

**RESIDENTIAL BUILDING PERFORMANCE ANALYSIS**



**Submitted To:**  
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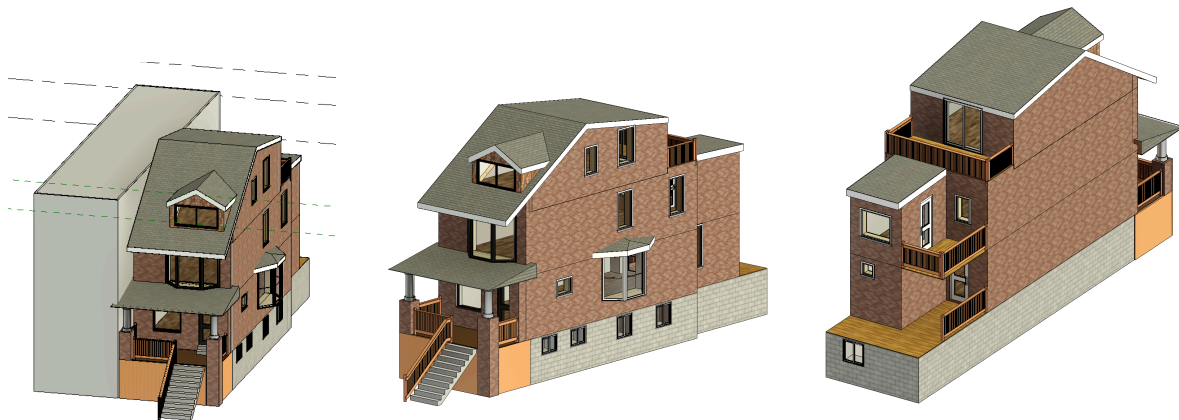
## 1.0 MODEL

**Location:** 376 Woodbine Ave, Toronto, ON M4L 3P6, Canada

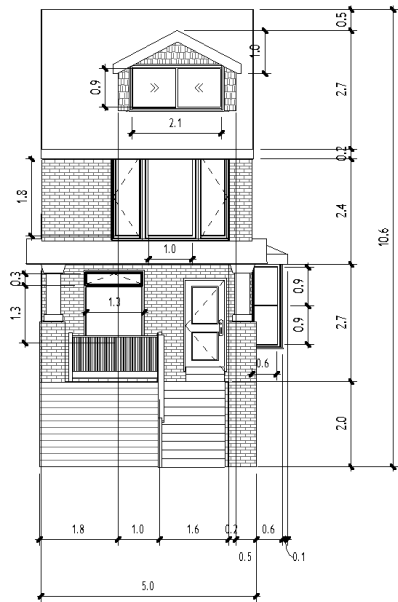


**Figure 1. 376 Woodbine Ave, Toronto**

The house is a semi-detached, east-facing dwelling, with a shared wall on the south side. The dimensions are outlined in meters. Some dimensioned images of the model are displayed below.



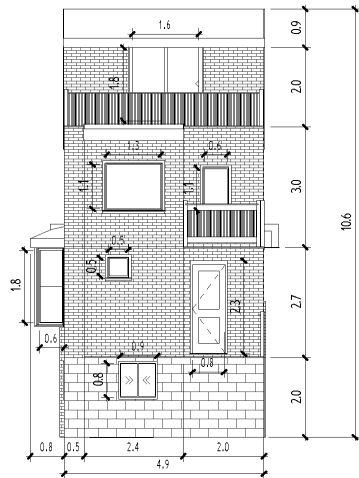
**Figures 2,3,4: 3D Views of the House**



