ABSTRACT

As Global Warming becomes an increasing problem, many cities across the world are looking for ways to reduce their harmful emissions and become more sustainable. Some cities are trying to accomplish this by adding park space, constructing more energy-efficient buildings or using electricity to power public transportation. These changes, while facilitating a reduction in emissions, do not allow a city to become sustainable because they are on too small a scale, nor do they account for emissions caused by other aspects of a city.

The existing theories on sustainability in cities are insufficient. They cover certain aspects of sustainability, but they do not address the entire city as a whole. They also fail to discuss the most important concept of sustainability, which is sustainable energy. Sustainable energy provides environmentally-friendly, inexpensive energy without the harmful side-effects or exorbitant costs associated with fossil-fuel plants.

This paper attempts to prove that a city can only be completely sustainable if it is powered solely by sustainable energy sources. To prove this, a case study of Frederikshavn, Denmark will be provided. By 2015, Frederikshavn will be the first city in the world powered exclusively by sustainable energy. The civic authorities in Frederikshavn are following a top-down approach that ensures that the sustainable energy conversion proceeds successfully, while at the same time being beneficial to both business interests and the local population. If and when Frederikshavn is successful, the techniques used and the lessons learned will be transferable to other cities in the world. This will ensure cities become increasingly sustainable, and Global Warming will be addressed in an appropriate manner.
# TABLE OF CONTENTS

Abstract.......................................................................................................................................... ii

Table of Contents ......................................................................................................................... iii

List of Abbreviations .....................................................................................................................v

Acknowledgements ...................................................................................................................... vi

Chapter I: Introduction.................................................................................................................1

Frederikshavn...............................................................................................................................3

Chapter II: The Theories and Ideas behind the Study of Sustainability.................................6

Addressing Sustainability.............................................................................................................7

Policy and Sustainability.............................................................................................................10

Problems with Theories on Sustainability................................................................................12

Aspects of a Sustainable City.......................................................................................................13

Industrial Cities ..........................................................................................................................13

History of Frederikshavn............................................................................................................15

Chapter III: A Case Study of Frederikshavn............................................................................17

Economic Aspects......................................................................................................................19

Frederikshavn’s Path..................................................................................................................21

Wind Energy ..............................................................................................................................23

Biofuel........................................................................................................................................25

Solar Energy...............................................................................................................................28

Transportation ............................................................................................................................29

DONG Energy............................................................................................................................31

Danish Sustainability..................................................................................................................33

State Assistance..........................................................................................................................35

Infrastructure Changes in Frederikshavn ...................................................................................37

Citizen Involvement ...................................................................................................................38

Education, Employment and Immigration ...............................................................................40

Potential Problems with Frederikshavn......................................................................................42

Sustainable Change Internationally............................................................................................43

Frederikshavn as a Model ..........................................................................................................47

Chapter IV: The Lessons from Frederikshavn.........................................................................49
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspects of Civic Sustainability</td>
<td>49</td>
</tr>
<tr>
<td>How Change Must be Enacted</td>
<td>51</td>
</tr>
<tr>
<td>Processes for Converting a City to 100% Sustainable Energy</td>
<td>53</td>
</tr>
<tr>
<td>Costs and Benefits</td>
<td>55</td>
</tr>
<tr>
<td>The Goals of Sustainable Energy in a City</td>
<td>59</td>
</tr>
<tr>
<td>Chapter V: The Feasibility of Sustainability in Vancouver</td>
<td>61</td>
</tr>
<tr>
<td>Sustainability in Vancouver</td>
<td>61</td>
</tr>
<tr>
<td>Public Support for Sustainability</td>
<td>65</td>
</tr>
<tr>
<td>Locations for Sustainable Energy Production</td>
<td>66</td>
</tr>
<tr>
<td>Potential Problems with Sustainability in Vancouver</td>
<td>69</td>
</tr>
<tr>
<td>Chapter VI: Discussion</td>
<td>71</td>
</tr>
<tr>
<td>Chapter VII: Conclusion</td>
<td>77</td>
</tr>
<tr>
<td>Bibliography</td>
<td>80</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>ADR</td>
<td>Association of Danish Regions</td>
</tr>
<tr>
<td>CHP</td>
<td>Combined Heat and Power</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>EUDP</td>
<td>Energy Development and Demonstration Program</td>
</tr>
<tr>
<td>GW</td>
<td>Gigawatt</td>
</tr>
<tr>
<td>GWh</td>
<td>Gigawatt Hour</td>
</tr>
<tr>
<td>IBUS</td>
<td>Integrated Biomass Utilization System</td>
</tr>
<tr>
<td>kW</td>
<td>Kilowatt</td>
</tr>
<tr>
<td>kWh</td>
<td>Kilowatt Hour</td>
</tr>
<tr>
<td>MS</td>
<td>Member States</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-Governmental Organization</td>
</tr>
<tr>
<td>TJ</td>
<td>TeraJoule</td>
</tr>
<tr>
<td>UAE</td>
<td>United Arab Emirates</td>
</tr>
<tr>
<td>UBC</td>
<td>University of British Columbia</td>
</tr>
<tr>
<td>UN</td>
<td>United Nations</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

I wish to acknowledge the enormous contributions made by a few people, on top of the fellowship and support of my fellow students, as well as the significant assistance from the support staff at the Institute of European Studies. First of all, many thanks to my supervisor, Dr. Kurt Hübner, and my professor, Dr. Mads Bunch, for their constant guidance, assistance and suggestions. Thank you to my many contacts in Europe for their aid including Petteri Vuorimaki, Catalin Gherman, Lars Gronbjerg, Anne Toft Sørensen, Tullik Helene Ystanes Føyn, Thomas Jensen, Bahram Dehghan, Nina Holst, Torsten Hasforth, Anna Harpsøe Clausen, Krista Olsen, Katrina Stevenson, Susanne Nørtoft Jensen, Karl Sperling, Mikael Kau (the Director of Energibyen Frederikshavn), and former Danish Ambassador to Canada Poul D. Kristensen. Last but not least, I would like to thank my parents for their constant help and support.
Chapter I: Introduction

Global Warming is one of the greatest threats that faces the earth today.¹ As the population of the world increases, there is an inexorable increase in the amount of energy that is needed to provide the population with heating and electricity. To provide this energy, many nations use power plants that are fired by fossil fuels such as coal and natural gas. As fossil fuels are burned to produce energy, many of the gasses that are produced cannot be broken down and become trapped in the atmosphere preventing heat from the sun from escaping and causing temperature levels to rise in a process known as ‘the greenhouse effect.’² Many believe that the “overutilization of energy by... society will result in severe degradation of the local and global environment.”³ As the sun’s rays shine on the earth, the planet increases in temperature. This causes myriad problems including the influencing of weather patterns, the melting of ice and affects on much of the flora and fauna on the planet.⁴ It is largely due to the need for increased energy production and the burning of fossil fuels that these greenhouse gases are created.⁵

It is puzzling as to why fossil fuels power plants are still being utilized as other forms of energy production are much more efficient and effective as well as having little or no detrimental

---

⁵ John-David Phyper & Paul MacLean, Good Green: Managing Business Risks and Opportunities in the Age of Environmental Awareness (Mississauga: John Wiley & Sons, 2009), 235.
effects on the environment. The forms of energy production, including wind, solar, tidal, hydro, combined heat and power and biofuel among others, are generally known as ‘green’ forms of energy production because they do not produce the harmful emissions that fossil fuel burning plants produce. They are easy to utilize, inexpensive to construct and operate, sustainable, effective in virtually every part of the world and most importantly do not have the significant detrimental effects on the environment that fossil-fuel burning plants have. There are myriad social benefits as well because they are helping their fellow citizens, government, nation and the world because they are helping to contribute to sustainable action against global warming through the utilization and embracing of green energy as the main form of power production.

Over the past few decades, many governments have begun to see merits of sustainable forms of energy production. While sustainable energy is seen internationally as being both beneficial and increasingly viable, many countries have not adopted sustainable energy among their national maxims. However, this is not the case in all nations. For example, France has used tidal energy as a means of energy production since 1966. Switzerland has been utilizing dams for hydroelectricity since the late 19th century. Despite the fact that many countries have embraced various forms of sustainable energy, the area that has embraced it the most is Denmark. The country is largely agricultural, and thus is capable of producing tremendous amounts of agricultural waste which can be turned into biofuel. It is also a flat country, which allows winds sweeping in from the North Sea to power windmills. These two aspects of Denmark have precipitated the construction of many wind turbines and Combined Heat and

---


Power Plants (CHP) which power many parts of the country. Within Denmark, certain cities have chosen to embrace sustainable energy even further.

Frederikshavn

One of the cities that has invested heavily in sustainable energy, more per capita than any other city in Denmark and the rest of the world, is Frederikshavn. This small city of approximately 25,000 people, located on the north-eastern coast of Denmark, across the Kattegat Strait from Sweden, is revolutionizing the way cities are powered.8 One of the reasons that Frederikshavn chose to invest in sustainable energy was because “in the 1990s... Frederikshavn was affected by the closure of the town’s major workplaces,”9 when the shipbuilding industry went bankrupt and collapsed. Since shipbuilding was the city’s main source of revenue and that vein was no longer available to the city, a new source of capital was needed. Forms of green energy such as windmills and biofuel were already in use in the city and it was seen as logical to increase production of green energy through increased investment in sustainable technology in order to raise revenues in the city. In 2008, Frederikshavn chose to start “an experimental laboratory and show other cities around the world that it is possible to transform consumption of fossil fuels into 100 per cent renewable energy in just a few years with existing technology.”10 By using a combination of wind, solar, biofuel and CHP power, Frederikshavn “will be 100

---


percent supplied by renewable energy within electricity, heat and transport. This makes Energy City Frederikshavn the first urban community in the world supplied only by renewable energy."\textsuperscript{11} It is a daunting position to take, but it is very achievable, as the city is proving it so.

The green energy that is produced in Frederikshavn will power the entire city (electricity, gas, heating and vehicles) when the plan is realized in 2015.\textsuperscript{12} The process of greening the energy production in Frederikshavn has to occur on a large scale. As a result, investment is a key factor of the project. Frederikshavn has made investment affordable and intelligent by showing that it is economically beneficial to companies to become involved with the city. Companies such as DONG Energy, Plan Energi, ForskNG, Xergi, Vestas, Natugas and Midt-Nord have all invested heavily in the project.\textsuperscript{13} They invested in it because Frederikshavn has created a business environment where it is beneficial to invest, economically, politically and socially.

For a city to be sustainable,\textsuperscript{14} it must focus on the micro level of sustainability. In this context, the micro level of sustainability refers to the civic level. It is of far greater significance to focus on the way a city is provided with energy rather than focusing on the smaller aspects of the city such as public transportation and housing in order to maximize the true benefits of

\textsuperscript{11} “Energy City Frederikshavn,” \url{http://www.energymap.dk/Profiles/Energibyen-Frederikshavn/Projects/Energy-city-demonstrates-a-unique-energy-system}, 1.

\textsuperscript{12} “Case: Frederikshavn: A Renewable Energy Town,” 9.


\textsuperscript{14} The concept of sustainability for this paper is based on the idea that a city must be powered by renewable forms of energy in order for it to be considered sustainable. This conversion to sustainable energy cannot be to the detriment of any other aspects of the city as there are other facets of a city such as economic, intergenerational, political and cultural that all must be addressed and considered sustainable. The conversion to sustainable energy sources must be the catalyst for the conversion of a city to sustainable energy, but, in turn, other aspects of a city must also be addressed in order to consider it sustainable.
sustainable energy because the results are greater and more tangible. It is beneficial if a city is comprised of various sustainable projects such as residential developments and hydrogen-powered public transit, but these projects do not account or benefit the residential developments nearby or the private vehicles that are not powered by sustainable energy. If a city focuses on systems that power it and chooses to use sustainable forms of power generation, then it will be able to create large scale changes throughout the city, including powering residential developments and public transit. Whatever the case, a city must abandon entirely the exploitation of fossil fuels and adopt sustainable energy systems if it wants to become a green, sustainable city. By using sustainable energy to power a city, the entire city will benefit. Frederikshavn’s goal of being completely powered by sustainable energy over such a short period of time proves that green energy is the crux for a sustainable city and without utilizing green energy, a city cannot truly consider itself as being sustainable.

