York University

York Neighborhood renewables

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1.0 **Introduction/Literature Review**

Climate change is one of the greatest challenges of this generation. The rising costs of energy coupled with the environmental need to reduce anthropogenic carbon dioxide emissions have created pressures to develop renewable/sustainable energy resources (Agugiaro et al. 2011). The cost of photovoltaic systems has plummeted recently allowing the suns energy to be harnessed in a more direct and efficient manner (Feldman 2012).

Incident solar radiation is described as the solar radiation interaction of energy between Earth's atmosphere and the surface (Dubayah 1995). The radiation coming directly from the Sun and received at the Earth's surface is called direct solar radiation or insolation. Some of this solar energy is scattered, which is usually diffused. The energy budget of solar radiation can be derived by combining observations with modeling studies (Kahle, 2003). Insolation is measured in kilowatt hours per square meter per day ($kWh/m^2/day$). According to NASA surface meteorology and solar energy, Toronto receives between 2.71 $kWh/m^2/day$ in January to 5.24 $kWh/m^2/day$ in July (Stackhouse n.d.)

Solar photovoltaic technology converts the sun's radiant energy directly into electricity. The radiant energy from the sun in the form of photons bump electrons of the silicon out of orbit around their nuclei, creating a flow of electrons known as Direct Current (DC) electricity. Solar resource potential is quantified by the intensity of the sun's rays, hours of direct sunlight and daily temperatures. Ontario possesses good solar PV potential. In fact, Toronto's cooler climate will result in more electricity generation throughout the year (Eng 2008).

1.1 Research Statement

Our group aims to develop a solar installation model for the York University campus that takes into consideration the limitations of installing solar photovoltaic systems on all of the building rooftops across the campus. From this model we can determine which buildings receive the highest amounts of solar radiation for one year at York. This in turn will allow us to create a table showing each buildings ability for receiving solar energy. These maps are intended to provide beneficial information for governments and/or policy leaders, ultimately encouraging the development of a solar energy system at York University (Gastli & Charabi, 2010).

In order to fully understand the purpose of finding the solar potential for York University, it is essential to understand the context in which the project is undertaken. The staff and student population the size of the York Keele Campus is comparable to small cities. It is also a campus that has onsite generation, so connecting to the York grid with low transmission loss will decrease costs and increase efficiency. The school's dated electrical generation facilities can handle a peak load of 21 MW (Cochrane 2013). Its current system uses a natural gas driven combined heat and power plant. This system creates electricity and hot steam that then heats buildings throughout the campus (Cochrane 2013). The levelized cost of electricity, which takes into account the total price to generate electricity, it includes initial investment and cost of fuel. Due to the recurring fuel cost of natural gas, this cost can never go below the price of natural gas. On the other hand, photovoltaic have no fuel cost. Once initial investment has been recuperated the remaining electricity is virtually free.

1.2 Hypothesis

The York University Keele Campus buildings have the potential, in both infrastructural and solar terms to support solar photovoltaic generation facilities on their rooftops.

Through the literature reviews, and data analysis, the groups aims to establish a clear display of the York University Campus, and the buildings on site which can be used in order to generate energy for the campus grid through rooftop solar photovoltaic generation facilities.

2.0 Data & Methods

2.1 Study Area

Our study area is the York University Keele campus located in Toronto, Ontario that covers a geographical area of 1.85 square kilometers (Ontario Universities' Application Centre 2014). Specifically, we are looking at the areas on top of the buildings on campus, and from here we will calculate which roof tops possess the best solar potential.

2.2 Data

First our group had to acquire a polygon layer that contained all of the buildings on campus. We retrieved this data from Scholars Geoportal. Once we had the building polygons we overlaid them with a campus map layer which was accessible on York's website. After we had the building layer and the campus map, we found a Digital Elevation model (DEM) for Toronto and overlayed the building polygon layer over the York Campus. This allowed us to perform a solar irradiance potential on our layers, thus showing the solar potential for each building on campus.

2.3 Methodology

Topography is a major part of determining the incident solar radiation at any point on the earth (Dubaya 1995). Variability in elevation, slope, orientation, and shadowing can all dramatically change the ground level insolation (Holland and Steyn 1975). In light of this, it is common practice to use a digital elevation model in combination with built in algorithms in GIS software (Dubayah 1994, Kumar et. al. 1997, Fu and Rich 2002, Piedallu and Gégout 2008).

