



# Senior Design Final Report

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**Northwestern**  

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**McCORMICK SCHOOL  
OF ENGINEERING**

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## Executive Summary

The Midwest is known as “America’s Heartland”; famous for expansive farmland and busy railroads. The region is often considered behind technologically, surviving off the backs of blue collar workers. It frequently pales in comparison to the coasts, regions that are thought of to be leading the way in technology and innovation. That being said, the Midwest has a variety of unique strengths in the food & agriculture, manufacturing, and transportation & logistics industries that are ripe for technological advancement. These industries are high energy intensity, and therefore much of the innovation focuses on increasing energy efficiency and reducing environmental impact.

The Midwest’s focus on these industries is particularly important because of the region’s unique strengths in these spaces. The Midwest has always been the home of major agricultural production, accounting for over one third of the country’s total agricultural output. Although still recovering from the global economic crisis, the Midwest manufacturing industry has continued to be a large source of GDP for almost every state in the region. Additionally, one of Chicago’s greatest advantages is the city’s placement as a central transportation hub for the entire country, home to many leading transportation and logistics companies serving both freight and passengers.

Chicago is quickly becoming the home of vertical, indoor farming, a process that can be used to farm year round with high yield ratios and reduced transportation costs. The Midwest region as a whole is leading the way with indoor farming as an alternative to other urban farming methods such as greenhouses, more prominent in other regions of the country. Reduced long term costs and energy savings makes indoor vertical farming a technology to not only watch, but invest in. This effort has high potential for success, but the lack of awareness and popularity has left it an untapped and underfunded area.

In the cross section of transportation and manufacturing are two very different, but similar purposed technologies: battery technology for electric vehicles and alternative fuels (biofuels). Biofuels is primarily useful for jet fuels, because airplanes cannot safely use battery technology. At the same time, the production capacity of biofuels makes it an unrealistic technology in terms of complete (or even majority) substitution for diesel, let alone gasoline. Vehicle electrification is growing in the Midwest, with various Chicago-area campaigns supporting this high-potential technology. The ease of use and reduced cost to consumers are additional reasons why the Midwest should prioritize investment in and growth of electric vehicles over biofuels.

We recommend a focus and prioritization of 1) the Midwest Manufacturing, Food & Agriculture, and Transportation & Logistics industries, and 2) Indoor vertical farming and vehicle electrification technologies. In an attempt to build the Midwest energy efficiency scene, the region needs to first understand its strengths, and then leverage them in order to ensure further growth and innovation.

## Problem Description and Context

The energy markets of specifically Chicago and the Midwest are diverse, complex and highly regulated. These qualities have resulted in a lack of innovation of energy efficient technologies that are also renewable and sustainable. When universities and companies patent and develop these technologies, there is a loss of mindshare and economic value, so there is a need to retain these assets.

Additionally, the utility industry is under dynamic change, so energy efficiency lags. Overall, there needs to be better acceptance of and preparation for disruption, change, and growth. Within the Chicago startup scene, these qualities are reflected. Startups work independently with their own agendas. There is a desire for a collective, focused energy efficiency space for startups. The same applies to professionals and university staffing.

A key part of being able to develop this collective space and effort is having the ability to identify strengths and weaknesses of the Midwest, analyze potential for growth and competitive forces, and understand the needs and abilities of the region. This is where our team comes in.

The overall goal is to map out the strengths of the Midwest energy market and energy efficiency initiatives. This includes a discussion of the niche for startups and innovation, the leaders in each area, technologies that have been developed and that have been successful, and the resources to leverage.

## Process

Before the team was able to truly analyze the Midwest market for energy efficiency, we had to look at the Midwest economy and working culture overall. With assistance from previous work done by Veritatis Advisors, WBC, and our own research, we performed a SWOT (Strengths-Weaknesses-Opportunities-Threats) analysis to identify the major areas where the Midwest may be able to grow and thrive in the energy efficiency space, as well as areas where there is no natural advantage, or the major regional competitors, the Northeast and the West Coast, are too advanced or advantaged. This allowed us to identify a better picture of what industries to pursue, and, later, explanations for why specific technologies would be able to succeed.

When deciding how to move forward with a large scoped project, the team built a simple model, consisting of: industries to focus on, trends within those industries, and technologies being developed or improved within those trends. There was significant overlap with the technology applications in different trends, and the trends existing in different industries. The first step of this, picking the industries, was mainly done looking at a few most important factors. These included: size of industry in the Midwest, size of industry in the U.S., a comparison of the Midwest's contributions to the U.S. size against the contributions of the other competitor regions, and current growth of industry in the Midwest. These factors were looked at in terms of dollar value output, mainly specified by the Gross Domestic Production (GDP) of the U.S. or the region, although labor numbers were used to analyze as well. By looking at how big the industry is in the Midwest, we were able to see if the industry was worth the effort of further analysis and if the Midwest might have an advantage in the area. This paired up well with the comparison of the Midwest's contributions against the other regions' contributions. If other regions are contributing significantly more to the national economy in the area, then it was a red flag for us. We wanted to grab the areas that not only would contribute the most to energy efficient growth, but also where the regional competitors would not have a natural advantage over the Midwest in developing innovation. For similar reasons, we wanted industries that are growing, to show that the industry is in good health and the energy efficiency innovation efforts will not go to waste. From here, we narrowed down to four industries: Food & Agriculture, Manufacturing, Transportation & Logistics, and Healthcare. Full explanation of the reasoning for the first three can be found in the *Industry Background* section. Healthcare was removed from the process when researching the trends in these industries. We hoped to find a 3-4 trends in each that would suggest where the industry is moving in a way that relates to energy efficiency. From there our goal was find technologies that are being developed to help those trends, and then narrow it down to those that may have the most impact, and are most worth future investment and research. During this stage, very few energy efficiency Healthcare technologies were found, and so that industry was removed from further analysis.

## Midwest SWOT Analysis and Support

The SWOT analysis (Figure 1) is a look into the strengths, weaknesses, opportunities, and threats to Chicago and the Midwest with regards to energy efficiency and the overall business health of the region. This was formed during early stages of research, in conjunction with previous efforts completed by WBC and Veritatis advisors.

| <b>Strengths</b>  | <b>Weaknesses</b>   |
|---|---|
| <ul style="list-style-type: none"> <li>● Low cost of electric energy</li> <li>● High nuclear power generation</li> <li>● Agriculture market</li> <li>● Hub for air, water, rail</li> <li>● Strong manufacturing economy</li> <li>● Lower cost for businesses to operate</li> <li>● Stable projected job growth</li> </ul> | <ul style="list-style-type: none"> <li>● Lack of reputation throughout majority of region</li> <li>● Lack of VC funding</li> <li>● History of hardware dominance over software</li> <li>● Nothing unique about Midwest healthcare industry</li> </ul>               |
| <b>Opportunities</b>  | <b>Threats</b>  |
| <ul style="list-style-type: none"> <li>● High level of thought innovation</li> <li>● Growing cities within the region</li> <li>● Central hub city (Chicago)</li> <li>● Multiple Research Class 1 Universities</li> <li>● Venture capital assets have growth</li> <li>● Large growth in wind energy production</li> </ul>  | <ul style="list-style-type: none"> <li>● The coasts have strong reputations</li> <li>● High funding to coastal startups</li> <li>● Stable industries lead to less innovation, VC funding</li> <li>● Low price of electricity reduces push for innovation</li> </ul> |

Figure 1: Strength-Weakness-Opportunities-Threat (SWOT) analysis for Midwest and Chicago

### **Strengths:**

#### *Low Price of Electricity*

Illinois electricity is regularly ranked as some of the most inexpensive in the country, allowing lower operating cost for businesses, especially those in energy-intensive industries, such as manufacturing. This low price of electricity stems from multiple sources. Illinois is the leading producer of electricity from nuclear power plants in the country, being home to 11 of the 99 plants.

<sup>1</sup> In addition to this, Chicago is a major transportation hub, allowing access to coal and natural gases. Illinois's geography allows for windmills producing electric energy to be viable both on land

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<sup>1</sup> "Illinois." *Illinois | Open Energy Information*, 23 Mar. 2018, [openei.org/wiki/Illinois](http://openei.org/wiki/Illinois).

and in Lake Michigan.<sup>2</sup> Regionally, the Midwest is close to the South for lowest average price of electricity (cents/kWh) when the average price across states is weighted based on the percentage of the population in the state relative to the region (Figure 2). Illinois would appear in this chart at 9.38 cents/kWh, right below the average of the Midwest.

