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Sioux Falls Renewable Project Final Report

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SUST 489 Capstone Course:

Final Report

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I. Executive Summary

The following report provides background information in support of a proposal for Sioux Falls to transition from carbon-based energy to 100% renewable energy by 2035.

The report was created by eight senior students in the University of South Dakota Department of Environment and Sustainability who researched and then wrote this document as their senior thesis (aka "Capstone Course").

The students divided the work into five focus groups, each addressing core issues that must be considered in any substantive effort to transition to 100% renewable energy. The focus groups included: technology assessment; health & public health impact; role of energy conservation & decreased energy demand; financial impact; education & communication strategy to build awareness and community support.

The report makes the following key points and specific conclusions and recommendations:

Key Points

1. Climate change is real and driven in large part by human activity leading to increased greenhouse gas emissions. Global temperatures have fluctuated over the past millennia, but the speed of temperature change in the past 100 years is unprecedented. According to the NASA Goddard Institute for Space Studies, 19 of the hottest recorded 20 years have occurred since 2001, and the past 5 years have been the 5 hottest ever recorded. The CIA, Department of Defense, NSA, UN Intergovernmental Panel on Climate Change are just a few of the institutions or agencies that have identified climate change as a crisis impacting national and global security, food security, economic stability, natural disaster risk, and public health - requiring an urgent response across all sectors.

2. Cities, including towns, medium-sized cities, and large urban centers continue to rely on carbon-based solutions to provide energy needs. Cities account for 70% of all greenhouse gas emissions and 2/3 of energy consumption.

3. There is, however, a growing commitment by large and small cities in the United States and around the world–to create and implement time-driven specific plans to transition from carbon-based to renewable energy. There are currently more than 175 cities in the United States that have already made the conversion to renewable energy or have made the commitment to do so, including Atlanta, St. Louis, San Diego, Houston, Seattle, and Minneapolis. There are over 150 cities around the world that have also already begun this

transition or are actively developing plans to do so, including Montreal, Nairobi, Auckland, and Oslo.

4. Cities not only cause the majority of greenhouse gas emissions, they also provide the best opportunity to address this challenge, this crisis. Cities have defined populations and specific political and strategic planning processes that, when committed to shared goals, can lead to real change.

5. South Dakota is ranked 5th nationally in the use of renewable energy receiving 70% of its energy from hydroelectric and wind. Sioux Falls receives 30% of its energy from renewable sources. The basic understanding of the importance of and technology needed for a transition to renewable future is already in place.

Key Conclusions & Recommendations

1. Sioux Falls' transition to 100% renewable energy by 2035 is a bold challenge that will require significant investment in infrastructure, political will, leadership, and carefully nurtured community education and participation. It will not be easy, but the impact and the return on investment (ROI) will be significant.

2. The ROI can be measured by economic/financial impact: "clean" job creation, improved air and water quality, improved public health, and by enhancing Sioux Falls' national reputation as a place to raise families, create business, and plan for the future.

3. "Bottom up" community participation and genuine collaboration with all "stakeholders" (communities, political leaders, the business community, regional power companies, and others) will take time – but it is essential.

4. Data-driven information on the required technology, grid improvements needed, financial ROI, and real job creation projections – are also essential to the sustainable success of this effort. Reliable storage systems to provide energy 24/7/365, and system design to meet maximum power demand month to month are examples of challenges that will also need to be addressed.

II. Introduction

Overview

Sioux Falls is the largest city in South Dakota with a population of 171, 117 and is one of only two cities in South Dakota to have an Office of Sustainability. South Dakota is a national leader in the amount of renewable energy produced. In 2019, renewable resources provided about 68% of South Dakota's electricity net generation. Hydroelectric power accounted for almost 45% of total generation and wind about 24% (EIA 2019). Additionally, the climatic conditions in South Dakota are conducive for additional wind and solar energy production. Sioux Falls, therefore, is well positioned to take a leadership role in mitigating climate change in South Dakota.

One way for Sioux Falls to mitigate climate change – and model climate action for the state and region – is to transition the energy use in the city to 100% renewable energy. There are currently more than 175 cities in the United States that have completed, are in the process, or have pledged to transition to 100% renewable energy. Although Sioux Falls is not yet one of these cities, we believe that there is potential for Sioux Falls to transition to 100% renewable energy. The primary uses of energy in a city include electricity, heating, and transportation. Based on reviews of the existing cities who are or have transitioned to 100% renewable energy, we determined that many cities first focus on a transition to 100% renewable electricity. The purpose of this report is to explore the opportunities and constraints – and to provide recommendations – for engaged stakeholders to develop a campaign for Sioux Falls to transition to 100% renewable electricity by 2035.

In 2019 Sioux Falls required 2,098,833,438 kw and 82,507,571 therms of natural gas to meet the demand for power and heating. These numbers are significant, but could – with improved technology, decreasing costs, and regional and federal support for initial capital expenditure – be met by a transition to 100% renewable energy.

What is “Renewable Energy”?

Renewable energy comes from replenishable sources such as wind, solar, geothermal, and hydropower - energy sources that emit no carbon. Nonrenewable energy such as coal, natural gas, and oil are all sources that cannot be replenished fast enough for sustainable use. These sources also harm the environment as well as air quality as they emit greenhouse gases like carbon dioxide, methane, and nitrous oxide. The one advantage that coal, natural gas, and oil do have on renewable energy is that the sources are stable and do not fluctuate based on sun availability for solar and wind availability for wind turbines. However, hydropower produces so much energy in the state of South Dakota that backloading with hydropower is just as effective as carbon based alternatives. South Dakota has an average wind speed of 6-8 m/s which is more than enough to supply energy for Sioux Falls (https://windexchange.energy.gov/states/sd). As of 2020, 888 wind turbines have been installed, with more planned in the future (https://energynews.us/2019/09/05/3-3-billion-wind-investment-will-add-2500-mw-of-clean-energy-in-south-dakota/). Overall, with many environmental, economical, and commercial benefits

from renewable energy, there is no reason that renewable energy cannot sustain Sioux Falls in the future

Climate Change: Nationally, Regionally, and in South Dakota

For the last few thousand years the Earth's climate has stayed relatively stable, but this is changing quickly. The atmospheric carbon dioxide levels were balanced until the last two centuries. Since the Industrial Revolution, humans have been releasing more greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, ozone) into the Earth's atmosphere. Human's reliance on fossil fuels for energy production has been one of the primary contributors to this rise in atmospheric emissions.

Increased greenhouse gases in the atmosphere block release of the sun's radiation, raising global temperatures, leading to climate change. Climate is different from weather. Weather is the changes we can see and feel from day to day. Climate change is the long-term change in the average weather patterns that have come to define Earth's local, regional and global climate patterns There are many effects that climate change is having and will have on Earth. According to the World Health Organization, "In the last 130 years, the world has warmed by approximately 0.85ºC. Each of the last 3 decades has been successively warmer than any preceding decade since 1850" (*Climate change and health*).

