[a]

site analysis

analysis of the current conditions of the house
additional designs for the house

A-01 Site Topography

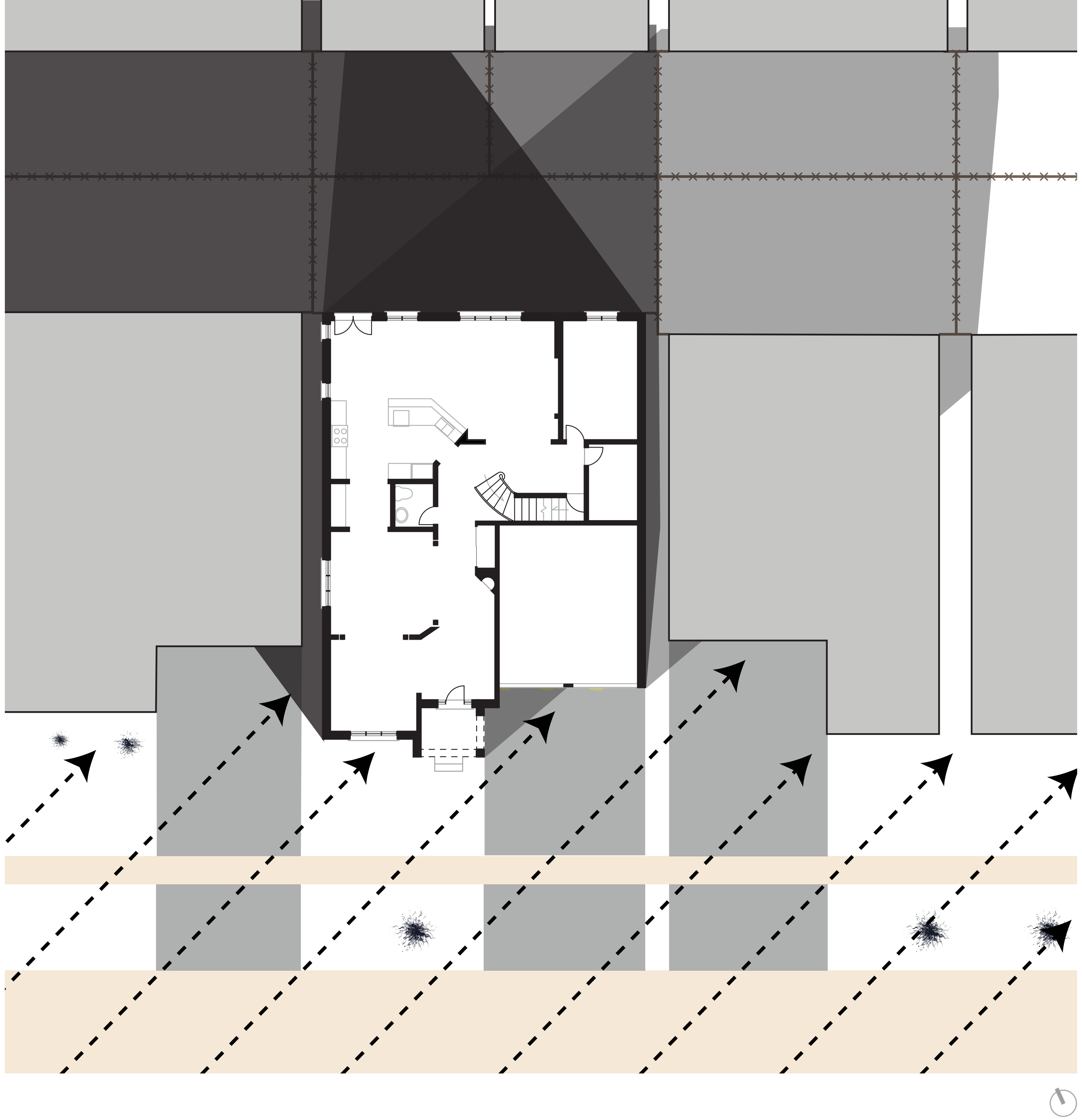
In general, Toronto's land is flat. The Markham area, where this house is located, is especially flat. A change of 6 inches in topography occurs approximately every 30 feet. Steps to the entrance of the house vary depending on the topographic changes. Two steps are required to enter this house.

There is only one tree in the lot, which is owned by the Ontario government. The government also owns the space between the sidewalk and the street. The tree cannot be removed or added to. Any ground surface that isn't gravel is covered by grass.

A-02 Site Plan [summer]

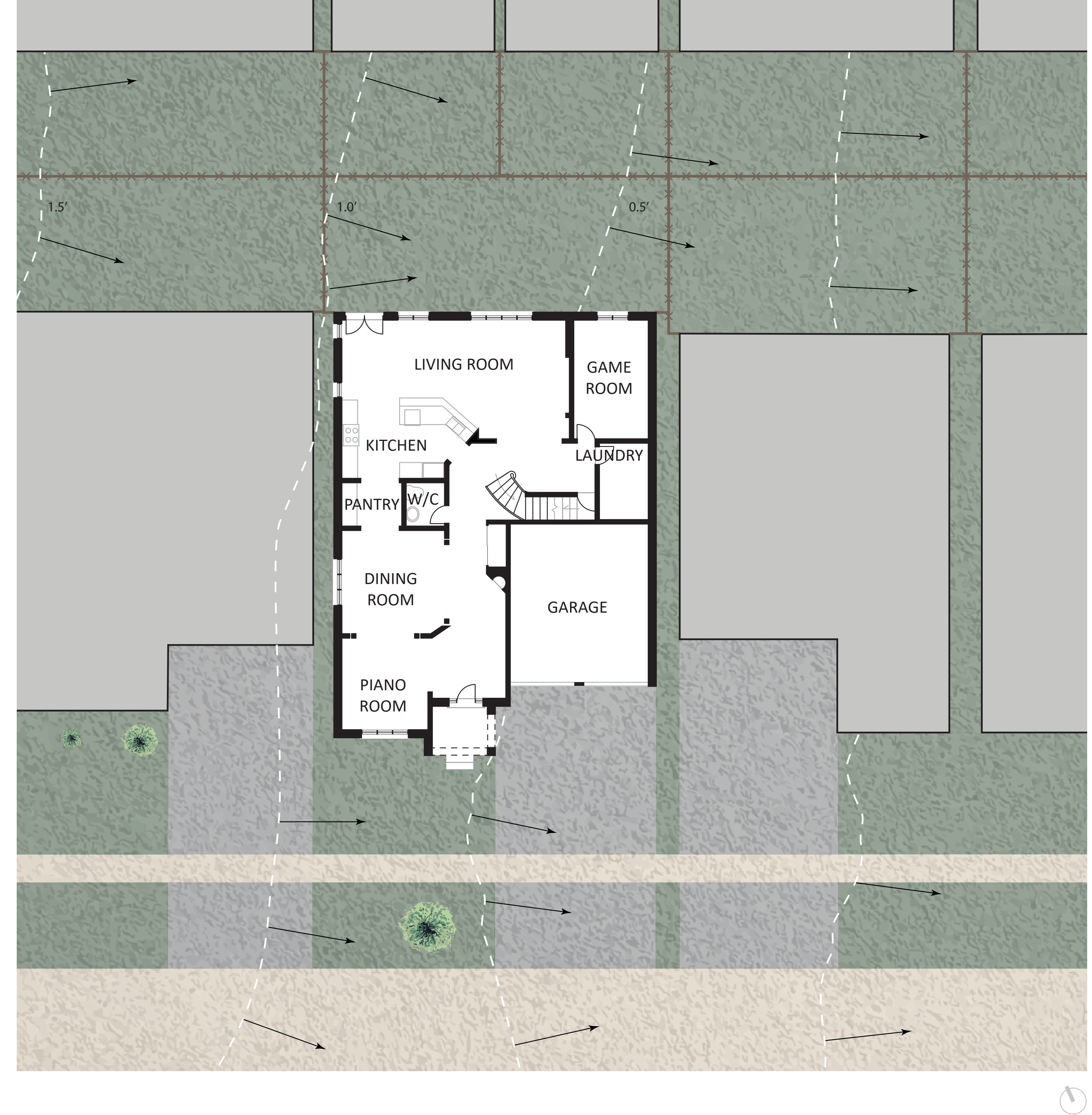
Summer prevailing winds come from primarily south, southwest and northeast. As the houses in this area are neatly organized into rows with fenced backyards, they act as barriers from the strong northeast winds for the northern facade. The south face experienes winds from the south as there is a wide road. This can be a problem at the entrance, which when opened, leads to a long corridor connecting the rest of the house.

As the neighbouring houses are located within close proximity, shadows are casted on each other. That has less effect on the interior as the west and east facades have minimal aperatures. The backyard is half shaded.



A-03 Site Plan [winter]

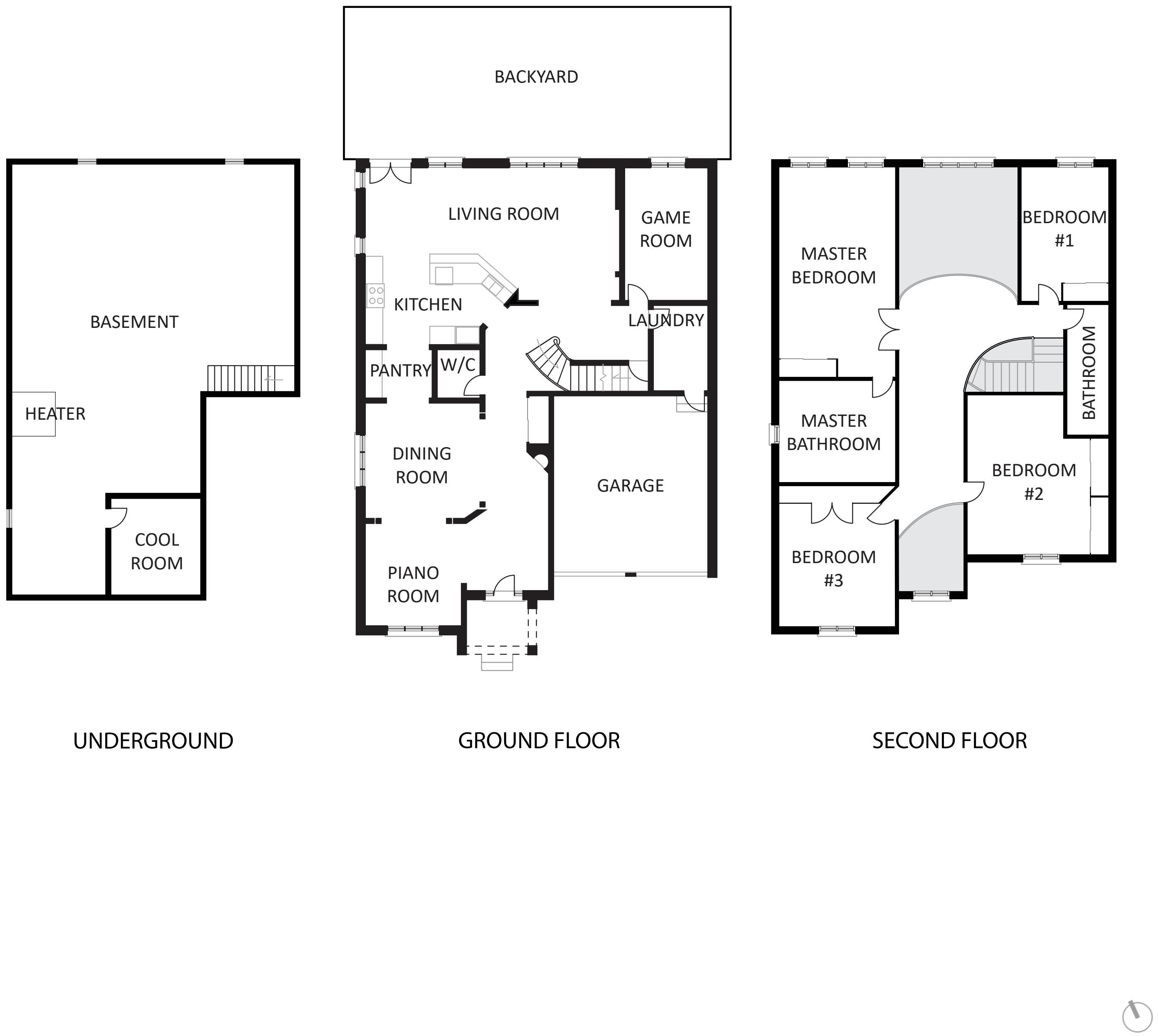
Winter prevailing winds come primarily from the west-southwest. The south facade experiences these winds, which during the harsh winters, would be problematic. Cold winds would enter the house through the front door, the garage and south-facing windows. In the winter, most of the backyard is in shade for the entire day. This causes the living room and bedroom in the north side to experience less warmth from the sun. Only the piano room on the ground floor has direct contact with warmth from sunlight. Other areas of the house receives indirect sunlight.