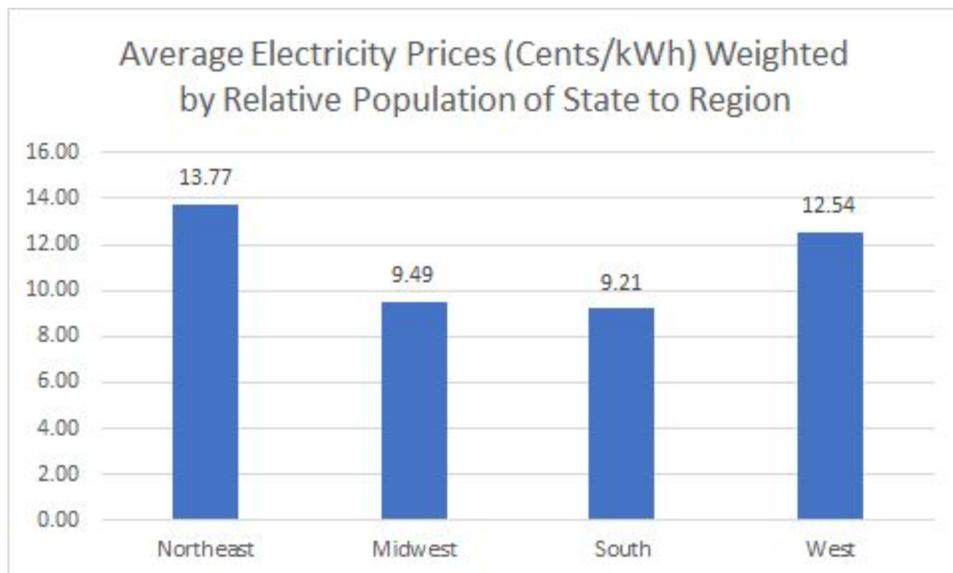


Figure 2: Average electricity prices (cents/kWh) for each region, where state averages are compared by the relative population of the state to its region<sup>3</sup>

### Large Agricultural Market

The Midwest has always been the home of major agricultural production, with some states being the largest producers of corn, wheat, soybeans, beef, poultry, and dairy products. The West and the Midwest have the highest Food and Agriculture output compared to other regions (Figure 3), but when analyzed per capita, the Midwest has significantly higher output than other regions (Figure 4). This agricultural market is deeply ingrained in the region, and is a major producer of income for rural areas. Unlike other areas of the country, the Midwest has large splaths of space suited for many crops, but still within range of transportation centers so the goods can be easily and efficiently moved to other parts of the region, country, or world.<sup>4</sup>

<sup>2</sup> “U.S. Energy Information Administration - EIA - Independent Statistics and Analysis.” *Illinois - State Energy Profile Overview - U.S. Energy Information Administration (EIA)*, 2017, [www.eia.gov/state/?sid=IL#tabs-3](http://www.eia.gov/state/?sid=IL#tabs-3).

<sup>3</sup> “U.S. Energy Information Administration - EIA - Independent Statistics and Analysis.” *State Electricity Profiles - Energy Information Administration*, 25 Jan. 2018, [www.eia.gov/electricity/state/](http://www.eia.gov/electricity/state/).

<sup>4</sup> Hatfield, J., 2012: Agriculture in the Midwest. In: U.S. National Climate Assessment Midwest Technical Input Report. J. Winkler, J. Andresen, J. Hatfield, D. Bidwell, and D. Brown, coordinators. Available from the Great Lakes Integrated Sciences and Assessments (GLISA) Center, [http://glisa.msu.edu/docs/NCA/MTIT\\_Agriculture.pdf](http://glisa.msu.edu/docs/NCA/MTIT_Agriculture.pdf)

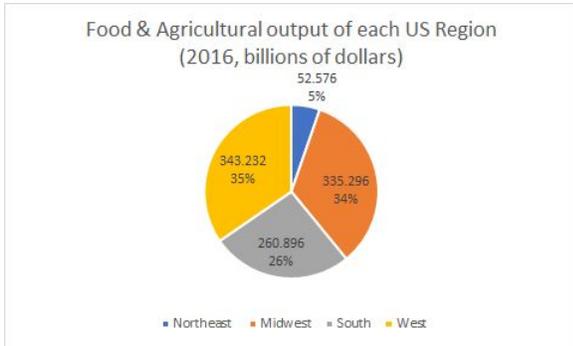


Figure 3: Food & agriculture output by US region

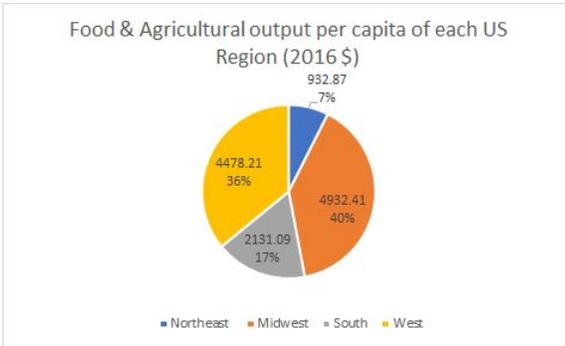


Figure 4: Food & agriculture output per capita by US region

### Hub for Air, Water, and Rail Transportation

Chicago, as the largest hub in the Midwest, has also continued to fulfill its reputation of being the major transportation hub of the nation, as evident in maps of national freight flows (Figure 5). While historically the center meeting place for all railroads, Chicago is also home to two major airports, which carry both passengers and freight in high quantities. Even with a reduced passenger demand for railways, Chicago continues to serve as a railway freight hub, in addition to do so for trucking, pipelines, and inland water transportation.

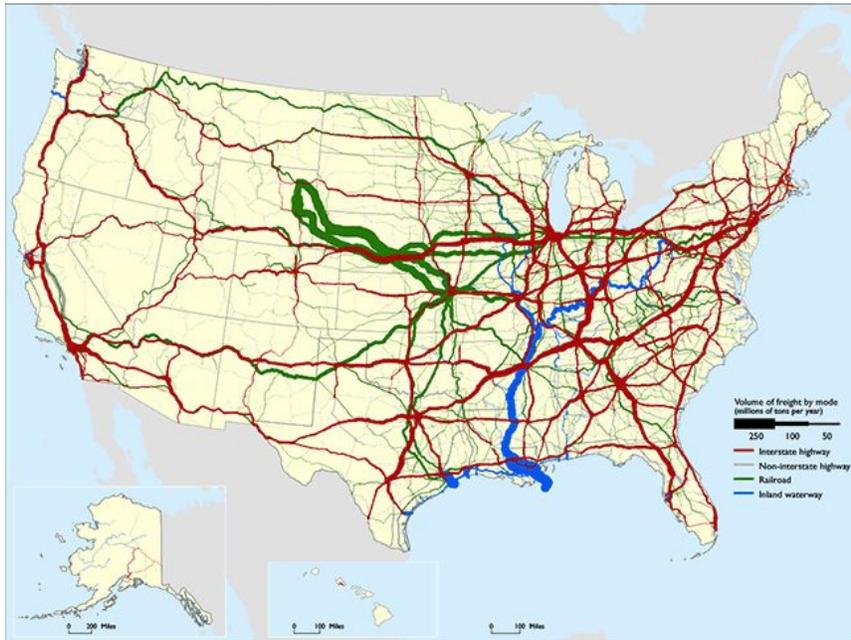


Figure 5: Freight flows by interstate highway (red), railroad (green), and inland waterway (blue), with volume indicated by thickness of line<sup>5</sup>

<sup>5</sup>“Freight Flows by Interstate Highway, Railroad, and Inland Waterway” *Bureau of Transportation Statistics*, [https://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/data\\_and\\_statistics/by\\_subject/freight/freight\\_facts\\_2015/chapter3/fig3\\_4](https://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/data_and_statistics/by_subject/freight/freight_facts_2015/chapter3/fig3_4)

### *Strong Manufacturing Economy*

The Midwest has a long history as the manufacturing center of the country, particularly in the areas of auto, heavy machinery, and food & beverage. Manufacturing requires large capital investments into infrastructure, and historically a large number of workers (although that is decreasing), so other regions of the country have had large barriers to entering the space. The South has the highest Manufacturing output compared to other regions (Figure 6), but when analyzed per capita, the Midwest shoots ahead significantly (Figure 7). Although manufacturing has decline in certain areas, particularly auto in Detroit, and the Midwest faces more significant international competition than ever, it is still a major part of the Midwest economy, and has continued to grow alongside the U.S. GDP for many years.

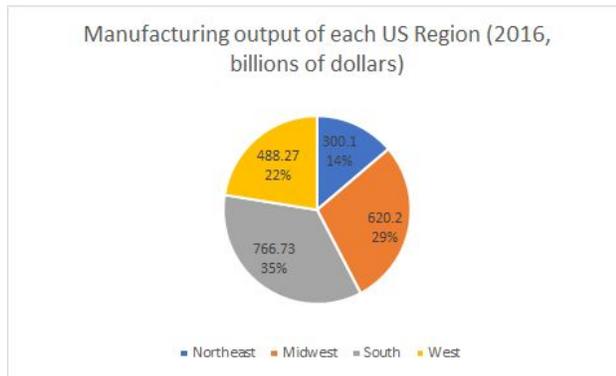


Figure 6: Manufacturing output by US region

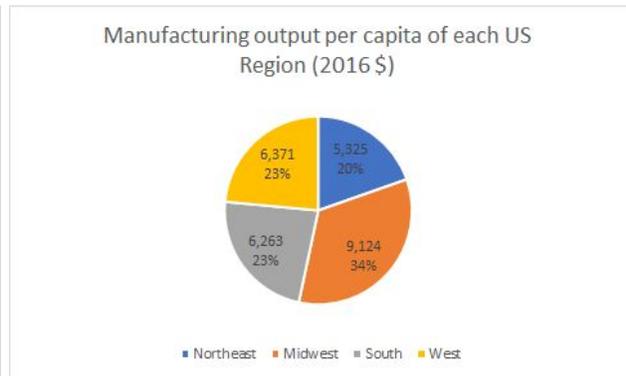


Figure 7: Manufacturing output per capita by US region

### *Lower Cost for Businesses to Operate*

The Midwest faces a unique advantage compared to the Northeast and West Coast, in that there are significantly lower costs for business to exist and operate. This stems from a number of different facets. Perhaps most importantly is the lower cost for building and living in the Midwest, especially when comparing the major hub city of Chicago to areas such as New York or Silicon Valley (Figure 8). The lower cost for buying or renting office buildings, in addition to the lower cost of living for workers, allow companies to have lower spending amounts and therefore higher profits, holding revenues the same.<sup>6</sup>

<sup>6</sup> "Cost of Doing Business Index." *Competitive Alternatives 2016*, KPMG, 2016, [www.competitivealternatives.com/default.aspx](http://www.competitivealternatives.com/default.aspx).

