2016 Green Energy Challenge

<u>Proposal</u>

Submission Date: April 4th, 2016

CECA/NECA

University of Toronto Student Chapter

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Project Summary

Executive Summary

Northern Lights Solutions is pleased to present its proposal for an energy efficiency retrofit and solar PV array installation for University of Toronto Schools, a grade 7-12 university preparatory school in downtown Toronto. University of Toronto Schools is the only merit-based university preparatory school in Canada that is affiliated with a university and located on a university campus. A prestigious institution such as this should have buildings that are on the cutting edge of science and technology to match its students, which is why the team has chosen this building and its aging infrastructure to be the focus of this proposal.

After conducting several site visits to University of Toronto Schools, Northern Lights Solutions identified the various efficiencies and deficiencies in the building with regards to its space heating, space cooling, and lighting. The two main design components are first the update of the buildings hallways and classrooms lighting. The second component is the installation of a solar PV array on the roof of the building to offset the building's carbon footprint and enable hands-on renewable energy education.

The lighting retrofit project cost is estimated at $5,078. Northern Lights Solutions has identified $1,235 in grants and incentives, bringing the total cost down to $3,843. All currency is in Canadian dollars (CAD). The team also proposes a bank loan structure to help finance the project, which can be paid off in just under 6 years. Starting in February 2017, the project is scheduled to be complete in 140 days while remaining sensitive to the school's operating schedule.

Northern Lights Solutions has created a comprehensive outreach strategy to support the development of this proposal. Through several initiatives, the team has promoted green energy awareness within its community, and plans to continue this work. As well, the team has maintained its excellent working relationship with CECA, its industry partners, and established a similar relationship with the project client. As a result, the proposal is very thorough and reflects significant industry involvement.

Mission Statement

Our mission is to provide our clients with innovative solutions that will best address their needs in a cost effective manner. We understand that there is no "one size fits all" solution, and our team makes every effort to deepen our understanding of our clients' needs in every project.

Client Overview

In 1910, University of Toronto Schools (UTS) opened its doors to 325 students from grades 7 through 12. A lot has changed between 1910 and the present, including the inclusion of female students and the removal of desks that were bolted to the floor. But one thing that hasn't changed at UTS is its prestige; UTS is the only merit-based university preparatory school in Canada that is affiliated with a university and located on a university campus. It offers students a specialized curriculum and a unique co-educational learning environment that encourages creative interest and physical activity as well as a sense of social responsibility. UTS is renowned for educating generations of outstanding graduates including two Nobel Laureates, 20 Rhodes Scholars and numerous leaders in commerce, industry, academics, the arts, sports, government and public service [1] Rosemary Evans, principal of UTS, and the wonderful staff at UTS graciously agreed to partner with Northern Lights Solutions and its industry supporters on this project.

Figure 1: UTS Facility

Facility Description

The UTS building is a 3-storey structure with a below-grade basement. The building has undergone several expansions and renovations since its construction in 1910 to add to its floor space and incorporate new technologies. The building is divided into three wings: west, central, and east. The central wing runs east-west, and the east and west wings continue south from the central wing. There are plans to add a fourth wing - midway through the structure, expanding south. This will add to the floor plate and allow for more teaching space.

The building is currently shared by UTS staff and students, the University of Toronto Sociology Department, and the Ontario Institute for Studies in Education (OISE). OISE occupies the west wing of the school on all four floors. OISE manages and renovates their own space and the focus of this report will be on the UTS occupied part of the building.

The majority of the space is dedicated to classrooms. Additional teaching spaces such as science labs, a library, and computer labs are interspersed throughout the building. There are two gyms on the main floor and a pool facility and fitness center in the basement. The rest of the facility is occupied by staff offices, storage areas, and washrooms. A first floor plan can be seen in Figure 2.

The building has a brick facade with single pane glass covering approximately 60% of the building exterior. There are plans of renovating the facility's facade to improve overall thermal efficiency and indoor comfort for students. Currently the building is heated via radiators fueled by natural gas, and cooled via individual A/C units in the classrooms.

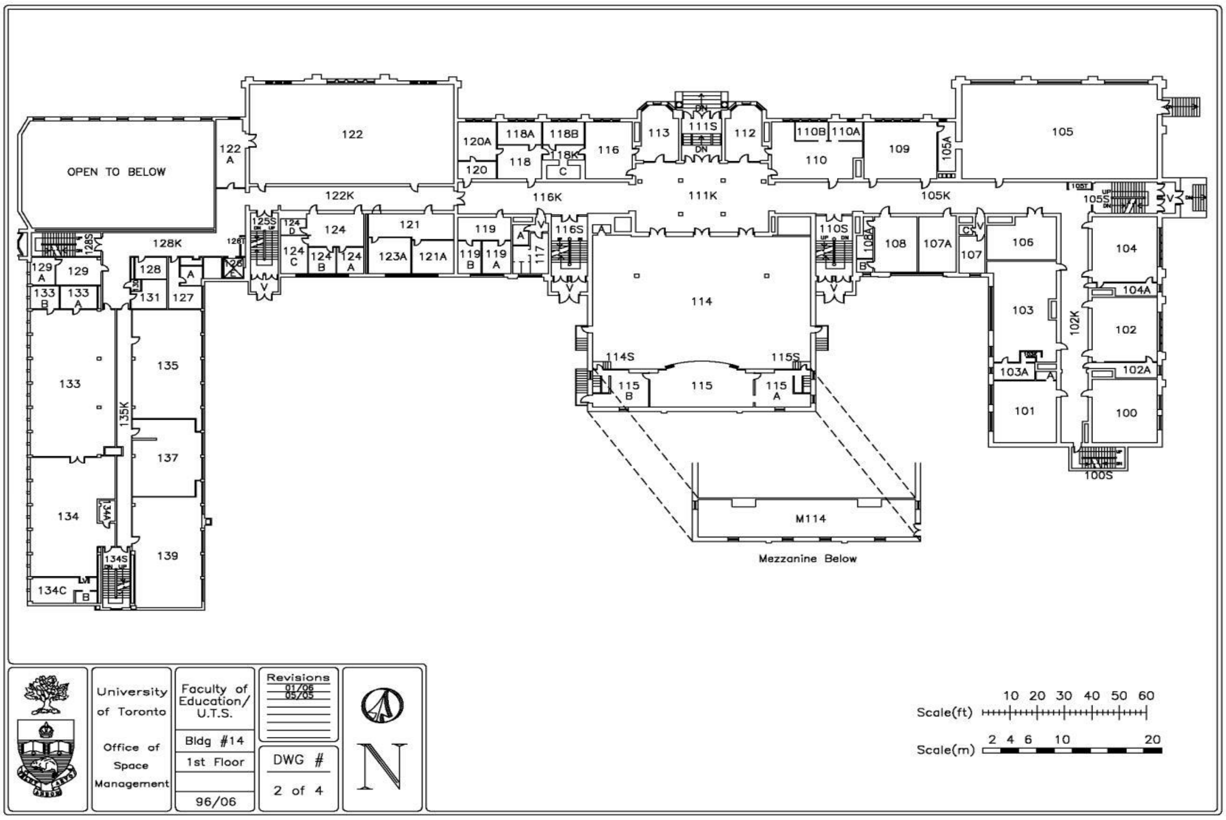


Figure 2: Level 1 Floor Plan

Project Team Resumes

Please find the team's resumes on the following pages.

Arthur Leung

Energy Analysis Team Lead

Arthur is currently in his fourth year of Chemical Engineering studies at the University of Toronto. He previously completed a 4-month summer exchange in environmental engineering in Germany and has worked on plant design projects. Arthur brings experience in HVAC Systems and Process Design through course work, work experience and extra-curricular activities into his role for the Green Energy Challenge.

Education	Skills & Certifications	Memberships
BASc, Chemical Engineering Class of 1T6 University of Toronto Toronto ON, Canada	• *Applications:* Microsoft Word, Excel, Powerpoint, Project, Visio • *Software:* AutoCAD, Google Sketchup	• Canadian Society for Chemical Engineering, University of Toronto Chapter

Relevant Experience

Team Member, ERCO Worldwide Plant Design Project — **September-December 2015**

- Responded to a plant design RFP for production of sodium chlorate in absence of toxic catalysts
- Responsible for updating meeting agenda, project Gantt chart in weekly meetings
- Conducted research in crystallizer systems with focus on environmental considerations, plant operations and safety. Sized process equipment such as centrifugal pumps, pipes, cooling tower and scrubber system. Performed heat balance around key reactor units such as heat exchangers
- Worked in teams with Visio and AutoCAD to produce plant layout, PFD and P&ID
- Produced detailed report in environmental considerations of the plant and HAZOP

Team Member, Environmental Consulting Project — **January-May 2014**

- Designed sampling and analytical process on metal pollution data of area surrounding an abandoned mine in Britannia Beach, BC
- Modelled a runoff coefficient based on Environment Canada data and provided recommendations on the establishment of a resort

Summer Exchange Student, University of Kassel — **June-July 2013**

- Studied climate change modelling and strategies, environmental engineering
- Visited the SMA Solar PV manufacturing facilities and Viessmann Inc. Headquarters

Extra-Curricular Activities

- **VP Technology**, Canadian Association of Food Engineers UofT Chapter
- **Co-founder**, University of Toronto Aviation Club
- **Production Director,** Footprint Publication

Claire Gao
Team Lead

Claire is an Energy Assistant student who is currently on a 12-month co-op term with Regional Municipality of York in system sustainability management team. He has previously project experience in energy conservation technology review and energy data analysis. Claire brings her past experience and strong passion in data analysis and energy audit to the Green Energy Challenge.

Education

BASc, Chemical Engineering

Class of 1T6+PEY with Honours

University of Toronto

Skills & Certifications

- *Applications:* Microsoft Word, Excel, Powerpoint, Visio, Project
- *Programming:* VBA, R, MATLAB, Python, C

Relevant Experience

Engineering Associate, Regional Municipality of York **May 2015 – present**

- Develop hydraulic modeling and analyze energy audit data for Water and Wastewater system
- Track monthly budget spending, budget forecasting and summarize monthly budget report
- Identify energy innovation ideas, energy saving strategies and potential funding sources
- Establish and update annual energy dashboard and local area municipality W&Ww data report
- Participate in energy working group and pump optimization project to further investigate the facility energy conservation opportunities

Research Assistant, Beijing University of Chemical Technology Laboratory **May 2014 - August 2014**

- Produced and examined catalyst for the metal-air battery and analyzed the methods to improve its efficiency
- Collected and classified the related metal-air battery development method documents
- Constructed the data curves for characteristics of each battery catalyst and clarified the future research goals

Prototype Fabrication Engineer, Sensassure, Toronto **September 2014 - October 2014**

- Collaborated on the adult diaper fabrication process for the pilot testing in October
- Systematized the production line by multitasking to save more than one third of the planned production time

Team Member, Indoor Air Quality in Air Force Base Project, U of T **January 2014 -May 2014**

- Researched methods to evaluate and test 4 chemical contaminate in air sample with different sampling methods
- Established the implementation plan with Gantt chart and cost analysis for this virtual site
- Presented the final project to both technical and non-technical clients

Extra-Curricular Activities

- **VP Marketing,** Chinese Engineering Students' Association (CESA)
- **NGO Volunteer Consultant,** Univeristy Consulting Group
- **Public Relation Team Member,** Cookly

Greg Peniuk
Finance and Estimation Team Lead

Greg is an Energy Systems Engineering student who is currently on a 16-month co-op term with Ontario's Independent Electricity System Operator in long-term power system planning. He has previously worked in academic research for renewable energy technology. Greg brings broad knowledge of the evolving sustainability industry and an understanding of project finance to his role in the Green Energy Challenge.

Education

BASc, Engineering Science
Class of 1T6+PEY with Honours
University of Toronto
Toronto ON, Canada

Skills & Certifications

- *Applications:* Microsoft Word, Excel, Powerpoint
- *Programming:* VBA, MATLAB, Python, C

Relevant Experience

Planning Analyst, Independent Electricity System Operator **May 2015-present**

- Quantifying the effects of energy efficiency, building codes, and retrofits on the operation of Ontario's electricity grid.
- Evaluating potential electricity conservation and emissions reduction programs by applying technical and financial tests.
- Producing detailed estimates of energy use in commercial, institutional, and industrial facilities in order to identify potential growth areas and opportunities for energy conservation.
- Researching global trends in renewable energy development and identifying the potential of disruptive new technology to dramatically alter grid operations and economics.

Research Associate, University of Toronto **May 2014-August 2014**

- Directed a research project to create a new method for the analysis of microalgae in biodiesel production.
- Created new methods for collecting, managing, and synthesizing measurements from different sources.

Finance and Fundraising Lead, Musical Minds Community Outreach **September 2013-present**

- Manages cash flow and documentation for a small non-profit, maintaining efficient operations.
- Identifies and pursues funding opportunities from government sources, foundations, and individual donors.
- Maintains databases to aid in record-keeping and daily operations.

