervention will have significant impacts on public health and safety as well, by providing cyclists a safe, and time-efficient way to commute to work.

Calculations

The table below reflects the calculations made for the conservative and optimistic estimates provided at the beginning of this section. The table reflects the compounding of mileage and corresponding CO2e emissions, because the CO2e total reductions per mile increases as the mileage of bike/bus lanes increases.

- Approximately 1.7% reduction in GHG emissions (in transportation sector) for every 7% increase in bike lane/route mileage[43]
    - 351,793 MT CO2e emitted every year (by transportation sector)

- The table below reflects the following equations, based on the information provided above:
    - "miles of bike lanes" = previous "miles of bike lanes" + (previous "miles of bike lanes" * 0.07)
    - "CO2e reduction" = previous "CO2e emissions total" * 0.017
    - "CO2e emissions total" = previous "CO2e emissions total" - "CO2 reductions"

Table 8: Emission reductions associated with the installation of bike lanes.		
Miles of Bike Lanes	**CO2e Reduction (MT)**	**CO2e Emissions Total (MT)**
2.5	–	351,793
4.9	5,152	296,361
10.4	4,244	245,420
15.5	3,829	221,428
20.4	3,576	206,750

[43] Seyed et al. "Exploring the link between the neighborhood typologies, bicycle infrastructure and commuting cycling over time and the potential impact on commuter GHG emissions."
Science Direct. http://www.sciencedirect.com/science/article/pii/S136192091630270X

Assumptions

- Approximately 1.7% reduction in GHG emissions (in transportation sector) for every 7% increase in bike lane/route mileage
- 351,793 MT CO2e emitted every year (by transportation sector)
- Currently 2.5 miles of bike lanes (on roads, 2013 base year) in Springfield
- Goal of Resilient Springfield is to construct 10 miles by 2020[44]

Overall Savings

This strategy could result in a conservative savings of 145,043 MT CO2e and an optimistic reduction of 165,255 MT CO2e—which is between an 11.9 and 13.5% reduction from the baseline year.

Case Study

The City of Portland, OR created a Climate Action Plan to address reductions to their greenhouse gas emissions, and put great emphasis on the role of bike-share programs and bike/bus lane infrastructure to cut overall emissions. These ideas fed into their goal of creating more "complete communities" (as discussed under the bike-sharing initiative case studies). Portland's CAP proposes improving street structure and planning in order to facilitate biking and walking safety, and increasing bikeways and bike-sharing. Additionally, there are plans to increase funding for transit to increase the number of lines and create youth transit passes and heightened accessibility to transit from affordable housing units.[45]

The numbers used in the calculations for this initiative were taken from a study conducted in Montreal, Canada. This study examined the progression of urban cycling in the city, and concludes that cycling-focused initiatives (specifically the establishment of bike/bus lanes) could have as much effect as transitioning all buses to hybrids, and all rails to electric power.[46]

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[44] Resilient Springfield. http://resilientspringfield.org/bike-lanes/

[45] City of Portland Climate Action Plan. https://moodle.smith.edu/pluginfile.php/419221/mod_resource/content/1/Portland%20OR%202015%20Climate%20Action%20Plan.pdf

[46] Seyed et al. "Exploring the link between the neighborhood typologies, bicycle infrastructure and commuting cycling over time and the potential impact on commuter GHG emissions." *Science Direct*. http://www.sciencedirect.com/science/article/pii/S136192091630270X

Solid Waste and Water

Emissions from processing solid waste from the City of Springfield were a minor portion (0.7%) of Springfield's overall greenhouse gas emissions. The majority of emissions in the solid waste sector are emitted from the combustion of solid waste at the Covanta-Springfield facility in Agawam. In 2015, a total of 7,672.34 metric tons of CO2e were emitted based on the 38,357 tons of rubbish sent to the incinerator from residents of Springfield. (Note that this figure does not account for rubbish collected by private contractors at businesses and multi-family buildings in Springfield, some of which may also be incinerated at Covanta-Springfield but is not collectively tracked.) Residential trash pickup in Springfield also generates greenhouse gas emissions itself. This includes transport of the trash to the Covanta facility, and fuel burned by dump trucks collecting trash from neighborhood streets. The combined greenhouse gas emissions between transport and collection emissions are 767.17 metric tons of CO2e. In 2015, 8,228.02 tons of organic yard waste was composted at Springfield Regional Compost Site on Bondi's Island, the biological process of which generated 616.410 metric tons of CO2e. Since ash is inert, no 2015 emissions are recorded from this source.