Increased global temperature results in even more issues like rising sea levels, ocean acidification, coral bleaching, acid rain, extreme heat waves, droughts, shifts in precipitation patterns, and more frequent and intense natural disasters. The rise of emissions since the mid-1900's, has resulted in numerous environmental, societal, and economic problems like food and price instability in the agricultural sector, yield difficulties in the livestock, forestry, and fishery industries, and even a decline in the productivity of the labour force. As temperature rises, it becomes increasingly difficult to work outdoors for long periods of time. These effects of climate change will directly impact many aspects of human life. When observing the agricultural sector, the Earth Institute at Columbia University states that "extreme rainfall has already increased by 37 percent in the Midwest since the 1950s, washing away crops and drowning livestock. Between 1961 and 2013 we have seen a decline in the amount of usable cropland per capita in the world. In the early part of 2019, Nebraska lost $440 million worth of cattle while Iowa suffered $1.6 billion in total losses (Cho)." The impact that climate change has on the agriculture industry alone will cause issues in the future like food insecurity, lack of adequate carbohydrate and meat sources, and increased prices for foods.

It is estimated that by the year 2090 the global temperature will increase by 4.5 degrees Celsius (Frumkin) if emissions are left unchecked. With the increase in temperature, evaporation from oceans, lakes, and rivers will increase with a subsequent increased precipitation leading to

increased risk of water and foodborne diseases, allergens, and vector borne diseases. The state of South Dakota is not exempt from these effects. In the future, Western South Dakota will experience more periods of drought while Eastern South Dakota will experience more flooding events. The Environmental Protection Agency stated that South Dakota is already experiencing some of these changes. In the last century, South Dakota's temperature has risen by a few degrees Fahrenheit. The image below is from States at Risk and displays the average temperature in Rapid City, South Dakota between 1951-20.

Climate change is not just a problem for South Dakota, the Great Plains region, or the United States;, it is a global issue. Through the implementation of policy at municipal, state, federal, and international levels it is possible to mitigate these effects of climate change.

The Role of Cities: Why They Matter

Over half the world's population lives in cities and according to the UN, that will increase to two-thirds by 2030. Cities are epicenters for suburban sprawl, intense water and energy use, and significant emissions of carbon dioxide and other greenhouse gases. Cities use of fossil fuel creates 70% of global CO2 emissions. Over time, inadequate city planning and lack of public transportation options has created a huge, detrimental environmental issue. However, cities also provide the opportunity for political, social, and cultural change.
Politically, mayors and city council leaders are able to take more definitive action in their local areas compared to at a state and federal level. At this level, laws and standards can often be passed through city and land-use planning much more efficiently. This can be done by developing greener building standards and codes, establishing a collaboration with local utilities to educate and offer retrofits, efficient heating and cooling systems, and water audits.

There is a growing commitment by large and small cities in the United States and around the world–to create and implement time-driven specific plans to transition from carbon-based to renewable energy. There are currently more than 175 cities in the United States that have already made the conversion to renewable energy or have made the commitment to do so, including Atlanta, St. Louis, San Diego, Houston, Seattle, and Minneapolis.

Additionally, shaping the behavior of a city socially and culturally through local grassroots efforts offers a successful individualistic approach that brings together members of a community. When looking at climate change from a local perspective solutions become clearer. Locally combating climate change helps that area build a resilience to climate impacts that are specific to that region, as climate change affects every area differently. Opportunities for communities working together include reclaiming green spaces, campaigning for behavioral change, developing a system for a more sustainable commute, or even finding local solutions for sustainable energy access and transformation.

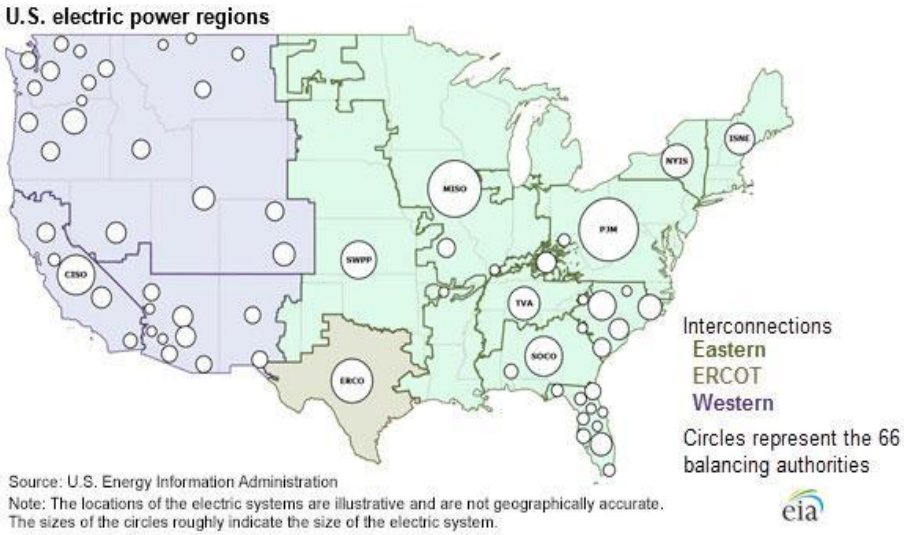
1. Technology Assessment

Why it Matters

Technology is a very important aspect that influences the future of renewable energy generation. In order for Sioux Falls and the rest of the United States to work towards becoming 100% renewable energy-independent, technology must continue to develop. Today, the current electrical grid that runs throughout the United States and delivers our power, was built in the early 1900s and was meant to specifically generate electricity via fossil fuels (AFCEG, n.d.).

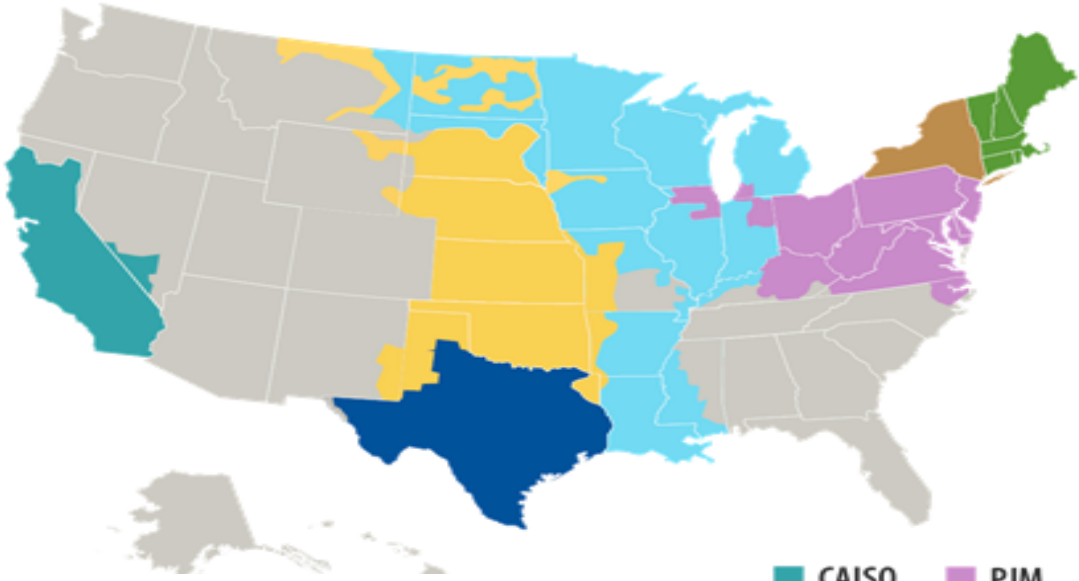
What We Learned

The current makeup of the electrical grid consists of three main interconnections that make up the United States. According to the U.S. Energy and Information Administration, the U.S. power grid contains over 7,300 power plants and about 160,000 miles of high-voltage power lines, as well as millions of miles of lower-voltage power lines and distribution transformers (EIA, 2016).