Extra-Curricular Activities

- **Paddler,** Engineering Iron Dragons Dragonboat
- **Team Member,** University of Toronto Quidditch
- **Estimation & Finance Team Lead,** CECA/NECA University of Toronto Student Chapter

Matheos Tsiaras

Outreach Team Lead

Matheos is completing his fourth year of Civil Engineering studies at the University of Toronto, and has completed a 16-month co-op term with IBI Group in their Transportation Systems Group. Matheos brings experience in Project Management and Sustainable Design through course work and extra-curricular activities into his role as Outreach Team Lead for the Green Energy Challenge, including his tenure as Project Manager for the 2015 Green Energy Challenge

Education	Skills & Certifications	Memberships
BASc, Civil Engineering Class of 1T5+PEY with Honours University of Toronto Toronto ON, Canada	• *Applications:* Microsoft Word, Excel, Powerpoint, Project, Publisher, Visio • *Software:* AutoCAD, VBA, Synchro	• Canadian Society of Civil Engineers, University of Toronto Chapter • Institute of Transportation Engineers, UofT Chapter

Relevant Experience

Transportation Systems Designer, IBI Group — **May 2014-August 2015**

- Pan Am/Parapan Am Games: developing operational plans for the Unified Transportation Control Centre, and Traffic Management Measures for the Games Route Network
- Involved in development, configuration, and testing of various Advanced Traffic Management Systems, including systems in British Columbia and South Africa
- Assisting IBI during the business development process, including RFP release, amendments, and proposal submittals

Project Manager, 2015 Green Energy Challenge — **May 2014-October 2015**

- Spearheaded the design of a backup system, resiliency plan, lighting retrofit, energy audit, financing/cash flow plan, and outreach initiatives for Good Shepherd Ministries, a homeless shelter in downtown Toronto
- Leveraged assistance from several industry contacts, as well as the shelter's operators
- Led the team to a 2nd place finish in the Challenge's Poster Competition, and a 4th place finish in the challenge overall

Team Member, Survey Camp — **August 2013**

- Created a topographic map of the entire campgrounds using distance, angle, and elevation measurements from over 200 points across the grounds
- Designed a highway curve on the campground, including station locations, elevations, and volumes of cut/fill
- Delivered a presentation on a proposed sustainable building design to be located at the camp

Team Leader, Engineering Strategies & Practice II — **January 2012-April 2012**

- Led a team of six students that produced a system for tracking the carbon footprint of campus clubs for a client
- Evaluated design solutions based on implementation requirements, accessibility, and cost
- Produced Project Requirements, and Conceptual and Final Design Specifications documents

Extra-Curricular Activities

- **Communications Coordinator**, CECA/NECA University of Toronto Student Chapter
- **Tenor Sax**, Skule (Engineering) Stage Band
- **Tenor Sax, Baritone Sax**, Skule Nite

(team logo)

Mackenzie de Carle
Team Lead – Lighting Retrofit

Mackenzie is currently in his third year of study at the University of Toronto for Civil Engineering. He previously completed two 4-month work terms; one with Dillon Consulting in their municipal department and another with MMM in their rail department. Mackenzie brings his knowledge of the local energy sector modeling experience to his role Lighting Retrofit.

Education	Skills & Certifications	Awards
BASc, Civil Engineering Class of 1T7 University of Toronto Toronto ON, Canada	• *Applications:* Microsoft Office • *Software:* AutoCAD, Python, C, Google Sketchup, Solidworks, SurfCAM	1st Place in Consulting at UTEK, 2nd Place in Consulting at OEC, invited to and participated in CEC (Canadian Engineering Competition for Consulting.

Relevant Experience

AutoCAD Technician, Dillon Consulting Ltd **May 2015-August 2015**

- Primarily produced AutoCAD drawings for site grading, site servicing, and road interchanges.
- Helped coordinate submissions for both the City of Toronto and Clients
- Calculated drainage areas and prepared figures for Storm Water Management reports
- Assisted in preparing letters of Interest for Work

Construction Inspector, MMM Group **May 2014-August 2014**

- Worked on a subway station rehabilitation and upgrade for the TTC
- Work involved reading and interpreting construction drawings to ensure compliance with the design including steel and concrete works
- Helped report contractor's progress in regards to the schedule and activities completed
- Confirmed how much of tasks were completed on a monthly basis

University Projects **September 2013-Present**

- Assisted in Development of MAC (Marginal Abetment Cost)
  - Analyzed benifts of converting existing natural gas plant to wind power
  - Assessed feasibility in local region
- Survey Camp
  - Developed an RFP for a new research building on survey camp property
  - Measured building temperatures with an IR pyrometer to asses optimum building orientation
  - Measured wind speeds and solar irradiance to size necessary wind and solar facilities to power survey camp

Extra-Curricular Activities

- **Lighting Retrofit Team Lead,** CECA/NECA University of Toronto Student Chapter (2016)
- **President,** CECA/NECA University of Toronto Student Chapter (2015-2016)
- **Estimation & Finance Team Lead,** CECA/NECA University of Toronto Student Chapter (2015)
- **Hull Design Lead,** Concrete Canoe (2016)

Dmitri Naoumov
Project Manager

Dmitri is completing his fourth year of Civil Engineering studies at the University of Toronto, and has completed a 12-month co-op term with Arup Canada Inc in their structural engineering department. Dmitri brings experience in solar design through work with his family's company Green Q. He has also been involved in the 2015 Student Passport Competition which gave him firsthand experience in solar system installation.

Education

BASc, Civil Engineering
Class of 1T5+PEY
University of Toronto
Toronto ON, Canada

Skills & Certifications

- *Applications:* MS Office Suite.
- *Software:* Autodesk Revit, PV Syst,

Memberships

- Canadian Society of Civil Engineers, University of Toronto Chapter

Relevant Experience

Structural Designer, Arup Canada Inc. **September 2014-August 2015**

- Worked with the Toronto structural group of 9 on various Canadian projects and bids
- Designed steel and reinforced concrete structures for the Edmonton LRT Expansion project. Gained proficiency in the use of SAP2000 and Oasys GSA
- Reviewed shop drawings for the Billy Bishop Pedestrian Tunnel, York Engineering building, and TTC York University and Vaughan CC subway station projects.
- Worked in AutoCAD, Revit and Microstation to generate drawings for several projects.

Team Lead, 2015 Green Energy Challenge **May 2014-October 2015**

- Submitted a proposal for the Green Energy challenge as part of a 25 student team
  - Proposal consisted of the schematic design, scheduling and funding for an energy retrofit of a homeless shelter in downtown Toronto
- Was group leader for the Energy Audit team – coordinating 5 other team members
- Created and maintained a Revit model of the project.

PM Assistant, Infrastructure Ontario **Summer 2015**

- Worked directly under the senior VP of the Major Projects group on the RFQ and RFP phases of two hospital projects in Ontario
- Attended and provided support at the RFP Design Proponent Meetings for the Milton General Hospital Project
- Attended weekly coordination meetings and maintained a project timeline chart for the Etobicoke General Hospital Project
- Processed RFI's on a daily basis and fast-tracked the process through VBA automation

Extra-Curricular Activities

- **Project Manager**, CECA/NECA University of Toronto Student Chapter
- **Team Member,** Electri International Student Passport Competition 2015
- **Athlete,** intermural volleyball and avid rock climber

Energy Efficiency Analysis

Northern Lights Solutions performed an energy audit for the University of Toronto Schools (UTS). This involved detailed documentation of all lighting, heating, and electrical appliances power specifications, summarization of the energy benchmark results and inspection of potential energy saving opportunities. The energy conservation suggestions will be provided in the end of this section.

Energy Audit Results

Through a site visit at UTS, energy data were gathered to conduct an energy audit. The data includes information on the school's interior lighting, HVAC units and their respective type, energy consumption and a tally of all units. Due to limited access, the team was unable to assess central heating units during the visit. Since the aim of this project is to provide a background for lighting retrofits, this analysis will focus on electrical energy usage. The primary use of electrical energy use at UTS is for lighting and air conditioning. Figure 3 and Table 1 summarize energy use data in kWh per year.

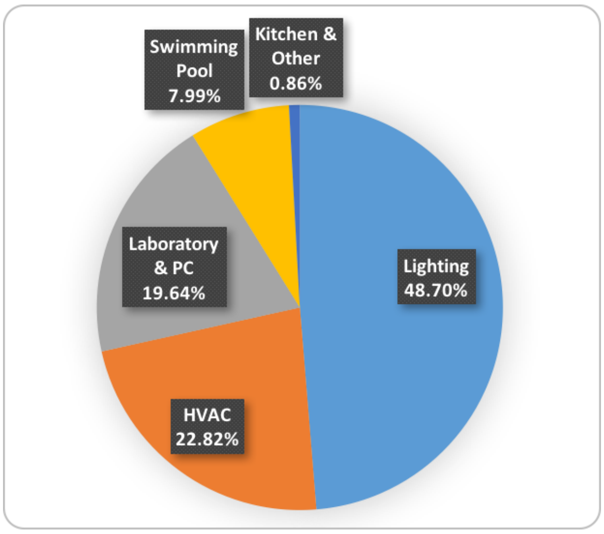


Figure 3: Energy Use Breakdown

Lighting accounts for nearly half (258 MWh/year) of the total. This is primarily because the facility does not require significant cooling in the summer and not having any other large power draws. The team assumed reduced the lighting loads to 40% during the summer months when the school is only partially occupied for calculations and modeling. Existing lighting fixtures consist of 4' and 2' T8 32W linear fluorescent lights (LFL) which are used in classrooms and hallways. A classroom lighting system is shown in Figure 4 for reference. This layout and lighting type is typical throughout all classrooms in the building. Additionally pot lights and spotlights are used in the auditorium and gymnasium and are estimated to be 15W, 60W and 200W respectively. The team did not have access to these lights directly and will have to verify the wattage during detailed design.

Figure 4: Sample Classroom

Table 1: Detailed Energy Breakdown Data

Energy use	Consumption (kWh/year)
Lighting	258,897
HVAC	121,303
Chemical and Computer Laboratories	78,480
Swimming Pool	42,480
Kitchen	2,346
Other	1,663

The building's HVAC consists of individual AC units and ceiling fans, accounting for 121 MWh or about 23% energy use. An estimate for the AC consumption was made based on the AC model in Room 210 with consumption calculated **[2]** based on the cooling degree-days (base 18 ^{o}C of downtown Toronto **[3]**.

The water pumps and heaters that service the 20m x 7m swimming pool are **[4]** estimated to be in use 600 hours per month and contribute significantly to energy consumption.

Additionally the science labs are in use approximately 4 hours each day and the equipment within them - 9 fume hoods draws 4.5kW/hr each. There are 3 computer labs each with 30 computers in the building. The computers use a 400W power supply and are expected to be on for the entire school year (10 months) with short interruptions for maintenance. The team estimated that due to variable use of the computers they will draw 250W per hour on average.

There is a cafeteria in the basement where microwaves (1.5kW each) are used only during lunch hour. Other power usage identified throughout the building were a 250W TV screen, 75 W photocopiers (print using 200 kWh/year) and 500W screen projector. Smart Boards interactive screens were also found in two sample rooms as shown in Figure 5. An estimated total of 6 boards are 200W each and used one hour per day on average. A detailed breakdown of all lighting data can be found in Appendix A.

Figure 5: Classroom Smartboard

Energy Benchmark

Northern Lights Solutions has completed an energy benchmark of the UTS facility with the EPA Portfolio Manager Tool. This software used building details (such as location and gross floor area), electricity and natural gas utility data obtained from the energy audit to provide an energy benchmark. The benchmark indicates a Source Energy Use Intensity (EUI) of 134 kBtu/ft^2 which exceeds the national median by 81%. An ENERGY STAR analysis **[3]** states that most K-12 Schools have a Source EUI below the national median. This indicates that UTS has potential improvements on energy savings and energy efficiency. However, it should be noted that limited information and estimated values were used, therefore it is a preliminary result. The sources of discrepancy in electricity consumption between the energy audit and electricity bill will be identified through further analysis.

LEARN MORE AT energystar.gov

ENERGY STAR® Statement of Energy Performance

1

ENERGY STAR® Score[1]

University of Toronto Schools (UTS)

Primary Property Type: K-12 School
Gross Floor Area (ft²): 181,909.9
Built: 1910

For Year Ending: August 31, 2015
Date Generated: April 03, 2016

1. The ENERGY STAR score is a 1-100 assessment of a building's energy efficiency as compared with similar buildings nationwide, adjusting for climate and business activity.

