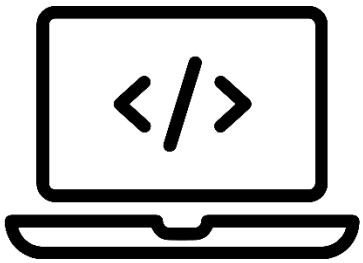
41st ONTARIO ENGINEERING COMPETITION



Competition Package

Programming

Table of Contents

1.0 Introduction

The goal of the Programming category is to encourage engineering students to produce a piece of industry-quality software with all the proper user and administrative documents. The teams will use their software development skills, their technical writing abilities, and their project management skills to design a solution to a problem posed. This solution will then be presented to the judging panel.

1.1 Competition Leads

Adam Lee	***Kathlene Titus***
alee30@uoguelph.ca	ktitus@uoguelph.ca

1.2 General Rules and Guidelines

1) Any competition questions should be asked publicly on Slack.
2) Visitors are NOT allowed at any time during the competition. Only competition volunteers and judges are allowed.
3) You are only allowed to use the following:
   - Computers
   - USB keys
   - Internet
   - Any material provided by the competition leads
4) Workspaces must be cleaned at the end of the competition

2.0 Competition Schedules

2.1 Schedule of Friday, January 17th, 2020

Timings	***Task***	***Location***
10:00 am – 3:00 pm	Registration & Check-In	Delta Hotel
4:00 pm – 5:30 pm	Opening Gala	Delta Hotel
5:30 pm – 6:00 pm	Prep for event	Delta Hotel
6:00 pm – 6:15 pm	Walk to campus	
6:20 pm – 7:00 pm	Competition Briefing for Competitors (You will have 15 minutes to ask us questions during this period)	THRN 1307
7:00 pm – 2:00 am	Work Period	UC Rooms
2:00 am (Sat Jan 18)	Submission folders due on USB	THRN 1307
2:00 am – 2:30 am	Clean-up work rooms	UC Rooms

2.2 Schedule of Saturday, January 18th, 2020

Timings	*Task*	*Location*
7:00 am – 9:30 am	Breakfast	UC Food Center
7:00 am	Presentation Order Released (Random)	
8:30 am – 10:00 am	Competition Briefing for Judges	THRN 1307
10:00 am – 10:30 am	Judging Team 1	THRN 1307
10:30 am – 11:00 am	Judging Team 2	THRN 1307
11:00 am – 11:30 am	Judging Team 3	THRN 1307
11:30 am – 12:00 pm	Judging Team 4	THRN 1307
12:00 pm – 12:30 pm	Judging Team 5	THRN 1307
12:30 pm – 1:30 pm	Lunch	UC Food Center
1:30 pm – 2:00 pm	Judging Team 6	THRN 1307
2:00 pm – 2:30 pm	Judging Team 7	THRN 1307
2:30 pm – 3:00 pm	Judging Team 8	THRN 1307
3:00 pm – 3:30 pm	Judging Team 9	THRN 1307
3:30 pm – 4:00 pm	Judging Team 10	THRN 1307
4:00 pm – 4:30 pm	Judges Deliberate & finalize top 3 winners	THRN 1307
5:30 pm – 7:00 pm	Busses to banquet hall from hotel	
6:00 pm – 7:00 pm	Reception	
7:00 pm – 10:00 pm	Banquet	
10:00 pm – 11:00 pm	Busses to hotel from banquet hall	
1:30 am – 2:30 am	Busses to hotel from banquet hall	

2.3 Schedule of Sunday, January 19th, 2020

Timings	*Task*	*Location*
8:00 am – 10:30 am	Breakfast	Delta Hotel
10:30 am – 12:00 am	Check-out	Delta Hotel

3.0 Programming Competition Description

3.1 Problem Background

The first AC power grid was installed in 1886 in Great Barrington, Massachusetts. This first power grid was a centralized, unidirectional system of electric power transmission, distribution, and demand-driven control. Throughout the 20th century, local power grids grew over time and were eventually interconnected for economic and reliability reasons. Throughout the 1970s and 1980s, growing power demands, especially during peak times, resulted in grids producing poor power quality including blackouts, power cuts, and brownouts.