The structure of this paper is as follows: chapter two will discuss the background to creating a sustainable city, as well as some of the theoretical processes behind addressing sustainability. Chapter three will be a case study of Frederikshavn, displaying what types of energy are being utilized and why, the different levels of support such as local, national business and civic that are required for such a project, a detailed account of what the goals of the city are, the changes that are made to the city itself and the benefits of green energy for the city. Chapter four will show the fundamental structural changes that must be present for a project such as the one Frederikshavn in undertaking can be possible and the effects of the changes on business and the citizens of the city. Chapter five will demonstrate how the city’s path can be followed and what lessons can be learned and transferred to other cities such as Vancouver from the project in Frederikshavn. Chapter six will be discussion. Chapter seven will conclude my results.
Chapter II: The Theories and Ideas behind the Study of Sustainability

It is difficult to study a sustainable city. There are many definitions as to what defines sustainability, as is visible through the work of many theorists on the subject including Breheny, Rookwood, Hunter, Haughton, Guy, Marvin and Nijkamp to name a few. The components of these definitions vary greatly and encompass everything from people and construction to energy production and transportation. As a result, there is “no single urban form solution or policy approach [that] can promote sustainability in every case. Rather, [scholars] must tailor [their] approach and policies to individual circumstances.”15 This is one of the main reasons as to why the definition of a sustainable city is so difficult to ascertain. As a result, it is mandatory to have multiple definitions for the term. Despite this being the case, many researchers have developed theories that can be used to study the concept of sustainability and how it relates to a city. Many of these theories contain requirements such as population, housing techniques, energy production methods and social striations, which are necessary for a city to attempt to become sustainable. These requirements assist in providing a foundation for studying a sustainable city.

The first thing to understand is that no two cities are identical when it comes to sustainability so it is impossible to group all cities that are attempting to increase their sustainability together. Some researchers such as Lafferty and Meadowcraft question whether sustainability can “be defined locally and autonomously, or is it a normative comprehensive policy concept that

requires priorities and measures on different levels, and across sectoral domains?"16 It is an interesting notion that Lafferty and Meadowcraft present because it questions which level sustainability should be addressed on. Since no two situations are identical, it would appear that studying and applying sustainable ideas and practices would be better suited at the individual level because the solutions would fit the problem better where as an all encompassing strategy, a strategy that would use the same set of solutions to approach each sustainability issue, would suffice for some concerns but would fail to concentrate on others.

Addressing Sustainability

While it is a positive step to address sustainability on a global level, it is virtually impossible to accomplish anything on such a grandiose scale because of the myriad differing factors such as energy production, population, governments, climate and geographic location that exist all over the world. For example, solar energy generation through large-scale development of solar panel plants is an excellent idea when utilized in the Middle East, but solar farms would not be effective if adopted for energy production in the Brazilian rainforest. Large scale organizations such as the United Nations (UN) Climate Council and the Climate Meetings in Copenhagen are effective at drawing attention to the problems associated with global warming and a lack of sustainability, but they are largely ineffective because too many nations have their own priorities and the solutions that arise from large-scale dialogue between such international bodies cannot be directly implemented in every nation as there are fundamentally different aspects of

sustainability issues in each nation. This is why sustainability, if not instituted locally, will be unsuccessful.

Since an all-encompassing global plan for sustainability has been rendered ineffective, it becomes apparent that sustainability must be a top down approach that is based on the civic level, not the national or international level. This is more beneficial for individuals because “people can identify with a town of 50,000 people in a way that they cannot identify with a city of five million.”\textsuperscript{17} If a project is addressed on a smaller scale, then people will be able to see what changes have taken place and identify with the effects more readily. A top down approach is the most effective method to ensure that the sustainability needs of a city are met while not causing adverse effects on one specific aspect of a city. This is an issue that Roberta Capello, Peter Nijkamp and Gerard Pepping address in their research. They believe that

“within the global context of sustainability, it makes sense to analyse and manage socio-economic and environmental processes at a ‘disaggregate’, i.e. local level. The inherent logic of a local or urban sustainable development analysis is based on the fact that such an analysis may make functional interdependencies at the local level more manageable, seen from the viewpoint of the long run development of cities and regions. From a management and policy point of view, the local level is more suitable for policy control and transformation than the global scale.”\textsuperscript{18}

Studying sustainability on the micro level, within a community or a city, is a more accurate way of addressing sustainability because it would lead to more effective decisions being made


\textsuperscript{18} Roberta Capello, Peter Nijkamp & Gerard Pepping, Sustainable Cities and Energy Policies (Heidelberg: Springer, 1999), 8.
when juxtaposed to a blanket, global solution that solves certain aspects of some global problems but fails to accurately address others.

There is a specific manner in which sustainability should be fostered. If it is not accurately addressed then it cannot be properly implemented. “It is important to develop strategies that can transform the existing systems into more sustainable systems.”¹⁹ By doing this, changes are less expensive and easier to undertake than adopting an instantaneous shift in policy and focus. Strategies that are adopted must encompass everything from the generation of energy, electricity, gas and heating to transportation methods and waste disposal. “Area specific developments that transcend sector policies,”²⁰ are the most effective techniques to make a city more sustainable because they cross sectors and incorporate strategies that can be applied beneficially to multiple sectors in a city or region. The planning that is performed in a city must be rational and comprehensive. The policy makers can aim for lofty goals such as total sustainability in all sectors in an absurdly short period of time, but they cannot aim too high and press for something that is well beyond their means because if they quest for an unachievable goal, then their policies will fail and the city will suffer. This will make the citizens reticent to push for similar changes in the future. Policy makers and governments must have a clear vision of what sustainability goals they want to achieve and when they want to achieve these goals by. These plans must be completely open and transparent or else there is the risk of losing public support because people are unaware of what is being attempted and are likely to withhold their support.²¹ People relate

---


²¹ Hallsmith, *The Key to Sustainable Cities: Meeting Human Needs, Transforming Community Systems*, 97.
better to ideas and changes that are proximate to them because they recognize these changes and can see what the results will be.

Policy and Sustainability

In general, there are five main policy fields that need to be addressed when making sustainable changes to a city. Officials should address urban land-use and urban architecture, conservation, strict regulatory energy policies, stimulation programmes (e.g. financial incentives for industrial activities and information campaigns for the public), market-based energy policies and policies encouraging technological innovations. By addressing urban land-use and urban architecture, the design, construction and allotment of building projects will be energy-efficient and will not draw excessively on the energy, gas or heating grids. Conservation and strict regulatory energy policies ensure that energy is not wasted and expenses do not increase for unnecessary reasons. Stimulation programs are extremely important because they are the foundation of the sustainability process. Without financial incentives, policy makers will find it difficult to attract investors to their city. It is equally as important to keep the public informed as to what is being done. It is also important to concentrate on the public’s needs because if a government concentrates “exclusively on getting [a city’s] natural environment right, and ignores the rest, [the government] could end up with most of [a city’s] people unemployed and [rioting] in the streets.” By utilizing market-based energy policies, a city will be very attractive to energy companies because the energy companies can work with the city and accomplish the


sustainable goals of the city while still profiting from their venture. This relationship is beneficial to both parties. Technological innovation is another important factor because it fosters advancement and developments in new technologies and techniques that can make existing technologies more efficient and affordable while also providing for cutting edge advancements in energy production and sustainability. If the aforementioned policy measures are taken, then the transfer to a sustainable city will be much simpler and effective.

Sustainability must be beneficial to the people in an area and cannot be fostered solely because of a desire for political gain, showmanship or for things to be more sustainable in a city. Civic Authorities have to address the needs of different aspects of a city before they attempt to make it completely sustainable. Satisfaction has to occur at all levels including business, government and citizen levels. A government has to make changes that will allow it to remain popular with its constituents or else it will not be able to govern effectively and it will not be able to further its objectives without protest and reprisals. This can be difficult because “any change means dealing with something that is already embedded in the human systems of production and consumption, ideas, institutions rules and organizations.” If the rate of change is too drastic, it can have many detrimental effects on the psyches of a population. This is most recently evident in the necessary, but widely despised, austerity measures that have been required in Greece and Spain. As well as satisfying the needs of the inhabitants of a city, policy-makers must also make decisions that appeal to business interests in order to further investment in a project because without investment, sustainability projects are impossible. Capello, Nijkamp and Pepping believe that

---

24 Nicholas Law et al., *The Green City: Sustainable Homes, Sustainable Suburbs* (Sydney, University of New South Wales Press, 2005), 177.
“to achieve sustainable development, an integrated economic and environmental approach to local level policy-making is needed in order to minimise conflicts between resource-using activities, [and] to enhance socio-economic opportunities (like optimising employment opportunities).”  

By integrating the economic approach and the environmental approach at the local level, a city is able to satisfy the majority of its citizens as well as business interests.

Problems with Theories on Sustainability

Many theorists include the aforementioned aspects in their theories pertaining to sustainability but they do not account for the most logical aspect of things. Theorists such as Rookwood, Guy and Marvin focus on aspects of sustainability that pertain to infrastructure or society. Others focus on building and vehicles and providing environmentally friendly methods for construction and transportation. These theories have valid points, but many fail to address the most crucial aspects of a sustainable city. For a city to be truly sustainable, the energy that powers it must come from sustainable sources. Many theorists do not take this concept into account and choose to ignore it in favour of other ideas. This is the reason as to why many theories on sustainability are inadequate. The only way a city can be truly sustainable is if it is powered by sustainable forms of energy. Every other form of sustainability within the city will flow from this.

Aspects of a Sustainable City

There are four main aspects which must be addressed when studying a sustainable city. They are economic, intergenerational, political and cultural. These are the four pillars of a sustainable city. If a city is powered by sustainable forms of energy and the aforementioned concepts are not addressed, then the city cannot truly consider itself to be sustainable. There must be economic investment that is beneficial to both the city and the investor. The benefit must be for the entirety of the civic population and it must be intergenerational. A government must be willing to make necessary changes and provide the support for sustainability while not alienating the inhabitants of the sustainability city and while preserving the politicians’ political future. Culturally, everyone must be united to make a city sustainable. People must realize that sustainability is a path that must be followed for the benefit of a city. It must be intrinsically woven into the cultural aspects of a city’s fabric to the point where it is immovable. Economic, intergenerational, political and cultural aspects in a city are significant and follow a city being powered by sustainable energy. It may sound paradoxical connecting the concepts, but it is a significant connection that must be made.

Industrial Cities

As the economy global economy contracted during the mid 20th century, many industrial areas such as Detroit, Hamburg, Manchester, and Frederikshavn “had to cope with severe economic restructuring as the manufacturing sector started to decline for the late 1960s
The industrial centres were not as significant as they once were because the products that were produced there were no longer as in demand. As a result, many cities could not adapt quickly enough to the changes in the world economy and unemployment increased and poverty ensued. In the altered economy, “heavy industrial regions...[faced] particular challenges.”

Some of the governments, such as those in Hamburg and Manchester, realized there was a pressing need to restructure the basis for the cities or else face increased stagnation. “In response to the economic changes of the 1980s and the need for active engagement with business, the [city of] Hamburg,” began to study less industrial paths of restructuring. In Manchester, the civic authorities sought “how to create conditions to achieve sustainable economic development in the region, to create more jobs and increase regional income.”

Other cities such as Detroit, due to poor civic leadership that sought temporary rather than permanent solutions for their city’s problems, did not attempt to adapt resulting in continued unemployment and stagnation.

Hamburg and Manchester chose to restructure in ways that differed from their history and this allowed them to prosper. “A change in emphasis, a change of perception of the role of the city region, symbolising a new conceptual understanding of, and attitude to, the metropolitan

---


region and its governance.\textsuperscript{30} was the most important step that a once-strong industrial city could take in order to evolve and maintain its significance. Without a politically supportive environment the evolution of cities such as Hamburg and Manchester would have been impossible because a lack of political will and support would doom a city to economic stagnation. Cities that were able to rebrand themselves did not escape from the economic problems unscathed but now those cities that chose to evolve are thriving and those that neglected to evolve are fading.

**History of Frederikshavn**

Frederikshavn used to be an industrial centre for ship building until the collapse of the port in the 1980s.\textsuperscript{31} Much like the aforementioned cities, Frederikshavn suffered tremendously losing a large portion of its population who left the city in search of a more successful life elsewhere. Frederikshavn suffered consistently until its civic authorities sought to make a radical change in the once industrial city and convert its power sources to 100 percent sustainable energy. The civic authorities were very interested in making the change, there was widespread public support for the project from the inhabitants of the city who trusted their elected officials, and there was a large amount of business investment in the city as well. Economic, intergenerational, political and cultural aspects were addressed during the sustainability process. These factors combined to precipitate the evolution of Frederikshavn from an industrial city to a sustainable city powered only by green energy. Now that a firm foundation is laid, it is now

\textsuperscript{30} Herrschel & Newman, “Global Competition and City Regional Governance,” 220.

apparent that to examine a sustainable city, a case study must be selected. Frederikshavn is an excellent case to study and there are a variety of reasons that make Frederikshavn good for that.
Chapter III: A Case Study of Frederikshavn

The idea behind Energy City Frederikshavn came about at a national event held in Denmark called Energy Camp in 2006.\footnote{32 “The Danish Model: Danish Experience with Sustainable and Low Carbon Urban Development,” 11.} The Camp was attended by business interests, political figures and energy experts who met in the hope of fostering more efficient and environmentally friendly forms of energy production in Denmark.\footnote{33 “The Danish Model: Danish Experience with Sustainable and Low Carbon Urban Development,” 11.} Energy experts were looking for new ways to improve the energy policies of Denmark and demonstrating in practice that an urban society would be capable of running on 100% renewable energy.\footnote{34 “The Danish Model: Danish Experience with Sustainable and Low Carbon Urban Development,” 11.} Frederikshavn was suggested as a model demonstration location due to the fact that it had much of the required infrastructure for such a project in place and it was well-situated geographically. Frederikshavn was selected because it was a place that would be willing to make the necessary changes on a grand scale in order to fulfill the designs of such a significant project. The city had suffered heavily after the cessation of operations in the ship building industry that had once been the economic heart of the city. The plan that is in place and the goals that are being achieved in Frederikshavn would be impossible if it was not for the actions of the local government and their fervent support of the project because “the necessity of a strong political and organizational willingness,”\footnote{35 Capello, Nijkamp & Pepping, \textit{Sustainable Cities and Energy Policies}, 189.} is required for such a significant project to be successful.