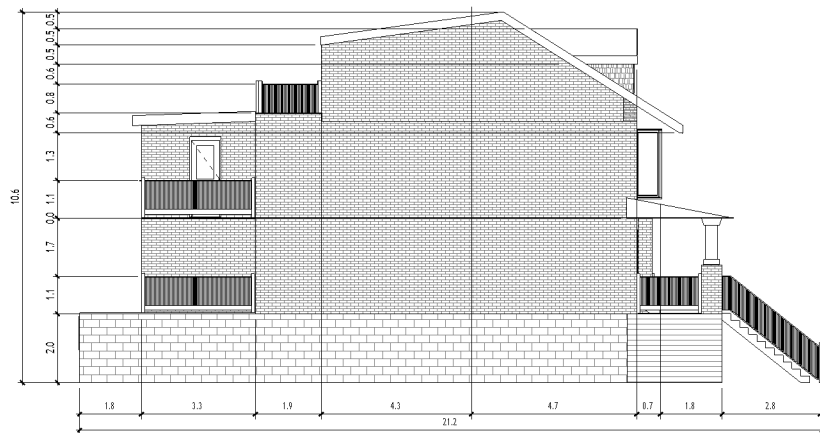
**Figure 5: East Elevation View**



**Figure 6: North Elevation View**

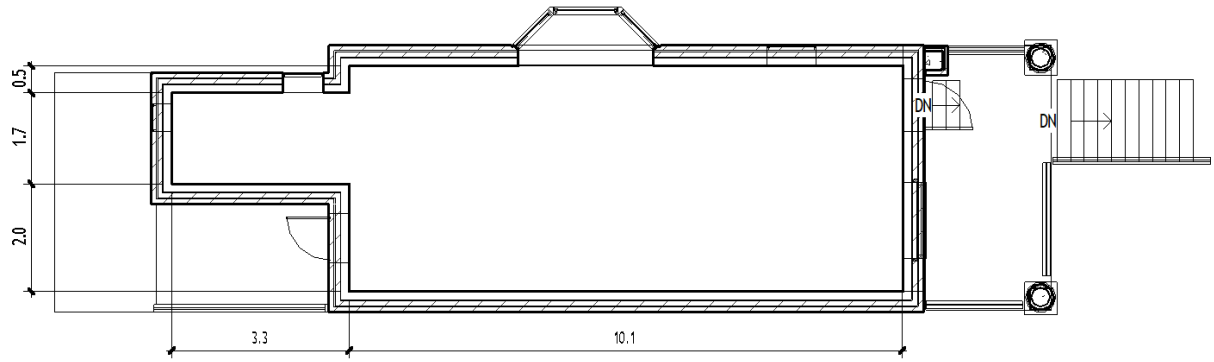


**Figure 7: West Elevation View**

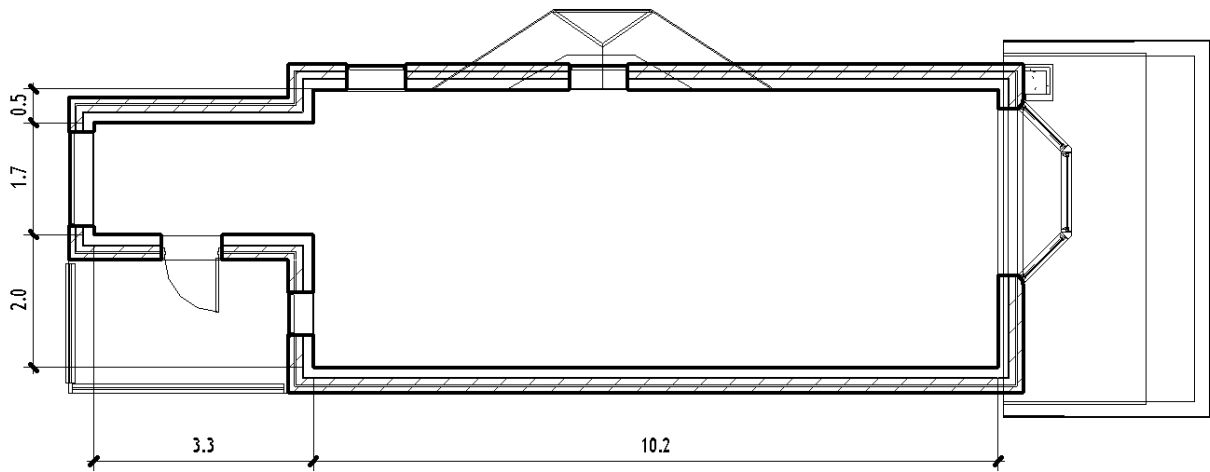


**Figure 8: South Elevation View**

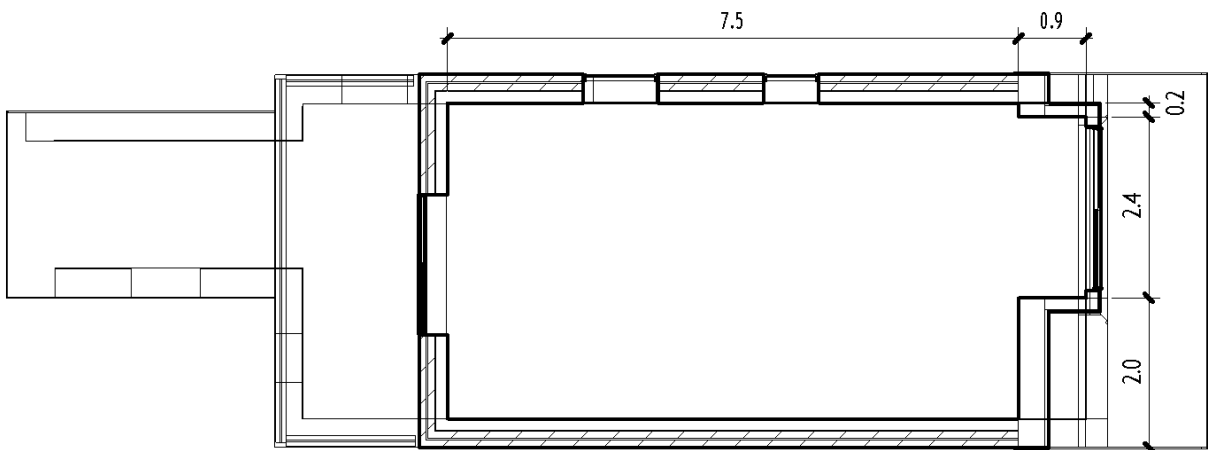
Floor plans for the first, second and third floors are shown below. The basement has been neglected as per the assignment instructions, as it will not be used for calculations. Dimensions were taken from the interior, as wall thickness is assumed to be zero for this assignment.