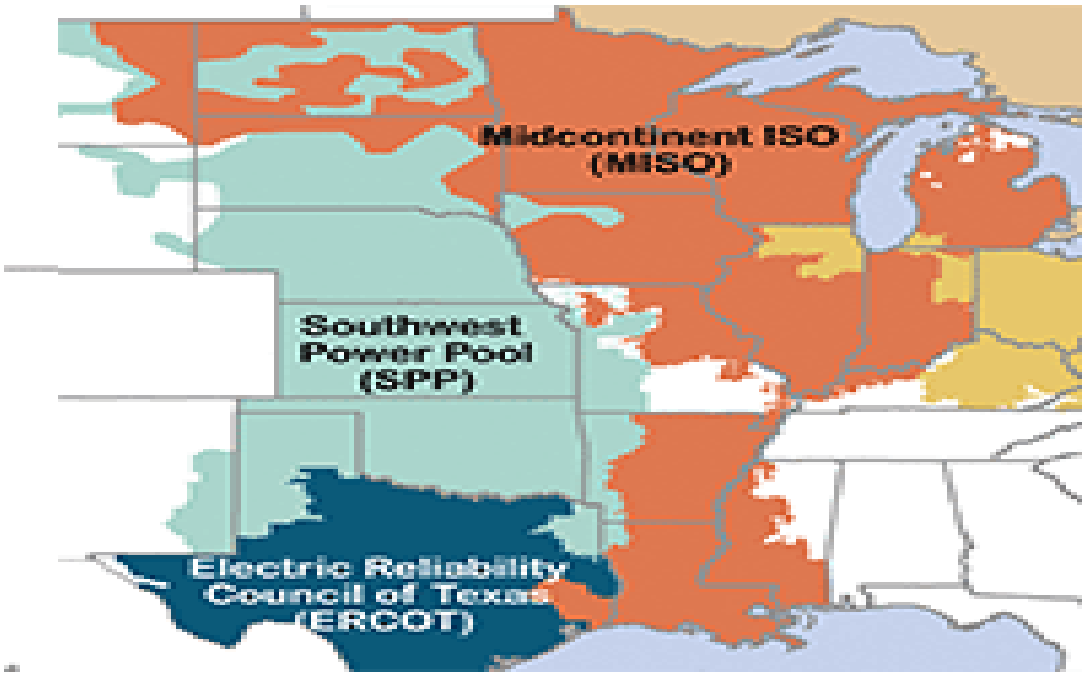
U.S. Interconnections Map (EIA, 2016).

Sioux Falls is grouped into the Independent System Operator called the Southwest Power Pool (SPP). The state of South Dakota however belongs to both the Southwest Power Pool as well as the Midcontinent Independent Systems Operator (MISO). These Independent System Operators both buy and sell electricity to different areas of the states. Xcel however purchases their energy from MISO and SPP because both independent systems operators are so close to Sioux Falls (Xcel Transmission, 2020).



U.S. Independent System Operators Map

U.S. Independent System Operators (FERC, 2020).



The image above shows the Independent System Operators in South Dakota and how closely each one is to Sioux Falls (FERC, 2021).

Table 1

Sioux Falls Electrical Companies	**Power Market Administrators**
Xcel Energy	MISO & SPP
City of Sioux Falls Light and Power	Western Area Power Administration (WAPA) & Heartland Power
Sioux Valley Energy	East River Electric & Basin Electric Power Cooperative
Southeastern Electric	East River Electric & Basin Electric Power Cooperative

Table 1 shows each electricity company in Sioux Falls and which Power Market they receive electricity from.

Table 2

ISO	**Energy Sources**
WAPA	Hydropower, coal
Heartland Power	Coal, renewables, nuclear, other utility providers
Basin Electric Cooperative	Coal, renewables
East River Electric	Buys power from WAPA & Basin Electric

Table 2 shows each Independent System Operator and how each one generates their electricity.

Conclusions and Recommendations

The first thing that must be done to implement more renewable energy into the electrical grid is to redesign and invest in our current outdated electrical grid. After this has been done, more people must be willing to add solar panels to their roofs as well as request a greater amount of renewable energy be added to the generation mix. Contacting each energy provider to find out

their long-term plan for different electricity sources and their willingness to consider switching to solely renewable energy sources is another very important step in getting Sioux Falls to become a 100% renewable energy independent city.

1. Technology Assessment Continued

Why It Matters:

Because the energy infrastructure of a city relates to suppliers, contracts, consumers, physical properties, policies, and even economics; the ability to transition to renewable energy without harming the consumer (i.e., the population) will require hard work and dedication (Business Roundtable). However, by understanding how other cities have made their transition, Sioux Falls will be able to more easily build out their transition plan and build a sustainable future. There are many cities around the world that have either begun or finished their energy transition. Understanding what Fort Collins has done is valuable because the city is similar to Sioux Falls. Fort Collins is also a midwestern city that has a current population of 165,609 and Sioux Falls has a population of 177,117 according to the United States census in 2019.

What We Learned:

In research about other cities and their transition an interview with Brian Tholl, who is the Energy Services Supervisor of Fort Collins, was conducted to learn about the nature of a transition related to infrastructure. In the interview it was mentioned that Fort Collins has one sole provider which is the Platte River Power Authority (PRPA). This energy provider is also committed to a 100% renewable energy transition. Fort Collins worked with the PRPA to construct a plan alongside with them to supply only renewable energy by the year 2030. PRPA now generates more than 50% of its energy from renewable energy sources (figure 1). A change to renewable energy from coal, natural gas, and oil does require major

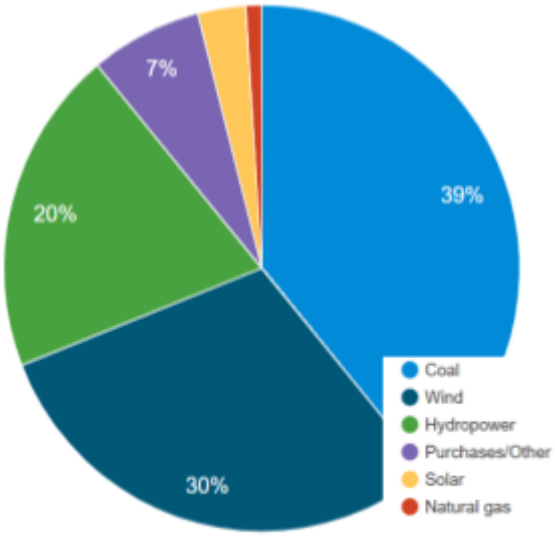


Figure 1. Deliveries of energy in Fort Collins for2021

https://www.prpa.org/generation/

changes to infrastructure. This means new generation sources, transmission lines, distribution centers, as well as software within the city's energy grid. These changes require carefully crafted changes and plans for the transition to be successful. Finally, Fort Collins supports battery storage systems and solar PV systems to help lower demand within the city which can be found on their utility information website.

