RENEWABLE ENERGY MOBILITY

ADVANCING MUNICIPAL ENERGY PLANNING – A CASE STUDY OF THE SOLAR PHOTOVOLTAIC ELECTRIC VEHICLE CHARGING STATION STRUCTURE AT YORK UNIVERSITY, TORONTO

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August 7th, 2015

Report of a Major Project submitted to the Faculty of Environmental Studies in partial fulfillment of the requirements for the degree of Master in Environmental Studies

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Acknowledgements

This project is a product of invaluable efforts and dedication that started with Dr. Jose Etcheverry and many other individuals without whom it would not have been possible.

I would like to take this opportunity to mention my advisor and supervisor, Dr. Jose Etcheverry whose continued support traces long before my admission to the MES program and continued throughout this journey. His guidance and patience has encouraged me to not only succeed academically, but also become a better human being.

My sincerest appreciation goes out to Henry Reinelt and Archie Haslauer from Kinetic Solar. This project would not have come to fruition were it not for your commitment and support. It has been a wonderful learning experience working at Kinetic Solar where both Henry and Archie have taught me industry skills that helped in developing this project.

Thank you to Joshua Abush for your utmost inspiring and much needed foresight. I applaud your insightfulness from the conception to the completion of this project. Your ability to offer industry expertise while maintaining theoretical integrity has taught me invaluable lessons.

This project would not have been made possible were it not for the many individuals at the CSBO, York University. Thank you to Nicole Arsenault, Helen Psathas, Richard Franki, Sean Thibeault, Amy Poon, Gary Gaso, and Brad Cochrane for your collaboration and expertise. A special thanks is owed to Ron Ogata who has been instrumental at the early development stage of this project.

To all my colleagues at the Sustainable Energy Initiative, thank you for your commitment and encouragement. I am deeply humbled and grateful to have shared this journey with you. I would like to recognize Bastian, Shreyas, and Kathy for their input, proofreading, and undivided encouragement of this project.

Finally, most of the acknowledgement is owed to my loving and caring family for their unrelenting support, particularly my father and mother, who have supported my decision to further my education with a Master’s degree. Thank you for allowing me to pursue my dreams.

Abstract

As the urban population soars to 86 per cent in Ontario, municipalities will face increased pressure to plan for energy as it is intrinsically linked to the urban infrastructure. The widespread deployment of renewable energy is severely limited by the provincial governments in Canada. This project report starts by discussing the role of municipalities in energy planning in Ontario. The report will mainly focus on my experiences on designing and implementing a modular solar photovoltaic (PV) charging station structure for electric vehicles at Keele Campus, York University. Mainly, this report outlines the steps involved in developing a 6.84 kW solar PV structure with local industry partners. It covers the design criteria established to maintain key aspect and goals of the Renewable Energy Mobility (REM) project. The report ends with discussions and concluding remarks regarding the development, design, installation, policy and energy structure implications of the REM project.

Foreword

I started the Master of Environmental Studies program at York University's Faculty of Environmental Studies with the intent to study renewable energy and urban planning. In particular, I wanted to analyze where planning and energy intersect in order to enhance my understanding of renewable energy deployment with regard to municipalities. Throughout the first year of the MES program I considered how to approach and/or develop a Plan of Study that uses a project to illustrate the presence or lack of renewable energy in municipal planning.

In my Area of concentration, "Analyzing Municipal Planning for Renewable Energy" I aimed to study municipal energy planning and its potential role in the implementation of renewable energy. At first, I intended to focus on researching Ontario municipalities that have successfully deployed renewable energy. It became apparent that researching municipalities that have incorporated and deployed renewable energy projects would not satisfy my Learning Objectives, specifically in relation to Energy and Planning. I then sought to be involved in a renewable energy project that municipalities or local communities initiated. While I would prefer to have been part of a real life renewable energy project that a municipality initiated in Ontario, it was not feasible to pursue that direction. After my planning internship at Hochschule für Technik (HFT) Stuttgart, Germany, I realized the benefits of 'learning from doing' as the local municipality of Ludwigsburg partnered with HFT to perform preliminary energy studies on developing an integrated energy concept for the urban core. This was an important point in my studies where I knew that I had to be part of a project to comprehensively understand the opportunities and limitations of local communities and municipalities with regards to energy planning.

As I intended to engage in a thorough understanding of energy and planning in Ontario with a specific project, an opportunity arose where York University was awarded funding to develop solutions for the advancements of renewable energy in the charging phase of electric vehicles. As such, this report presents the findings of the Renewable Energy Mobility (REM) project and also connects it to the broader municipal implications of energy and planning.

Mainly, this project report outlines my findings in developing a solar photovoltaic (PV) electric vehicle charging station structure at York University. The establishment of design criteria and principles in the development of the REM project ensures that while this project serves to further the development of renewable energy generation and electric vehicle infrastructure, it also achieved a viable product for the local industry partner.

Filled with challenges and opportunities, my experience with this project has been full of enlightenment. I hope that future students see the value in experiential education by learning from doing. This project and the MES program have helped me realize the enormous significance of energy planning for municipalities. Further, I have learned that there is a need for municipalities to play a leading role in energy planning in order to develop sustainably while tackling climate change. As municipalities play a key role in our energy future, it is my intent with this project report to illustrate some key lessons and challenges that can help advance renewable energy within planning.

This report is a culmination of my research and experiences where I connect all components of my Plan of Study. In the past three years, I have explored planning and energy. Exploring successful renewable energy strategies at the local and regional level while being at the Folkecentre, Denmark, developing a sustainable energy concept for the urban core in Ludwigsburg, Germany, and developing the first solar EV charging station structure at York University with Kinetic Solar have equipped me with the know-how to understand the intersection of energy and planning

Contents

Acronyms

AC	Alternating Current
AMO	Association of Municipalities Ontario
BCIT	British Columbia Institute of Technology
CEP	Community Energy Plan
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
CSBO	Campus Services and Business Operations
CUB	Central Utilities Building
DC	Direct Current
DE	District Heating
DG	Distributed Generation
EVs	Electric Vehicles
FIT	Feed-in Tariff
GEGEA	Green Energy and Economy Act
GHG	Greenhouse Gas
HSS	Hollow Structural Sections
ICE	Internal Combustion Engine
IESO	Independent Electricity System Operator
km	Kilometers
kV	Kilovolt
kWh	Kilowatt Hours
MEP	Municipal Energy Plan
MOL	Ministry of Labour
MW	Megawatt
OEB	Ontario Energy Board
OPA	Ontario Power Authority
PV	Photovoltaic
REM	Renewable Energy Mobility
RFP	Request for Proposal
SEI	Sustainable Energy Initiative
TAF	Toronto Atmospheric Fund
V	Volts
WHO	World Health Organization

1.0 Introduction

This project report details the development, methodology, design, and building of a 6.84 kW solar charging station structure for electric vehicles at the Keele Campus of York University. This is a Renewable Energy Mobility (REM) project that was predominantly funded by Metcalf Foundation, Toronto Atmospheric Fund (TAF), and Mitacs Accelerate Scholarship. The initial development of the project was made in March 2014. Upon Mitacs' grant and design concept approvals, the project was submitted for engineering approval and an initial installation of March 2015 was planned. It was expected to be fully operational before the end of the winter term, 2015. However, due to York University's labour disputes, the installation time was pushed back to July 2015.

This report also includes a major component on planning and energy. This component will present specific planning tools and areas that can accommodate for local deployment of renewable energy. This section will present some of the key aspects of planning and energy at the municipal level. The main focus of the report will centre on the development, design, and installation of the REM project. Further, this report will outline and discuss lessons learned from the project and will make recommendations to further the development of solutions towards renewable energy generation aimed at electric vehicles and energy planning in Ontario municipalities.

In 2015, Ontario adopted a cap and trade system to limit greenhouse gas (GHG) emissions and reward companies that aim to lower their emissions.[1] Ontario follows Quebec and California to adopt a cap and trade system to tackle climate change. It is imperative for the cap and trade system to address emissions from transportation and buildings. Since Ontario has phased out coal generation as of April 2014 from electricity generation, the transportation sector remains as the largest contributor of the GHG emissions. Figure 1 illustrates Ontario's emissions of 167 Mt by sector as of 2012.

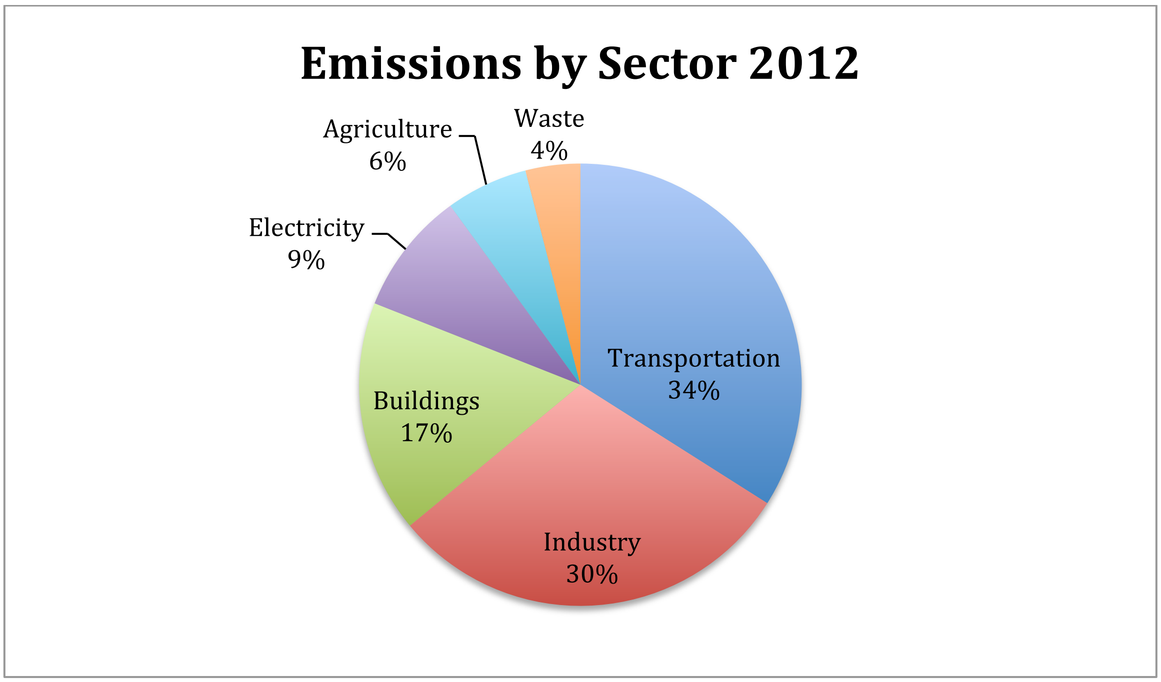

Figure 1: Ontario emissions by sector. Source: Ontario Climate Change Update 2014

Ontario transportation emissions have grown by 24 per cent since 1990 levels (Ministry of the Environment and Climate Change, 2014).

[1] "A cap and trade program effectively reduces the amount of greenhouse gas pollution going into our atmosphere by setting a limit on emissions, rewarding innovative companies, providing certainty for industries, and creating more The "cap" sets a maximum limit on the amount of greenhouse gas pollution industry can produce. Over time, the cap is lowered, reducing greenhouse gas pollution.
The "trade" creates a market for pollution credits where industries that do not use all their credits can sell or trade with those that are over." (Government of Ontario, 2015)

1.1 Background

Electric vehicles (EVs) provide one of the best platforms to transition to clean sources of energy consumption. Historically, internal combustion engines (ICEs) have dominated our infrastructure planning. The advent of ICEs has shaped cities and, inadvertently, cities have impacted the social, economic, and environmental well-being of its inhabitants. This phenomenon has been more prevalent in North America and Canada in particular where freeways connect cities coast to coast as they cut across urban cores. With the wide adoption of the ICEs, the demand for the infrastructure to support the ICEs has grown. This has created a volatile economic market for the finite fossil-fuel industry. Furthermore, the transportation and energy sectors combined for the 39 per cent of global GHG emissions in 2004 (United States Environmental Protection Agency, 2013). The burning of fossil fuels is the leading cause of human induced climate change according to an overwhelming sea of scientific research. Since the beginning of the Industrial Revolution, human activities have resulted in an increase of atmospheric carbon dioxide (CO_2) unprecedented in the last thousands of years (NASA, 2015). Figure 2 illustrates the CO_2 concentrations in the past 650,000 years.

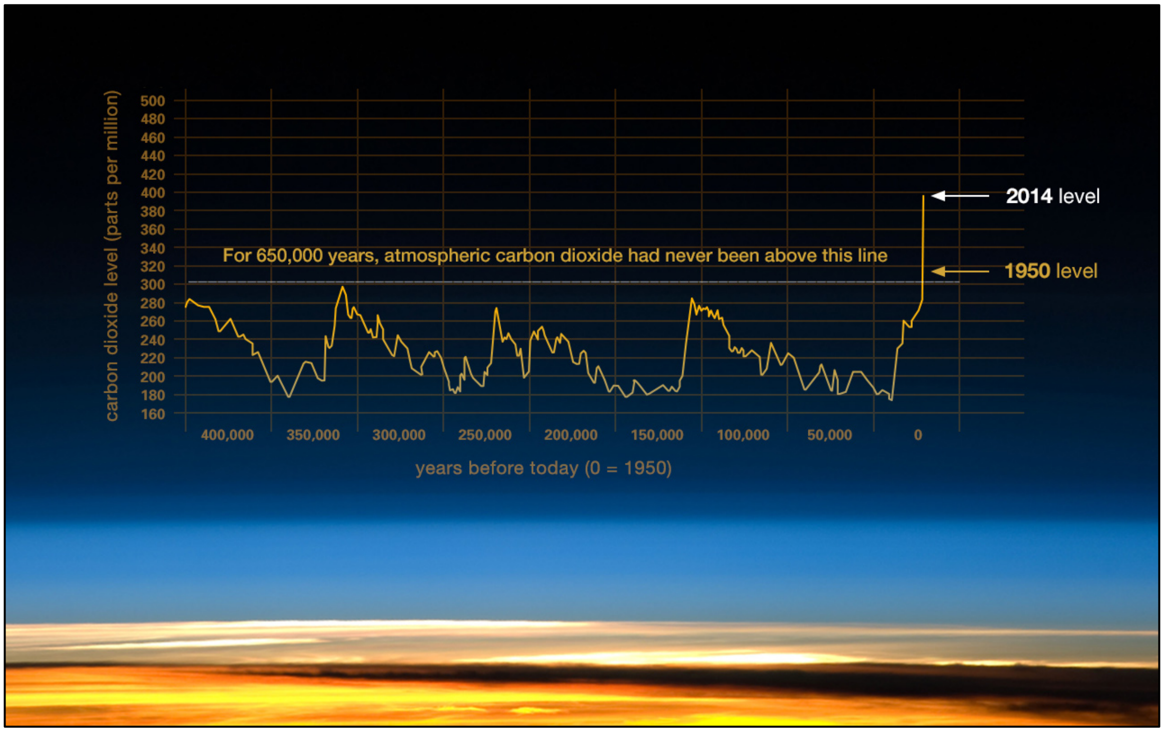

Figure 2: Atmospheric CO_2 increase since the industrial revolution. Source: NASA

Locally, in one of its most comprehensive efforts, Ontario has phased-out coal as of 2014. By eliminating coal from electricity generation, Ontario has reduced its annual CO_2 emissions by 30 megatonnes (Ministry of Energy, 2014). Also, Ontario implemented the *Green Energy and Economy Act* in May 2009, which was modelled mainly after the German FIT program.[2] By 2014, Ontario became the first province or state in North America to fully phase-out coal from its electricity production. This resulted in one of largest GHG reductions in North America. Further, the current premier Kathleen Wynne has introduced legislation that will permanently ban the use of coal for electricity generation in Ontario.[3] While coal has been eliminated from Ontario's electricity

[2] Passed on May 14, 2009, *the Green Energy Act* aimed to stimulate the green energy sector in Ontario by enabling amendments to 15 other statutes.

[3] Ending Coal for Clean Air Act was introduced in 2013 to ensure the public health and climate change benefits of eliminating coal use for electricity generation in Ontario would be protected by legislation.

generation, the central electricity grid remains dominated by nuclear, natural gas, and oil sources that account for 67 per cent of the total installed capacity.[4] Figure 3 illustrates Ontario's installed electricity generation capacity.

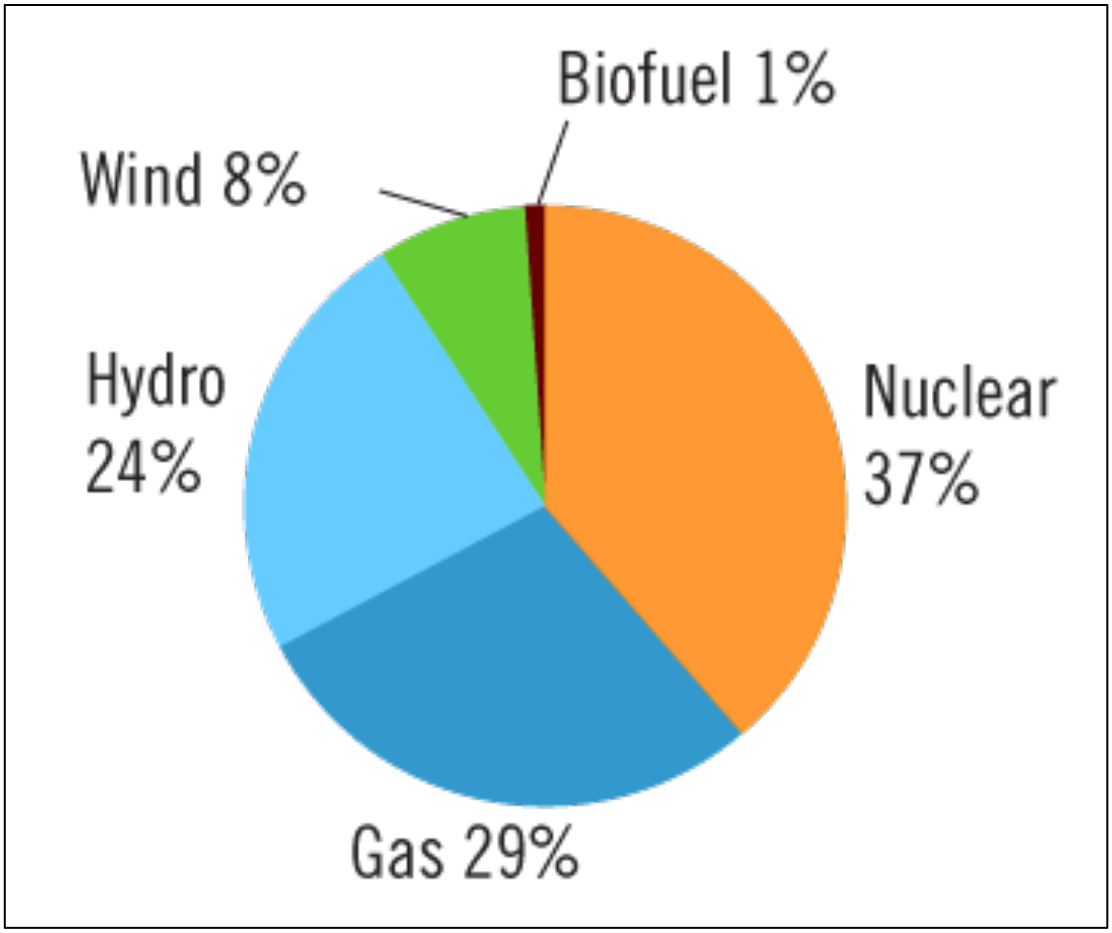

Figure 3: Ontario's installed capacity by fuel type as of June 22, 2015. Source: IESO

The REM project aims to tackle the aforementioned sectors by providing renewable sources of electricity generation. Because EVs receive their electricity needs from renewable energy sources, they eliminate emissions that otherwise would have been generated at oil and gas power plants that feed the central grid.

[4] In Ontario, Nuclear generation capacity as of June 22, 2015 is at 12,978 MW (39 per cent) and Gas/Oil generation capacity is at 9,920 MW (29 per cent) respectively (IESO, 2015).

1.2 Objectives

The main objective of the REM project is to facilitate renewable energy and, more specifically, solar energy use in the charging phase of EVs. Other objectives include charging infrastructure and illustrating the need for a greater role for energy planning in municipalities. Currently, EVs are charged mainly at home. One of the main problems associated with EV adoption is range anxiety.[5] This project aims to tackle that issue by providing a solution that can provide charging while at work, school, or shopping. The REM project illustrates that EV infrastructure can be incorporated to existing buildings and parking infrastructure with minimal disruption. Also, the REM project's overarching objective is to illustrate that energy planning, when added to the planning platform of municipalities and local communities, can positively impact all fabrics of the community. This is demonstrated through a rich number of cases in Ontario.

1.3 Relevance

The benefits of EV adoption versus ICE vehicles are numerous. In Canada, ICE vehicles are the primary source of urban air pollution in addition to GHGs (Health Canada, 2013). Some of the pollutants caused by the burning of the fossil fuels include particulate matter, nitrogen oxides, volatile organic compounds, benzene, metals, and sulphur dioxide, which contribute to the creation of smog. These complex mixtures of substances are

[5] Range anxiety is the fear of completely depleting the battery in an EV in the middle of a trip, which leaves the driver stranded (Neubauer & Wood, 2014).

known as hydrocarbons, which contain additional chemicals that are known as fuel additives (Health Canada, 2013). Globally, air quality in most cities fails to meet the World Health Organization (WHO) guidelines for safe levels, which puts urban populations at risk of developing respiratory diseases and other health problems (WHO, 2015).