A-04 Drainage

Drainage runs from west to east. As the slope of the topography is very minimal, rushing water is not an issue.

Flooding has never happened within the past decade since the housing district was developed. This may be due to the slight slope as well ast he mechanical drainage system that was incorporated as the housing is relatively new.



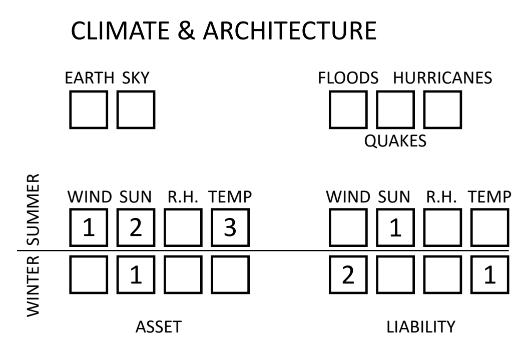
A-05 Floor Plans

The circulation of the house runs north-south, which is also where bigger aperatures are located. Double height ceiling is used on the north and south end to maximise sunlight. The corridor then turns into an L-shape to lead to the stairs.

The ground floor is organised such that the areas used more frequently are in the north side. Bedrooms are located on the four corners of the second floor, with the two bathrooms in between.

The basement can be accessed through the same staircase, but it is very rarely used as it stores mechanical equipments. The backyard can be accessed through the living room.

SPACE	AREA (SQ FT)	USE	TIME IN USE	# OF PEOPLE	MET	CLO	INTERNAL LOADS (L/M/H)	ENV INTERESTS	H C V	S W	S	S E	E	N E	N	N W	W	1 2 3
Living Room	310	Living	All Day Daily	0-4	0.7 - 2.0	0.6 - 1.4	Medium	Backyard Access + Views + Fireplace + Sun	H C					X	X	X	X	1
Kitchen	210	Living	All Day Daily	1-4	1.2 - 2.0	0.6 - 1.0	High	Sun + Views	H C					X	X	X	X	1
Pantry	48	Support	Daily	0-4	1.2 - 1.4	0.6 - 1.0	Low		H C	N/A								2
½ W/C	28	Support	Daily	1	1.0 - 2.0	0.6 - 2.0	Low		H	N/A								2
Dining Room	325	Support	Special Occasions	0-4	1.0 - 1.2	0.6 - 1.4	Medium	Views	H C	X	X						X	3
Piano Room	130	Support	Special Occasions	0-4	1.0 - 2.6	0.6 - 1.4	Medium	Sun + Views	H C	X	X	X						3
Game Room	145	Recreation	Daily	1-2	0.7 - 1.2	0.6 - 1.0	High	Sun + Fireplace	H C					X	X	X		2
Laundry	62	Support	Daily	1-2	1.2 - 3.0	0.6 - 2.0	High		H C	N/A								2
Storage	13	Support	Daily	1-4	1.2 - 2.0	0.6 - 1.0	Low			N/A								2
Corridor & Stairs	348	Circulation	All Day Daily	4	2.0	0.6 - 2.0	Low		H C	X	X	X		X	X	X		3
Bedroom 1	138	Living	Night Daily	1	0.7 - 2.0	0.6 - 1.4	Medium	Views	H C					X	X	X		1
Bedroom 2	235	Living	Night Daily	1	0.7 - 2.0	0.6 - 1.4	Medium	Views	H C	X	X	X						2
Bedroom 3	182	Support	Occasionally	0-1	0.7 - 2.0	0.6 - 1.4	Medium	Views	H C	X	X	X						1
Master Bedroom	300	Living	Night Daily	2	0.7 - 2.0	0.6 - 1.4	Medium	Sun + Views	H C					X	X	X		1
Master Bathroom	150	Support	Daily	1	1.0 - 2.0	0 - 1.4	Low	Sun	H C				X					3
Bathroom	68	Support	Daily	1	1.0 - 2.0	0 - 1.4	Low	Sun	H C								X	3
Corridor & Stairs	323	Circulation	All Day Daily	4	2.0	0.6 - 1.4	Low	Sun + Views	H C	X	X	X		X	X	X		3
Garage	360	Support	Leaving/Arriving	1-2	1.2 - 2.0	0.6 - 2.0	Low		H C	X	X	X						3
Storage	72	Support	Daily	1-4	1.2 - 2.0	0.6 - 1.4	Low			N/A								3



A-06 Programming

Toronto summers range between cool to warm. Wind and sun in the summer are asests, which can bring light into the home and provide ventilation.

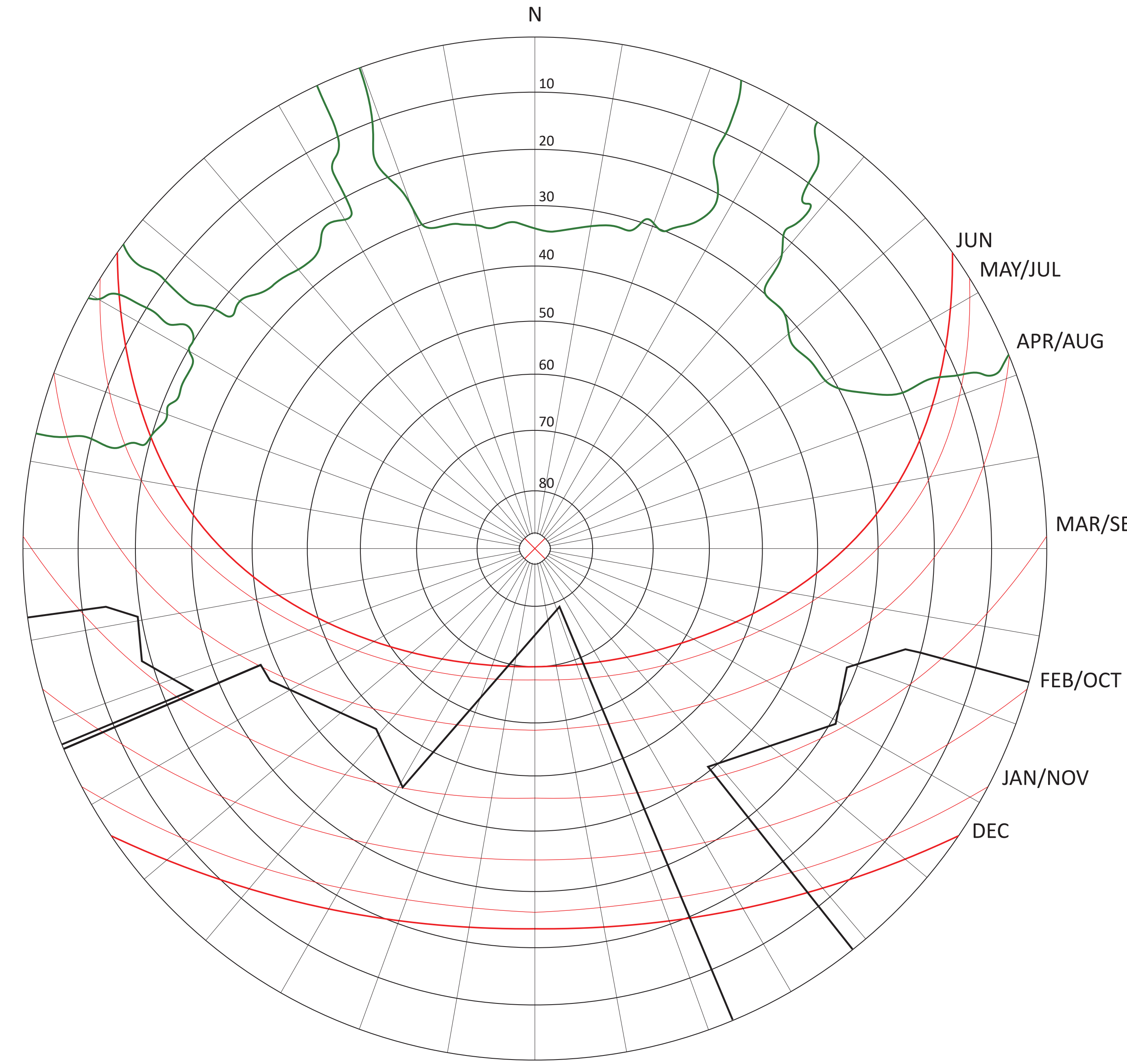
Winters are cold and windy, so any exposure to sunlight is ideal. Protection against winds from the south is ideal as well.

A-07 Axon

This home is located in Markham, Ontario, Canada. The home is approximately 3200 square feet, with a lot width of 45 feet. There are four bedrooms, two and a half bathrooms and living spaces.

The houses in the area are constructed out of wood with insulation due to the harsh winters.

Most of the windows are on the north and south facades. Windows on the east and west facades are not prioritised as there are neighbouring houses on either sides that cause shade and block views.



A-08 Solar Window

The red X in the centre of the solar window indicates the location of the backyard, which is north of the house.