Property & Contact Information

Property Address	Property Owner	Primary Contact
University of Toronto Schools (UTS) 371 Bloor St W Toronto, Ontario M5S 2R7	______________ , (___)___-_____	____ ______ , (___)___-_____ ______________

Property ID: 4864984

Energy Consumption and Energy Use Intensity (EUI)

Site EUI
107.7 kBtu/ft²

Source EUI
134 kBtu/ft²

Annual Energy by Fuel	
Electric - Grid (kBtu)	4,262,271 (22%)
Natural Gas (kBtu)	15,333,000 (78%)

National Median Comparison	
National Median Site EUI (kBtu/ft²)	59.4
National Median Source EUI (kBtu/ft²)	73.9
% Diff from National Median Source EUI	81%
Annual Emissions	
Greenhouse Gas Emissions (Metric Tons CO2e/year)	946

Figure 6: Energy Star Benchmark Results

Building Assessment

Building energy Asset Score is another tool used during the energy analysis to evaluate the building physical and structural energy efficiencies. This tool not only provides a score for the existing building mechanical and electrical systems, but also identifies future energy conservation opportunities.

The benchmarking result shows the current system UTS has the current score of 9.0 out of 10 with potential 29% of the energy savings to obtain the full score. The identified opportunities from Asset Score tool are included in the following sections.

The data inputted into the DOE tool primarily used estimated information that undervalued the inefficiencies of aging infrastructure. Therefore the Northern Lights team believes that the building performance is much worse than what these estimates show. Particular inefficiencies and potential building improvements include:

- An aging boiler with an estimated installation date of 1980
- Single pane glazing throughout the building
- Outdated lighting fixtures and bulbs throughout the building

After assessing the source energy intensity report (Figure 8) the Northern Lights Solutions proposes that major improvements can be made to the interior lighting which would greatly reduce the total load. There is potential to renovate the cooling system and switch it to a centralized one. This would greatly reduce the local loading and allow to create a consistent indoor comfort level.

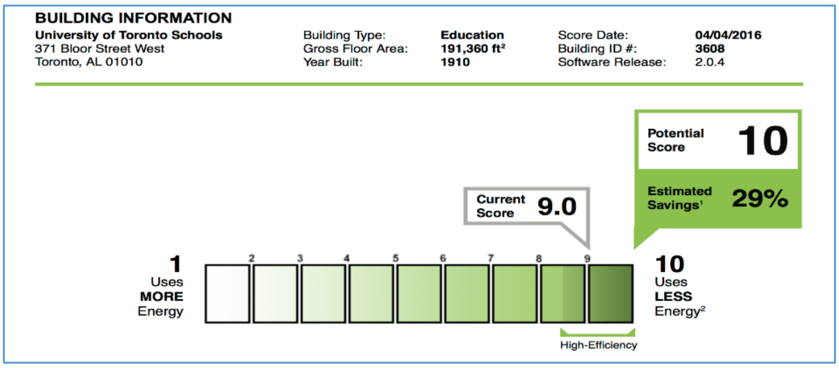


Figure 7: Building Energy Asset Score Benchmark

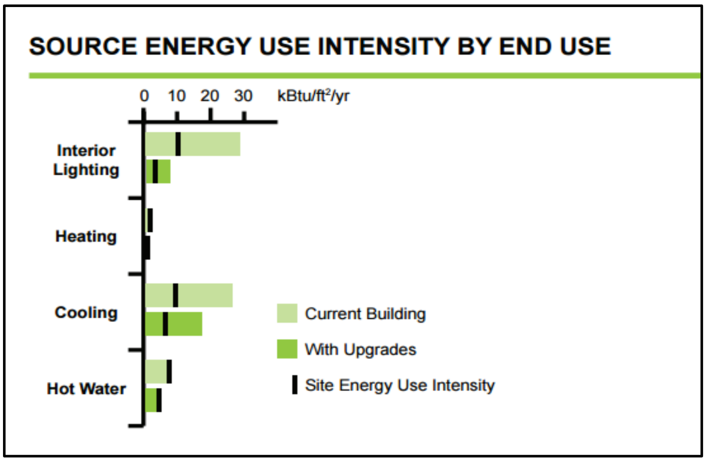


Figure 8: Energy use intensity after upgrade

Proposed Improvements

According to the energy analysis results and the provided budget, Northern Lights Solutions is proposing a building energy efficiency retrofit which will comprise of two main components.

The first component is to reduce the current building lighting energy consumption by upgrading the lighting system. The main focus is to upgrade the incandescent lighting with compact fluorescent lighting and to upgrade T12 fluorescent lighting with LED lighting.

The second complementary is on optimizing the lighting system by installing occupancy sensors for interior lighting control and adding daylighting controls above the basement levels in UTS. This can bring most energy savings to areas such as computer labs, gyms and rooms where periodical occupancy occurs. There are also some other future considerations, such as adding low flow fixtures in UTS to reduce water usage.

Technical Analysis 2: Lighting Retrofit

For the lighting study two classrooms were investigated namely room 203 and 210. Room 203 is east facing while room 210 is south facing. These rooms were chosen as they are representative of most of the rooms in building and face two different directions. The difference in facing creates different lighting needs. The following section will depict the current lighting conditions and then propose two retrofit options. These options are cumulative as option 1 will focus on updating the lighting fixtures and bulbs and option 2 will expand on this by adding integrated lighting controls.

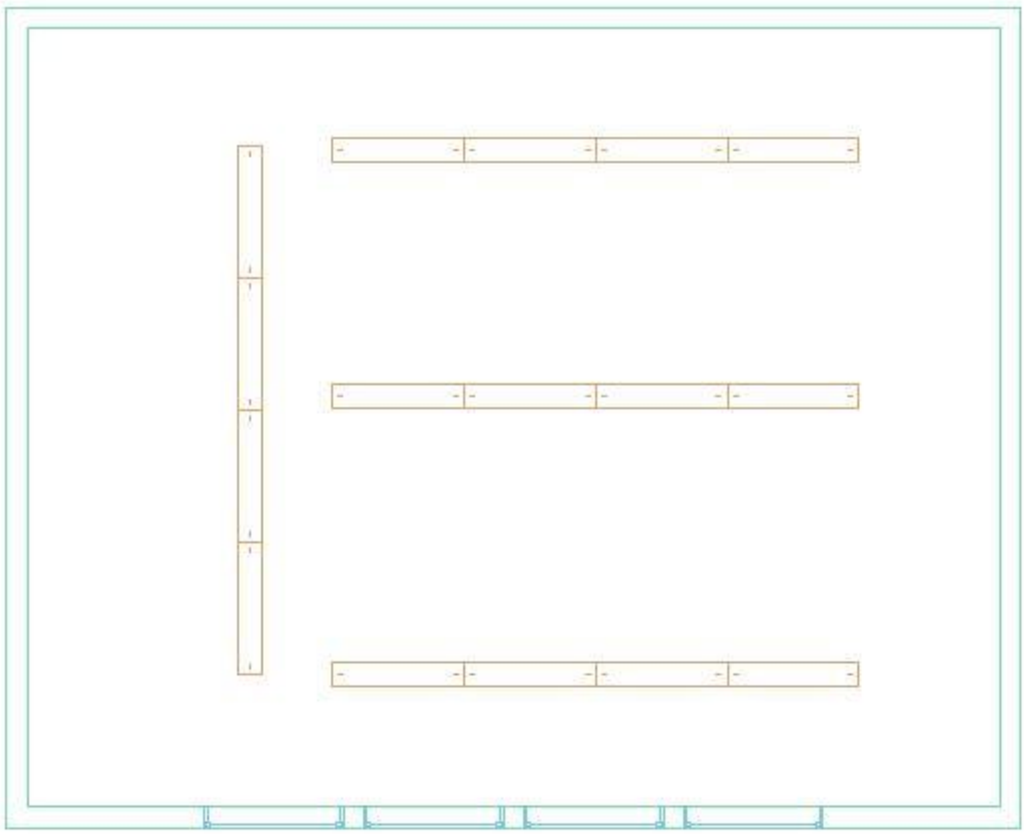
Figure 9: Classroom Rendering

Existing Conditions

As is typical of most industrial buildings the lights for the rooms are linear fluorescent lamps (LFLs). Both classrooms have the same existing light structure shown below. Typically lights are turned on around 7:00 AM and are turned off around 7:00 PM by the janitors. Therefore for base case it was assumed that lights run 12 hours a day 200**[6]** days a year (weekdays only).

Number	Type	Wattage	Light intensity (lums)	Life time (hours)	Unit cost ($)
32	4 ft LFL T8	32	2600	36,000	1.01

The lighting layout was the same in both rooms. An example of a reflected ceiling drawing is shown below for room 210. Each fixture contains two 4 foot T8's. The system is operated by two switches located at the entrance. The first switch operates the individual left line of lights which provides lighting to the main chalkboard and teacher's desk. The second light switch operates the remaining 3 lines of lights which illuminate student desks.



Option 1: Lights and Fixture updates

This section focuses entirely on improving the rooms through replacement of lights and fixtures. This section will be broken into Option 1A which will focus on a proposed solution for room 203 and then Option 1B which is a proposed solution for room 210.

Option 1A consists of replacing the current LFLs with brighter liner LED Lights. Linear LEDs are used as they are able to utilize existing fixtures as well as better distribute the light. Due to partially blocked windows and an east facing exterior this room is not readily adjustable to take advantage of daylighting. During a site visit, with lights on Illumination levels were all below 500 lux with all but one of the readings less than or equal to 400 lux. Working spaces such as schools and offices are recommended and to have an illuminance of 500 lux [1] so brighter lights are advisable to enhance student environment.

Number	Type	Wattage	Life time (hours)	Unit cost ($)	Labor cost ($)
32	4 ft Linear T8 LEDs balast bypass	24	30,000	10.99	25

Option 1B consists of replacing the current LFLs with comparable liner LED Lights. Linear LEDs are once again recommended as they offer better light distribution and will be easier to replace. Due to the south facing nature of this room daylighting is more readily available. For this reason it would be reasonable to install lights of comparable brightness of the LPLs they are replacing. This is also to provide the client with a cheaper option which provides a better ROI and payback period if that is their focus.

Number	Type	Wattage	Life time (hours)	Unit cost ($)
32	4 ft Linear T8 LEDs	18	50,000	14.50

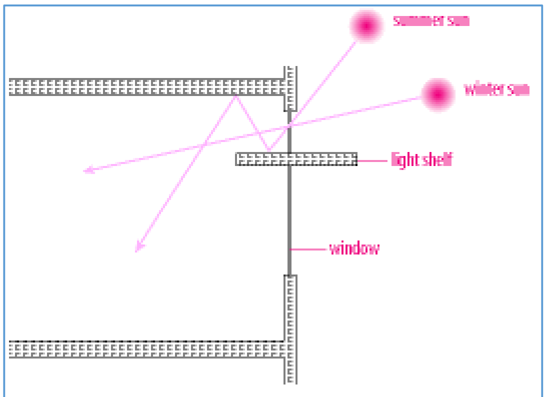
Option 2: Integrated Controls

This section focuses on improving the rooms through integrated controls. This section will be broken into Option 2A which will focus on a proposed solution for room 203 and then Option 2B which is a proposed solution for room 210.

Option 2A uses occupant sensing light switches to decrease the time the lights are in use. The recommend occupant lights would have the added features including manual shut off and daylight sensing. It is essential that these lights are able to manually shut off so that the teacher is able to give presentations via projectors or to utilize the smart board located in the classroom. Daylight sensing features means the light will stay turned off if enough daylight is detect though can be manually overridden if desired. This feature will help ensure that daylight is the preferred choice when available. With this installation it is predicted that lighting use will be restricted to 8am to 4pm meaning resulting in 8 hours of use. This is a significant cutback from the current 12 hours.

Number	Type	Additional features	Unit cost ($)
2	Occupant sensing light switches	Adjustable timer, day light sensing, manual shutoff	19.97

Option 2B uses light shelves to further utilize daylighting in order to decrease the need for artificial light. Classroom 210 with many south facing windows has an abundance of daylight. During a late afternoon site visit the entire southern third of the classroom had adequate illumination. The majority of lux readings were 1000 lums while all the readings were 500 or more lums. Light shelves are reflective surfaces that are usually placed horizontally at windows. This allows to the system to reflect light further into the room and illuminate the ceiling. Light shelves can also address the problem of glare from direct light while still utilizing the light by directing it to the ceiling. This means that the blinds can be kept open more often to take advantage of the daylight. With the installation of the light shelves the southernmost line of lights can be turned off most days and exclusive daylighting can be used more frequently. An interior light shelf is recommended as it is easier to install and maintain.



A light shelf that divides a window into a view section below and a clerestory section above.

Due to the cold climate and significant energy use spent on heating low U windows are recommended. Therefore double paned low-e windows are recommended. This is to ensure a U-factor lower than 0.4 to minimize heat loss. At the same time this allows solar for a large solar heat gain coefficient defined as greater than 0.7 to reduce the heating loads. Heating demands are the main concern due to the northern location and the fact the school is not in session over the summer. Glass should have a visible transmittance larger than 70% so that daylighting is not negatively impacted by the window update.