In order to ensure accurate assessment of solar potential, topography and buildings must be included. From the two dimensional shapefile of the York campus, the three dimensional objects can be rendered based on the heights listed in the attributes table. This layer can be added to the digital elevation map to create a single layer to run through the solar radiation algorithm. Once completed, the insolation map can be clipped to show only the rooftops and other areas where photovoltaic can be installed. With this layer the total potential can be calculated based on 100% utilization.

Unfortunately, not all buildings on York's campus will support photovoltaics, therefore, this research can be combined with further engineering research and is therefore a continuous research process. Structural analysis of buildings on campus will determine which buildings can support the required weight. This collaborative work could then be sent to the utilities building and the Sustainable Energy Initiative for further analysis on the feasibility of these systems.

3.0 Results

3.1 Common Projection

Partial building shape files were downloaded from Scholars Geoportal that is projected in NAD 1983. Therefore, each of the files also used the NAD 1983 projection in order to maintain consistency.

3.2 Maps with Data Layers

1. York University Buildings Polygon layer
2. Toronto Digital Elevation Model (DEM)
3. Digital Elevation Model (DEM) & Buildings Polygon Layer of York University

3.3. Final Maps

The maps with the solar insolation of buildings at York show there is variance in the amount of radiation hitting each rooftop. For instance, Vari Hall and Accolade West (ACW) receive lower amount of solar radiation than other builds around campus. This trend seems to be consistent throughout the year, so there is could be some objects on the roof which are inhibiting direct solar radiation as the other buildings around campus seem to receive. Also, the months of Jan to April receive lower amounts of solar radiation than the months of May-August. This is due to there being higher insolation values in the summer month since the sun is high above the horizon and takes longer to set.

4.0 Discussion

With a complete insolation map of York University, it can be determined what the total electrical generation capacity is. A 390-Watt Monocrystalline Grid Tied PV Solar Panel from the Home Depot costs around $950 and is essentially maintenance free. The solar panel is capable of withstanding various weather conditions experienced at York, including snow and wind loads which are greater than 50 lbs/2 ft. with its low iron tempered glass. It weighs 78.2 lbs. and operates at 18% efficiency. At the standard insolation level for Toronto in January (2.71 kWh/m^2/day) this panel would generate 1.25 kWh/day. When insolation is at its highest point in the year for Toronto (5.24 kWh/m^2/day in July), this panel would generate 2.42kWh/day.

The mean Toronto yearly insolation is 3.98 kWh/m^2/day. At this rate a panel anywhere in Toronto would generate roughly 1.84 kWh/day. 100 solar panels would take up roughly 256 m^2. It would cost roughly $100,000 after installation and other costs. This array could generate 184 kWh/day or 67.16 MWh over 4% of the total energy demand at the university (Cochrane 2013). If this was tied into Ontario's Feed-In Tariff (FIT), this installation would sell its electricity generated at 32.9 cents/kWh. With this program, the panels would bring York roughly $61 per day and $22,000 per year. This would allow for return on investment time of around 5 years. Once the panels are paid for they will continue to operate and save the university money for the duration of their lives. The panel these calculations are based on are rated to retain 80% of its power output for 25 years. This means more than 20 years of free electricity.

