Team Brundtland
Executive Summary of Fort Worth

The city of Fort Worth offers a unique opportunity to pursue energy efficiency measures with its large number of buildings, wide variety of sectors, and rapidly growing population. With over 200,000 buildings using 10 billion kilowatt hours of electricity and consuming over 20 trillion BTUs of natural gas, a large-scale energy efficiency program implementation would offer not only substantial savings to its consumers but also a model on which other cities can emulate in the future.

In order to maximize the impact of any recommended energy efficiency strategies, we first identified the most significant targets by building sector. Due to lack of a centralized database for building energy use in Fort Worth, we devised our own method with which to estimate energy consumption and end use of energy for buildings within the city. We contacted the city of Fort Worth to obtain building zoning data. Once this was obtained, we were able to combine the zoning data and parcel data to obtain the sector type and area of every individual building within Fort Worth. Using these data, we calculated the energy intensity by consumption (electricity and natural gas) and end use (air conditioning, space heating, water heating, refrigeration, and other) by combining with the Residential Energy Consumption Survey (RECS) and Commercial Building Energy Consumption Survey (CBECS) from the Energy Information Agency (EIA).

We found that single-family detached dwellings and industrial buildings consumed the most energy at 3 billion kWh annually for each, and 14 trillion and 4 trillion BTUs of natural gas respectively. As these were the two most energy intensive sectors, we chose these two as the first set of targets. For the third targeted sector, we decided to choose schools as the last focus. Despite lower overall energy consumption, there are a number of strategic benefits including high visibility for efficiency implementation measures and because they encourage students to engage in sustainable practices.

In the residential sector, we focused on two strategies: promoting the effective use of smart meter data and promoting the installation of learning thermostats. These strategies empower homeowners by providing them with more useable information on their energy consumption in order to more intelligently pursue energy reduction. We believe these two strategies can reduce residential energy consumption by 6%-13%.

We proposed three strategies for the academic sector: joining the Collaborative for High Performance Schools for K-12 institutions, implementation of LEED standards for all new construction and renovations on university campuses, and the use of real-time energy dashboards in conjunction with gamification to encourage the adoption of energy efficient habits among students, faculty, and staff.

For the industrial sector, we recommend lighting retrofits and motor system efficiency improvements, specifically targeting large industrial players such as Lockheed Martin and Bell Helicopter in the hopes that they would be able to set an example for smaller players within the city to follow suit.

I. Introduction

The city of Fort Worth, Texas offers a unique opportunity to implement an energy efficiency program to help reduce its energy consumption. With over 200,000 buildings and a rapidly growing population[1], there is a huge potential in both the existing building stock and new buildings to decrease both electricity usage and natural gas consumption. As per the success of the Fort Worth Energy Conservation Program's reduction of municipal building energy, we believe that a similar reduction can be implemented in other building sectors within the city. Our plan takes a three-step approach to increase building efficiency in the most efficient and practical way possible. The first step is targeting. In order to ensure that the strategies we suggest will have the greatest impact, we first determine the current energy intensity in various building sectors in Fort Worth. We examine a broad range of specific efficiency measures that can be used while taking into account the targets chosen in step one. Lastly, in order to promote adoption of what are typically capital intensive efficiency measures, we suggest a plan to a set of stakeholders that have the greatest financial incentive to participate. We would further encourage greater participation and awareness on the individual level within the Fort Worth community by capitalizing on synergies between the occupants of the sectors.

II. Targeting building sectors in Fort Worth

The initial priority in our analysis was to focus the scope of the problem on building sectors that would have the greatest impact when improving energy efficiency. In order to identify which buildings to target, we first estimated the total overall energy consumption by sector with a variety of data sources. In addition, we also broke down consumption by end use so that we were able to identify specific consumption habits that could be targeted.

Given the vast number of buildings within the city of Fort Worth, individual structure analysis to determine building population statistics would be impractical. However, we were able to obtain zoning shapefiles for use in ArcGIS by directly contacting the city of Fort Worth. By combining the zoning data with publicly available city parcel data, we were able to break down the entire city and identify each individual building by unique codes corresponding to different building sectors.