The idea of Frederikshavn being powered entirely by sustainable energy was brought to the city council and discussed at length. After some deliberation, Mayor Erik Sørensen and the
rest of “the city council decided that Frederikshavn should be a sort of model town, showing that with existing technology, and in a relatively short period, the municipality could free itself fully from fossil fuels.”

When asked about the decision, Mayor Sørensen stated that he “saw the opportunity for [Frederikshavn] to become part of a new energy adventure in Denmark... People can keep on holding conferences, but if you [do not] do something, nothing will happen.”

After the decision was made that Frederikshavn would convert to entirely sustainable means of energy production, the city council with some assistance of the Organigram, a council composed of business, civic, university and civilian representatives that acts in an advisory capacity towards the project, was in charge of the vast majority of the operation of the project. The civic council planned how the project was to be carried out and made the majority of the pertinent decisions involved. It was because of this that the endeavour could have success because the civic government was best positioned in order to make effective decisions and to run the project. Without the strong support of Frederikshavn’s city council, the conversion of Frederikshavn to sustainable energy would have been impossible.

Frederikshavn is well-situated to be a sustainable city. While Frederikshavn may have been suggested as a place to attempt to become completely sustainable, it was the civic authorities who chose accept the plan, how to push forward with the project and are in charge of its administration and practice. Frederikshavn is a good location to attempt a conversion to sustainable energy because it is a self-contained city with its own regional catchment area, has the right location near agricultural and port areas, already has plants for electricity and heat

---

production and already has an offshore wind farm research project in place.\textsuperscript{38} These are very significant attributes because they are all necessary requirements for a sustainable city and if they are present, then it is considerably easier to begin to make a city subsist solely on sustainable energy. A certain amount of risk was involved in the project, but there was “a strong political commitment and willingness to risk caused by the fight to survive and recover when the city’s two shipyards closed in the eighties resulting in 7000 workers unemployed.”\textsuperscript{39} Due to the energy investments in the city, Frederikshavn will have the ability to function as its own entity, off the grid from the rest of Denmark. It will not have to import energy and it will be able to sell energy and fuel to the Danish grids for profit.

**Economic Aspects**

“Implementing clean-tech involves in a very high degree political processes at all levels and education, information and involvement of the citizens to be successful.”\textsuperscript{40} It must be demonstrated that there is a desire to benefit the inhabitants of a city or they are not going to support the project. Without civic support, a project as large as what Frederikshavn is undertaking is virtually impossible to achieve. If Frederikshavn city council can influence “society as a whole to act in a more climate-friendly and energy-efficient way,”\textsuperscript{41} then they will have gained the support of the people of Frederikshavn, thus making the undertaking possible.

\textsuperscript{38} “Energy City Frederikshavn,” 1.

\textsuperscript{39} “The Danish Model: Danish Experience with Sustainable and Low Carbon Urban Development,” 11.

\textsuperscript{40} “The Danish Model: Danish Experience with Sustainable and Low Carbon Urban Development,” 8.

Before the project in Frederikshavn could proceed, some economic assurances had to be extracted. Denmark “has higher environment and energy taxes than any other country in the world. The aim is to provide incentives to both private consumers and companies to reduce energy consumption or change to more environmentally friendly alternatives.”42 These incentives are significant because they encourage people and companies to adhere to strict environmental guidelines in return for economic benefits. If people do not adhere to the guidelines then they will be subject to stiffer taxation and penalties. While the incentives that have been provided are substantial, the council of Frederikshavn has not publicized the numerical value of them.

Frederikshavn city council has pushed for changes to be made in the city’s construction industry. All new construction on energy projects such as CHP Plants, solar panels and wind farms must be carbon-neutral in order to maintain the sustainable mantra. Within the city, environmentally-friendly construction is mandatory. New buildings must adhere to strict guidelines and many older buildings are beginning to receive retrofitting in order to make them more sustainable. Frederikshavn city council wanted to lead by example, as it is a good way of encouraging change. By January of 2010, 150m² of solar cells and 400m² of solar collectors were added to city hall in order to power it. There is also intelligent lighting which shuts off if there is no motion in a room for an extended period of time and a rain catchment system for water and sewage purposes.43 To further their commitment to sustainability, the city has adopted more

---


efficient forms of transportation such as electricity and methanol for the public transportation
sector as well as for civic vehicles.

Municipal support for the project in Frederikshavn is not solely capable of making the
project a success. Therefore heavy investment is also required. The government knew that
“public and private companies must invest in new plants and technologies,”44 in order to make
the project successful. It was important that the “investments must be able to pay for themselves
– both environmentally and financially,”45 in Frederikshavn. The amount of financial investment
required for the conversion of Frederikshavn to entirely sustainable forms of energy production
is significant. For the duration of the project, from 2008 until 2015, the estimate for the amount
of money required is between one and two billion Danish Kroner, or between 170 and 350
million Canadian Dollars.46 At an initial glance, this seems like an exorbitant amount of money
to invest in a project over such a short period of time. However, the numbers are deceiving
because if the amount of investment required for the project was invested in a similar project
over an extended period of time, then it would appear to be a more viable option but in reality,
would require an equal sum of money.

Frederikshavn’s Path

The three-phase plan was decided upon because it would allow for tremendous investment
from entrepreneurs, businesses and energy companies. As a result of the heavy investment, large

45 “Energy City Frederikshavn,” 5.
sums of money would be deposited in the city’s coffers to offset the losses from the shipbuilding industry. The utilization of green energy would also put the city on the figurative map as a centre for advancement in sustainable energy production and distribution. Not only would the city be powered entirely by sustainable forms of energy, but areas such as housing and transportation would also be sustainable. Frederikshavn would become a place that researchers and scientists could visit in order to study how a city could be powered by completely sustainable energy without having detrimental effects on the economy, inhabitants or infrastructure of the city itself. In effect, Frederikshavn would become more prominent and prosperous than it had ever been in the past as a ship-building centre, due entirely to its transformation city that is powered entirely by sustainable energy.

There are many different methods that can be utilized to produce sustainable energy. The authorities in Frederikshavn chose to utilize forms of energy production that they were familiar with. They wanted an energy “transformation not based on a single technology or scope, but the development of a coherent system for renewable energy.”47 To power the city, the policy-makers selected wind, solar power and biofuel as the main forms of energy production.48 Each of these types of energy production does not cause environmental damage to construct, nor do they cause any sort of environmental damage when they produce energy. Wind, solar and biofuel are also inexpensive to operate and maintain, so their usage would save Frederikshavn a substantial amount of money. The three types of power production are inexpensive and efficient and improve the economic forecast for Frederikshavn considerably with their utilization.

47 “Energy City Frederikshavn,” 2.

Wind Energy

The type of green energy that will be used the most in Frederikshavn is wind energy. Due to its geographic location, Frederikshavn is well disposed to using wind turbines to produce energy. Wind turbines were already providing 24% of the city’s energy in 2008, so increasing their production would not be difficult.\(^49\) These wind turbines consist of a “total of four 2-2.5 MW [Mega-Watt]... wind turbines [that] supply the Energy City Frederikshavn with renewable energy.”\(^50\) Also, the government of Frederikshavn were already familiar with wind as a form of energy production and the idea of electing to construct further wind turbines was an easy decision to make.

For the construction of further wind farms, it was decided that the majority of wind turbines in Frederikshavn would be built offshore. This was decided because the wind that travels over water is more powerful than wind that travels over land. There are strict requirements as to the construction of wind turbines because they cannot interfere with shipping lanes or flight-paths.\(^51\) As a result, the turbines and blades are generally constructed between 70 and 270 metres in height.\(^52\) Also, the wind farms must be constructed at “relatively shallow sea depths, so as to allow for the most cost-effective construction of the farm’s foundations and cable


This does not mean that it is impossible for wind farms to be constructed further out to sea, in fact this is a process that is being tested in Norway currently, but it is more economically viable to construct wind turbines closer to shore. DONG Energy was selected as the firm that would manufacture, install and run the turbines. The first offshore wind farm that the company created had a total of 7.6 MW output from three turbines. This wind farm was not as large as the existing power generation capacity of the wind turbines located near the port of Frederikshavn, but it increased the production of energy for the city substantially.

To further the production of energy from offshore wind farms, DONG Energy has been asked to construct a further wind farm. This new wind farm will be larger than both existing wind farms in Frederikshavn. The new wind farm, currently under construction and slated for completion by 2012, will be situated at a deeper depth than the previous wind farms. This will allow for the construction of larger wind turbines that produce increased energy levels compared to smaller wind turbines. The new wind farm will be located 4 kilometres offshore at a depth of 15 to 20 metres and will consist of six turbines that will produce a total output of 25 MW. The new wind farm will be very powerful and, when coupled with the existing wind farms, will produce the majority of the sustainable energy required to power Frederikshavn.

53 “Stakeholder Interests,” 1.


Biofuel

One of the other forms of energy that will power Frederikshavn is biofuel. Biofuel is produced through the biological breakdown of organic products, but generally limited to waste products, particularly from the agriculture sector.57 As agriculture is one of the main industries in Denmark, especially on the Jutland peninsula, biofuel, much like wind, is a logical idea for powering Frederikshavn as well as providing heat to the city. The production of biofuel on its own is not enough to create any energy or heat. The breakdown of waste materials must occur inside a CHP plant and from there, the biofuel that is created, is burned to produce power and heat. One of the positive things about CHP is the

“fundamental technology behind waste-firing is well-proven and efficient. It utilises both the heat from incineration and the heat in the flue gas from incineration. Firing with waste rather than coal, natural gas and oil delivers a reduction in CO₂ emissions from power and heat generation.”58

The CO₂ emissions are reduced substantially because there are no fossil fuels being burned in order to produce heat or energy and the emissions that are created and trapped and dissipated. This is beneficial because a resource that would otherwise be wasted is being utilized efficiently while improving the quality of the environment and producing both heat and power for the city of Frederikshavn.

In Frederikshavn, the CHP plant is operated by DONG Energy. The plant has “a high efficiency ratio of around 90-95% of the fired energy. At the same time most of the fuels used


are CO₂ neutral, which makes the CHP plant’s emission into the global environment negligible, if
existent at all.\textsuperscript{59} The efficiency rate is very significant because it prevents most heat or energy
loss in the transfer of power from biofuel to heat and energy. The CHP plant in Frederikshavn
has an incineration capacity of 5.5 tonnes per hour. In 2006, the plant produced 16 GW and 227
TJ of heat and energy on the basis of 35, 637 tonnes of waste.\textsuperscript{60} The amount of heat and energy
produced is significant because it provides the majority of Frederikshavn with heating and it
contributes to the energy that the wind turbines produce. Since DONG Energy owns and runs the
CHP plant, it owns what is produced in it. The heat and energy that is created is sold to the
municipality of Frederikshavn at an affordable price. This is mutual beneficial because it
provides Frederikshavn with both heat and electricity at an affordable rate, but it also provides
DONG Energy with profit, thus giving them incentive to continue to produce energy and heat in
the region. “The fact that heat and power production are combined at the waste-fired CHP plant
means that resources are better utilized than would be the case had the heat and electricity been
produced separately.”\textsuperscript{61} By 2015, the CHP will produce approximately 15% of the city’s
electricity as well as approximately 64% of the city’s heating needs, totalling 185 GWh/year.\textsuperscript{62}
The heat and power that is produced is quite substantial and it is made available to a large
portion of the inhabitants of the region because “more than 94% or Frederikshavn city joined the

\textsuperscript{59} “Waste to Energy Plants,”

\textsuperscript{60} “Frederikshavn Waste CHP Plant,”

\textsuperscript{61} “Waste to Energy Plants,” 2.

collective district heating where heat is produced as a secondary product in the production of
electricity in a combined heat and power plant. This further strengthens the idea of how
efficient and beneficial the CHP plant in Frederikshavn is.

There is also the possibility that excess gas is produced in the CHP plant. If this is the
case, DONG Energy has the right to re-distribute the surplus gas in which ever manner it
chooses. The most likely method of re-distribution would be the possibility of transporting or
derivering the gas to the national natural gas grid in Denmark after it has been cleaned of CO2.
The system that will make this re-distribution possible is scheduled for completion in the first
quarter of 2010. The project will increase the profits of investor DONG Energy, but it will also
be significant because it will demonstrate that the production and utilization of CHP as a source
of power and heat will also create profits, not just from the area that is being powered and
heated, but also from the possibility of selling surplus biofuel into the national pipeline. Such
new ideas not only affect the producers and suppliers or heat and power, by they also affect the
infrastructure. As energy prices in Denmark rose, they

“became the driving force for innovative thinking in many industries: in the district
heating sector, Danish pipe manufacturers created the world’s first pre-insulated pipes;
furnace manufacturers greatly improved the combustion technologies; and Danish
companies developed electronic control systems to prevent energy waste.”