**Figure 9. Floor Plan - First Floor**



**Figure 10. Floor Plan - Second Floor**



**Figure 11. Floor Plan - Third Floor**

## 2.0 FLOOR AREA, VOLUME AND EXPOSED SURFACE AREA

Using the model, estimate the conditioned (heated) floor area, volume, and exposed surface area of your home. Keep it simple and assume walls have zero thickness.

Assumptions:

- Walls have zero thickness
- The basement is neglected (prof's instructions)
- Floors 1 and 2 have the same floor area since their dimensions are the same
- Revit-generated schedules are correct

**Table 1. Conditioned Floor Area, Volume, and Exposed Surface Area Calculations**

<b>Conditioned Floor Area</b> (Area <sub>rectangle</sub> = Length x Width)		
Floor/Level	Calculations A (m <sup>2</sup> ), Length & Width (m)	Area (m <sup>2</sup> )
1,2	$A_{1,2} = A_{\text{rect1}} + A_{\text{rect2}}$ $= (1.7 \times 3.3) + [(2+1.7+0.5)(10.2)]$ $= 5.61 + 42.84$	48.45
3	$A_3 = A_{\text{rect3}} + A_{\text{rect4}}$ $= [7.5 \times (2+2.4+0.2)] + (2.4 \times 0.9)$	36.66
1 + 2 + 3	$A_{\text{total}} = 2A_{1,2} + A_3$ $= 2(48.45) + 36.66$	133.56
<b>Volume</b> (Volume <sub>cube</sub> = Area x Height, Volume <sub>triangle</sub> = 0.5 x Base <sub>area</sub> x Height)		
Floor/Level	Calculations V (m <sup>3</sup> ), A (m <sup>2</sup> ), Height (m)	Volume (m <sup>3</sup> )
1	$V_1 = V_{\text{cube}}$ $= (48.45) (1.1 + 1.7)$	135.66
2	$V_2 = V_{\text{cubeFront}} + V_{\text{cubeBack}} + V_{\text{triangle}}$ $= (42.84) (2.7) + (5.61)(2.6) + 0.5(5.61)(0.4)$ $= 115.668 + 14.586 + 1.122$	131.38
3	$V_3 = V_{\text{cubeBack}} + V_{\text{cubeFront}} + V_{\text{cubeDormer}} + V_{\text{triBack}} + V_{\text{triFront}} + V_{\text{triDormer}}$ $= [(5.2\text{m})(4.9\text{m})(2.1\text{m})]$ $+ [(3.8\text{m})(4.9\text{m})(0.5\text{m})]$ $+ [(2.4\text{m})(0.9\text{m})(1.1\text{m})]$ $+ [0.5(5.2\text{m})(4.9\text{m})(1.0\text{m})]$ $+ [0.5(3.8\text{m})(4.9\text{m})(2.6\text{m})]$ $+ [0.5(2.4\text{m})(0.9\text{m})(1.0\text{m})]$	103.22
1+2+3	$V_{\text{total}} = V_1 + V_2 + V_3$	370.26