The distribution/collection and processing of water and wastewater consume electricity and generate other sources of greenhouse gas emissions within the city. Electricity used to process the City of Springfield's wastewater is the largest generator of greenhouse gas emissions within the Water/Wastewater sector of this inventory, generating 5,117.76 metric tons of CO2e in 2015.The de-nitrification process (removal of nitrogen) at the wastewater treatment plant also generates 415.18 metric tons of CO2e.

While an overall minuscule portion of Springfield's greenhouse gas emissions, reductions from the solid waste and water sectors will be important in reaching the 80% reduction goals. The reduction of waste diverted from the landfill and stormwater that must be treated at Springfield's wastewater treatment plant are two of the primary strategies of focusing in reducing emissions from these sectors.

Strategy #1: Plant 66,000 trees

Overview

The five natural disasters (all classified as national disasters) that struck Springfield between 2011-2013 decimated the City's trees.[47] Through the process of photosynthesis, trees take in CO2 from the atmosphere and sequester it in their biomass. Planting additional trees can therefore increase the City's carbon "sinks" and offset emissions from other sectors. A lack of a tree canopy is a major vulnerability because it increases the demand on grey infrastructure to handle stormwater. Green infrastructure slows the movement of water and allows it to gradually filter back into the ground as opposed to the current system of grey infrastructure that quickly becomes overwhelmed in heavy precipitation events. When grey infrastructure fails, it results in flooded streets, an overwhelmed wastewater treatment plant, and combined sewer overflows, all of which interrupt a City's ability to function properly.

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[47] Springfield Climate Action and Resilience Plan. 2017. Pg 9.

As Springfield's CARP outlined, a few of the expected impacts of climate change in Western Massachusetts include an increase in the number of heavy precipitation events and higher temperatures. The Northeast Climate Impacts Assessment estimated that annual precipitation in New England could increase by as much as four inches per year by 2100. The same report also found that rainfall is expected to become more intense and periods of heavy rainfall are expected to become more frequent.[48] Given that trees can help slow and filter the runoff created by heavy precipitation events, the city identified the goal of planting a total of 66,000 new trees before 2060 as a primary goal. In the citywide survey asking residents what climate actions should be prioritized, increasing the number of shade trees and improving the health of existing trees tied for first place, indicating there would be considerable support from citizens. The plantings would occur in phases: 5,000 new trees on public property and 5,400 trees on private property by 2022 and an additional 55,000 trees on public property by 2060 (CARP, pg 54). If this goal is met, the City will save 1,320 MT CO2e per year.

Co-benefits

The co-benefits associated with increasing the City's tree canopy are extensive. Trees function as green infrastructure by slowing the movement of surface runoff and reducing demand on the wastewater treatment plant during heavy precipitation events. A common occurrence during heavy rain events are combined sewer overflows (CSOs) and investing in green infrastructure is a way to reduce the number of CSOs in Springfield. Planting trees also overlaps with the City's commitment to improving the Urban Watershed Resilience Zone as a way to address the impacts of climate change. An increase in the City's tree canopy will also mitigate the urban heat island effect, particularly in the downtown, and improve air quality all over the city.