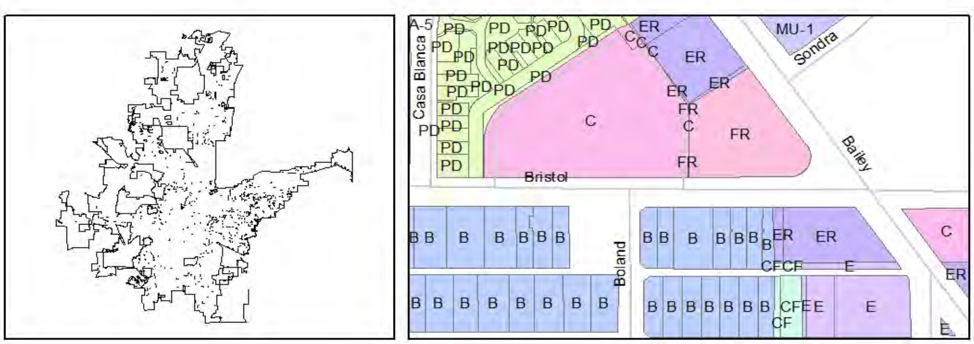

Figure 1: ArcGIS analysis: Fort Worth (left) broken down by parcel and building sectors (right)

[1] Population increased by approximately 50% within the last decade. *Source US Census Bureau, North Central Texas Council of Governments.*

As can be seen in Figure 1 (right), the building type, location, and size can be obtained through ArcGIS, which was then used to form a database recording every building. These data were validated against some of the provided information from the case document[2]. Our squared area coverage overestimated the data due to discrepancies between the parcel lot size and actual size of the building. In addition, the presence of empty lots (particularly for industrial) contributed to these overestimates. We randomly sampled areas in Fort Worth to determine scaling factors to reduce the overall shape area corresponding to each sector (approximately 0.4 for industrial buildings, 0.8 for commercial and school buildings, and 0.6 for residential homes).

In order to determine energy consumption from the base area of the buildings, we combined our dataset with the US Energy Information Administration's Residential Energy Consumption Survey (RECS) and the Commercial Buildings Energy Consumption Survey (CBECS). Using the consumption and expenditures data, we scaled the energy uses by square foot for both electricity and natural gas to the Texas average to obtain overall energy consumption as seen below in Figure 2.