Countries, cities, regions, communities, and businesses are currently planning independence from fossil fuel energy. Shifting to 100 per cent renewable energy is not a far distant fantasy, rather it is a near reality. Countries, cities, and regions are setting 100 per cent renewable energy targets. Denmark, a world leader in wind energy, aims to have all of its energy derived from renewable energy by 2050 (Danish Ministry of Climate, Energy and Building, 2011). In North America, prominent cities such as San Diego and San Francisco have targets to be completely powered by renewable energy by 2035 and 2020, respectively (City of San Diego, 2015) (San Francisco Department of Environment, 2012). Similarly, The City of Sydney with a population of over 4.5 million aims to get 100 per cent of its electricity, and heating and cooling from renewable energy by 2030. The establishment of the renewable energy master plan has specific targets and outlines how this target can be accomplished (City of Sydney, 2014).

Vancouver is the first Canadian city to have set a target of 100 per cent renewable energy by 2050. The city's target includes electricity, heating and cooling, and transportation (City of Vancouver, 2015). Vancouver has made a bold statement as the city aims to include transportation within their plan. Oxford County is the first municipality in Ontario to follow Vancouver's lead to commit to 100 per cent renewable energy by 2050

(Oxford County, 2015). The shift from ICEs to EV helps transition to a 100 per cent renewable energy scenario where transportation is included. In order for that to be entirely true, the fuel used to make electricity must be from a renewable energy source. Most of the electricity grids in the world are dominated by fossil fuels. In 2012, of the 21500 billion kWh of total electricity generation in the world, 14500 billion kWh were fossil fuels, which accounts for 67.4 per cent.[6] The York University REM project aims at illustrating that renewable energy can provide the electrical needs of EVs while cities and regions transition to 100 per cent renewable energy grids.

1.4 Purpose

The purpose of this project report is to illustrate how local solutions and deployment of renewable energy not only can be accomplished but also applied in variety of scenarios. This report presents a specific case where different stakeholders including government, fronting agencies, and private industry partnered to arrive at a solution that helps transition towards a sustainable future.[7] More specifically, the REM project showcases an environmentally sound solution that can be achieved in a very competitive market. Further, it serves as a stepping-stone for Canada's third largest University, York University, to integrate renewable energy in its operation, education, development,

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[6] Total Global Electricity Net Generation (billion kilowatthours) for the year 2012 was 21,531.709 billion kWh. Fossil fuels total global electricity net generation was 14, 497.706 billion kWh where as total non-hydroelectric renewables accounted only for 1,068.763 billion kWh, which accounts for 5 per cent. (EIA, 2015)

[7] Sustainable in this case refers to "*development that meets the needs of the present without comprising the ability of future generations to meet their own needs*" (United Nations, 1987).

research and promotion. Finally, this report aims to illustrate some of the key lessons from the challenges when incorporating renewable energy projects with the existing urban infrastructure.

1.5 Project Funding

The REM project was completed thanks to three main sources of funding, which were the Toronto Atmospheric Fund (TAF), Metcalf Foundation, and Mitacs Accelerate Scholarship. Established in 1991 by the City of Toronto, the TAF aims to reduce local GHG and air pollution emissions through investments in urban solutions. As a testament to their mission, TAF is aiming to reduce Toronto's GHG emissions by 80 per cent in 2050 (TAF, 2015). In 2011, TAF awarded York University a grant for "Research on Renewable Energy Charge Stations for Electric Vehicle".[8]

The next major funder partner of the REM project is Metcalf Foundation, which provided Dr. Jose Etcheverry with financial support to "craft an electric vehicle strategy that is accessible, affordable and that uses local renewable energy resources to offset the electrical demands of electric vehicles, and to develop policy suggestions for municipalities, transportation agencies, other universities, and Ontario provincial government agencies wishing to expand renewable energy powered personal

[8] The Toronto Atmospheric Fund (TAF) awarded $30,000 to York University in 2011 to "Research on Renewable Energy Charge Stations for Electric Vehicle: Analysis of practical data on the environmental and business case for building and operating standardized renewable energy charging stations to complement electric vehicles in Toronto" (TAF, 2015).

transportation".[9] Metcalf Foundation (also known as The George Cedric Metcalf Charitable Foundation) was established in 1960 to assist people and organizations that work together in order to build a healthy, creative, and just society. One of its major goals is to help electrify the transportation sector that accounts for the largest sources of GHG emissions in Ontario (Metcalf Foundation, 2015).

Lastly, I was the recipient of the Mitacs Accelerate internship scholarship to design a solar EV structure with Kinetic Solar, a private sector manufacturing partner, and York University. Mitacs, a non-profit national organization, provides research and training programs in Canada. Over 60 universities, thousands of companies, and both federal and provincial governments have partnered with Mitacs in the past 15 years to support industrial and social innovation in Canada.[10] Mitacs matched the funding received from Kinetic Solar for a period of four months that ended in March 15, 2015.

2.0 Planning and Energy

Cities and towns provide the essential municipal services that rely on energy to function. Since over 50 per cent of the world's population now lives in urban environments, municipalities face greater challenges to sustainably provide their essential services (WHO, 2015). Over 80 per cent of the population in Canada lives in urban areas. Hence,

[9] Metcalf Foundation awarded $29,000 through its "Green Prosperity Challenge" stream and "Environment" program to York University's Dr. Jose Etcheverry (Metcalf Foundation, 2015).
[10] Used by over 50 Universities, the Mitacs Accelerate scholarship allows students to apply their academic skills towards business-related research challenges (Mitacs, 2015).

energy should be at the core of urban planning. Mostly, Ontario municipalities are local governments under a provincial and/or federal jurisdiction that have the opportunity to not only influence the energy choices of their inhabitants and operations, but also help shape their built environment in a sustainable manner.[11] According to the Association of Municipalities Ontario (AMO), municipal governments in Ontario are responsible for the following services:

- Airports
- Ambulance
- Animal Control and By-law Enforcement
- Arts and Culture
- Child Care
- Economic Development
- Fire Services
- Garbage Collection and Recycling
- Electric Utilities
- Library Services
- Long Term Care and Senior Housing
- Maintenance of Local Road Network
- Parks and Recreation
- Public Transit
- Planning New Community Developments and Enhancing Existing Neighbourhoods
- Police Services
- Property Assessment
- Provincial Offences Administration
- Public Health
- Side Walks
- Snow Removal
- Social Services
- Social Housing
- Storm Sewers
- Tax Collection
- Water and Sewage

[11] There are 444 municipalities in Ontario, which are categorized in Regions, Counties, Districts, and Single-Tiers. A local municipality may be called a city, a town, a township, or a village (AMO, 2013).

Municipalities spend billions each year to ensure that these services are provided to the public (AMO, 2013). While electric utilities are listed under the municipal services, it essentially is the local electricity distributors who are responsible for providing electricity from the transmission lines to the end users. Since most municipal services require energy, it is crucial for municipalities to be able to determine and/or control their energy source. Furthermore, the presence of an efficient local energy-planning platform helps municipalities to achieve at least a 10 per cent reduction on energy demand (Brandoni & Polonara, 2012). Others have indicated an inclusive urban planning process wherein the key focus rests on the integration of solar energy. That focus on our energy can be integrated in the urban design component of planning to improve energy supply and efficiency within existing areas and in new developments (Amadoa & Poggi, 2014).

Currently, most Ontario municipalities are focused in improving energy efficiency and conservation measures. These measures are necessary to reduce the energy demand while managing growth. However, it is also important to tackle the source of energy. A small number of municipalities have developed policies and projects to utilize local sources of renewable energy (International Renewable Agency, 2009). Successful renewable energy policies that have resulted in significant deployment of local renewable energy sources can be adopted. The size and type of renewable energy source and project will have to be based on the resources available in the locality of the municipalities.

Projects such as REM are geared to help municipalities, communities, institutions, and small businesses understand and implement similar projects to reap the benefits of energy security and environmental protection. More specific to the REM project, municipalities can develop ‘Municipal electric vehicle charging infrastructure plans’ and introduce EVs in public authorities with dedicated parking spaces for EVs. While there are no federal incentives towards EVs, several Canadian provinces offer incentive for purchasing EVs.[12] Municipalities, however, should also provide local plans and incentives to help shift from ICEs to EVs (Sperling, Hvelplund, & Mathiesen, 2011).

2.1 Background

The provincial government primarily governs energy planning in Canada. The federal government is responsible for interprovincial energy focus and international management. The provincial governments are responsible for the exploration, development, conservation, and management of non-renewable energy sources (NRCan, 2015). Historically, the provinces have had a centralized electricity generation and planning system. This also holds true for Ontario where ministries, public agencies, and private companies have been adapting to support that specific system. The Ministry of Energy establishes the energy policy in Ontario through the Long Term Energy Plan. While it is referred to as “The Plan,” it is a policy document that considers all components of the province’s electricity system, which includes generation, transmission, distribution, and technologies (Ontario Ministry of Energy, 2015). The Ontario Power Authority (OPA) was established in 2004 as an independent, non-profit corporation that reports to the province’s legislature through the Ministry of Energy (Canadian Urban

[12] Provincial incentives are offered in British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, and Prince Edward Island.

Institute, 2013). The OPA is responsible for planning the electricity system, contracting generation resources, and coordinating wide range of electricity conservation efforts (Canadian Urban Institute, 2013). The Independent Electricity System Operator (IESO) is also a not-for-profit corporate entity that was established in 1998 by the *Electricity Act of Ontario* (Ontario Government, 2015). The Ontario Energy Board (OEB) determines and sets the IESO's licenses and fees to operate (IESO, 2015). In 2009, when the Green Energy and Economy Act (GEGEA) came into effect, Ontario municipalities lost power to influence the outcome of renewable energy projects when a section was added to the Ontario Planning Act. At first this may have appeared counter-intuitive to the establishment of of the GEGEA. But this was strategically planned so that municipalities that opposed green energy generation projects consistent with good planning could not refuse the application. This mainly stemmed from the fact that the local public opinion towards renewable energy projects act as a stumbling block in the local neighborhoods. As a result, municipalities in Ontario receive bonus priority points for applying to the Feed-in Tariff (FIT) programs (IESO, 2015). However, the public forum where opposition, support, and alteration to a renewable energy project has been stripped from the municipality, by the province. A look back in the history of energy policy in Ontario shows that most, if not all, decisions were made at the provincial level. This focalize decision-making focus has resulted in the establishment of the centralized energy generation plants that today characterize Ontario's electricity sector.

2.2 Importance of Municipal Energy Planning

2.2.1 Challenges and Opportunities

Municipalities are the government levels that are closest to the citizens. Consequently, climate change introduces severe energy-related stresses. Cities and towns must be the central hubs of sustainability practices. The sustainability of a city is defined as "local, informed, participatory, balance-seeking process, operating within a budget, exporting no harmful imbalances beyond the territory or into the future, thus opening the spaces of future opportunity and possibility" (The Vienna Institue of Urban Sustainability, 2015). Municipal energy planning is key in this matter as in cities the use of renewable energy resources to provide energy services must be integrated into the local built environment. However, the incorporation of energy within a municipal planning platform has many challenges including existing urban infrastructure, fossil fuel dependency, limited practicing power, and public opinion and education. In Ontario, population projections for the next 28 years are at 31.3 per cent, which translates to an additional 4.2 million people (Ontario Ministry of Finance, 2015). Since over 86 per cent of the current population lives in urban areas (Statistics Canada, 2011), municipalities in Ontario have a responsibility to ensure that energy planning is a strong component of the long-term sustainability and is included within the planning platform.

Some of the areas where municipalities have the opportunity to implement renewable energy policies include land use zoning, property development, transportation systems, and tax mechanisms (Columbia Institute , 2013). These areas provide a great opportunity for municipalities to mandate a specific renewable energy source that is accessible. Many

Canadian municipalities have been pioneers in these areas by planning and developing district heating systems, deploying renewable energy sources, energy efficiency, and conservation as part of their Community Energy Plan (CEP). Moreover, the Ontario Ministry of Energy offers financial support for municipalities that want to develop a Municipal Energy Plan (MEP) as of 2013. It is worth mentioning that MEP and CEP are terms used interchangeably by municipalities to describe local energy plans. Either term should include community energy planning because that focus helps municipalities understand better their energy needs by identifying opportunities for energy efficiency, conservation, and clean energy. The MEP program provides 50 per cent of the costs (with a maximum of $90,000) to develop a MEP (Ontario Ministry of Energy, 2015). The City of Guelph developed its CEP in 2007 as a 25-year plan that will place the city at the forefront of North America (City of Guelph, 2014). Similarly, The City of Toronto, The Town of East Gwillimbury, The City of Pickering, The City of Burlington, and The Town of Woodstock are some of the prominent municipalities that have developed extensive CEPs. Others such as The City of Markham and The Town of Newmarket are in the process of establishing their respective CEPs.

While the above-mentioned municipalities are developing, or have developed CEPs, others are hesitant to develop and implement comprehensive energy plans. A better understanding of the state of the CEP in Canada is needed (Rizi, 2011). More importantly, there is a lack of support from higher levels of government in terms of funding, resources, and policies related to the CEP (Rizi, 2011). Other barriers affecting implementation of the CEPs are unclear jurisdiction, high cost, limited capacity and scarce experience, and the challenges of creating behavior change (Tozer, 2012).

The provincial governments define, plan, and implement energy policies in Canada. With adequate resources and financial support from upper tier governments, municipalities can manage to mitigate all of the impacts of climate change and develop resilient and sustainable energy systems. This may also help alleviate some of the barriers that municipalities face in implementing their CEPs. Energy efficiency and conservation are the ‘low hanging fruit’ in the success of the CEPs. However, CEPs are having difficulty in the energy generation component specifically where renewable energy is the target (Tozer, 2012).

2.2.2 Pilot Projects

Municipalities are better positioned to initiate pilot projects where renewable energy is the central element. Although local governments aim towards the low hanging fruits in terms of GHG reduction and energy efficiency measures, pilot projects provide an illustration where implementation challenges and lessons can be learned by pursuing renewable energy resources (Krause, 2011). Municipalities and local governments should start with renewable energy projects for municipal facilities (Pitt & Bassett, 2013). In 2013, The Ministry of Energy in Ontario announced changes that encourage renewable energy projects. A dedicated municipal allocation for MicroFIT and FIT program was announced where municipalities are eligible to receive priority. It also included a pilot project for rooftop solar PV projects under the small FIT, which is intended to promote buildings to be designed ready for rooftop solar installations (AMO, 2013). Similarly, the REM is a pilot project that aims to enhance research and development of renewable energy generation and implementation at York University's Keele Campus, which can be compared to a municipal facility.

2.3 Distributed Energy Generation

Distributed generation (DG) refers to energy generation that is close to the energy consumers. In other words, energy is generated on-site, often in small scales, rather than a central generation facility (Alanne & Saari, 2006). Historically DG has not been from renewable sources, however solar energy has become a leading distributed energy generation option. Distributed renewable energy generation has positive social and economical benefits that have been largely understated. Benefits of DG include eliminating high costs, central generation complexity, avoiding energy losses due to transmission, and distribution. The table below shows typical DG and Centralized average sizes.

Region	Decentralized	Centralized
Country	<2 MW	>1000 MW
Territory	<250 kW	>100 MW
Municipality/City/Town	<100 kW	>2 MW
Village/Group of houses	<25 kW	>100 kW
Residential building	1–5 kW	>25 kW

Table 1: Average size of DG vs. Centralized generation plants by different regions (Alanne & Saari, 2006).

Local citizens that are informed of their energy consumption and generation can play a vital role in a healthy, sustainable, and prosperous community. Renewable energy has the potential to be a key solution for distributed generation. Municipal and local authorities can successfully accomplish this by mandating renewable energy within their planning platforms such as zoning by laws, incentives, official plans, and secondary plans. In order to promote distributed renewable energy generation some of the more serious impediments must be addressed. First, municipal governments should conceptualize, develop and enforce plans that promote distributed renewable energy generation within their planning platform. CEPs have been successful in conservation and energy efficiency but have failed to deploy a significant amount of renewable generation (Rizi, 2012). As a result, CEPs have also failed to deploy DG. Municipalities should enforce local renewable energy generation requirements not only on new developments but also on existing facilities. Second, this increased role in local government's involvement to promote and manage distributed renewable energy resources will shift centralized energy generation from broader governments such as provinces and countries to local governments and communities. Lastly, DG offers local governments with lower footprint, as less land is required for generation, transmission, and distribution of energy.

2.4 (Smart) Microgrids

The innovation of microgrids holds the most promising piece in the integration of renewable and distributed energy generation. In short, a microgrid is a local energy grid that has the control capability to be disconnected from the traditional/central grid and operate autonomously (Department of Energy, 2014). What distinguishes the central grids from microgrids is their ability to break off and operate from the central grid in emergency cases such as storms and power outages. Microgrids also have the capacity to easily integrate battery storage, combined heat and power (CHP) plants and renewable energy sources, such as wind, solar, and geothermal to create a reliable local energy solution.

Currently, national and provincial central grids are transitioning towards "Smart Grid" systems. A smart grid refers to the type of grid that has the capability to use the 21st century two-way communication systems and computer processers. Smart grids use digital information from end users and generation sources to manage supply and demand more efficiently (Department of Energy, 2015). Furthermore, smart grids are designed to allow bi-directional energy flow with the addition of advanced electronics. As a result, many states and provinces in North America are developing smart grid policies to make the shift (Natural Resources Canada, 2014).

While the benefits of smart central grids are numerous and the transition is merited, there is an important place for the adoption of microgrids. Microgrids vary in size and scope that range from a few buildings to citywide and provide demand reliability and load enhancements measures where greater use of renewable energy can be incorporated (Lasseter, 2011). In an ever-changing urban environment, microgrids provide the best platform for the decentralization of energy systems. Further, local governments and communities that develop microgrids build a strong and resilient system that makes them independent from regional and global fluctuations of energy. More importantly, microgrids have local appropriate renewable energy resources that are environmentally and socially benign with benefits that transcend to the community, beyond the investors (Palavicino, Echeverría, Estévez, Reyes, & Behnke, 2011).

In 2007 BC Hydro and The British Columbia Institute of Technology (BCIT) installed Canada's first Smart Microgrid at BCIT's Burnaby campus. It is comprised of power plants, loads, command and control, and communication systems (BCIT, 2015). The Microgrid project at BCIT incorporates a solar component that includes a 250 kW solar parking canopy structure with a 500 kWh lithium-ion battery storage system, which enables fast charging stations for EVs. The energy stored is used for two level 3 EV chargers and two level 2 EV chargers. Smart meters and power analyzers for data measurement ensure the process of gathering and analyzing the data from the solar PV and storage system (BCIT, 2015). The benefits of microgrids with PV and EVs have been researched extensively. A case study by van der Kam and van Sark (2015) found that the benefits of smart charging in a microgrid include lowest impact on battery life, balanced demand and supply, and halves the largest peak in demand.

3.0 Renewable Energy Mobility (REM) project

This component of the report focuses on the development and installation of a new grid-connected solar PV charging station for EVs in York University. The REM structure will enable EV solutions in one of Canada's largest university campuses. The project focuses on gathering performance and demand data to help the university craft a broader EV strategy that is accessible, affordable and that uses local renewable energy resources to offset the electrical demands. The data gathered by the REM project will be synthetized and shared to help inform new policy solutions for municipalities, transportation agencies, and the Ontario and Federal governments.

3.1 The Role of Academia and Industry

In the past, academic knowledge and research have often been conducted in isolation within the confines of academic institutions. The movement towards a more open knowledge utilization system where academic research and innovation are connected with industry to achieve social benefits is gaining salience. A partnership between academia and industry can result in value added for society as a whole (Vie, 2012). With this in mind, many governments have promoted research collaborations between academic institutions and industries (Sohn & Lee, 2011). This approach is in use in Ontario where many ad hoc programs are in place. One of the programs that were successfully utilized in the REM project was the Mitacs Accelerate program. Supported by the provinces and the federal government, Mitacs spends 80 per cent of its annual budget on student awards and training (Mitacs, 2015). I was fortunate to be accepted for this project where my academic and technical skills were combined with the expertise of industry leaders to develop solutions aimed at developing a reduction in GHG emissions and air pollution.

3.2 Methodology

The REM project followed a set process that was initially stated in the conception of the project with Dr. Jose Etcheverry and I. The following methodology was conceptualized after funding from TAF, Metcalf foundation, and Mitacs Accelerate was approved.

Phase 1: Preliminary Project Analysis

Phase 2: Project Design

Phase 3: Manufacturing, Installation, and Commissioning

3.3 Preliminary Project Analysis

3.3.1 Industry partner

Determining the industry partner is an important process of any successful project. This was not an exception in the REM project. It is vital to have an industry partner that can understand and comprehend the problem and work from preliminary project analysis to conception of the design, and to develop and manufacture the product. Kinetic Solar, as one of the leading solar racking companies, was selected as a design partner as it showed a keen interest to develop solutions with solar energy generation at its core. Kinetic Solar Racking and Mounting is an Ontario-based company that has been manufacturing for the past 35 years. Known for their innovative design, quality of workmanship, and ease of installation, Kinetic Solar products have been an industry favorite for many years (Kinetic Solar Racking and Mounting, 2015). More importantly, Kinetic Solar has quick turnaround and a very experienced team that not only understands the challenges within the solar industry but also provides diverse and versatile solutions. Dr. Jose Etcheverry and I met with Henry Reinelt and Archie Haslauer, who are joint partners at Kinetic Solar, on March 5th, 2014 to discus the opportunity to partner with the faculty of Environmental Studies' Sustainable Energy Initiative (SEI) in order to develop and implement the REM project.