Calculations

0.02 MT CO2e per year per tree * 66,0000 trees= 1,320 MT CO2e per year

Assumptions

The numbers used to estimate the amount of CO2 sequestered per tree planted in Springfield came from a study by Nowak and Crane (2001).[49]

- Springfield has a similar climate to Boston and trees will generally sequester the same amount of CO2 in each city
- Carbon storage per tree can vary depending on local conditions
- Boston has a net annual sequestration (tons of carbon per year) of 6,900
- There are 1,183,000 trees in Boston
- 6,900 tC per year / 1,183,000 trees = 0.006 tC per year per tree
- 1 ton of carbon = 3.67 tons of CO2[50]

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[48] Union of Concerned Scientists. "Northeast Climate Impacts Assessment- Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions." http://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/pdf/confronting-climate-change-in-the-u-s-northeast.pdf

[49] David J. Nowak and Daniel E. Crane. "Carbon storage and sequestration by urban trees in the USA," 2001. *Environmental Pollution*. https://ac.els-cdn.com/S0269749101002147/1-s2.0-S0269749101002147-main.pdf?_tid=f65d4de2-e2a5-11e7-866c-00000aab0f6b&acdnat=1513458989_9715c11d2389729f2815d13067a46283

- $0.006 tC * 3.67 = 0.022 tCO_2$ per year
- $0.022 tCO_2 = 0.02 MT CO_2$

Overall Savings

This strategy could result in a savings of 1,320 MT CO_2e—which is a 0.10% reduction from the baseline year.

Case Studies

Cambridge, MA and Pittsburgh, PA both have urban forestry plans that could help provide a model for Springfield. In partnership with Earthwatch, Cambridge's Department of Public Works published an Urban Forestry Management Plan that summarizes the City's policies, goals, and targets for the city to achieve, like planting trees in 65% of the open tree grates by 2020.[51] Pittsburgh has also gone through an extensive planning process to create a master urban forest plan with values that align with Springfield's CARP, including engaging with residents, forming partnerships with local agencies, and equitably planting the trees.[52]

Strategy #2: Composting

Overview

Springfield's Greenhouse Gas Emissions Inventory found that 9,089 MT CO_2e are emitted from the processing of 129,715 tons of solid waste (SW) annually. To reduce the amount of waste generation, the city should adopt a composting program to divert food waste being sent to the Covanta incinerator. Quantum Biopower, a company based out of Southington, CT, is working with the City of Holyoke to install an anaerobic digester that has the capacity to handle Springfield's waste as well. Anaerobic digestion is a biological process that breaks down organic material in the absence of oxygen to create biogas. The biogas, which is mostly methane, can then be used to generate electricity, heat buildings, or power vehicles. The end product is a biosolid that can be used as fertilizers on fields.[53] Diverting food waste to an anaerobic digester reduces CO_2e emissions by more efficiently capturing the methane in organic matter and using it to generate power that otherwise may be generated by burning fossil fuels. Quantum Biopower installed an anaerobic digester in Southington, CT in 2016 that can divert 40,000 tons of food waste from the solid waste stream.

Co-benefits

Two primary co-benefits of capturing food waste and processing it in an anaerobic digester are (1) the generation of electricity and (2) the reduction of wet solids being sent to the Covanta incinerator. At capacity, the Southington anaerobic digester will produce enough methane to generate 1.2 MW of electricity

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[50] ThinkProgress. "The biggest source of mistakes: C vs. CO2." https://thinkprogress.org/the-biggest-source-of-mistakes-c-vs-co2-c0b077313b/

[51] EarthWatch Institute. "City of Cambridge, Massachusetts Urban Forest Management Plan- Current State of the Urban Forest." https://www.cambridgema.gov/~/media/Files/publicworksdepartment/Forestry/2016/earthwatchinstitutereports/Urban-Forest-Management-Plan-Section-2_.pdf?la=en

[52] Tree Pittsburgh. "Pittsburgh Urban Forest Master Plan." https://www.treepittsburgh.org/resource/pittsburgh-urban-forest-master-plan/

[53] Quantum Biopower. "Anaerobic Digestion." http://www.quantumbiopower.com/clean-energy/anaerobic-digestion/

each year.[54] This will help to offset the slight reduction in power generated by Covanta as a result of the diversion of food waste. Additionally, diverting food waste helps the Covanta incinerator operate more efficiently because food waste tends to be dense and wet, which requires more energy to burn.