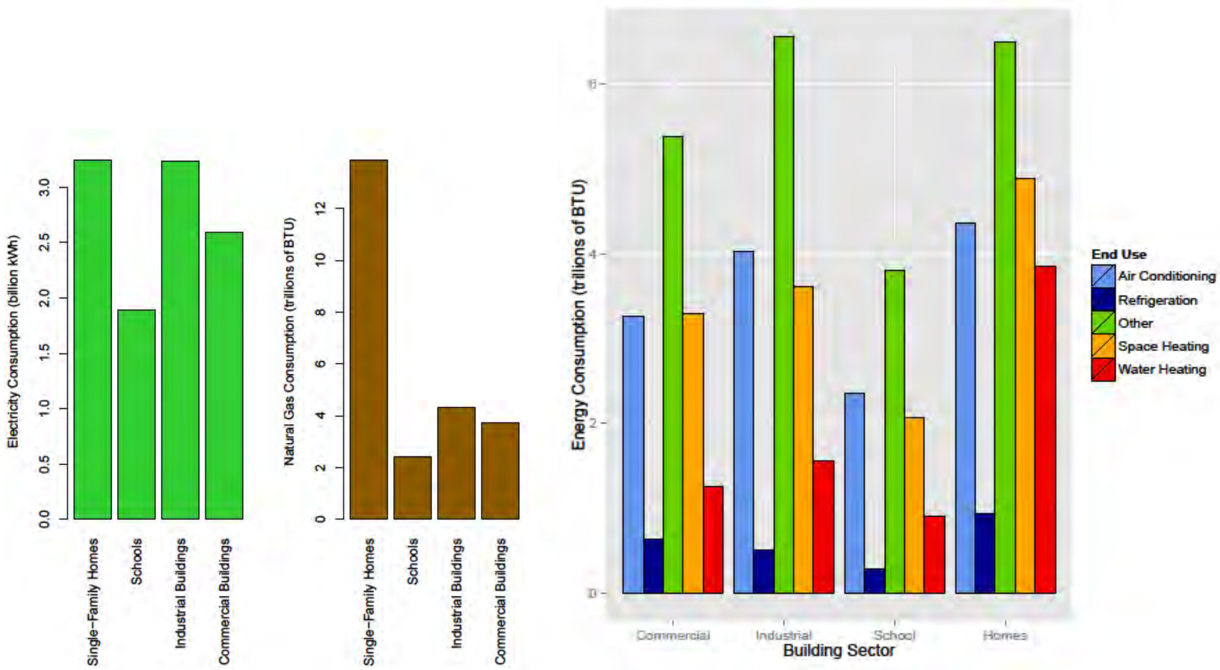

Figure 2: Total electricity consumption and natural gas consumption broken down by building sector (left) and total end use energy consumption broken down by sector and use (right)

The city of Fort Worth consumes approximately 3 billion kilowatt hours in its residential sector, a comparable amount in industrial buildings, and slightly less in commercial buildings and schools. In natural gas, single-family homes actually use significantly more gas than every other sector due to higher intensity of usage compared with sectors that have similar areas.

[2] *The City of Fort Worth, Texas*. Office of Energy Efficiency and Renewable Energy. U.S. DOE. p. 5, 12-14

When examining the end use by building sector (Figure 2 right), the "other" category is always dominant. This use category includes lighting, computers, cooking, and office use to name a few. Second on this list is air conditioning, which is consumed at higher rate than other end uses except in the case of single-family detached homes which use higher energy amounts for space heating. Seen below in Figure 3 are the breakdowns of energy consumption by building sector.