Such is the drive that many companies possess in order to produce increased levels of sustainable
and efficient energy that many firms are becoming progressively involved in ensuring that the
production, transportation and use of biofuel is increasingly efficient and effective.

65 Trade Council, Ministry of Foreign Affairs Denmark, “Energy the Danish Way.” In Focus Denmark, 7.
Despite the benefits of the current CHP plant in Frederikshavn, DONG Energy is striving to make the plant even more productive and efficient. The company hopes to build a plant that would be 100% renewable and would be known as an Integrated Biomass Utilization System (IBUS) plant.\textsuperscript{66} Not only can an IBUS plant convert waste to biofuel, but it can also convert straw to biofuel. DONG Energy plans to connect the IBUS plant to the CHP to create a synergy between the two that would see the new plant produce 90% of the biofuels that run the CHP plant.\textsuperscript{67} This is significant because it would make the CHP plant in the city more efficient and it would minimize Frederikshavn’s reliance on importing waste products to be used for fuel for biofuel production from outside Frederikshavn.

**Solar Energy**

The third component that Frederikshavn is using for the production of sustainable energy is solar power. Solar panels may seem like an odd choice for energy production in an area that is not renowned for its sunshine, but they are still important and useful to Frederikshavn’s goal. For example, as of the start of 2010, the city hall in Frederikshavn was predominantly powered by solar panels and not reliant on the city’s power grid.\textsuperscript{68} This is an example of the dedication to the cause of being a completely sustainable city that the authorities in Frederikshavn possess. Other than the fact that the city lacks consistent sunshine, one of the main reasons that solar panels are not used to a greater degree in Frederikshavn is because “silicon solar cells are efficient, but


\textsuperscript{67} Lund, Møller & Mortensen, “Frederikshavn – Supplied 100% with Energy from renewable sources in 2015,” 9.

\textsuperscript{68} “The Local Government,” <http://www.frederikshavn.dk/da/menu/PolitikOgDemokrati/raad_naevn_kommisioner/lokal_t_beskaeftigelsesraad/> , 2.
expensive... Certain plastic materials are also able to convert the sun’s rays into electricity, they are cheaper than silicon, but not as efficient and durable yet,"⁶⁹ and are not used as a result. As the technology for solar panels improves, so too will the utilization of solar panels in Frederikshavn. Despite the high initial costs associated with solar panel usage in the city, “solar-power systems have a near-zero maintenance requirement."⁷⁰ By 2015, “2% of Frederikshavn’s energy will come from solar power.”⁷¹ This may seem like a small amount of power, but if the figure of 2% were measured as a percentage of the population, solar power in Frederikshavn would produce enough energy for 500 people. While a lesser part of the city's plans, solar energy is still an integral part of Frederikshavn’s sustainable energy production.

Transportation

The hardest aspect of Frederikshavn to make sustainable is the transportation sector, both public and private. For transportation methods to be efficient, a city must have “a sufficient density of people and workplaces to stimulate energy-efficient forms of transportation.”⁷² The public transportation sector in Frederikshavn consists predominantly of buses. These buses are powered by either gasoline or diesel. These are pollutant rich types of fuel, and if a city wants to be completely sustainable, then it is inefficient and to utilize those vehicles for regular use. The civic authorities in Frederikshavn recognized this dilemma and were open to any idea that would


⁷² Capello, Nijkamp & Pepping, Sustainable Cities and Energy Policies, 23.
utilize a more efficient method of fuel. As a result of extensive research, the authorities in
Frederikshavn chose to focus on multiple different methods in an effort to create a greener public
transportation sector. “In the traffic strategy, they operate with vehicles powered by upgrated
[sic] biofuel (where CO$_2$ is removed), electricity and fuel-cell hybrids powered by methanol,”\textsuperscript{73} in order to keep the public transportation sector functioning effectively and running on
sustainable fuels. Each of these methods is in use as fuel for vehicles in various parts of the
world such as Whistler and Vancouver, British Columbia where hydrogen powers many
busses.\textsuperscript{74} The fuels are more environmentally friendly and sustainable when compared to the
previous sources of fuel which were used. As technology improves, so will energy options. The
overhaul of the system was not difficult because there were a finite number of vehicles that
needed to have their fuel systems altered. The investment in new vehicles was expensive, but it
was only marginally more than purchasing new gasoline or diesel powered vehicles.

The private transportation system is considerably harder to alter. This is because vehicle
owners are not restricted by district boundaries like the public transportation sector is. If a driver
desires to, he or she is entitled to leave Frederikshavn at will. Some civic authorities wanted to
have private vehicles running on biofuels. This suggestion, while beneficial to the environment,
was problematic because the cars that leave Frederikshavn have no way of re-fuelling because
there are no biofuel refilling points outside the city. The problem is reversed for vehicles that
enter Frederikshavn from other points in Denmark because there would be no gasoline or diesel

\textsuperscript{73} “The Danish Model: Danish Experience with Sustainable and Low Carbon Urban Development,” 12.

\textsuperscript{74} Some civic busses in Vancouver and all civic busses in Whistler started operating on hydrogen as of February
2010.
stations available for re-fuelling inside Frederikshavn.\textsuperscript{75} A ‘one size fits all’ solution would be impossible for the private transportation sector. As a result, the government of Frederikshavn pursued “experimenting with biofuel, electric cars and fuel cell hybrids,”\textsuperscript{76} to resolve the private transportation question. Civic authorities have offered heavy discounts and incentives for people to switch from gasoline and diesel powered vehicles to one of the more sustainable options such as hybrids or hydrogen powered vehicles. This strategy met with initial success, but ultimately failed in converting all private vehicles in Frederikshavn to sustainable ones. Until it becomes more feasible to travel in a non-polluting vehicle, Frederikshavn will not be able to make the private transportation sector completely sustainable and the city will have to subsist with the carbon neutral strategy of offsetting sustainably fuelled vehicles with unsustainably fuelled ones.

DONG Energy

To compose an entire list of companies that have invested in Energy City Frederikshavn for analysis would be exhaustive and unproductive so it is best to focus on the most invested firm. The firm that has invested the most heavily in Frederikshavn is DONG Energy. The company is one of the largest energy firms in Denmark; producing approximately 50% of Denmark’s power and 40% of Denmark’s heating.\textsuperscript{77} The firm is heavily invested throughout the country, utilizing multiple different forms of power generation such as CHP, geo-thermal and wind to power and heat much of Denmark. DONG focuses primarily on green methods of energy


\textsuperscript{76} “Case: Frederikshavn: A Renewable Energy Town,” 8.

production. The reason the company invests in green energy is because, “as an energy company DONG Energy is co-owner of the CO₂ problem. Therefore, [they] should naturally be part of the solution, too. [Their] vision is CO₂-neutral energy.”78 This statement is not buried deep in the company’s website, but is visible near the homepage. This shows that the firm has a deep commitment to sustainable energy production. As of 2008, PricewaterhouseCoopers conducted a survey of energy production plants and companies amongst the 27 Member States (MS) of the European Union (EU). The survey found that Dong Energy had the “second lowest specific CO₂ emission for each kWh produced and the highest total electricity efficiency.”79

The area that DONG Energy is investing most significantly in presently is wind energy. “After more than 19 years developing offshore wind farms, [DONG Energy is] the market leader in offshore wind power generation,”80 in Denmark. The company continues to produce wind farms and CHP plants throughout Northern Europe including Germany, Poland, France Sweden, Norway, United Kingdom and of course Denmark.81 The company is responsible for much of the construction and operation of the windmills in and around Frederikshavn, as well as the CHP plant in the city. Its commitment to Frederikshavn and their goal of sustainable energy is very significant.


Danish Sustainability

As a state, Denmark has fostered the growth of green energy through its insistence on the advancement of sustainable energy. During the energy crisis of the 1970s, the goals of Denmark’s “energy policy were to secure the supply of energy at the lowest possible cost and to reduce the vulnerability of the Danish energy supply system.”\(^8\) Denmark’s “policies [also] restricted the location of manufacturing facilities and were intended to reduce the harmful effects of pollution.”\(^8\) Now, large percentages of Denmark are powered by sustainable energy such as wind, solar, geothermal and CHP. For example, “the world’s largest wind park, located in Middelgrunden...provides energy to over 100,000 households.”\(^8\) While Denmark has many windmills generating power for the population, there are also other green energy technologies that are used. As a result of the “relative abundance of fertile land for farming and the export of agricultural products to the European market,”\(^8\) Denmark produces copious amounts of agricultural waste. Agricultural waste, particularly straw, is an excellent product to use for fuelling a CHP plant. Since farming is prevalent across Denmark, CHP plants have vast fuel reserves available to them. When Denmark held the rotating presidency of the EU in 2002, it included on its agenda how to govern the environment and how sustainability should be

---


\(^8\) Christine Ingebritsen, “Norm Entrepreneurs: Scandinavia’s Role in World Politics.” In *Small States in International Relations* (Seattle: University of Washington Press, 2006), 276.


addressed. This helps in demonstrating that Denmark, as a nation, is one of the leaders in preserving the environment and utilizing sustainable energy.

The association between the central government in Denmark and its cities and rural areas is complex.

“The relationship between the counties and the national centre is characterised by the interplay of factors, e.g. that Denmark is a centralized state, but that counties and municipalities formally have self-governance, and that the sub-national level controls more than 65 percent of the total public expenditure. This underlies why a system of negotiations is important. The three parties in this system are: the national government (and its central administration), the Association of Danish Regions (with its secretariat) and the Organization of Municipalities (with its secretariat). All three parties have democratic legitimacy, thus creating a system of shared statehood or ‘internal multi-level governance.’”

The central government, the county and the city all have a say in how things are done at the civic level, but each city is able to oversee its own plans and make its own decisions. This is one of the reasons that Frederikshavn is able to attempt to revolutionize its power systems. This is significant because it allows the Danish government to oversee all of the decisions that are being made by the cities and municipalities, but as long as the cities “do not interfere with free market forces...do not discriminate against certain groups of citizens, and... do not interfere with policies of the parliament,” then they can follow whichever path they desire. Despite the complexity of the relationship, it is beneficial to all parties.

Frederikshavn is not alone in its quest to achieve complete energy sustainability. It has the support of the central Danish government behind it. Ever since Frederikshavn declared its

---

intentions “to become, within seven years [starting in 2008], the first city powered solely by renewable energy,” Copenhagen has been fully supportive. The state has invested large sums of money in the project, though many of these numbers are not available, because it believes that Frederikshavn will become a good showpiece for how other cities and countries can work together in order to achieve their sustainability goals. Apart from the monetary aspects, Frederikshavn has relied “on Copenhagen lifting some road blocks,” in building, transportation and the energy sectors in order for Frederikshavn to pursue its goal of becoming sustainable. One of the key roadblocks that still exists for the city is in the transportation sector. Taxation on Danish cars is high and this discourages people from purchasing newer, more environmentally friendly cars such as hybrids and electric vehicles because of the extra cost that is associated with them. In order to encourage people to purchase more environmentally friendly and energy-efficient vehicles, the Danish government must reduce taxes on those aforementioned types of vehicles. Since the transportation sector is one of the hardest sectors to make sustainable, it is integral to Frederikshavn’s goals that Copenhagen can provide assistance and reduce taxes on vehicles.

State Assistance

Frederikshavn is the starting point for a larger scenario for Denmark. As a nation, Denmark relies increasingly on sustainable forms of energy production. When the current government was re-elected, it stated in its “platform from November 2007 Denmark should be a

green and sustainable society with a visionary climate and energy policy... The government’s long-term vision is for Denmark to be 100 percent independent of reliance on fossil fuels.”92 To accomplish their goal, the Danish government created the Energy Development and Demonstration Program (EUDP). EUDP focuses on bringing together knowledge centres, innovative companies, venture companies, energy companies and many other potential investors in a public-private consortium.93 Being inclusive is significant because groups will not be barred from the planning process and the flow of ideas will be increased.

There is funding associated with this consortium as well, with the Danish government earmarking 1 billion Danish Kroner, approximately 170 million Canadian Dollars, for the consortium to use for research purposes.94 The heavy investment from the Danish government benefits both municipalities and businesses. In regards to cities, “the Climate and Energy Ministry works closely together with... municipalities to reduce energy usage.”95 It is important for the Danish central government to aid and encourage cities because it will increase the likelihood that those municipalities will excel in conversion to sustainable energy production methods. Business interests are acknowledged through the Danish governments mandating that “economic growth for Danish companies must be combined with a reduction in greenhouse gas

92 “Denmark’s Climate and Energy Policy,” 1-3.
emissions.” So far, Denmark has proven that it is possible for businesses to thrive while reducing their emissions. Between 1990 and 2007, economic activity increased in Denmark by 40 percent while at the same time CO₂ emissions decreased by 14 percent. As of 2009, renewable energy comprised approximately 28 percent of Danish energy production. 28 percent is a large proportion of a state’s total energy production. The percentage will increase because, by 2030, Denmark’s goal is to be completely reliant on renewable, sustainable energy.