Number	Type	Unit cost ($)
4	Horizontal interior light shelf	$100.00

[5]

Financial Analysis and Electricity Savings

Light Option	Base Case	Option 1A	Option 1B
Hours/year	2400	2400	2400
Life span (years)	15.0	12.5	20.8
Electricity Use (kWh/yr)	2458	1843	1382
Electricity Savings (kWh/yr)	-	614	1075
Annual Cost Savings ($/yr)	-	123	215
Capital Cost ($)	-	1151.68	287.68
ROI (%)	-	74	645
Straight Payback (years)	-	9.37	1.34

This section analyzes the financial and electricity benefits of the different options. It also provides an estimate of the Return on Investment (ROI) and the Straight Payback period. For this calculation upkeep was ignored as it is assumed to be similar to the current system.

For Option 1 the analysis is provided in the table to the right. It was assumed that the school operated 12 hours a day 200 days a year. Electricity costs were assumed to be $0.20/kWh as was provided in the Green Energy Challenge 2016 rules. Capital Costs were assumed to be just the cost of the bulbs as replacing the lights for Option 1B as they are plug and play bulbs. For Option 1A the cost includes a $25 installation cost as the upgrade requires a ballast bypass. The Return on Investment was calculated with a 10% interest rate.

Light Option	Base Case	Option 2A	Option 2B
Hours/year	2400	1600	2400
Life span (years)	15	20	40
Electricity Use (kWh/yr)	2458	1638	1843
Electricity Savings (kWh/yr)	-	819	614
Annual Cost Savings ($/yr)	-	164	123
Capital Cost ($)	-	139.94	600
ROI (%)	-	997	156
Straight Payback (years)	-	0.85	4.88

For Option 2, the analysis is provided in the table to the left. For the capital cost it was assumed for both options that the installation would cost $50 in labor as both installations are very quick and straightforward. Both options would be considered with the improved lights but were evaluated separately to ensure they were installed only if they provide a significant net benefit. If only one of the two options is to be considered, then Option 2A is recommended due to significantly better payback period as well as a greater electricity reduction.

Solar Education System

Northern Lights Solutions has designed a 20 panel array to install on the UTS building roof. After conducting a detailed shading study the team found an optimal location for the array on an inclined roof on top of the building. In Toronto weather conditions this array should generate 6.67 MWh per year to be sold back onto the grid through the Ontario MicroFit program.

System Design

The UTS building has a convenient tilted roof located on the north west corner of the building. This roof is estimated to have a 34° slope and faces 16° west of north. The roof allows to place up to 30 1m x 1.6 m panels and has no shade from adjacent buildings or other roof-top features cast on it throughout the year. The roof of the building will need to be inspected for structural stability and reinforced as needed. The team had assumed that the roof can support the panel load as is.

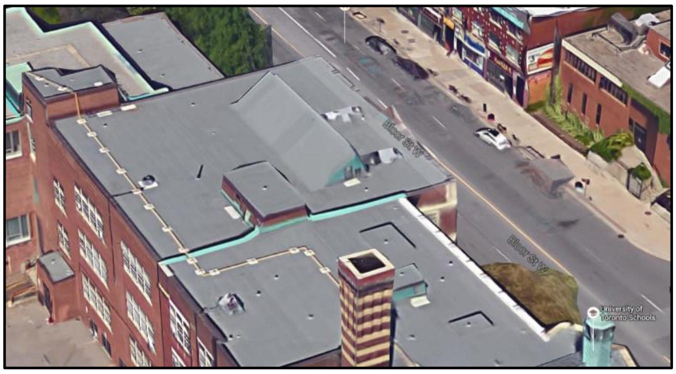


Figure 10: Selected solar array site

With the inverter specified - the team has utilized PVSyst to develop a full solar photovoltaic system, the design report can be viewed in appendix B along with the solar panel and inverter spec sheets. To match the inverter two sets of 10 Canadian Solar CS6P-260P panels will be used, connected in parallel. The system will them be connected to an industry grade meter (Ontario MicroFit requirement) and subsequently to the grid.

The arrangement of 2 by 10 panels was decided based on:

- the maximum potential 110 panel array voltage of 448 V (at -30°C) when operating at full capacity. The Fronius inverter can handle up to 480V allowing it to handle the load of the array in this arrangement.
- The geometry of the roof - which allows for two rows of portrait oriented panels.
- The specified inverter can handle two MPPT’s - with two rows this feature is used in full

Shading Study

The team utilized Autodesk Revit to conduct a shading study (Figure 11) of the proposed rooftop location of the solar array. Four elements were identified using Google Maps Earth View (Figure 12) to cause potential shading and a mass model was developed. After locating the project and the surrounding buildings a shading analysis was run for noon of the winter solstice. No shade was cast on any of the panels. On consultation with an industry expert this was deemed an appropriate measure of shading.

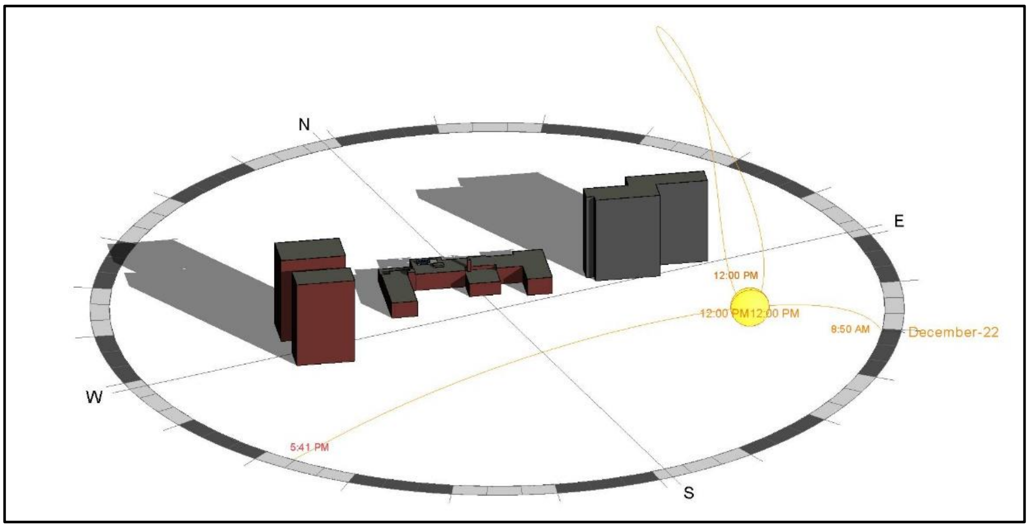


Figure 11: Revit Solar Shade Analysis Setup

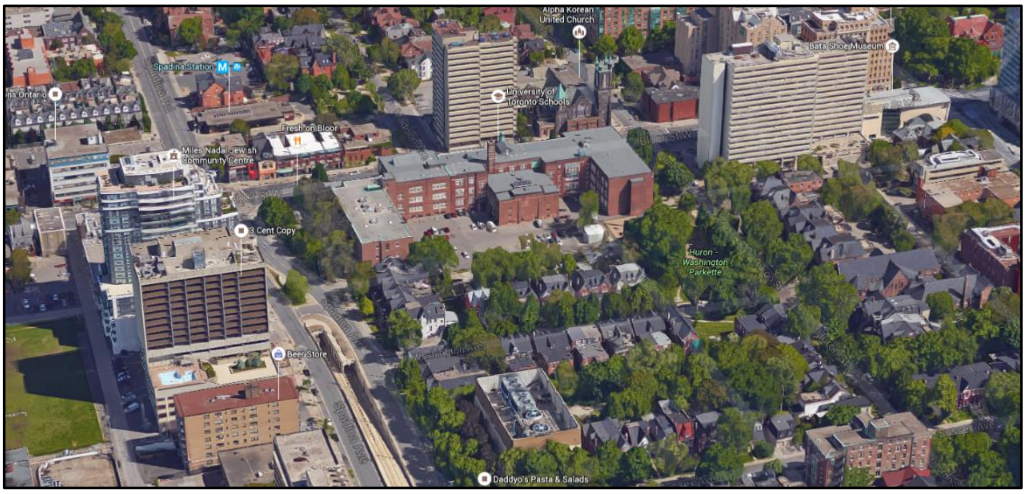


Figure 12: Google Earth view of site

The four elements with the potential to cast shade on the panels are:

- 341 Bloor St West - east of array - an 18 storey apartment building estimated to be 72 m tall.
- 732 Spadina Ave - west of array - a 20 storey condo estimated to be 80m tall
- 720 Spadina Ave - west of array - an 18 storey condo estimated to be 72m tall
- Chimney on roof south - east of the array - estimated to be 6m tall and a 2.25m cross-section
- A room on the room - south east of the array - estimated to be 8m x 4m x 1.5m

Shade from the buildings and chimney did not fall on the array for 90% of the year, and when they did it was within one hour of sunrise/sunset. The team did not expect much output from the array during this time of day and therefore disregarded the shading.

The room on the roof did cast shade on the sloped roof for a significant part of the day and due to this the team pushed the array as far west as they could and then conducted a more detailed shading analysis. This showed that a 20 cm strip of the two east most panels covered during the winter months in early morning and late evening. Again - this was not a significant solar gain time period so the team disregarded the small amount of shading. Below you can see the shading on the roof on the 21st of four months (vernal/autumnal equinox and summer/winter solstice) at noon in Figure 13.

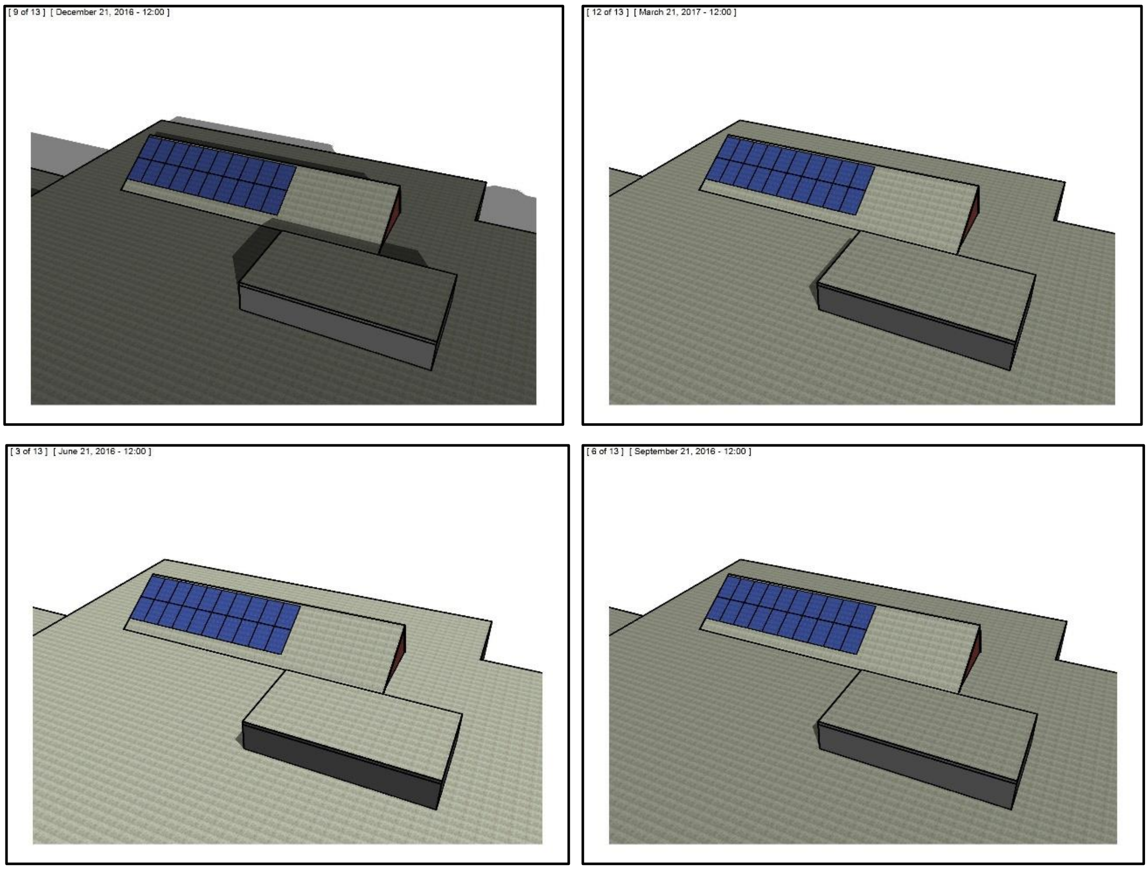


Figure 13: Rooftop Solar Shading Study

Electrical Schematic

The solar system is detailed in Figure 14 in a three line electrical diagram. Following the system from the panels to the grid the components are as follows:

- 2 x 10 CS6P-260P modules connected in series (see appendix for spec sheet)
- Wiring to the combiner box:
- Ground wire - connected to the solar racking grounding anchors which is connected to each panel
- PV+/PV- wires (must support up to 85 A/450V)
- Combiner box with 10A fuses which connects the wiring from the two rows of panels
- Fronius Primo 3.8 Inverter (see appendix for spec sheet)
- Contains DC disconnect
- Wiring to the Watthour meter, breaker and panel:
- Ground wire
- Neutral and two lines to carry AC current (must support up to 15.8A/240V)
- Meter - specified and purchased by Toronto Hydro as part of Ontario MicroFit
- AC Breaker with 20A breakers as per Fronius Primo 3.8 spec sheet
- Connection to grid (to be designed based on full building wiring)
- Earth ground