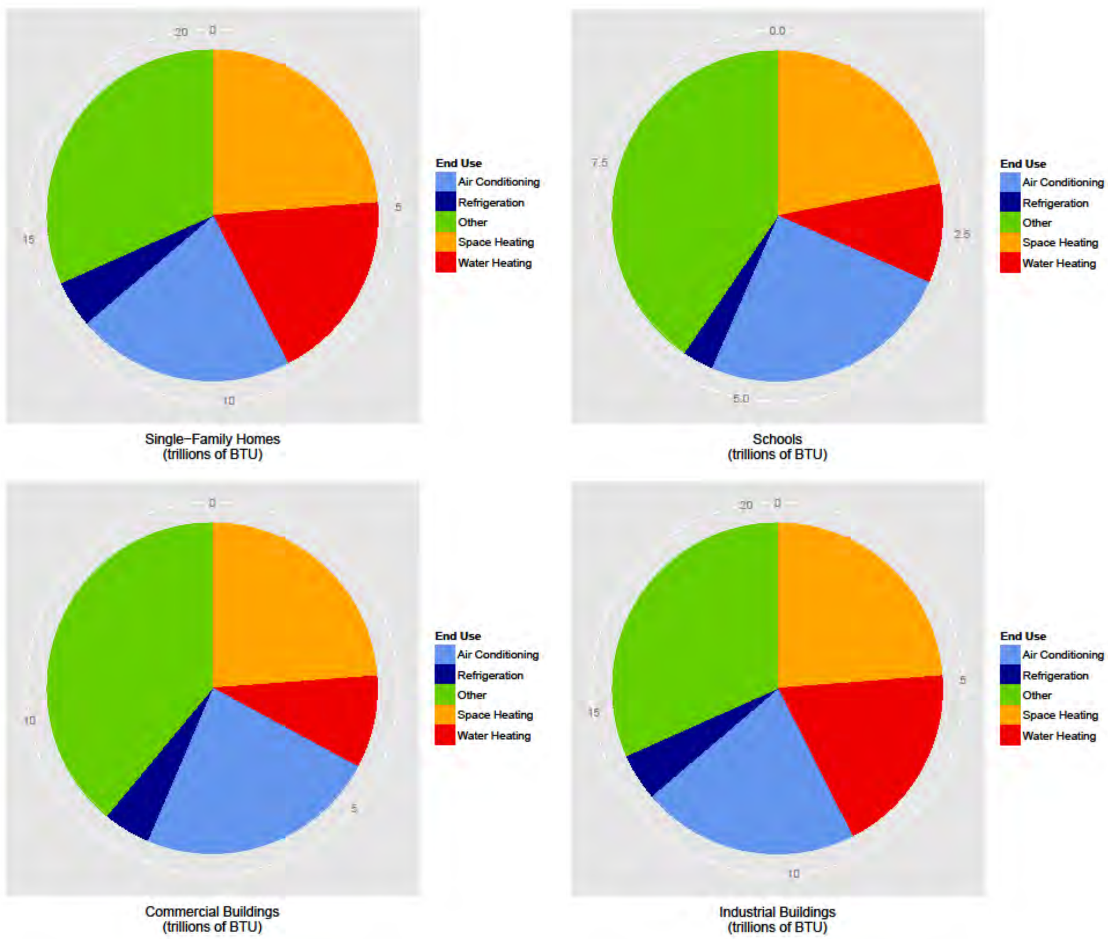

Figure 3: Percentage of end uses for each of the individual building sectors

In terms of our targeting decision, we decided to focus on the highest energy consuming sectors which included residential single-family detached homes and industrial buildings. However, for the third sector we chose to target schools instead of commercial buildings. The typical age of school buildings leads us to believe that there are higher energy efficiency gains to be realized there than from Fort Worth's commercial buildings (In 1998 the national average age of schools was 40 years [Lewis, 2000]) . We also believe focusing on schools will have greater strategic benefits in encouraging city-wide adoption of sustainable measures because the buildings themselves are highly visible and therefore make ideal demonstration platforms for sustainable technology. In addition, by engaging schools, we hope to make a significant long-term impact toward the greening of Fort Worth by encouraging a younger generation of students to participate in sustainable practices.

III. Strategy and Implementation

i. Schools

Currently about 30% of energy used in schools nationally is used inefficiently, or unnecessarily (Energy Star, 2006). As stated above, in 1998 schools across the country were an average of 40 years old. These factors combine to provide a promising opportunity for the reduction in overall energy use in this sector.

To achieve a 20% overall reduction in energy usage as part of the Better Building Challenge we recommend that Fort Worth encourage all of its schools to participate in the Collaborative for High Performance Schools (CHPS). CHPS is a green building rating program similar to LEED that is specifically formulated to produce high performance buildings for K-12 schools. Presently, the Fort Worth Independent School District participates in the CHPS program for all of its new schools. Applied city-wide, the CHPS guidelines would be used for all new construction as well as renovations. Fort Worth should encourage schools that occupy older buildings to undertake renovations by encouraging them to explore PACE financing or Energy Performance Savings Contracts in partnership with local ESCOs. Overall, it has been found that schools built to green guidelines consume 33% less energy (Kats, 2006).

Along with the adoption of CHPS guidelines for K-12 schools, Forth Worth should encourage universities within the city to adopt policies that stipulate that all new buildings and renovations will achieve a minimum of LEED certification. This follows examples set by many schools such as the University of California, and Duke University. Additionally, we suggest that building projects scored with the LEED system optimize energy use for minimum of 20% for new construction and renovation. The University of Texas(UT) at Arlington is the largest university in Fort Worth. We recommend that Fort Worth form a prominent partnership with the university's administration to craft a LEED policy for the school. As the largest higher education player in the Fort Worth area, our hope is that UT Arlington's adoption of the policy will encourage other universities and colleges in the area to follow suit. UT would also be encouraged to share what they've learned about the LEED certification process and sustainable buildings with other schools for their benefit.