	= 135.66 + 131.38 + 103.22	
<b>Exposed Surface Area (using the Revit schedules below)</b>		
Face	Calculations A (m <sup>2</sup> )	Area (m <sup>2</sup> )
East Exterior Wall	$Total Area East = \sum_{i=1}^n A_i$ Walls = 1 + 1 + 2 + 2 + 1 + 1 + 1 + 1 + 1 + 1 + 1 + 8 + 10 + 3 = 34 Windows = 2 + 5 + 2 = 9 Doors = 2 Total = 34 + 9 + 2 = 45	45
West Exterior Wall	$Total Area West = \sum_{i=1}^n A_i$ Walls = 22 + 8 + 25 + 9 + 16 + 1 = 81 Windows = 2 + 1 = 3 Doors = 2 + 4 = 6 Total = 81 + 3 + 6 = 90	90
North Exterior Wall	$Total Area North = \sum_{i=1}^n A_i$ Walls = 22 + 8 + 25 + 9 + 16 + 1 = 81 Windows = 1 + 1 + 1 + 1 + 1 + 1 + 5 = 11 Total = 81 + 11 = 92	92
South Exterior Wall	$Total Area South = \sum_{i=1}^n A_i$ Walls = 30 + 9 + 29 + 7 + 20 + 1 = 96 Doors = 2 Total = 96 + 2 = 98	98
Exposed Roof	$Total Roof Area = \sum_{i=1}^n A_i$ = 49 + 8 + 19 + 4 + 8 = 88	88
Total	$Total Roof and Wall Area = \sum_{i=1}^n A_i$ = (45 + 90 + 92 + 98) + 88 = 325 + 88 = 413	413

<Wall Schedule>

A	B	C	D	E
Type	Function	Length	Area	Orientation
Generic - 100mm Brick	Exterior	440	1 m <sup>2</sup>	East
Generic - 100mm Brick	Exterior	360	1 m <sup>2</sup>	East
Generic - 100mm Brick	Exterior	544	2 m <sup>2</sup>	East
Generic - 100mm Brick	Exterior	490	2 m <sup>2</sup>	East
Generic - 100mm Brick	Exterior	490	1 m <sup>2</sup>	East
Generic - 100mm Brick	Exterior	544	1 m <sup>2</sup>	East
Generic - 100mm Brick	Exterior	390	1 m <sup>2</sup>	East
Generic - 100mm Brick	Exterior	494	1 m <sup>2</sup>	East
Generic - 100mm Brick	Exterior	490	1 m <sup>2</sup>	East
Generic - 100mm Brick	Exterior	490	1 m <sup>2</sup>	East
Generic - 100mm Brick	Exterior	494	1 m <sup>2</sup>	East
M_Exterior - Double Brick on Wood Stud	Exterior	4496	8 m <sup>2</sup>	East
M_Exterior - Double Brick on Wood Stud	Exterior	4496	10 m <sup>2</sup>	East
M_Exterior - Wood Shingle on Wood Stud	Exterior	2547	3 m <sup>2</sup>	East
M_Exterior - Double Brick on Wood Stud	Exterior	10532	22 m <sup>2</sup>	North
M_Exterior - Double Brick on Wood Stud	Exterior	3256	8 m <sup>2</sup>	North
M_Exterior - Double Brick on Wood Stud	Exterior	10532	25 m <sup>2</sup>	North
M_Exterior - Double Brick on Wood Stud	Exterior	3256	9 m <sup>2</sup>	North
M_Exterior - Double Brick on Wood Stud	Exterior	8643	16 m <sup>2</sup>	North
M_Exterior - Wood Shingle on Wood Stud	Exterior	1700	1 m <sup>2</sup>	North
M_Exterior - Double Brick on Wood Stud	Exterior	10532	30 m <sup>2</sup>	South
M_Exterior - Double Brick on Wood Stud	Exterior	3256	9 m <sup>2</sup>	South
M_Exterior - Double Brick on Wood Stud	Exterior	10532	29 m <sup>2</sup>	South
M_Exterior - Double Brick on Wood Stud	Exterior	3256	7 m <sup>2</sup>	South
M_Exterior - Double Brick on Wood Stud	Exterior	8830	20 m <sup>2</sup>	South
M_Exterior - Wood Shingle on Wood Stud	Exterior	1700	1 m <sup>2</sup>	South
M_Exterior - Double Brick on Wood Stud	Exterior	2034	5 m <sup>2</sup>	West
M_Exterior - Double Brick on Wood Stud	Exterior	1969	2 m <sup>2</sup>	West
M_Exterior - Double Brick on Wood Stud	Exterior	493	2 m <sup>2</sup>	West
M_Exterior - Double Brick on Wood Stud	Exterior	2034	4 m <sup>2</sup>	West
M_Exterior - Double Brick on Wood Stud	Exterior	1969	4 m <sup>2</sup>	West
M_Exterior - Double Brick on Wood Stud	Exterior	493	3 m <sup>2</sup>	West
M_Exterior - Double Brick on Wood Stud	Exterior	4502	6 m <sup>2</sup>	West