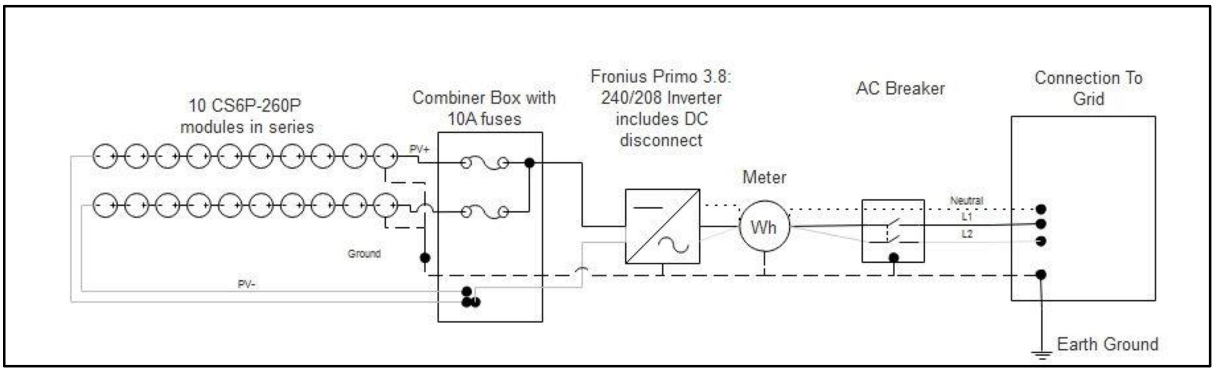


Figure 14: Solar System 3 Line Diagram

Finance and Schedule

Financial information for the lighting retrofit project as a whole is shown below. The project cost includes materials, labour, and other operational costs. The simple payback period of 5.81 years includes applicable incentives.

Cost Estimate

The total cost of the University of Toronto Schools project was estimated using information from equipment manufacturers and the NECA Manual of Labour Units, supplemented with the expert judgement of our partners at Graybar Canada. We have not evaluated the cost of the “donated” solar system, but we allowed time for its installation in the work plan.

Design was estimated as 2% of total lighting retrofit costs. In addition to direct expenses from labour and materials, ancillary costs for items such as permitting, equipment, and travel are also included. Overhead and profit are set at 6%. With these preliminary assumptions, total project for the lighting retrofit cost is estimated at $8,526.

The project cost estimated here represents capital cost only. Grants, incentives, financing, and payback periods are evaluated in the following sections. Annual operations and maintenance for the project as a whole are estimated at $20/year on average. All components of the project are expected to have a lifetime of at least 20 years before requiring replacement.

Table 2: Cost Estimate for Lighting Retrofit Component of Work Plan

Category	Description	Quantity	Units	Material Cost ($/unit)	Cost ($, 15% Markup)	Hours	Labour Cost ($)	Total Cost ($)
Design Costs								
	Design of Lighting Retrofit							$ 200.00
Lighting Retrofit								
	24 Watt LED 4ft tube	32	ea	$ 11.00	$ 404.80	16	$ 2,400	$ 3,918.00
	18 Watt LED 4ft tube	32	ea	$ 9.00	$ 331.20	16		
	Remove 32 Watt 4ft tube	64	ea	$ -	$ -	16		
	Disposal of old fixtures	64	ea	$ 10.00	$ 736.00	0		
Classroom Lighting Automation								
	Occupancy sensors (Option 2A)	2	ea	$ 20.00	$ 46.00	2	$ 172	$ 218
Additional Costs								
	Permits							$ 83
	Consumables and Tools (5%)							$ 207
	Travel and Site Expenses							$ 165
							Subtotal	**$ 4,791**
							Overhead and Profit	**$ 287**
							Project Total	**$ 5,078**

Work Schedule

The estimated project length is 140 days, with construction activities starting on June 29, 2017 and running to September 1, 2017. It is important to the client that the project not interfere with the normal operation of the school (September-June), so the main project activities take place during the summer.

There are other planned renovations taking place at UTS beginning in Summer 2017. Coordination with other contractors will be essential in order to avoid scheduling conflicts and duplicated work. It may also be possible to realize cost savings for the client by sharing fixed construction costs between the Northern Lights Solutions project and the broader renovation. The work schedule will be updated as details on the renovation project become available.

The pre-construction and design phase will take place during Spring of 2017. During this time, the project schedule will be finalized and detailed engineering designs will be completed for the lighting retrofit and the solar system. Extra time has been allocated to securing the required solar microFIT permits, since this will require the cooperation of at least three external organizations.

The lighting retrofit will take 42 days from subcontractor selection to commissioning, and the solar PV will be installed in parallel over 37 days. The solar system is relatively small, and we expect local subcontractors to have experience with similar systems. Work can take place at all hours of the day, since the building will not be operating normally. However, planned power outages and other disruptions will have to be scheduled around the activities of the other renovation crew.

Preconstruction, permitting, and design will require one electrical engineer. The same engineer can also perform the project management required to complete the lighting retrofit and solar installation while other renovations are ongoing. One electrician could perform the installation and testing of the 4 foot LED tubes and occupancy sensors. A team of 3-5 workers could perform the solar installation. Finally, we would require 2 school employees to be present for brief training on the solar system and lighting occupancy sensors.

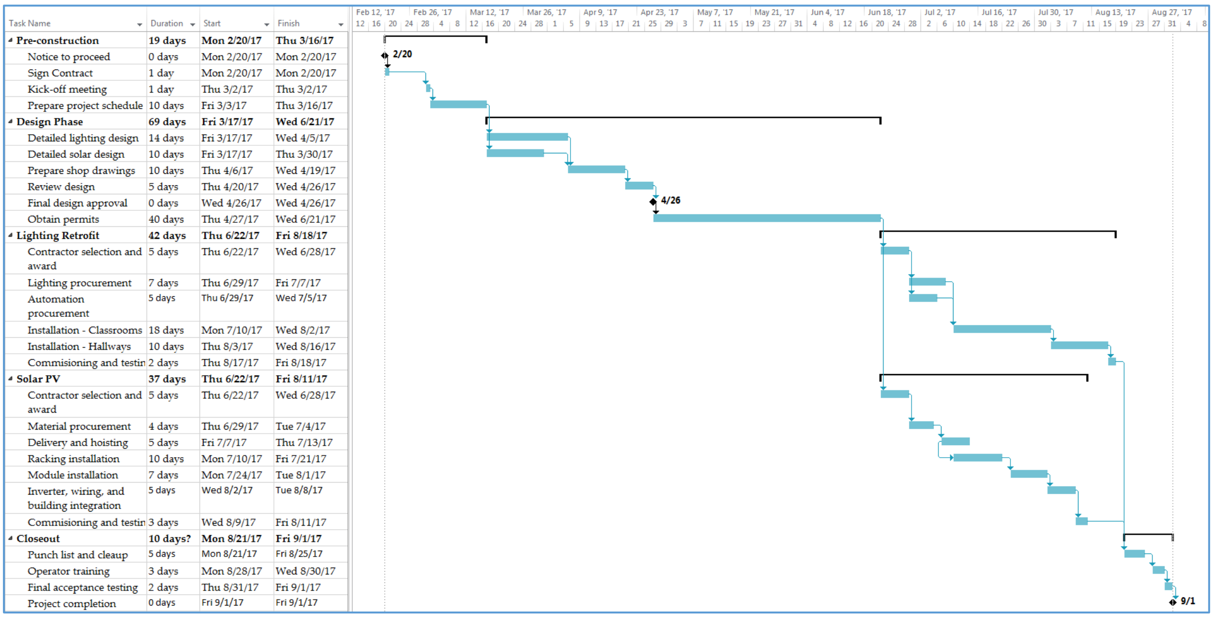


Figure 15: Project Schedule Gantt Chart

Grants and Incentives

TD Friends of the Environment Foundation Grant:

This grant is targeted at charities, municipalities, and educational institutions who are planning an environmental initiative. Because the UTS project includes energy conservation and an education component, it may be eligible for funding. The average grant size is $4,000, but due to the small scope of this project we would apply for $1,000.

Toronto Hydro Retrofit Program:

The local electricity utility, Toronto Hydro, offers incentives to commercial and institutional customers who are planning energy efficiency projects. For a generic lighting retrofit, Toronto Hydro offers $0.05 per kWh of annual savings. Savings from lighting controls and other efficiency measures can receive $0.10 per kWh. If options 1A, 1B, and 2A of the lighting retrofit is chosen, $235.09 in incentives would be available.

IESO microFIT:

MicroFIT (micro feed-in-tariff) is a program operated by Ontario's Independent Electricity System operator (IESO) to encourage the development of small renewable energy projects. Qualifying projects can sell energy to the system operator at a guaranteed, above-market rate for the length of a 20-year contract. The microFIT program offers financial security and a reasonable rate of return to new renewable projects. For solar power under 10kW, the current microFIT price is 0.294 $/kWh. The UTS solar project is an ideal candidate for microFIT.

Table 3: Project Financial Information

Lighting Retrofit Project Parameters	
Project Cost	$ 5,078
Incentives Available	$ 1,235
First Year Bill Savings	$ 681
First Year O&M	$ 20
Simple Payback (Years)	5.81
Net Present Value (8% discount)	$ 3,661

Cash Flow and Finance

Figure 16 presents the cash flow estimate for the lighting retrofit project, net of incentives and using $0.20/kWh electricity cost. This represents the 20-year lifetime of the project if UTS decides to pay the upfront capital costs using their own financing methods.

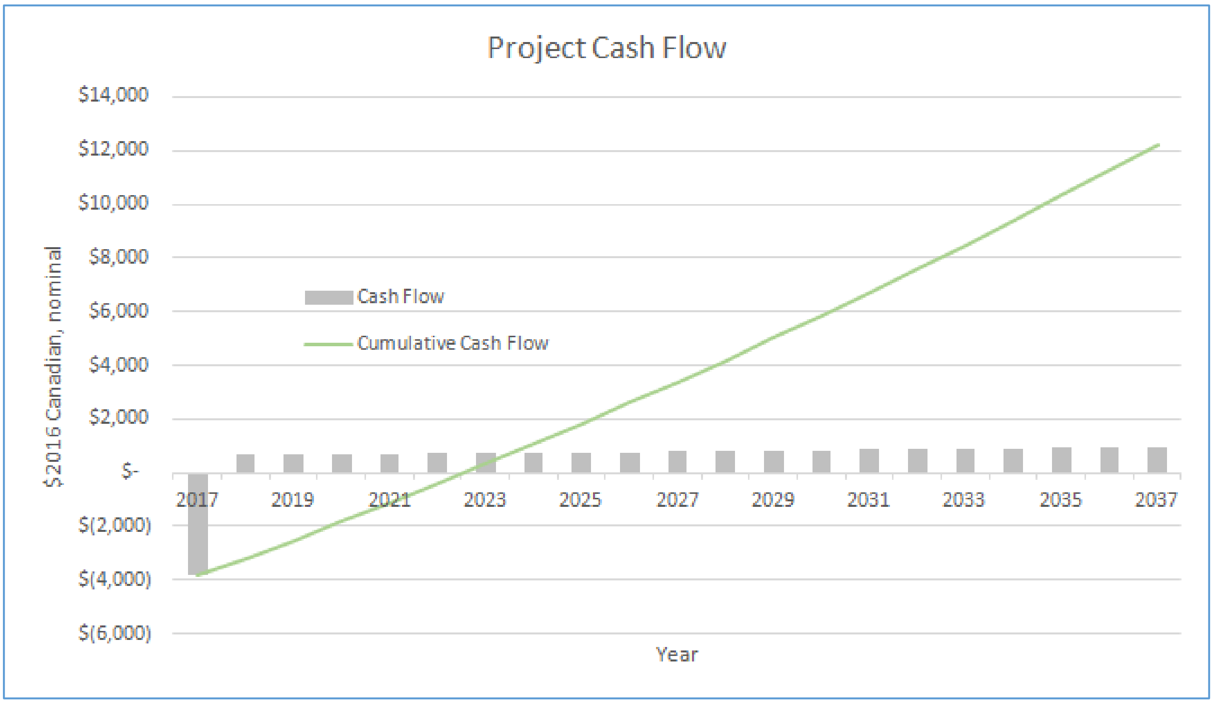


Figure 16: Cash flow estimate

Figure 17 presents the cash flow for the project assuming a $4,000 bank loan paid back in 9 installments over the next 10 years. Financing for the project is available at 5.7% term, with no requirement to pay back any principal during the first 12 months of the loan.