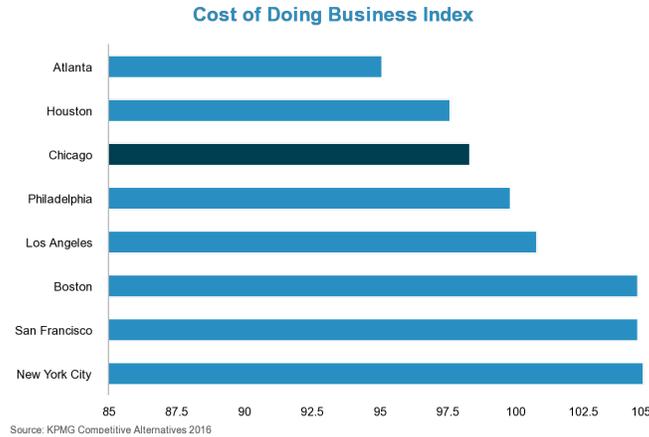


Figure 8: Cost of doing business index, includes factors such labor costs, utilities, facilities, transportation, financing costs, and taxes<sup>7</sup>

### *Stable Projected Job Growth*

Almost all projects of the Midwest state for stable job growth over the next few years. This is important as it suggests that there will also be growth in the relevant Midwest Industries, allowing for startups to work on areas that may improve these industries, and VCs or other funders to worry less about investing in a project that may affect a future non-existent industry.<sup>8</sup>

### **Weaknesses:**

#### *Lack of Reputation*

Midwest cities unfortunately don't have the best reputation in comparison to the rest of the US. Cities like Detroit and Cleveland suffer a "Midwestern inferiority complex"<sup>9</sup>, especially following the economic decline both cities faced. Smaller Midwest cities are simply known as the places where people on the coast are from. This may lead individuals, especially young entrepreneurs who frequently found startups, to choose one of the coasts over the Midwest, and for the VC funding to follow them.

#### *Lack of VC Funding*

There is a significant lack of funding and a shortage of professional venture capital firms within the Midwest's major metro areas (Figure 9). This directly impacts the region's ability to innovate, successfully develop and implement technologies, and become a part of the tech scene so prominent in Silicon Valley. This ties in to where startups are being founded, and also what type of startups are being founded, which are often tied to the major economic outputs of those areas.

<sup>7</sup> "Cost of Doing Business." *World Business Chicago*, KPMG, 2016, [www.worldbusinesschicago.com/cost-of-doing-business/](http://www.worldbusinesschicago.com/cost-of-doing-business/).

<sup>8</sup> "Midwest Economy - Labor Force Statistics." *U.S. Bureau of Labor Statistics*, U.S. Bureau of Labor Statistics, Jan. 2018, [www.bls.gov/regions/midwest/data/xg-tables/ro5xg02.htm](http://www.bls.gov/regions/midwest/data/xg-tables/ro5xg02.htm).

<sup>9</sup>Saunders, Pete. "The Midwest: Inferiority Complex And Economic Decline." *Forbes*, Forbes Magazine, 3 Oct. 2017, [www.forbes.com/sites/petesaunder1/2017/09/30/the-midwest-inferiority-complex-and-economic-decline/#1b5bcb2173d5](http://www.forbes.com/sites/petesaunder1/2017/09/30/the-midwest-inferiority-complex-and-economic-decline/#1b5bcb2173d5).

Chicago currently ranks 10th for VC funding when looking at major metro areas, with around \$650 million or 2% of total funding.<sup>10</sup>

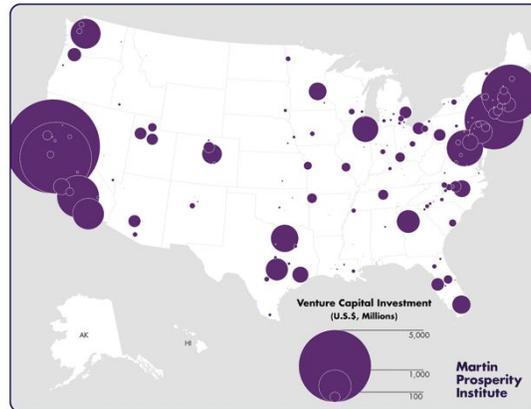


Figure 9: VC Investments in millions of dollars for major metro areas

#### *History of hardware dominance over software*

The Midwest has a history of focusing on hardware or tangible, asset based firms, over software or information and proprietary based firms. When software firms became popular on the west coast, it lead to more firms going to those areas in a snowball effect. This has left the midwest with a significantly lower amount of technology firms and software that may be used by startups to improve and revolutionize the midwest industries.

#### *Lack of Uniqueness in Healthcare*

While the healthcare industry in the Midwest is important and sizable, with a number of large companies calling the region home, there is not anything that stands out as particularly unique to the Midwest. This lack of advantages to founding in the region may lead to less startups doing so, and therefore a continued lack of innovation for the Healthcare industry.

#### **Opportunities:**

##### *High Level of Thought Innovation*

Multiple major research universities across the region (Chicago has Northwestern and University of Chicago), paired with a rise in startup incubators in Chicago has lead to a great deal of discoveries and ideas to be arising from the area. However, these ideas are not being taken advantage of and actual innovation has yet to take root in any major ways.

##### *Growing Cities Within the Region*

Multiple Midwest cities have had an accelerated growth rate over the past few years, fueled often by the population of cities with major university. Columbus, Ohio; Urbana-Champaign, Illinois; Ann

<sup>10</sup> Florida, Richard. "The Spiky Geography of Venture Capital in the U.S." *CityLab*, University of Toronto's Martin Prosperity Institute, 23 Feb. 2016, [www.citylab.com/life/2016/02/the-spiky-geography-of-venture-capital-in-the-us/470208/](http://www.citylab.com/life/2016/02/the-spiky-geography-of-venture-capital-in-the-us/470208/).

Arbor, Michigan; and Madison, Wisconsin are all home to major universities and population growth equal with or beating the U.S. average. This shows that the places where people are moving in the Midwest are to the educational beacons, which may suggest a larger amount of interest in research and innovation, as opposed to increases blue collar labor force in the largest cities such as Chicago.<sup>11</sup>

### *Central Hub City- Chicago*

Chicago, as the 3rd largest city in the nation, the largest city in the midwest, acts as a hub through which all Midwest cities connect. However, it is not yet the innovative center which utilizes the ideas and work from all other areas of the Midwest, in the way New York City and Silicon Valley are for their regions. While Chicago is currently growing as an innovative hub, it has not dominated the other cities in the Midwest yet. For example, Minneapolis (and by extension St. Paul) has been growing as a center for initial stage funding for startups, according to the M25 group, and has been outperforming all other cities in the Midwest, especially in areas of life science and software startups.<sup>12</sup> While Chicago still is the best for startups, as would be expected due to its size and central location, the growth being seen in Minneapolis shows that Chicago has not cemented the market. While it is beneficial to the Midwest to have as much innovation as possible, Chicago should look to cement itself as a central hub for it, similar to that of New York City or Silicon Valley.

### *Multiple Research Universities*

The Midwest is home to a thriving university and research space, with multiple Class 1 Research universities such as Northwestern and University of Chicago. These schools, along with many other suchs, promote research into the energy efficiency, and are a large source of advancements in the space. In addition, these schools are also home to thousands of very early stage startups that students are trying to get off the ground. These startups could be the beginning of innovative methods and technologies that could greatly improve energy efficiency. They are also catching the attention of more national organizations that are granting larger and more frequent grants to Midwest universities for these startups, such as the National Science Foundation.<sup>13</sup>

### *Venture Capital Assets are Growing*

While in the past the Midwest has significantly lagged behind both the Northeast and West Coast in both total size and growth of venture capital funding, it has begun to grow immensely over the past few years. Total size may still be behind, but growth suggests that more funders are seeing potential in the Midwest and Midwestern firms. An increase in awareness and funding in the

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<sup>11</sup> Saunders, Pete. "State Capitals And College Towns: A Recipe For Success." *Forbes*, Forbes Magazine, 29 Nov. 2017, [www.forbes.com/sites/petesaunder1/2017/11/29/state-capitals-and-college-towns-a-recipe-for-success/#119bdd3b781a](http://www.forbes.com/sites/petesaunder1/2017/11/29/state-capitals-and-college-towns-a-recipe-for-success/#119bdd3b781a).