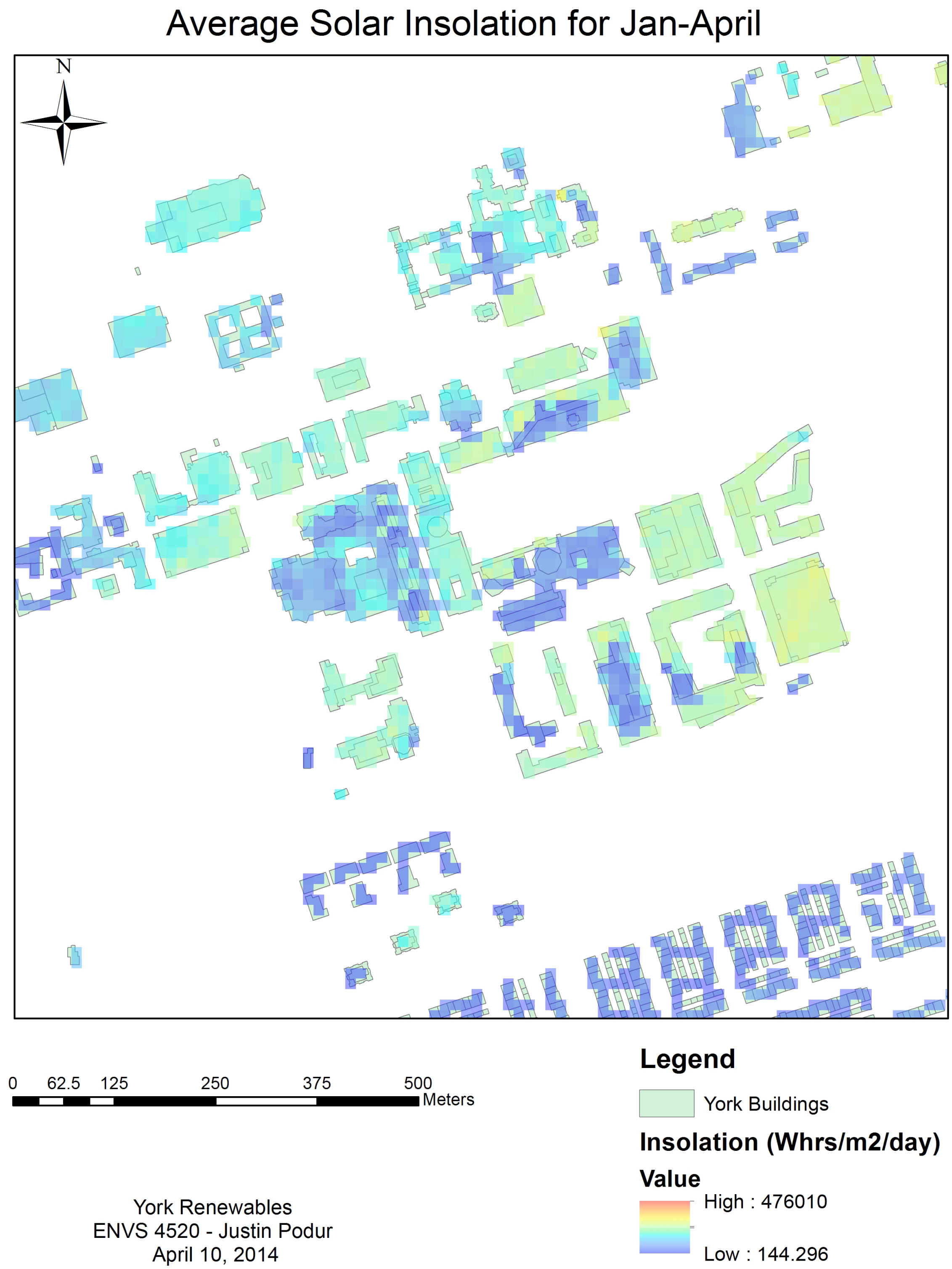
Some of the limitations experienced when conducting this project vary. One of the biggest limitations would be the extent of the data acquired. Additional and extensive research would be required to identify the specific buildings capable of honing solar energy to full efficiency and potential. The buildings that are capable of handling solar panels, from an infrastructural perspective need to be identified, and unfortunately our group did not have access to that form of information.

If this work were to continue, it would be possible to obtain the information for each building, and calculate the potential of York based directly on the buildings capable of participating. Also, in order to make these calculations as accurate as possible, collecting the varying solar radiation levels throughout the year would give up to date solar radiation levels that can be used to develop an accurate assessment of solar potential. A Solmetric Sun Eye can be used as an efficient tool in order to create estimates that are accurate, and also provide information such as shade free areas, elevation, incidence angles, as well as rooftop measurements. Because of the complexity of solar panel efficiency, there are various variables that require consideration in order to understand the correlation and causation between different factors which can increase or decrease efficiency. Also, in addition to the use of thermal heating as the center focus of solar energy production, the university could make the use of thermal cooling technologies, and broaden the energy production potential for the campus (Olivarez-Giles, 2009).