3.2 The Challenge

Create a program that acts as a single power grid for the entire province of Ontario. The program will read two input files containing hourly power demands for Ontario along with other relevant power supply parameters. The program should produce an output file of specified format detailing power delivered from the various power sources in Ontario and other parameters that will be used for scoring.

Input to the program will be given through an input file. The first few lines of `inputFile` starting with a '0' contain initial conditions of power output of the current day being simulated. Lines from `inputFile` leading with a '1' correspond to hours of the day where your program must decide how to deliver power required according to the input demands and available resources. Your program MUST read lines of `inputFile` starting with '1' one line at a time (corresponding to the relevant hour of day) - no reading data in advance from future hours to predict power demands!

INPUTS *(hourly)*		***OUTPUTS*** *(hourly)*	
Hour (24-hour clock)	1-23	*Hour (24-hour clock)*	1-23
Power demands for regions of Ontario	MW	*Total power supplied to Ontario*	MW
Available power for each source (x7)	MW	*Supply for each source (x7)*	MW
5-hour temperature forecast	°C	*Total power deficit or surplus*	+/- MW
Solar power coefficient	Dec.	*Total green energy generated*	MW
Hydro power coefficient	Dec.	*Total energy bought*	MW
Wind power coefficient	Dec.	*Total energy sold*	MW
Power demands of neighbor grids	MW	*Tonnes CO2 produced*	Tonnes
Selling price to neighbor grids	$/MW	*Selling cost of electricty*	$/kWh
Available power from neighbor grids	MW	*Cost to produce electricity*	$/kWh
Price of power from neighbor grids	$/MW	*Cost difference (sold – produce)*	+/- $/kWh

Table 1 – Summary of program inputs and outputs. Sample input and output file formats are found in Appendix 6.1, 6.2 and 6.3.

Assessment of program performance will be based on how well it handles fluctuations in input parameters to avoid blackouts, power cuts, and brownouts. Excess power production will also be penalized as this results in damage to transmission equipment and fluctuations in Ontario's 60 Hz power frequency. Penalties assessed for power production deficits and surpluses are explained in the rubric.

Ideally, the smart grid program will implement green energy sources as much as possible and aim to minimize greenhouse gas emissions produced from power generation and distribution. See Appendix 6.7 for details on how your program can calculate greenhouse gas emissions for each method of power generation.

Finally, the smart grid program will aim to reduce the cost of producing electricity ($/kWh), so deficits are avoided. In Ontario, the electricity rates charged to hydro customers are fixed. Your smart grid program should aim to keep the cost of electricity production and distribution as close as possible to the published hourly rates. Appendix 6.5 contains current rates charged to Ontario hydro customers, and Appendix 6.8 has details on how your program can calculate the price of electricity generated.

Note: modern power grids can sell surplus power to neighboring grids (Quebec, Michigan, New York, etc.) and purchase power from neighbors to help meet power demands. It is important to consider the following scenarios:

1) Avoid producing surplus energy for the purpose of selling to neighbors and creating extra profit. They may not want or need to purchase energy at the specific hour, leaving you with no place to "dump" the extra power and thus causing damage to Ontario's electrical infrastructure by electrical overloading.

2) It may not be a good idea to heavily rely on purchase of extra power from neighbors to stabilize fluctuating supplies in green energy – their grids may be experiencing their own surge in power demand and will not be able to sell you power to avoid a blackout. Example: a hot and humid summer day with cloud cover over Ontario and no wind has increased power demand from HVAC systems trying to cool down homes and offices, results in regional blackouts.

4.0 Competition Deliverables

Teams in Programming are required to design, develop, test, provide documentation, and construct a presentation of their project during the limited time provided in the first phase of the competition and then present an oral presentation and demonstrate their solution in the second phase of the competition.