3.3.2 Site and Location Selection

As a pilot project and prototype product, it is imperative that the site and location selection is performed thoroughly. The site of the structure is determined by sun access, shading, and grid connection. A solar site assessment was performed using the Solmetric Suneye 210, which is a shade measurement tool which allows to obtain solar insolation data by day, month, and year for the selected site (Solmetric, 2015). The proposed site yields 94 per cent annual sun access. It is worth noting that sun access is at 98 per cent during summer months and 85 per cent during winter months. (Please refer to Appendix A for the full detailed solar access and shade report.)

The selection of the location and site came to fruition thanks to our partnership with the CSBO. Extensive collaboration with key CSBO staff ensured that the location and site determination was systematic. The location of the structure was determined by carefully analyzing publicly available parking lots at Keele Campus, York University. While most of the parking lots have gates and require passes each term, the Vanier parking lot (Appendix B) has public access with no gates. As a publicly funded project, the solar EV charging station structure needs to have public access. This is to ensure that limitations such as gated parking lots will not provide obstacle for EV drivers in need of chargers. Vanier parking lot is strategically located close to York Lanes shopping mall, Student Centre, and Ontario Archives building. Also, Vanier parking lot is less than five minutes walking distance from the proposed York University subway station that is scheduled to be operational by the end of 2017 (TTC, 2015)

3.3.3 Defining Key Design Criteria/Principle

When developing a new product or design solution, it is essential to define key criteria that will dictate the design process. The design criteria are a list of proposed benefits that the product must feature in order to satisfy the end result. More importantly, the design criteria help guide the designer to develop creative and alternative ways to arrive at a solution. The REM project's first phase was the development of design parameters where each criterion was given a priority and a starting point was established. With the conceptualization of every design, the key design criteria derived was evaluated to ensure that the product's performance goals were achieved. With this focus, the REM project ultimately achieved 10 of the design criteria that it initially set out.

The following is the list of the key design criteria/principles ranked with the highest priority first:

Criterion	Definition and Rationale
Modular	Modularity is a key component of this project. In this case, modularity is accomplished when products are prefabricated and assembled in a manner that can be fit together in a variety of ways and also expanded without redesigning the structure. In the project design process, modular design was established as a key tool to increase the product variants.
No Parking Spot Loss	Conventional solar carports require concrete foundation that results in new parking lines and excessive digging and excavation. In the case of the self-ballasted solar carports, the high volume of the ballast results in loss of parking spots. The REM project aims to maintaining existing parking infrastructure intact with no excavation and digging.
Universal	Designed specifically to withstand wind loads of up to 150 mph, which is greater than Category 3 Hurricanes, the REM project can accommodate any 60-cell solar PV panel. Also, it can be installed in most of the climates that have sufficient solar insolation.
Easy to Install	The installation process is a component of the REM project that aims at using no or minimal machinery. It is very important for the structure to have buildability and ease of installation when designing.
Durable	Durability of the REM project is a tricky yet mandatory criterion. In order to ensure durability of the product, specific material grade and type should be selected.
Affordable	Using standard steel members and simple engineering design, the goal of the REM project is to develop a product that is affordable globally.
Beautiful	This criterion can easily be overlooked when emphasis is mainly geared towards the process and end purpose. However, REM project maintained to develop an aesthetically pleasing structure.
Functional	Functionality component of the REM project refers to all components fitting well so that it serves the purpose.
Secure	This criterion was included to ensure that the structure can withstand an impact from a vehicle and also not be dissembled by vandals.
Integrated	This criterion refers to the ability of the structure to serve more than just electric vehicles with charging. It aims to provide a mobility hub where options such as energy storage, data monitoring and gathering, and other mobility vehicles and devices can be charged.

Table 2: Design criteria and principle ranked with the highest priority

3.3.4 Selecting Contractors

Joshua Four Limited is the construction company that was selected to install the structure at York University. Joshua Abush, a professional engineer that holds a Masters degree in Engineering, has been part of the REM project since its conceptualization. His expertise in engineering construction, installation, and 'buildability' has been invaluable to this project. Mr. Abush has collaborated with Kinetic Solar and the SEI from the very early stages of this project as he specializes in applied engineering and building.

Telstorm Corporation, a multi-disciplinary Canadian design and engineering firm, performed the engineering analysis component of this project. Previously, Telstorm had been hired to perform engineering analysis for Campus Services and Business Operations (CSBO) projects and was recommended by the engineering staff at CSBO. It was important to work with an engineering firm that was recognized by the University's staff to ensure confidence levels with the REM project remain high. Established in 2004 by Alex Fulop, Telstorm has conceptualized and developed solutions in many different sectors and industries (Telstorm, 2013). Their contribution to the REM project started from preliminary engineering load analysis to complete full-blown engineering load analysis that determined specific component sizes. Initially, we looked into the possibility of developing a self-ballasted structure that would require no foundational work. The self-ballasted volume and support compromised most of the design criteria and was thus deemed undesirable. Since the product that is being developed is designed for replication, it had to be designed with global distribution in mind. At that stage, I researched an alternative foundation solution to substitute for conventional concrete foundations. This led me to discover the innovative ground screw solution that is provided by Krinner.

Aduvo construction is a licensed installer of the Krinner ground screw, which was recommended by Tomas Johansson, Head of Business Development for Krinner in North America (Aduvo, 2015). Krinner ground screws can be installed by machinery if the application requires large support or manually drilled to the ground for smaller applications. The anchoring option of the structure with the ground screw system provides many benefits. First, ground screws eliminate the need for conventional concrete foundations. The time it takes to install and drill the ground screws is significantly shorter than those of concrete foundations. Also, ground screws are versatile in that they can be drilled in all soil conditions. Furthermore, ground screws have the ability to be removed and reused. This feature made it a very desirable attribute for the REM project.

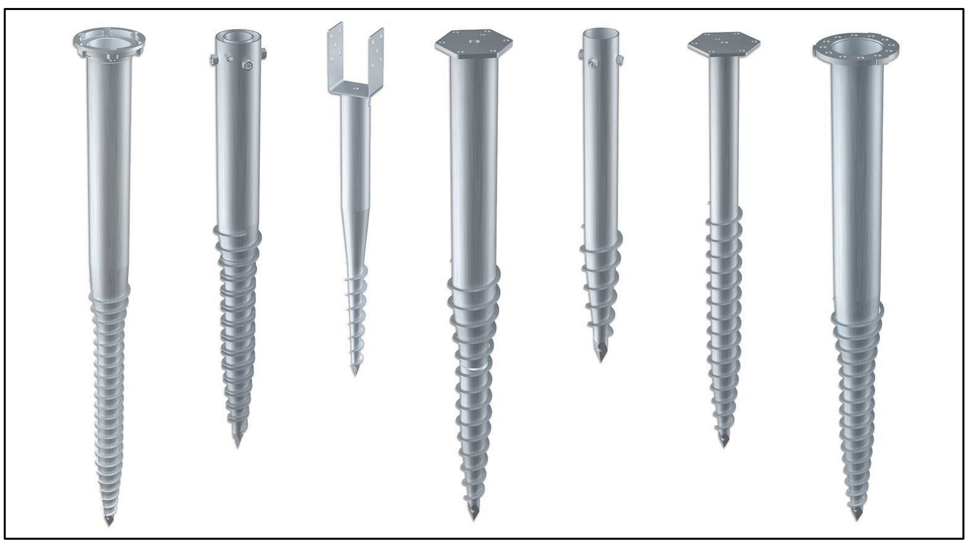

Figure 4: Ground screws design accommodates many connections. Source: Krinner

3.3.5 Preliminary Engineering Analysis

The main purpose of the preliminary engineering analysis is to start collecting more comprehensive information about the project. The initial assessment of the engineering component of the REM project was discussed with Ron Ogata from CSBO in order to have a better understanding of the engineering phase. A thorough explanation of the planning and rationale of the project was presented to Ron. It was in this phase of the project that the many design concepts were analyzed but only a few that met all our design criteria were seriously considered for preliminary engineering load analysis. When all the information pertaining to the project was analyzed and agreed upon, I derived a rough sketch of the design concept. The preliminary engineering load analysis progressed by submitting a rough sketch of the design concept with the design criteria in mind. The sketch was submitted to Alex Fulop for cursory review and the feedback was received from Alex on June 30, 2014. Appendix C shows the comments from Telstorm. Subsequently, a more detailed design sketch was submitted to Telstorm for preliminary engineering load analysis. Appendix D shows the preliminary engineering analysis with unfactored load for the structure.[13] The preliminary engineering loads provided a good reference point on how the structure would be affected by acting loads, which allowed further progression with the design concept. With the preliminary engineering loads concluded, I was able to develop and design the final structure that can incorporate all of our design criteria. On October 8th, 2014 a request for proposal (RFP) was submitted by Telstorm to provide structural engineering services for the solar PV structure at York

[13] Service loads are loads that the structure will be subject to and this is not factored with construction discrepancies, tolerances, additional weight, and uneven distribution of load. When these items are factored to the load, it is considered a factored load. This is also referred to as "Safety factor".

University, Keele Campus. Appendix E illustrates RFP submitted by Telstorm. At this stage, Kinetic Solar, Dr. Jose Etcheverry and I approved the design of the structure. It was then necessary to perform further engineering analysis to ensure that the latest design can be modular and universal. Modularity as a key design component, dictates whether the structure can be scaled up. In simple terms, modularity, as it pertains to our structure, ensures that additional support legs to the structure would not adversely impact the existing members. To satisfy that requirement we tested the frame of the structure with higher wind loads to ensure that it can be installed in regions and/or countries with higher wind loads than Ontario. On December 4th, 2014 Telstorm submitted a RFP for the additional engineering services, which were not included in the original RFP. Appendix F indicates the RFP submitted by Telstorm to perform the additional work.

3.4 Project Design

Small inventive steps that derive from insights and design principles help achieve worthwhile project design (Chakrabarti, 2002). In this regard, design principles are powerful tools that shape any project. And this was not an exception with the REM project. The most intensive and detail-oriented aspect of the REM project was performed during the project design component. It became evident that in order to meet the design criteria, we needed to provide foundational support as a self-ballasted structure would result in a greater footing and, hence, would result in loss of parking spots. This would significantly impact the economical feasibility of the project. Once approximate load values were established, it became clear to have a more detailed project design where anchoring, materials, and an extensive engineering analysis were determined.

3.4.1 Site Anchoring (Ground Screws)

Many options were considered to fulfill the foundation requirement of the structure. These included helical piers, ballasted conventional concrete foundation, self-ballasted above grade, and ground screws.[14] Since helical piers, conventional concrete foundations, and self-ballasted above grade foundation systems would not satisfy the terms of the design criteria and conversely ground screws met all of the design criteria while additionally providing adequate support, it was an unanimous decision to use ground screws as the foundation support for the structure. Appendix G shows the Krinner ground screw used for the REM project.

A meeting was set up with representatives of the Krinner Ground Screw at Kinetic Solar on August 15, 2014 to determine the feasibility of using ground screws for the REM project. Felix Hacke, Finance Manager and Tomas Johansson, International Business Development provided details regarding installation of the ground screws, specifically with regards to the precise drilling and the instruments and machinery that is required to drill the ground screws in various applications. As the ground screw option was selected, scenarios with different soil types, extreme climates, connection points, and integration with the existing infrastructure were evaluated. Ground screws can be incorporated with the existing infrastructure with minimal disruption and in a very timely manner. And because of this, ground screws have become prominent in construction of PV projects. Krinner ground screws were selected as an ideal ground screw provider that has used

[14] Helical piers, also known as screw piles, are steel screw-in or ground anchoring systems used for foundation requirements of structures. Helical piers are mostly hollow tubular steel with galvanized protection (FLI Structures, 2015).

their ground screws in a variety of small and large projects globally. They have licensed installers in almost every country around the world. More importantly, Krinner has setup a manufacturing plant in Chatham-Kent, Ontario for distribution in the North American market (Chatham This Week, 2013).

3.4.2 Structure Materials

The material selected for the structure is with specific purpose. Aluminum is used to make a custom and versatile rail that serves as the racking for the solar panels. This rail is specifically designed to incorporate modularity, ease of installation, universality, integrated, durability, and functionality components of the design criteria.

Hollow Structural Sections (HSS) that are made of steel are used to transfer the loads to the ground screw. The benefits of using standard steel members for our structure are numerous. HSS members offer superior corrosion resistance, higher strength, safety, lower cost, and practicality. Having a superior safety factor compared to aluminum, steel provides a significantly improved impact resistance when hit by vehicles. Also, it is readily available, which makes it practical and cost effective. HHS members with a nominal size of $4 \times 4 \times \frac{1}{4}$ were used as the load bearing upright and a top moment connection of $5 \times 3 \times \frac{1}{4}$ was used for side moment connection (Steel Tube Institute of North America, 2015). Please note that HSS used to for this project is square and rectangular steel tubing.

Figure 5: HSS members during the welding process. Photo Source: Mustafa Nazari

3.4.3 Engineering (Structural) Analysis

The Engineering Analysis or Structural Analysis component of the REM project was the most time consuming. It was performed to determine the breaking down of the structure with regards to each of its elements including connections, moment members, and foundation supports. As this was the first product of its kind to use the ground screw technology in a very innovative way, it introduced its challenges during the engineering analysis. This REM project consists of a main structure that uses aluminum and steel members to carry the loads. Therefore, the structure should have connection parts that both support and transfer the loads. In this structure, as is the case with most of the structures, there are dead loads and live loads that need to be calculated. For this structure, dead loads refer to the weight of the members such as solar panels, mid and end clamps, aluminum rail, nuts and bolts, any other fixed attachments that are permanent. Live loads include wind loads, snow loads, impact loads, seismic loads, and any other natural loads. What distinguishes live loads from dead loads is the fact that live loads differ in magnitude depending on the geographical location of the structure (Leet, Uang, Gilbert, Leet, & Leet, 2002). Therefore, structural analysis was a key part of the project design for the REM project structure.

3.4.3.1 Design considerations

The engineering analysis was confined by many factors that were thoroughly studied and implemented in the design of the structure. What may seem functional and durable is not always a visually pleasing structure. Design considerations were made with the design criteria in mind. A designer may design a very desirable structure but fundamentally it must be realistic to come to fruition. Failure to do this will result in waste of resources in time and funds.

One of the first design considerations that had to be made was the solar panel angle or tilt. Since we are in the northern hemisphere, solar panels should always be facing true south, or 180° azimuth. In the southern hemisphere the panels should be facing true north, which is 0° azimuth. Solar panels are positioned optimally when the angle at which they intercept the solar radiation (photons) is perpendicular or 90° with the panels. This is referred to as the incident irradiation, which is an excellent proxy for power output (Lave & Kleissl, 2011). However, the sun's location varies throughout the year. Therefore, it is important to determine a tilt that can be optimal for annual solar radiation with the structure in mind. Analysis have determined that in Toronto, Ontario, the desired tilt is between 32° and 35° when market price of electricity is accounted (Rowlands, Kemery, & Beausoleil-Morrison, 2011). For the REM project, higher tilt results in higher wind loads and, more specifically, it increases the tensile and compression loads as the surface area that the wind intercepts is increased. Prior analysis have researched the difference between optimum fixed angle versus 2-axis tracking where the findings concluded that the irradiation received by a 2-axis panel was 25 to 45 per cent higher compared to irradiation by optimum fixed angle (Lave & Kleissl, 2011). However, when economic and structural considerations are taken into account, optimum tilts would be closer to zero degrees with higher solar radiation values. By determining the optimum fixed angle in the context of southern Ontario, it was decided that 10° tilt would result in a desirable solar electricity output while ensuring that the loads were manageable for the foundation support. Running the PV Designer using 24 Silfab SLA 285M panels at 10° tilt for the site at the Vanier parking lot resulted in a 6,900 kWh annual electricity (Appendix J). This value is relatively similar to a 15° tilt, however, the extra wind load support by the 5° increase would have significantly increased the member sizes as well as foundational support.

3.5 Manufacturing, Installation, and Commissioning

On March 16th 2015 the engineering analysis was completed as Telstorm provided the stamped and approved engineering drawings. Appendix K shows the stamped engineering drawings of the main structure including the connection details. Completion of this phase meant that manufacturing, installation, and commissioning of the REM project could be initiated.

3.5.1 Manufacturing

Upon receiving the approved engineering drawings, Kinetic Solar began the fabrication and manufacturing of the custom members, including the aluminum rail and steel plate connections. In this phase, I had to collaborate with the welder to ensure that the connection of plates and member sizes were according to the engineering standards as specified in Appendix K. The structure's steel frame was assembled at Kinetic Solar on June 29th, 2015. This was performed to ensure that the parts fit as designed and approved before it was sent for coating and paint. HSS components have PPA 571 coating that is a versatile powder coating technology that outlasts most of the other powder coatings in the market.[15]

[15] PPA 571 is thermostatic plastic powder coating, developed by Plascoat, that provides long lasting protection for metals against harsh environments for exterior applications The PPA 571 has superior resistance to sun, salt and seawater. It also has outstanding impact and sand abrasion resistance that will perform in temperatures to -70° C (Plascoat , 2015).

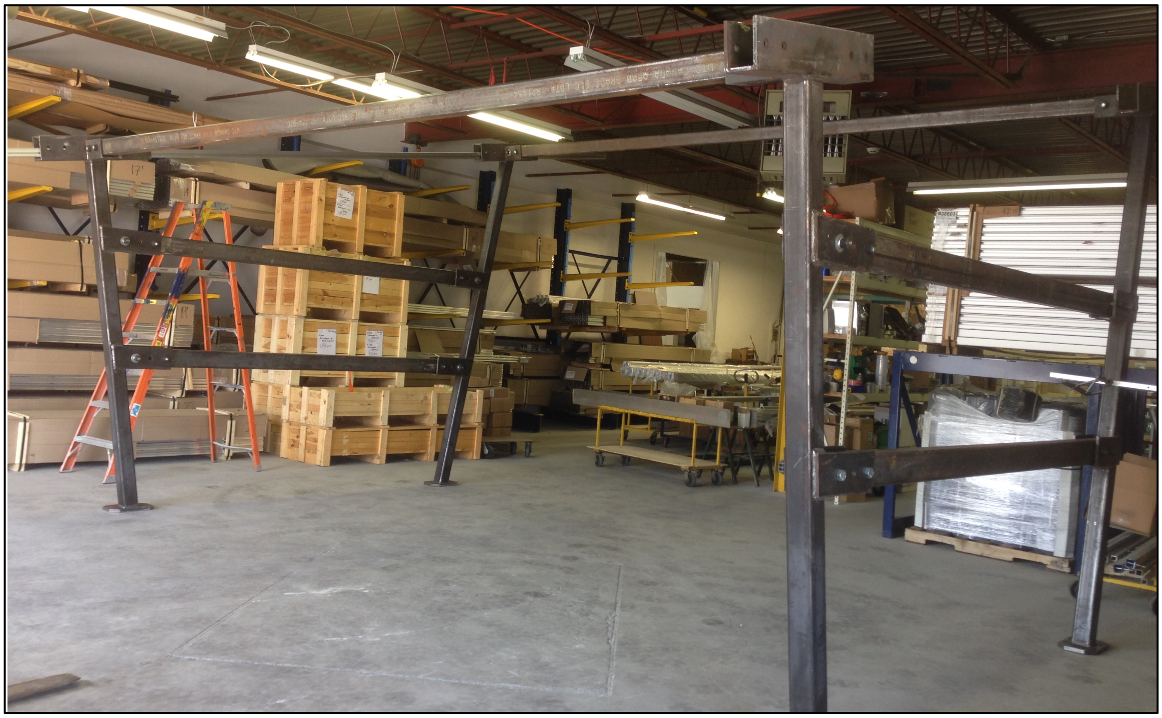

Figure 6: Assembled steel structure frame at Kinetic Solar. Photo Source: Mustafa Nazari

3.5.2 Ground Screw Installation

Aduvo performed ground screw installation on June 30th, 2015 at the Vanier parking lot. Four KSF M 140x2100 M24 (Appendix G) Krinner ground screws with 72.5 kN compression, 40.0 kN tensile, and 19.5 kN horizontal loads were drilled successfully. In order to achieve high precision for location of each ground screw, pre-drilling holes with smaller diameter augers were made. Also, laser technology was used to ensure the height of each ground screw was leveled with the others. Further, on-site testing of each ground screws' loading capacity confirmed to match and exceed those stated in the Krinner ground screw load values in Appendix H. While ground screws have been utilized for ground mount solar installation, this is the first time ground screws are used for a solar PV structure on a parking lot. Although, the design criteria aims to use minimal machinery, the 2.2 meter length of the ground screw, meant that a carrier machine such as the excavator in figure 7 was required to attach the KR B 40 Ground Screw Driver to drill the ground screw in to the ground (Krinner , 2015).

Figure 7: KR B 40 driver pre-drilling pilot hole. Photo Source: Mustafa Nazari

Figure 8: Drilling of the first ground screw. Photo Source: Mustafa Nazari

3.5.3 Structure Installation

Although ground screw installation took place on June 30th, 2015, installation of the main structure began on July 23rd, 2015. Joshua Abush of Joshua Four Limited led the installation of the structure between July 23rd and 25th, 2015. This phase of the project included the installation of the steel frame, aluminum rails, and solar panels. The first task was to train all workers for fall arrest. Next, we had to make sure than the site was fenced-off so that public access and safety was intact. Once the fencing and scaffolding were set up, the structure material was delivered from Kinetic Solar to the erection site. Originally, it was anticipated that the installation of the structure would take two days without using heavy equipment or machinery. Joshua Abush of Joshua Four Limited ensured that the installation could be performed without machinery. It was agreed that I, Dr. Jose Etcheverry, along with SEI colleagues Bastian Acevedo and Shreyas Prakash, would provide assistance with the installation. This was made possible by taking the *Working at Heights – Fundamentals of Fall Prevention* training on July 21st, 2015 offered by Infrastructure Health & Safety Association (IHSA, 2015).[16]

The structure installation with solar panels was completed on July 25th, 2015 as seen in figure 9. It is anticipated the interconnection between the panels and inverter with battery and/or grid will be completed within the next 2-4 weeks from this date.