<sup>12</sup> "M25 Home." *M25*, 2018, [m25vc.com/#home](http://m25vc.com/#home).

<sup>13</sup>Hustad, Karis. "UIUC & 3 Other Universities Launch a Midwest Hub for Commercializing Tech." *Americaninno.com*, 2 Nov. 2016,

[www.americaninno.com/chicago/uiuc-3-other-universities-launch-a-midwest-hub-for-commercializing-tech](http://www.americaninno.com/chicago/uiuc-3-other-universities-launch-a-midwest-hub-for-commercializing-tech)

Midwest could lead to a greater discovery and success of innovative energy efficiency technologies.

#### *Large Growth in Wind Energy Production*

The Midwest region has maintained a high level of investment in wind energy. Both Iowa and South Dakota generate over 30% of the state's electricity demand from wind.<sup>14</sup> Various companies have announced large scale investments in wind energy in Midwest states, and Fortune 500 companies and wind developers are helping to drive growth as well. Wind is currently the largest source of renewable energy, making this a clear bonus for the Midwest region.

#### **Threats:**

#### *"The Coasts" Have Strong Reputations*

Many think of Silicon Valley and the New York area as the two major regions for startup growth and tech innovation. The high levels of investment, big name companies, and branding that come out of these areas aren't helping put the Midwest on the map. These are areas of fierce competition and large-scale funding, things that the Midwest is not typically known for. The reputation and talk surrounding the coasts pose a threat to the Midwest as the region gets overlooked and overshadowed.

#### *High Funding to Coastal Startups*

As discussed under "Lack of VC Funding" in the weaknesses, the West and Northeast regions receive high levels of funding, especially in comparison to the Midwest. This is a severe disadvantage to the Midwest as the region is in constant competition with the rest of the country, but doesn't have access to the capital to fuel as much growth.

#### *Stable Industries Lead to Less Innovation, Funding*

The Midwest is known for being very stable, always following the status quo. Industries such as manufacturing and agriculture are big in the region, but because the Midwest has been good at them for so long, there is a lot less innovation happening in these spaces. There is somewhat of a "if it ain't broke, don't fix it" mentality in these stable industries.

#### *Low Price of Electricity Reduces Push for Innovation*

While a low price for electricity, as seen in the strengths section, can certainly have benefits for the region, it also has the potential to be a threat towards innovation. Extremely high prices and low availability typically drives change or innovation, so in turn the low prices have meant a lower need for companies and startups to innovate to reduce prices. It is possible that this has led to less innovation and may continue to have a dampening effect on future energy efficiency research.<sup>15</sup>

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<sup>14</sup> "AWEA U.S. Wind Industry Annual Market Report, Year Ending 2016." *American Wind Energy Association*, 2018, [www.awea.org/amr2016](http://www.awea.org/amr2016).

<sup>15</sup> Munson, Dick. "Industry Expert Interview with Dick Munson." Telephone interview. 26 Feb. 2018.

## Industry Research

### **Food & Agriculture Industry**

The food and agriculture industry consists of all growing, harvesting, storing, and preparing of agrarian products. On the agriculture side, there is farming of crops (both food and non-food) as well as livestock, and fishing. This industry also contains all processing of the products, and overlaps with the manufacturing industry for food manufacturing. Beverages and tobacco are also counted as a part of food and agriculture.

The Midwest has a large amount of flat, fertile land that allows for the growing of many crops and livestock, and states such as Illinois, Minnesota and Wisconsin are top 5 in producers of goods such as corn, wheat, soy, poultry, and pigs.<sup>16</sup> Other regions are not nearly as capable of producing as many agricultural products for several reasons, either due to space issues or environmental concerns. Because of this, the Midwest is uniquely primed over all region competitors in the U.S. Internationally, there are many other countries that can produce food goods, however the U.S. is still the major player in good such as wheat and corn, with Illinois alone exporting \$8.1 billion of food goods in 2014, doubling its amount in only 7 years.

The food industry also ties is closely with the vast transportation system in the Midwest. Since farming inherently takes up a great deal of space, farmers needs large and robust transportation to move products around the country and the world. Railroads are the most popular means of moving agricultural products, although waterways are still useful in some scenarios, and trucks move a great deal of manufactured foods products. Chicago's strength as a transportation hub, and the Midwest's interconnectedness to it, means that the area benefits from producing crops, manufacturing finished products, and shipping them, which greatly benefits the economy.

The Midwest's strong manufacturing core also benefits the food industry. Many of the food products consumers buy are not plain crops, but goods that have had additives. These can include preservatives, flavoring, mixing with other food products, pre-cooking, and packaging. The Midwest's large industrial core, especially around Chicago, means that factories can complete these changes quickly and in mass quantities.

Because of these reasons, many of the largest food companies have been founded or are headquartered in the Midwest. Illinois houses food giants such as Kraft Heinz, US Foods, McCain Foods, MillerCoors, and ConAgra Foods; Minnesota is home to General Mills and Land O'Lakes; Missouri has Anheuser-Busch; Michigan has Kellogg; and Kansas has the Dairy Farmers of America. These companies, and many more, are titans of their industry, and operate out of the Midwest because of how important it is to their business.

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<sup>16</sup> Wang, Sun Ling. "Summary of Recent Findings." *USDA ERS - Summary of Recent Findings*, 10 Oct. 2017, [www.ers.usda.gov/data-products/agricultural-productivity-in-the-us/summary-of-recent-findings/](http://www.ers.usda.gov/data-products/agricultural-productivity-in-the-us/summary-of-recent-findings/).

In addition, the Midwest is home to many of the top agricultural research universities and laboratories in the United States. The University of Illinois has one of the top agricultural programs in the country, and Illinois as a state is a “leader in biotechnology and agroecology research and innovation”. Many other universities and labs, such as Argonne National Laboratory, Fermi National Laboratory, Northwestern University, Southern Illinois University, University of Chicago, and the USDA’s National Center for Agricultural Utilization Research (NCAUR), are all doing work in Illinois in the food and agricultural spaces.

The food and agriculture space is particularly sensitive to environmental change and energy efficiency for multiple reasons. Farming and livestock are obviously growing activities, and changes to the environment such as temperature, air pollution, and rainfall can all have huge impacts on their success. In addition, farms are extremely spread out due to their massive size, and as such it can be very energy intensive to grow and process the crops. Especially in tractor use, there is significant fuel emissions from diesel needed to move the tractor or other heavy machinery over the large fields. Factories used to manufacture foods are highly energy intensive, as is almost all manufacturing. However, due to relatively short lifespans of most foods, especially when compared to the product of cars or machinery, factories cannot absorb power shortages nearly as well, and do not have much flexibility in changing operational hours to avoid peak power usage times.

## **Manufacturing Industry**

The manufacturing industry is the production of goods using machinery and typically done in bulk amounts. The goods being produced could be machinery, chemical, food/beverage, pharmaceutical, electronic, etc. The largest areas of production in the United States are in machinery, chemical, transportation equipment, and food/beverage/tobacco. The Midwest has a long history of being a manufacturing center, with strengths in all the major areas, but specializing especially in heavy machinery production. Many of the Midwest cities grew significantly during the U.S. industrialization period, with Chicago, Cleveland, and Detroit being the most significant. Manufacturing GDP over the past 35 years has run parallel to the U.S. GDP, although there is more competition than ever international. Manufacturing is very asset intensive, so a history of strength in the Midwest has allowed the region to stay strong for many years, as other regions avoid the heavy capital input. Although there are many fears about automation hitting manufacturing jobs the hardest, jobs in manufacturing continue to grow, and in 2012 alone it saw a growth rate of 14% of jobs.

The manufacturing industry benefits greatly from clustering, or putting companies of similar types near each other, especially because there are a great deal of federal, state, and local regulations limiting where manufacturing plants can take place. These regulations usually because of environmental concerns, but also out of safety and athletics worries. Environmental concerns are not unwarranted, as manufacturing is extremely energy intensive, and puts a great strain on the energy grid during peak hours. Because of this, many companies have headquarters in the Midwest. Illinois houses Deere and Co, Caterpillar Inc, Navistar, Boeing, Abbvie, and Abbott Labs;

Ohio has Goodyear Tire and Rubber and Cardinal Health; Michigan has Dow Chemicals, General Motors, Kellogg Co, Ford, and Whirlpool Corp; Minnesota has Mosaic Co, and Indiana has Cummins Inc.

## Transportation & Logistics Industry

The transportation and logistics industry consists of the movement of both passengers and freight using a number of different means, including auto, rail, water, air, pipeline; as well as the planning and logistics that goes into the operation of each of these. Transportation is a major part of the U.S. economy, and tends to grow parallel to the overall economic growth. It makes up about 8.6% of the overall GDP of the U.S. and employs about 8.8% of the U.S. labor force.