The oral presentation should shortly summarize the team's layout, the design process, the management process, and the development process. If there were required components that could not be constructed in the time given, teams need to highlight the mistakes made and provide an explanation on how the problem could be solved in the future. If the solution included any open-source libraries, the presentation should highlight the components that contain the code and if there is an alternative library that should have been used. Teams should contain a separate, larger portion of the presentation that showcases the solution for approval. The presentation should introduce the software, present the core functions of the software, how the program's components work from a development standpoint, its user documents, the installation method, and any unique components of the solution that were not suggested in the problem. The presentation should also include who the potential customers may be, what benefits the program would give this customer, and provide a short demo of the product and its components for the panel. Judges reserve the right to ask questions during the presentation. Teams must deliver answers within a

reasonable time (determined by event official) to avoid deduction and/or a committee investigation (based on the context of the question).

In the report and the presentation, you are required to explain the "Principles of Technological Stewardship in Engineering" used in the solution (Please refer to appendix 6.4 for the criteria). You must select at least 2 out of the 8 pillars to incorporate in your solution.

Note: You can use any programming language you are comfortable with as long as you have the correct environment set up.

All deliverables must be included in a submission folder, saved on the USB and given to the competition leads by 2:00 AM on Saturday, January 18th, 2020.

Please use "`OEC 2020 Programming Submission – [team name]`" as the folder name. The team name cannot be your school name.

4.1 Outfiles

Include in the submission folder the five output CSV files your program creates as it analyzes input "hour by hour". You will be supplied with five pairs of input files to run with your program. The five output files produced by your program need to be included in your submission folder.

Format: The CSV values should be written in the order given by Table 1.

For input file "`inputFile1.csv`", the output file is "`[team name] - output1.csv`"

4.2 `readme.txt`

Include in the submission folder `readme.txt`, with the following information:

- Administrative information such as names, emails of team members, group number, and project title
- Location of all code used for the project with directories
- Instructions to compile and run the project for the judges

4.3 Report

Include in the submission folder a brief, 2-page report outlining the engineering problem to be solved:

- Identify the stakeholders and the problem, explaining why the problem is relevant to stakeholders
- Identify the chosen solution and how it addresses the chosen problem

- Identify the target users
- Give a high-level overview of the solution design
- Explain at least 2 of the "Principles of Technological Stewardship in Engineering" used in the solution (Please refer to appendix 6.4 for the criteria)
- Shortly summarize the design process, management process, and development process
- If there were required components that could not be constructed in the time given, highlight the mistakes made and provide an explanation on how the problem could be solved in the future
- If the solution included any open-source libraries, highlight the components that contain the code and if there is an alternative library that should have been used
- Indicate the core functions of the software and how the program's components work from a development standpoint
- Clearly mention the installation method, and any unique components of the solution that were not suggested in the problem.

4.4 Presentation

Include in the submission folder your final presentation for the judges demonstrating the solution and how it works. Oral presentations should:

- Be no more than 12 minutes in length, NOT including an 8-minute Q & A period
- Briefly summarize the contents of the report
- Walk the judges through the implementation, including technologies used and any difficult technical challenges the team has faced
- Demonstrate the solution, including inputs defined by judges and/or test cases
- A presentation test case will be provided that is the same for all groups
- Do not wear anything with your school name or logo

5.0 Competition Scoring and Marking Methods

CRITERIA	*TOTAL POINTS*

PERFORMANCE/CODE:
• ABLE TO MEET POWER DEMANDS
  ○ NO POWER OUTAGES
  ○ DID NOT EXCEED OR FALL SHORT OF DEMAND BY MORE THAN 2.5%
• TOTAL GREEN ENERGY PRODUCTION, RANKED AND NORMALIZED (HIGHER IS BETTER)
• TOTAL CO_2 PRODUCTION, RANKED AND NORMALIZED (LOWER IS BETTER)
• TOTAL COST OF ENERGY PRODUCTION, RANKED AND NORMALIZED (LOWER IS BETTER)
• STRUCTURE OF CODE AND COMMENTS INCLUDED
	/30