Besides physical improvements to school and university buildings, there is also a large potential for energy savings through the encouragement of sustainable practices among building occupants. To achieve positive changes and the promotion of energy efficient habits we recommend that Fort Worth's educational institutions use gamification as a tool to educate their students, teachers, and staff to consume less energy. Gamification is a strategy that uses friendly, reward-based competition to motivate participants to achieve set goals. Schools can facilitate gamification through the use of energy dashboards.

A dashboard is a web-based interface that can be used to display a building's energy consumption. It can be used for viewing, comparing and monitoring the energy consumption of all the schools within Fort Worth. They can also be connected to social networking web-sites with feeds that automatically update a given school's profile page. This would increase awareness amongst students and create competition both within and between schools to reduce energy consumption. Figure 4 below shows an example of a dashboard design that can be used in Fort Worth to benchmark schools against one another. The cost is estimated to be in the range of $25,000 to $50,000 if meters are not yet installed and $10,000 to $20,000 if meters are present (BuildingGreen.com, 2008). Using a dashboard in dormitories of colleges and universities has routinely seen a 10% to 15% reduction in energy consumption. Using data from CBECS, schools in Fort Worth consumed a total of 2 billion kWh of energy annually. Since the total number of school buildings is 3000, we assumed each building consumes 667 MWh per year. Based on electricity rate of $0.08 (Adminstration, 2013), 10% to 15% reduction in energy consumption and an installation cost of $10,000 to $50,000, the simple payback period was calculated to be between 1 year and 8.5 years.

Figure 4: Example of dashboard for schools (adapted from dashboard under development at Team Brundtland's University and Lucid Design Group (2013))

ii. Single-family Homes

Single-family homes were found to account for largest energy consumption. According to RECS energy consumption data, aggregate space heating and cooling and water heating energy requirements account for over 60% of total home energy requirement on average in Texas [EIA, 2009]. Given this, we recommend that efforts should be targeted towards the reduction of energy usage for these functions. We also found that space heating is 15% electric and 85% natural gas while water heating is 30% electric and 70% natural gas, requiring consideration of both energy types in order to significantly decrease total energy consumption.

In addition to this information, one of our biggest considerations for choosing our recommended strategies for single-family homes was ease of implementation. This is a function of home-owner receptiveness, financial investment, and level of change required in terms of infrastructure, technology, and behavior. We chose two strategies, namely: 1) promoting the effective use of Smart meter data and 2) promoting the installation of learning thermostat.

These strategies empower home owners with more usable information on their energy usage in order to more intelligently pursue energy consumption measures. Fischer's review of the existing literature on electricity consumption feedback found that 5-10% energy reductions can be achieved by providing more complete information to consumers. These programs can also aid the users by including feedback mechanisms that serve as affirmation for better energy consumption habits as well as suggestions for better practices.

a. Promoting Smart Meter Data Usage

There are two components to this strategy: 1) increased adoption of smart meters and 2) wider awareness and better knowledge on the use of smart meter data.

Based on available data, we estimate that a range of 80% - 90% of Fort Worth single-family homes have smart meters, based on (Llorca 2012) and IBM (2013). We think that this is a relatively high adoption rate; thus, we focus on creating a wider awareness and better use of smart meter data. For this, we recommend an information campaign regarding smart meters. A pilot program can be implemented in the two other sectors that we target in this study – heavy industrial sector and universities. Through this approach, we hope to engage the family as a unit for smarter energy consumption. We recommend a forum on smart meters for employees of the industrial sector, specifically Lockheed Martin and Bell Helicopter, to educate the parents. In addition, smart meter education can be integrated into the science curriculum of schools to likewise inform kids on smart meter data usage.

Oncor is a founding partner of a program called the Biggest Energy Saver, which rewards consumers who utilize their smart meter data the most in order to reduce energy usage. With this in place, the information campaign can be done in partnership with Oncor and have the added competitive aspect of encouraging consumers to participate in the Biggest Energy Saver program.