[16] As of April 1st, 2015, the Ministry of Labour (MOL) requires that workers on construction projects must have successfully completed a working at heights training program.

Figure 9: Photo sequence of REM structure installation. Photo Source: Mustafa Nazari

The installation of the 6.84 kW solar PV structure is the first phase of the REM project. Subsequently, the system will be connected to a grid interactive inverter with battery back-up. The interconnection of the system to the grid and/or battery and EV chargers is anticipated to occur before the beginning of the academic year 2015/16. However, the deadline for this report is well before the full commissioning of the REM project. The two parking spots will each have a dedicated Sun Country Highway level II charger. Figure 10 shows the fastest level II chargers offered by Sun Country Highway.

Figure 10: Sun Country Highway Level II fast charger. Source: Sun Country Highway

3.5.4 Associate and Industry Partners

Silfab Solar Inc.

The solar panel manufacturer decision merited a criterion that would require the panels to be manufactured locally. Having its 180 MW manufacturing facility located in Mississauga made Silfab Solar Inc. the leading solar panel manufacturer in Ontario an ideal partner. Silfab kindly offered to donate 24 SLA-M 60-cell 285-Watt Monocrystalline panels for our REM project. The SLA-M 285 Watt panels have a 17.4 per cent module efficiency rating and come with a 12-year module warranty. Also, the panels are expected to perform at 82 per cent rated capacity by the end of the 25th year (Silfab Solar, 2014). Appendix I illustrates the electrical specifications, physical attributes, and all data of the SLA-M panel.

Figure 11: Delivery of the 24 SLA-M panels from Silfab. Photo Source: Mustafa Nazari

Canadian Energy

Canadian Energy is an industry leader in renewable energy generation and storage. An agreement was established with Canadian Energy to donate grid-interactive inverter and batteries. This will allow the system to have the flexibility to store the electricity generated by the solar PV panels to the battery and also to have a grid connection. Battery back-up allows the system to be completely off-grid and run on the batteries. Further, the grid-interactive inverter allows for excess electricity from York University's Cogeneration plant to be stored in the batteries at night. These components will make the REM installation into a smart microgrid system.

Sun Country Highway

Sun Country Highway is a Canadian-owned company that provides electric vehicle infrastructure in Canada and across the globe. Further, Sun Country Highway is the first company to provide EV charging for free and from coast to coast in Canada. Currently, there are two EV40P EV chargers from Sun Country Highway that are ready for installation. The EV40P is equipped with Nema 14-50 and is rated as 7.2 kW of power with a 240V plug that enables quick charging and easy installation (Sun Country Highway, 2015). Additionally, Sun Country Highway possesses the fastest level II chargers in the world. The SCH 100 evCharger requires 100 amps and has a 19.4 kW power rating for fast charging. The REM project connection will have the capacity to upgrade the charging unit to fast chargers by Sun Country Highway (Sun Country Highway, 2015).

4.0 Discussion

Past planning practices have assumed the presence of reliable energy resources, which has resulted in planning communities without an energy plan. In Canada, provinces have been responsible for energy resources. Yet, municipalities rarely determine the energy intensity of buildings, transportation, and municipal operations. The results of our REM project show that partnership projects where academia, government agencies, and industry are involved pose great opportunities, however, there are challenges that may negatively impact future cooperation. One of the most evident factors that can derail future knowledge and expert mobilization is the time it takes to complete individual tasks. Although clear design criteria were established, evidence suggests that most, if not all, stakeholders and partners were not clear on their specific responsibilities. Moving forward, partnerships where more than two stakeholders are involved, a tentative agreement of roles and involvement should be established at the beginning phase of the project to prevent project delays and cost increases.

In the initial phase of any project it is very difficult to identify the areas that may pose a challenge. As the project progressed and the installation of the REM structure was completed, this project faced challenges that ranged in the policy, energy structure, physical structure, and electrical connection.

4.1 Policy and Energy Structure Challenges

Renewable energy projects by institutions and municipalities in Ontario face many impediments when applying for government incentives such as the FIT and MicroFIT program. MicroFIT projects are defined as renewable energy projects that are equal or less than 10kW. FIT projects, however, have greater generation capacity that is greater than 10 kW and up to 500 kW. Though IESO encourages community and municipal projects to apply for the FIT program with added incentives that includes community engagement, the extent of non-rooftop solar projects remain ambiguous. When the IESO was contacted by phone to determine if the REM project would be considered a non-rooftop solar project, a lack of understanding and subsequently no answer was given. A further email regarding this matter was replied by the IESO. According to the IESO, the main purpose of the solar structure is to support the solar installation and thus it is considered as a non-rooftop solar facility. If municipalities and local communities are eligible to apply for the FIT program, it is important to understand whether a solar PV EV charging station system can meet the requirement. A full analysis of the Ontario FIT program affecting municipalities is beyond the scope of this report. Nevertheless, municipalities and local communities should be able to perform preliminary financial feasibility analysis of solar PV EV charging station systems in order to determine their viability. Since the REM project is eligible under the non-rooftop solar project, the lead-time for non-rooftop projects is three years (IESO, 2015).

This, issue combined with the fact that the Central Utilities Building (CUB), located at the northeast corner of the Keele campus, has the main connection to the central grid, limited the potential for the REM project to consider applying for the FIT program. The CUB connects to the core buildings through a distribution network by providing heating and cooling, and electricity.

Initially, the CUB had installed a 13.8 kV microgrid that distributed electricity on the Keele campus from the 27.6 kV distribution system operated by Toronto Hydro (MacMillan, 2014). The CUB building houses a 10 MW CHP plant that uses steam. It is connected to 90 buildings that stretch up to 3.5 kilometers serving a gross floor area (GFA) of 650,000 m^2. The CHP plant produces 60 per cent of the electrical requirements of the campus while the remainder is purchased from the central grid (CSBO, 2015). Further, the completion of the subway extension will spur an array of new developments within the boundaries of the campus. This presents a perfect opportunity to enhance the existing microgrid so that locally produced renewable energy generation can be injected to help generate all of the campus's electrical needs on site. At a first glance the CUB structure may appear challenging, but further examination indicates an opportunity to integrate future developments with the CHP and enhance the REM microgrid with the ability to manage electricity demand during peak times. Currently there is no storage option available at the campus to store excess electricity and, in fairness, the district heating (DE) system, and the microgrid was not initially designed to provide all of the heating and cooling, and electricity loads. However, going forward, there is a reasonable opportunity for the development of a smart microgrid system.

4.2 Physical Structure

One of the main criteria of the REM project was to ensure that the structure was easy to install. Ease of installation contributes to lower costs and less installation/labour time, as well as faster adoption. Joshua Four Limited was able to install the structure without using any machinery, which satisfies our ease of installation criterion. However, there were a few tasks that would have provided a smoother installation of the structure. First, the structure design had very low tolerance with regards to clearance holes. As Joshua reiterated, “when” and not “if” the placement of the ground screw is off by millimeters in relation to the other three-ground screws, it activates the tolerances that are part of the structure design, which is then added by other tolerances that may have occurred due to the displacement of the bolts on the structure. Although the ground screw location was not precisely accurate, Joshua Abush was able to use shims to line them up while maintaining a minimum of 75 per cent required contact between baseplate and ground screw plate.

Moreover, the side HSS members where the moment connection is located introduced a gap that required shims in order to keep the mid connection brace intact and to prevent bending. This was a time-consuming process as each mid connection was required to be shimmed and fastened tightly. By selecting the same HSS member size for the side moment connection as the up right HSS member, the spacing issue would have been avoided. The decision to choose a different member size in the first place arose due to the aesthetics.

Another aspect of the physical structure that required excessive installation time was the drilling of the holes on the two aluminum rails that fitted into the top saddle connection. Since it is easier to drill holes in the aluminum than in steel, from the design phase it was decided that the 1-inch holes would be drilled on site. This, however, resulted in a very time consuming process, as the aluminum wall thickness of ¼ inches required strong drilling equipment. A preventative measure could have been using slotted holes on the aluminum member with high tolerance to omit on-site drilling.

Any tall person who may attempt to hang from the rail can reach the structure's entrance point, which exceeds the minimum clearance requirement of 2.0 meters by the City of Toronto parking spot guidelines. Although, the structure is secure and safe, the relatively low entrance point may invite people to attempt to reach and hang from the structure. This could be improved by setting the lowest point of the structure to 2.5 meters. Although this would alleviate the structures low hanging point, it adds extra material and weight to the structure due to long member lengths.

4.3 Electrical Connection and Storage

The installation of the REM project at York University introduced many issues that municipalities and local communities may face during connection. First, in an ideal world, the REM project would receive a contract under the MicroFIT program in a timely manner. However, this was not possible due to the grid connection at York University as well as the uncertainty of the FIT program regarding solar carport projects. Second, the REM project would have a bi-directional connection to the grid where electricity generated by the solar panels is first consumed and/or stored on site via storage batteries. If the system generates excess electricity, it can be sent to the grid where it can be sold at retail price. In the event that the system generates less electricity in future months, the excess electricity generated in the past would be credited back through the grid. Generally, this is how a net metering system works. Net metering refers to a policy and/or system where customers of the local distribution company (LDC) are allowed to offset some, if not all, of their electricity use with locally generated renewable energy. Normally at the end of the month the customer is billed with the net electricity used from the grid. A net metering connection for the REM project would have cost approximately $1,000, which includes the bidirectional meter and the connection fee. As confirmed by Hydro One, a typical net metering setup would require no more than a month for full connection.

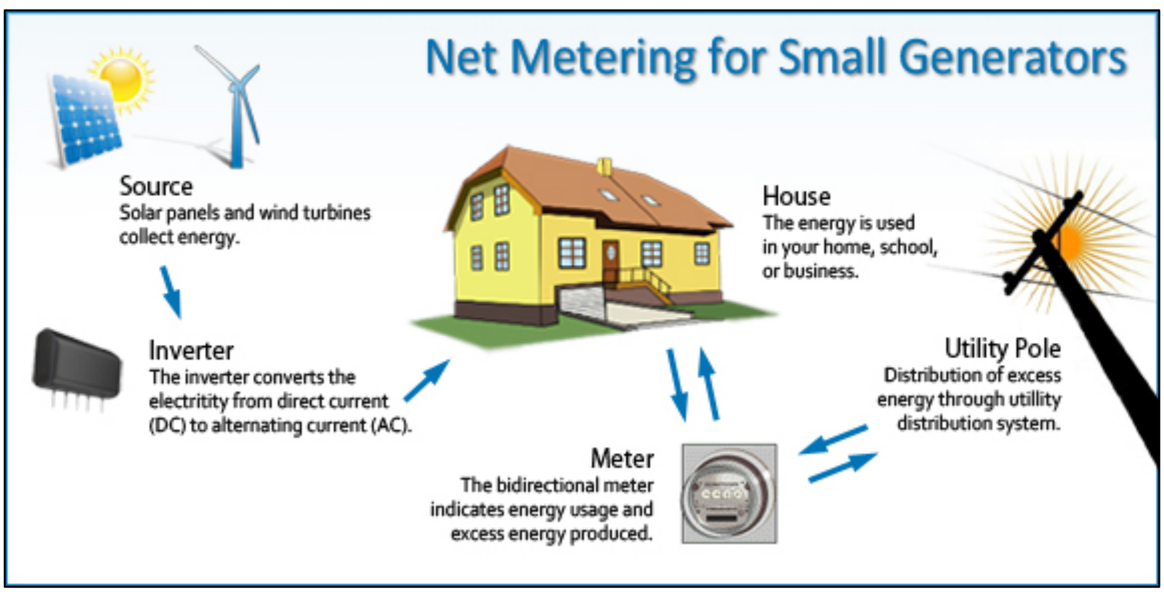

Figure 12: Typical net metering for small generators. Source: Michigan State

5.0 Conclusion

The REM project has been a challenging journey for me and has introduced an array of challenges and success. I believe when ideas are developed and aimed to improve our energy future, societies can foster and become sustainable. Evidently, the first solar PV installation at York University introduced new challenges to the faculty, CSBO, Kinetic Solar, and other associate partners.

Although this was a new and innovative structure, during the preliminary project analysis and development, communication between Kinetic Solar, York University, and Telstorm Corporation was slightly poor. As has been indicated in the past, poor communication results in project failures. One of the first things that I would improve about this project would be communication. Despite my best efforts to coordinate with all stakeholders, specific strategies must be applied to close the communication gap with various private industries. One of the strategies for better communication is to maintain a short wiki-like written track of deadlines, requests, and deliverables. Further, specific communication with respect to each stakeholder should be developed and applied. This stems from understanding the value of the project from each stakeholder's view and therefore exercising that effectively.

Another challenge that was encountered was time management. I have learned to set more realistic timelines, especially when more than two stakeholders are involved. This would avoid disappointments when certain components are delayed. Our first learning curve started with understanding the timeline and pace at which tasks are completed.

Depending on the nature of the work, certain project components require a longer time to formulate compared to others. It has less to do with unwillingness and more to do with the fact that developing new products require trial and error.

Also, I have realized that the technical and financial aspect of designing the REM project was sorted out in a relatively organized and planned manner. When I realized that self-ballasted concrete foundation support would not comply with the design criteria due to size and weight, I had researched and found an innovative foundation solution in ground screws that met the requirement of all design criteria. Further, the assimilation of ground screws with the steel structure provided technical challenges that were solved by communicating with experts from both Krinner and Kinetic Solar. However, dealing with York University offered a lot of 'red tape' that hindered the timeline to deliver the project in a timely manner. In particular, significant time was spent by York University in order to obtain the insurance policies from Kinetic Solar, Telstorm Corporation, and Joshua Four. Given the opportunity to repeat this project, I would have simultaneously coordinated some of the tasks by sharing project development, milestones and timelines in a wiki-like environment for all partners and stakeholders.

In the mean time, the development and design of the REM project has paved way for the successful installation of the first Solar PV for the charging of the EV at York University. This installation has demonstrated how solar energy can be incorporated within existing urban infrastructure to not only provide charging station for the EVs but also aid in mitigating the harmful causes of ICE vehicles. Additionally, maintaining the design criteria throughout every phase of this project has proven to be the key in achieving the innovative and aesthetically pleasing structure. As the structure can evolve to house smart microgrid equipment, it will provide many more learning and research opportunities to York University staff and students.

Overall, the completion of this project has been one of the most rewarding accomplishments and experiences in my life. As I started the MES program, I wanted to be able to understand if local municipalities can have widespread deployment of renewable energy. My experiences in Europe have provided with me the ability to realize the vast role municipalities paly in successful renewable energy policies and distribution.

My research on municipal energy planning in Ontario shows that municipalities play a passive role with respect to renewable energy deployment. While most of the focus is geared towards conservation and efficiency, renewable energy is often marginalized. By developing the first Ontario-made solar PV charging station structure at York University, I have demonstrated how municipalities and local institutions could play a significant role in renewable energy deployment.

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7.0 Appendices

Appendix A – Solar Access and Shade Report for the REM project site.

Solar Access and Shade Report

25/05/2015

For:

York University
4700 Keele St
Toronto, Ontario M3J 1P3
(416) 736-2100

By:

Mustafa Nazari
Faculty of Environmental Studies, York University
HNES 109, 4700 Keele Street
Toronto, Ontario M3J 1P3
416-736-2100 ext: 44022

Measurements made by **Solmetric SunEye™** -- www.solmetric.com

Solmetric

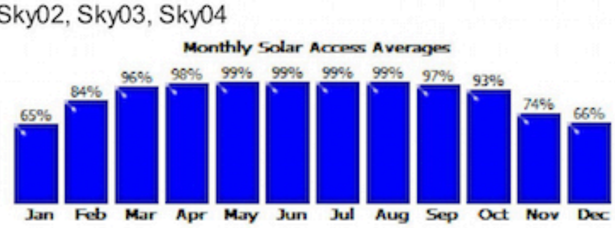
Session Properties

Name	Vanier Lot
Creation Date	07/05/2015 9:48
Note	proposed solar ev carport site
Location	43.8°N, 79.5°W Mag Dec: 10.5°W Time Zone: GMT-05:00

Solar access averages of 4 skylines in this session

Skylines Averaged: Sky01, Sky02, Sky03, Sky04

Annual	May-Oct	Nov-Apr
94%	98%	85%

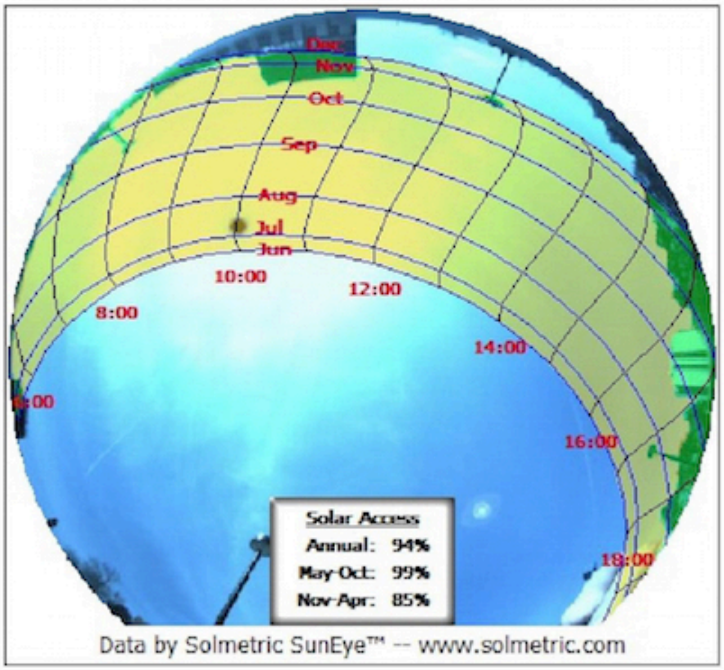


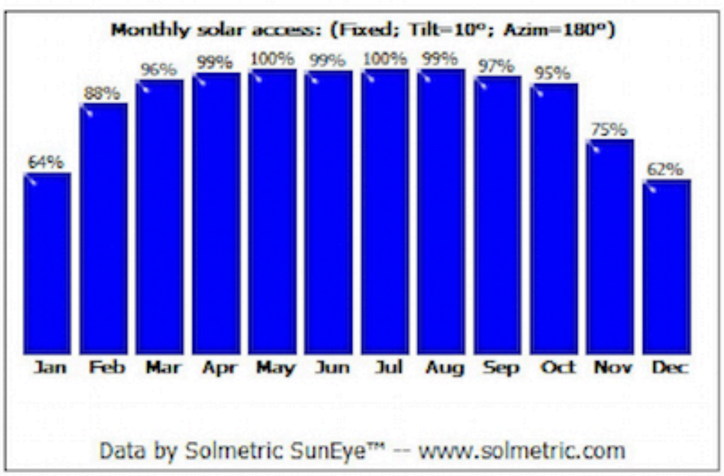
TSRF averages of 4 skylines in this session: 88%

The average solar access of the 4 corners of the REM structure is 94 per cent.

Sky01 -- 07/05/2015 9:52 -- NE CORNER

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=162°**
GPS Location: Latitude=43.77582°N -- Longitude=79.50128°W
Solar Access: Annual: 94% -- Summer (May-Oct): 99% -- Winter (Nov-Apr): 85%
TSRF: 89% -- **TOF:** 94%

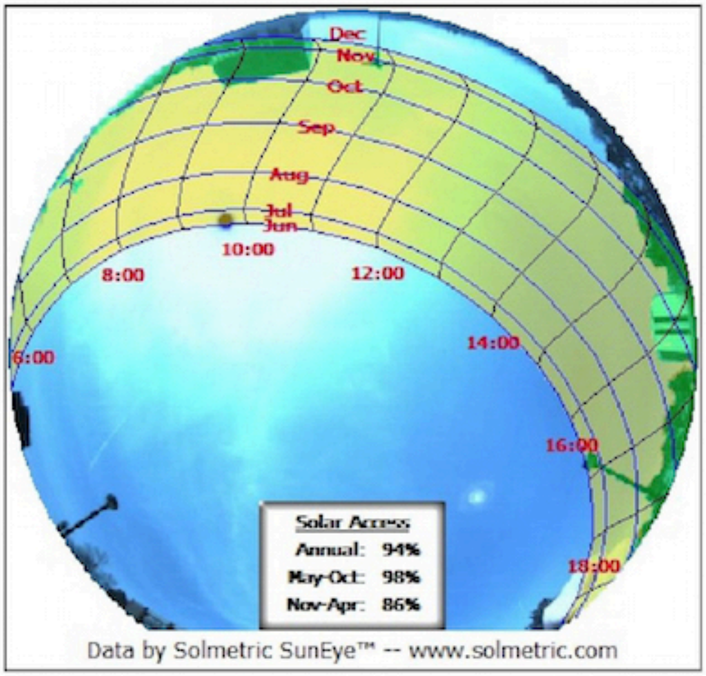


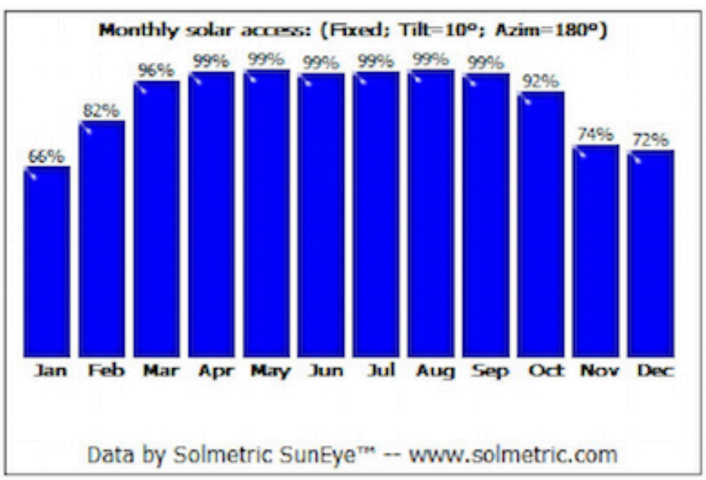


Solar access of the NE corner of the REM structure is 94 per cent.