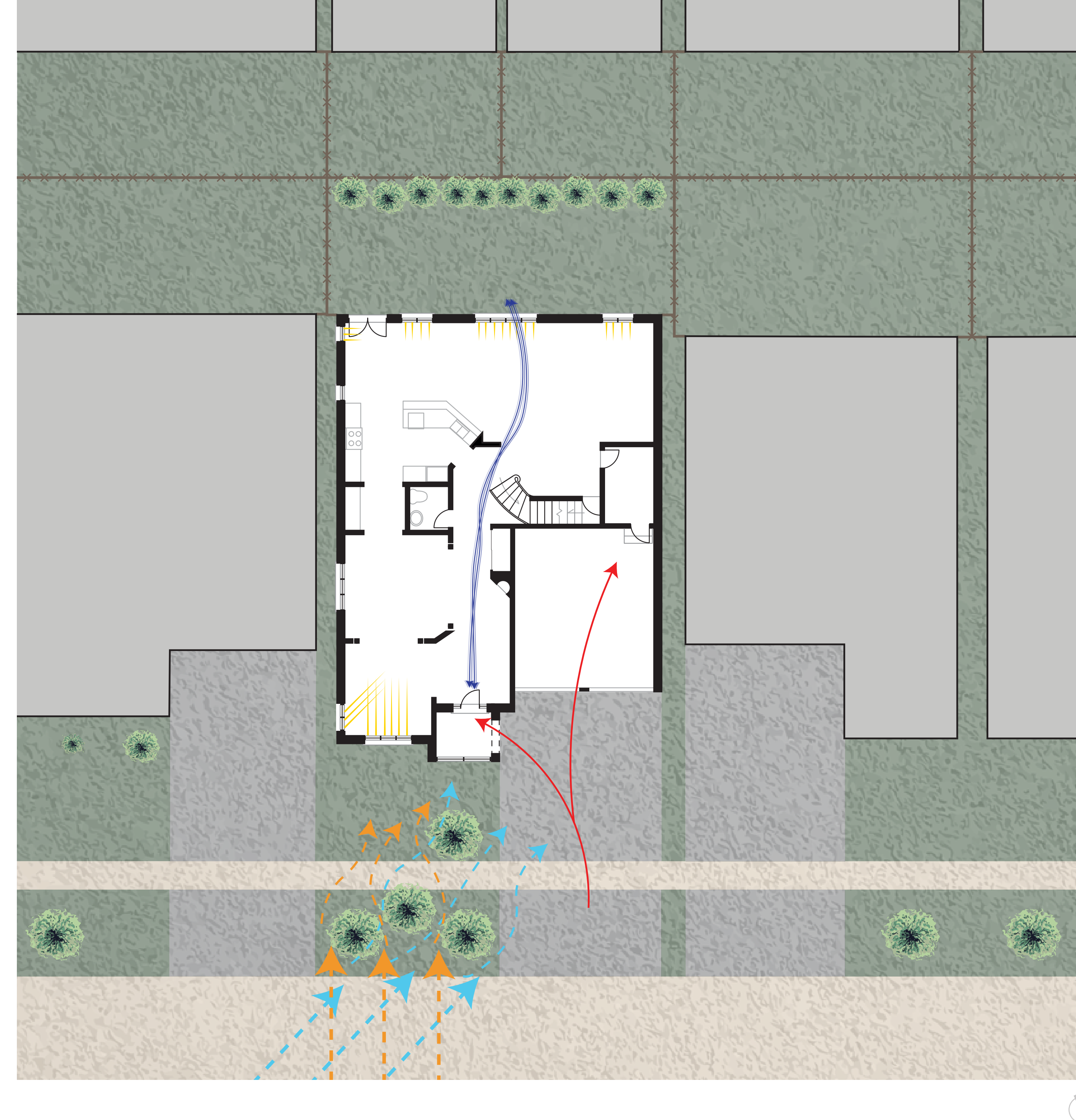
The houses cast an inevitable shadow on the backyard (depending on the time of day). This solar window shows that planting more trees only on the north side of the backyard does not impact the amount of sun received.

A-09 Floor Plans [re-designed]

Changes I've suggested are based upon two main factors: sunlight and frequency of use. The dining room and bedroom #3 are rarely used, yet receives the most sunlight. By switching the game room and the dining room, sunlight from the south facing windows can enter the room. Similarly, switching bedroom #3 and the master bedroom will provide more light and warmth.

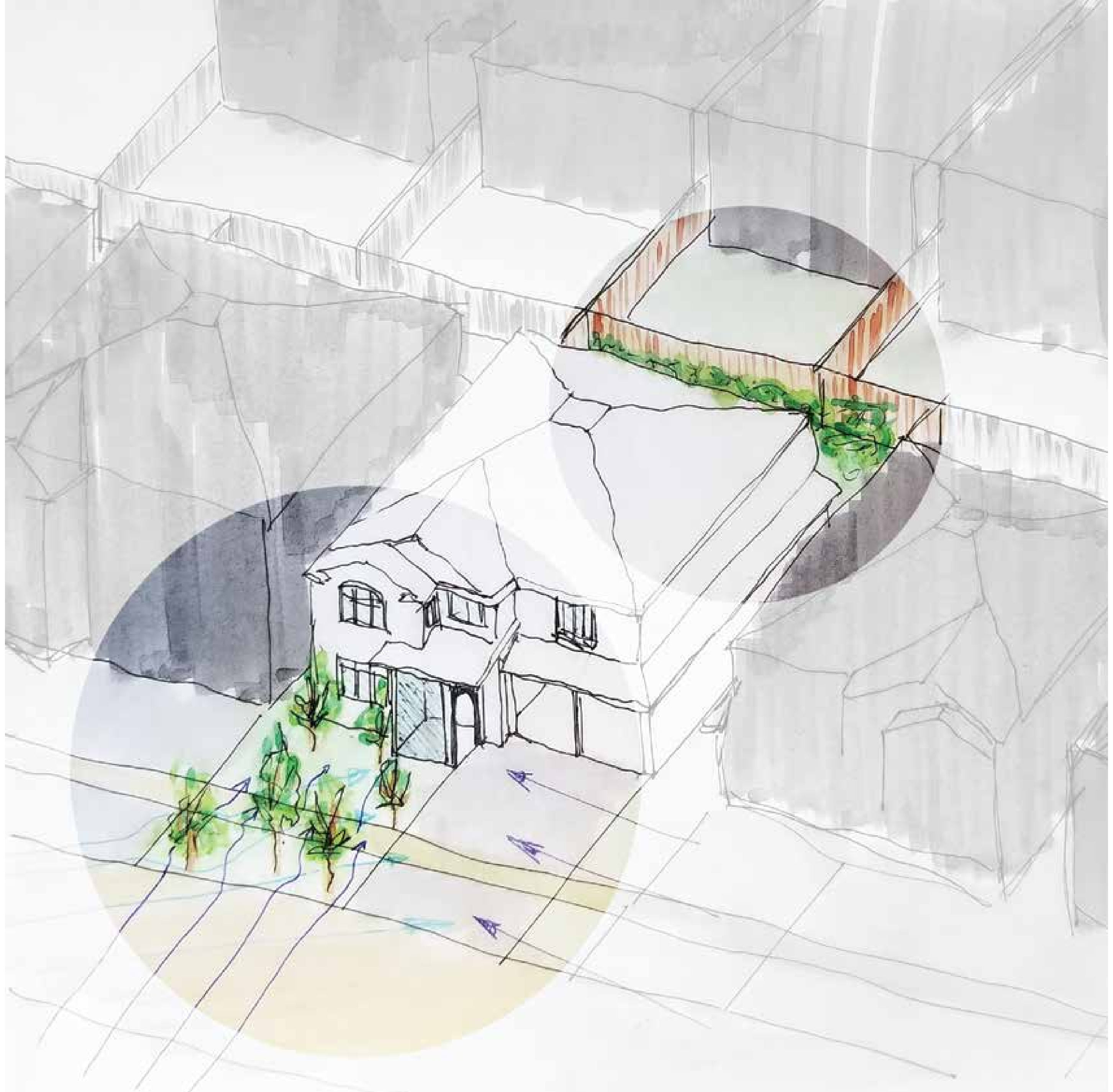
By removing the west wall, the new dining room will become part of a bigger living area. North facing windows will bring in some light to that big space.

The step to the entrance of the house can be on the east instead of the south to avoid strong winds.



A-10 Site Plan [re-designed]

Light blue arrows	winter winds
Orange arrows	summer winds
Red arrows	entrance from east side instead of south to avoid cold winter winds
Dark blue arrows	cross ventilation



A-11 Axon [re-designed]

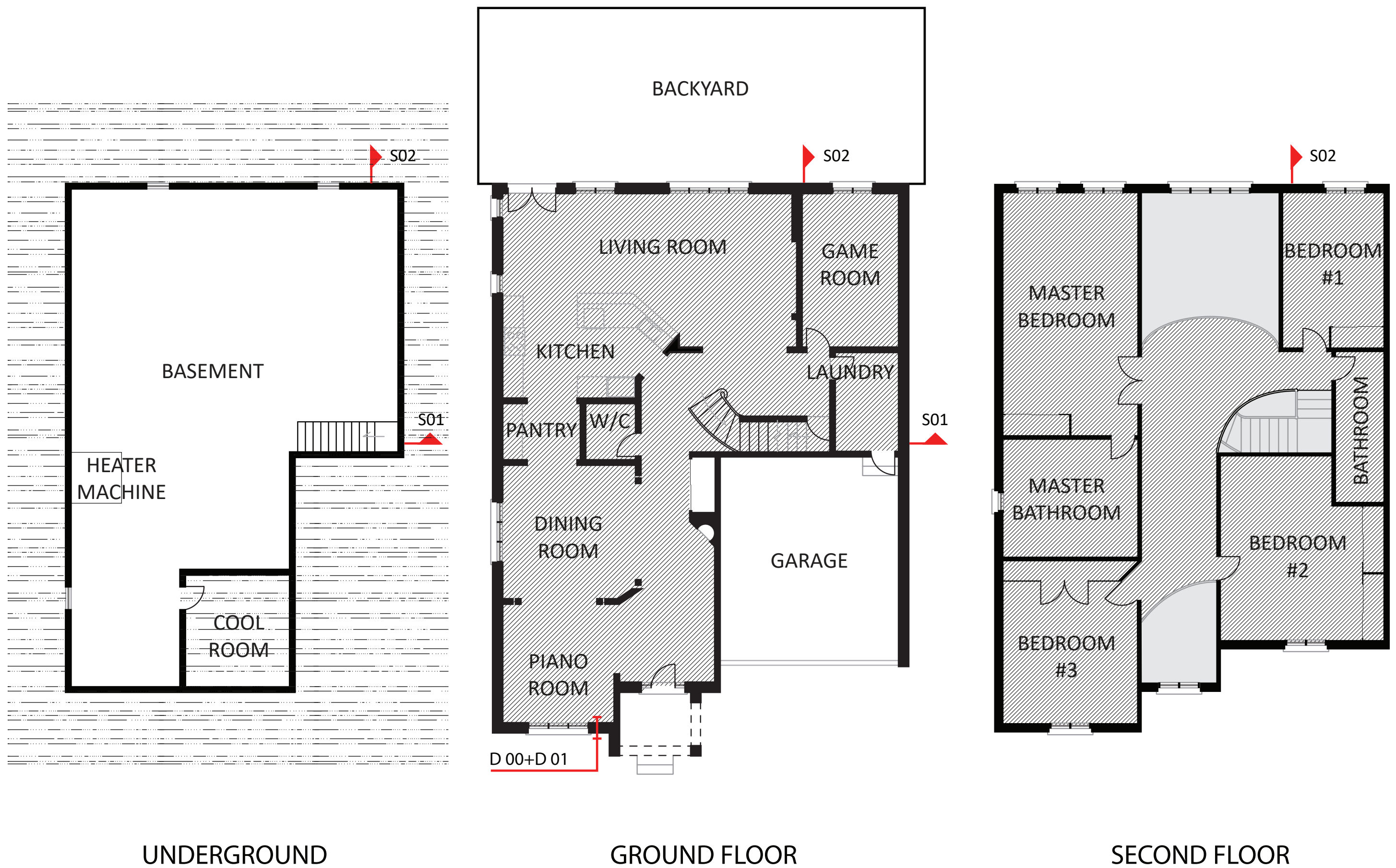
Planting more trees and plants not only provide a greener view, but also allows for protection from wind.

As nothing is currently planted in the back yard, deciduous trees or plants can be planted on the northern side where there isn't a shadow casted by the house in the summer. Evergreen trees, such as pine trees, can be planted in the front to provide protection from the cold winter winds from the south.

Turning the entrance to the house to face the east allows prevent winter winds from entering the house, but welcomes summer winds to cross ventilate the interior.