Infrastructure Changes in Frederikshavn

Changes in the infrastructure in Frederikshavn were necessary to further the sustainable goals of the city. One of the specific areas that needed to be addressed was construction. “Special attention must... be paid to the relations between spatial planning and the environment,” in order to maximize the potential of the project and its associated benefits. There are many different facets to the construction of a building such as excavation, foundation laying, roofing and framing. When trying to make construction efficient and effective it is important to have


“relatively low per capita costs for the construction and maintenance of energy infrastructure,”\textsuperscript{101} projects. “Better insulation, power savings and efficiency,”\textsuperscript{102} were incorporated into existing structures as well as all new construction in Frederikshavn. In the city “decisions regarding construction and renovation of buildings, public transport and overall planning are made locally,”\textsuperscript{103} thus ensuring that the decisions will be energy efficient and beneficial to the city. In Frederikshavn, as of “January 2006, all public buildings larger than 1500m² must renew their energy label every five years. From 1 July 2009, this...also [applies] to buildings smaller than 1500m².”\textsuperscript{104} This ensures that buildings are constructed using efficient technologies and that they preserve those efficient technologies over time.

Citizen Involvement

Fortunately for the authorities in Frederikshavn, the citizens of the city have supported the project fully. This has not always been an easy task for the inhabitants of the city because of the scale of the project. It was not something as simple as living “in low energy houses and [using] sun light collectors in... back yards.”\textsuperscript{105} It was an intense re-imagining of the entire way of life for Frederikshavn. Since “the success or failure of climate and energy initiatives almost


\textsuperscript{105} Lund, Møller & Mortensen, “Energy City Frederikshavn: Frederikshavn – Supplied 100% with Energy from renewable sources in 2015,” 11.
always rests with the individual,“106 the government of Frederikshavn knew that support from the 
local population was required. Mayor Erik Sørensen believed that if the government was

“clever enough to convince the citizens about the perspectives of this magnificent project 
for sustainable prosperity the politicians on all levels will sport it too and the investors 
will see the business possibilities. If [the government of Frederikshavn is] clever enough 
[they] can convince the citizens that despite the disadvantages in the transition process, 
the advantages are much bigger. That is why involvement of the citizens is so 
important.”107

From the onset, citizen involvement was deemed as integral to the process by the government of 
Frederikshavn and intense consultation, “education, information and involvement of the 
citizens,”108 was undertaken. The consultation and education program was important because it 
involved the citizens of Frederikshavn in the project. The inhabitants of Frederikshavn have 
shown their support for the process by backing the government of Mayor Erik Sørensen through 
the project.

The citizens involved with the project are not solely leaders within the community, but 
consist of people of all age groups and genders. To make sure that people were being consulted 
and informed about the program, a group was created to further the education of the inhabitants 
of Frederikshavn. The group, called ‘Frederikshavn as a Green City’, “by means of information, 
mobilization of citizens, companies and institutions, will work toward the goal,”109 of teaching 
the inhabitants of the city how they can benefit from the project and how they can assist with the


109 Lund, Møller & Mortensen, “Energy City Frederikshavn: Frederikshavn – Supplied 100% with Energy from 
renewable sources in 2015,” 11.
process. One of the main goals of the group was to convince the citizens that “power consumption must be reduced by 3% over the next 3 years,” starting in 2007. This was necessary because some strain had to be relieved from the energy sector in order to ease the change to sustainable energy. The intergenerational aspect of civilian involvement was important so all age groups were involved. To accomplish this, children in schools were charged with the task of sorting of waste for recirculation purposes as well as recycling projects to educate them at an early stage to the benefits of maintaining a more sustainable lifestyle. The involvement of children is also significant because they will inherit the decisions that are made presently and they must decide whether to maintain those changes or not.

Education, Employment and Immigration

Education will increase in Frederikshavn as a result of the project because of the vast amounts of “cooperation with universities and technical institutes,” associated with the project. New technological advancements will be developed and tested in the city and, if plans go as anticipated by Energy City Frederikshavn, the city will become a national and international meeting place for companies and experts who want to research and develop new technological energy solutions. Due to the education program that the city underwent for its citizens at the onset of the project, many of them have the basic skills that are necessary to work in the

---


112 Energy City Frederikshavn,” 4.

sustainable energy field. The inhabitants have learned how the different types of energy are produced and what is necessary to keep those power generation systems functioning. Coupled with the education programs was a “mobilization among firms and other actors to develop local skills in the field of energy technology.”114 This is significant because it means that the vast majority of the jobs in the sustainable energy field could go to people from Frederikshavn, providing needed employment. This education starts at the childhood level and continues all through adulthood in order to ensure that the people of Frederikshavn have the opportunity to benefit from their new environment.

There is a mobilization of “resources among firms and other actors and [a development] of local skills in the field of energy technology [as well as the]... development of energy capabilities in the local education institutions.”115 The increase in education leads to an improvement in employment perspectives amongst the inhabitants of Frederikshavn. Energy City Frederikshavn “provides enormous opportunities for economic growth and hundreds of new jobs in the local community because the renewable energy is produced, distributed and consumed locally.”116 Many of these new jobs will be for locals, but jobs will be available for people from outside the city. On a social level, the decision to power Frederikshavn with sustainable energy will put the city “on the map as an attractive place to live, study, work and do business.”117

Immigration to the city will increase and lead to new construction and the enlargement of the

city. New inhabitants bring new investments and new ideas which will benefit the people who currently reside in Frederikshavn. If the civic authorities can brand “Frederikshavn as a city aiming at a knowledge-based development within energy supplies, business, residence, settlement and education,” it will have a positive effect on the local culture.

Potential Problems with Frederikshavn

While work on the conversion of Frederikshavn to 100% sustainable energy has been largely successful, problems may arise upon completion of the project. Originally, some saw the conversion of Frederikshavn to sustainable energy as being difficult because “Frederikshavn... is located in one of the most industrial areas in... Scandinavia.” Industrial areas are generally polluted, thus making a city powered by sustainable energy that is located within an industrial area theoretically difficult to achieve. It can only be achieved as a result of considerable investment and involvement from business interests. When the project is completed, there is some thought that some of this business investment will be withdrawn from Frederikshavn because the project will no longer need investment on the scale that it previously received. Investment will still be required in the city to maintain the changes that have occurred, but there is the possibility that it will be harder to receive.

If there is a withdrawal of business investment upon completion of the project, a reduction of jobs may ensue. Some of these jobs would have been associated with the construction and installation of the sustainable energy systems and upon completion of the

---


project they would cease. The subsequent unemployment would be problematic, but it would not rival the collapse of the shipbuilding industry. If the education programs that are being enacted in the city fail, then the government runs the risk of alienating some of the citizens of Frederikshavn. This is problematic because the stable support that is required for Energy City Frederikshavn would not be present and the project would be impossible to continue. If “the marketing and invitations towards young people,”¹²⁰ are unsuccessful there is the possibility of a generation that is not interested in sustainable energy. If the conviction of the people of Frederikshavn cannot be maintained over time, the there will significant consequences for the civic authorities. The sitting government will most be removed from office as they were the ones who supported the project in the first place. A successor government would probably advocate changes to the current system, so as to distance themselves from the previous administration, thus creating the potential for reverting to a less sustainable path for the city.

One of the biggest problems for Frederikshavn, and for the rest of the world, will be if the project fails entirely. If it fails, it is possible that many people will believe that if converting a city to green energy is impossible for a city of 25,000 people that had large amounts of business, civic, national and popular support, then maybe it is impossible to power a city through only sustainable forms of energy.

Sustainable Change Internationally

There are many benefits to having a green city that is entirely subsistent on sustainable energy. A city can only improve through the utilization of green energy because the

“environmentally benign development of a city through focused environmental and energy initiatives which stimulate a balance between economic progress, social equity and environmental quality,” benefits a city extensively. The creation of new forms of green energy for Frederikshavn means that it would be completely self-sufficient for energy and it would not have to rely on importing energy from further afield, thus saving costs. Pollution associated with the import of energy would also be eliminated, as would emissions from the fossil fuel plants that would no longer be used. “When [Frederikshavn switches] over [their] energy production to being independent of fossil fuels [they] will create growth in the local society.” Frederikshavn will also be contributing to the slowing of global warming by reducing CO₂ emissions in the city by 3 percent a year until the emissions are at negligible levels.

Energy City Frederikshavn has repercussions for the rest of the world. In other parts of Denmark, places such as Bornholm, Ålborg and even Copenhagen are learning from Frederikshavn. Even though the places are considerably larger than Frederikshavn, the principals enshrined in what the city is trying to accomplish are easily transferable. Green building practices as well a public transportation and the utilization of wind power and CHP plants abound in Ålborg and Copenhagen. Bornholm is undertaking a project similar to Frederikshavn by constructing large quantities of windmills in order to provide power for the entire island.

Recently, Copenhagen hosted a summit on international climate change in December 2009.125 Unfortunately it was not a productive summit, but the intent was present and there is hope that it will further dialogue and action on the utilization of sustainable energy and a reduction on the reliance on fossil fuels.

Europe appears to be leading the field in sustainable energy. Many Europeans see “competitiveness and sustainability... [as] the keys to the long term future of the European Union’s Economy.”126 Sustainability is so integral to Europe that “since the Treaty of Amsterdam, sustainable development has been legally enshrined among the fundamental objectives of European integration.”127 By enshrining it in the constitution, the EU has forced MS to incorporate aspects of sustainability into decisions whenever possible. Some European areas are more aggressive in their pursuits of sustainability. Scandinavia actively pursues sustainability projects. “At the Nordic level, a general political desire to harmonise the Nordic power markets to... create a common, well functioning Nordic power market is prevalent.”128 Norwegian oil reserves, which are predominantly exported and not utilized for energy production aside, Scandinavian energy production frequently revolves around sustainable methods of power production. The Netherlands are another area where sustainable energy is popular. The province of Drenthe has favoured sustainable energy since 1999. The provincial authorities want to make

---

the province entirely sustainable by 2019. This includes energy production as well as transportation and housing, much like in Frederikshavn. Sustainability must start at the civic level, but it can progress rapidly to the state level.

Europe is not the only place where sustainable energy is being utilized. Many countries on other continents are attempting to make use of sustainable energy as well. This even occurs in oil rich states such as the United Arab Emirates (UAE). The emirate of Abu Dhabi is attempting a project in Masdar that will be “designed to not only be free of cars and skyscrapers but also powered by the sun.” Solar power in the middle of the Persian Gulf is a logical use of sustainable energy because of the copious amounts of sunshine that the area receives. If the anticipated goes according to plan, then Masdar will be “home to 50,000 people and at least 1,000 businesses and a university.” The project is ambitious as the city is double the size of Frederikshavn but it is achievable due to the amount of sustainable solar energy in the region and the desire of the local authorities to realize the project. The ambitious project will cost between 15 and 30 billion Canadian Dollars. This is a large sum of money, but once the technology is in place, it will be adaptable to other parts of the region for negligible costs. After seeing that a project like Frederikshavn’s is achievable, many leaders, both civic and national, have been inspired to try to adapt the lessons learned from Frederikshavn to various projects in their own countries.


Frederikshavn as a Model

Frederikshavn is important because it shows that a city of a substantial size of approximately 25,000 people, not a village of 500 people, can convert to sustainable energy production from fossil fuel production in a condensed period of time while utilizing existing technology. As a result, many other cities are beginning to take notice. A “green city now evokes not only a city that is physically greening its streets and its public and private spaces and byways, but also one that strategically embraces development of renewable energy, less-polluting fuels, widely available local food, efficient public transit, innovative treatment of wastes, polluted lands and water, walkability, sufficient affordable housing and green buildings.”133

Frederikshavn proves that environmentally conscious people are realizing that using sustainable energy and abandoning fossil fuels is very important and has many associated benefits. These benefits range from environmental and social to educational and economic.

One significant goal of Frederikshavn is to inspire other cities.134 If a city the size of Frederikshavn is able to revolutionize its entire energy system in the space of seven years, then the goal can be achieved by other cities around the world. “The results and the process of the project will become visible to all energy companies, municipalities and other stakeholders in Denmark,”135 and act as a model where people can come to learn how a city can be reliant on sustainable energy. Frederikshavn will serve as a demonstration site that comprises integrated

---


solutions for utilizing renewable sources. Now, “sustainable development has clearly taken on a global dimension,” and is no longer confined to a country or continent. As global warming increases exponentially, sustainability, particularly in the field of energy production, becomes increasingly important. An “emphasis on the central role played by renewable energy in cities as a key element in achieving sustainable urban development,” is increasing. In Frederikshavn, “when the project has been realized, it should be transferable to other towns in Denmark and, for that matter, the rest of the world.”