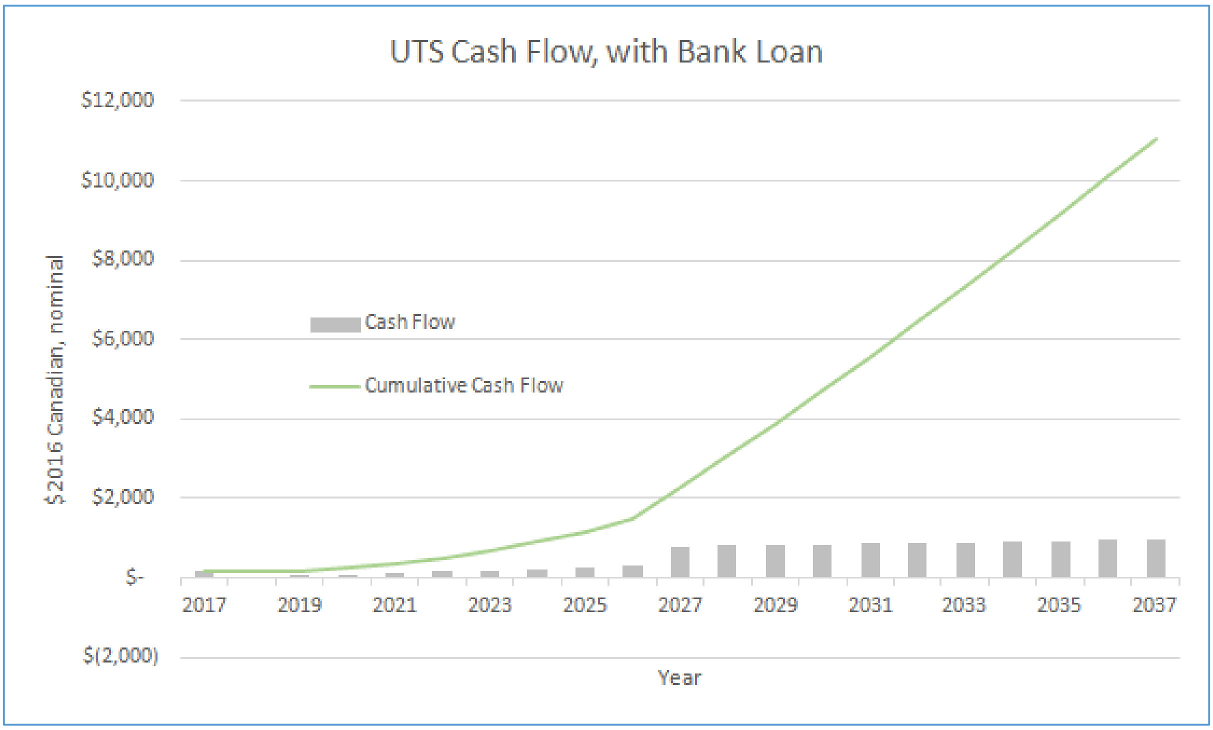


Figure 17: Cash flow estimate - loan option

Using this option, UTS would use electricity bill savings to pay off the loan. The payback period would be extended slightly, but the loan would finance all cash flow requirements. By 2026 the loan would be fully paid off. It is important to also consider the non-financial benefits to the client of improving the brightness in Room 203, which is currently below ideal levels for a work environment.

The solar system was considered as a separate project. At current installation rates, the all-in cost of the 6kW system described in the Solar Education System section would be approximately $22,000. With a microFIT contract for $0.294/kWh produced and 6500 kWh/year, the system would earn $1,911 in revenue annually. Even if the system were not donated, it would represent a relatively safe investment with an 11.5 year payback period.

The calculations in this section are in nominal 2016 Canadian dollars. We have assumed that electricity rates, and electricity bill savings resulting from the lighting retrofit, will increase with inflation at 2% per year on average. Operations and maintenance for the project also increase with inflation. MicroFIT rates, however, do not increase with inflation.

Outreach

Energy Awareness & Business Development

Northern Lights Solutions has developed a comprehensive business development plan to promote energy awareness through the project solution that is complementary to and builds upon several existing initiatives in the City of Toronto. The plan leverages a combination of events, online resources and other activities to maximize target audience.

Project Blog

Northern Lights Solutions developed an online blog to share the progress of the project, as well as the any other student chapter activities with the community. Five entries have already been published to the blog, and it has received 250 views and has twelve followers.

Northern Lights Solutions proposes that, following Notice to Proceed, the blog will continue to be updated. The online blog can also be integrated with University of Toronto School's' website to increase visitors. Furthermore, this blog can be leveraged to share information on best practices related to energy savings so that readers not only learn about the status of the project but also learn energy-reducing strategies they can implement at home. Figure 18 below is a screenshot of the most recent blog entry, via www.cecauoft.wordpress.com.

Figure 18: CECA UofT Blog

University of Toronto Sustainability Conference

Northern Lights Solutions attended existing conferences and events focused on sustainability as a key component of its' business development strategy. As the largest and most diverse city in Canada, Toronto hosts dozens of events where the team can advertise the project and increase energy awareness.

On January 30, 2016, Northern Lights Solutions participated in the University of Toronto Sustainability conference, an event organized by the Sustainable Engineers Association (Figure 19). This annual conference attracts thousands of students, academics and members of the university to

Figure 19: Northern Lights Solutions at the UofT Sustainability Conference

participate in workshops, lectures, and a tradeshow of clubs that work on sustainability related topics. The team attracted hundreds of visitors to its booth who asked questions about the chapter, its history, and about the project. In the future, Northern Lights Solutions plans to work with University of Toronto Schools to identify similar events that can be used to promote this project.

Partnership with Peel Environmental Youth Alliance

In addition to promoting the project through online resources and attendance at community events, Northern Lights Solutions organized several social events dedicated to promoting the project. These events were designed as fun, competitive challenges where participants could learn about the project and related topics on energy conservation in an informal setting.

One very exciting event that Northern Lights Solutions will be hosting on April 16th, following the submission of this proposal, is an Energy Jeopardy Event in collaboration with the Peel Environmental Youth Alliance (PEYA). PEYA is a network of action-oriented high school students in Peel Region (Greater Toronto Area) concerned about environmental issues and determined to make positive change, and assists students and teachers looking to create sustained environmental change in their schools, and helps students build their capacity to affect positive environmental change in their schools and community. PEYA unites students across Peel working to improve the environment in their schools and neighborhoods through monthly networking meetings, and an online community **[m1]**. They provide a forum for students to learn from one another and form relationships with local environmental organizations, including fun and effective educational events such as the Energy Jeopardy event that Northern Lights Solutions will be hosting.

Northern Lights Solutions met a representative of PEYA at the University of Toronto Sustainability Conference in January 2016, and is very excited about its partnership with PEYA moving forward. This partnership is an excellent opportunity to meet students soon to enter university who are already interested in sustainable energy and show them an example of where this interests can take them into their future education and career beyond.

Figure 20: Group of PEYA students attending a previous event

[m1] http://peyalliance.ca/about/

Feedback Letters

UTS
UNIVERSITY OF TORONTO SCHOOLS

April 1, 2016

Mr. Dmitri Naoumov
Project Manager, 2016 Green Energy Challenge
CECA/NECA University of Toronto Student Chapter
Room GB134, Galbraith Building
Department of Civil Engineering
University of Toronto
35 St. George Street
Toronto, ON M5S 1A4

Dear Mr. Naoumov:

I am writing to thank you for the time and energy you have given to preparing a CECA/NECA submission for University of Toronto Schools (UTS).

Thank you for your thorough collection of data and identification of where we may require lighting and energy retrofits. As our building is old, we have many outdated lighting systems. Your analysis team was a pleasure to work with and their understanding of how to improve efficiency within our building was impressive. As you know, we are an Eco School and aim to reduce our environmental footprint as well as energy costs.

I also look forward to seeing the final design for a roof top solar energy system. It was interesting to learn that our Canadian weather patterns will affect the size of the array installed. Thank you for following protocol and working with UofT for access to the roof and the mechanical rooms.

Your team has my enthusiastic support in the Green Energy Challenge. I wish you great success in the 2016 Green Energy Challenge and look forward to working with you further.

Sincerely,

J. Martin

Julie Martin
Manager, Facilities & HR Services
University of Toronto Schools

Articles in Department / University Newsletter

CECA – Canadian Electrical Contractors Association U of T Chapter

An interview with CECA, Matheos Tsiaras, co-founder, former projects manager, and current communications co-ordinator.

By: Nataliya Pekar

Nataliya: First thing's first - what is CECA and what does the U of T Student Chapter aim to accomplish?

Matheos: Primarily, The Canadian Electrical Contractors Association brings together electrical contractors across the country to share experience and advice. Our chapter is an extension of this initiative to the student community, and we're the first in Canada! Our goal is to engage students to learn about electrical contracting from firsthand experience, and to bridge the gap between contracting and engineering both within Canada, and between Canada and the United States (our chapter is also affiliated as the 30th chapter of the National Electrical Contractors Association, the American equivalent of CECA).

Nataliya: More specifically, what have you done so far?

Matheos: The majority of our success has been spreading awareness and increasing excitement around electrical contracting within the engineering community at U of T. With the incredible support of our industry contact with CECA, Tom Vivian, our faculty advisor, Brenda McCabe, and everyone else who has helped along the way, the successful launch of the chapter in May 2014 and a great first year is a huge success on its own.

More specifically, the chapter competed in the 2015 Green Energy Challenge and scored fourth place for their lighting and back-up power retrofit proposal for Good Sheppard Ministries – a shelter in downtown Toronto. Additionally, the chapter placed second in the poster competition for the 2015 challenge. This year, with the help of CECA and several local contractors, our proposal is actually being realized at Good Sheppard, which we are really excited about.
In late fall of 2015 the U of T CECA Student chapter was approached by the Penn State University NECA to join them to construct a solar powered water pumping station for a community of 600 in Roatan, Honduras. This is part of the Student Passport Competition which Penn State won with their proposal last year. Two members of our chapter, Mackenzie de Carle and Dmitri Naoumov, were in Honduras during the week of March 7 to build the station. We hope to join this competition again next year.

Nataliya: Tell me more about the specifics of these competitions.

Matheos: The majority of the work is for the Green Energy Challenge. Typically the project consists of conducting an energy audit of a site and then proposing a renewable energy implementation and a lighting retrofit. We plan a new electrical system, figure out the construction scheduling, and work with local contractors to do a cost estimate. Then we put together a short pre-proposal and then a final proposal submission in April. A winner is picked from a selection of finalists at the annual NECA Convention, last year it was in San Francisco and a bunch of us from the chapter actually attended for the 2015 poster competition!
For the Student Passport Initiative, the idea is similar. Teams who wish to participate submit a short proposal detailing a renewable energy solution that they would like to implement in a developing country or rural community of their choice. The most exciting part is that the winning proposal receives funding to allow the students to go and implement their design.

Nataliya: Can you expand on participating in the Passport Competition and your trip?

Matheos: Participating in the Student Passport Competition was an incredible experience. Not only was it a great way to get introduced to the competition and how it all works, but Mackenzie de Carle and Dmitri Naoumov, the students who went on the trip, will both say that being able to actually travel to Honduras and help build the solar powered water pumping station and see first-hand the positive impact it will have on the community was a feeling that is tough to put into words. We would like to thank Penn State for allowing us to piggyback on their proposal this year, and we hope to submit our own proposal next year.

Nataliya: What are you currently working on?

Matheos: The 2016 Green Energy Challenge is currently in full swing, and the team is hard at work on it. The competition this year centres on an energy audit, lighting retrofit, and solar PV array installation at a local school, and we are working with University of Toronto Schools (UTS), a high school near campus, for this competition. The team is holding a site visit on March 21 to collect data about the existing conditions of the school, and the final proposal is due on April 4. As well, the team is working on its outreach strategy for the competition, which will likely include an event hosted by the team either at the school itself or on university grounds to spread sustainable energy awareness.

Nataliya: Where are you hoping to expand?
Matheos: As early as next year, we hope to submit our own proposal for the Student Passport Initiative. Into the future, we hope to be a part of the initiative that leads to the creation of more CECA chapters across Canadian universities.
Overall, we want to spread awareness and education and are always looking to collaborate with others clubs at U of T.

Nataliya: So, what can students do if they join your club? What kind of expertise is required?

Matheos: All students are welcome to join the CECA chapter, being an engineering student is not required whatsoever. We hope students are not turned away by feeling their expertise does not match with the work that we do, we welcome everybody as anyone can meaningfully contribute.

We are proud to say participating is a great learning experience for everyone involved. There is something for everyone who is interested in green energy and sustainable design.
Nataliya How can students get involved and where can they get more information?
Matheos: Students can send us an email at ceca.uoft@gmail.com if they are interested in anything that the chapter is doing. We can also be found at a booth at both the Frosh Week Clubs Fair and the U of T Sustainability Conference Tradeshow, which occur annually.
Students can also check out our blog at www.cecauoft.wordpress.com. This blog is being regularly updated as part of the outreach strategy during the Green Energy Challenge, and summarizes all activities surrounding the chapter.
Nataliya: Thank you! Good luck in the Green Energy Challenge!

Matheos: Thanks!