[b]
heat loss

determining heated zones of the house
analysis on materials between outdoor and heated indoors
calculations of heat loss through materials



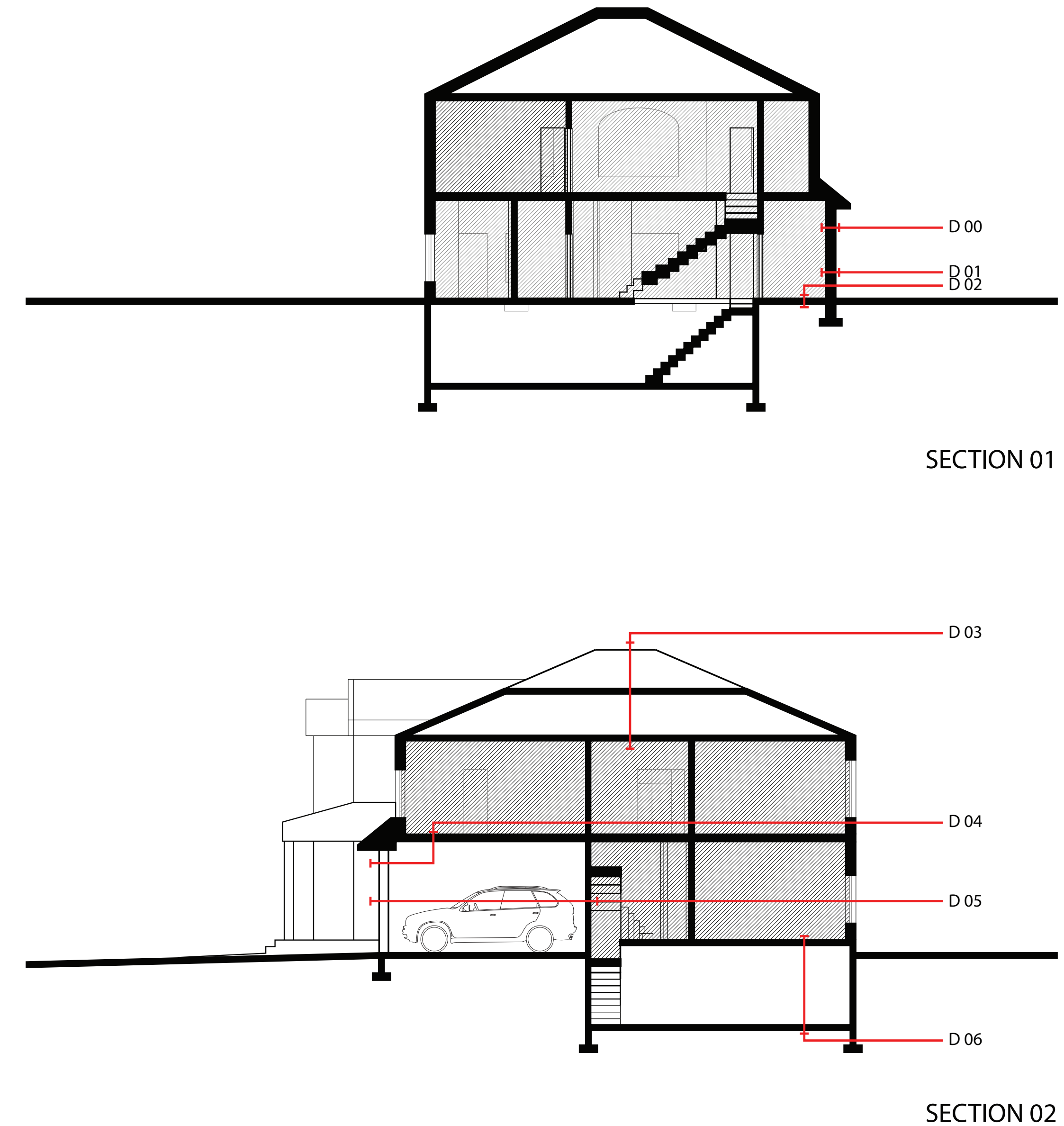
B-01 Heated Zones Floor Plans

All rooms are heated except the garage and the cold room.

The double height areas are heated from vents on the first floor.

The basement is indirectly heated by the vents that go up to heat the first and second floor. The basement is warm, but not as warm as the upper floors.

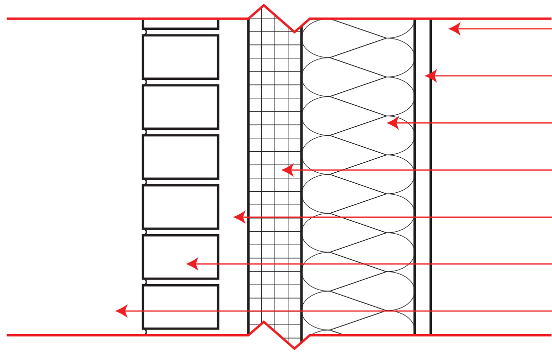
Based on Canadian law, the basement cannot be underneath the garage, which gives it the L-shape.



B-02 Heated Zones Sections

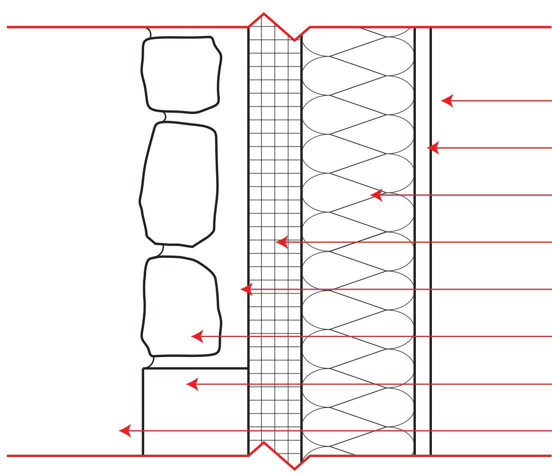
All rooms are heated, except the garage, basement and the attic.

EXTERIOR WALL (BRICK)



MATERIALS	R - VALUE
INTERIOR AIR FILM	0.68
1/2" GYPSUM BOARD	0.45
4" INSULATION	11.00
2" RIGID INSULATION	10.00
1" AIR GAP	1.00
3" BRICK	0.33
EXTERIOR AIR FILM	0.17
TOTAL R VALUE	**23.63**
TOTAL U VALUE	**0.042**

EXTERIOR WALL (STONE)



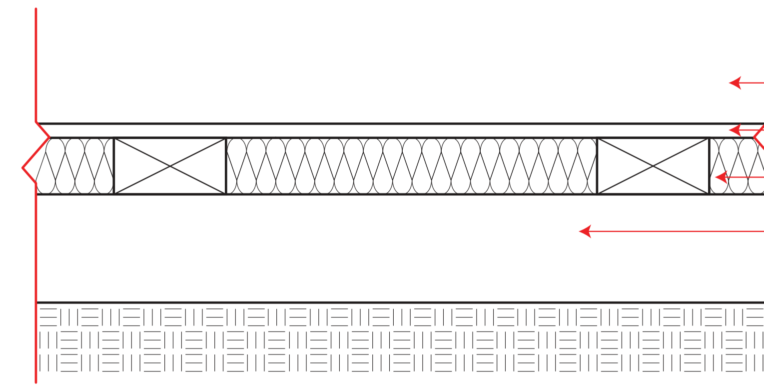
MATERIALS	R - VALUE
INTERIOR AIR FILM	0.68
1/2" GYPSUM BOARD	0.45
4" INSULATION	11.00
2" RIGID INSULATION	10.00
1" AIR GAP	1.00
3" STONE	0.11
CONCRETE	0.32
EXTERIOR AIR FILM	0.17
TOTAL R VALUE	**23.73**
TOTAL U VALUE	**0.042**

B-03 Detail 00 + 01

The exterior walls consist of a layer of brick veneer on all facades.

*Note: the stone veneer on the south facade only applies from above the concrete base to below the window sill (at about 3 feet above ground).

SLAB TO GROUND



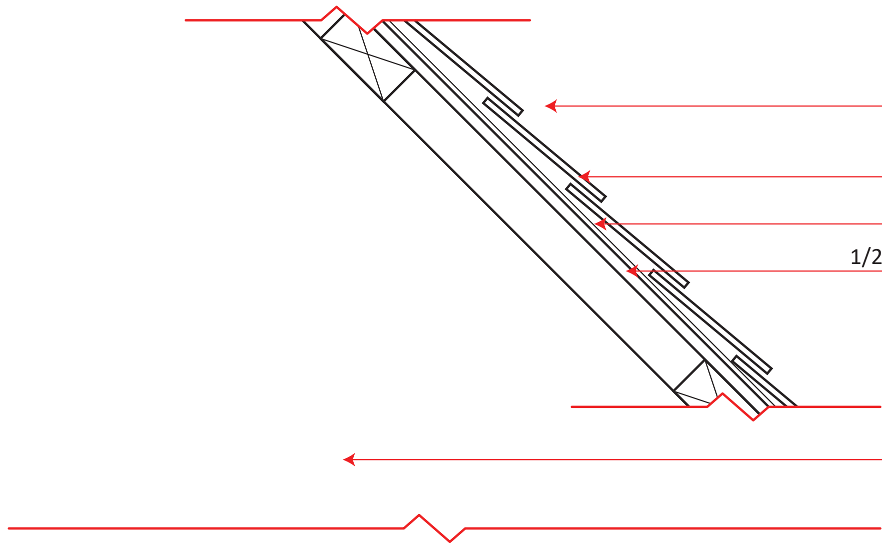
MATERIALS
AIR SPACE
HARDWOOD FLOOR
2" INSULATION
CONCRETE

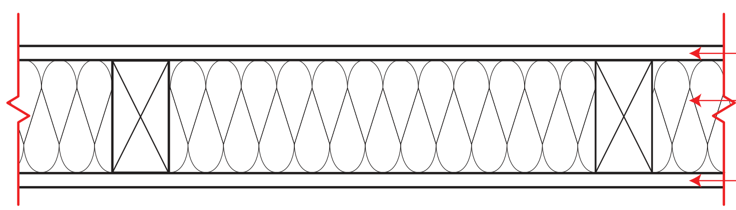
F VALUE	**0.55**
TOTAL PERIMETER (FT²)	**68.052**

B-04 Detail 02

The only ground floor slab with insulation layer that meets the ground is the laundry room and game room's floor.

2/F CEILING TO ATTIC DETAIL



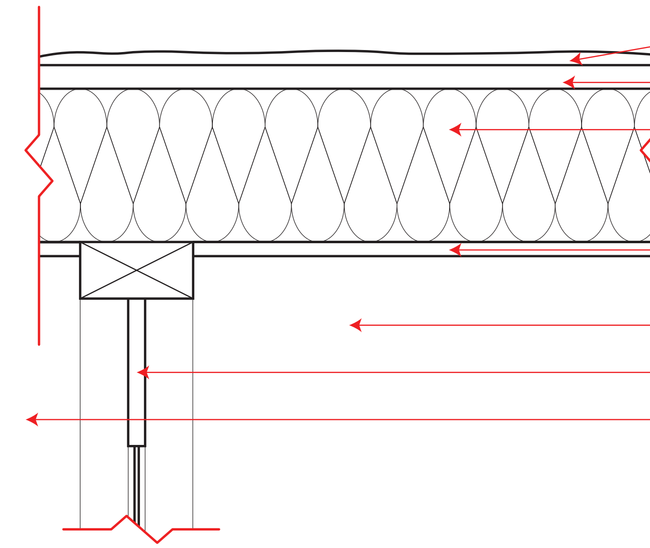


MATERIALS	R - VALUE
EXTERIOR AIR FILM	0.17
ASPHALT SHINGLES	0.44
ROOFING FELT	0.06
1/2" PLYWOOD SHEATHING	0.62
6' AIR GAP	1.00
5/8" PLYWOOD	0.77
INSULATION	11.00
1/2" GYPSUM BOARD	0.45
INTERIOR AIR FILM	0.68
TOTAL R VALUE	**23.62**
TOTAL U VALUE	**0.042**

B-05 Detail 03

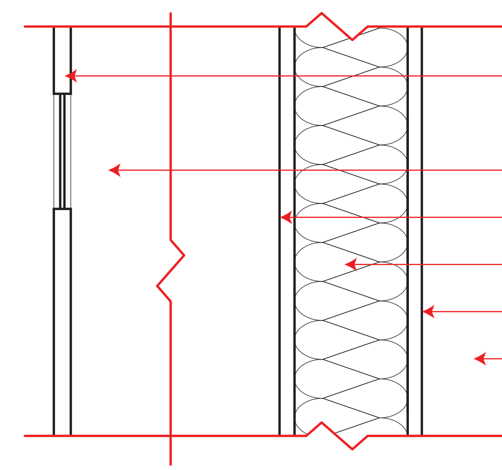
The attic is not heated and not vented. The air gap between the second floor ceiling and the roof is taken into account.