5.0 Conclusion

There are many variables that determine which buildings on the York University campus could handle new photovoltaic installations. First and foremost, it is whether the building receives significant shading throughout the day. Any building that has a major portion of the day blocked by a taller building would not be ideal for solar panels. Second, the building must be able to handle the additional load of the panels and mounting systems. Third, electrical infrastructure of the building must be able to support the addition of electrical generation capacity. The second and third issue must be calculated by civil and electrical engineers respectively, both of which York University has complete access to. With this work and the leadership of a few dedicated individuals, engineers from the various departments will be able to come together to produce a complete and accurate representation of how much photovoltaic capacity York University has. Then, a convincing case for the installation of photovoltaic can be made. This would help to wean York of the natural gas it currently uses.

Switching to clean, solar energy would empower York to be a sustainable school, and would be an investment into its future development. Solar panels would also reduce the vulnerability of the university since it would no longer have to worry about the severe blackouts that have happened over the past decade. The initiative would also help make York a leader in clean energy and a role model for other Canadian universities.



Average Solar Insolation for Jan-April
N
0
62.5
125
250
375
500
Meters
Legend
York Buildings
Insolation (Whrs/m2/day)
Value
High : 476010
Low : 144.296
York Renewables
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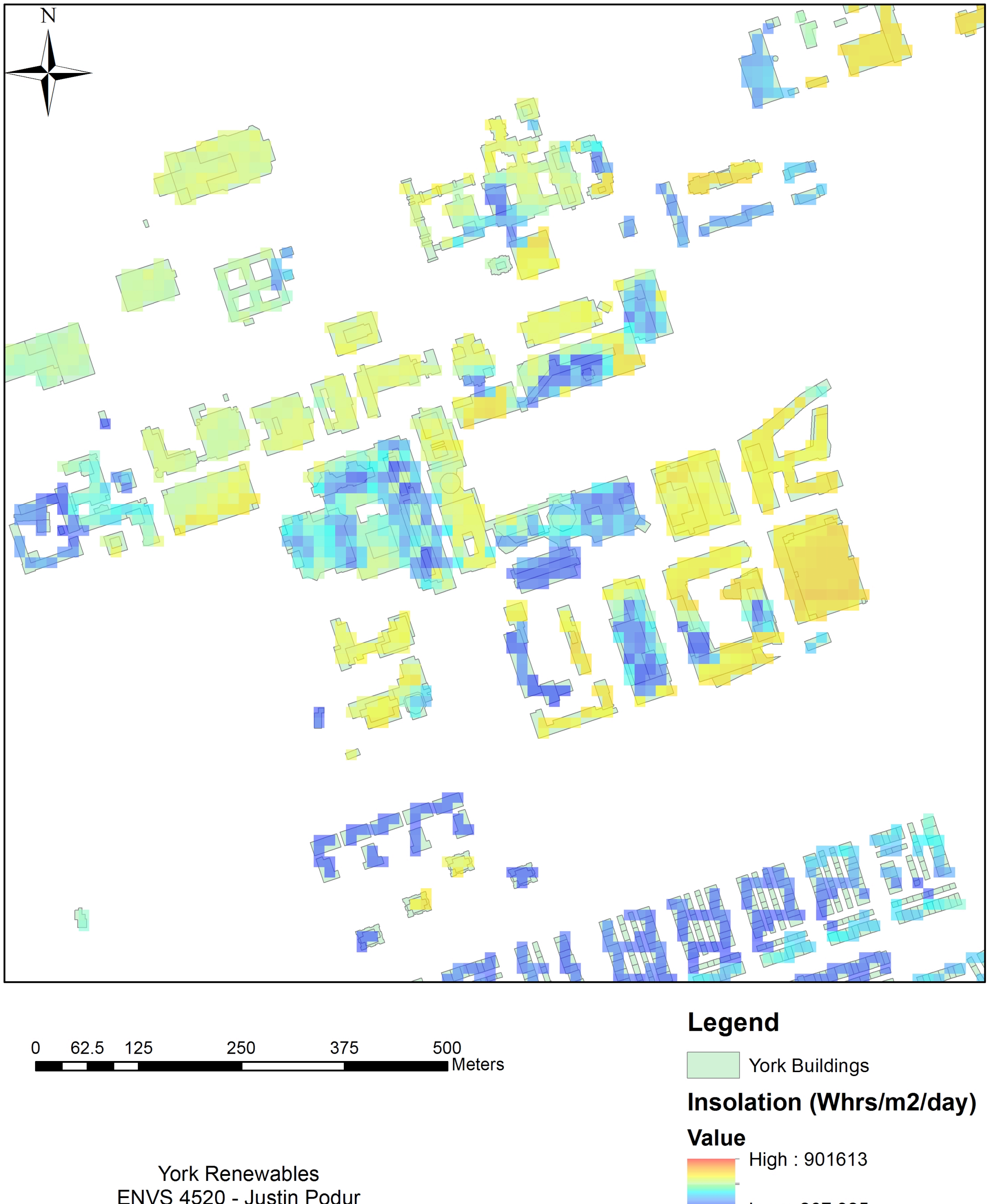
Average Solar Insolation for May-August