Local CECA Chapter Interaction

Throughout the project, Northern Lights Solutions enjoyed immense support from and interaction with several industry connections, including CECA, the Electrical Contractors Association of Ontario (ECAO), and Alltrade Industrial. Throughout the 2015-2016 school year, the student chapter executives held several meetings with Tom Vivian of CECA, Eryl Roberts of ECAO, and Bob Ritzmann of Alltrade Industrial to discuss the general progress of the student chapter and the Green Energy Challenge.

Additionally, the chapter received incredible support for its involvement in the 2015 Student Passport Competition. Two executive members of the chapter joined Penn State University's project, which was the installation of a solar powered water pumping station for a community of 600 in Roatan, Honduras, and these two chapter members were able to travel to Honduras to help construct the station with local contractors. CECA and ECAO were instrumental in making all operations and communications between the chapter and the Penn State chapter go smoothly, and the chapter also received generous financial contributions from three contracting companies, Alltrade Industrial, Fitzpatrick Electric, and Fusion Énergie.

Finally, as a follow-up to Northern Lights Solutions' 2015 Green Energy Challenge Proposal with Good Shepherd Ministries, Northern Lights Solutions is very excited to announce that the proposal put forward will be implemented at Good Shepherd Ministries. The team has been involved in a few meetings with the key stakeholders in that project, including CECA, ECAO, Alltrade Industrial, and of course Good Shepherd Ministries itself, but it is these organizations who have been primarily responsible for carrying the project forward. Northern Lights Solutions is prepared to assist in the implementation process as needed moving forward.

Appendix A: Lighting Summary

The following table provides a brief summary of light number and energy usage sorted by light types.

Type of Fixture	Total Fixtures	Wattage (W)	Total wattage (W)
4’ T8 LFL	2264	32	72448
2’ T8 LFL	12	32	384
15W Recessed Spherical Incandescent	47	15	705
60W CFL	37	60	2220
200W Gym Spotlight (unidentified)	6	200	1200
TOTAL	**2366**		**76957**

Appendix B: Solar Array Design Report

Please see next page.

Grid-Connected System: Simulation parameters

Project :	**UTS**			
Geographical Site	**Toronto**		Country	**Canada**
Situation	Latitude	43.8°N	Longitude	79.5°W
Time defined as	Legal Time	Time zone UT-5	Altitude	196 m
	Albedo	0.20		
Meteo data:	**Toronto**	MeteoNorm 7.1 station - Synthetic		

Simulation variant :	**PV Analysis**			
	Simulation date	04/04/16 01h03		

Simulation parameters

Collector Plane Orientation	Tilt	34°	Azimuth	-16°
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Array Characteristics

PV module Si-poly	Model	**CS6P - 260P**		
Original PVsyst database	Manufacturer	Canadian Solar Inc.		
Number of PV modules	In series	10 modules	In parallel	2 strings
Total number of PV modules	Nb. modules	20	Unit Nom. Power	260 Wp
Array global power	Nominal (STC)	**5.20 kWp**	At operating cond.	4642 Wp (50°C)
Array operating characteristics (50°C)	U mpp	269 V	I mpp	17 A
Total area	Module area	**32.2 m²**	Cell area	29.2 m²

Inverter	Model	**Primo 3.8-1 / 240**		
Original PVsyst database	Manufacturer	Fronius USA		
Characteristics	Operating Voltage	80-800 V	Unit Nom. Power	3.80 kWac
Inverter pack	Nb. of inverters	2 * MPPT 50 %	Total Power	3.8 kWac

PV Array loss factors

Array Soiling Losses			Loss Fraction	2.5 %
Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Global array res.	272 mOhm	Loss Fraction	1.5 % at STC
Module Quality Loss			Loss Fraction	-0.2 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP

Incidence effect, user defined profile

10°	20°	30°	40°	50°	60°	70°	80°	90°
1.00	1.00	1.00	0.99	0.99	0.95	0.89	0.70	0.00

Unavailability of the system	1.0 days, 2 periods	Time fraction	0.3 %

User's needs : Unlimited load (grid)

Grid-Connected System: Main results

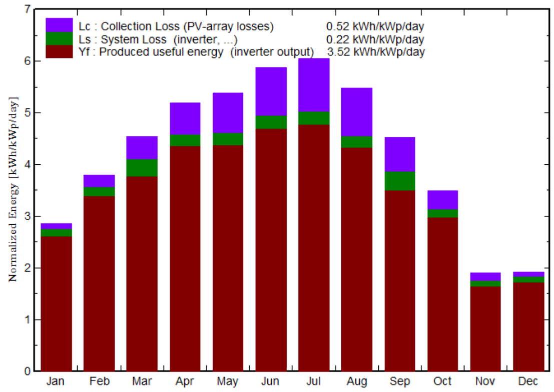
Project : **UTS**

Simulation variant : **PV Analysis**

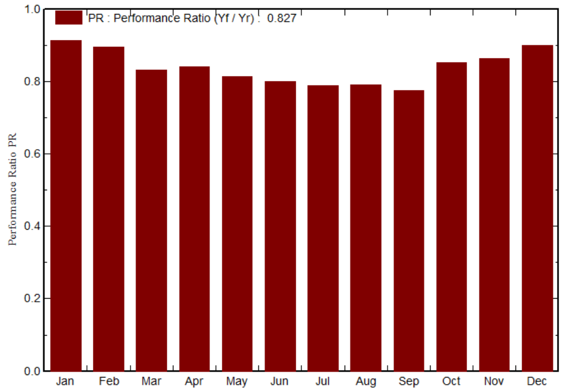
Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	34°	azimuth	-16°
PV modules	Model	CS6P - 260P	Pnom	260 Wp
PV Array	Nb. of modules	20	Pnom total	**5.20 kWp**
Inverter	Model	Primo 3.8-1 / 240	Pnom	3800 W ac
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**6.67 MWh/year**	Specific prod.	1284 kWh/kWp/year
	Performance Ratio PR	82.7 %		

Normalized productions (per installed kWp): Nominal power 5.20 kWp



Performance Ratio PR



PV Analysis

Balances and main results

	GlobHor	T Amb	GlobInc	GlobEff	EArray	E_Grid	EffArrR	EffSysR
	kWh/m²	°C	kWh/m²	kWh/m²	MWh	MWh	%	%
January	50.6	-4.92	88.6	84.6	0.444	0.421	15.56	14.76
February	71.2	-4.57	106.0	101.2	0.519	0.494	15.21	14.49
March	112.3	0.29	140.9	134.0	0.663	0.609	14.62	13.44
April	142.4	6.91	155.6	147.6	0.715	0.680	14.29	13.59
May	169.5	13.07	166.8	157.8	0.745	0.706	13.88	13.16
June	183.6	18.84	176.2	166.8	0.773	0.733	13.63	12.94
July	191.2	21.59	187.8	177.8	0.812	0.771	13.44	12.76
August	160.7	21.11	169.6	160.9	0.735	0.697	13.47	12.78
September	115.9	16.93	135.7	128.9	0.603	0.547	13.82	12.52
October	78.1	9.96	108.1	102.8	0.507	0.480	14.56	13.80
November	41.0	4.35	57.2	54.2	0.274	0.257	14.90	13.96
December	35.7	-2.08	59.7	56.8	0.297	0.279	15.46	14.55
Year	1352.2	8.53	1552.3	1473.3	7.085	6.675	14.19	13.37

Legends:	GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
	T Amb	Ambient Temperature	E_Grid	Energy injected into grid
	GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
	GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

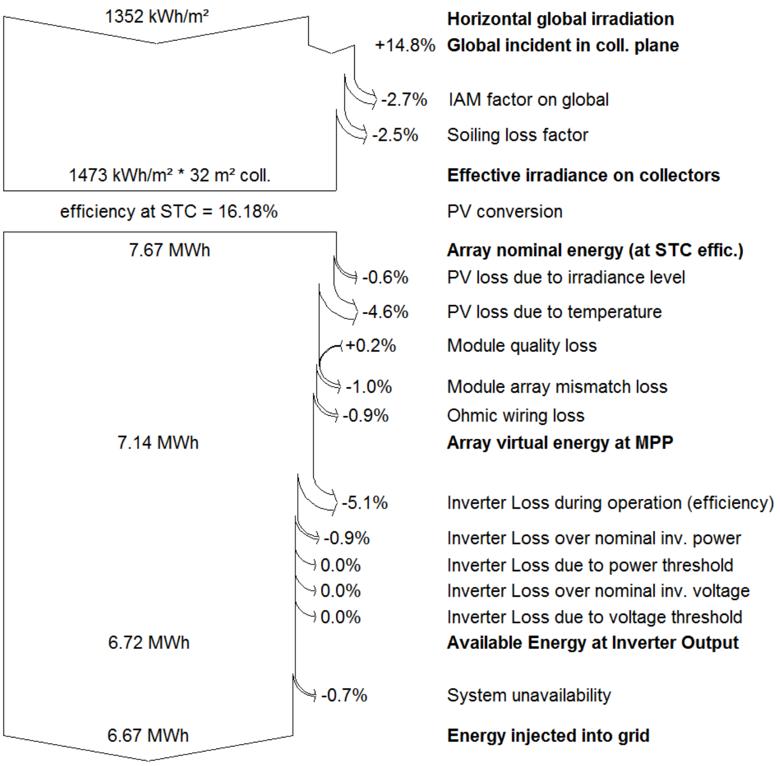
Grid-Connected System: Loss diagram

Project : **UTS**

Simulation variant : **PV Analysis**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	34°	azimuth	-16°
PV modules	Model	CS6P - 260P	Pnom	260 Wp
PV Array	Nb. of modules	20	Pnom total	**5.20 kWp**
Inverter	Model	Primo 3.8-1 / 240	Pnom	3800 W ac
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



CanadianSolar

*Black frame product can be provided upon request.

CS6P-260 | 265 | 270P

The high quality and reliability of Canadian Solar's modules is ensured by 15 years of experience in module manufacturing, well-engineered module design, stringent BOM quality testing, an automated manufacturing process and 100% EL testing.

25 years linear power output warranty

10 years product warranty on materials and workmanship

KEY FEATURES

- Excellent module efficiency of up to 16.79 %
- Outstanding low irradiance performance: 96.5 %
- +5Wp: Positive power tolerance of up to 5 W
- No. 1 PTC: High PTC rating of up to 92.0 %
- IP67: IP67 junction box for long-term weather endurance
- Heavy snow load up to 5400 Pa, wind load up to 2400 Pa
- Salt mist, ammonia and blown sand resistance, for seaside, farm and desert environments*

MANAGEMENT SYSTEM CERTIFICATES*

ISO 9001:2008 / Quality management system
ISO/TS 16949:2009 / The automotive industry quality management system
ISO 14001:2004 / Standards for environmental management system
OHSAS 18001:2007 / International standards for occupational health & safety

PRODUCT CERTIFICATES*

IEC 61215 / IEC 61730: VDE / CE / MCS / JET / SII / CEC AU / INMETRO / CQC
UL 1703 / IEC 61215 performance: CEC listed (US) / FSEC (US Florida)
UL 1703: CSA / IEC 61701 ED2: VDE / IEC 62716: VDE / IEC 60068-2-68: SGS
Take-e-way / UNI 9177 Reaction to Fire: Class 1

* As there are different certification requirements in different markets, please contact your local Canadian Solar sales representative for the specific certificates applicable to the products in the region in which the products are to be used.

CANADIAN SOLAR INC. is committed to providing high quality solar products, solar system solutions and services to customers around the world. As a leading manufacturer of solar modules and PV project developer with over 14 GW of premium quality modules deployed around the world since 2001, Canadian Solar Inc. (NASDAQ: CSIQ) is one of the most bankable solar companies worldwide.