2/F GROUND (GARAGE CEILING)



MATERIALS	R - VALUE
INTERIOR AIR FILM	0.68
CARPET	2.08
3/4" HARDWOOD	0.68
INSULATION	11.00
1/2" GYPSUM BOARD	0.45
GARAGE AIR SPACE	1.00
1/2" WOOD GARAGE DOOR	0.31
EXTERIOR AIR FILM	0.17
TOTAL R VALUE	**16.37**
TOTAL U VALUE	**0.061**

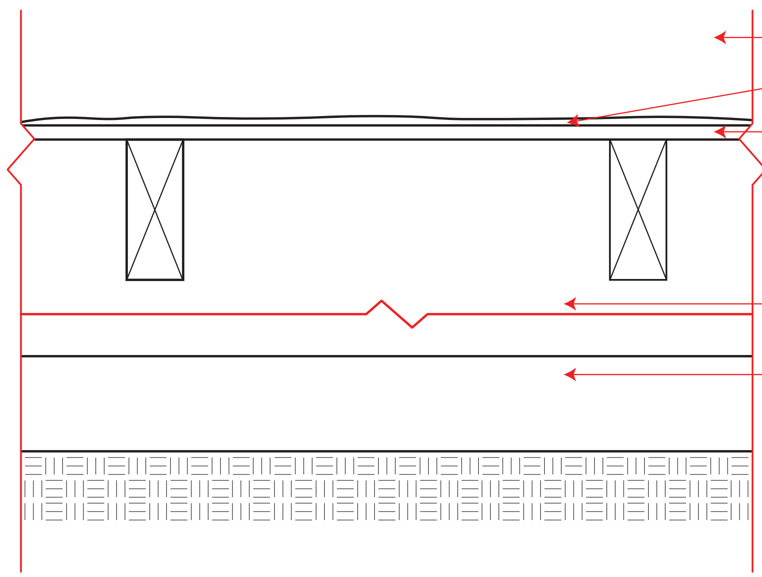
GARAGE WALL



MATERIALS	R - VALUE
1/2" WOOD GARAGE DOOR	0.31
GARAGE AIR SPACE	1.00
1/2" GYPSUM BOARD	0.45
4" INSULATION	11.00
1/2" GYPSUM BOARD	0.45
INTERIOR AIR FILM	0.68
TOTAL R VALUE	**13.89**
TOTAL U VALUE	**0.072**

B-06 Detail 04 +05

Garage is in the inside of the house on the south side. It is not heated, but the walls that are shared with heated rooms (laundry room and entrance corridor) are insulated. The garage door is not insulated.



FLOOR BUFFER

MATERIALS	R-VALUE
INTERIOR AIR FILM	0.68
CARPET	2.08
1/2" PLYWOOD	0.62
AIR SPACE	1.00
CONCRETE	0.32
TOTAL R VALUE	**4.7**
TOTAL U VALUE	**0.106**

B-07 Detail 06

*Note: total U value is halved due to buffer space of the basement space below ground

*Note: basement ceiling is not insulated. There are only ceiling joints present.

DETAIL	DETAIL #	U-VALUE (Btu/hrft²°F)	TOTAL AREA (FT²)	HEAT LOSS COEFF. (UA = Btu/hr°F)
Exterior Wall (brick)	Detail 00	0.042	2467	103.62
Exterior Wall (stone)	Detail 01	0.042	26	1.10
Slab to Ground	Detail 02	f value 0.55	perimeter (ft) 68	37.43
2/F Ceiling	Detail 03	0.066	1795	118.17
2/F Floor	Detail 04	0.061	392	23.91
Garage Wall	Detail 05	0.072	184.46	13.28
1/F Floor	Detail 06	0.110	1150	126.50
Exterior Doors		0.500	70	35.0
Windows (Double Glazed)		0.490	328	160.72
		SUBTOTAL HEAT LOSS COEFFICIENT		619.73

	AIR CHANGES/HR	HEATED VOLUME (FT³)	HEATED CAPACITY	HEAT LOSS COEFF. (UA = Btu/hr°F)
INFILTRATION	0.75	27662	0.018	373.43
		TOTAL HEAT LOSS COEFFICIENT		993.16

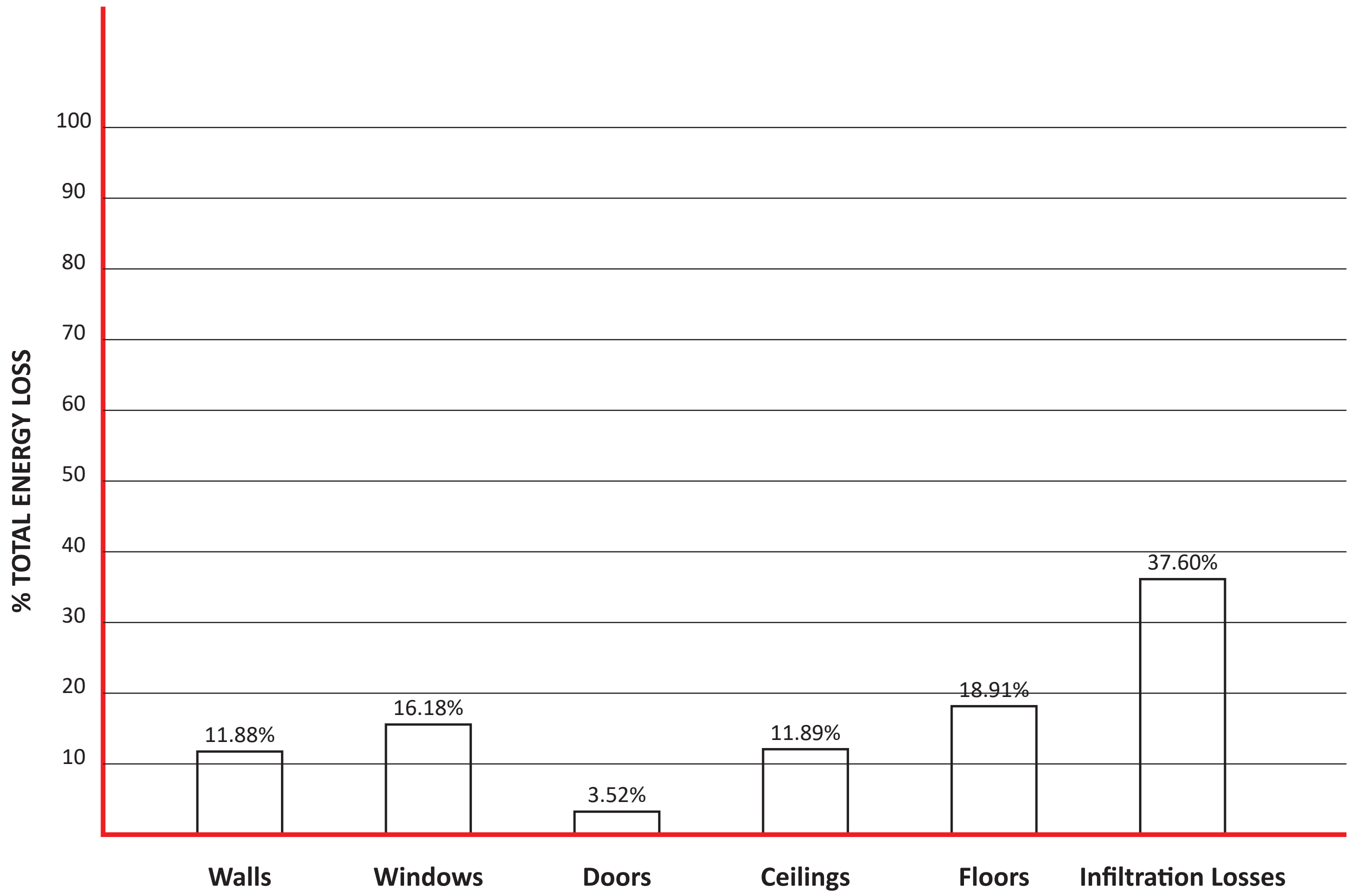
PEAK HEAT LOSS	(993.16 Btu/hr°F)*(60°F-1°F) =	58596.44
ANNUAL HEAT LOSS	(993.16 Btu/hr°F)*(24 hr)*(4937 HDD) =	117,677,542.10
ANNUAL BLDG ENERGY PERFORMANCE	(117,677,542.10)/(3087 ft²) =	38,120.35 Btu/ft²/year

B-08 Peak & Annual Heat Loss Table

U values are taken from totaled values on each detail page.

Air changes per hour is 0.75 as windows and the door to the backyard are not often opened. Infiltration comes mainly from the main entrance door.

	COMPONENT	HEAT LOSS COEFF. (UA = Btu/hr°F)	PERCENTAGE LOSS
HEAT LOSS SOURCES	Walls	118.0	11.88%
	Windows	160.72	16.18%
	Doors	35.0	3.52%
	Ceilings	118.17	11.89%
	Floors	187.84	18.91%
	Infiltration Losses	373.43	37.60%



B-09 Heat Loss Visual

UA values are based upon values from the calculation table.

[c]
total energy loss

calculations of where energy is going
calculations of what money is spent on
analysis on distribution of all loads

HEATING

total ua value (btu/hr°F): 993.16
dd base: 60°
heating type: gas

total gas usage/year (m³): 3972
total gas usage/year (mmbtu) : 146.80
total gas cost charged/year: $1428.84
COST/mmbtu: ($1428.84)/(146.80) = 9.73

MONTH	BLC (btu/day°F)	mo. HDD	Htg. LOAD (btu x 10⁶)	SYSTEM EFFICIENCY	Htg. SYSTEM DEMAND (btu x 10⁶)	COST/mmbtu ($/mmbtu)	COST/MONTH ($)
JANUARY	23835.84	952	21.79	0.9	25.21	9.73	245.32
FEBRUARY	23835.84	792	18.13	0.9	20.97	9.73	204.09
MARCH	23835.84	892	20.42	0.9	23.62	9.73	229.86
APRIL	23835.84	360	8.24	0.9	9.53	9.73	92.77
MAY	23835.84	226	5.17	0.9	5.98	9.73	58.23
JUNE	23835.84	30	0.68	0.9	0.79	9.73	7.73
JULY	23835.84	0	-	-	-	-	-
AUGUST	23835.84	13	0.29	0.9	0.34	9.73	3.35
SEPTEMBER	23835.84	58	1.32	0.9	1.53	9.73	14.94
OCTOBER	23835.84	193	4.41	0.9	5.11	9.73	49.73
NOVEMBER	23835.84	476	10.89	0.9	12.60	9.73	122.66
DECEMBER	23835.84	945	21.63	0.9	25.02	9.73	243.51
		total HDD: 4937			**YEARLY TOTAL HEATING COST:**		**$1272.19**

C-01 Energy Loss: Heating

This house is heated by gas, which partially goes towards heating water.