Conclusions and Recommendations:

Within the interview, Brian mentioned that lowering demand is one of the most important parts of the energy transition. With a lower amount of energy needed to produce for the future the city can more easily meet the demand. Within their plan *Our Climate Future* they allow for bi-annual revisits to account for new obstacles that may have not been accounted for initially. This would benefit Sioux Falls as a bi-annual update to the Sustainability Master Plan would be a great reference to energy demand within the city. Sioux Falls will need to restructure their contracts with each energy provider that allows for a renewable energy goal that works for them. Lastly, to meet demand for the future of the city, conservation tactics would need to be applied such as solar PV systems. By lowering the demand for the future, it would allow Sioux Falls to more easily structure a plan that works for the city, its suppliers, and the citizens.

2. Financial Impact:

Why It Matters

The *Intergovernmental Panel on Climate Change* reports that we have 6 years to adjust our habits in order to combat the increasing global temperatures or else humanity will be faced with irreversible implications (Pörtner, H, et al). It is clear that in order to protect all life on earth, communities must come together to play their role in halting increasing global temperatures.

As the largest city in South Dakota, Sioux Falls has the opportunity to set a precedent for the rest of the state through transitioning to 100% renewable energy. Any serious proposal for Sioux falls to transition to 100% renewable energy must first and foremost address cost, return on investment, and the impact on job creation and economic development.

What We Learned

The following report aims to emphasize the financial aspect of Sioux Falls' transition to clean energy, including the following focuses: current costs of energy in Sioux falls for the average household, upfront costs of switching to renewable energy, and how job creation will be impacted by transitioning to renewable energy.

1. *current & projected costs* of energy in Sioux falls for the average household

The average electricity bill for a Sioux Falls resident is $99 per month. With the results found from Colorado's proposal (Aspen's Climate Action Plan: A Roadmap to Our Sustainable Future), the average Sioux Falls resident could save a month's worth of electricity each year through transitioning to renewables. Similarly, with the average heating bill costing $372.11 monthly, a transition to renewables will likely save each household over a month and a half's worth of heating costs each month (Average Utility Bill Spent By U.S. Households Each Year). In sum, the average household spends around $4,470 annually on energy, and it's projected that the bill could be cut in half if renewable energy was implemented statewide (Griffith, Saul, and Sam Calisch). In this way, it is beneficial to note that through the data depicted by Colorado's transition plan towards renewables, there is potential for Sioux Falls residents to feel a substantial financial gain upon transitioning to renewables.

2. Upfront costs of switching to renewable energy

Transitioning to 100% renewable energy has high, up-front costs; yet, doing so ensures very low costs in the future. In general, fossil fuels are cheaper at their point of purchase but require an expensive infrastructure investment. The costs are divided into public sector expenses (grid upgrades, solar panels, wind turbines, etc.) and private sector including small businesses and private homes. Private sector users could simply retain current equipment and benefit from Sioux Falls changing from carbon based to non-carbon sources of energy. If opted to take the next step and transition businesses or homes to renewable energy (in addition to the city's investment) cost would be a significant amount that most Americans can't afford. It is projected that it would cost the average Sioux Falls resident $70,000 to completely decarbonize their household (Griffith, Saul, and Sam Calisch).

With this large sum of money in mind, it is clear that the households would not be able to afford such an expense and that certain financial support systems would need to be put in place in order for this transformation to happen. First of all, this price could be cut through utilizing regulatory reform and industrial scaling. Financing options should also be highly prioritized in order to help households afford these items. Saul Griffith and Sam Calish argue that the cost of financing the future upgrades is lower than the cost of fueling today. According to them, to get there, Sioux Falls and the United States at large would need to "prioritize reductions in three areas: soft costs

through regulatory reform, hard costs through massive industrial scale and steady technological progress, and finance costs through government–backed loans" (Griffith, Saul, and Sam Calisch).

In the above graphic, it can be demonstrated that "Business as Usual" (BAU) will not benefit the overall household savings, in fact, it will continue to cost thousands of dollars per year to continue paying this energy cost. However, through a "good" implementation of energy efficiency technologies, implying not 100% of the city adapts renewables but some residents do, it is shown that there will be a net gain of over $1,000. Furthermore, if the city of Sioux Falls were to reach a "great" adaptation, still not perfect but closer, there would be a household net gain of nearly $2,500 per year saved from using renewables. In this way it is clear that if the technology can be affordable to households, many will partake in implementation due to the stark savings that they will receive long-term (Griffith, Saul, and Sam Calisch).

3. how job creation can be impacted by the transition to renewable energy

There are multiple examples of positive job creation with a switch to renewable energy. The following are only three of many:

Table 3

State	Jobs Created by Transitioning to Renewables	Population
Tennessee	40,000	6.8 million
Massachusetts	42,000-48,000	6.9 million
Colorado	59,000	5.7 million

Considering the population to job creation ratio of the above states, Sioux Falls could create 1,825 new jobs within the first 10 years of transitioning to renewables.

Conclusions & Recommendations

It is imperative that Sioux Falls find a way to reduce the cost of technology necessary in transitioning households from non-renewable to renewable energy. If the cost can be reduced and the savings potential broadcasted clearly, there is a realistic possibility that the city could adopt some variance of a renewable energy policy.

It is unclear exactly how many jobs could be created in Sioux Falls through the transition to renewables; however, there is potential for the city to create nearly 2,000 new jobs through transitioning to renewables if similar to the strategy of the above states. Furthermore, the sooner the city decides to transition, the quicker the area can dominate the market in the Midwest for providing green energy technologies for surrounding areas to purchase. It is expected that across the U.S., a complete transition to renewable energy could bring over 25 million new jobs to the country. This would absolutely include Sioux Falls and the betterment of South Dakota if the state selected to participate.

In order to play a role in the race against climate change, it is imperative that we find solutions to the pollution that our cities, including that of Sioux Falls, create. In understanding the voting demographic, it is clear that the way to convince green energy policy within this area is by framing the argument from a positive financial perspective, which is very possible. By highlighting the potential savings from yearly deductions of fossil fuel expenses and demonstrating methods to help compensate for the cost of early adaptation, there is a strong case for Sioux Falls to transition to renewables. In this way, we can not only positively impact the economy, but also the planet.