This can be done with relatively low cost as it requires only better presentation of data that is already available in the Smart Meter Texas website. The most successful programs use interactive computerized information with data that is updated frequently. It is suggested that the hourly or daily electricity consumption information provided to consumers in conjunction with specific suggestions for home improvements and behavioral changes based on the consumer's past energy consumption pattern. Comparisons to neighbors or past consumption should be avoided. Consumers who know they are at the low end of energy consumption relative to their neighbors or historic consumption have been shown to increase energy use.

If we get 100% of current smart meter users to use their data effectively and assuming a 5% - 10% reduction in electricity consumption from this information, we estimate a 4% - 8% decrease in total single-family electricity consumption. Based on RECS data, electricity accounts for about 25% of single-family home energy use. Thus, better smart meter data usage could result in about 1.25% - 2.5% of total home energy use. This amounts to a total of $ 13-25 million per month of electricity savings for single-family homes in Fort Worth.

b. Installation of Learning Thermostats

To complement the use of smart meter data in reducing electricity consumption, we recommend the wider installation of the learning thermostat, such as the Nest or similar solutions, to reduce natural consumption which makes up 70%-85% of fuel used for space and water heating. This technology is estimated to decrease cooling and heating energy requirement by 20% [Nest Labs 2013]. These thermostats can learn when residents are home and their preferred temperature settings and adjusts heating and cooling to both provide a comfortable living environment and minimize energy usage. It also subtly encourages great savings with a green leaf light that turns on when users choose settings that lower their energy requirements. We take a conservative lower bound of 10% as the technology is nascent. This means that the installation of learning thermostats can result in an additional 5% - 10% decrease in total energy consumption of single family homes. This equates to a $20-$40 million dollar savings per month for the Fort Worth area. These thermostats can cost around $300, which we estimate to be paid back by the energy savings in 2 years.

To facilitate the implementation of learning thermostats, we recommend that the local government look at providing financial incentives to help offset initial investment costs. For purposes of benchmarking, we looked into energy efficiency and conservation programs that are currently being implemented by California. In San Francisco City, there is a stratified local rebate program where rebates to home energy upgrades, ranging from $ 1, 500 to $ 4, 000, as a function of the energy reduction, 15% to 40%. A compendium of Financial Incentives for renewables and efficiency in California are found in DSIRE. We found that most of these incentives pertain to rebates on purchase of more energy efficient appliances and building retrofits.

There are existing residential energy efficiency rebate programs currently available to the Fort Worth area. For example, Texas Gas Service currently provides HVAC-related retrofits and efficient appliances of up to $ 1, 575. It could be recommended that purchase of learning thermostats be included in their list of eligible items. Oncor also provides incentives for energy efficiency measures such as increasing insulation, replacing air conditioning units, and installing Energy Star appliances. However, their website currently indicates that they have been out of funding since 2012 and so they may need additional funding to be able to start new projects.

Once these additional incentives are in place, Fort Worth could advertise these programs to the residential sector in partnership with hardware stores and contractors. While broadening the impact of incentive programs, efforts should also be made to further knowledge of existing programs. Campaign ads may be put up in appliance stores or built in to contractor packages for HVAC retrofits. This partnership could also include the point-of-sale application of rebates. The goal is to increase awareness of the financial incentives and reduce the consumers' effort in obtaining the incentives. Doing this could decrease the inertia against adopting new technologies, such as the learning thermostat, by lowering the financial barrier.

iii. Industrial Buildings

Figure 5 shows the energy consumption of Texas sorted by end-use sector in 2010 (Energy Information Administration). Industrial is the largest energy end-use sector which accounts for 49.2% of the total energy consumption in 2010 in Texas. Hence, the industrial sector presents the largest potential for reducing energy consumption through the implementation of energy efficient technologies and strategies.