Historically, transportation was one of the most important industries for Chicago as the central hub of the Midwest and the country. Railroads were built that would intersect in Chicago to move goods and people easily across the entire country. Although railways have become much less popular for long distance transit, they are still used in high amounts for daily work commuting into the city and for the transportation of freight across the country. The railway network still expands across the country and the Midwest, and is vital to the transportation of goods such as coal, grain, and corn, that do not special care or accommodations that trucking may have. The interstate highway system also connects the region with the country, allowing for easy movement of people in automobiles or freight goods in trucks. Chicago is also home to one of the largest airports in the nation for freight and passenger travel, O'Hare airport, along with Midway Airport, another top 25 airport. Throughout the region other major airports include Minneapolis-St. Paul International Airport, Detroit Metropolitan Airport, and St. Louis Lambert International Airport<sup>17</sup>. Water transportation is vital to cities such as St. Louis, while lies along the Mississippi, and allows for cheap and easy movement of goods down river. The Midwest holds about a third of all U.S. natural gas pipelines, almost half of the natural gas storage fields, and about 40% of crude oil pipelines, which go across state and regional boundaries throughout the U.S. to their respective refinery stations.<sup>18</sup>

There has been significant growth in the transportation industry, following the end of the global financial crisis. Trucking has been growing at a steady 2.3% since 2009, and is expected to grow slightly about the national average of 2.8% over annually for the next five years.<sup>19</sup> There are particularly large opportunities for growth in air travel and air freight at the major hub airports, such as O'Hare.

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<sup>17</sup> "Major International Airports in the United States and Canada." *Nations Online Project*, One World Nations Online, 2018, [www.nationsonline.org/oneworld/major\\_US\\_airports.htm](http://www.nationsonline.org/oneworld/major_US_airports.htm).

<sup>18</sup> "State and Regional Energy Risk Assessment Initiative." *Energy.gov*, Office of Electricity Delivery & Energy Reliability, 2018, [www.energy.gov/oe/activities/energy-assurance/state-and-regional-energy-risk-assessment-initiative](http://www.energy.gov/oe/activities/energy-assurance/state-and-regional-energy-risk-assessment-initiative).

<sup>19</sup> Hawes, Clarissa. "New ATA Report Forecasts Steady Growth for Trucking Industry." *Trucks.com*, American Trucking Association, 20 July 2017, [www.trucks.com/2017/07/19/trucking-industry-steady-growth/](http://www.trucks.com/2017/07/19/trucking-industry-steady-growth/).

The logistics industry is by far the fastest growing part of the transportation industry, at 4.8 annual profit growth, although the growth would be much larger if not for rising costs.<sup>20</sup> Most logistics companies operate under zero or minimal assets, and provide planning and logistics programs or systems to the major transporters in order to better manage their business. While many large companies have internal logistics departments, most of the small companies do not, and so the proprietary software or service provide by these companies is vital. Better logistics is especially a boon to consumers, as it boosts safety, allows for more certainty with delivery arrivals, and ultimately can reduce errors and costs. However, logistics growth in the Midwest specifically has been slower than on the coasts, especially due to the high technological focus that is found there. Because of its centralization and the important of moving goods from the area, some major companies are headquartered in the Midwest. Illinois is home to DSC Logistics, Hub Group, and United Airlines; Michigan houses Penske, Universal Logistics Holdings, and Syncreon Holdings; Minnesota is home to C.H. Robinson Worldwide; Nebraska is home to Union Pacific; Ohio houses DHL Supply Chain and Total Quality Logistics, and Missouri houses Kansas City Southern.

The transportation and logistics industry is one of the largest users of energy and producers of air pollutants. Current estimates by the Department of Energy suggest that transportation is responsible for 70.5% of total petroleum consumption, and 27%-29% of total U.S. greenhouse gas (GHG) emissions.<sup>21</sup> Energy in the transportation industry is mainly the result of the fuel needed to move the different transportation modes. Although there has been a small reduction in GHG emissions in recent years, it is still a major environmental hazard. Most cars still use petroleum and or diesel, although there have been pushes towards electric vehicles, this has yet to fully grip the industry. In some cases, such as airlines, the use of electric fuel or natural gases is too dangerous, and so liquid fuel will be used in the near future. The impact can be clearly seen in that airplanes are responsible for about 2% of global GHG emissions.

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<sup>20</sup> "The Logistics and Transportation Industry in the United States." *SelectUSA.gov*, Mar. 2018, [www.selectusa.gov/logistics-and-transportation-industry-united-states](http://www.selectusa.gov/logistics-and-transportation-industry-united-states).

<sup>21</sup> "Energy Use for Transportation." *EIA.gov*, U.S. Energy Information Administration, 17 May 2017, [www.eia.gov/energyexplained/?page=us\\_energy\\_transportation](http://www.eia.gov/energyexplained/?page=us_energy_transportation).

## Trends and Technologies

A major trend in the food and agriculture space is the idea of precision farming. The International Association of Agricultural Economics projects worldwide population will grow 35 percent by 2050, leading to a 59 to 98 percent increase in demand for food. There are two ways to meet this hunger. Cut down more forests to open more arable land—an approach that is both unwise and unsustainable—or find new ways through bioengineering and precision farming to increase yields from existing farmland. Precision farming aims to do the second - in a lot of ways, farmers are trying to use the same amount of space and resources, but improve their yields as much as they can. Various startups including Aker, Metropolitan Farms, and Amber Agriculture are using various tools to improve their crop yields. Their toolkit of technologies includes drones for aerial survey, plant genomics, and alternative proteins are all raising solid funding rounds. The Midwest especially is primed for success here because of the level of establishment and deep roots that already have here.

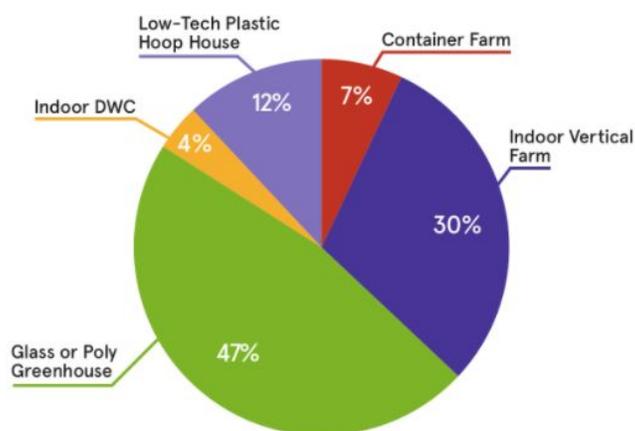
Another trend in the manufacturing industry that is gaining traction is fuel efficiency. Fuel efficiency is important because it helps to significantly reduce the amount of fuel consumed. The interesting thing about this trend is that a majority of the work being done in making vehicles more fuel efficient is by larger automotive companies. That being said, the driver of this is primarily government regulations and energy acts. Some of these include the Energy Interdependence and Security Act by the Department of Transportation (DOT) and the Environmental Protection Agency (EPA) in 2007, as well as the Federal Advanced Technology Vehicle Manufacturing Loan program (ATVM Loans). Because this is such a prominent trend, there is a high level of economic competitiveness that helps to drive growth. Advanced gasoline and hybrid vehicles are two technologies that help to achieve these fuel efficiency standards, reducing fuel usage and minimizing emissions.

While these trends are changing the face of energy efficiency as we know it, the trends and technologies further explored below, in the analysis, have potential to change the Midwest landscape. The following two sections make up the foundation of our recommendation, and are thus discussed at length.

## Analysis of Urban Farming

There are multiple types of urban farming, all of which offer similar advantages over traditional farming in terms of longer crop cycles, shorter growth time, higher number of crops per meter, less need for pesticides or herbicides, lower water consumption per crop, less post-harvest handling, and a shorter distance for farm to table. All of these advantages, coupled with the increasing size of cities as more people move to urban areas, suggest a need to invest in and improve the urban farming landscape. Urban farming, however, is a broad topic, and can be broken down into several different facility types, each with their own needs and advantages, as well as a number of different growing systems. Currently, the urban farming facility type breakdown of the United States is made up of mostly glass or poly greenhouses and indoor vertical farms (Figure 10).

### Facility Type



agrilyst

Figure 10: Urban farming facility breakdown<sup>22</sup>

The 5 types shown in this graph are as follows:

**Glass or Poly Greenhouses-** The “classic” looking greenhouse, which is a transparent, enclosed structure, made of glass or polycarbonate. Allows for an greater control over environmental factors such as temperature, light, and humidity, and carbon dioxide enrichment allows enhanced plant growth.

**Indoor Vertical Farms-** Fully enclosed and opaque rooms with a vertical growing system, allowing for plants to grow on multiple “floors” of a building. Less heat is lost through the walls when compared to glass or poly greenhouses, which is especially important for colder climates. The opaque walls mean that sunlight cannot be utilized in the same way as with greenhouses, so LED lights are used to provide the plants with artificial sunlight.

<sup>22</sup> Higgins, Chris, and Henry Gordon-Smith. “State of Indoor Farming.” *State of Indoor Farming 2017 - Agrilyst*, 2017, [www.agrilyst.com/stateofindoorfarming2017/](http://www.agrilyst.com/stateofindoorfarming2017/).