Chapter IV: The Lessons from Frederikshavn

The success of the changes in Frederikshavn is very significant. The project should have a tremendous effect on the conversion of other cities to entirely sustainable forms of energy production. One of the most important things about Frederikshavn is the manner in which the city converted its energy systems. The city did not search for revolutionary technologies or adopt the newest techniques. Instead, Frederikshavn invested in existing technologies, relying on systems that were already proven to be both effective and efficient. This is very important because it proves that while beneficial and potentially significant in the future, the advent of new technologies is not a mandatory requirement for a city that plans to convert to 100 percent sustainable energy production. This removes one of the major perceived impediments for the conversion to sustainable energy in some cities and makes the conversion to sustainable energy production considerably more appealing and attainable.

Aspects of Civic Sustainability

One of the pertinent things to understand is that the concept of “sustainability has to be defined for each individual project.”\(^{139}\) Utilizing sustainable forms of energy production is beneficial, but civic parameters must be applied and a government cannot simply state that their city is to become sustainable. Therefore, a city must define what types of sustainable energy it will utilize in order to become sustainable. This will allow the concept of sustainability to be more effective in a city and give it more resonance amongst business interests and the local inhabitants. A city itself is important because

\(^{139}\) de Roo, “Coping with the Growing Complexity of our Physical Environment: The Search for New Planning Tools in the Netherlands,” 165.
“the city is the economic, social, cultural and political heart of a society. It provides new impulses and energy for new activities and initiatives. The nodal position of a city in a broader regional, national and international network offers enormous potential with many challenges.”

Within the context of a region or a country, a city has the most power to be able to introduce and invoke changes. It is large enough to make its own decisions, and those decisions do not have to be reliant on national governments. This means that the majority of the choices that are made will be solely for the benefit of the city and its inhabitants.

There is a specific structure and relationship that must be in place in a city before its energy systems can be converted to sustainable ones. The relationship must be symbiotic and include “the individuals/households, the organizations [such as businesses] and the government,” in order for positive change to be enacted. The local government must be in favour of the changes because they have the power to implement. “Investment incentives are used to reduce the capital cost of deploying renewable energy technologies. They can also reduce investor risk,” thus encouraging business interests to invest, something that is crucial to a sustainability project. The inhabitants of a city must be consulted and their interests must be recognized and considered if an energy conversion project is to be successful. Their support is significant because they can remove the elected civic officials if the people are unhappy with them, thus making any future progress impossible. Only if a harmonious relationship is in place between civic authorities, business interests and citizens, then a conversion of polluting energy systems to sustainable ones is possible.


141 Hallsmith, The Key to Sustainable Cities: Meeting Human Needs, Transforming Community Systems, 49.

142 Renewable Energy: Market & Policy Trends in IEA Countries, 86.
How Change Must be Enacted

The major concept that must be adhered to if a city attempts to become powered solely by sustainable energy is the manner in which the process is to be carried out. For energy system conversion to be successful there must be a top down, fundamental structural change that is initiated at the civic government level. While “the private sector, non-governmental organizations, community-based organizations, and civil society groups have organized around issues of growth, environment and social welfare,”143 they are not in a position to make effective decisions for an entire city. Competent civic authorities have to be present in order for any change to be enacted because “political cooperation and organization of the energy supply system are very important factors,”144 during the sustainable energy conversion process. The officials must create a path in which the changes will be effectively enacted. They must also be the ones instituting the changes. The civic government is the group that holds the power and can decide what needs to be done and how it can be achieved.

While it is significant if the push for energy conversion comes from the inhabitants of a city, they do not have the power to foster the necessary changes to make the process happen. It is a positive step if citizens build windmills in their yards or affix solar panels to their houses but it is insignificant in the grand scheme of things. While these changes will benefit those individuals who undertake them, they will not benefit their neighbours, their community or the rest of the city as a whole. Citizens can also rally and hope their numbers will convince civic authorities to


144 Capello, Nijkamp & Pepping, Sustainable Cities and Energy Policies, 189.
enact changes, but this is not an effective method. While they do not have the power to institute change, the inhabitants of a city must still support it. This being said, the individual level is too small a place to initiate a conversion to total civic sustainable energy production.

Large amounts of business investment are crucial to the process of civic energy conversion and must be controlled by the government. While business investment is necessary, it cannot be the area from which the process starts. If business interests dictate decisions during a civic conversion project, hostility from both the inhabitants of the city and from the elected civic authorities will ensue. Citizens will be unresponsive to the project because they will perceive that businesses are initiating the project solely for their economic benefit. Civic leaders will not be supportive of the project for much the same reasons as the inhabitants. Business interests leading the conversion process is infeasible.

The benefits that will come about from the conversion to sustainable energy must be for business interests as well as for citizens. If either group’s interests are neglected, then the process will be unsuccessful. With the amount of investment from business interests, a government must be wary about making decisions that are excessively beneficial to businesses. This is one of the harder pitfalls to avoid due to the fact that investment in a sustainable energy conversion is integral to the realization of the project. This is why the civic authorities must balance the desires of both sides of the project. A top down approach, starting at the level of civic governance is the only way in which both the interests of businesses and the interests of citizens can be recognized and respected. The civic authorities in Frederikshavn accomplished this task, and that is one of the reasons that the project was so successful.

145 Hallsmith, The Key to Sustainable Cities: Meeting Human Needs, Transforming Community Systems, 54.
Processes for Converting a City to 100% Sustainable Energy

As energy is the main impetus for change in a sustainable city, it is the area where change must start. “As the prices for fossil fuels rise, with the energy demands of our technology, exciting ideas and innovations are hoping to provide reliable sources of renewable energy,”¹⁴⁶ in order to make energy production more efficient and more affordable. The diversification of energy production is one of the most important processes that a city must undergo in order to attempt to adopt sustainable form of energy production. While there are many beneficial forms of sustainable energy production, it is not beneficial to rely on one type specifically because if there is any economic fluctuation pertaining to the price of one type energy production, economic hardships for a civic government will follow. For example if there is a shortage in agricultural waste or if the wind ceases to blow for a period of time, then having power production capabilities that utilize other techniques to produce energy will be necessary. One of the most important aspects of energy production is the carrying capacity. Carrying capacity refers to “the sustainable level at which a particular natural or physical resource can be used.”¹⁴⁷ If a certain energy source’s carrying capacity is too low, then it cannot be heavily relied upon for energy production. If a city utilizes an “efficient use of [sustainable] technology,”¹⁴⁸ to produce energy and does not rely too heavily on one specific type of energy production, then the city will prosper.

¹⁴⁷ Hallsmith, The Key to Sustainable Cities: Meeting Human Needs, Transforming Community Systems, 52.
The size of a city is a determining factor as to how many sustainable forms of energy production are to be utilized. As a general rule, the larger a city, in terms of population and urban area, the larger the production of sustainable energy required in the city. An example would be of a city that may be on the coast but have a large river flowing through it as well as vast agricultural lands located nearby. This means that the city could be powered by using tidal bore energy, a hydro-electric dam or a CHP plant. A combination of all three would be most beneficial for the aforementioned reasons. Each energy production method is fundamentally different from the others so if there were problems with one type of production, the same problems would not be associated with another.

Civic authorities should launch “business strategies to ensure that [sustainable energy companies] take advantage of [a city’s] strong position in the climate change area.”149 This will provide incentive for firms that utilize sustainable energy to invest in a city. The local government must tailor the structure of the investment strategy in order to maximize the effectiveness of the investments. The authorities have to ensure that the investment is mutually beneficial to both the city as a whole, encompassing the civic authorities and the inhabitants, as well as the business interests.

“Sustainability in an urban setting... describes the potential of a city to reach qualitatively a new level of socio-economic, demographic and technological output which in the long run reinforces the foundations of the urban system.”150 This was the case in Frederikshavn, as well as other formerly industrial cities that had fallen on harder times such as Manchester and

---

149 “Co-operation with Businesses,” 1.
Hamburg. New ideas in sustainability have allowed the economic aspects of the cities to improve significantly. “Technological development has created jobs... [and] directly translated into an improved quality of life for the majority of people.”\textsuperscript{151} The energy changes in Frederikshavn are designed so the city “will be converted from fossil fuels to 100 percent renewable energy in the electricity, heat and transport area by 2015,”\textsuperscript{152} and the project was only initiated in 2008. The changes that Frederikshavn made were substantial, but they were easily achieved in a brief period of time. If Frederikshavn could accomplish such large scale changes in seven years, then the same is possible for other cities even if they are considerably larger. If the civic authorities have the impetus and the financial backing to convert a city from being reliant on fossil fuels to being reliant on sustainable energy, the conversion can be quickly and easily achieved. The new system was easy to adopt because the government ensured that the energy transition went smoothly. The construction of the new energy plants did not cause major disruption of service throughout the city. This is important because if a conversion project can be performed without causing a major disturbance in the daily lives of the local population, then it is increasingly likely that the inhabitants will accept the project.

Costs and Benefits

Many of the existing power plants that produce energy for cities can be considered outdated. Due to the age of many of these plants there are high maintenance and operational costs associated with them. Other downsides to fossil fuel plants, specifically coal plants, is “the


\textsuperscript{152} “Case: Frederikshavn: A Renewable Energy Town,” 9.
fact that a coal-fired power station with a construction time of 5 years and a lifetime of maybe 30 years... will cause CO₂ emission problems.”¹⁵³ There are also the large costs of importing fossil fuels because, though “some [are] still locally mined... much is imported by ship from countries,”¹⁵⁴ that have large fossil fuel deposits. Being dependent on other countries for energy is frequently problematic, as is evidenced by the United States involvement in Iraq and the nationalizing of energy firms in Venezuela and Bolivia. It is increasingly beneficial to be self-sufficient in energy production capacity for most cities and countries. The emissions problems, coupled with the high costs of production, operation, importation, maintenance and the eco-political ramifications associated with the use of fossil fuels make them an infeasible option for energy production when compared with sustainable energy production methods.

One of the benefits of sustainable energy production such as solar, wind and biofuels is that they are inexpensive to utilize because the systems used to produce energy from them are inexpensive to construct and operate. “Given the fact that most of the costs of the electricity... are accounted for by the need to pay back the capital investment, with day-to-day operating costs being relatively minor... there is a great incentive to maximize the efficiency,”¹⁵⁵ of the sustainable production plants and devices. Most forms of sustainable energy production are very affordable to build because they have fewer working parts and are far less complex than large fossil fuel burning plants. As long as “the level of the incentive is adequate to bridge the gap


between the market price of energy and the cost for renewable energy,”156 the businesses will recoup their original investments quickly and the economical and environmental benefits of converting to sustainable energy will considerably outweigh the costs.

One of the benefits about a conversion project for the inhabitants of a city is the civic pride that they will feel when the project is completed. Many people have already “developed a mindset of awareness for the environment and taking care of the earth’s limited resources.”157 Cities powered entirely by sustainable energy do not exist in the world, with the future exception of Frederikshavn. The citizens would also feel positive and trendsetting because their city would evolve into “an attractive city to live [in] and visit.”158 There would be an influx in visitors to a sustainable city because it would be an excellent place to visit, study or work. Also, a sustainable energy conversion project will create “new enterprises in the energy sector,”159 and these new enterprises will create new jobs for many of the local inhabitants.

There are many business investments that are associated with participating in a civic sustainable energy conversion project. The vast majority of these investments will be beneficial to companies. One of the most important aspects of financial incentives for businesses is that they “are used to reduce the capital cost of deploying renewable energy technologies.”160 This allows a firm to build energy production facilities on a larger scale, which will benefit the

156 Renewable Energy: Market & Policy Trends in IEA Countries, 86.
158 “Energy City Frederikshavn,” 5.
159 “Energy City Frederikshavn,” 5.
company through increased profits, and the city through increased energy production. Another of
the fundamental aspects of the incentives is that they “must be of an adequate size and must be
predictable and consistent over time to be effective.” If this is the case, then investing in a
city’s sustainable energy project will be beneficial and will encourage increased investment from
many firms.

“Environmental quality has always been an important driver in charge, linked both to
human health and to economic viability.” If companies can demonstrate this position, then
they will be encouraged to increase participation in more projects. This will lead to a rise in the
profits of these businesses because

“the first in [one’s] industry to go green provides first-mover advantage... As
shareholders increasingly hold organizations accountable for their GHG emissions and
environmental performance, firms that willingly adopt measures to reduce emissions and
improve environmental performance... are seen in a better light by investors.”

As mentioned previously, inhabitants of cities gain pride when their city is powered entirely by
sustainable energy. The same concept can be associated with businesses that invest in a
sustainable city project. This is one of the reasons that DONG Energy, the Danish energy firm,
has gained such prestige. The firm is heavily involved in environmentally friendly energy
production, as well as being heavily invested in the Frederikshavn project specifically. The fame
associated with the project leads to recommendations of the company and potentially new

163 Tommy Linstroth. “Green from the Inside Out.” In The Green Building Bottom Line: The Real Cost of
projects in other areas, thus demonstrating the benefits for businesses of being attached to a civic sustainable energy conversion.