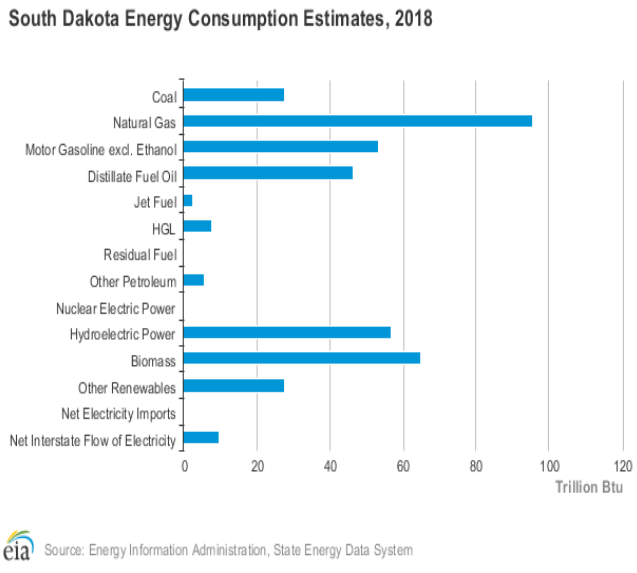
3. Decreasing Demand – Energy Conservation

Why it Matters

Although energy efficiency and energy conservation are related, there are fundamental ways in which they are different. One way to differentiate between the two is by thinking of it this way:

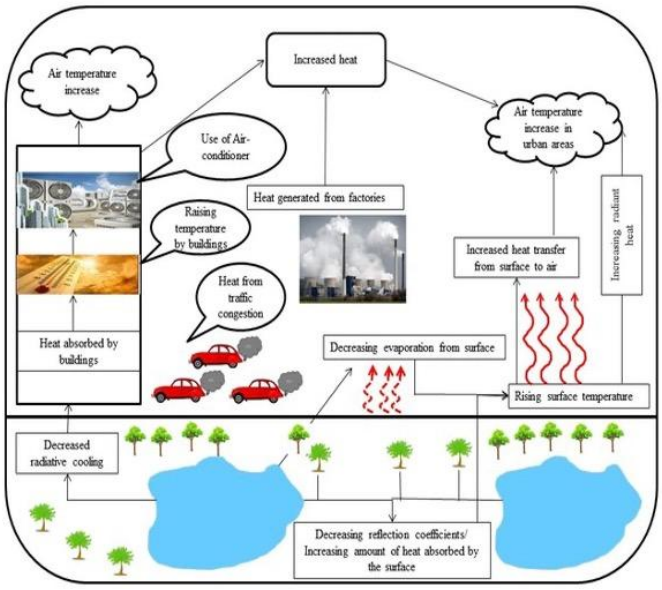
- Using a technology that requires less energy for a given function is the way that things can be more energy efficient.
- Changing daily behaviors and actions that result in the use of less energy is how people can participate in energy conservation.

The consumption of energy in the United States on an annual basis is roughly 100 quadrillion BTUs, and only about 11% of that energy is derived from renewable sources. However, if more communities would make the commitment to reduce energy consumption, less energy will need to be generated which leads to greater energy conservation. Sioux Falls is a rapidly growing city, and the energy, including electricity, demands of the residents and



businesses in the city continue to grow. One way to facilitate the transition of Sioux Falls to 100% renewable energy would be to reduce the total energy demand thereby reducing the amount of renewable energy that would need to be generated.

What We Learned



Studies have shown that medium and large cities often have a greater density of urban heat islands than rural areas. These heat islands tend to result in higher rates of energy consumption, increased levels of air pollution and elevated cases of respiratory ailments within the community. Urban greening can reduce energy consumption by combatting the effect of urban heat islands. Partially or completely covering rooftops in the city with a waterproofing membrane and covering it with a growing medium and some sort of vegetation is how green roofs are created. The resulting insulation provided by the plants aids in reducing the building's energy consumption since the amount of solar radiation that reaches the roof is reduced, which in turn reduces the surface temperature, meaning less electricity would be used to cool the building. When correctly placed, trees deliver shade, which helps to cool the air and reduces the amount of heat that reaches buildings. This can reduce the amount of energy needed to cool buildings in warm weather. Since trees release water into the atmosphere, which helps to reduce a building's energy consumption because the air temperature will be cooler. It has been proven that when trees are placed on the west and southwest side of buildings to shade windows, the amount of energy saved on heating and cooling can approach 50% (ASLA, 2021).

Conclusions & Recommendations

We recommend Sioux Falls to reduce the total electricity demand by 30% by adopting aggressive energy conservation and efficiency strategies. Accomplishment of this would require a systematic assessment of the city's current energy conservation and

efficiency levels to create a baseline. From that assessment, the future energy needs within the city can be established, resulting in improved energy conservation goals.

One of the easiest steps that Sioux Falls should take to conserve energy while making the transition to renewable electricity is through relatively simple and very effective methods of urban greening. Some forms that could be incorporated in Sioux Falls include planting green roofs and the strategic placement of trees. All urban greening actions have added benefits beyond energy conservation (Brown et. al, 2018). The plants used in urban greening directly sequester carbon, reducing atmospheric CO_2 and since energy use is reduced, carbon dioxide emissions from electricity generation are reduced. This in turn results in cleaner air and less respiratory issues for citizens because plants used in urban greening filter airborne pollutants such as greenhouse gasses and particulate matter.

4. Health Impacts

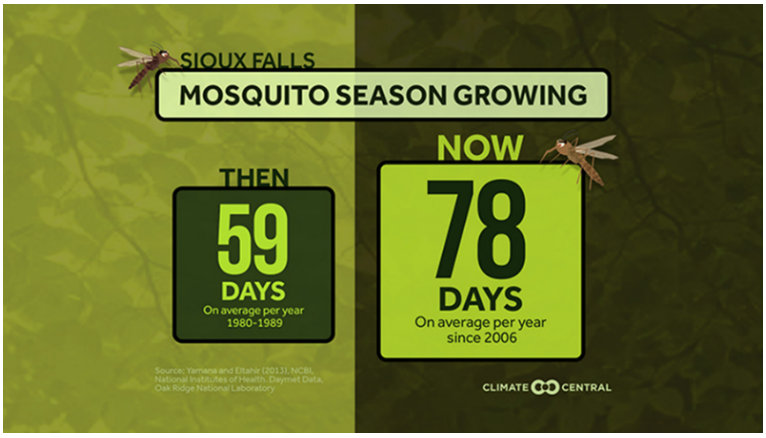
Why It Matters

There will likely be an increase in respiratory, cardiovascular, and vector borne diseases as well as the severity in their symptoms. When the temperature increases, it becomes more difficult to avoid environmental triggers that affect cardiovascular and respiratory diseases, like dust and particulate matter in the air. A report done by Respiratory Research states that globally "the total number of CRD (chronic respiratory disease) cases increased by 39.5% from 1990 to 2017" (Xie). This increase of respiratory disease cases are likely caused by the rising temperature and particulate matter. This study remains consistent with current Sioux Falls respiratory illness cases. According to the 2017 Behavioral Risk Surveillance Survey and the 2018 joint report from the Centers of Disease Control's National Program of Cancer Registries, National Cancer Institute's SEER program, and the state of South Dakota's cancer registry, Minnehaha County, which Sioux Falls resides in, has 3,511 cases of pediatric asthma, 11,371 cases of adult asthma, 5,934 cases of COPD, 19,133 cases of adult chronic lung disease, and 114 cases of lung cancer (*Estimated Prevalence and Incidence of Lung Disease*). These statistics are alarming because with a population of 192,876 people, one out of every five people in Minnehaha County is currently affected by some form of respiratory illness.