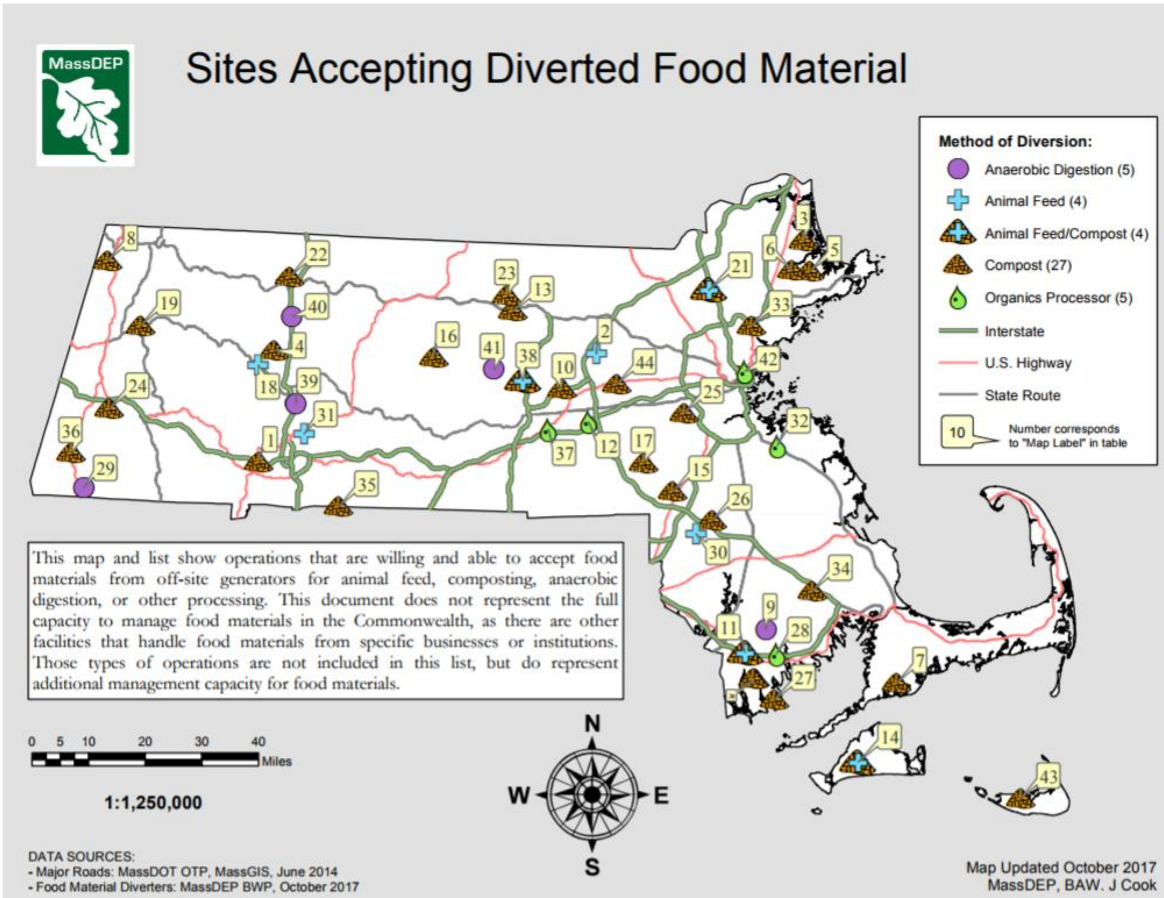

Image 8: There are currently five Anaerobic Digesters in the state that are able to accept diverted food material.
Source: http://www.mass.gov/eea/docs/dep/recycle/reduce/06-thru-l/fdcomlst.pdf

Calculations

Conservative

- Capture 50% of food waste (14,269 tons)
- 0.115 MT CO2 * 14,269 tons = 1,641 MT CO2e per year

Optimistic

- Capture 100% of food waste (28,537 tons)
- 0.115 MT CO2 * 28,537 tons = 3,282 MT CO2e per year

Assumptions

- 22% of solid waste is food waste– Springfield generates 129,715 tons of solid waste so approximately 28,537 tons is food waste[55]

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[54] Quantum Biopower. "Quantum Biopower commissions 1.2 MW CHP unit." http://www.quantumbiopower.com/about-us-2/news/quantum-biopower-commissions-12-mw-chp-unit/

- Anaerobic digester in Southington, CT avoids 5,080 tCO2 per year and has a capacity of 40,000 tons[56]
- 5,080 tCO2e / 40,000 tons = 0.127 tCO2e avoided per ton of waste
- 0.127 tCO2e = 0.115 MT CO2e

Overall Savings

This strategy could result in a conservative savings of 1,641 MT CO2e and an optimistic reduction of 3,282 MT CO2e—which is between a 0.13 and 0.26% reduction from the baseline year.