**Figure 12. Exterior Wall Area**

<Windows>					
A	B	C	D	E	F
Type	Width	Height	Area	Level	Window Orientation
2135mm x 1020mm (84/40) - Black Frame	2135	1020	2 m <sup>2</sup>	Third Floor	East
710mm x 1145mm (28/45) White Frame 2	710	1145	1 m <sup>2</sup>	Third Floor	North
965mm x 1525mm (38/60) White Frame	965	1525	1 m <sup>2</sup>	Third Floor	North
Bay - 30/70, 40/70, 30/70 White Frame	2641	1963	5 m <sup>2</sup>	Second Floor	East
865mm x 1575mm (34/62) White Frame	865	1575	1 m <sup>2</sup>	Second Floor	North
865mm x 1575mm (34/62) White Frame	865	1575	1 m <sup>2</sup>	Second Floor	North
1400mm x 1170mm (55/46) White Frame	1400	1170	2 m <sup>2</sup>	Second Floor	West
635mm x 1070mm (25/42) White Frame	635	1070	1 m <sup>2</sup>	Second Floor	West
Top Hung Window - 1400mm x 1780mm (55/70) - Black Framing	1400	1780	2 m <sup>2</sup>	First Floor	East
915mm x 660mm (36/26) White Frame	900	645	1 m <sup>2</sup>	First Floor	North
Bay - 30/70, 40/70, 30/70	2641	1963	5 m <sup>2</sup>	First Floor	North
760mm x 1780mm (30/70) White Frame 2	745	1765	1 m <sup>2</sup>	First Floor	North

**Figure 14. Window Area**

<Doors>				
A	B	C	D	E
Type	Height	Width	Area	Door Orientation
900 x 2100mm	2100	900	2 m <sup>2</sup>	East
800 x 2200mm WHITE	2200	800	2 m <sup>2</sup>	West
800 x 2200mm WHITE	2200	800	2 m <sup>2</sup>	South
1830mm x 2035mm (72/80) White Frame - 2 P 2035		1830	4 m <sup>2</sup>	West

**Figure 15. Door Area**

<Roof Schedule>	
A	B
Type	Area
Wood Rafter 184mm - Asphalt Shingle - Insulated	49 m <sup>2</sup>
Wood Rafter 184mm - Asphalt Shingle - Insulated	8 m <sup>2</sup>
Wood Rafter 150mm - Asphalt Shingle	19 m <sup>2</sup>
Wood Rafter 184mm - Asphalt Shingle	4 m <sup>2</sup>
Wood Rafter 235mm - Asphalt Shingle	8 m <sup>2</sup>

**Figure 13. Exterior Roof Area**

### 3.0 WINDOW TO WALL RATIO

**Table 2. Window to Wall Ratio Calculations**

Window to Wall Ratio		
Face	Calculations A (m <sup>2</sup> ), dimensions (m)	Ratio (%)
East WWR	$\begin{aligned} \text{East WWR} &= \frac{\Sigma \text{Galzing Area (m}^2\text{)}}{\Sigma \text{Gross Exterior Wall Area (m}^2\text{)}} \times 100\% \\ &= \frac{\Sigma 2 + 5 + 2 \text{ (m}^2\text{)}}{45\text{m}^2} \times 100\% \\ &= 20.0\% \end{aligned}$	20.0
North WWR	$\begin{aligned} \text{North WWR} &= \frac{\Sigma \text{Galzing Area (m}^2\text{)}}{\Sigma \text{Gross Exterior Wall Area (m}^2\text{)}} \times 100\% \\ &= \frac{\Sigma 1 + 1 + 1 + 1 + 1 + 1 + 5 \text{ (m}^2\text{)}}{92\text{m}^2} \times 100\% \\ &= 11.96\% \end{aligned}$	11.96
South WWR	$\begin{aligned} \text{South WWR} &= \frac{\Sigma \text{Galzing Area (m}^2\text{)}}{\Sigma \text{Gross Exterior Wall Area (m}^2\text{)}} \times 100\% \\ &= \frac{\Sigma(0.8 \times 1.8) \text{ (m)}}{98\text{m}^2} \times 100\% \\ &= 1.74\% \end{aligned}$	1.47
West WWR	<p>(alternate calculation type)</p> $\begin{aligned} \text{West WWR} &= \frac{\Sigma \text{Galzing Area (m}^2\text{)}}{\Sigma \text{Gross Exterior Wall Area (m}^2\text{)}} \times 100\% \\ &= \frac{\Sigma (1.8 \times 1.6) + (1.1 \times 1.3) + (0.5 \times 0.5) + (0.6 \times 1.1) + 2(0.8 \times 1.8) \text{ (m)}}{90\text{m}^2} \times 100\% \\ &= 7.40\% \end{aligned}$	7.40
Total	$\begin{aligned} \text{Total WWR} &= \frac{\Sigma \text{Galzing Area (m}^2\text{)}}{\Sigma \text{Gross Exterior Wall Area (m}^2\text{)}} \times 100\% \\ &= \frac{\Sigma 2.88 + 1.43 + 0.25 + 0.66 + 2(1.44) + 6(1) + 2(5) + 2(2) \text{ (m}^2\text{)}}{\Sigma 45 + 92 + 98 + 90 \text{ (m}^2\text{)}} \times 100\% \\ &= \frac{28 \text{ m}^2}{325 \text{ m}^2} \times 100\% \\ &= 8.62\% \end{aligned}$	8.62