Low-Tech plastic hoop house- Also known as polytunnels, these are typically lower cost and quality versions of glass greenhouses. A lighter, and often temporary, plastic covering forms a rounded roof above the crops, allowing for higher temperatures and humidities around the plants, and some (but less) light. Typically these are used for crops over the winter, and more investments can be made to improve control over the various conditions.

Container Farms- Container farms are small, completely enclosed farm units which utilize elements of vertical farms on smaller scales. They have been traditionally used in recycle shipping containers, hence the name.

Indoor Deep Water Culture (DWC)- Full enclosed and opaque rooms, with non-vertical growth systems, where plants roots are submerged in highly oxygenated water without the need for soil. This system is the most different from the others, as it requires a more complex system of filters, aerators, pumps, and temperature control, but can all for higher nutrient uptake.

Green or poly houses currently make up the largest piece of the facility breakdown, and not without good reasons. The greenhouses allow for higher levels of control and heat in colder climates, while also still allowing in sunlight.<sup>23</sup> Historically, indoor farming practices with opaque walls were much less sustainable, because of the high costs of lighting an indoor space. Especially in regions such as the South, it was much easier to use a greenhouse that would take in light, and need little help maintaining the high temperature, while still having the advantages of carbon enriching, pest control, and some other environmental controls over traditional farming. However, the Midwest faces much colder and less sunny conditions than the lower half of the country. Here, Indoor Vertical Farming offers unique advantages. The opaque walls used allow for less heat to leave the greenhouse, especially in the fall and winter when the weather is colder and heating costs increase dramatically.<sup>24</sup> The heating cost alone makes glass green houses significantly less viable, and the major advantage of the glass green houses, the extra sunlight, has a much smaller effect when there is constant cloud coverage or snow in the winter. Indoor Vertical Farming relies on artificial LED lights which can be controlled to allow for constant sunlight (or varying levels of shade when needed) for plants, regardless of the weather conditions outside.

There are also significant advantages for vertical farming when compared to greenhouses in a number of other areas. Vertical farms have been shown to have shorter growth times, larger amounts of crops per meter, use less pesticides/herbicides, require less water and post-harvest handling, and have more frequent crop cycles. All of these point to more use and more crops from the farm. Both greenhouses and vertical farms far outrank traditional outdoor farming in these areas, but vertical farms also have a distinct advantage over greenhouses (Figure 11)

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<sup>23</sup> Higgins, Chris, and Henry Gordon-Smith. "State of Indoor Farming." *State of Indoor Farming 2017 - Agrilyst*, 2017, [www.agrilyst.com/stateofindoorfarming2017/](http://www.agrilyst.com/stateofindoorfarming2017/).

<sup>24</sup> Link, Jeff. "Why Chicago Is Becoming The Country's Urban Farming Capital." *Fast Company*, Fast Company, 23 Sept. 2016, [www.fastcompany.com/3059721/why-chicago-is-becoming-the-countrys-urban-farming-capital](http://www.fastcompany.com/3059721/why-chicago-is-becoming-the-countrys-urban-farming-capital).

|  | Outdoor    | Greenhouse | Vertical Farm |
|--|------------|------------|---------------|
| Location                               | Open field | Open field | Anywhere      |
| Crop Cycles                            | Seasonal   | Seasonal   | Anytime       |
| Growth Time                            | 70 days    | 45 days    | 21 days       |
| Number of Crops per Meter <sup>2</sup> | 18         | 25         | 25-300        |
| Pesticides/Herbicides                  | Often      | Less Often | Never         |
| Water Consumption per Crop             | 35 L       | 15 L       | 1.5 L         |
| Post-Harvest Handling                  | High       | Medium     | Low           |

Source: Urban Crop Solutions

Figure 11: Comparison of outdoor, greenhouse, and vertical farming<sup>25</sup>

When comparing the other three types, there are some advantages to each, but on a large scale all pale in comparison to vertical farming and glass greenhouses. Indoor DWC is extremely labor intensive, requires a much higher level of capital to begin, and has higher risks of issues with pumps. This, along with the high level of water it uses, means that while some DWC farms can be profitable, many will not be able to keep up with high costs and needed expansion. Hoop houses can be extremely profitable due to the low investment costs when compared to glass greenhouses, but depending on the crop type may only be temporary or small scale. When trying to scale to much larger levels of urban farming, the necessary upgrades and technology needed by these hoop houses essentially turn them into full greenhouses. Finally, container farms, while popular as a form of urban farming in areas with a large amount of container freight, fail to utilize the advantages of scaling, since many of the containers are kept in individual or only somewhat connected environments. This again becomes a problem of scale, and if the containers were more highly connected to allow shared utility from heating and lighting systems, they would essentially become a vertical farm.

Midwest Urban areas, and in particular Chicago, can benefit the most from the unique differences between indoor vertical farms and glass or poly greenhouses. The advantages offered to glass or poly greenhouses, namely in allowing light from the sun to help the plants grow, is significantly less of a factor when there is less light being allowed throughout the year because of the climate. And the major disadvantage, the high cost of heating due to temperature loss through the glass or poly roof and walls, becomes even more disadvantageous when the climate is significantly colder than many other parts of the country. On the flip side of this, indoor vertical farming holds in more heat, reducing the cost needed to maintain the high temperature of the farm. And low electric prices, coupled with continuing advances in LED light technology, allow for artificial sunlight to be created for a much lower cost. In total, estimates for vertical farming growth over the next few years across the U.S. range from 22.4%-24.2% CAGR over the next 5 years.<sup>26</sup> This puts the

<sup>25</sup> Perelman, Mark. "Vertical Farming Climbs in Cleveland, Chicago, New York." *GreenBiz*, GreenBiz Group Inc., 22 Nov. 2017, [www.greenbiz.com/article/vertical-farming-climbs-cleveland-chicago-new-york](http://www.greenbiz.com/article/vertical-farming-climbs-cleveland-chicago-new-york).

<sup>26</sup> "Vertical Farming Market Size Worth \$9.9 Billion By 2025 | CAGR: 22.4%." *Market Research Reports & Consulting*, Apr. 2017, [www.grandviewresearch.com/press-release/global-vertical-farming-market](http://www.grandviewresearch.com/press-release/global-vertical-farming-market).

worldwide industry at a value of about \$9.9 billion by the year 2025.<sup>27</sup> As it currently stands, the Midwest has the largest percentage of indoor vertical farms compared to the other types of facilities than any other region, putting the Midwest at an advantage with this technology. (Figure 12)

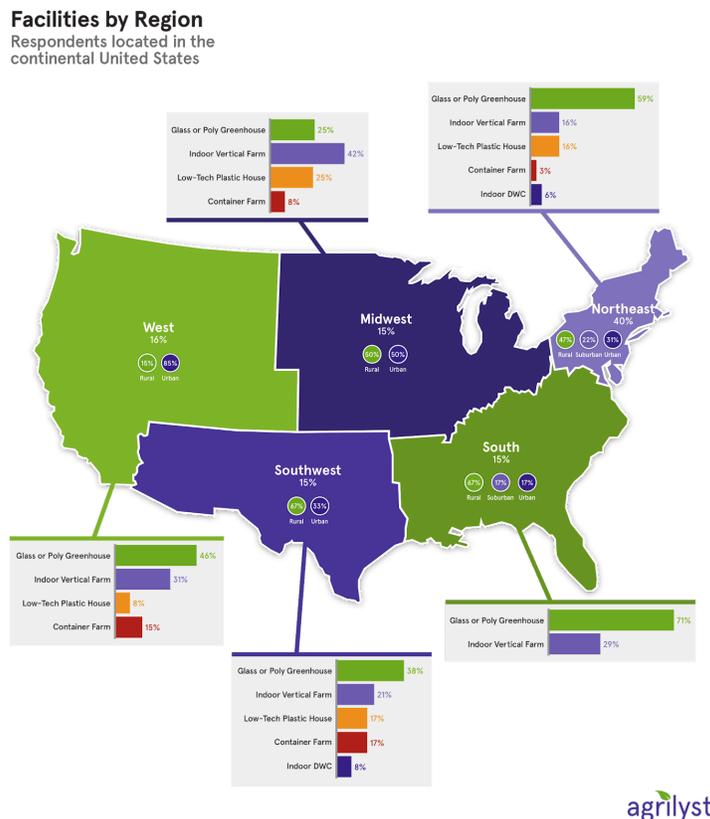


Figure 12: Breakdown of facilities types by region

Vertical/Indoor farming is a relatively new idea, with urban cities taking the lead on this for a couple of reasons. It is an attractive option because of not only how close to the market the farms tend to be, but also because you are able to do it year-round without weather concerns. There are many startups in the Chicago area itself that are taking advantage of this, and have even had recent success in terms of funding. For example, Urban Till is a startup here that has raised \$3.13 million in investments since 2013. In addition, there is confidence and growth potential for this industry, and Chicago and the Midwest are primed for that success. With a key network of already established startups, there are a couple of external factors that will help fuel growth. The two main reasons for this are customer demand and solar power. Consumers are more and more looking to get fresher and fresher food, and the only way that the distance from farm to table gets lower is through more urban farming. In addition, the abundance of solar power has driven down prices, making lighting of these farms more affordable.