York Renewables
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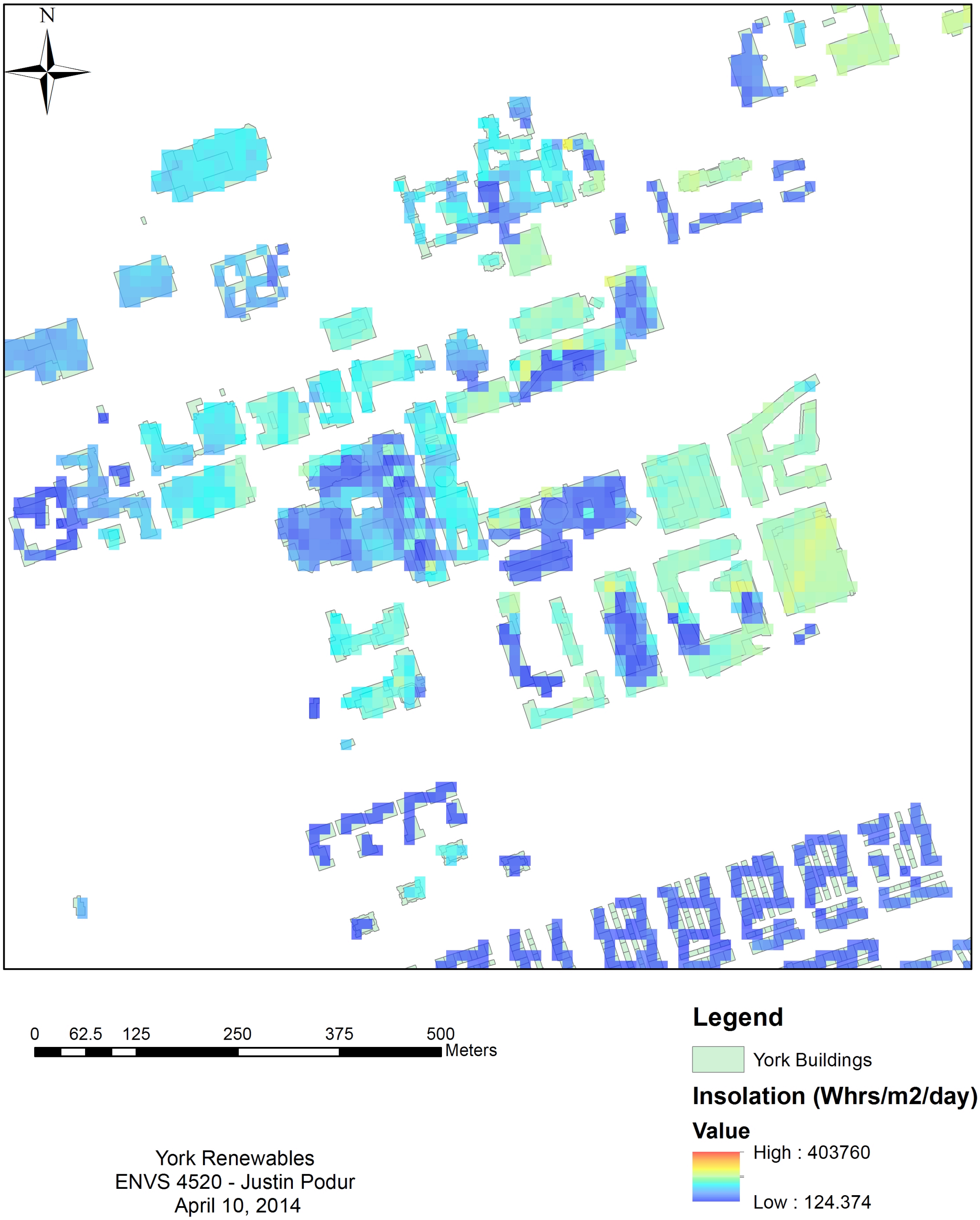
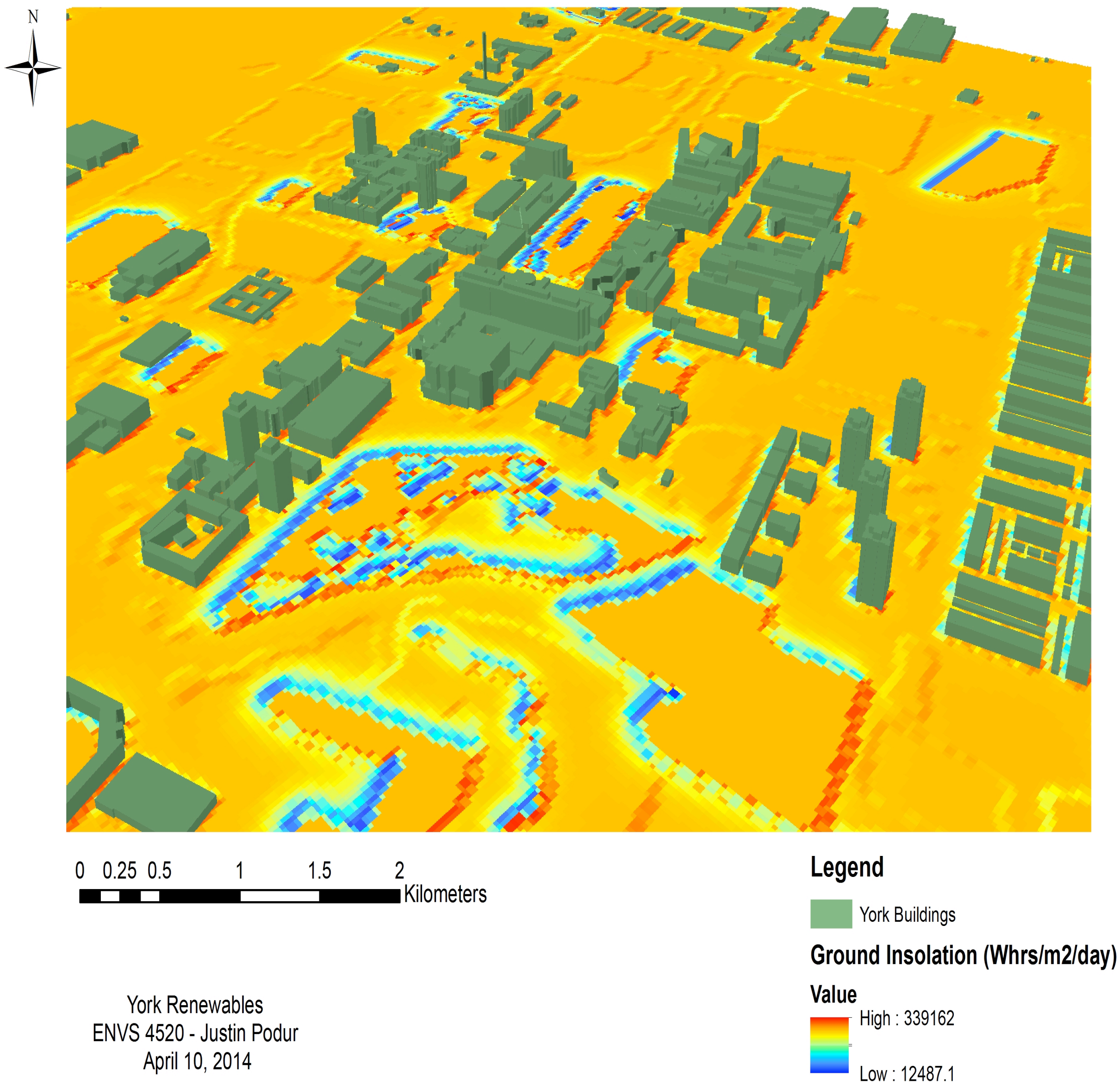