## 4.0 R-VALUES & U-FACTORS

**Table 3. Material R-Values and U-Factors**

Building Element	Description	Estimated Thermal Property	Value	Units	Justification
Foundation	Cement block wall with interior insulation	R-Value	2.1	m <sup>2</sup> ·K/W (RSI)	50mm XPS ≈ R-10 + block ≈ R-2  Common retrofit approach for conditioned basements [1].
Exterior Wall	Double-wythe Brick with lath and plaster (uninsulated)	R-Value	0.9	m <sup>2</sup> ·K/W (RSI)	Historic solid-masonry wall with no cavity insulation (R ≈ 0.7-1.0) [2].
Roof	Pitched roof with blown-in insulation	R-Value	7.9	m <sup>2</sup> ·K/W (RSI)	Equivalent to R-45 attic insulation (minimum for Toronto retrofits) [1].
Windows (Retrofitted Double-Pane)	Vinyl-frame double-glazed	U-Factor	1.6 [1]	W/m <sup>2</sup> ·K	Typical modern retrofit performance [2].

**Sample Calculation for R-Value → RSI (Foundation):**

$$RSI = \frac{R\text{-Value (imperial)}}{5.678} = \frac{12}{5.678} = 2.1$$

## 5.0 INFILTRATION RATE

Given that I do not have a previous energy audit, I will be using the reference in slide 48 of Lecture 5, which shows that older homes typically have an ACH value of approximately 4, which makes sense considering there is occasional draft in the house.

**Table 4. Airflow and Infiltration Rate Calculations**

<b>Airflow Rate</b>	$ACH\ Normal = \frac{ACH}{20}$ $= \frac{4}{20}$ $= 0.2\ ACH$ $Airflow\ Rate\ (m^3/s) = \frac{ACH\ (Volume)}{3600}$ $= \frac{0.2ACH\ (370.26m^3)}{3600s}$ $= 0.0206\ m^3/s$
<b>Infiltration Rate</b>	$Infiltration\ Rate = c_p pV$ $= (1000 \frac{J}{kg\ K})(1.2 \frac{kg}{m^3})(0.0206 \frac{m^3}{s})$ $= 24.68\ W/K$

## 6.0 HEAT LOSS COEFFICIENT

**Table 5. Conduction and Heat Loss Coefficient Calculations**

<b>Conduction through Opaque Surfaces</b>	$Conduction_{Opaque} = \sum_{opaque} (\frac{A_i}{R_i})$ $= \sum_{opaque} (Walls + Roof)$ $= \sum_{opaque} (\frac{325m^2}{0.9 \frac{m^2}{K/W}} + \frac{88m^2}{7.9 \frac{m^2}{K/W}})$ $= 372.25\ W/K$
<b>Conduction through Windows</b>	$Conduction_{Windows} = \sum_{windows} (A_i \times U_i)$ $= \sum_{windows} (28m^2 \times 1.6 \frac{W}{m^2 \times K})$ $= 44.8\ W/K$
<b>Total Heat Loss Coefficient (UA)</b>	$UA = \sum_{opaque} (\frac{A_i}{R_i}) + \sum_{windows} (A_i \times U_i) + c_p pV$ $= 372.25\ W/K + 44.8\ W/K + 24.68\ W/K$ $= 441.73\ W/K$ $= 441.73\ W/^\circ C$

## 7.0 INSTANTANEOUS HEAT LOSS

I will be assuming that the indoor temperature is 21 °C as per the assignment instructions.

**Table 6. Instantaneous Heat Loss and Gain Calculations**

<b>Max Temperature</b>	32.5 °C
<b>Min Temperature</b>	-19.4 °C
<b>Maximum instantaneous heat loss in Winter</b>	$\begin{aligned}q_{Loss} &= UA \times (T_{in} - T_{out}) \\ &= 441.73 \text{ W/}^\circ\text{C} \times (21^\circ\text{C} - (-19.4^\circ\text{C})) \\ &= 17845.89 \text{ W}\end{aligned}$
<b>Maximum instantaneous heat gain in Summer</b>	$\begin{aligned}q_{Gain} &= UA \times (T_{out} - T_{in}) \\ &= 441.73 \text{ W/}^\circ\text{C} \times (32.5^\circ\text{C} - 21^\circ\text{C}) \\ &= 5079.90 \text{ W}\end{aligned}$