Sky02 -- 07/05/2015 9:53 -- NW CORNER

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=156°**
GPS Location: Latitude=43.77578°N -- Longitude=79.50132°W
Solar Access: Annual: 94% -- Summer (May-Oct): 98% -- Winter (Nov-Apr): 86%
TSRF: 88% -- **TOF:** 94%

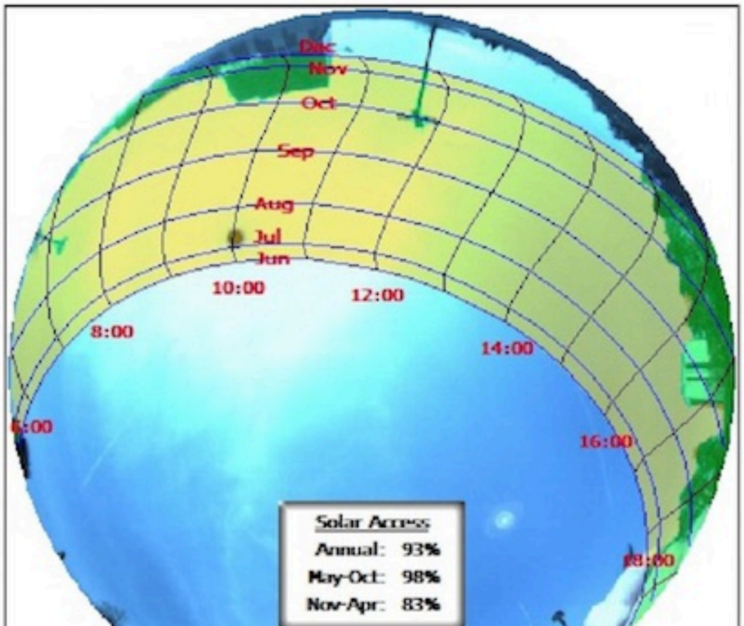




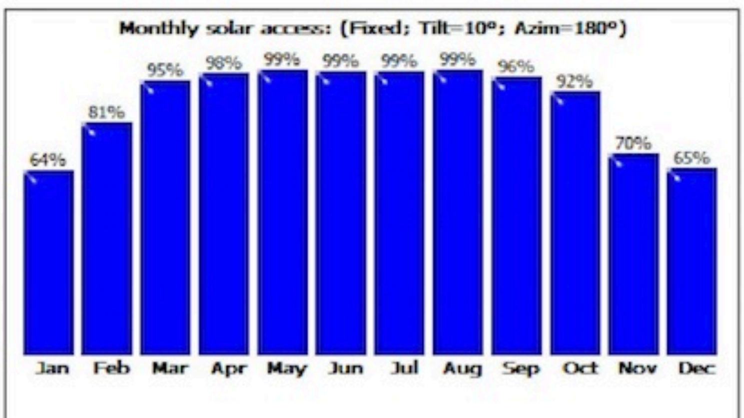
Solar access of the NW corner of the REM structure is 94 per cent.

Sky03 -- 07/05/2015 9:54 -- SW CORNER

Panel Orientation: Tilt=10° -- Azimuth=180° -- **Skyline Heading=164°**
GPS Location: Latitude=43.77570°N -- Longitude=79.50128°W
Solar Access: Annual: 93% -- Summer (May-Oct): 98% -- Winter (Nov-Apr): 83%
TSRF: 87% -- **TOF:** 94%

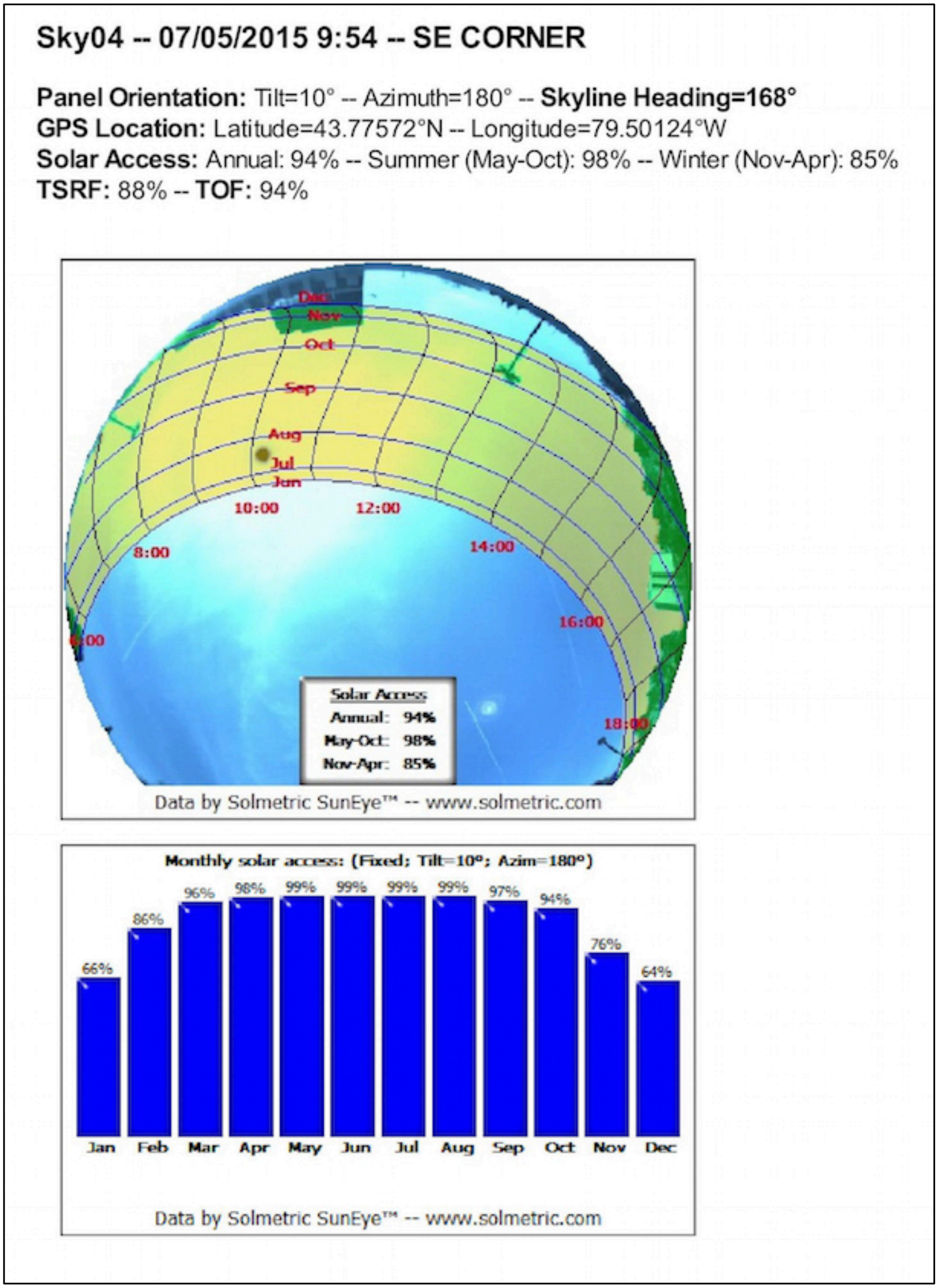


Data by Solmetric SunEye™ -- www.solmetric.com



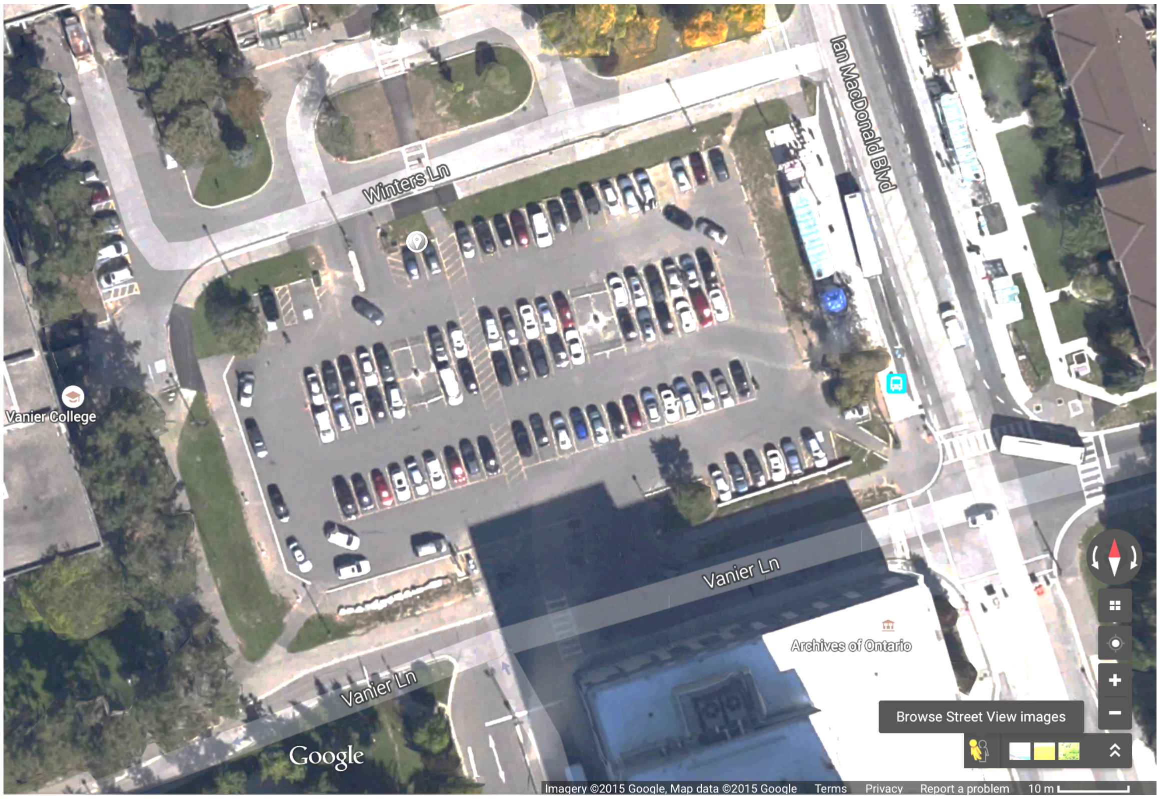
Data by Solmetric SunEye™ -- www.solmetric.com

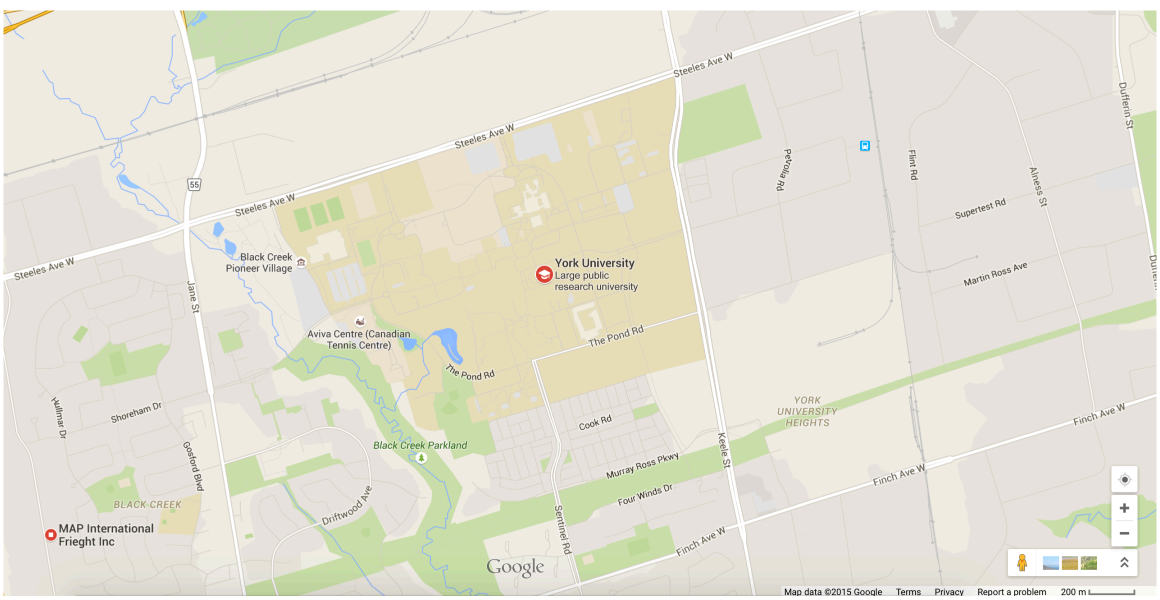
Solar access of the SW corner of the REM structure is 93 per cent.



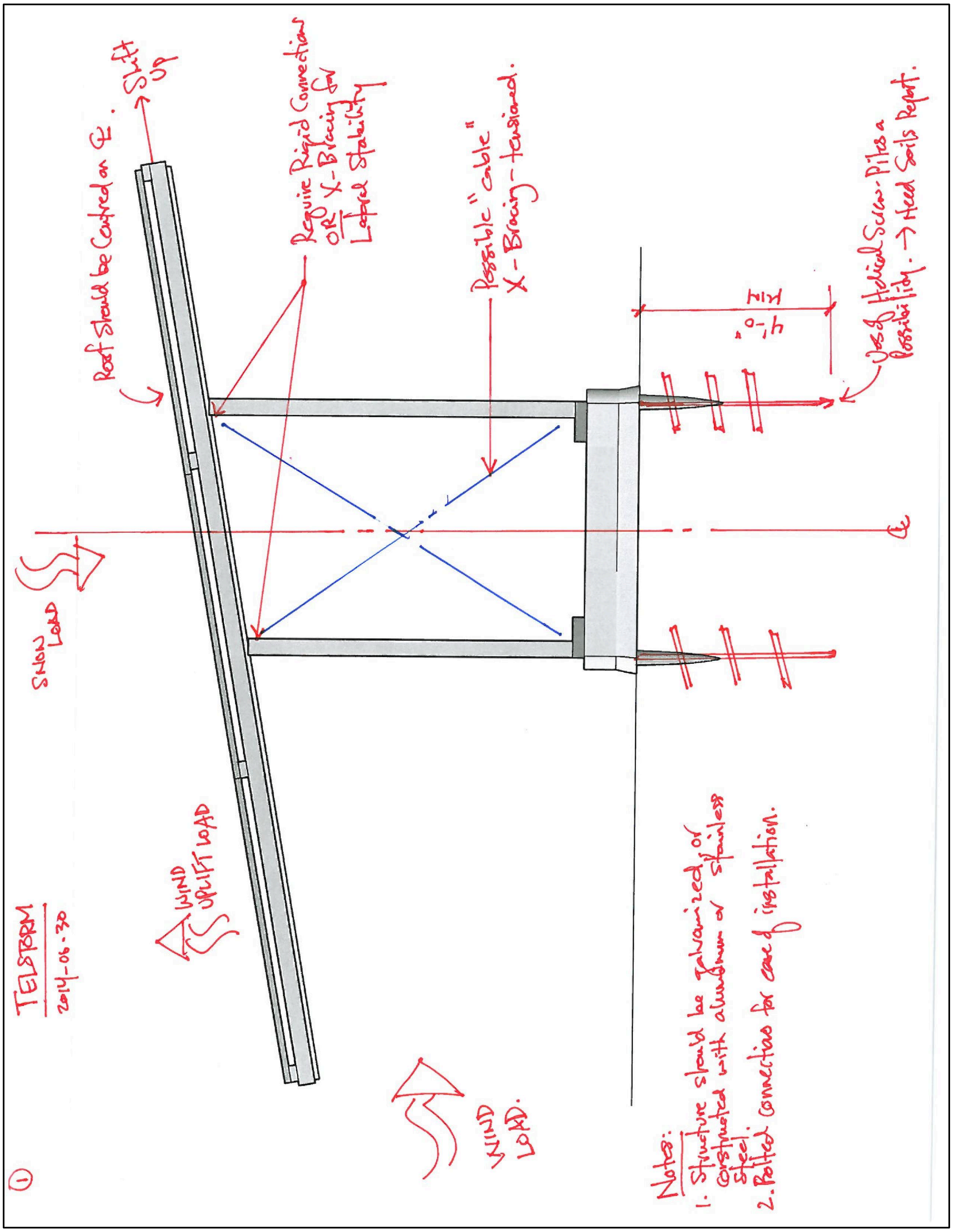
Solar access of the SE corner of the REM structure is 94 per cent.

Appendix B – Vanier Parking Lot, the location and site of the REM project

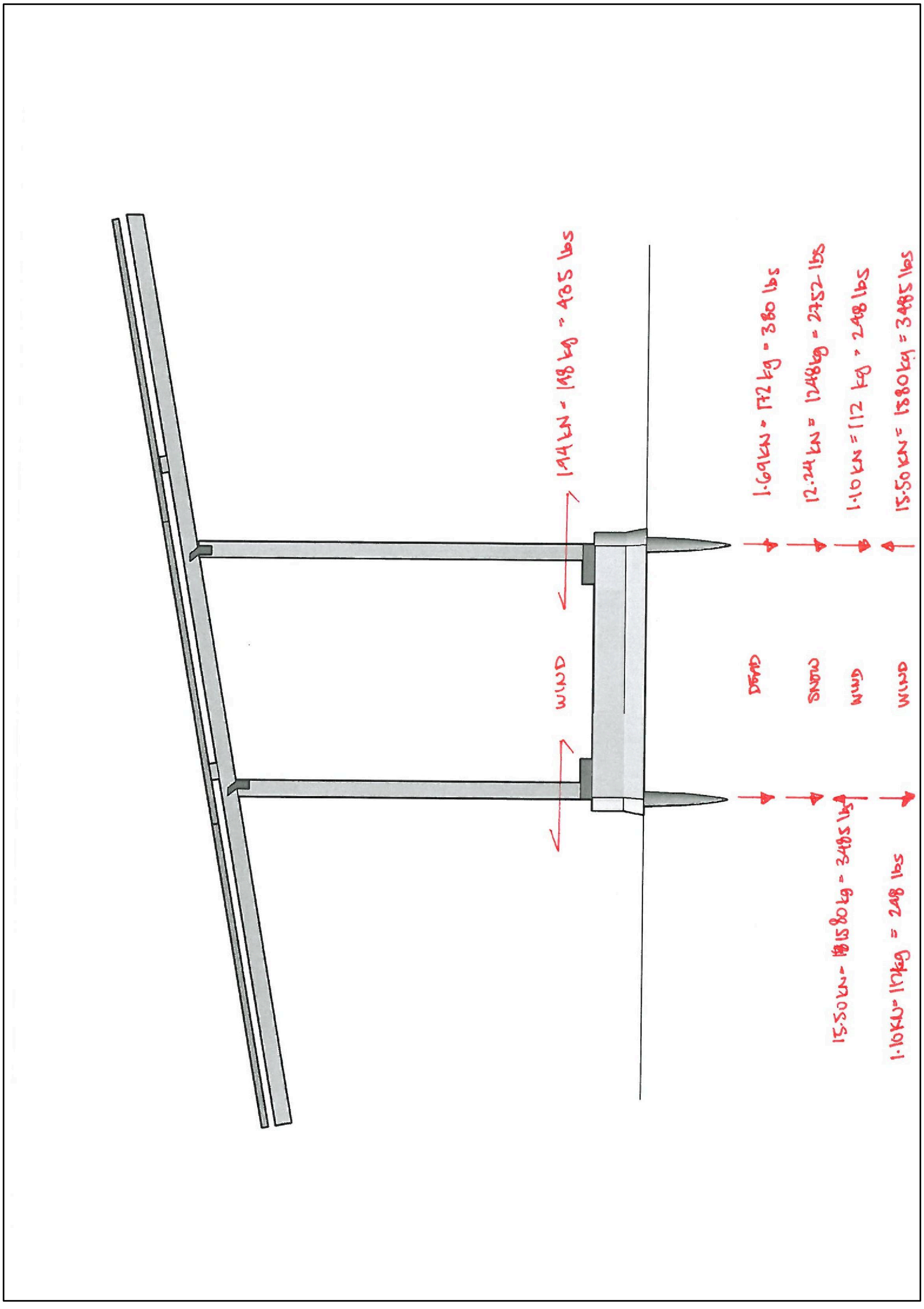




Appendix C –Telstorm comments regarding the preliminary design concept.



Appendix D – Preliminary Engineering analysis (loads) by Telstorm.



Appendix E – RFP by Telstorm to perform structural engineering services.

telstorm

October 8, 2014

TELSTORM Project No: 1153036.0

Mustafa Nazari, B.E.S
Graduate Candidate
Planning Program
Faculty of Environmental Studies
York University
4700 Keele Street
Toronto, ON
M3J 1P3

Dear Mustafa,

RE: Request for Proposal – Structural Engineering Charging Station Framing Design, York University Keele Campus. 4700 Keele Street, Toronto, ON

TELSTORM Corporation would like to take this opportunity to thank York University for giving us consideration to submit this proposal to provide Structural Engineering Services for the charging station slated at the above noted address.

Project Scope of Work

We foresee our scope of work to be as follows:

1. Complete structural analysis to design the members constituting the framing of the charging station.
2. Provide member sizes, sketch of connection details and notes to be incorporated into the design package.
3. Review design package prior to proceeding with construction.
4. Perform one (1) site inspection to review progress of construction.