The Goals of Sustainable Energy in a City

Sustainable energy comes in many different forms. This is evident in Frederikshavn, where the city uses wind, solar and biofuel as different methods of energy production. This diversity is beneficial to the city because it allows the city to not have to rely on one form of energy in particular, thus alleviating the stress on any one type. Frederikshavn lends itself to being a microcosm for differing forms of sustainable energy production. The goal of any sustainable city is to have increased energy efficiency, less pollution, reduced energy costs, less dependence on foreign energy and the enhancement of regional growth.\textsuperscript{164} As evidenced in Frederikshavn, different geographical locations lend themselves to different forms of sustainable energy production. There is no perfect form of sustainable energy production. No individual form can be placed in any location in the world and be expected to produce energy successfully. Since “the cost of new energy technologies is the most crucial factor for the development of renewable energy,”\textsuperscript{165} it makes sense to invest in the technologies that will be most beneficial to a city. This may mean ignoring more established forms of energy production, such as wind or solar, for less utilized form such as tidal bore or run of river projects. The crucial thing to understand is that there are many different forms of sustainable energy production and each one of these has a diverse array of attributes, benefits and detriments. The main notion that must be

\begin{footnotesize}

\end{footnotesize}
maintained in the mind of civic authorities when they are deciding on which forms of sustainable energy production to use in their city is that almost all sustainable energy forms are inexpensive, efficient, self-sustaining and infinite.
Chapter V: The Feasibility of Sustainability in Vancouver

As a result of the example of Frederikshavn, some insight is able as to how the essence of the project can be transferred to other cities. The city which will be discussed is Vancouver, Canada.

Sustainability in Vancouver

Vancouver is located in south western Canada. The city has a population of approximately 578,000 people, totalling 2.1 million inhabitants in the urban area. The geography of Vancouver is varied. The city is located on the shores of the Pacific Ocean, but there are also mountains, rivers, lakes, islands and agricultural areas located within the city’s urban area. This geographic diversity leads to problems for construction and transportation. The large distances that need to be covered in the city make vehicle use mandatory and new construction is rampant due to an ever increasing population. The city spreads out over a wide area that includes many natural boundaries such as rivers and mountains. Despite this diversity, much of the energy that is produced in the city comes from a network of hydroelectric dams in the city including Ruskin and Stave Falls. These dams provide clean and efficient energy to the city but they are ageing. Construction on the Stave Falls dam started in 1926 Ruskin dam was started in 1950. Despite renovations performed by TRB Architecture Inc., the energy production capacity of the dams must be supplemented in order “to meet the future energy


demand in British Columbia.” New opportunities and technologies should be investigated for energy production in Vancouver before the current energy production capabilities for the city are pushed to the brink.

The urban diversity of Vancouver is beneficial to the energy sector because it provides a variety of scenarios where different types of energy production can be utilized. This diversity lends itself to the use of many different types of energy production. Hydroelectricity is one of the many types of power that the geography of Vancouver lends itself to. However, it is not the only type of sustainable energy production that should be utilized in the city. A variety of other technologies including wind, solar, tidal bore and biofuel are all viable options for power production in Vancouver. This diversity in energy production presents many opportunities for the city to explore new energy production methods. Provided that the civic authorities maintain the top-down approach that is necessary for converting a city to sustainable energy production, then Vancouver, despite its size, can follow Frederikshavn’s lead and be powered entirely by sustainable energy.

The energy sector must be more heavily subsidized by the civic government. Due to the ageing hydroelectric dams powering Vancouver, other forms of sustainable energy production must be introduced. If these systems are in place before the dams extend beyond their capacity, then the new energy production infrastructure will be more feasible to install because there will not be an impetus to rush completion of the project, ensuring successful construction and future operation. The completion of more sustainable energy production methods will help in “making

Vancouver one of the world’s first fossil-fuel free cities.”\textsuperscript{170} If the new types of sustainable energy production are coupled with the existing forms of energy production in the Vancouver, the city will benefit. Provided that the fundamental change in energy production that is necessary for Vancouver to achieve its sustainable energy goals occurs, and increased investment from business in sustainability is encouraged, the city will achieve its goal of becoming a fossil-fuel free city by 2020.\textsuperscript{171}

As was evident in Frederikshavn, the costs of construction of sustainable energy projects are generally inexpensive when compared with fossil-fuel burning power systems. The most feasible types of sustainable energy production not currently utilized in Vancouver are wind, solar and, tidal. As of 2007, wind turbines have significant economies of scale and cost between $1.5 and $3 million Canadian Dollars per MW of energy produced, to construct.\textsuperscript{172} To put this number in perspective, the average home only needs 10 kilowatts of energy.\textsuperscript{173} These production figures are considerably less than large fossil-fuel plants but windmills are not hazardous to the environment. Solar panels are even more affordable costing approximately $1000 Canadian Dollars to power one household annually.\textsuperscript{174} The costs associated with tidal bore energy production are relatively high, but the operating costs are low, thus allowing investment costs to


\textsuperscript{173} “How much do Wind Turbines Cost?” 4.

be recouped at a relatively rapid pace.\textsuperscript{175} CHP plants are larger than both windmills and solar panels and have higher initial costs associated with them as a result. However, the price per kW of energy produced by a CHP plant is approximately $700 Canadian Dollars annually, which is less than the cost of energy that many fossil-fuel burning plants produce.\textsuperscript{176} CHP plants produce energy on a large scale, thus making them significant contributors to sustainable energy production.

Constructing new forms of energy production and connecting them to the civic power grid will be inexpensive and viable because the new forms of energy production do not require vast areas of land for construction, nor do they require great infrastructure costs. Much of the infrastructure is in place for increased energy production in the city because it was constructed for use with the existing hydroelectric dams. This infrastructure will need to be expanded, but the expansion will be necessary regardless due to the increasing growth of the city. The power grid that is in place in Vancouver is inter-connected with the power grid for the rest of the province, as well as the power grid that continues into the Western United States as far south as the border with Mexico. Increased energy production in Vancouver will lead to a surplus of energy and this surplus can be sold for profit to parties outside Vancouver that are connected to the grid. As energy costs in Vancouver are currently low, it may seem paradoxical to invest in other forms of sustainable energy production. However, the population of the city will increase, thus making sole reliance on the existing energy production methods infeasible.


Vancouver already prides itself as being progressively sustainable. The city is “leading the new green industry with clean energy, mobility and green building projects.”\textsuperscript{177} The vast majority of new construction projects in the city should adhere to Passive Design Toolkits that the city published in 2009. These Toolkits provide the “best practices for passive design elements such as layout, orientation, insulation, landscaping and ventilation. They help designers and developers move towards a new, higher standard of energy efficiency.”\textsuperscript{178} These guidelines encourage investment from many companies that utilize energy efficient technology. The city already has “one of the smallest carbon footprints of any major city in North America,”\textsuperscript{179} which places it in an excellent position to install increased sustainability changes. Vancouver is increasingly trying to shape itself “into a global leader in the new green economy, making [the city] a hub for green jobs and green economic development.”\textsuperscript{180} Vancouver will continue to become a greener city, eventually culminating in complete sustainability for the city.

Public Support for Sustainability

Vancouver has historically been a centre for environmental support. The non-governmental organization (NGO) Greenpeace was founded in Vancouver in 1971 and it has since become one of the world’s foremost NGO’s in environmental protection.\textsuperscript{181} The city also


annually hosts EPIC, the Sustainable Living Expo which teaches people how they can lead more sustainable lives.\(^{182}\) Critical Mass is a bike rally that is held in the city of Vancouver on the last Friday of every month to try to remove cars from the roads of Vancouver.\(^{183}\) These events have high levels of local participation. Environmentally friendly buildings in the city are also supported by the local inhabitants. These buildings include the Vancouver Convention Centre, which has a green roof that is composed of grass, and the Net Zero Building which is a residential apartment complex that generates as much energy as it consumes.\(^{184}\) These buildings originally met with some friction during the construction process, but that friction was largely based on unforeseen economic overruns, rather than the buildings themselves which have largely been embraced by the inhabitants of the city.

**Locations for Sustainable Energy Production**

Frederikshavn and Vancouver differ considerably in population, having populations of approximately 25,000 and 2.1 million respectively. Attempting to replicate the sustainable energy production facilities that Frederikshavn has seems like a daunting task for Vancouver because the facilities would have to be increased exponentially. Fortunately for the city of Vancouver, its differing geographic nature lends itself to the construction of various types of sustainable technology. It is difficult to convert a city the size of Vancouver to sustainable forms of energy production rapidly. However, Vancouver is already heavily reliant on hydroelectric

\(^{182}\) “About,” EPIC, the Sustainable Living Expo, [http://www.epicvancouver.com/overview/about](http://www.epicvancouver.com/overview/about), 3.


power; so much of the energy in the city is already sustainable, thus making a conversion to 100 percent sustainable energy increasingly feasible. That being said, due to the differing terrain in the city, there is no blanket, all-encompassing sustainable energy production technique that will work for the entire city. As a result, it is best to focus on the individual municipalities in the city and ensure they are reliant on sustainable energy and thus Vancouver.

There are various areas of Vancouver where sustainable energy production is well suited. Some of these areas are Richmond, the University of British Columbia (UBC) and Langley. All of these areas are considered suburbs of Vancouver but are located within the Metro Vancouver area. The aforementioned places are three distinct parts of the city where different types of energy production can be utilized. This will provide a cross-section for other areas of Vancouver. The city of Richmond, an island located directly on the coast, has a population of approximately 188,100. Due to its proximity to the ocean, with a long coastline to the west and bordered by river channels on the other sides, Richmond is well-suited to utilizing tidal bore projects for energy production. The city’s location and its broad, flat geography lends itself to the use of wind-farms. The usage of windmills in Richmond is beneficial because of the force of the wind that blows in from the ocean. The use of both wind and tidal bore for power generation would aid the production and distribution of power in Richmond significantly. It would also help to make the region increasingly self-reliant on its own energy production.

UBC is located to the northwest of Richmond, on the promontory of a peninsula. The university has approximately 45,000 students, as well as a large population on non-students who

---

reside on the campus and surrounding endowment lands.\textsuperscript{186} Much like in Richmond, UBC’s location makes it an excellent site to use windmills for energy production as the wind in the area is consistently strong. UBC plans on utilizing other forms of green energy as well. The university has plans to construct a bioenergy system that “will breakdown waste to produce a synthetic gas that [the power plant] will use to power a gas engine. The energy from the engine will partially provide the UBC campus with heat and electricity.”\textsuperscript{187} The project is expected to “reduce natural gas usage by 12%, power 1500 homes, [and] eliminate 4500 tonnes of greenhouse gas emission per year.”\textsuperscript{188} The combination of wind power and bioenergy will combine to heat and power much of the university. The campus will no longer be solely reliant on the power produced from the hydroelectric dams that are located far to the east of UBC. Instead, the university will be more self-sufficient and will be in a position to negotiate a contract to sell some of the excess energy produced on campus back to the civic power grid, allowing it to be utilized in other location.

Langley is located inland from the coast in a predominantly agricultural area to the east of Vancouver. It contains approximately \(\frac{2}{3}\) of the population of Richmond or 120,000 people.\textsuperscript{189} “The City [of Langley] is currently developing a plan to reduce energy consumption and greenhouse gas emissions in the community,”\textsuperscript{190} in an effort to become more sustainable. Due to


\textsuperscript{188} Kolenko, “UBC gets Bioenergy Project,” 21.

\textsuperscript{189} “Living in Langley,” City of Langley, \(<\text{http://www.city.langley.bc.ca/residents.htm}\>\), 6.

\textsuperscript{190} “Sustainability,” City of Langley, \(<\text{http://www.city.langley.bc.ca/sustainability.htm}\>\), 5.
the area being prime agricultural land, Langley has many farms. These farms produce large amounts of agricultural waste. This waste would be well-suited to use in a CHP plant. If one was built in Langley, it would be able to provide the community, as well as much of the surrounding area with energy. The initial costs would be high, as they are with the construction of any large power plant, but they would be recouped quickly because there is abundant fuel for the plant. The use of other types of energy would take a lot of the strain off the current hydroelectric projects in Vancouver as well as provide jobs, both for installation and operation, as well as heat and power to regions of Vancouver. There is little utilization of biomass in Vancouver but “BC Hydro is widening the definition of biomass energy with a new green-power call,”191 that will allow for an increase in the use of biofuel as an energy source. This would be beneficial in helping the city achieve its goal of becoming fossil-fuel free by 2020.192

Potential Problems with Sustainability in Vancouver

As the process of converting Vancouver to entirely sustainable forms of energy production, it may become apparent that the task is difficult to achieve for a variety of reasons. A sustainability project on this scale has never been attempted before. As a result of the diversity of Vancouver, there is a high probability that the project can be successful if civic authorities can demonstrate to the inhabitants of the city what the fundamental changes are in order for the project to be a success. This will involve the civic authorities utilizing the required top-down procedure that was used in Frederikshavn in order to have any success. The city must also convince the people of Vancouver that the project is economically beneficial, morally beneficial

191 Scott Simpson, “Hydro Widens Hunt for Biomass Power,” The Vancouver Sun, June 2, 2010, C8
and in the inhabitants’ best interests. This may be easier stated that accomplished because the citizens of Vancouver, though generally supportive of sustainable development and change, as evidenced by the rallies and events supporting sustainability in the city, are not always trusting of civic politicians because of past broken promises. If the local authorities can gain the trust of the citizens, there will be strong support for the project.