Case Studies

Springfield can look to nearby West Hartford, CT for a curbside composting model. The city is currently testing out a 15-week pilot program on 130 homeowners in the hope to divert food waste from incineration and landfills. The participating residents each received "caddies" for their kitchens and a brown bin that they bring to the curb each week for pickup. A garbage truck then brings the waste to the anaerobic digester in Southington. The trial program that began in October 2017 is made possible through the combined efforts of the city, Quantum Biopower, Covanta (the city's waste contractor), and Paines, Inc. (the city's garbage hauling company). The three companies are covering the cost of the trial program to make it free for the participants.[57]

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55 Hartford Courant. West Hartford Launches Curbside Food Waste Recycling Program."
"http://www.courant.com/politics/hc-news-ct-food-waste-recycling-20171018-story.html

56 Quantum Biopower. "Services." http://www.quantumbiopower.com/services/

57 Hartford Courant. West Hartford Launches Curbside Food Waste Recycling Program." http://www.courant.com/politics/hc-news-ct-food-waste-recycling-20171018-story.html

State and Federal Regulatory Interventions

There are state and federal agreements and regulations, that if upheld will result in greenhouse gas emission reductions. These reductions will reverberate down to the local level and thus should be considered contributors to Springfield's reduction goals. Given the tumultuous political times, there is concern that these existing regulations and commitments could be rescinded or rolled back in scale. Thus, it is important that both the city and its citizens advocate at the state and federal levels for the continued support of these regulations.

The two regulations that are expected to have the greatest impact on greenhouse gas emissions reductions in Springfield are the Regional Greenhouse Gas Initiative (which is a state adopted regulation) and the Corporate Average Fuel Economy (CAFÉ) Standards (which are federal mandates). Combined, the implementation of these two policies are expected to optimistically reduce emission in Springfield by 36% or 348,714 MT CO2e.

Regulatory Intervention 1: Regional Greenhouse Gas Initiative

<u>Overview</u>

The Regional Greenhouse Gas Initiative (RGGI) was established in 2009 and is the first mandatory market based greenhouse gas reduction program based in the United States. RGGI comprises the nine states of Massachusetts, Maine, Delaware, Connecticut, Rhode Island, New York, New Hampshire, Vermont, and Maryland. The goal of RGGI is to cap and reduce CO2 emissions from the power sector.

<u>Co-benefits</u>

The current emissions cap as of 2014 for all nine states is 91 million metric tons of CO2. These CO2 allowances are distributed primarily through regional auctions. The revenue that Massachusetts obtains from the allowances, which are anticipated to sell for a few dollars each, will be used to fund energy efficiency projects. A number of program details will limit prices and price volatility. These programs include offset allowances, three year compliance periods, early reduction allowances, and trigger events. By capping the electricity sector RGGI will significantly reduce the amount of energy demanded from fossil fuels, will give consumers over their energy use and cost, and will create more jobs for contractors, architects, and engineers. On a regional level, investments in energy efficiency drive down overall electricity demand, improving electricity system reliability, and reducing wholesale electricity prices.[58]

<u>Calculations</u>

According to RGGI, all nine states must reduce 30% of the emission cap by 2030 from 2020 levels. As of now, all nine states have reduced 20% of the emission cap, which equates to approximately 84 million metric tons CO2 equivalents. Massachusetts is 20% of this cap or 13 million metric tons CO2 equivalents.

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[58] Regional Greenhouse Gas Initiative: An initiative of the Northeast and Mid-Atlantic States of the U.S.
http://rggi.org/rggi_benefits/37-rggi-benefits/rggi-benefits/82-why-energy-efficiency
https://www.rggi.org/

In other words, this 13 million metric tons CO2 equivalent is the contribution of the state of Massachusetts for this agreement. The population of Massachusetts is 6.8 million and the population of Springfield is 155,000.