## 8.0 ANNUAL WATER AND ENERGY CONSUMPTION

I was not able to acquire my own energy consumption bills, seeing as I recently moved, which is why I used the ones provided. I have scaled it to my conditioned floor area (133.56m<sup>2</sup>).

$$\text{Scaling Factor} = \frac{133.56\text{m}^2}{80\text{m}^2} = 1.6695$$

**Table 7. Annual Water and Energy Constumption**

Month	Electricity (kWh)	Natural Gas (m <sup>3</sup> )	Natural Gas (kWh equiv.)	Water (m <sup>3</sup> )
Jan	619	214	2 214	7
Feb	514	209	2 162	8
Mar	531	195	2 026	7
Apr	474	144	1 488	7
May	569	65	675	7
Jun	548	32	329	5
Jul	668	18	190	8
Aug	621	17	174	7
Sep	321	20	207	7
Oct	401	20	207	8
Nov	608	262	2 717	5
Dec	456	27	278	5
<b>Annual</b>	<b>6 328 kWh</b>	<b>1 223 m<sup>3</sup></b>	<b>12 668 kWh equiv.</b>	<b>80 m<sup>3</sup></b>

## 8.1 EUI Calculations

**Table 8. EUI Calculations**

Total annual energy	$\begin{aligned} \text{Total Energy} &= \text{Electricity (kWh)} + \text{Natural Gas (kWh equiv.)} \\ &= 6328 \text{ kWh} + 12668 \text{ kWh equiv.} \\ &= 18996 \text{ kWh} \end{aligned}$
Annual EUI $\frac{kWh}{m^2}$	$\begin{aligned} EUI &= \frac{\text{Total annual energy use (kWh)}}{\text{Floor area (m}^2\text{)}} \\ &= \frac{18996 \text{ kWh}}{133.56 \text{ m}^2} \\ &= 142.23 \frac{kWh}{m^2} / \text{year} \end{aligned}$
Annual EUI $\frac{MJ}{m^2}$	$\begin{aligned} EUI &= 142.23 \frac{kWh}{m^2} \times 3.6 \frac{MJ}{kWh} \\ &= 512.02 \frac{MJ}{m^2} / \text{year} \end{aligned}$

## 9.0 MINIMUM PV AREA



Figure 14. PVWatts Software at PV=1 [3]

Table 9. PV Multiplier Calculation

<b>PV Multiplier Calculations</b>	$\begin{aligned} \text{Multiplier} &= \frac{\text{Total Annual Energy Use}}{\text{Annual Energy Use at PV=1}} \\ &= \frac{18996 \text{ kWh/yr}}{1287 \text{ kWh/yr}} \\ &= 14.76 \end{aligned}$
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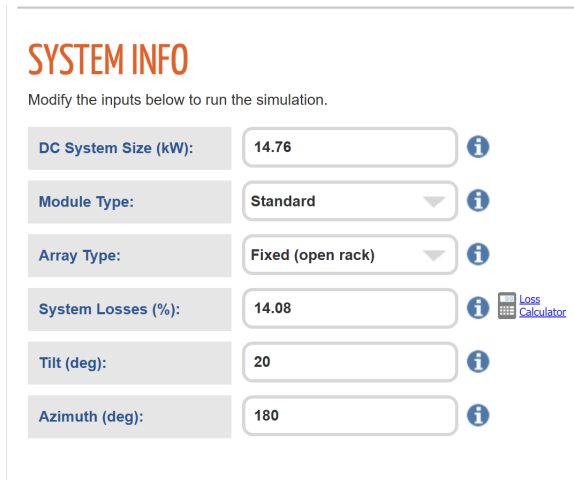


Figure 15. PVWatts Software System Settings [3]

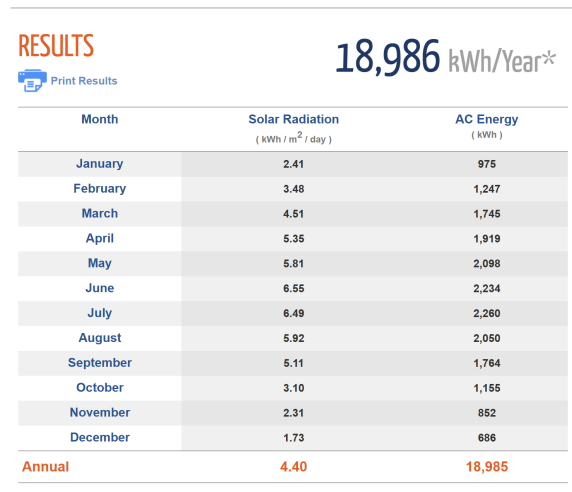


Figure 16. PVWatts Software Results at PV=14.76 Part 1 [3]