Vancouver’s grid is attached to the rest of the province as well as that of the west coast of the United States. Therefore, the power that is produced in the city does not always remain in the city because of agreements with other areas. If new forms of sustainable energy production are created, then more energy can be produced in the city and much of this excess energy will be transported out of the city. Unless the existing agreements are re-negotiated, Vancouver could transmit more energy than the previously negotiated amounts to other places, essentially meaning that the energy will be exported for free.

If Vancouver is not able to become powered entirely by sustainable energy, then the city should push for sustainable energy production wherever possible. This will alleviate some of the stress on the existing hydroelectric projects in the city. It will also help to counter-balance the emissions from any fossil-fuel powered plants that are still used by the city. If Vancouver cannot be powered 100 percent by sustainable energy, then it should at least ensure that the emissions from the non-sustainable plants are neutralized by the sustainable ones. If the city is capable of neutralizing the emissions that are produced in the city, or at least offsetting them, then Vancouver has the potential to be one of the largest carbon-neutral cities in the world.
Chapter VI: Discussion

Frederikshavn is a viable case study of a sustainable city. The city was a good candidate for conversion to sustainable energy for a variety of reasons, but most significantly, due to economics. The city had suffered tremendously as a result of the closure of the local shipbuilding industry. Since the shipyards were such an irreplaceable aspect of Frederikshavn, their closure left a void in the city. Unemployment in Frederikshavn coupled with an increase in economic stagnation to make the city’s future prognosis dire. Without a feasible plan to extricate Frederikshavn from its economic predicament, the city would have languished like other, formerly industrial cities did.

The civic authorities in Frederikshavn knew that fundamental changes would be required if the city was to prosper again. This is one of the most significant reasons as to why the city’s officials chose to pursue sustainable energy. The effect on jobs the energy conversion will have will be significant. Many positions related to infrastructure improvements in the city, including the construction of the energy production facilities, will be available to the local population. These kinds of positions will be well-suited to the inhabitants of Frederikshavn who lost their source of income when the city’s ship building industry collapsed. Frederikshavn itself will benefit economically from the financial contributions of firms which are looking to invest in the project. Fiscal support from Copenhagen will combine with investment from companies such as Vestas and DONG Energy to cover the majority of the costs required for the $350 Million Canadian Dollar Canadian conversion process. Without the conversion to sustainable energy providing an impetus for investment and the creation of jobs, they would not exist.
The change was seen as a way to revitalize the city and improve the fortunes of the many unemployed people. Frederikshavn already had some necessary aspects of sustainable energy production in place, which made the conversion both easier and logical. The city was capable of converting to sustainable energy because it had considerable amounts of economic support, both from the Danish state and business interests. Much of the investment from business interests consisted of reduced production, construction and infrastructure costs while the majority of economic support from the Danish state consisted of tax breaks as well as capital to be invested by Frederikshavn in the project. The economic situation, the main catalyst for change in the city, can also act as a restriction on the transferability of the techniques utilized by Frederikshavn to other cities.

Some scholars believe that a city has to face economic adversity in order to precipitate a significant, sustainable change. However, this is not the case as myriad factors can manifest in order for a city to be convinced of the merits of a conversion to sustainable energy. The case study of Frederikshavn provides examples of mechanisms for cities for how to covert to sustainable forms of energy production. It is easiest to lobby for significant changes in a city when the city is suffering economically because a city needs a catalyst to be able to transform its economic fortunes. This was the case in Manchester, as well as in Frederikshavn. However, any city that believes it can benefit from converting to sustainable forms of energy production can make the necessary changes. As each city is different, there is no general strategy that must be followed in order for conversion to be successful. However, there has to be a reason for the change to be adopted. Even if the inhabitants of a city are not suffering economically, they still need to be convinced of the merits of converting to sustainable energy production. This must be accomplished by the civic authorities who should use whichever approaches are necessary in
order to present the benefits of the inevitably necessary sustainable changes to both business interests and the local population. The easiest way to accomplish this is by providing economic, environmental and social projections that demonstrate the benefits of utilizing sustainable energy production. The authorities in Frederikshavn were successful because of their transparency and their myriad education programs.

Since each city is different, it is crucial that the municipal officials use a technique that will appeal to the general population. In Frederikshavn, besides the economic justifications, civic authorities were able to argue the merits of a conversion to sustainable energy by demonstrating that some of the infrastructure required was already in place and the necessary changes were technologically and socially beneficial to the city. These techniques were successful in the city. As a result, the lessons extracted from the Frederikshavn conversion process can be employed by civic authorities in other places who wish to convert their cities to sustainable energy.

The transferable nature of a sustainable city is very important. A project like the one in Frederikshavn must be capable of inspiring change, not only conceptually but through its strategies and processes. It is necessary to select another city to demonstrate this, and a city that is dissimilar will strengthen the potential of transferability. Frederikshavn and Vancouver are dissimilar cases to study. Frederikshavn’s population of 25,000 is considerably less than Vancouver’s 2.1 million. Frederikshavn was formerly industrial while Vancouver’s enterprises are predominantly primary or tertiary. Frederikshavn is located on a plain whereas Vancouver is geographically diverse, comprising mountains, rivers, swamps and plains. Frederikshavn suffered substantial economic hardship due to the collapse of the major local industry but Vancouver has not suffered similar debilitating economic issues.
Despite the significant disparities between the two cities, there are some similarities. Frederikshavn was powered by some levels of sustainable energy, in the form of windmills, before it underwent its conversion. Vancouver was powered by sustainable energy in the form of hydroelectric dams. The other major similarity between Frederikshavn and Vancouver is the significant level of political and social desire for sustainable change that is present in the two cities. There are considerably more differences than similarities between Frederikshavn and Vancouver. This is helpful in demonstrating that the strategies utilized in converting to sustainable energy in Frederikshavn can be adopted in cities that have a different set of circumstances associated with them, such as Vancouver.

Vancouver and Frederikshavn are considerably different, but this does not detract from the notion that Vancouver can utilize some of the techniques that were used in Frederikshavn’s conversion. One of the easiest ways of presenting a task to a city is to make the task appear easily accomplished. In Frederikshavn, this was achieved with great success. In Vancouver, the task will be more difficult to accomplish because many people believe that the city is sustainable at present and little change needs to be enacted to preserve the current levels of sustainability in the city. One of the important traits that can be taken from Frederikshavn and used in Vancouver is the appeal to the business community. Frederikshavn made it beneficial for businesses to invest in sustainable technology in the city, and Vancouver must do the same.

Since Vancouver does not suffer from the same levels of economic hardship that Frederikshavn did, much of the ground level driving force for a conversion to sustainable energy must come from the inhabitants of the city. Already, there is a large, environmentally conscious population in Vancouver and if the civic authorities can market necessary sustainability changes
to this increasing sector of the population, then one of the significant driving forces for sustainable change in the city will be invigorated. Another important trait in regards to transferability can be the ease with which sustainability was fostered in Frederikshavn. The entire process was designed to be completed in seven years. If this process can be replicated in Vancouver, regionally rather than city-wide, then the short-term political memories and fears of many Vancouverites will be assuaged and their sustainable desires will be recognized.

Despite the fact that the drivers for sustainable change in Vancouver are different from those in Frederikshavn, Vancouver is a good city to study sustainability. The reasons for this lie in its dissimilarity to Frederikshavn. Vancouver is not a small city that has fallen on tough economic times, but a large city with a thriving economy. However, Vancouver, like Frederikshavn, has some of the sustainable systems in place, the large power grid and the hydroelectric dams, in order for a conversion to occur. With the existing infrastructure in place, it is easier to convince the general population that a city is ready for a sustainable change. The fact that if the dams in Vancouver are not supplemented they will no longer be able to power the city in its entirety is another good impetus for constructing sustainable forms of energy production in the city. This idea has to be recognized at a greater extent than it is presently. Currently, Vancouver is seen as an environmentally-friendly city. This prevalent attitude, seemingly paradoxically, makes the city a good candidate for becoming increasingly sustainable.

The processes that can be drawn from Frederikshavn are not limited. While situations in other cities differ, the techniques and structural processes that Frederikshavn underwent, including the top-down approach, the involvement of businesses as well as the local population
and the manner in which the conversion occurred can each be followed by other cities in order for them to convert to sustainable cities.
Chapter VII: Conclusion

The threats and problems associated with global warming are real. As a result of the significant amount of current “global change...[there will be] cumulative losses of ecosystems function [and] components may reach... critical points of no return beyond which systems structure and behaviour change critically and irreversibly,”\textsuperscript{193} causing detrimental effects on the world in perpetuity. Much of the cause of global warming comes from the burning of fossil-fuels. These emissions come from a variety of things, two of the most significant sources being vehicles and power plants. The fuels that power these are not only damaging to the environment, but are unsustainable as the stockpiles of these resources, such as oil and coal, are being reduced at a rapid rate. Eventually, these stockpiles will cease and new fuels and methods for energy production will be necessary or else the current rates of energy production will be impossible to maintain. If new sources of fuel and methods of producing energy are not utilized, the effect on people across the world will be significant.

Sustainable energy production provides many of the solutions to the global warming problem. If sustainable forms of energy such as wind, solar and biofuels are harnessed at an early stage, then it is possible that global warming can be protracted or even eliminated. The aforementioned forms of energy, among other sustainable forms, are inexpensive, plentiful and effective. They have the ability to produce energy for a variety of things and can be utilized in many different conditions. Sustainable forms of energy production are superior to unsustainable forms because sustainable types will work perpetually. The resources will not diminish over time as they will be consistently available, regardless of the method that is being used for energy

production. Sustainable energy is versatile and can be used in a variety of locations and situations, thus making it an attractive concept when deciding on which type of energy to produce. Certain types of sustainable energy are more suitable to some locations than others, but a combination of types yields exceptionally positive results for a region.

Apart from power plants, cities are some of the largest producers of harmful emissions. This is because many of the things that cause harmful emissions such as cars, buildings, people and power plants, are located within cities. If sustainability is the path to follow to ensure that a city reduces and eliminates its polluting emissions then, logically, it would be best to make a city sustainable. Many cities around the world attempt to become sustainable by constructing buildings that have rain-water catchments or energy-saving lighting. Others construct transportation networks that are powered by electricity. These methods, while they reduce emissions, they are ineffective because they do not solve the root of the problem. Both construction and transportation methods, regardless of whether they are themselves sustainable, are futile because they could be powered by non-sustainable forms of energy, thus rendering any sustainable progress redundant. A city must be powered by sustainable energy if it is to label itself sustainable.

The only way for a city to become truly sustainable is to convert to 100 percent forms of sustainable energy production. The only way to guarantee that every building and every vehicle runs on sustainable energy is to ensure that the only source of power available to them is sustainable itself. If the power sources are sustainable, then other aspects of the city will soon follow. Frederikshavn, Denmark is proof that the process of converting a city to 100 percent sustainable forms of energy production is possible. By 2015, the formerly industrial city will
have completed a conversion that will make it the first city in the world to be powered by completely sustainable energy. The process is economically viable, advantageous to everyone involved and beneficial to the world as a whole. The fact that what is happening in Frederikshavn is completely transferable to other cities in the world, such as Vancouver, Canada, only strengthens the case of the possibility of a city being powered entirely by sustainable energy. Provided the top-down structural changes are headed by the local government, the project is widely supported by the inhabitants of the city in question and there are financial incentives for investors then a city powered completely by sustainable energy will be achievable.


“The Challenges may be Global, but the Solutions must be found Locally.” EcoCities. 

“Copenhagen Climate Plan: The Short Version.” City of Copenhagen. 
<http://www.kk.dk/sitecore/content/Subsites/Klima/SubsiteFrontpage/HvadGoerKoebenhavnsKommune/~media/12E701459AD14B7C81FCD6D33F2EC9CF.ax> (Accessed March 14, 2010).

“Climate Communities.” Danmarks Naturfredningsforening. 


“Dutch City of the Sun.” Euranet.  


“Energy City Frederikshavn.” Energy City Frederikshavn.  


“The Energy City Frederikshavn Foundation.” Energy City Frederikshavn.  

“Energy City Frederikshavn Home.” Energy City Frederikshavn.  


“The ForskEL Project.” EnergiNet.dk.

“Frederikshavn.” Offshore Center Danmark.

“Frederikshavn II.” Offshore Center Danmark.


“Frederikshavn Municipality.” Climate Action Map.


“Generation.” DONG Energy.


Simpson, Scott. “Site C Hydroelectric Dam gets go-ahead from Province,” The Vancouver Sun, April 19, 2009.  

“Smarting from the Wind.” The Economist Technology Quarterly. 6-12 March 2010.


“Walking the Talk.” City of Vancouver.  


“Wind.” DONG Energy.  