The owners of the house does not maintain a high indoor temperature through heating by gas. This is because the vents are located on the floor and there are double height areas in the house, which would require a lot of energy to fully heat the house. An electric heater fan is used only if it does get too cold at night.

COOLING

ac unit: carrier comfort 15" central ac
seer: 14 btu/hrs: 36000
capacity (tons): 3 seer (btu/kwh): 2.57

MONTH	mo. CDD	DEMAND FACTOR (btu/kwh)	MONTHLY DEMAND	ELECTRICITY COST ($/kwh)	COST/MONTH ($)
JANUARY	0	-	-	-	-
FEBRUARY	0	-	-	-	-
MARCH	0	-	-	-	-
APRIL	1	2.57	2.57	0.132	0.33
MAY	17	2.57	43.71	0.132	5.77
JUNE	63	2.57	162.00	0.132	21.38
JULY	132	2.57	339.42	0.132	44.80
AUGUST	109	2.57	280.28	0.132	36.99
SEPTEMBER	35	2.57	90.00	0.132	11.88
OCTOBER	1	2.57	2.57	0.132	0.33
NOVEMBER	0	-	-	-	-
DECEMBER	0	-	-	-	-
			YEARLY TOTAL COOLING COST:		**$121.51**

C-02 Energy Loss: Cooling

Cooling is needed mainly in the hottest days of July and August. The occupants of the house work or go to school during the day, so the AC unit is in use mainly in the late afternoons.

Electricity cost is the mid-peak rate of $0.132/kwh to get the average.

DOMESTIC HOT WATER

ACTIVITY	WATER USAGE (gallons)	USAGE AMT (times/month)	TOTAL (gallons/month)
washing clothes	20	8	160
showering	14	90	1260
bathing	20	0	-
automatic dishwashing	12	0	-
preparing food	5	30	150
handwashing dishes	4	30	120
		MONTHLY TOTAL WATER USAGE:	1690 gal

	GALLONS/MO	DHW MMBTU/MO	COST/MMBTU	TOTAL COST
MONTHLY	1690	1.69	9.73	16.44
			YEARLY TOTAL HEATING COST (WATER):	$197.32

LIGHTING

LIGHTBULB TYPE	QUANTITY	AVG LAMP WATTAGE (watt)	AVG HOURS ON /MONTH (hr/mo)	TOTAL (wh/mo)
Flourescent	32	15	168	80640
			TOTAL LIGHTING (wh/mo):	80,640

MONTHLY

LIGHTING LOAD (wh/mo)/1000	ELECTRICITY COST/KWH ($/kwh)	MONTHLY LIGHTING COST ($)
80.64	0.132	10.64
	YEARLY LIGHTING COST:	$127.73

APPLIANCES

APPLIANCES	QUANTITY	AVG WATTAGE IN USE (watt)	AVG HOURS ON /MONTH (hr/mo)	TOTAL (wh/mo)
COFFEE MACHINE	1	1100	5	5,500
CPU DESKTOP	2	100	338	67,600
COPIER	2	25	2	100
DRYER	1	2750	12	44000
ELECTRIC HEATER	1	2500	2.25*	5,625
ELECTRIC KETTLE	1	1200	12	14,400
FRIDGE	1	275	200	55,000
GAME CONSOLE	1	160	2	320
HAIR DRYER	1	2150	15	32,250
KITCHEN FAN	1	75	30	2,250
LAPTOP	3	100	338	101,400
MICROWAVE	1	1000	10	10,000
MICROWAVE OVEN	1	1200	10	12,000
RICE COOKER	1	225	31	6,975
PHONE CHARGER	4	5	360	7,200
TOASTER	1	1000	90	90,000
TV	2	138	220	60,720
VACUUM MACHINE	1	650	3	1,950
WASHER	1	2750	12	44,000
			TOTAL APPLIANCES (wh/mo):	561,290

MONTHLY

APPLIANCE LOAD (wh/mo)/1000	ELECTRICITY COST/KWH ($/kwh)	MONTHLY APPLIANCE COST ($)
561.29	0.132	74.09
	YEARLY APPLIANCE COST:	$889.08

*note: the electric heater fan is only used 3-4 hours on cold winter nights

C-03 Energy Loss: Hot Water

The water boiler is located in the basement.

Hot water is used for laundry, showering and cooking. To save water and gas, the dishwasher is not used and they do not take long showers.

C-04 Energy Loss: Electricity

The list of appliances includes most often used appliances as well as appliances that require higher wattage. Only flourescent lightbulbs are used throughout the house, which are only turned on when spaces are occupied. The monthly lighting loads are approximately the same.

The Canadian system for electricity charge charges based on peaks and time of usage:

on-peak $0.18/kwh mid-peak $0.132/kwh off-peak $0.087/kwh

For this assignment, I have chosen to use the mid-peak value to get an average.

CAR

avg cnd/litre: ~1.1 for the past 6 months

CAR	MILES	MPG	GALLONS	MMBTU	AVG USD/GALLON	$/MMBTU	TOTAL CAR COST ($)
CAR 1	12400	25.8	480.62	60.07	3.24	25.98	1560.99
CAR 2	6200	24	258.33	32.29	3.24	25.98	839.03
CAR 3	12400	29	427.58	53.44	3.24	25.98	1388.75
						TOTAL COST OF ALL CARS:	$3788.78

CAR 1: NISSAN SENTRA 2012

CAR 2: VOLVO XC90

CAR 3: VOLVO XC60

C-05 Energy Loss: Car

All four members that live in this house are drivers. In total, they own three cars to accommodate the work location and schedule differences. The nissan car is more oftenly used.

GAS

MONTH	$ HEATING	$ DOMESTIC HOT WATER	ESTIMATED MONTHLY TOTAL COST	ACTUAL GAS BILL
JANUARY	245.32	16.44	261.76	208.46
FEBRUARY	204.09	16.44	220.53	172.58
MARCH	229.86	16.44	246.30	153.93
APRIL	92.77	16.44	109.21	134.93
MAY	58.23	16.44	74.68	80.45
JUNE	7.73	16.44	24.17	50.42
JULY	-	16.44	16.44	62.18
AUGUST	3.35	16.44	19.79	54.28
SEPTEMBER	14.94	16.44	31.38	69.88
OCTOBER	49.73	16.44	66.17	93.34
NOVEMBER	122.66	16.44	139.10	152.41
DECEMBER	243.51	16.44	259.96	195.98
		ESTIMATED COST:	$1469.54	ACTUAL COST: $1428.84

ELECTRICITY

MONTH	$ COOLING	$ LIGHTING	$ APPLIANCES	ESTIMATED MONTHLY TOTAL COST	ACTUAL ELECTRICITY BILL
JANUARY	-	10.64	74.09	84.73	102.76
FEBRUARY	-	10.64	74.09	84.73	112.80
MARCH	-	10.64	74.09	84.73	121.16
APRIL	0.33	10.64	74.09	85.06	98.46
MAY	5.77	10.64	74.09	90.50	82.78
JUNE	21.38	10.64	74.09	106.11	101.81
JULY	44.80	10.64	74.09	129.53	98.90
AUGUST	36.99	10.64	74.09	121.72	92.12
SEPTEMBER	11.88	10.64	74.09	96.61	88.75
OCTOBER	0.33	10.64	74.09	85.06	79.54
NOVEMBER	-	10.64	74.09	84.73	237.05*
DECEMBER	-	10.64	74.09	84.73	-
			ESTIMATED COST:	$1138.24	ACTUAL COST: $1216.13

*Only nov and dec electricity bills were combined, because PowerStream merged with two other companies to form Alectra on Feburary 1, 2017
After that, the electricity bills were charged monthly

C-06 Actual Costs VS Estimated Costs

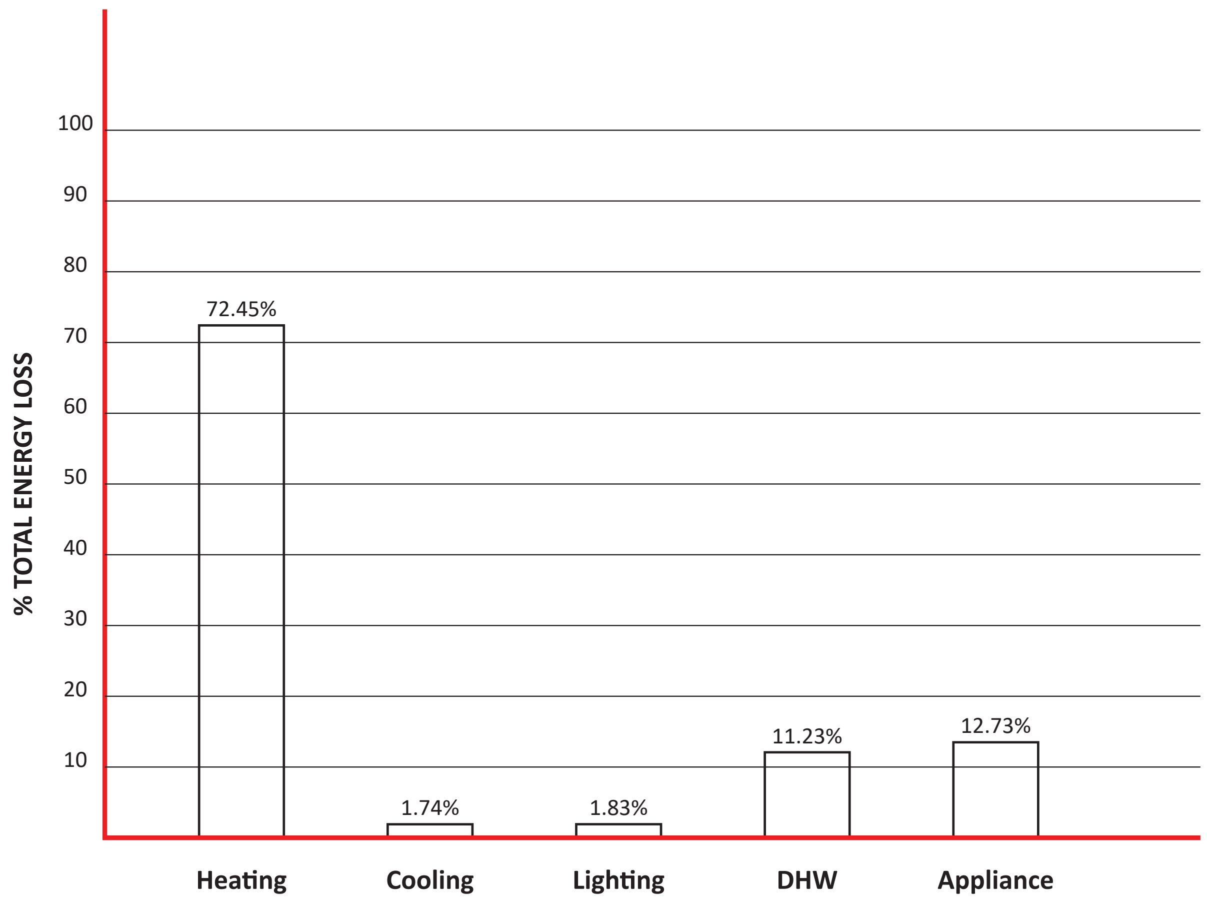
The electricity estimated cost is slightly different most likely due to using the mid-peak rate for an average. Sometimes the family chooses to cook before or past on-peak hours in order to save $0.05 per kwh used.