Additionally, cardiovascular health is heavily impacted by the effects of climate change. As temperature rises the heart becomes less efficient, needing to work harder to circulate blood and

adding additional stress. “Short-term and long-term BPV (blood pressure values) are associated with the development, progression, and severity of cardiac, vascular, and renal damage and with an increased risk of cardiovascular events and mortality.” “According to an assessment done by Nature Reviews Cardiology, these variations (of blood pressure) are the result of complex interactions between environmental factors (like climate) and the cardiovascular mechanisms (Parati).” If you follow the temperature fluctuations in climate, which have been steadily increasing over the past few centuries, you can see a correlation between temperature and hypertension in humans exposed over time. Similarly to the triggers of pulmonary diseases, particulate matter in the air due to prolonged periods of drought have been seen to cause systemic inflammation which compromises the heart's ability to function properly.

As the Earth’s temperature continues to increase there will be seasonal impacts which prolong the summer months. This extension of warm, and in some place humid weather, will alter the environment and make it suitable for vectors like mosquitoes, ticks, and fleas to immigrate.



These vectors can begin to transmit diseases like West Nile Virus, Lyme disease, and STARI (Southern Tick Associated Rash Illness). According to the National Institute of Environmental Health Sciences, “Change in incubation period of pathogens in invertebrate vectors due to precipitation and temperature can alter transmission. For instance, an increase in temperatures and precipitation can increase the population of vectors where they normally live” (*Vectorborne and Zoonotic Diseases*). It is necessary to recognize that vector borne diseases are not foreign diseases. They are right here in our own backyards throughout South Dakota and the Upper Great Plains region.

Droughts, floods, increased heat and weather patterns also play a huge role in the health of humans Transitioning to 100% renewable energy not only will lessen the impact of greenhouse gases on the atmosphere and will help the climate, but it will also help our bodies not have to process all the toxins and pollutants that come with fossil fuels. As stated by the EPA, “In 2019, about 70 million tons of pollution were emitted into the atmosphere in the United States. These

emissions mostly contribute to formation of ozone and particles, the deposition of acid visibility impairments" (EPA.gov). Currently there are more than 82 million people in the United States that are living in areas that have ambient air standards that have pollutants that exceed the EPAs quality standards. The are many byproducts of fossil fuel combustion, the six most common pollutants are as follows, "... particulate matter (PM), ozone (O3), Sulfur dioxide (SO2), nitrogen oxides (NOX), carbon monoxide (CO) and lead" (Kurt et al.). These pollutants come from many different sources, but they all are harmful to the environment and to humans. Particulate matter consists of fine particles in the atmosphere; if these particles are inhaled they are small enough to enter the bloodstream," nonfatal heart attacks, irregular heartbeat, aggravated asthma, and decreased lung function" (EPA.gov).

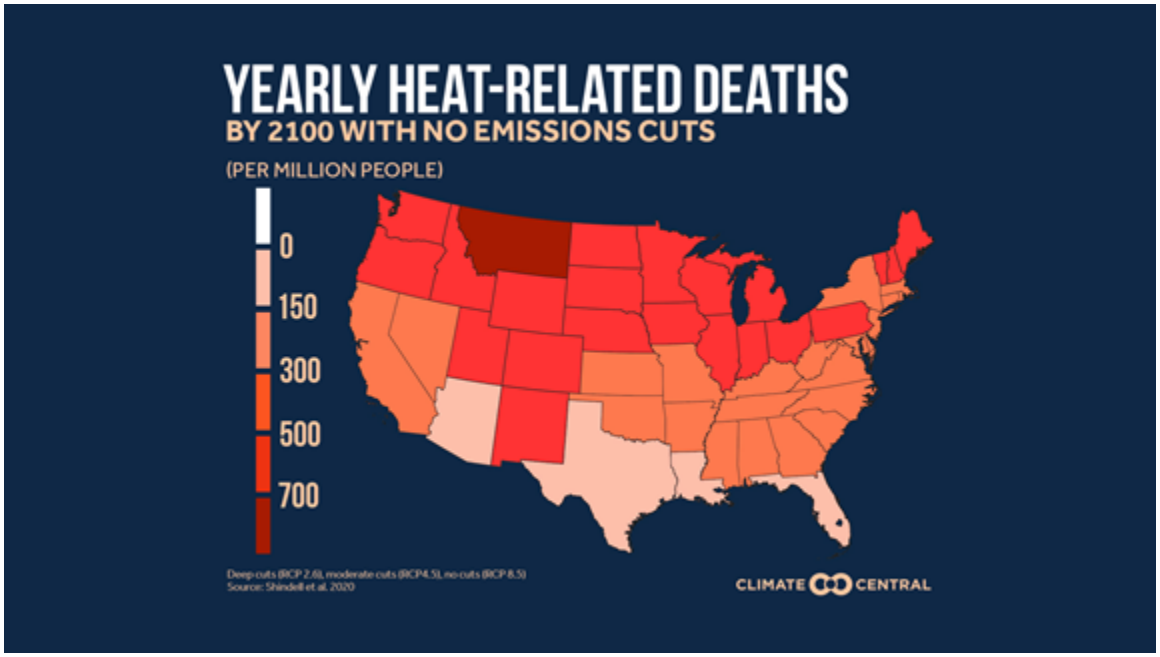
Ozone is also very dangerous and causes the same side effects if inhaled Sulfur dioxide is also very dangerous and causes lung issues for older people and young children. Nitrogen oxide is also a gas that is produced by fossil fuel combustion and can cause birth defects and bronchitis in babies. Water acidification is also a problem caused by greenhouse gases. Carbon monoxide is the last of the gases and this one is one of the most dangerous because it is odorless and hard to detect. "Breathing air with high concentrations of CO reduces the amount of oxygen that can be transported in the bloodstream to critical organs like the heart and brain" (EPA.gov).

Water quality can also be impacted by climate change. Sioux Falls tests for ammonia, iron, nickel nitrates, sulfate, total dissolved solids (TDS), total organic carbon (TOC) and total phosphate. Here is the data for Sioux Falls.

Sioux Falls Water Division
Big Sioux River Water Quality 2019

	Concentration		
Parameter	Average mg/L	Minimum mg/L	Maximum mg/L
Alkalinity, as $CaCO_3$	295	77	354
Ammonia, as NH_3-N	0.07	BDL	0.28
Calcium Hardness, as $CaCO_3$	298	94	660
Chloride	19	4	31
Fluoride	0.38	0.23	0.49
Total Hardess, as $CaCO_3$	551	152	750
Iron	0.31	0.11	3.31
Magnesium Hardness, as $CaCO_3$	255	58	376
Manganese	0.14	0.04	1.00
Nickel	BDL	BDL	0.01
Nitrate, as Nitrogen	2.2	0.1	5.1
pH, units	8.0	7.3	8.5
Sulfate	287	38	451
Total Dissolved Solids	700	202	1033
Total Organic Carbon	12.2	6.8	18
Total Phosphate	0.9	0.2	1.8
Turbidity, NTU	18	3.0	108
Temperature, C	13	0.1	29.4
UV-254, CM^{-1}	0.21	0.09	0.35
Zinc	BDL	BDL	0.12

An increase in the frequency and severity of natural disasters also impacts human health. Because of the location of Sioux Falls, the city sees a mix of all weather patterns from extremely frigid winters to excruciating hot summers. As climate change intensifies floods, draughts, and heat waves will continue to increase. Heat stress, vector, food, and water borne disease will put more and more people at risk.