<sup>27</sup> “Global Vertical Farming Market Size, Share, Development, Growth and Demand Forecast to 2023 - Industry Insights.” *P&S Market Research*, Nov. 2017, [www.psmarketresearch.com/market-analysis/vertical-farming-market](http://www.psmarketresearch.com/market-analysis/vertical-farming-market).

## Analysis of Vehicle Electrification and Alternative Fuels

When looking at energy uses and efficiency, one of the major topics that comes to mind is transportation in all forms, but especially by automobile and by plane. Chicago, which grew in its early stages because of its unique position as a transportation hub, has always maintained a strong position in the transportation field. It has been historically assisted in this because of its manufacturing base, and by other cities in the region such as Detroit, Michigan, which is still home to the headquarters of multiple major U.S. car companies. Naturally, all transportation needs a fuel source to operate, and although some sources are better suited to different needs, the major fuel consumed is gasoline by cars, diesel by heavy machinery, and jet fuel (which is similar to diesel) by airplanes. The problem with all of these fuel sources is they come from fossil fuels, which pollute the air with toxic carbon dioxide and carbon monoxide during their combustion. As a result, government regulators have long pushed car companies to develop more fuel efficient vehicles, allowing automobiles to go further on less gas, reducing this pollution.

But this is not the only type of innovation taking places. Alternative fuel choices are becoming increasingly popular, of which there are two major fuel choices to consider: electricity and biofuels. In the sense being discussed here, electric vehicles are those with batteries as their fuel source, which can be charged with no emission electric energy. Biofuels are fuels produced from biological waste and byproducts, such as old farm goods, waste from medical procedures, and even certain types of algae. Both of these fuels are significantly cleaner than oil-derived fuels, and each have their own advantages to the market and to the Midwest. However, both are still not widely spread in the nation or the Midwest, and a great deal of technological innovation is needed to popularize them. In this matter, we suggest the Midwest focuses on improving battery technology to allow for better and cheaper electric vehicles, and focuses less on biofuels and the biodiesel it produces.

To give more context on biofuels and their current role in the energy landscape today, it is important to understand a little bit of background on them as well as a comparison with battery technologies. Biofuels, also called agrifuels, can be defined as solid, liquid, or gas fuel derived from plant or animal materials (biomass). Today, the most popular biofuel worldwide is ethanol. According to the Renewable Fuel Association, the American trade association for the ethanol industry, the United States and Brazil together produce approximately 90 percent of the world's fuel ethanol. In the last couple decades A serious fuel crisis again hit the various countries during the period of 1973 and 1979, because of the geopolitical conflict. Thus (OPEC), organization of the petroleum Exporting countries made a heavy cut in exports especially to the non OPEC nations. The constant shortage of fuel attracted the attention of the various academics and governments to the issues of energy crisis and the use of biofuels. The twentieth century came with the attention of the people towards the use of biofuels. Some of the main reasons for the people shifting their interest to biofuels were the rising prices of oil, emission of the greenhouse gases and interest like rural development.

In addition, there are a few intricacies that need to be spelled out. A couple major points regarding diesel fuel are also relevant to know before reviewing our analysis. While diesel stores more energy, it is not as clean and most cars cannot use diesel, rendering it useless in those situations. It's also important to look at the background of battery technologies and how they apply to transportation.<sup>28</sup>

In addition, the breakthrough of battery technologies in recent years, specifically in the space of electric vehicles, has made major strides. The primary battery tech used in electric vehicles now are lithium-ion batteries, which are positively charged lithium ions that travel between the anode and the cathode in the electrolyte. These batteries have a high cyclability – the number of times the battery can be recharged while still maintaining its efficiency – but a low energy density – the amount of energy that can be stored in a unit volume. When comparing the usage of both biofuels and electric vehicles, one stark contrast appears. Biofuels are carbon neutral, while electric vehicles don't produce anything. This inherently puts electric vehicles at an advantage when it comes to emissions, as being carbon neutral doesn't help when it comes to smog and other environmental factors.

When looking at plug-in electric vehicles (PEVs), it is important to note that there are two major subdivisions: battery electric vehicles (BEVs) and plug-in hybrids (PHEVs). BEVs run entirely on battery power, while PHEVs combine battery and internal combustion engine power. There is some difference with the amount of fossil fuel consumption due to the existence or absence of an internal combustion engine, leading BEVs to be a more environmentally friendly option. BEVs have also grown in popularity quicker than the PHEV, and currently there are slightly more BEVs on the road in the U.S. Because both types rely heavily on the capacity and strength of an internal, rechargeable battery, they will both be discussed under the single label of “electric vehicles” in this report.

As per reports by the Bureau of Transportation Statistics (BTS), total fuel consumption by US airlines in 2017 was 17.3 billion gallons<sup>29</sup>. This number is consistent with usage from as far back as 2004. (Figure 13)

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<sup>28</sup> Threewit, Cherise. “Diesel vs. Gas Trucks.” *U.S. News & World Report*, U.S. News & World Report, 2 Nov. 2016, cars.usnews.com/cars-trucks/best-cars-blog/2016/11/diesel-vs-gas-trucks.

<sup>29</sup> “Airline Fuel Cost and Consumption (U.S. Carriers - Scheduled).” *Bureau of Transportation Statistics*, United States Department of Transportation, 14 Mar. 2018, www.transtats.bts.gov/fuel.asp.

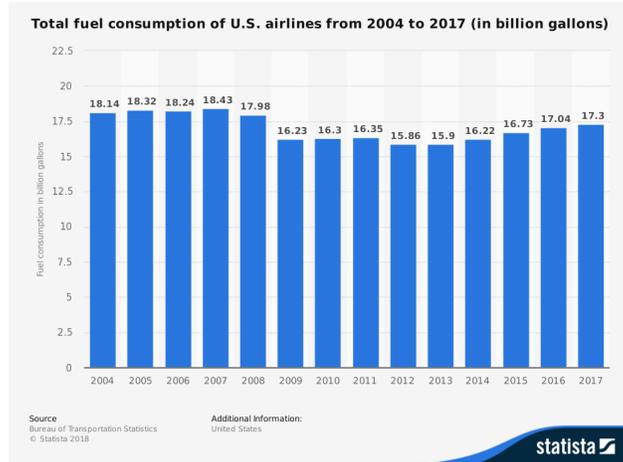


Figure 13: Total Fuel Consumption of US Airlines from 2004 to 2017, BTS<sup>30</sup>

The total production of biofuels in 2017 was just over 1.5 billion gallons, a number far below the prospective demand of jet fuels alone. At the same time, because not all US airlines are using biofuels in their planes, the actual demand is a lot lower, justifying the current production numbers. That being said, the biofuels production capacity of the US, or the maximum amount of biofuels the US has the ability to produce, is a lot higher, reaching just over 2 billion gallons per year, or around 27.5 billion gallons for all of 2017. These exact values, are reported by the U.S. Energy Information Administration (EIA) (Figure 14)<sup>31</sup>.

| Period                | Annual Production Capacity | Monthly B100 Production |
|-----------------------|----------------------------|-------------------------|
| <b>2017</b>           |                            |                         |
| January               | 2,316                      | 93                      |
| February              | 2,316                      | 94                      |
| March                 | 2,360                      | 116                     |
| April                 | 2,326                      | 127                     |
| May                   | 2,327                      | 136                     |
| June                  | 2,327                      | 140                     |
| July                  | 2,330                      | 150                     |
| August                | 2,319                      | 149                     |
| September             | 2,348                      | 147                     |
| October               | 2,355                      | 148                     |
| November              | 2,415                      | 148                     |
| December              | 2,399                      | 148                     |
| <b>12 Month Total</b> | --                         | <b>1,595</b>            |

Figure 14: Potential and actual production values of biofuels in the US by month in 2017, EIA

If the United States were producing biofuels at full capacity (ignoring the barriers of costs, labor), then the 27.5 billion gallons of biofuel would be enough to satisfy demand of 17.3 billion gallons of jet fuel alone. But this doesn't include other forms of transportation. Cars use nine times more fuel every year than planes do, so it's a much larger market. In 2016, about 143.37 billion gallons of finished motor gasoline were consumed in the United States, as per the EIA. It is important to

<sup>30</sup> Bureau of Transportation Statistics. "Total Fuel Consumption of U.S. Airlines from 2004 to 2017 (in Billion Gallons)." Statista - The Statistics Portal, Statista, [www.statista.com/statistics/197690/us-airline-fuel-consumption-since-2004/](http://www.statista.com/statistics/197690/us-airline-fuel-consumption-since-2004/)

<sup>31</sup> "Monthly Biodiesel Production Report." U.S. Energy Information Administration, Jan. 2018, [www.eia.gov/biofuels/biodiesel/production/table1.pdf](http://www.eia.gov/biofuels/biodiesel/production/table1.pdf).

note in this statistic that this is different than diesel fuel. Diesel is not a substitute for this type of fuel, and biodiesel does not meet any of the demand needed. The production capacity of the entire United States couldn't cover even 6% of this overall demand.