DESIGN/STRATEGY/ALGORITHM: • DOES THE DESIGN WORK? • HOW WELL DOES THE DESIGN MEET THE REQUIREMENTS OF THE PROJECT? • DID SOLUTION INCLUDE RELEVANT EXTRA COMPONENTS ON TOP OF THOSE REQUESTED? • DID THE SOLUTION COME WITH APPROPRIATE USER DOCUMENTS? • HOW WELL DID THE REPORT OUTLINE THE ENGINEERING PROBLEM SOLVED? • IS THE SOLUTION SIMPLE, SUSTAINABLE AND ENVIRONMENTALLY FRIENDLY? • SOLUTION IS WELL-THOUGHT OUT AND ANALYZED • DESIGN SYNTHESIZES APPLICATION OF ENGINEERING PRINCIPLES • SIMPLICITY	/40
PRESENTATION: • DESIGN PROCESS • DESIGN JUSTIFICATION • DESIGN CRITIQUE • WERE THE BENEFITS AND PRINCIPLES OF THE SOLUTION CLEARLY EXPLAINED? • WAS TIME USED APPROPRIATELY? • LOGICAL STRUCTURE IN PRESENTATION • IF SOLUTION HAD ERROR, WERE THEY IDENTIFIED DURING THE PRESENTATION? • DID ALL TEAM MEMBERS PARTICIPATE EQUALLY IN THE PRESENTATION? • VOICE/AUDIBILITY • WERE THE POTENTIAL CUSTOMERS CORRECTLY/TARGET AUDIENCE IDENTIFIED?	/20

• WAS THE CODE WELL EXPLAINED & DEMONSTRATED DURING THE PRESENTATION? • QUICK OVERVIEW OF USER DOCUMENTS AND INSTALL PACKAGES INCLUDED • WERE THE PROGRAM'S COMPONENTS DEMONSTRATED THOROUGHLY? • RESPONSE TO QUESTIONS	
ORIGINALITY & RESOURCE MANAGEMENT: • IDEA/CONCEPT IS NEW AND ORIGINAL • ALL GROUP MEMBERS EQUALLY CONTRIBUTED IN EVERY STAGE • SOLUTION HAS INCORPORATED THE PRINCIPLES OF TECHNOLOGICAL STEWARDSHIP IN ENGINEERING • PROGRAMS CPU USAGE • MEMORY USAGE EFFICIENT	/10

PENALTIES:
• CODE IS PLAGIARIZED OR SOLUTION INCLUDES OPEN-SOURCE CODE
• INCOMPLETE PROJECT SUBMITTED/LATE SUBMISSION FOLDER
• PROGRAM DOES NOT READ POWER DEMANDS HOUR BY HOUR
• PROGRAM FAILED A FEW TESTCASES
• MAJOR / MINOR BUGS FOUND BY QA VOLUNTEERS, SOME EXAMPLES:
  ○ UNEXPECTED OUTPUT
  ○ UNEXPECTED OR WRONG PROGRAM TERMINATION
  ○ PROGRAM UNABLE TO TERMINATE
  ○ OTHER
• PROJECT DOES NOT COMPILE/RUN
• PRESENTATION UNDER/OVER TIME BY LESS THAN 2 MINUTES
• PRESENTATION UNDER/OVER TIME BY MORE THAN 2 MINUTES
• INSUFFICIENT CITATION
• ABSENT TEAM MEMBER
• DISCLOSURE OF SCHOOL (VERBALLY AND PHYSICALLY)
	-50
	-50
	–50
	-15
	-25
	
	-30
	-5
	-10
	-50
	-25
	-10

TOTAL	***/100***

6.0 Appendix and Additional Resources

6.1 Sample Input Conditions

See sample Excel sheet – lines starting with '0'.

6.2 Sample Input

See sample Excel sheet – lines starting with '1'.

6.3 Sample Output

See sample Excel sheet – lines starting with '2'.

6.4 Principles of Technological Stewardship in Engineering

- **Widen Approaches:** Used a wide range of new and innovative technologies to address the problem
- **Expand Involvement:** Performed extensive research on the proposed topic and applied technical expertise
- **Advance Understanding:** Foster dialogue on technologies used to create awareness
- **Shared Action:** Shared attention and collective effort ensures optimal results
- **Realize Diversity:** Ensure the society's (stakeholders and users) needs are met
- **Deliberate Values:** Understand technological development as inherently infused with values and consider underlying values connected to the project and actively discuss value trade-offs related to the project
- **Seek Purpose:** Does the work impact the world? Does the problem engage with urgent global issues? Consider broad/positive outcomes in project conceptualization and rationale
- **Take Responsibility:** Consider potential impacts (Economic, environmental, and social), ways to track the impacts, and precautions to take when serious unintentional problems are encountered. Can this technology be misused/abused? Consider the complex impacts of technology across the entire life cycle.