*Note: the Canadian government makes adjustments to the gas charge per month based on the data from the previous year (re-examined every September). There is an adjustment aspect to the bill, which either adds or subtracts from the subtotal cost, so that the total costs during the winter months are not a lot more than the total costs during summer months. Many other charges aside from charges for gas are included in the total (eg. 13% HST tax, delivery charge, transportation charge etc.) The subtotal of only gas charges are used for the calculations.

LOAD SUMMARIES

	HEATING	COOLING	LIGHTING	DHW	APPLIANCE	TOTALS
annual kwh	38309.40	920.57	967.68	5941.98	6735.48	52875.12
annual mmbtu	130.75	3.14	3.30	20.28	22.98	180.46
% of total energy	72.45%	1.74%	1.83%	11.23%	12.73%	100%

LOAD SUMMARIES CHART



C-07 Energy Loss: Load Summary

The load summaries chart shows that most of the energy used goes towards heating by gas.

[d]

retrofits

suggestions as to how to reduce loads and costs

CAULK: DAP 18656 Alex Plus White Acrylic Latex Caulk Plus Silicone, 10.1 oz from TheHomeDepot

DESCRIPTION:

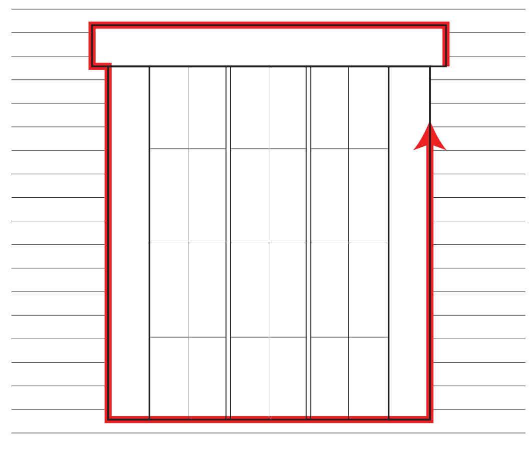
Easy to spread	White
Can be painted	55 linear ft/tube
Tolerates extreme temp	5 years longevity

INSTALLATION:
1. Clean and pre-dry any surfaces with cracks/openings
2. Hold gun at 45° and apply continuously along identified areas
   Apply to all joints in window frame
   Apply to all joints between frame and wall

COST:
$24.57/unit of 12pk x 1

$2.77/unit of caulk gun x 1
(HDX smooth rod caulk gun 10oz)

total $41.50



*Note: only require 6-7 tubes but since this model of caulk lasts 5 years, can be saved and used later

WEATHERSTRIPPING: Frost King E/O 7/8in x 17ft Self-Adhesive V Seal from TheHomeDepot

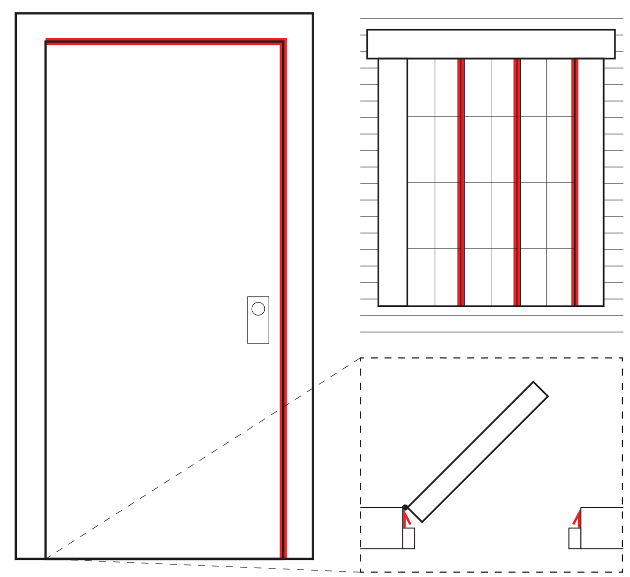
DESCRIPTION:
Effective barrier
Easy to install

INSTALLATION:
1. Clean and pre-dry any surfaces with cracks/openings
2. Peel paper off and attach adhesive to door frame
   Make sure the V tip is facing the inside.

*19 total windows + 2 doors (front door, backyard door)
*total length to cover ~170 ft

COST:
$3.97/unit x 10

total $39.70



Door Plan Detail with V-Strip

THERMOSTAT: Honeywell RTH6580WF 7-Day Programmable Wi-Fi Thermostat from Amazon

DESCRIPTION:
7-Day programming function
Remotely control via app and wifi
Easy to read and program

INSTALLATION:
1. Remove old thermostat
2. Install new thermostat based on instructions provided

COST:
$89.99/unit x 1

total $89.99

	12 AM	2 AM	4 AM	6 AM	8 AM	10 AM	12 PM	2 PM	4 PM	6 PM	8 PM	10 PM
Sunday					60°F			56°F				60°F
Monday				60°F				56°F			60°F	
Tuesday				60°F				56°F				60°F
Wednesday				60°F				56°F			60°F	
Thursday				60°F				56°F				60°F
Friday				60°F				56°F			60°F	
Saturday					60°F			56°F				60°F

New Heating Degree Days =
Based on 82 hours of 60°F and 86 hours of 56°F per week

[(82hr)(60°F) + (86hr)(56°F)] / [(24hr)(7days)] = 57.95°F (~58°F)

S

D-01 Retrofit: Infiltration Losses

Infiltration consumes 43% of the total building heating loss. Reducing infiltration losses will save money.

Analysis:

Total Cost	$81.20	
Infiltration Reduction	20%	
New Infiltration UA	298.74 BTU/hr°F	
Annual Energy Saved	(373.43 - 298.74)(24)(4937)	= 8.84 mmbtu
Annual Dollars Saved	(8.84 mmbtu)($9.73/mmbtu)	= $86.01
Payback	$81.20 / $86.01	= 0.94
		= 11 months

D-02 Retrofit: Setback Thermostat

Analysis:

Total Cost	$89.99	
Current HDD at 60°F	4937 (gas used: 125.58 mmbtu)	
New HDD at 58°F	4473 (gas used: 113.78 mmbtu)	
Annual Energy Saved	125.58 - 113.78	= 11.80 mmbtu
Annual Dollars Saved	(11.80 mmbtu)($9.73/mmbtu)	= $114.81
Payback	$89.99 / $114.84	= 0.78
		= 9 months

INSULATION: R-19 Insulation Kraft Faced Batts 15 in x 93 in (10 bags) from HomeDepot

Arrow Fastener T50 1/2 in Leg x 3/8 in Crown Galvanized Steel Staples (1250 pack)
SharpShooter Heavy-Duty Staple Gun

DESCRIPTION:
- Pre-cut to typical dimensions of joists on centre
- Provides thermal performance to lower heating/cooling costs
- Insulation batts for easy self installation

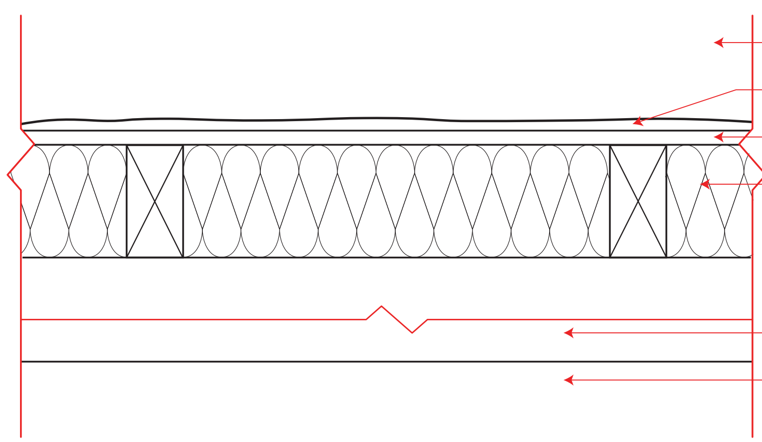
INSTALLATION:
1. Use caulk to seal any openings/cracks as necessary
2. Carefully push insulation batt into ceiling cavity
3. Use stapler on the stapling flange to secure insulation to joists

COST:

$576.42/unit insulation batt	x 1	
$15.97 /unit staple gun	x 1	
$3.22 /unit staples	x 1	
	total	$595.61

Each bag covers 106.56 sqft
10 bags cover 1065.6 sqft
Total basement ceiling area is ~1150 sqft
*includes area of joists
*so 10 bags would be sufficient

(NEW) FLOOR BUFFER



MATERIALS	R-VALUE
INTERIOR AIR FILM	0.68
CARPET	2.08
1/2" GYPSUM BOARD	0.45
6" INSULATION	19.00
AIR SPACE	1.00
CONCRETE	0.32
TOTAL R VALUE	23.53
TOTAL U VALUE	0.021
AREA (FT²)	1150
UA VALUE	24.43

D-03 Retrofit: Basement Ceiling Insulation

Insulation batts installed on the ceiling between the joists would minimise heat loss through the basement.

Analysis:

Total Cost	$595.61		
New Floor UA	24.43 btu/hr°F		[current 126.50]
New Floor Heat Loss	(24.43 btu/hr°F)(24)(4937)	= 2.89 mmbtu	[current 14.98]
Annual Energy Saved	14.98 - 2.89	= 12.09 mmbtu	
Annual Dollars Saved	(12.09 mmbtu)($9.73/mmbtu)	= $117.63	
Payback	$595.61 / $117.63	= 5.06	
		= 5 years	

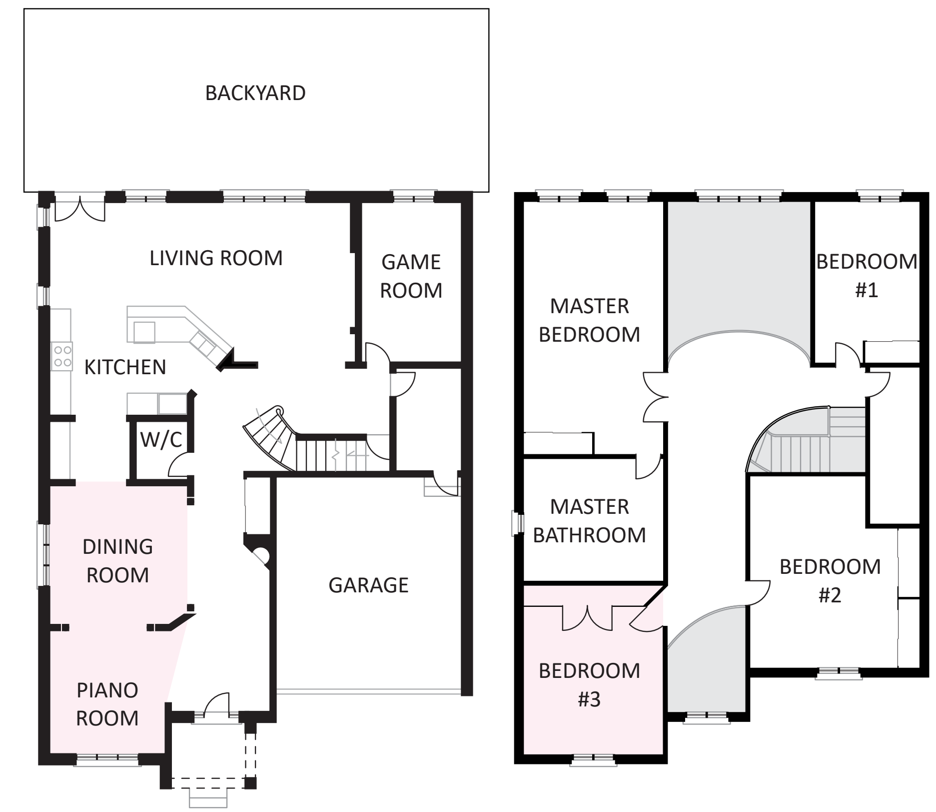
REZONE: ZoneFirst RDM6 Zone Damper 6" Modulating from PlumbersStock
Honeywell RTH6580WF 7-Day Programmable Wi-Fi Thermostat from Amazon

DESCRIPTION:
- Allows for controlling temperatures in different zones
- Opens and closes butterfly valve depending on thermostat
- Saves money by heating/cooling less of the house

INSTALLATION:
1. Remove old thermostat
2. Install new thermostat based on instructions provided
3. Make sure these two thermostats remain constant at 53 degrees

COST:

$88.68/unit	x 2	
$89.99/unit	x 2	
	total	$357.34



Bedroom #3 is rarely used throughout the year. This room should be closed, unless used, and maintained at 50 degrees. The dining room and piano room is also rarely used. The Lau family eats their meals on the table between the living room and kitchen. The second thermostat will control the temperature of that room.