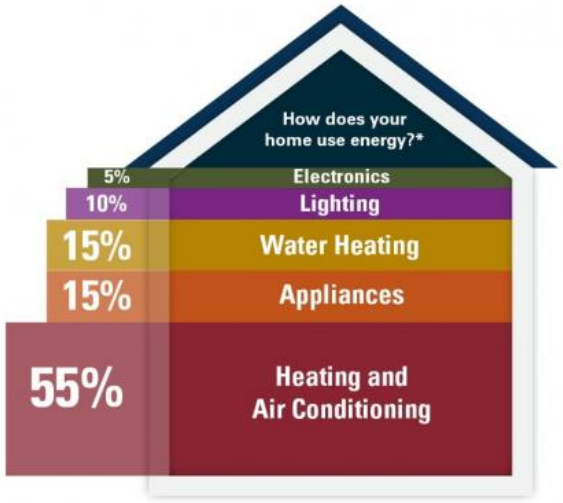
Conclusions & Recommendations

- The risk to health from climate change is real and is already affecting Sioux Falls.
- Increased respiratory and cardiovascular disease, expanding vector and water borne disease, injury and loss of life from increased natural disasters – are a few of the many climate associated health risks.
- Sioux Falls obviously does not have complete control of the city's air or water quality because both are driven, to some degree, by regional factors. The city however does have some impact and certainly is in the position to be a leader in the state and the region.
- When looking for reasons for Sioux Falls to switch to a renewable energy sector- look no further than the health benefits that can be gained from doing so. The future of our world lies in our hands and to keep it healthy and happy we all need to come together and do what is right for our planet.

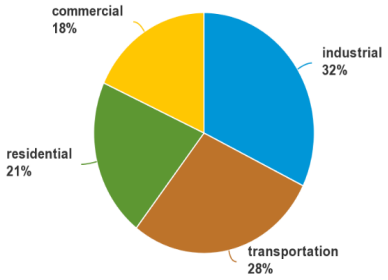
5. Energy Efficiency

Why it Matters

Residential sectors of cities rely a lot on the grid for their energy demands. The largest two areas for energy in the residential sector are the demand for heating and cooling as well as general electricity usage. There are ways to conserve and save energy in many ways. This sector covers two forms of energy efficient certification programs as well as covering solar panels. By aiming at having higher efficient homes and producing their own electricity leads to a residential sector that is more independent and less reliant upon the overall grid system. Whether this is done by designing new buildings to be energy efficient, retrofitting current buildings to meet higher standards, or other ways; they all lead to greener and more renewable-reliant residential sectors.



Share of total U.S. energy consumption by end-use sectors, 2019
Total = 100.2 quadrillion British thermal units



Note: Sum of individual percentages may not equal 100 because of independent rounding.
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 2.1, April 2020, preliminary data

What We Learned

The first and probably most well-known area for conservation and efficiency is the certification of a building as a LEED building. That is a building that has achieved its Leadership in Energy and Environmental Design certification as a green building. This is a building that is designed in all aspects such as materials, lighting, heating, air flow, and more factors. This can be applied in both residential and commercial areas. EnergyStar is another certification and evaluation system which focuses on general energy usage in many different products. For example, an EnergyStar light bulb may use somewhere from 70-90% less energy than a standard incandescent bulb. This is a government supported system of certification that is used for products, homes, and other buildings. Other steps that could be taken would be getting smarter devices and meters; as well as generating your own energy at home through the power of photovoltaic solar panels.

Existing homes of Sioux falls can begin producing their own power and removing their dependencies on the carbon depend on grid systems through the power of photovoltaic cells. They are a more expensive option but save money the longer they are used by a household as

they pay themselves off in savings. This can lead to homes becoming zero-energy. A zero-energy structure will generate enough renewable energy to meet its own yearly energy consumption requirements. This is one of the goals of establishing new technology into the future of Sioux Falls as well as upgrading older homes.

Conclusions & Recommendations

By pushing more for a greener Sioux Falls, the demand for energy is a constant topic. Not only will energy production and how they get energy going to be important, but using less energy is also important. By certifying homes through LEED standards and combining efforts with EnergyStar products, new and existing homes can quickly pave the wave for residential sectors to become more green and less demanding. The final product of adding solar panels to homes and incorporating those systems into sectors that are existing, Sioux Falls can quickly transition and evolve into a less demanding and more efficient city.

Important Terms and Definitions

URBAN GREENING	green roofs, community gardens and intentional placement of trees, etc.
GREEN INFRASTRUCTURE	a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces… and other physical features in terrestrial…areas. On land, green infrastructure is present in…urban settings" (European Commission, 2013).
LEED	A certification system for energy efficient homes that stands for the Leadership in Energy and Environmental Design
ENERGYSTAR	A government backed program of energy efficient devices and technologies
ZERO-ENERGY BUILDINGS	A zero-energy structure will generate enough renewable energy to meet its own yearly energy consumption requirements
SMART GRID/HOMES	able to communicate between itself and the grid it is connected to
NET METERING	where your provider pays back or credits you what you produce in excess

6. Education, Communication, Building Consensus

Why It Matters

Because we are working towards transitioning electricity within the *community* of Sioux Falls, it needs to be a *community* effort. To understand how this can be done, Sioux Falls is compared to the five cities within the US that have reached 100% renewable electricity based on the Sierra Club's "100% Renewable Campaign." This program gives cities the strategies and targets they need to reach their goals; thus, giving hundreds of cities in the US that have pledged themselves a better understanding of where to start. Additionally, when looking into Sioux Falls and the state of South Dakota's characteristics, gaining the public's support in a bottoms-up or going the legislative route in a top-down approach for participation and educational outreach is considered.

What We Learned

As of April, 2021, only five cities across the US have reached 100% renewable electricity. These reasons included climate concerns, natural disasters, and/or economic benefits. Each town had differing levels of legislative and financial support from their states; as well as differing political affiliations, population sizes, and differing utilities carrying out the transitions. All of this information was beneficial to show that Sioux Falls has every potential of success for this project. They each showed a different scenario, which notes that there is not one single way of going about this transition. To give an example, Aspen, Colorado developed their renewable electricity plan for over a decade and are still developing climate action plans. Their transition was a full-blown community effort involving 40 city leaders that advise over several city organizations and departments. These members have jurisdiction that vary anywhere from aviation, forestry, community development, waste, to business. Their model flourished under a completely transparent transition with investors and co-ops through offering town hall meetings, surveys, tabling, and heavy web presence. The state of Colorado also gave funding and helped pass statewide incentives due to concern for climate change.

A study from Columbia University concluded that there were five main reasons for transitioning their cities:

- **Economic:** local economic development, job creation, utility cost savings, and secure energy futures
- **Environmental:** enviro consciousness, climate change concerns, natural disaster vulnerability, preservation of local enviro and wildlife, and climate leadership
- **External**: regional partnerships, existing state policies, existing or prior municipal policies and/or initiatives, and non-profit partnerships
- **Public health:** clean air and water, and pollution-related illnesses
- **Renewable resource supply:** availability and proximity of renewable energy resources to draw from

In over 63% of their cities being studied, they found that the economic benefits were the reason behind their transitions into renewable energy (Martiñez, 2018).