Fee Schedule

Our total fee for the project is **$2,100+HST**. All expenses have been included in our fees. For additional work outside of the outlined scope, please refer to Appendix A for Hourly Rates and Schedule of Disbursements.

Project Assumptions and Limitations

1. All work under this scope of work is only related to structural engineering scope of work.
2. Drawings are completed by others.
3. Building permit application will be completed by others.

Page 1 of 3

3100 Steeles Ave. West, Suite 406 Vaughan, ON L4K 3R1 O 905.760.7646 F 905.760.7663 www.telstorm.com

We look forward to working with York University to successfully complete this project. If you have any questions relating to this proposal, please contact the undersigned at your convenience.

Yours truly,
TELSTORM Corporation

Earl Espinueva

Earl Espinueva, P.Eng.
Structural Engineer

3100 Steeles Ave. West, Suite 406 Vaughan, ON L4K 3R1 O 905.760.7646 F 905.760.7663 www.telstorm.com

telstorm

Appendix A – Hourly Rates and Schedule of Disbursements

Hourly Rates:

Work outside of the base scope of work including two or more background revisions, changes to scope, work on additional square footage, work related to addenda and change notices and additional work related to delays in the project will be billed hourly in addition to the base project fees at the following rates:

Structural Engineer	$150 per hour
Intermediate Engineer	$100 per hour
CAD Technician:	$85 per hour
Administration	$65 per hour
Additional Site Visit:	$500/visit

Disbursements

Specific rates are as follows:

Out of Pocket expenses	Amount
Printing and reprographics	Cost
Long distance telephone charges	No Fee
Mileage	0.50/km
In house plotting	1.75/sq ft
In house printing/photocopying	0.10/ 8 ½ x 11
Parking	Cost
Courier	Cost
Taxi	Cost
Airfare and lodgings	Cost

3100 Steeles Ave. West, Suite 406 Vaughan, ON L4K 3R1 O 905.760.7646 F 905.760.7663 www.telstorm.com

Appendix F – Request for Proposal by Telstorm to perform additional engineering services.

telstorm

December 4, 2014

TELSTORM Project No: 1153036

Dr. Jose Etcheverry
Faculty of Environmental Studies
York University
4700 Keele Street
Toronto, ON
M3J 1P3

Dear Mustafa,

RE: Request for Proposal – Additional Engineering Fee Request, York University Keele Campus. 4700 Keele Street, Toronto, ON

TELSTORM Corporation would like to take this opportunity to thank York University for giving us consideration to submit this proposal for additional engineering fees for the charging station design at the above noted address.

Project Scope of Work

Based on recent requests, and our SOW identified in our original proposal, we foresee the additional scope of work as follows (items not covered in original proposal):

1. Review and design charging station structure for environments outside of the York U Keele Campus (Toronto snow and wind loading).
2. Review charging station design for modularity.

Fee Schedule

Our requested additional fee for the project is **$1,100+HST**. Expenses have been included in our fees.

Project Assumptions and Limitations

1. All work under this scope of work is only related to structural engineering scope of work.
2. Drawings are completed by others.
3. Building permit application will be completed by others.

3100 Steeles Ave. West, Suite 406 Vaughan, ON L4K 3R1 O 905.760.7646 F 905.760.7663 www.telstorm.com

telstorm

We look forward to working with York University to successfully complete this project. If you have any questions relating to this proposal, please contact the undersigned at your convenience.

Yours truly,
TELSTORM Corporation

Alex Fulop, P.Eng.
President

3100 Steeles Ave. West,   Suite 406   Vaughan,   ON   L4K 3R1   O 905.760.7646   F 905.760.7663   www.telstorm.com

Appendix G – Krinner ground screw used for REM: KSF M 140x2100 M24

KRINNER
The Ground Screw

Technical Data Sheet M Series

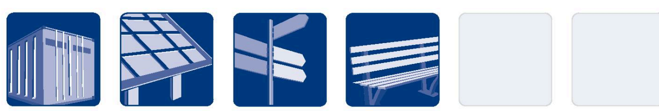
Basic Info

	KSF M 140x2100-M24	KSF M 114x2100-M24	KSF M 114x1600-M24	KSF M 114x1300-M24
Nominal length (mm)	2100	2100	1600	1300
Tube diameter (mm)	139.70	114.30	114.30	114.30
Weight (kg)	26	21	16	13
Item number	25400	25352	25351	25350

Construction

- Flange: Sheet metal S355
- Nut: DIN EN ISO 4032-8
- Continuous welded helix
- Coating: Hot-dip galvanized according to DIN EN ISO 1461

Applications



KSF M 140x
2100-M24

Subject to technical change!
Krinner Schraubfundamente GmbH | Passauer Straße 55 | D-94342 Straßkirchen
Phone: +49 9424 9401-80 | E-Mail: service@krinner.com | www.krinner.com

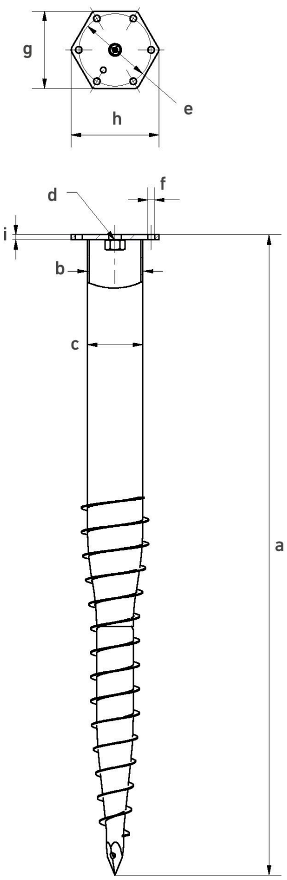
efficient · no concrete · durable

Basic dimensions of the selected Krinner ground screw for the REM structure.

KRINNER
The Ground Screw

Technical Data

	KSF M 140x2100-M24	KSF M 114x2100-M24	KSF M 114x1600-M24	KSF M 114x1300-M24
a Length (mm) (±25 mm)	2070	2075	1575	1325
b Shaft outer diameter (mm)	139.70	114.30	114.30	114.30
c Inner diameter (mm)	132.50	107.10	107.10	107.10
d Thread	M24	M24	M24	M24
e Pitch circle diameter (mm)	180	150	150	150
f Pitch circle holes (mm)	6 x ∅ 14	6 x ∅ 14	6 x ∅ 14	6 x ∅ 14
g Flange wrench size (mm)	200	160	160	160
h Flange outer diameter (mm)	225	182	182	182
i Flange thickness (mm)	10	10	10	10



Online Service

	KSF M 140x2100-M24	KSF M 114x2100-M24	KSF M 114x1600-M24	KSF M 114x1300-M24
Webkey	M2540011D	M2535211D	M2535111D	M2535011D

Subject to technical change!
Krinner Schraubfundamente GmbH | Passauer Straße 55 | D-94342 Straßkirchen
Phone: +49 9424 9401-80 | E-Mail: service@krinner.com | www.krinner.com

Technical dimensions of the selected Krinner ground screw for the REM structure.

Appendix H – Krinner ground screw load values.

PROVISIONAL PRE-DIMENSIONING TABLE

for KRINNER Ground Screws

The values in the table below are only provided for rough pre-dimensioning for creating an offer. The final foundation design must be based on onsite load tests and a structural analysis proving the internal load bearing capacity of the KRINNER Ground Screw in compliance with DIN EN 18800, based on a relevant structural analysis model.

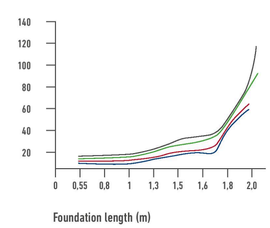
Item	KRINNER screw foundation		Tube diameter		Steel tube	Steel tube	Flange plate	Load values (tension in N/compression/horizontal)		
	Type desig. New version	Type desig. Old version	ø	Wall thickness	MRd, el kNm	MRd, pl kNm	MRd, el kNm	Compression (kN)	Tension (kN)	Horizontal (kN)
M-Series										
27		(KSF M24 140x2000)	139.70	3.60	11.140	15.980	3.97	72.50	40.00	19.50
	KSF M 140x2100-M24		139.70	3.60	≙	≙	≙	≙	≙	≙
28		(KSF M24 114x2000)	114.30	3.60	7.329	10.610	2.66	66.00	37.50	17.00
	KSF M 114x2100-M24		114.30	3.60	≙	≙	≙	≙	≙	≙
29		(KSF M24 114x1600)	114.30	3.60	7.329	10.610	2.66	47.50	27.50	13.50
	KSF M 114x1600-M24		114.30	3.60	≙	≙	≙	≙	≙	≙
30		(KSF M24 114x1200)	114.30	3.60	7.329	10.610	2.66	35.00	20.50	9.50
	KSF M 114x1300-M24		114.30	3.60	≙	≙	≙	≙	≙	≙
31		(KSF M24 90x2000)	88.90	3.60	4.314	6.220		55.00	35.00	14.00
	KSF M 89x2100-M24		88.90	3.60	≙	≙		≙	≙	≙
32		(KSF M24 90x1600)	88.90	3.60	4.314	6.220		41.00	24.50	11.00
	KSF M 89x1600-M24		88.90	3.60	≙	≙		≙	≙	≙
33		(KSF M24 90x1200)	88.90	3.60	4.314	6.220		30.00	16.50	7.50
	KSF M 89x1300-M24		88.90	3.60	≙	≙		≙	≙	≙
34		(KSF M24 76x2000)	76.10	4.00	3.386	4.990		45.00	32.50	11.50
	KSF M 76x2100-M16		76.10	3.60	3.097	4.100		≙	≙	≙
35		(KSF M24 76x1600)	76.10	4.00	3.386	4.990		35.00	21.50	8.50
	KSF M 76x1600-M16		76.10	3.60	3.097	4.100		≙	≙	≙
36		(KSF M24 76x1200)	76.10	4.00	3.386	4.990		25.00	12.50	5.50
	KSF M 76x1300-M16		76.10	3.60	3.097	4.100		≙	≙	≙
37		(KSF M12 76x1200)	76.10	2.00	1.834	2.640		18.50	11.50	5.50
	KSF M 76x1300-M12		76.10	2.60	2.328	3.065		≙	≙	≙
38		(KSF M12 76x1000)	76.10	2.00	1.834	2.640		16.50	9.50	4.50
	KSF M 76x1000-M12		76.10	2.60	2.328	3.065		≙	≙	≙
39		(KSF M12 76x800)	76.10	2.00	1.834	2.640		13.50	7.00	3.50
	KSF M 76x800-M12		76.10	2.60	2.328	3.065		≙	≙	≙
U-Series										
40		(KSF U111x1000)	66.00	2.00	1.363			10.50	5.50	3.50
	KSF U 66x865-111		66.00	2.00	≙			≙	≙	≙
41		(KSF U91x1000)	66.00	2.00	1.363			10.50	5.50	3.50
	KSF U 66x865-91		66.00	2.00	≙			≙	≙	≙
42		(KSF U111x865)	66.00	2.00	1.363			6.00	4.50	2.50
	KSF U 66x730-111		66.00	2.00	≙			≙	≙	≙
43		(KSF U91x865)	66.00	2.00	1.363			6.00	4.50	2.50
	KSF U 66x730-91		66.00	2.00	≙			≙	≙	≙
44		(KSF U71x865)	66.00	2.00	1.363			6.00	4.50	2.50
	KSF U 66x730-71		66.00	2.00	≙			≙	≙	≙
45		(KSF U71x685)	66.00	2.00	1.363			2.50	1.70	0.50
	KSF U 66x550-71		66.00	2.00	≙			≙	≙	≙

*In the context of the former geotechnical standard DIN 1054, Nov. 1976 global safety factor approx. 2.0

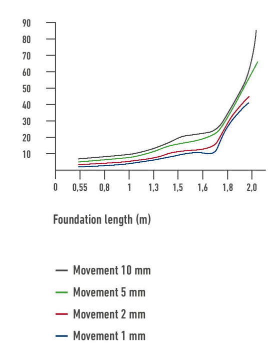
Load tests on KRINNER Ground Screws according to DIN 18800 for measuring the external load bearing capacity, carried out in compliance with DIN EN 1537, DIN 4125 and DIN 1054

Example diagrams: Correlation of axial tensile force as a factor of foundation anchoring depth and extraction distance or axial shift for KRINNER Ground Screws.

WORK CURVE FOR AXIAL COMPRESSIVE LOAD TEST ON ALLUVIAL OR LOESS LOAM, SEMISOLID



WORK CURVE FOR AXIAL TENSILE LOAD TEST ON ALLUVIAL OR LOESS LOAM, SEMISOLID



Subject to change, revision 12/2011

Engineering load chart for different Krinner ground screw size and lengths.

Appendix I – Silfab Module: SLA 285M

MONOCRYSTALLINE
PV MODULE

SLA-M 260/265/270/275/280/285/290

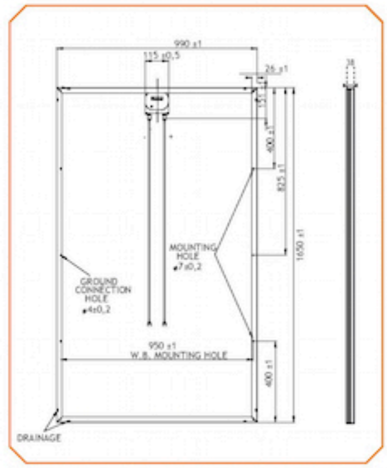
The Silfab SLA-M 60-cell monocrystalline modules are ideal for ground-mount, roof-top and solar tracking installations where maximum power density is required.

Maximum Efficiency... 60 of the highest efficiency, best quality monocrystalline cells result in a maximum power rating of 290 Wp.

Positive Tolerance... (-0/+5W) module sorting achieves the maximum electrical performance of the PV system.

Highest Automation... Strict quality controls during each step of the world's most automated module production facilities.

Increased Quality... Top quality materials and 100% EL testing guarantee a trustworthy 25-year performance warranty.



60 cells 12 years

Electrical Specifications - Standard Test Conditions		SLA260M	SLA265M	SLA270M	SLA275M	SLA280M	SLA285M	SLA290M
Module Power (Pmax)	Wp	260	265	270	275	280	285	290
Maximum power voltage (Vpmax)	V	30.8	31.0	31.2	31.4	31.7	32.0	32.4
Maximum power current (Ipmax)	A	8.49	8.55	8.65	8.76	8.83	8.91	8.97
Open circuit voltage (Voc)	V	37.8	38.0	38.2	38.4	38.7	39.1	39.6
Short circuit current (Isc)	A	9.04	9.11	9.22	9.32	9.40	9.47	9.54
Module efficiency	%	15.9	16.2	16.5	16.8	17.1	17.4	17.8
Maximum system voltage (VDC)	V				1000			
Series fuse rating	A				15			
Power tolerance	Wp				-0/+5			

Measurement conditions: STC 1000 W/m² • AM 1.5 • Temperature 25 °C • Measurement uncertainty ≤ 3% • Sun simulator calibration with modules calibrated by Fraunhofer Institute.
Electrical characteristics may vary by ±5% and power by -0/+5W.

Temperature Ratings		SILFAB SLA Mono
Temperature Coefficient Isc	%/K	0.03
Temperature Coefficient Voc	%/K	-0.30
Temperature Coefficient Pmax	%/K	-0.38
NOCT (± 2 °C)	°C	45
Operating temperature	°C	-40/+85

Mechanical Properties and Components		SILFAB SLA Mono
Module weight (± 1 kg)	kg	19
Dimensions (H x L x D; ± 1mm)	mm	1650 x 990 x 38
Maximum surface load (wind/snow)*	N/m²	5400
Hail impact resistance		ø 25 mm at 83 km/h
Cells		60 - Si monocrystalline - 3 busbar - 156 x 156 mm
Glass		3.2 mm high transmittance, tempered, antireflective coating
Encapsulant		PID-resistant EVA
Backsheet		Multilayer polyester-based
Frame		Anodized Al
Bypass diodes		6 diodes-45V/12A
Cables and connectors*		1300 mm ø 5.7 mm (4 mm²), MC4 comparable

Warranties	SILFAB SLA Mono
Module warranty	12 years
Guaranteed power	≥ 97% end of 1st year ≥ 90% end of 12th year ≥ 82% end of 25th year

Certifications	SILFAB SLA Mono
Product	ULC ORD C1703, UL 1703, IEC 61215, IEC 61730, CEC listed Product traceability
Factory	ISO 9001:2008

Also available as... Silfab Smart Module Optimized by: Tigo energy

Appendix J – PV Designer Report for the REM project

PV Designer Report

20/06/2015

For:

York University
4700 Keele St
Toronto, Ontario M3J 1P3
Canada
(416) 736-2100

By:

Mustafa Nazari
Sustainable Energy Initiative (SEI), Faculty of of Environmental Studies, York University
HNES 109, 4700 Keele Street
Toronto, Ontario M3J 1P3
Canada
416-736-2100 ext: 44022

Simulation results provided by **Solmetric PV Designer** -- www.solmetric.com

Session Design Summary:

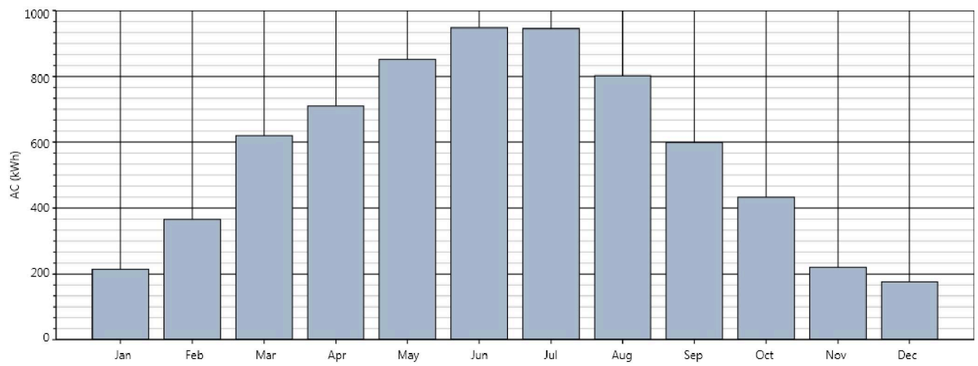
Session Design Summary:

Name: Vanier Lot
Location: 43.80 °N, 79.50 °W
Minimum Temperature: -18.40 °C
Maximum Temperature: 31.82 °C

Weather Properties:

Station Name: Meteonorm
Data Source: Meteonorm
Location: 43.80 °N, 79.50 °W

Design Result Chart:



Monthly Total AC kWh:

Month	REM Project AC (kWh)
Jan	215.3
Feb	367.0
Mar	621.7
Apr	711.3
May	852.6
Jun	948.9
Jul	946.3
Aug	803.6
Sep	599.8
Oct	434.4
Nov	221.5
Dec	177.1
Annual	6899.7

Solmetric

Expected output (kWh) of the solar PV system based on the solar access and shading analysis tool and Silfab SLA285M panels.