Optimistic

Assuming that the RGGI agreement reaches the goal of 20% by 2030.

(13.5 million metric tons CO2e) / (6.8 million people) * (155,000 people) = 310,000 metric tons CO2e

Conservative

Assuming that the RGGI agreement only fulfills 15% of the goal by 2030.

63 million metric tons CO2e is 15% of the agreement.
(63 million metric tons CO2e) * (0.15) / (6.8 million people) * (155,000 people) = 230,585 metric tons CO2e

Assumptions

1. Springfield's share of the reduction from the entire state of Massachusetts can be quantified on a per capita basis
2. Conservative and optimistic values of reaching the reduction goal
3. RGGI will continue beyond 2050

Overall Savings

This strategy could result in a conservative savings of 230,585 MT CO2e and an optimistic reduction of 310,000 MT CO2e—which is between an 18.9 and 25.4% reduction.

Regulatory Intervention 2: Compliance with CAFE Standards

Overview

The Corporate Average Fuel Economy (CAFE) Standards were established in 1975 to lower carbon emissions in the transportation sector by increasing mileage-per-gallon mandates for new cars. These regulations, established through 2025, aim to:

- "Result in an average industry fleetwide level of 163 grams/mile of carbon dioxide (CO2) in model year 2025, which is equivalent to 54.5 miles per gallon (mpg) (if achieved exclusively through fuel economy improvements);
- Cut 6 billion metric tons of GHG over the lifetimes of the vehicles sold in model years 2012-2025;
- Save families more than $1.7 trillion in fuel costs; and
- Reduce America's dependence on oil by more than 2 million barrels per day in 2025."[59]

[59] Environmental Protection Agency. https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-greenhouse-gas-emissions-passenger-cars-and

Though not a direct intervention that needs to be taken by the City of Springfield, this calculation projects the savings assured by the CAFE standards, assuming the regulations remain stable under the current administration. Massachusetts needs only to continue to comply with CAFE regulations - meaning they continue to increase the fleet mpg average of commuter cars and light trucks until 2025 - to achieve the savings projected to be accomplished by CAFE Standards.

The conservative estimate above reflects the scenario in which Springfield and the state of Massachusetts continue to comply with CAFE Standards up to 2025, and that 15% of miles driven within Springfield will be driven by vehicles with 54.5 mpg (per regulation). The optimistic estimate assumes 30% of these miles will be driven by 54.5 mpg, fuel-efficient vehicles.

Co-benefits

The United States adopted this plan in order to address the broader effects transportation emissions have on climate change, with the goal to decrease emissions by raising the fleet average mpg of passenger cars and light trucks. There are a plethora of co-benefits associated with the continued implementation of the CAFE Standards, many of which have been described in prior interventions in the transportation sector of this report. Increasing the mpg fleet standards across the US, and in Springfield specifically, will provide better air quality (cars will produce less exhaust), decreased noise pollution (hybrid/electric cars are quieter) and individual savings (higher mpg saves money at the pump).

Calculations

For each calculation, the following formula was used, swapping out **0.25** for other percentages:

> 791,385,408 miles/year driven within boundaries of Springfield x **0.25** = 197,846.352 mi/yr
> / 54.5 mpg = 3,630,208 gal/year
> x (8.887x10^-3) = 32,262 MT CO2e (assuming in 2025, 25% of miles will be driven by 54.5 mpg cars in Springfield)

By 2025:

> 15% = 19,357 MT CO2e (conservative)
> 20% = 25,809 MT CO2e
> 25% = 32,262 MT CO2e
> 30% = 38,714 MT CO2e (optimistic)

The percentages indicate the estimated percentage of miles driven in Springfield by 54.5mpg vehicles in 2025. The larger the percentage of miles being driven by more fuel-efficient vehicles, the greater the decrease in CO2e emissions.

Assumptions

- 791,385,408 mi/year driven within Springfield
- 8.887 × 10-3 metric tons CO_2/gallon of gasoline[60]
- For purposes of this calculation, assumed there are no substantial number of cars with greater the 54.5mpg by 2025.