Location and Station Identification																									
Requested Location	376 Woodbine Avenue, Toronto																								
Weather Data Source	Lat, Lng: 43.69, -79.3 1.3 mi																								
Latitude	43.69° N																								
Longitude	79.30° W																								
PV System Specifications																									
DC System Size	14.76 kW																								
Module Type	Standard																								
Array Type	Fixed (open rack)																								
System Losses	14.08%																								
Array Tilt	20°																								
Array Azimuth	180°																								
DC to AC Size Ratio	1.2																								
Inverter Efficiency	96%																								
Ground Coverage Ratio	0.4																								
Albedo	From weather file																								
Bifacial	No (0)																								
Monthly Irradiance Loss	<table border="1"> <tr> <td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May</td><td>June</td> </tr> <tr> <td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td> </tr> <tr> <td>July</td><td>Aug</td><td>Sept</td><td>Oct</td><td>Nov</td><td>Dec</td> </tr> <tr> <td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td><td>0%</td> </tr> </table>	Jan	Feb	Mar	Apr	May	June	0%	0%	0%	0%	0%	0%	July	Aug	Sept	Oct	Nov	Dec	0%	0%	0%	0%	0%	0%
Jan	Feb	Mar	Apr	May	June																				
0%	0%	0%	0%	0%	0%																				
July	Aug	Sept	Oct	Nov	Dec																				
0%	0%	0%	0%	0%	0%																				
Performance Metrics																									
DC Capacity Factor	14.7%																								

Figure 17. PVWatts Software Results at PV=14.76 Part 2 [3]

**Table 10. Solar Panel Energy Production, Required Number of Panels and Roof Area Calculations**

<b>Annual Energy Production of the Selected PV System</b>	18986 kWh/yr
<b>Assumptions</b>	<ul style="list-style-type: none"> <li>- A residential solar panel is about 265W [4]</li> <li>- One solar panel measures roughly 5ft x 3ft = 15ft<sup>2</sup> (1.4m<sup>2</sup>) [4]</li> <li>- Panels are assumed to be flush-mounted on the roof</li> <li>- Minimal shading is assumed (neighbouring building is the same height)</li> </ul>
<b>Number of Solar Panels Required</b>	$\begin{aligned} \text{Number of Panels} &= \frac{PV \text{ in kW} \times 1000}{W/\text{Panel}} \\ &= \frac{14.76 \text{ kW} \times 1000}{265 \text{ W/Panel}} \\ &= 56 \text{ Panels} \end{aligned}$
<b>Required Roof Area</b>	$\begin{aligned} \text{Area} &= \# \text{ Panels} \times \text{Area/Panel} \\ &= 56 \text{ panels} \times 1.4 \text{ m}^2/\text{Panel} \\ &= 78.4 \text{ m}^2 \end{aligned}$
<b>Discussion</b>	Based on the PV Watts system output (14.76 kW required) and typical solar panels, approximately 78m <sup>2</sup> of roof space is required to meet the home's total energy demand of 18996kWh. The model has a roof area of 88m <sup>2</sup> , which is probably sufficient when accounting for obstructions. However, since it is an east-facing building with limited southern exposure, the solar panels may be less efficient than the calculations, and a supplemental PV surface may be required elsewhere to achieve the net-zero energy goal.

## 10.0 ROOF RAINWATER COLLECTION

Assuming only rain and not snow, as per assignment instructions.

**Table 11. Required Roof Size for Water Demand**

<b>Annual Precipitation (mm) [5]</b>	$\begin{aligned} \text{Annual Precipitation} &= \Sigma \text{precipitation/month} \\ &= 33.9+29.2+36.6+78.0+76.4+81.6+76.5+71.9+69.4+69.1+64.7+36.6 \\ &= 723.9 \text{ mm} \\ &= 0.724 \text{ m} \end{aligned}$
<b>Roof Catchment Area (m<sup>2</sup>)</b>	88m <sup>2</sup> (obtained from model)
<b>Total Required Area (m<sup>2</sup>)</b>	$\begin{aligned} \text{Total Area Required} &= \frac{\text{Annual Water Consumption (m}^3\text{)}}{\text{Total Precipitation (m)}} \\ &= \frac{80 \text{ m}^3}{0.724 \text{ m}} \\ &= 110.50 \text{ m}^2 \end{aligned}$
<b>Discussion</b>	The total rainfall for Toronto is 724mm/yr, excluding snowfall [5]. Using this value, approximately 110 m <sup>2</sup> of horizontal collection area would be required to meet the home's annual water demand of 80m <sup>3</sup> . The Revit model shows a catchment area of 88m <sup>2</sup> , which is smaller than the required area, meaning that the roof by itself is not enough to supply the full annual demand. However, it would still cover a lot of the home's needs. Additional collection surfaces, like the garage roof, could be used to make up the difference.

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