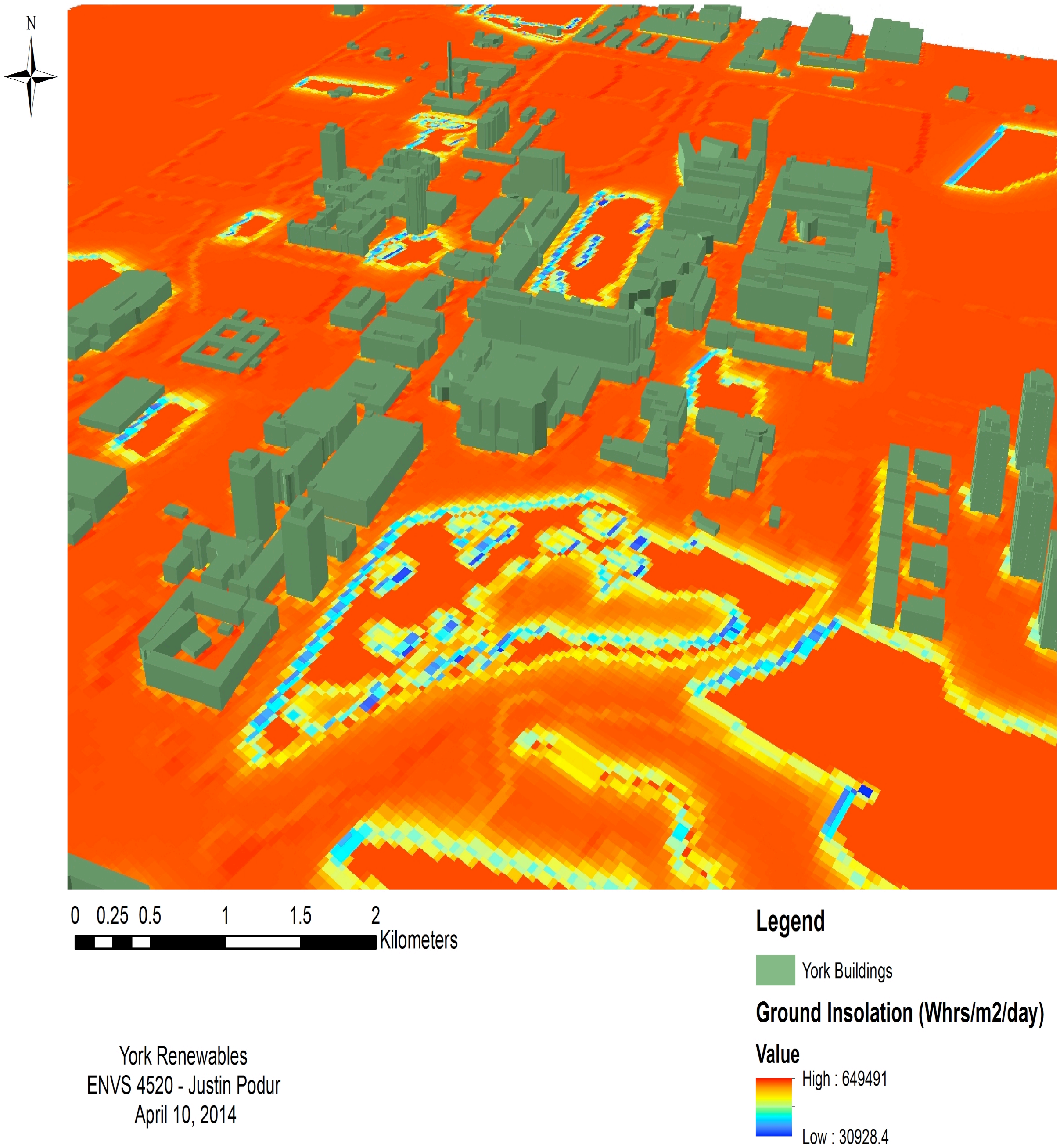
Average Solar Insolation for Sept-Dec