The state of South Dakota's legislation has been considered as a pathway for assistance in a top-down approach as its dynamic is heavily based around its economics. A top-down approach means building the public's awareness and participation through state and local government. Which can be done from assistance through state funding, passing legislation for statewide tax incentives, net metering, and retail rates. At first, this seemed very feasible - it would help create new jobs and we are only 1 of 3 states in the US that does not have net metering options. As it turns out, through research and interviews, it can be noted that South Dakota is not politically driven to make incentives in private markets like the budding renewable energy industry. South Dakota drives towards local economic development, job creation, utility costs, but it is not concerned with climate change and carbon emissions for now. Although this is true, there are efforts for a federal carbon tax to be passed at a federal level. Barb Cromwell, a leader for Citizens Climate Lobby in Rapid City, South Dakota primarily focuses on national carbon laws and taxes. They provide educational opportunities within South Dakota. Cromwell is optimistic at this national level, as she expects to see a federal carbon tax passed within the next five to ten years. Although state legislation will eventually be beneficial to look into as more development and coalition is built through the public, it is not the best place to start.

A bottom-up approach, which is the assembling of local grassroots to unite to support each other with bringing attention to renewable energy seemed to be another option. This approach can be done by offering:

- Educational programs
- Tabling at local events
- Town hall meetings
- Heavy web and social media presence
- Giving educational talks at local universities and community centers
- Community, residential, and business surveys
- Open development plans
- Utility collaboration for efficiency standards and education

Getting the message of renewable energy out there in a way that gets citizens interested in helping, learning more, and calling for action has proven to be crucial in the development for other communities.

The five 100% renewable electricity towns heavily relied on considering community outreach to be ⅓ of the trifecta in an all-inclusive program to "ensure buy-in." When showing the community every detail of the plan, they feel heard and valued in a way that makes them support a transition like this. Overall, it seems that the most efficient route time-wise and overall success will be based on a bottom-up approach of public education and involvement through local

grassroots, city leaders involvement, and the several higher education establishments within the city.

Conclusions

All things considered, there is not one single way of going about this transition. However, what was identified were effective and comprehensive options for the participation of the community of Sioux Falls. It was found that financial and legislative support from the state is feasible in a top-down approach after the initiation of a developed, educational, and supported plan that people know about, feel heard, and can fully support. In the meantime, that support can be developed through a bottoms-up approach of public education and involvement from local grassroots, city leaders, and the several higher education establishments within the city. This means educating the community through open communication, marketing and awareness and overall consensus through citizen participation.

Town	Year	Renewable Energy Type	Utility and Supplied Source	Population	Politics	State Leg on RE
Georgetown, TX	2018	50% solar 50% wind	GUS- municipally owned	54,898	Democrat Mayor Support	State goal of 10 GW RE by 2025
Burlington, VT	2014	50% hydro 30% wood chip 20% solar, wind, landfill methane	BED- municipally owned,	42,282	Democrat Mayor support	VT has a renewable energy standard (RES) of 75% by 2032. Cooperative utility
Aspen, CO	2015	53% wind 46% hydro 1% landfill methane	COA utility - municipally owned	6, 658	Libertarian Mayor support	CO has >20% by 2020 on RE
Rock Port, MO	2008	>125% wind	Investor owned utility (PPP)	1,300	Nonpartisan mayor support	MO has RES of 15% RE by 2021
Greensburg,	2013	166% from	Co-op owned	778	Republican	KS RE goal of

KS		town's own wind	KS Power Pool and utility owned		mayor	20% by 2020

III. Final: Summary & Recommendations

Summary

Climate change is a growing issue that will impact us all and must be addressed. It is going to take quick and effective action from multiple angles to stop and hopefully reverse the changes that are happening right now. Working at the scale of a city like Sioux Falls represents real opportunity. It is small enough to be able to effect change while being large enough to have a measurable impact.

In this report, we focused on five factors that are likely to affect the ability of a group of stakeholders to develop a campaign to get Sioux Falls to transition to 100% renewable electricity by the year 2035.

1. The current status of the electricity grid in and around Sioux Falls, and opportunities for renewable energy sources for Sioux Falls.
2. The financial implications of transitioning to 100% renewable electricity in Sioux Falls.
3. Methods and techniques to reduce the energy demand for Sioux Falls through energy conservation and efficiency.
4. The public health impacts of current and future climate change on Sioux Falls.
5. Recommended methods for the process of developing a renewable energy campaign.

Recommendations

Technology & Energy Use

- Sioux Falls needs to have current/baseline data on all energy use
- The long-term plans of the Sioux Falls electricity providers (ISOs and electrical companies) and their willingness to/interest in switching to renewable energy needs to be determined
- A strategy for "next steps" needs to be determined – e.g., only focus on one electrical company (e.g., Xcel), coordinating with other cities to pressure electrical companies to transition to 100% renewable electricity, and/or determining to what extent this campaign wants to focus on grid-provided electricity versus distributed (i.e., home- or business-produced) electricity

Financials

- It is imperative that Sioux Falls find a way to reduce the cost of technology necessary in transitioning households from non-renewable to renewable energy. If the cost can be reduced and the savings potential broadcasted clearly, there is a realistic possibility that the city could adopt some variance of a renewable energy policy.
- It is unclear how many jobs could be created in Sioux Falls through the transition to renewables; however, the sooner that the city decides to transition, the quicker the area can dominate the market in the Midwest for providing green energy technologies for surrounding areas to purchase. It is expected that across the U.S., a complete transition to renewable energy could bring over 25 million new jobs to the country. This would absolutely include Sioux Falls and the betterment of South Dakota if the state selected to participate.
- In order to play a role in the race against climate change, it is imperative that we find solutions to the pollution that our cities, including Sioux Falls, create. In understanding the voting demographic, it is clear that the way to convince green energy policy within this area is by framing the argument from a positive financial perspective. By highlighting the potential savings from yearly deductions of fossil fuel expenses and demonstrating methods to help compensate for the cost of early adaptation, there is a strong case for Sioux Falls to transition to renewables. In this way, we can not only positively impact the economy, but also the planet.

Conservation & Efficiency

- Reduce total electricity demand
- Determining baseline for current electricity efficiency and conservation policies and practices
- Promote/require urban greening especially strategic tree planting
- Promote/require building & appliance efficiency standards
- Promote distributed (especially PV solar) energy production

Public Health

- The risk to health from climate change is real and is already affecting Sioux Falls.
- Increased respiratory and cardiovascular disease, expanding vector and water borne disease, injury and loss of life from increased natural disasters – are a few of the many climate associated health risks.
- Sioux Falls obviously does not have complete control of the city's air or water quality because both are driven, to some degree, by regional factors. The city however does have some impact and certainly is in the position to be a leader in the state and the region.

- Finally, when looking for reasons for Sioux Falls to switch to the renewable energy sector- look no further than the health benefits that can be gained from doing so. The future of our world lies in our hands and to keep it healthy and happy we all need to come together and do what is right for our planet.

Education, Communication, Building Consensus

- Use a bottom-up approach
- Educate the community through open communication, marketing and awareness and consensus through citizen participation
- Seek state and federal financial support is feasible after the initiation of a developed, stable, educational, and supported plan that people know about, feel heard, and can fully support.
- Build coalitions with a diverse group of stakeholders to determine the different reasons why different groups are interested in moving to renewable energy (or are resistant to moving to renewable energy)

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