Overall Savings

This strategy could result in a conservative savings of 19,357 MT CO_2e and an optimistic reduction of 38,714 MT CO_2e—which is between a 1.58 and 3.17% reduction from the baseline year.

Case Studies

All information used in the calculations for the regulatory intervention came from the language and broader goals outlined in the CAFE Standards. Though not precisely a case study, a report submitted by the Committee on the Effectiveness and Impact on CAFE Standards Staff National Research Council, Board on Energy and Environmental Systems Staff National Research Council, and the Transportation Research Board Staff National Research Council, provided valuable information on the past and future trends of CAFE Standards impacts.[61]

[60] Environmental Protection Agency. https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references
[61] Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards. https://ebookcentral.proquest.com/lib/smith/detail.action?docID=3564005

Conclusion

Overall, interventions from the building, transportation, and waste sectors that have the most beneficial greenhouse gas reduction long-term impacts on the City of Springfield were examined. These long-term impacts would be achieved through declining costs of the proposed interventions, as well as a continued greenhouse gas reduction beyond the 80% target.

From the building sector, the City of Springfield should consider investing a program to incentivize the installation of spray foam insulation for older, less energy efficient homes built in the 1930s, and retrofit at least half, if not all, of their 14,000 street lights to LEDs. In ten years, just one 1,600 square foot home that is insulated will save roughly $34,000, which will equate to a CO2e reduction of over 7 metric tons. Additionally, MassSave offers 75% off of insulation upgrades and Eversource offers $2,000 for energy efficient home improvements. With LED street lights, if 14,000 are retrofitted overall savings will equate to roughly $750,000 based on the Los Angeles LED street light case study, and in ten years these CO2 reductions will double.

Initiatives for the transportation sector, which makes up almost 30% of Springfield's carbon emissions, are largely focused on improvements and additions to the PVTA. The revamp of the PVTA system, as well as the establishment of bike/bus lanes would make the bus system more attractive to commuters and reduce the amount of people driving alone to work in combustion engine vehicles. In addition, the implementation of electric buses in lieu of combustion engine buses can achieve reductions of CO2e of over 18,000 MT per year. Encouraging the use of other transportation alternatives like biking, and carsharing will also decrease the number of cars on the road each day, and the continuation of Federal CAFE standards will increase the fuel efficiency of vehicles country-wide, and will aid in the City of Springfield's overall CO2e reductions.

In the waste and wastewater sector, which together contribute to 1.4% of Springfield's total emissions, somewhere between 2,961 and 4,602 MT CO2e can be reduced if the City plants the 66,000 trees they set out to in the CARP, and begins a composting program that can divert between 50-100% of the City's food waste. Beyond the CO2 reductions, both interventions have numerous co-benefits that will increase Springfield's overall resilience.

This report indicates that it is possible for the City of Springfield to significantly reduce its greenhouse gas emissions. While the sum of all the conservative estimates results in a 66% reduction in GHG emissions (643,123 MT CO2e), the optimistic estimates allow the City to reach its 80% goal by reducing emissions by 969,570 MT CO2e. Our aim was to provide the city with a "buffet" of interventions they could choose from, and it is important to note that the city is not tied to the sample calculations we provided. For instance, if Springfield finds that it is in its best interest to insulate more than 75% of businesses and homes with spray foam, than the City can (for example) choose to replace fewer street lights with LEDs and still achieve the 80% reduction goal. Furthermore, the city is not limited to the strategies outlined in this report. If the City feels that incentivizing residential solar is a fitting strategy, than emission reductions can be calculated and accounted for as part of the 80% goal.

It is the role of the City to determine exactly which strategies and to what degree they are implemented, but it will require a citywide effort to successfully execute them. Public-private partnerships should be formed and used whenever possible. Every effort should be made to keep the public informed and engaged throughout the implementation phase, because grassroots organizers can hold the City accountable to their 80% goal when the reductions become harder and harder to make. Hopefully with this report as a blueprint, Springfield will be able to meet its 80% reduction goal while simultaneously becoming more resilient and serve as a role model for other cities trying to achieve similar greenhouse gas reductions.