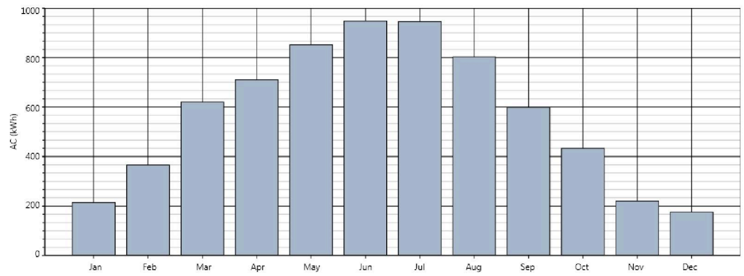
REM Project:

Design Properties:

Module Manufacturer: Silfab
Module Model: SLA285M
Inverter Manufacturer: Enphase Energy
Inverter Model: M250-60-2LL-S24 (208)
(Due to spacing constraints, only the manufacturer and model of the first inverter is include in this report)
Derate Factor: 0.80

Month	REM Project AC (kWh)
Jan	215.3
Feb	367.0
Mar	621.7
Apr	711.3
May	852.6
Jun	948.9
Jul	946.3
Aug	803.6
Sep	599.8
Oct	434.4
Nov	221.5
Dec	177.1
Annual	6899.7

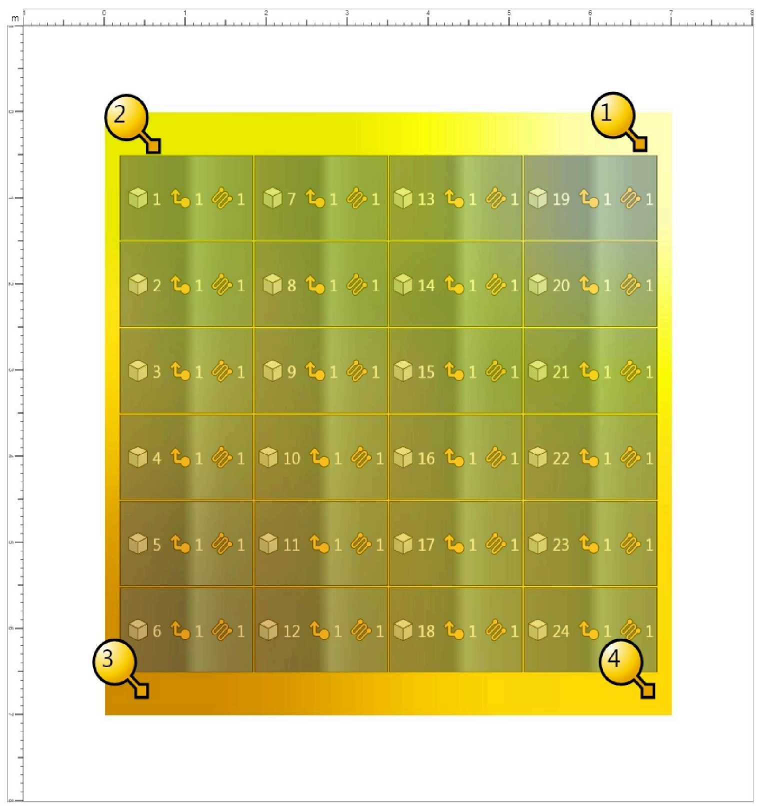
Design Result Chart:



Layout View:

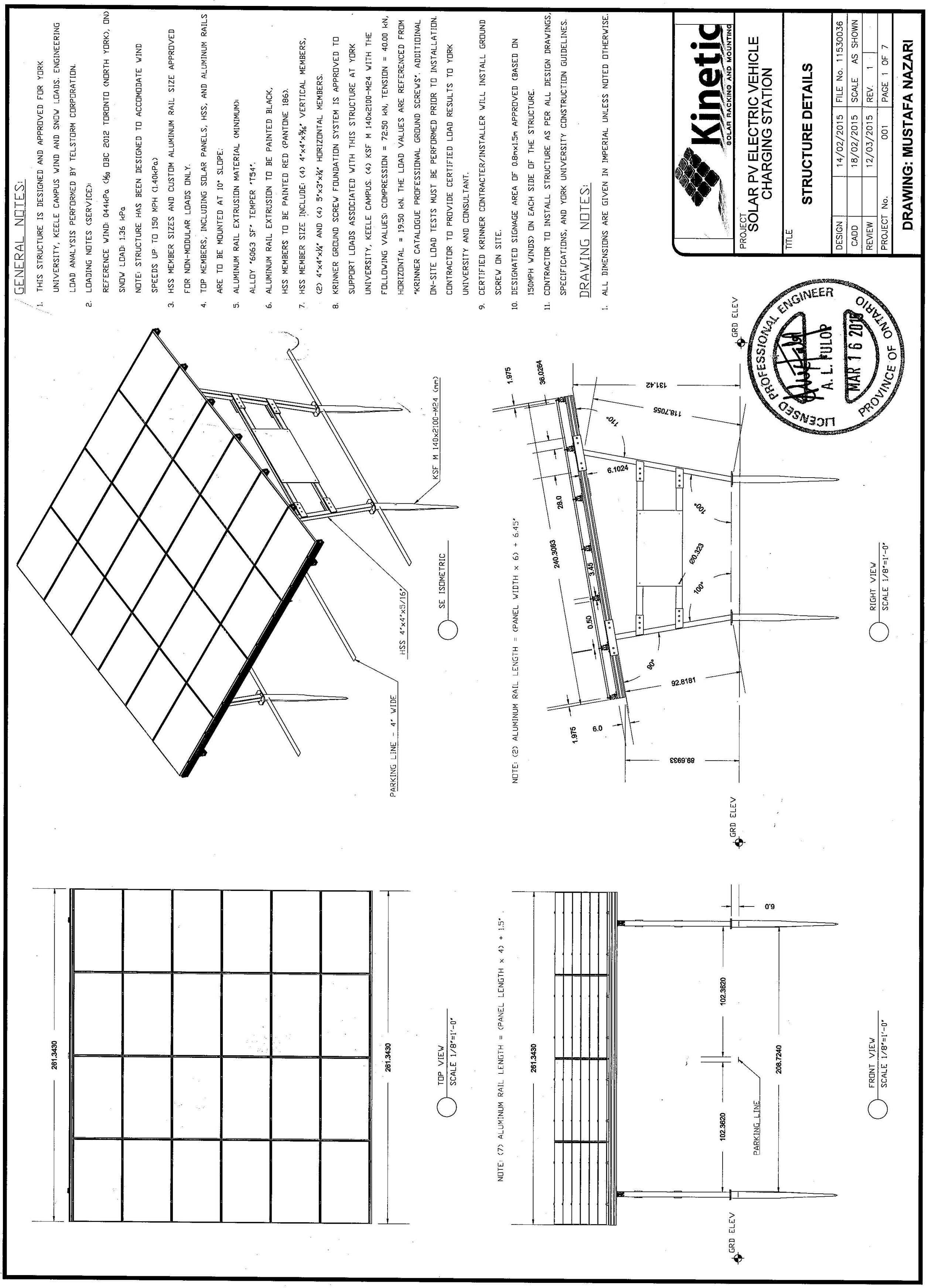
Length: 7.00 m
Width: 7.00 m
Azimuth: 170.00 °
Slope: 10.00 °
Total Modules: 24

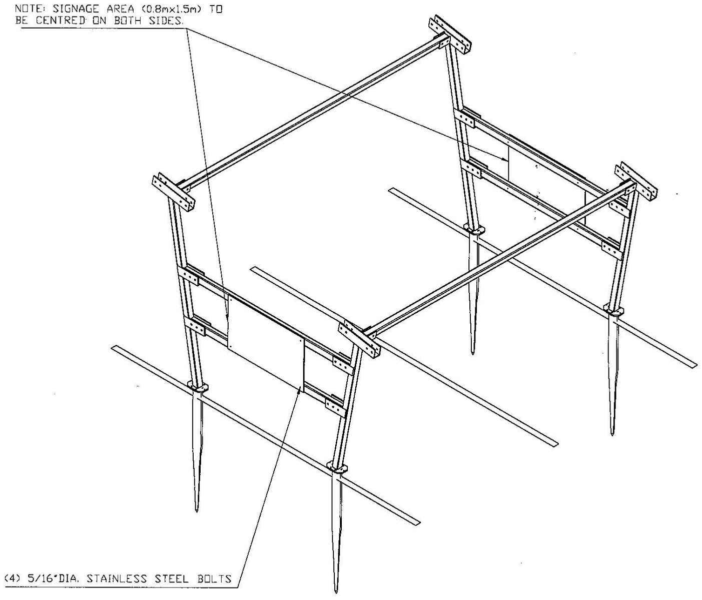
Color	Solar Access
	95%
	90%



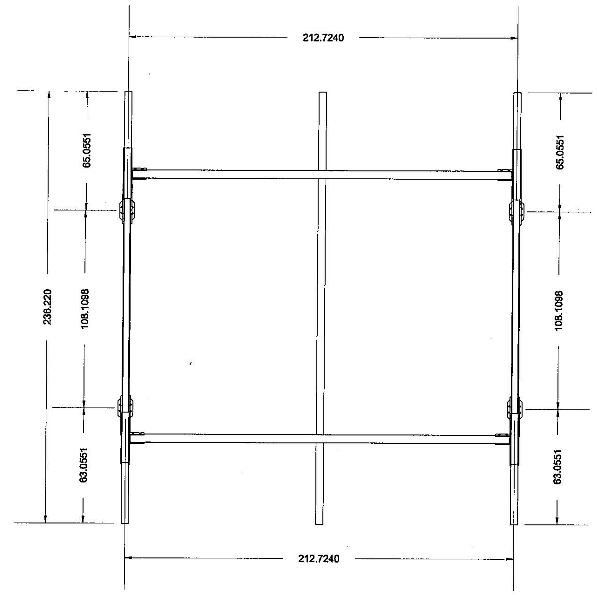
Solmetric

Appendix K – Stamped and Approved Engineering Drawings

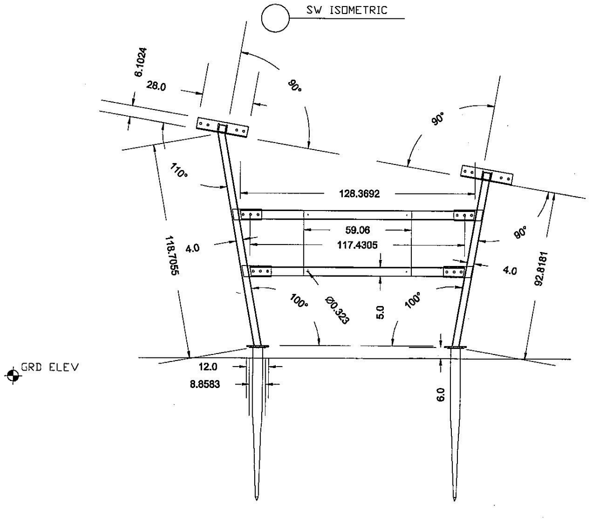




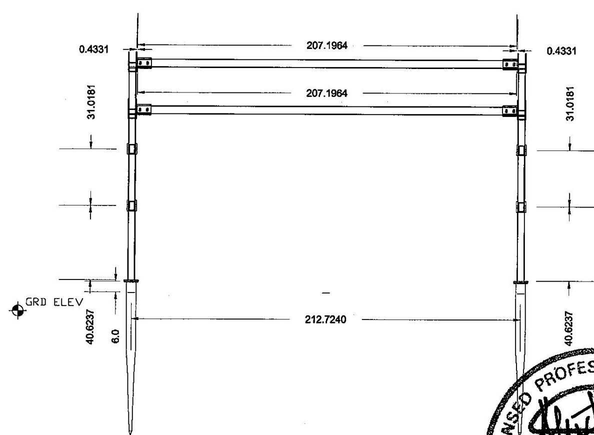
SW ISOMETRIC



TOP VIEW
SCALE 1/8"=1'-0"



LEFT VIEW
SCALE 1/8"=1'-0"



FRONT VIEW
SCALE 1/8"=1'-0"

GENERAL NOTES:

1. THIS STRUCTURE IS DESIGNED AND APPROVED FOR YORK UNIVERSITY, KEELE CAMPUS WIND AND SNOW LOADS. ENGINEERING LOAD ANALYSIS PERFORMED BY TELSTORM CORPORATION.
2. LOADING NOTES (SERVICE):
   REFERENCE WIND: 044kPa (1/50 OBC 2012 TORONTO (NORTH YORK), ON)
   SNOW LOAD: 1.36 kPa
   NOTE: STRUCTURE HAS BEEN DESIGNED TO ACCOMODATE WIND SPEEDS UP TO 150 MPH (1.40kPa)
3. HSS MEMBER SIZES AND CUSTOM ALUMINUM RAIL SIZE APPROVED FOR NON-MODULAR LOADS ONLY.
4. TOP MEMBERS, INCLUDING SOLAR PANELS, HSS, AND ALUMINUM RAILS ARE TO BE MOUNTED AT 10° SLOPE.
5. ALUMINUM RAIL EXTRUSION MATERIAL (MINIMUM): ALLOY "6063 SF" TEMPER "T54".
6. ALUMINUM RAIL EXTRUSION TO BE PAINTED BLACK, HSS MEMBERS TO BE PAINTED RED (PANTONE 186).
7. HSS MEMBER SIZE INCLUDE: (4) 4"x4"x5/16" VERTICAL MEMBERS, (2) 4"x4"x1/4" AND (4) 5"x3"x1/4" HORIZONTAL MEMBERS.
8. KRINNER GROUND SCREW FOUNDATION SYSTEM IS APPROVED TO SUPPORT LOADS ASSOCIATED WITH THIS STRUCTURE AT YORK UNIVERSITY, KEELE CAMPUS. (4) KSF M 140x2100-M24 WITH THE FOLLOWING VALUES: COMPRESSION = 72.50 kN, TENSION = 40.00 kN, HORIZONTAL = 19.50 kN. THE LOAD VALUES ARE REFERENCED FROM "KRINNER CATALOGUE PROFESSIONAL GROUND SCREWS". ADDITIONAL ON-SITE LOAD TESTS MUST BE PERFORMED PRIOR TO INSTALLATION. CONTRACTOR TO PROVIDE CERTIFIED LOAD RESULTS TO YORK UNIVERSITY AND CONSULTANT.
9. CERTIFIED KRINNER CONTRACTER/INSTALLER WILL INSTALL GROUND SCREW ON SITE.
10. DESIGNATED SIGNAGE AREA OF 0.8mx1.5m APPROVED (BASED ON 150MPH WINDS) ON EACH SIDE OF THE STRUCTURE.
11. CONTRACTOR TO INSTALL STRUCTURE AS PER ALL DESIGN DRAWINGS, SPECIFICATIONS, AND YORK UNIVERSITY CONSTRUCTION GUIDELINES.

DRAWING NOTES:

1. ALL DIMENSIONS ARE GIVEN IN IMPERIAL UNLESS NOTED OTHERWISE.

LICENSED PROFESSIONAL ENGINEER
A. L. FULOP
MAR 16 2015
PROVINCE OF ONTARIO

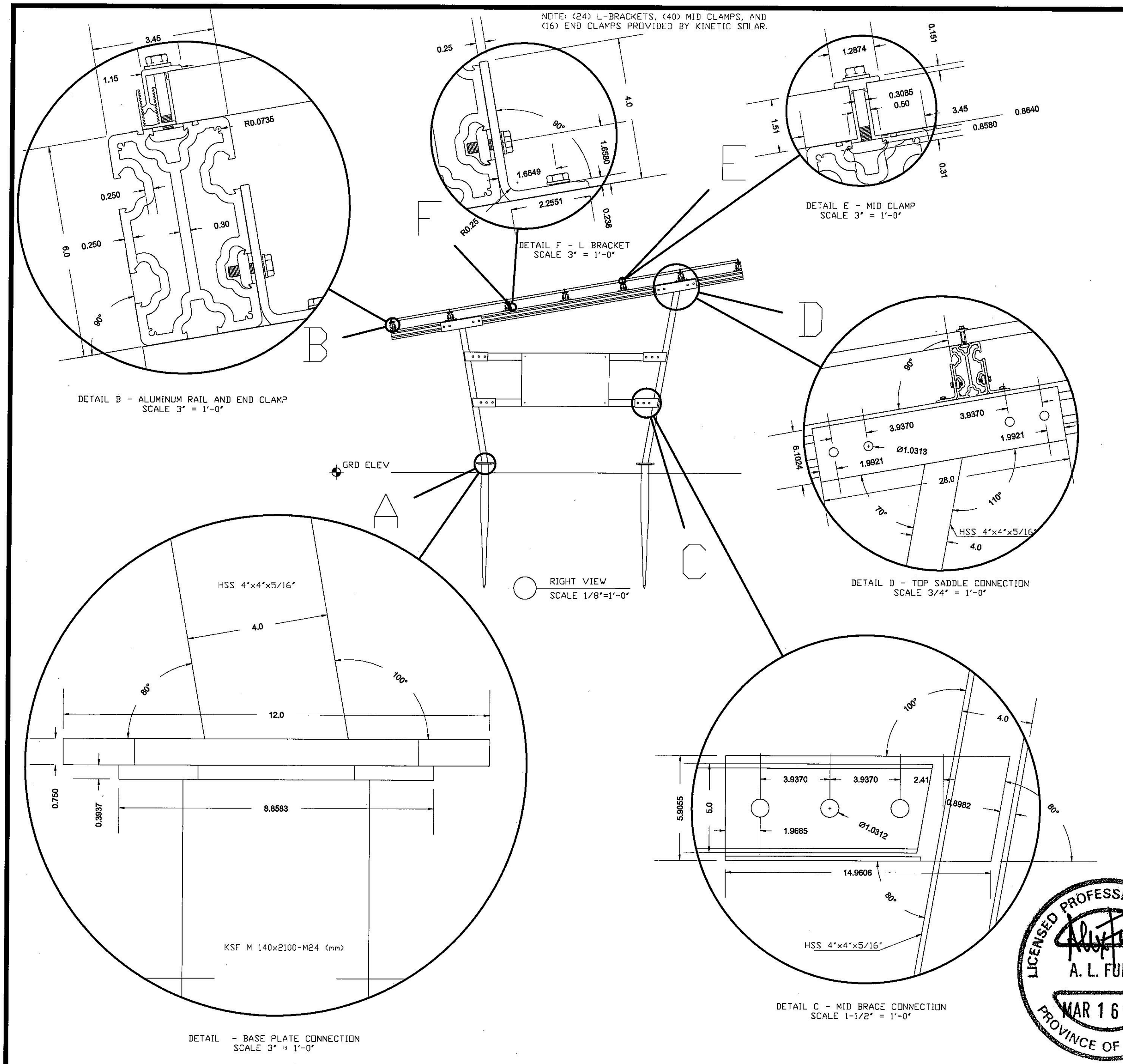
Kinetic
SOLAR RACKING AND MOUNTING

PROJECT
SOLAR PV ELECTRIC VEHICLE CHARGING STATION

TITLE
STEEL STRUCTURE FRAME

DESIGN	14/02/2015	FILE No.	11530036
CADD	18/02/2015	SCALE	AS SHOWN
REVIEW	12/03/2015	REV.	1
PROJECT No.	001	PAGE 2 OF 7	

DRAWING: MUSTAFA NAZARI



GENERAL NOTES:

1. THIS STRUCTURE IS DESIGNED AND APPROVED FOR YORK UNIVERSITY, KEELE CAMPUS WIND AND SNOW LOADS. ENGINEERING LOAD ANALYSIS PERFORMED BY TELSTORM CORPORATION.
2. LOADING NOTES (SERVICE):
   REFERENCE WIND: 044kPa (1/50 OBC 2012 TORONTO (NORTH YORK), ON)
   SNOW LOAD: 1.36 kPa
   NOTE: STRUCTURE HAS BEEN DESIGNED TO ACCOMODATE WIND SPEEDS UP TO 150 MPH (1.40kPa)
3. HSS MEMBER SIZES AND CUSTOM ALUMINUM RAIL SIZE APPROVED FOR NON-MODULAR LOADS ONLY.
4. TOP MEMBERS, INCLUDING SOLAR PANELS, HSS, AND ALUMINUM RAILS ARE TO BE MOUNTED AT 10° SLOPE.
5. ALUMINUM RAIL EXTRUSION MATERIAL (MINIMUM):
   ALLOY "6063 SF" TEMPER "T54".
6. ALUMINUM RAIL EXTRUSION TO BE PAINTED BLACK,
   HSS MEMBERS TO BE PAINTED RED (PANTONE 186).
7. HSS MEMBER SIZE INCLUDE: (4) 4"x4"x5/16" VERTICAL MEMBERS, (2) 4"x4"x1/4" AND (4) 5"x3"x1/4" HORIZONTAL MEMBERS.
8. KRINNER GROUND SCREW FOUNDATION SYSTEM IS APPROVED TO SUPPORT LOADS ASSOCIATED WITH THIS STRUCTURE AT YORK UNIVERSITY, KEELE CAMPUS. (4) KSF M 140x2100-M24 WITH THE FOLLOWING VALUES: COMPRESSION = 72.50 kN, TENSION = 40.00 kN, HORIZONTAL = 19.50 kN. THE LOAD VALUES ARE REFERENCED FROM "KRINNER CATALOGUE PROFESSIONAL GROUND SCREWS". ADDITIONAL ON-SITE LOAD TESTS MUST BE PERFORMED PRIOR TO INSTALLATION. CONTRACTOR TO PROVIDE CERTIFIED LOAD RESULTS TO YORK UNIVERSITY AND CONSULTANT.
9. CERTIFIED KRINNER CONTRACTER/INSTALLER WILL INSTALL GROUND SCREW ON SITE.
10. DESIGNATED SIGNAGE AREA OF 0.8mx1.5m APPROVED (BASED ON 150MPH WINDS) ON EACH SIDE OF THE STRUCTURE.
11. CONTRACTOR TO INSTALL STRUCTURE AS PER ALL DESIGN DRAWINGS, SPECIFICATIONS, AND YORK UNIVERSITY CONSTRUCTION GUIDELINES.