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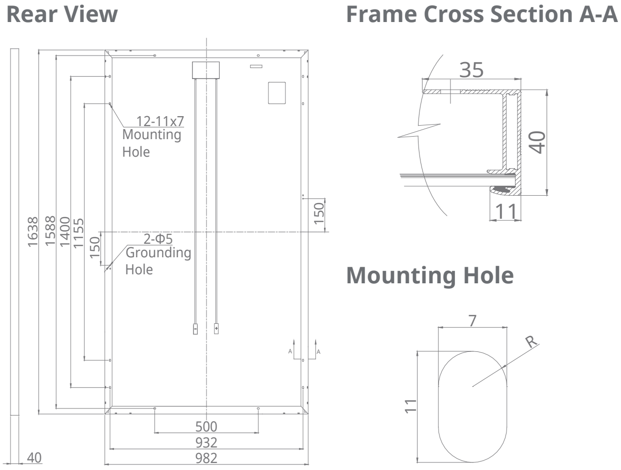
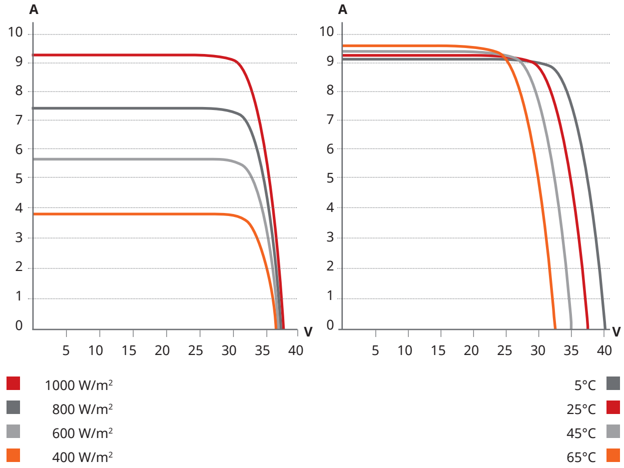
ENGINEERING DRAWING (mm)



CS6P-265P / I-V CURVES



ELECTRICAL DATA | STC*

CS6P	260P	265P	270P
Nominal Max. Power (Pmax)	260 W	265 W	270 W
Opt. Operating Voltage (Vmp)	30.4 V	30.6 V	30.8 V
Opt. Operating Current (Imp)	8.56 A	8.66 A	8.75 A
Open Circuit Voltage (Voc)	37.5 V	37.7 V	37.9 V
Short Circuit Current (Isc)	9.12 A	9.23 A	9.32 A
Module Efficiency	16.16 %	16.47 %	16.79 %
Operating Temperature	-40°C ~ +85°C		
Max. System Voltage	1000 V (IEC) or 1000 V (UL)		
Module Fire Performance	TYPE 1 (UL 1703) or CLASS C (IEC 61730)		
Max. Series Fuse Rating	15 A		
Application Classification	Class A		
Power Tolerance	0 ~ + 5 W		

* Under Standard Test Conditions (STC) of irradiance of 1000 W/m², spectrum AM 1.5 and cell temperature of 25°C.

ELECTRICAL DATA | NOCT*

CS6P	260P	265P	270P
Nominal Max. Power (Pmax)	189 W	192 W	196 W
Opt. Operating Voltage (Vmp)	27.7 V	27.9 V	28.1 V
Opt. Operating Current (Imp)	6.80 A	6.88 A	6.97 A
Open Circuit Voltage (Voc)	34.5 V	34.7 V	34.8 V
Short Circuit Current (Isc)	7.39 A	7.48 A	7.55 A

* Under Nominal Operating Cell Temperature (NOCT), irradiance of 800 W/m², spectrum AM 1.5, ambient temperature 20°C, wind speed 1 m/s.

PERFORMANCE AT LOW IRRADIANCE

Industry leading performance at low irradiance, average relative efficiency of 96.5 % from an irradiance of 1000 W/m² to 200 W/m² (AM 1.5, 25°C).

The specification and key features described in this datasheet may deviate slightly and are not guaranteed. Due to on-going innovation, research and product enhancement, Canadian Solar Inc. reserves the right to make any adjustment to the information described herein at any time without notice. Please always obtain the most recent version of the datasheet which shall be duly incorporated into the binding contract made by the parties governing all transactions related to the purchase and sale of the products described herein.

Caution: For professional use only. The installation and handling of PV modules requires professional skills and should only be performed by qualified professionals. Please read the safety and installation instructions before using the modules.

MECHANICAL DATA

Specification	Data
Cell Type	Poly-crystalline, 6 inch
Cell Arrangement	60 (6×10)
Dimensions	1638×982×40 mm (64.5×38.7×1.57 in)
Weight	18 kg (39.7 lbs)
Front Cover	3.2 mm tempered glass
Frame Material	Anodized aluminium alloy
J-Box	IP67, 3 diodes
Cable	4 mm² (IEC) or 4 mm² & 12 AWG 1000 V (UL), 1000 mm (39.4 in) (650 mm (25.6 in) is optional)
Connectors	Friends PV2a (IEC), Friends PV2b (IEC / UL)
Standard Packaging	26 pieces, 515 kg (1135.4 lbs) (quantity & weight per pallet)
Module Pieces per Container	728 pieces (40' HQ)

TEMPERATURE CHARACTERISTICS

Specification	Data
Temperature Coefficient (Pmax)	-0.41 % / °C
Temperature Coefficient (Voc)	-0.31 % / °C
Temperature Coefficient (Isc)	0.053 % / °C
Nominal Operating Cell Temperature	45±2 °C

PARTNER SECTION

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SHIFTING THE LIMITS

FRONIUS PRIMO

/ The future of residential solar is here - Introducing the new Fronius Primo.

/ PC board replacement process

/ SnapINverter mounting system

/ Wi-Fi®* interface

/ SuperFlex Design

/ Smart Grid Ready

/ Arc Fault Circuit Interruption

/ With power categories ranging from 3.8 kW to 15.0 kW, the transformerless Fronius Primo is the ideal compact single-phase inverter for residential applications. The sleek design is equipped with the SnapINverter hinge mounting system which allows for lightweight, secure and convenient installation. The Fronius Primo has several integrated features that set it apart from competitors including dual powerpoint trackers, high system voltage, a wide input voltage range, Wi-Fi* and SunSpec Modbus interface, and Fronius' online and mobile monitoring platform Fronius Solar.web. The Fronius Primo also works seamlessly with the Fronius Rapid Shutdown Box for a reliable NEC 2014 solution** and offers a Revenue Grade Metering option completely integrated.

TECHNICAL DATA FRONIUS PRIMO

GENERAL DATA	FRONIUS PRIMO 3.8 - 8.2	FRONIUS PRIMO 10.0-15.0
Dimensions (width x height x depth)	16.9 x 24.7 x 8.1 in.	20.1 x 28.5 x 8.9 in.
Weight	47.29 lb.	82.5 lbs.
Degree of protection	NEMA 4X	
Night time consumption	< 1 W	
Inverter topology	Transformerless	
Cooling	Variable speed fan	
Installation	Indoor and outdoor installation	
Ambient operating temperature range	-40 - 131°F (-40 - 55°C)	-40 - 140°F (-40 - 60°C)
Permitted humidity	0 - 100 %	
DC connection terminals	4x DC+ and 4x DC- screw terminals for copper (solid / stranded / fine stranded) or aluminum (solid / stranded)	4x DC+1, 2x DC+2 and 6x DC- screw terminals for copper (solid / stranded / fine stranded) or aluminum (solid / stranded)
AC connection terminals	Screw terminals 12 - 6 AWG	
Revenue Grade Metering	Optional (ANSI C12.1 accuracy)	
Certificates and compliance with standards	UL 1741-2010, UL1998 (for functions: AFCI and isolation monitoring), IEEE 1547-2003, IEEE 1547.1-2003, ANSI/IEEE C62.41, FCC Part 15 A & B, NEC Article 690, C22. 2 No. 107.1-01 (September 2001) , UL1699B Issue 2 -2013, CSA TIL M-07 Issue 1 -2013	UL 1741-2015, UL1998 (for functions: AFCI, RCMU and isolation monitoring), IEEE 1547-2003, IEEE 1547.1-2003, ANSI/IEEE C62.41, FCC Part 15 A & B, NEC Article 690-2014, C22. 2 No. 107.1-01 (September 2001) , UL1699B Issue 2 -2013, CSA TIL M-07 Issue 1 -2013

PROTECTIVE DEVICES	STANDARD WITH ALL PRIMO MODELS
AFCI & 2014 NEC Ready	Yes
Ground Fault Protection with Isolation Monitor Interrupter	Yes
DC disconnect	Yes
DC reverse polarity protection	Yes

INTERFACES	STANDARD WITH ALL PRIMO MODELS
Wi-Fi*/Ethernet/Serial	Wireless standard 802.11 b/g/n / Fronius Solar.web, SunSpec Modbus TCP, JSON / SunSpec Modbus RTU
6 inputs or 4 digital inputs/outputs	External relay controls
USB (A socket)	Datalogging and/or updating via USB
2x RS422 (RJ45 socket)	Fronius Solar Net, interface protocol
Datalogger and Webserver	Included

*The term Wi-Fi® is a registered trademark of the Wi-Fi Alliance.

**Fronius Primo 10.0-15.0 kW requires an external disconnect button for code compliance.

TECHNICAL DATA FRONIUS PRIMO

INPUT DATA	PRIMO 3.8-1	PRIMO 5.0-1	PRIMO 6.0-1	PRIMO 7.6-1	PRIMO 8.2-1
Recommended PV power (kWp)	3.0 - 6.0 kW	4.0 - 7.8 kW	4.8 - 9.3 kW	6.1 - 11.7 kW	6.6 - 12.7 kW
Max. usable input current (MPPT 1/MPPT 2)	18 A / 18 A	18 A / 18 A	18 A / 18 A	18 A / 18 A	18 A / 18 A
Total max. DC current	36 A				
Max. array short circuit current (1.25 Imax) (MPPT 1/MPPT 2)	22.5 A / 22.5 A				
Operating voltage range	80 V - 600 V				
Max. input voltage	600 V				
Nominal input voltage	410 V	420 V	420 V	420 V	420 V
Admissable conductor size DC	AWG 14 - AWG 6				
MPP Voltage Range	200 - 480 V	240 - 480 V	240 - 480 V	250 - 480 V	270 - 480 V
Number of MPPT	2				

OUTPUT DATA		PRIMO 3.8-1	PRIMO 5.0-1	PRIMO 6.0-1	PRIMO 7.6-1	PRIMO 8.2-1
Max. output power	240 V	3800 W	5000 W	6000 W	7600 W	8200 W
	208 V	3800 W	5000 W	6000 W	7600 W	7900 W
Max. continuous output current	240 V	15.8 A	20.8 A	25.0 A	31.7 A	34.2 A
	208 V	18.3 A	24.0 A	28.8 A	36.5 A	38.0 A
Recommended OCPD/AC breaker size	240 V	20 A	30 A	35 A	40 A	45 A
	208 V	25 A	30 A	40 A	50 A	50 A
Max. Efficiency		96.7 %	96.9 %	96.9 %	96.9 %	97.0 %
CEC Efficiency	240 V	95.0 %	95.5 %	96.0 %	96.0 %	96.5 %
Admissable conductor size AC		AWG 14 - AWG 6				
Grid connection		208 / 240 V				
Frequency		60 Hz				
Total harmonic distortion		< 5.0 %				
Power factor (cos $\varphi_{ac,r}$)		0.85-1 ind./cap				

INPUT DATA	PRIMO 10.0-1	PRIMO 11.4-1	PRIMO 12.5-1	PRIMO 15.0-1
Recommended PV power (kWp)	8.0 - 12.0 kW	9.1 - 13.7 kW	10.0 - 15.0 kW	12.0 - 18.0 kW
Max. usable input current (MPPT 1/MPPT 2)	33.0 A / 18.0 A			
Total max. DC current	51 A			
Max. array short circuit current (1.25 Imax) (MPPT 1/MPPT 2)	41.3 A / 22.5 A			
Operating voltage range	80 V - 600 V			
Max. input voltage	600 V			
Nominal input voltage	415 V	420 V	425 V	440 V
Admissable conductor size DC	AWG 14 - AWG 6 copper direct, AWG 6 aluminum direct (AWG 10 copper or AWG 8 aluminium for overcurrent protective devices up to 60A, from 61 to 100A minimum AWG 8 for copper or AWG 6 aluminium has to be used), AWG 4 - AWG 2 copper or alu-minum with optional input combiner			
MPP Voltage Range	220 - 480 V	240 - 480 V	260 - 480 V	320 - 480 V
Integrated DC string fuse holders	4- and 4+ for MPPT 1 / no fusing requried on MPPT 2			
Number of MPPT	2			

OUTPUT DATA		PRIMO 10.0-1	PRIMO 11.4-1	PRIMO 12.5-1	PRIMO 15.0-1
Max. output power	240 V	9995 W	11400 W	12500 W	15000 W
	208 V	9995 W	11400 W	12500 W	13750 W
Max. continuous output current	240 V	41.6 A	47.5 A	52.1 A	62.5 A
	208 V	48.1 A	54.8 A	60.1 A	66.1 A
Recommended OCPD/AC breaker size	240 V	60 A	60 A	70 A	80 A
	208 V	70 A	70 A	80 A	90 A
Max. Efficiency		96.7 %			
CEC Efficiency		96.0 %			96.5 %
Admissable conductor size AC		AWG 10 - AWG 2 copper (solid / stranded / fine stranded)(AWG 10 copper or AWG 8 aluminium for overcurrent protective devices up to 60A, from 61 to 100A minimum AWG 8 for copper or AWG 6 aluminium has to be used) , AWG 6 - AWG 2 copper(solid / stranded) MultiContactWiringable with AWG 12			
Grid connection		208 / 240 V			
Frequency		60 Hz			
Total harmonic distortion		< 2.5 %			
Power factor (cos $\varphi_{ac,r}$)		0-1 ind./cap.			

/ Perfect Welding / Solar Energy / Perfect Charging

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Further information about all Fronius products and our global sales partners and representatives can be found at **www.fronius.com**

v05 May 2015 EN

C US SUNSPEC ALLIANCE

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