That all being said, biodiesel production from the Midwest region (Petroleum Administration for Defense District 2) accounted for 66 percent of the United States total. It is evident that the Midwest is currently investing in biofuels, however, this is not a succeeding or growing market for the region. Chicago based Emerald Biofuels was awarded \$55 Million in 2014 from the Department of Defense for a 10 million gallon biorefinery producing bio-equivalent fuels. This project has not made any progress, and industry experts say that the project will not reach fruition. This large scale project falling through is an indication of the climate surrounding biofuels innovation and growth in the Midwest. At the same time, Chicago headquartered United Airlines was the first airline to begin use of commercial-scale volumes of sustainable aviation biofuel, both sourced from and utilized in California. The west coast is a hotspot for biofuels usage and innovation, and although the Midwest region currently has the capacity to produce around two-thirds of all the biofuels in the United States (Figure 15) the limited scope and previous failures is reason enough to shift focus to other areas<sup>32</sup>.

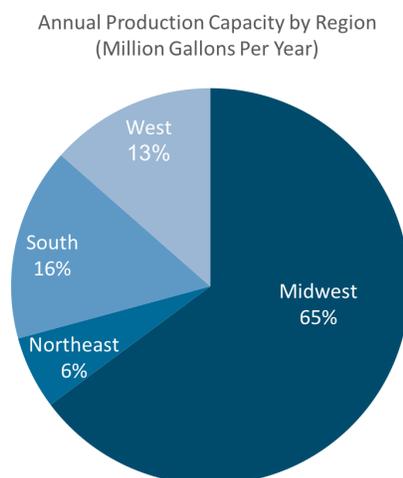


Figure 15: Annual Biofuel Production Capacity by US Region, EIA

Electric vehicles have been steadily growing in popularity in the United States and abroad for a number of years. However, there have been a few significant issues that need to be solved in order for them to truly be common and popularized across the nation. The two major issues are range and price of electric vehicles. The first of these, the range, is the numeric representation of how far, on average, the vehicle can travel on a single charge. This is comparable in an internal combustion engine car to its total tank size multiplied by its average fuel efficiency (in miles/gallon). The best selling all electric vehicle in the world, the Nissan Leaf, has a range of just

<sup>32</sup> "Monthly Biodiesel Production Report." *U.S. Energy Information Administration*, 28 Feb. 2018, [www.eia.gov/biofuels/biodiesel/production/](http://www.eia.gov/biofuels/biodiesel/production/).

around 100<sup>33</sup> miles on a single charge, which is problematic because a the 2018 Nissan Sentra, a new ICE compact car model, can travel upwards of 400 miles on a tank (mixed highway and city). This range has lead many consumers to fear they may get stranded or be unable to make it to a destination. This fear is further exacerbated because the time to charge a Nissan Leaf at a home charge station is about 4 hours. Of course, these numbers are only for one model, and other electric vehicles, such as the Tesla Model 3 boasts being able to travel over 300 miles on a single charge. But it is still problematic that those vehicles on average cost twice the price of the Nissan Sentra.

However, large companies have recognized the growing trend toward electric vehicles.<sup>34</sup> Every major car company that operates in the United States has stated that they are working towards all electric vehicles, and nearly every company offers a hybrid vehicle option. Especially as the government tightens regulations on ICE vehicles, these major companies are seeing this as the only way keep their business strong and meet consumer demand.

Chicago is uniquely primed to be the center of all battery technology innovation in the nation. Most important to this is the Argonne National Laboratory, which is operated by the University of Chicago and is one of the Department of Energy's energy innovation hubs.<sup>35</sup> The Argonne Lab leads the Joint Center for Energy Storage Research (JCESR), which has partnerships with Universities such as Northwestern, MIT, Harvard, University of Chicago, University of Waterloo, and others; as well as with other national labs such as Pacific Northwest, Sandia, and the Berkley lab; and major private sector partners such as Dow, the Clean Energy Trust, United Technologies Research Center, and others. JCESR brings together many of the most important researchers and much of the most innovative research from around the country and the world into the Argonne lab in Chicago.

There are other reasons why Chicago should be focusing more on battery technology. As discussed in the SWOT, the low price of electricity should be a major attraction to consumers. Gas prices are extremely volatile, and can be affected greatly from political events on a local, national, or even global level, while electric price tend to stay much more consistent. When comparing the two Nissan vehicles mentioned earlier, the price to drive 100 miles would be able equal to charging the 40 kWh battery, at the Illinois average of 9.38 cents/kWh<sup>36</sup> would be about \$3.75. Meanwhile, the Nissan Sentra, travelling at about 30 miles/gallon, at Illinois average gas price of \$2.53/gallon<sup>37</sup> (at time of this report, subject to volatility as mentioned above) would be about \$8.43 to drive 100 miles, and even more expensive closer to urban areas. This reduced

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<sup>33</sup> "Nissan LEAF® Range." *Nissan LEAF® Q&A*, [www.nissanusa.com/electric-cars/leaf/owner-questions/ev-daily-range](http://www.nissanusa.com/electric-cars/leaf/owner-questions/ev-daily-range).

<sup>34</sup> "Global EV Outlook 2017." *International Energy Agency*, [www.iea.org/publications/freepublications/publication/GlobalEVO Outlook2017.pdf](http://www.iea.org/publications/freepublications/publication/GlobalEVO Outlook2017.pdf).

<sup>35</sup> "JCESR Partnerships." *Joint Center for Energy Storage Research*, U.S. Department of Energy, [www.jcesr.org/partnerships/](http://www.jcesr.org/partnerships/).

<sup>36</sup> "State Electricity Profiles." *Energy Information Administration*, 25 Jan. 2018, [www.eia.gov/electricity/state/](http://www.eia.gov/electricity/state/).

<sup>37</sup> "Gas Prices- Illinois." *AAA Gas Prices*, AAA, 13 Mar. 2018, [gasprices.aaa.com/?state=IL](http://gasprices.aaa.com/?state=IL).

price can have an obvious effect on all Midwest drivers, including those in automobiles for personal use, businesses, and can be incorporated into public transportation such as busing systems, as it has begun to be in California.<sup>38</sup>

There is a final advantage to focusing on battery technology which exists outside of the transportation industry. By improving the storage ability of batteries, and making them cheaper for production and purchase, localized batteries can be used in areas of high energy usage, such as factory clusters, to store energy during non-peak times. By taking some stress off of the grid during these peak hours, not only can companies save money on energy costs, but electric providers can use less of their older and less environmentally friendly forms of producing electricity.<sup>39</sup> By doing so, these plants can be closed and more focus can be put onto cleaner methods such as wind, solar, and nuclear power. A deeper analysis is required to look into batteries connection with the grid, which is currently outside the scope of this report.

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<sup>38</sup> "Fleet Rule for Transit Agencies." *CA.gov*, California Environmental Protection Agency Air Resources Board, 2 June 2017, [www.arb.ca.gov/msprog/bus/bus.htm](http://www.arb.ca.gov/msprog/bus/bus.htm).

<sup>39</sup> Golden, Matt. "Industry Expert Interview with Dick Munson." Telephone interview. 12 Feb. 2018.

## Conclusion

After thorough research and calls with industry experts, we identified the manufacturing, food & agriculture, and transportation & logistics industries to be core strengths of the Midwest region, especially with respect to energy efficiency. Indoor vertical farming and vehicle electrification are two high-potential trends that the Midwest has the potential to take to the next level, among other trends such as fuel efficiency and precision farming. Because of the potential of electric vehicles, we think the Midwest should refocus its efforts to play to the strengths of the region.

## **Change/Implementation Plan**

The change and implementation plan that we propose is multi-faceted and involves an approach that tackles the issues from various angles. The main themes of our plan involve collaboration and branding.

The first major theme we want to implement is collaboration. There are two ways this can be done: working with startup hubs/universities, and pooling resources to increase funding. Working with startup hubs in Chicago such as 1871, mHUB, and WeWork, and specifically reaching out to startups that are working in these spaces would be create very valuable resources, and potential future partners. Many promising startups are in these spaces, but sometimes lack the visibility to get to where they want to be, and working with them can help mitigate that issue. In addition, pooling of resources can be a strong method to create symbiotic relationships and networks across Chicago and the Midwest that are mutually beneficial, helping each other climb the ladders of success, and overall bringing more attention to the Midwest culture.

The other area we want to focus on is branding. Specifically, the way we brand the Midwest and the image we invoke in the minds of entrepreneurs, politicians, and funding sources alike. We know what we are good at here in the Midwest, and we need to proudly own it and excel in it. This image is what will lead to more national attention and funding headed our way. For example, the Silicon Valley established itself as a software hub of the world, and continued to push agendas in that space itself, which is what began the domino effect of success, funding, and press for that region. The Midwest can adopt a similar strategy for the identified critical spaces in this report.

## **Future Impact**

Future impact of this project could be in the space of opening a startup incubator, or providing a toolkit of resources for energy efficiency. Both methods help centralize a lot of what is lacking in these regions, and could lead to an easier transition into some of the recommendations and plans discussed above. A startup incubator focused solely on energy efficiency startups would benefit both the region and the startups/culture around them, giving the region a platform to grow and showcase its talent, developing a pipeline that would grow into a strong foundation of success. On the other hand, startups in the space would have a solidified network of mentors, peers, and a larger space to help put them on the map.