DRAWING NOTES:

1. ALL DIMENSIONS ARE GIVEN IN IMPERIAL UNLESS NOTED OTHERWISE.

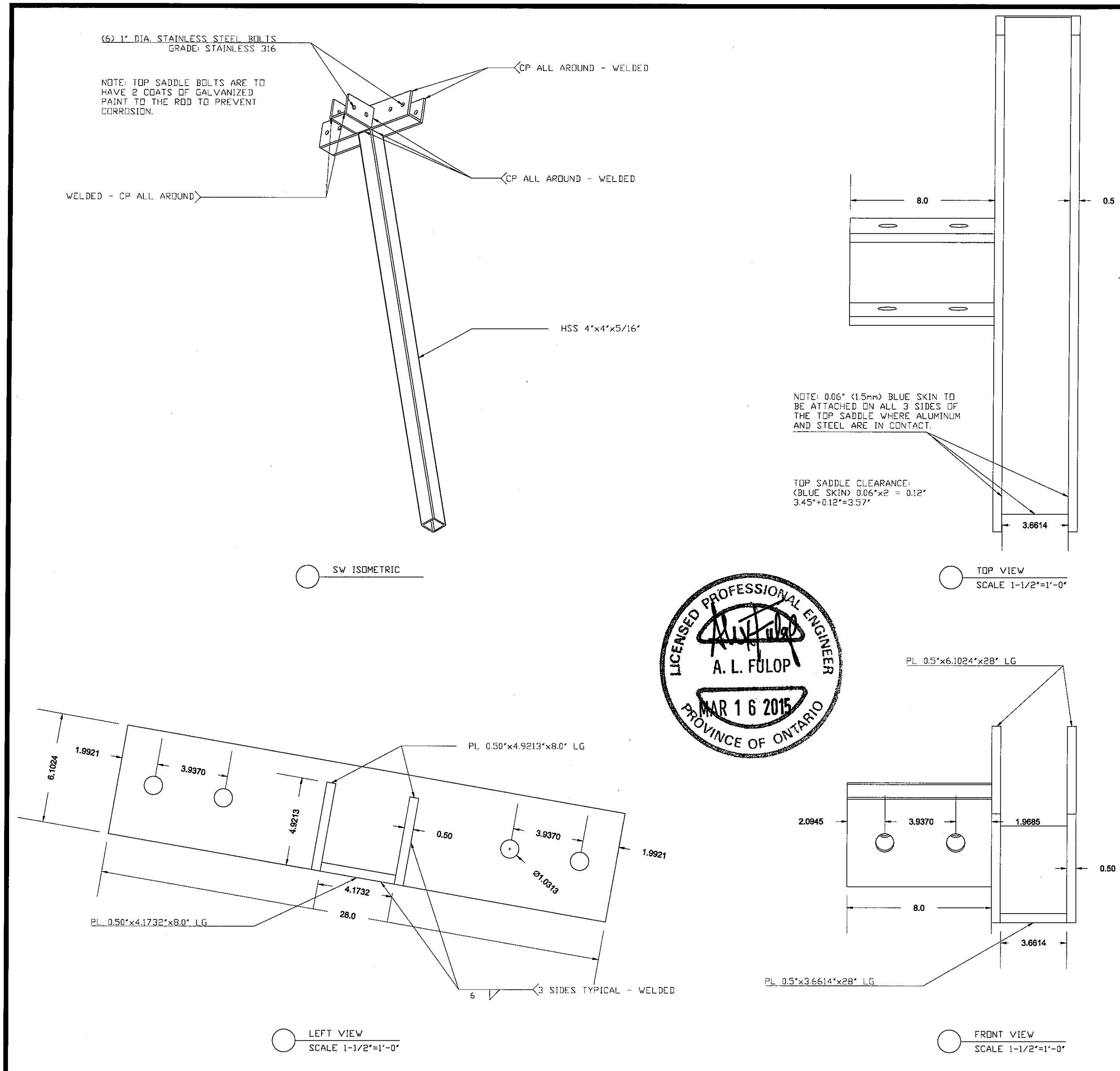
Kinetic
SOLAR RACKING AND MOUNTING

PROJECT
SOLAR PV ELECTRIC VEHICLE CHARGING STATION

TITLE
RAIL AND CONNECTION DETAILS

DESIGN	14/02/2015	FILE No.	11530036
CADD	18/02/2015	SCALE	AS SHOWN
REVIEW	12/03/2015	REV.	1
PROJECT No.	001	PAGE 3 OF 7	

DRAWING: MUSTAFA NAZARI



GENERAL NOTES:

1. THIS STRUCTURE IS DESIGNED AND APPROVED FOR YORK UNIVERSITY, KEELE CAMPUS WIND AND SNOW LOADS. ENGINEERING LOAD ANALYSIS PERFORMED BY TELSTORM CORPORATION.
2. LOADING NOTES (SERVICE):
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   NOTE: STRUCTURE HAS BEEN DESIGNED TO ACCOMODATE WIND SPEEDS UP TO 150 MPH (1.40kPa)
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6. ALUMINUM RAIL EXTRUSION TO BE PAINTED BLACK, HSS MEMBERS TO BE PAINTED RED (PANTONE 186).
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11. CONTRACTOR TO INSTALL STRUCTURE AS PER ALL DESIGN DRAWINGS, SPECIFICATIONS, AND YORK UNIVERSITY CONSTRUCTION GUIDELINES.

DRAWING NOTES:

1. ALL DIMENSIONS ARE GIVEN IN IMPERIAL UNLESS NOTED OTHERWISE.

Kinetic
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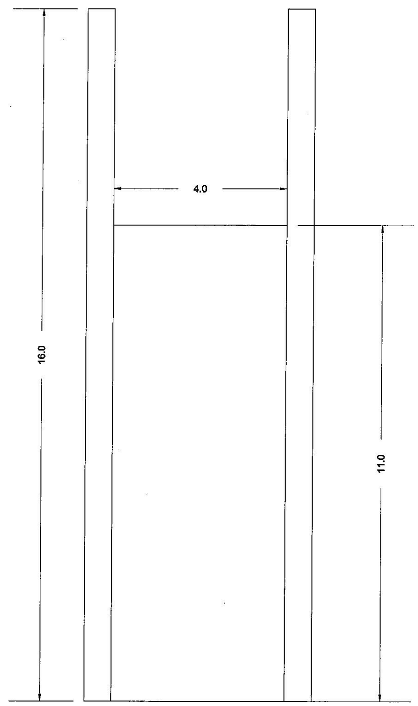
PROJECT
SOLAR PV ELECTRIC VEHICLE CHARGING STATION

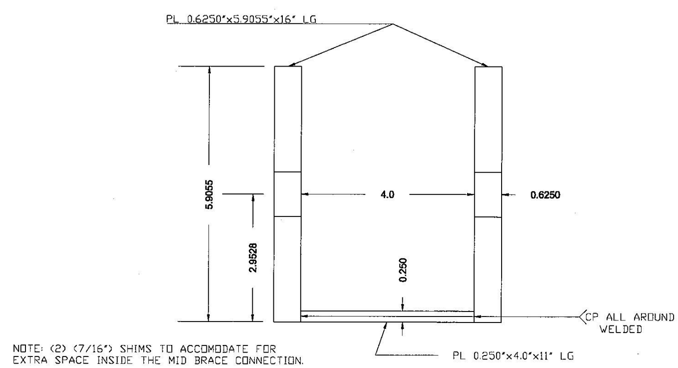
TITLE
TOP SADDLE CONNECTION

DESIGN	14/02/2015	FILE No. 11530036	
CADD	18/02/2015	SCALE	AS SHOWN
REVIEW	12/03/2015	REV.	1
PROJECT No.	001	PAGE 4 OF 7	

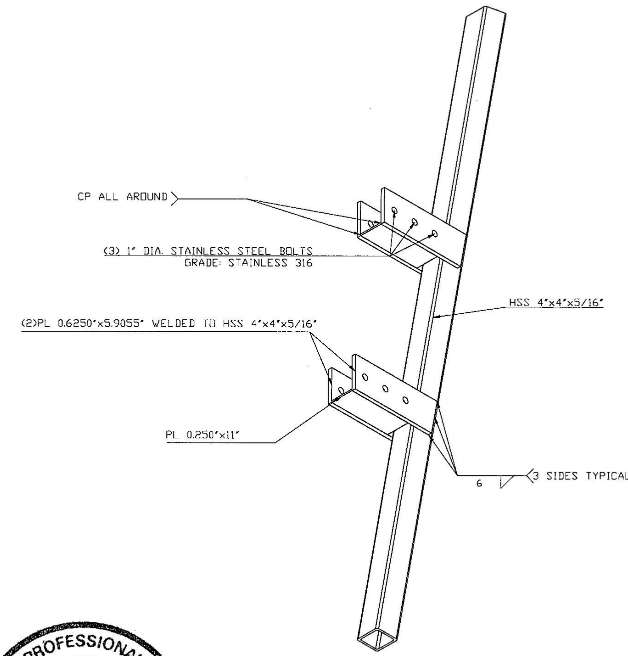
DRAWING: MUSTAFA NAZARI



TOP VIEW
SCALE 3"=1'-0"



FRONT VIEW
SCALE 3"=1'-0"



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LICENSED PROFESSIONAL ENGINEER
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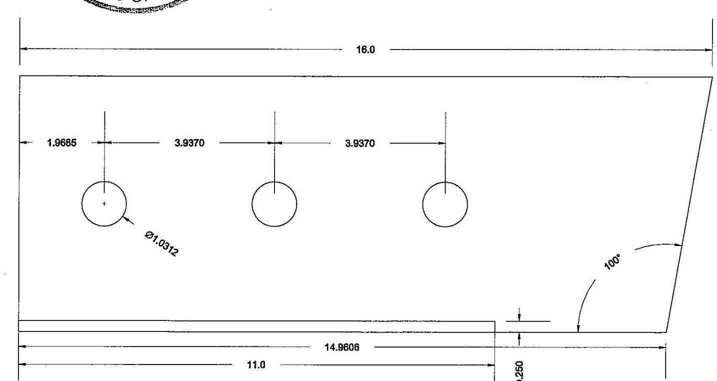

RIGHT VIEW
SCALE 3"=1'-0"

GENERAL NOTES:

1. THIS STRUCTURE IS DESIGNED AND APPROVED FOR YORK UNIVERSITY, KEELE CAMPUS WIND AND SNOW LOADS. ENGINEERING LOAD ANALYSIS PERFORMED BY TELSTORM CORPORATION.
2. LOADING NOTES (SERVICE):
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DRAWING NOTES:

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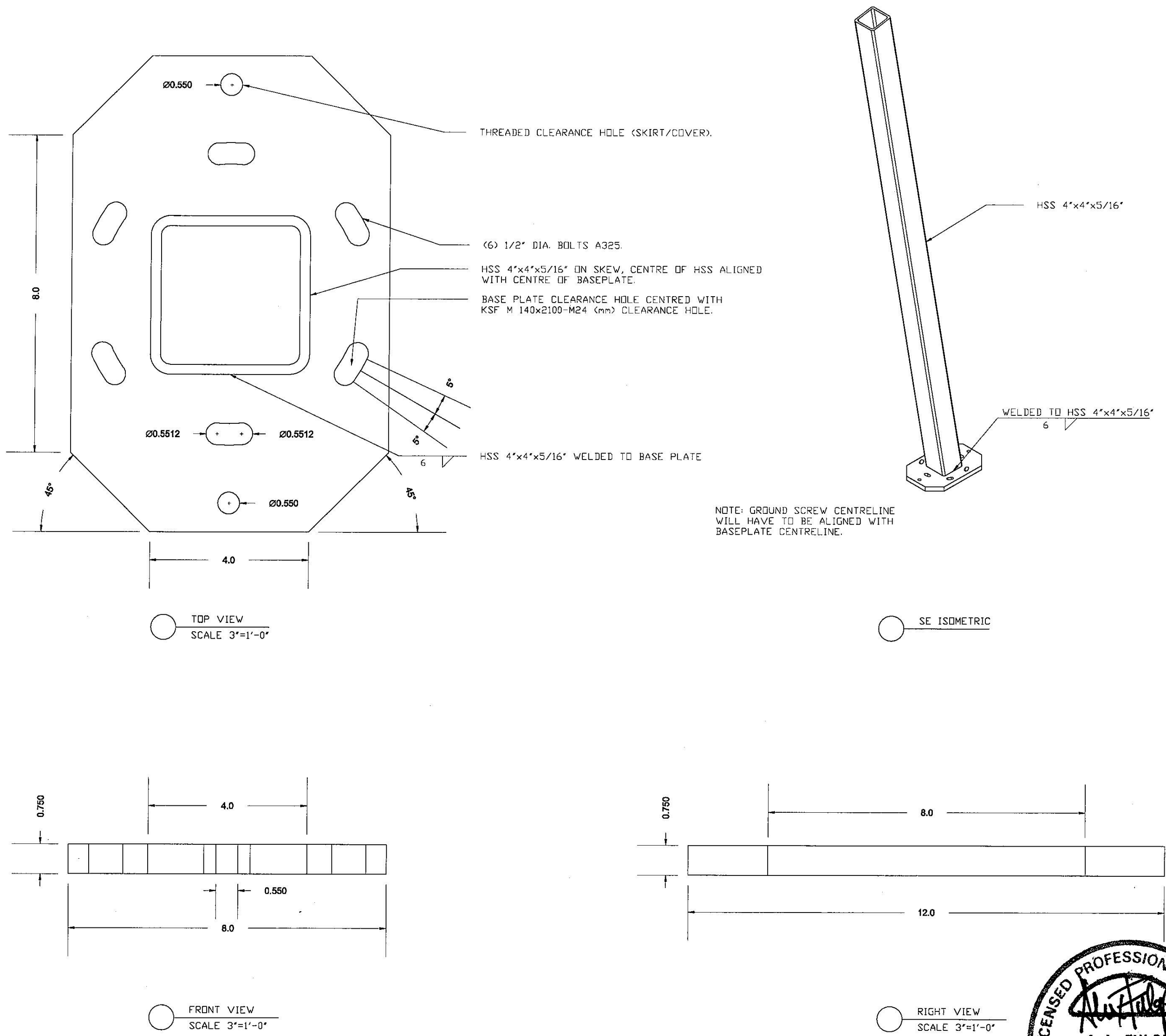
Kinetic
SOLAR RACKING AND MOUNTING

PROJECT
SOLAR PV ELECTRIC VEHICLE CHARGING STATION

TITLE
MID BRACE CONNECTION

DESIGN	14/02/2015	FILE No.	11530036
CADD	18/02/2015	SCALE	AS SHOWN
REVIEW	12/03/2015	REV.	1
PROJECT No.	001	PAGE	5 OF 7

DRAWING: MUSTAFA NAZARI



GENERAL NOTES:

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   NOTE: STRUCTURE HAS BEEN DESIGNED TO ACCOMODATE WIND SPEEDS UP TO 150 MPH (1.40kPa)
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5. ALUMINUM RAIL EXTRUSION MATERIAL (MINIMUM): ALLOY "6063 SF" TEMPER "T54".
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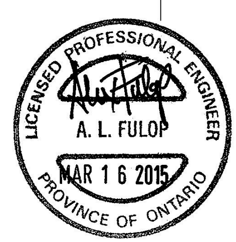

PROJECT SOLAR PV ELECTRIC VEHICLE CHARGING STATION			
TITLE **BASE PLATE CONNECTION**			
DESIGN		14/02/2015	FILE No. 11530036
CADD		18/02/2015	SCALE AS SHOWN
REVIEW		12/03/2015	REV. 1
PROJECT No.		001	PAGE 6 OF 7

DRAWING: MUSTAFA NAZARI

STRUCTURAL STEEL, ALUMINUM, AND GENERAL NOTES PROVIDED BY TELSTORM CORPORATION

STRUCTURAL STEEL NOTES:

1. CONTRACTOR IS RESPONSIBLE FOR FOLLOWING ALL CURRENT CODES, REGULATIONS, AND STANDARDS SPECIFIED ON THIS SHEET.
2. ALL STRUCTURAL STEEL FABRICATION AND CONSTRUCTION SHALL CONFORM TO THE REQUIREMENTS OF CAN/C.S.A.-S16.1 AND CAN/C.S.A.-G40.20/G40.21 FOR 300W AND 350W STEEL.
3. ALL COLD FORMED STEEL FABRICATION AND CONSTRUCTION SHALL CONFORM TO THE REQUIREMENTS OF C.S.A.-S136.
4. ALL WELDING SHALL CONFORM TO THE REQUIREMENTS OF C.S.A.-W59-M (METAL ARC WELDING) AND BE PERFORMED BY ORGANIZATIONS APPROVED BY THE CANADIAN BUREAU CERTIFIED TO THE REQUIREMENTS OF C.S.A.-W47.1. ELECTRODES TO BE USED ARE E480XX UNLESS NOTED OTHERWISE.
5. ALL EXPOSED STRUCTURAL STEEL TO BE HOT-DIPPED GALVANIZED MEETING THE REQUIREMENTS OF C.S.A.-G164.
6. ALL STRUCTURAL STEEL BOLTS TO BE 19mm DIA., HIGH STRENGTH STEEL CONFORMING TO ASTM A325 UNLESS NOTED OTHERWISE.
7. ALL ANCHOR BOLTS, U-BOLTS, THREADED RODS SHALL MEET THE SPECIFICATIONS OF ASTM A307, GRADE C.
8. ALL DAMAGED OR FIELD CUT AREAS OF GALVANIZED STEEL MUST BE REPAIRED USING TWO COATS OF ZINC-RICH PAINT (i.e. GALVACON).
9. ALL BEARING PLATES FOR STRUCTURAL STEEL MUST BE CENTERED UNDER SUPPORTING ELEMENTS.
10. CONTRACTOR SHALL PROVIDE THREE SETS OF STRUCTURAL STEEL, METAL DECKING AND/OR O.W.S.J. SHOP DRAWINGS TO THE CONSULTANT FOR REVIEW PRIOR TO FABRICATION.

ALUMINUM NOTES:

1. ALL ALUMINUM MEMBERS TO BE DESIGNED IN ACCORDANCE WITH THE ALUMINUM DESIGN MANUAL, BY THE ALUMINUM ASSOCIATION INC. (LATEST EDITION)
2. ALL ALUMINUM TO STEEL CONNECTIONS TO BE BOLTED.
3. PROVIDE PROTECTION BETWEEN STEEL AND ALUMINUM MEMBERS.
4. WHEN STEEL BOLTS ARE USED THEY SHALL BE HOT-DIP GALVANIZED, ZINC-ELECTRO PLATED, ALUMINIZED, OR 300 SERIES STAINLESS STEEL.
   WHEN OTHER PLATINGS AND/OR COATINGS ARE TO BE USED, EVIDENCE SHALL BE SUBMITTED TO SUBSTANTIATE THE CORROSION RESISTANCE OF THESE PRODUCTS.
5. WHEN ALUMINUM ALLOY PARTS ARE IN DIRECT CONTACT WITH STEEL, THE STEEL MEMBERS SHALL BE PAINTED WITH GOOD QUALITY NON LEAD CONTAINING PRIMING PAINT, SUCH AS ZINC MOLYBDATE, ALKYD TYPE PRIMER IN ACCORDANCE WITH U.S. FEDERAL SPECIFICATION TT-P-645B, FOLLOWED BY TWO COATS OF PAINT CONSISTING OF 2lb OF ALUMINUM PASTE PIGMENT (ASTM SPECIFICATION D962-81,TYPE 2, CLASS B) PER GALLON OF VARNISH MEETING U.S. FEDERAL SPECIFICATION TT-V-81, TYPE II, OR THE EQUIVALENT.
   PROVIDE ADDITIONAL PROTECTION BY APPLYING SUITABLE SEALANT TO THE FAYING SURFACES TO PREVENT MOISTURE FROM ENTERING THE JOINT.

GENERAL NOTES:

1. DRAWINGS ARE NOT TO BE SCALED. CONTRACTOR TO REFERENCE DIMENSIONS GIVEN ON DRAWINGS.
2. CONTRACTOR TO EXAMINE ALL SITE CONDITIONS PRIOR TO ANY CONSTRUCTION ACTIVITIES TAKING PLACE. THE CONTRACTOR IS TO NOTIFY THE CONSULTANT OF ANY DISCREPANCIES, OMISSIONS, OR CHANGES IN SITE CONDITIONS PRIOR TO PROCEEDING WITH THE WORK.
3. CONTRACTOR TO FIELD VERIFY ALL DIMENSIONS REFERENCED ON DRAWINGS. NOTIFY CONSULTANT OF ANY DISCREPANCIES.
4. CONTRACTOR SHALL NOT CUT ADDITIONAL HOLES, OTHER THAN THOSE SHOWN ON DRAWINGS THROUGH WALLS, BEAMS, AND/OR OTHER ELEMENTS WITHOUT THE PRIOR APPROVAL OF THE CONSULTANT.
5. REFER TO DRAWING SPECIFIC NOTES, SCHEDULES, AND DETAILS FOR WORK REQUIRED.
6. FEATURES OF CONSTRUCTION NOT FULLY SHOWN ARE OF THE SAME CHARACTER AS THOSE NOTED FOR SIMILAR CONDITIONS.
7. ALL MATERIALS INDICATED ON THE DRAWINGS ARE NEW UNLESS NOTED OTHERWISE.
8. CONTRACTOR SHALL ABIDE BY ALL CURRENT FEDERAL, PROVINCIAL, AND LOCAL CODES AND REGULATIONS IN CARRYING OUT THE WORK, AND ABIDE BY THE REQUIREMENTS OF THE OCCUPATIONAL HEALTH AND SAFETY ACT.
9. CONTRACTOR TO ENSURE THAT EXISTING STRUCTURES ARE FULLY PROTECTED DURING CONSTRUCTION. THE CONTRACTOR WILL BE RESPONSIBLE FOR ALL DAMAGES CAUSED BY THEIR FORCES.
10. THE STRUCTURE SHOWN ON THESE DRAWINGS HAS BEEN DESIGNED IN ACCORDANCE WITH ALL REQUIRED CURRENT BUILDING CODES AND REGULATIONS IN THE MUNICIPALITY IN WHICH THE STRUCTURE WILL BE BUILT.
11. CONTRACTOR NOT TO APPLY ANY CONSTRUCTION LOADS WHICH EXCEED THE BUILDING'S ORIGINAL DESIGN LOADS.
12. CONTRACTOR SHALL PROVIDE TEMPORARY SUPPORTS WHERE REQUIRED.
13. ALL ELEMENTS SHOWN ON THESE DRAWINGS HAVE BEEN DESIGNED USING LIMIT STATES DESIGN.
14. CONTRACTOR SHALL SUBMIT TO THE CONSULTANT THREE SETS OF FABRICATION / ERECTION DRAWINGS PRIOR TO FABRICATION.
    CONTRACTOR IS RESPONSIBLE FOR LOCATING ALL BURIED SERVICES AND UTILITIES PRIOR TO EXCAVATING, AND FOR COORDINATING WITH LOCAL UTILITIES FOR THE WORK REQUIRED.
15. FOLLOW ALL MANUFACTURER'S INSTRUCTIONS AND SPECIFICATIONS FOR MATERIALS USED TO CARRY OUT THE WORK.
16. ALL REPAIR WORK REQUIRED BY THE CONTRACTOR DUE TO THE WORK PERFORMED SHALL BE TO MATCH THE ORIGINAL CONDITION OR BETTER.
17. CONTRACTOR IS RESPONSIBLE FOR FULLY UNDERSTANDING AND ADHERING TO ALL REQUIREMENTS STATED ON THIS SHEET.

LICENSED PROFESSIONAL ENGINEER
A. L. FULOP
MAR 1 6 2015
PROVINCE OF ONTARIO

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SOLAR RACKING AND MOUNTING

PROJECT
SOLAR PV ELECTRIC VEHICLE CHARGING STATION

TITLE
PROJECT NOTES

DESIGN		14/02/2015	FILE No. 11530036
CADD		18/02/2015	SCALE AS SHOWN
REVIEW		12/03/2015	REV. 1
PROJECT No.		001	PAGE 7 OF 7

DRAWING: MUSTAFA NAZARI