Average Ground Solar Insolation for Jan-April



Average Ground Solar Insolation for May-August



York Renewables
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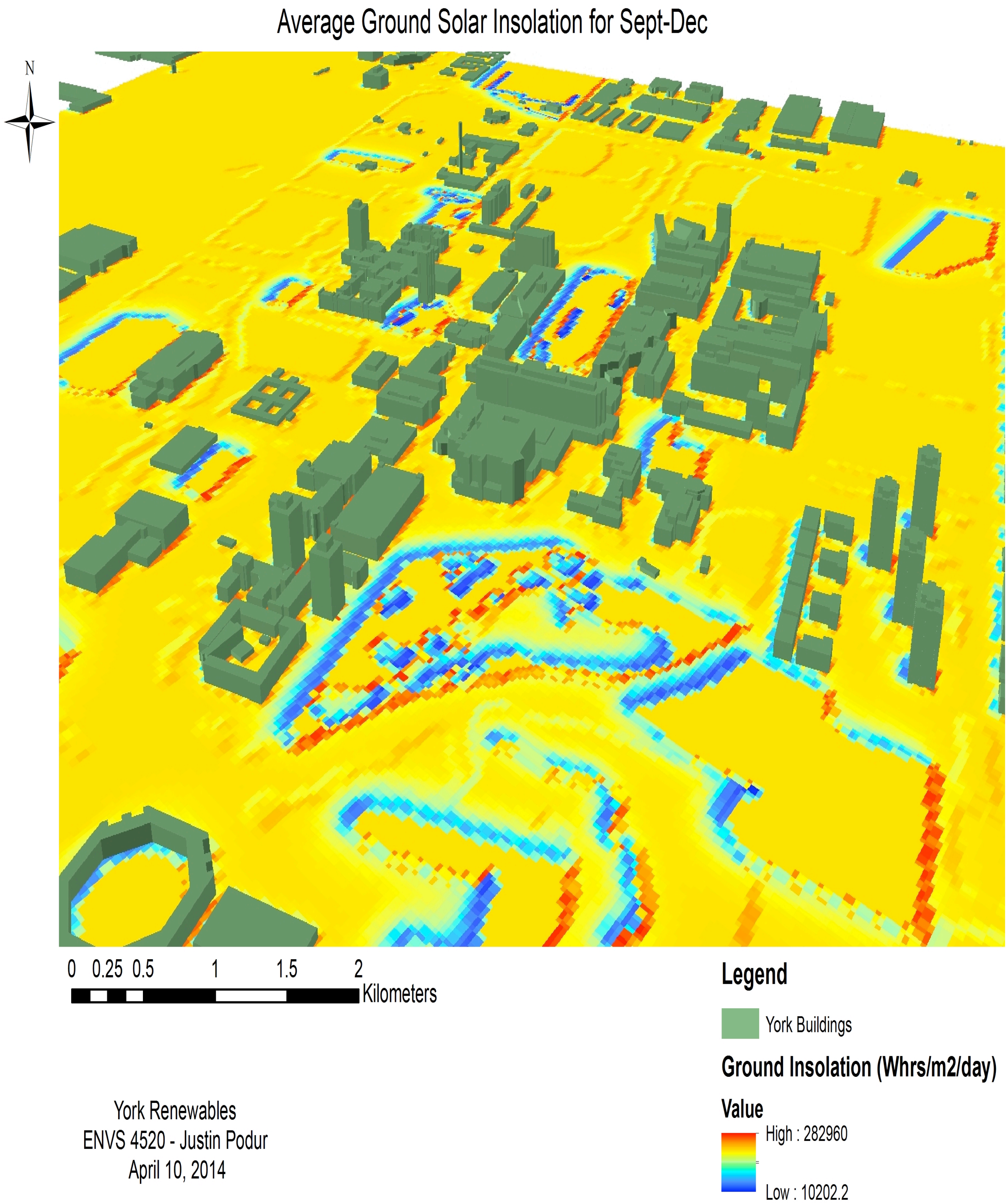
Average Ground Solar Insolation for Sept-Dec
N
0 0.25 0.5 1 1.5 2
Kilometers
Legend
York Buildings
Ground Insolation (Whrs/m2/day)
Value
High : 282960
Low : 10202.2
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April 10, 2014

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