6.5 Published hydro rates charged to Ontario customers

On-peak: 13.4 cents/kWh
Mid-peak: 9.4 cents/kWh
Off-peak: 6.5 cents/kWh

From	To	Summer Rate (May - Oct)	Winter Rate (Nov - Apr)
7:00 AM	8:00 AM	mid-peak rate 9.4 cents/kWh	on-peak rate 13.4 cents/kWh
8:00 AM	9:00 AM		
9:00 AM	10:00 AM		
10:00 AM	11:00 AM		
11:00 AM	12:00 PM	on-peak rate 13.4 cents/kWh	mid-peak rate 9.4 cents/kWh
12:00 PM	1:00 PM		
1:00 PM	2:00 PM		
2:00 PM	3:00 PM		
3:00 PM	4:00 PM		
4:00 PM	5:00 PM		
5:00 PM	6:00 PM	mid-peak rate 9.4 cents/kWh	on-peak rate 13.4 cents/kWh
6:00 PM	7:00 PM		
7:00 PM	8:00 PM	off-peak rate 6.5 cents/kWh	off-peak rate 6.5 cents/kWh
8:00 PM	9:00 PM		
9:00 PM	10:00 PM		
10:00 PM	11:00 PM		
11:00 PM	Midnight		
Midnight	1:00 AM		
1:00 AM	2:00 AM		
2:00 AM	3:00 AM		
3:00 AM	4:00 AM		
4:00 AM	5:00 AM		
5:00 AM	6:00 AM		
6:00 AM	7:00 AM		

6.6 Published power demands and average (monthly) related to temperature

Historical demands for Ontario: http://www.ieso.ca/en/Power-Data/Demand-Overview/Historical-Demand
Average monthly temperatures:

Year	*Month*	*Max (°C)*	*Min (°C)*
2018	Oct	29.0	-1.5
2018	Nov	16.2	-13.3
2018	Dec	12.4	-9.2
2019	Jan	8.2	-22.8
2019	Feb	12.7	-19.1
2019	Mar	12.5	-15.3
2019	Apr	21.8	-5.5
2019	May	26.6	1.1
2019	Jun	29.6	6.3
2019	Jul	33.0	14.3
2019	Aug	30.4	12.2
2019	Sep	28.9	8.6

6.7 Calculations for CO2 emissions

Power	***C02 Emission***
Nuclear power	6 g/kWh
Solar power	105 g/kWh
Wind power	13 g/ kWh
Hydro power	4 g / kWh
Coal power	909 g/ kWh
Geothermal power	58 g / kWh
Neighboring power purchased	258 g/ kWh

6.8 Calculations for cost of electricity production

Power	***Cost***
Nuclear power	$68 per MWh
Solar power	$481 per MWh
Wind power	$133 per MWh
Hydroelectric power	$57 per MWh
Gas/Oil power	$140 per MWh
Biofuel	$131 per MWh
Neighboring power purchased	$160 per MWh

6.9 Calculations for solar, wind, and hydro power using competition coefficients

6.9.1 Solar power

Theoretical hourly average: 85.62 MW

Cloudy Day:

85.62 * 0.3 = 25.69 MW

Normal Day:

85.62 MW * 1.0 = 85.62 MW

Sunny Day:

85.62 MW * 3.6 = 308.23 MW

6.9.2 Wind power

Theoretical hourly average: 776.26 MW

No Wind Day:

776.26 * 0.40 = 310.51 MW

Normal Day:

776.26 MW * 1.0 = 776.26 MW

Windy Day:

776.26 MW * 2.59 = 2010.51 MW

6.9.3 Hydroelectric power

Theoretical hourly average: 3675.79 MW

Below Average Day:

3675.79 * 0.88 = 3234.69 MW

Normal Day:

3675.79 MW * 1.0 = 3675.79 MW

Above Average Day:

3675.79 MW * 1.13 = 4153.64 MW

Please note that these numbers were calculated based on power produced within Ontario in 2018. However, the coefficients used are from September 2019.