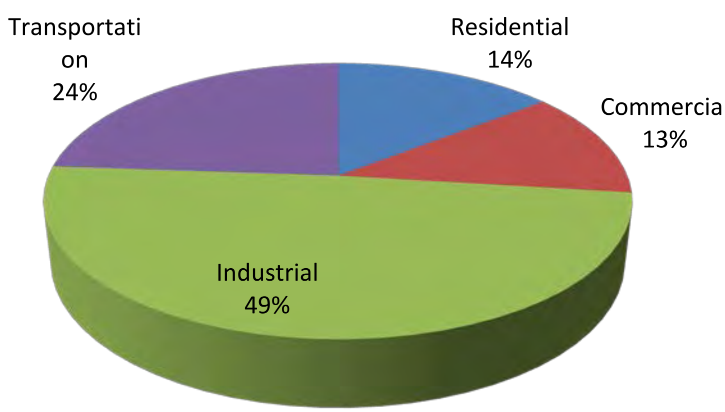

Figure 5: Texas Energy Consumption by End-Use Sector, 2010

Unlike the building sector, most of the energy use in the industrial sector is related to specific processes that changes materials into products. Furthermore, the energy usage intensities of the industrial sector vary widely between different industries. Hence, the recommended energy-efficient strategy also varies between industries. Having taken into consideration the type of industries in Fort Worth, we therefore recommend the following technologies for implementation by the industrial sector in Fort Worth.

Table 1 Recommend technologies for different industries (Martin et al. 2000)

Technology	Industries	Savings (%) Primary energy			Simple payback period (yr)
		Electricity	Fuel	Primary energy	
High-intensity fluorescent replacements for high bay high-intensity discharge	Lighting Manufacturing	50%	N/A	50%	1.3
Daylighting with dimmable fluorescent replacement for HID	Lighting Manufacturing	80%	N/A	80%	2.97
CHP using natural gas	Utilities	100%	-120%	33%	6.9
Motor system optimization	Motor System	20%	N/A	20%	1.5
Improve pump efficiency	Motor System	17%	N/A	17%	3.0

a. *Identifying Players*

As a first step, Bell Helicopter and Lockheed Martin were identified as the major players in the industrial sector and at the same time leaders in green building practices. Bell Helicopter's is a leader in green building retrofit, following the practices of LEED (Bell Helicopter 2012). Bell Helicopter is also committed to reduce their company's waste and energy use by 20% by 2015. So far what they have done is focused on higher efficient lighting and HVAC systems. Hence, by using the technologies recommended above, more energy can be saved. Lockheed Martin also plays an active role in energy saving practices (Lockheed Martin 2011).

The strategy is therefore to form a consortium and to entice these two major players to join it and exert pressure on smaller players to do so likewise. This would be done by emphasizing the short payback period of the technologies identified in Table 1 above.
In addition, since the industrial sector is a significant energy consumer, and improving energy efficiency in manufacturing processing is an expensive endeavor, we encourage the following strategies:

- Have major player involved in R&D with other companies and share the fruits
- Seek more industry partner to overcome the technology barriers and participate in demonstration to showcase the benefits to encourage uptake in Fort Worth
- Give awards and tax rebates to the companies which performs the best in energy saving

IV. Conclusions

Using a novel method of identifying energy consumption and intensity provided by the city of Fort Worth and combined with the Residential Energy Consumption Survey and the Commercial Buildings Energy Consumption Survey we were able to identify the building sectors with the greatest impact for targeting energy efficiency strategies. The three sectors that were chosen were schools, single-family homes, and industrial buildings. For schools, we recommend CHPS program for K through 12 schools, LEED certification for university buildings, and building dashboards to encourage active competition and fostering energy efficient habits. For single-family homes, we recommend more effective use of smart meter data and wider adoption of learning thermostats to help reduce load for heating and cooling in residential sectors. Lastly, for the industrial sector, we recommend lighting retrofits and motor system efficiency improvements, specifically targeting large industrial players such as Lockheed Martin and Bell Helicopter in the hopes that they would be able to set an example for smaller players within the city to follow suit.

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