The room is ~209 sqft and the dining room and piano room is ~315 sqft, which is 16% of the total heated area of the house (3271.6 sqft).

D-04 Retrofit: Zoning the House

Analysis:

Total Cost	$357.34		
Current HDD at 58°F	4937 (normal spaces)		
New HDD at 60°F	2965 (bedroom #3)		
New Annual Heat Loss	(998.86)(24)(4473)(0.84) + (998.86)(24)(2965)(0.16)		= 101.44 mmbtu
Annual Energy Saved	118.35 - 101.44	= 16.91 mmbtu	
Annual Dollars Saved	(16.91 mmbtu)($9.73/mmbtu)	= $164.53	
Payback	$357.34 / $164.53	= 2.17	
		= 2 years and 2 months	

NIGHT INSULATION: Windowquilt High Performance Shade
from WindowQuilt

DESCRIPTION:
- Expensive but useful in the long term
- Very easy installation, also washable
- Retains heat in winter, keeps cool in summer

INSTALLATION:
1. Screw brackets into window frame
2. Attach headrail onto brackets
3. Attach panel quilt to rail

COST:
$8.40/sqft x 328 sqft
total $2755.2

OPTION #1

New Window R Value
5.88

Effective U Value
[(U_closed*HRS_closed)+(U_opened*HRS_opened)]/24 =
[(0.17*12)+(0.49*12)]/24 =
0.33

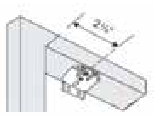
New Heat Loss Coefficient
(0.33)(328 sqft) =
108.24 Btu/hr°F

Annual Energy Saved
(160.72 - 108.24)(24)(4937) =
6.21 mmbtu

Annual Dollars Saved
(6.21 mmBTU)($9.73/mmBTU) =
$60.50

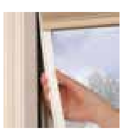
Cellular Shades: Double Cell Light Filtering ComforTrack with Side Tracks
from CellularWindowShades

DESCRIPTION:
- Less expensive and more aesthetically pleasing
- Sidetracks increase privacy and room darkening by closing edge gaps



INSTALLATION FOR BRACKETS:
1. Measure and mark 2.5" from end of shade for drilling
2. Make sure two drilled holes for mounting brackets are level

INSTALLATION FOR HEADRAIL:
1. Hold shade up near brackets
2. Insert front clip of bracket into front groove of rail
3. Make sure shade is centred in window opening
4. Push rail until back clips of bracket are inserted in back groove of rail



INSTALLATION FOR SIDETRACKS:
1. Peel tape from first magnetic strip to reveal adhesive backing
2. Attach magnet to window frame
3. Place magnetically-backed sidetrack over strip

COST:
$156.46/unit x 10
*total 10 windows need coverage
*each unit is 24" x 36"
total $1564.60

OPTION #2

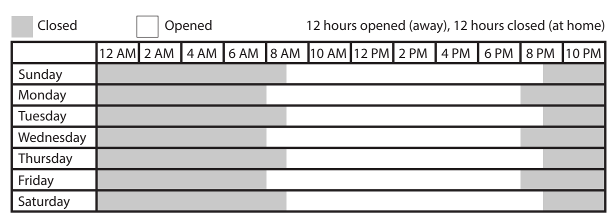
New Window R Value
5.10

Effective U Value
[(U_closed*HRS_closed)+(U_opened*HRS_opened)]/24 =
[(0.196*12)+(0.49*12)]/24 =
0.34

New Heat Loss Coefficient
(0.34)(328 sqft) =
112.50 Btu/hr°F

Annual Energy Saved
(160.72 - 112.50)(24)(4937) =
5.71 mmbtu

Annual Dollars Saved
(5.71 mmBTU)($9.73/mmBTU) =
$55.59



D-05 Retrofit: Night Insulation

Both options are possibilities for night insulation. However, the window quilt is not an ideal choice based on the cost of purchase and payback. The cellular shades allow for 3.6% less cooling/heating.

Analysis:

Payback for Option 1 $2755.20 / $60.50 = 45.54
= 45 years and 6 months

Payback for Option 2 $1564.60 / $55.59 = 28.14
= 28 years and 2 months

POWER STRIP: Niagara Conservation Energy Saving 8 Oulet Smart Surge Protector N9122 from Amazon

DESCRIPTION:
- Saves energy based on a master-slave system
- Helps group appliances together depending on usage
- 1 master outlet, 4 slave outlet, 3 always on outlet

INSTALLATION:
1. Unplug old power strip
2. Plug new master-slave power strip
3. Plug in electronics based on grouped appliances

COST:
$26.50/unit x 2
total $53.00

GROUPED APPLIANCES
1. Game Room
   - Master: Desktop
   - Slave: Printer, game console, computer 2 and 3 laptops
2. Kitchen
   - Master: Electric kettle
   - Slave: Coffee machine, microwave oven, microwave, rice cooke

APPLIANCES	QUANTITY	AVG HOURS OFF /MONTH (hr/mo)	AVG WATTAGE WHILE OFF (watt)	TOTAL (wh/mo)
COMPUTERS	2	280	4.55	2,548
LAPTOPS	3	300	15.77	14,193
PRINTERS	2	300	5.26	3,156
GAME CONSOLE	1	300	1.01	303
MICROWAVE OVEN	1	120	3.08	369.6
ELECTRIC KETTLE	1	100	0	0
COFFEE MACHINE	1	300	1.35	405
MICROWAVE	1	300	3.15	945
RICE COOKER	1	300	2.00	600
		TOTAL APPLIANCES (wh/mo):		22,519.6

D-06 Retrofit: Power Strips

Power strips allow for 4.0% less energy consumption from appliances.

Analysis:

Total Cost $53.00
Current Annual Cost $889.09
Current Annual Energy 6735.48 kW
Annual Energy Saved (22519.6 wh/mo)/(1000)(12) = 270.23 kW
Annual Dollars Saved (270.23 kW)($0.132/kW) = $35.67
Payback $53.00 / $35.67 = 1.48
= 1 years and 6 months

LIGHT BULB: Philips 60W Daylight A19 LED Light Bulb (4-pack) from HomeDepot

DESCRIPTION:
Life of 22.8 years (assuming 3 hrs/day)
Brightness of 800 lumens
Uses 80% less energy than incandescent bulbs

INSTALLATION:
1. Unscrew old light bulb
2. Remove new light bulb from packaging and screw into socket

COST:
$7.97/pack of 4 x 8

total $63.76

*Energy Used: 8 watts

LIGHTING

MONTHLY

LIGHTBULB TYPE	QUANTITY	AVG LAMP WATTAGE (watt)	AVG HOURS ON /MONTH (hr/mo)	TOTAL (wh/mo)
LED	32	8	168	43,008
		TOTAL LIGHTING (wh/mo):		**43,008**

LIGHTING LOAD (wh/mo)/1000	ELECTRICITY COST/KWH ($/kwh)	MONTHLY LIGHTING COST ($)
43.00	0.132	5.67
YEARLY LIGHTING COST:		**$68.11**

D-07 Retrofit: Light Bulbs

LED light bulbs allow for 6.7% less energy consumption for lighting.

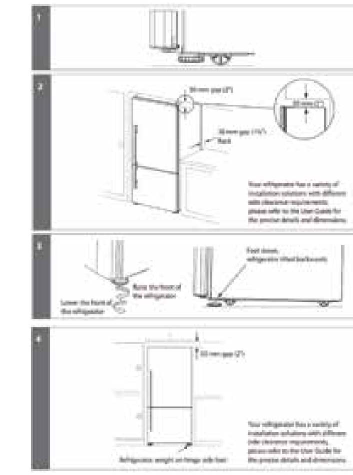
Analysis:

Total Cost	$63.76	
Current Annual Cost	$127.73	
Current Annual Energy	80.64 kW	
Annual Energy Saved	(80.64 kW - 43.00 kW)(12)	= 451.68 kW
Annual Dollars Saved	(451.68 kW)($0.132/kW)	= $59.62
Payback	$63.76 / $59.62	= 1.07
		= 1 years and 1 months

REFRIGERATOR:

DESCRIPTION:
Energy Star certified
Much lower estimated yearly electricity usage
Warranty: 2 yr for parts & labour, 5 yr for sealed system parts

INSTALLATION:
1. Remove all contents from old refrigerator
2. Unplug and remove old refrigerator
3. Roll refrigerator into final position
4. Adjust front feet down
5. Align refrigerator with cabinetry



CURRENT MODEL: KitchenAid KSRA25KNSS

SPECS:

25.2 cubic feet	Capacity
9.9 cu ft	Freezer
15.3 cu ft	Refrigerator
35.5 inches	Width
35.75	Depth
70.25	Height
561 kWh	Estimated Yearly Electricity Use
$60	Estimated Yearly Energy Cost

SUGGESTED #1: Bosch B10CB80NVW

SPECS:

11.4 cubic feet	Capacity
2.5 cu ft	Freezer
8.9 cu ft	Refrigerator
23.5 inches	Width
25.125 inches	Depth
72.875 inches	Height
314 kWh	**Estimated Yearly Electricity Use**
$42	**Estimated Yearly Energy Cost**

Cost: $2245.00

**Much smaller capacity, but more efficient
**Saves more money in the long term

Annual Energy Saved
[(55,000 wh/mo)(12mo)]/1000 - 314 kWh = 346 kWh

Annual Dollars Saved
(346 kWh)($0.132/kWh) = $45.67

SUGGESTED #2: LG LFC21776C

SPECS:

20.7 cubic feet	Capacity
5.6 cu ft	Freezer
15.1 cu ft	Refrigerator
35.75 inches	Width
28.5 inches	Depth
70.25 inches	Height
400 kWh	**Estimated Yearly Electricity Use**
$42	**Estimated Yearly Energy Cost**

Cost: $2399.00

**More capacity for similar price as Bosch
**Not as efficient

Annual Energy Saved
[(55,000 wh/mo)(12mo)]/1000 - 400 kWh = 260 kWh

Annual Dollars Saved
(260 kWh)($0.132/kWh) = $34.32

D-08 Retrofit: Refrigerator

It is suggested that, unless the current fridge requires replacement, to not replace the current fridge as the payback is unreasonable. Although discontinued, the current fridge is already relatively efficient within the market. Hence, the benefits from a more efficient fridge is not worth it.

Analysis:

Payback for Option 1	$2245.00 / $45.67	= 49.15
		= 49 years and 2 months
Payback for Option 2	$2399.00 / $34.32	= 69.90
		= 69 years and 11 months

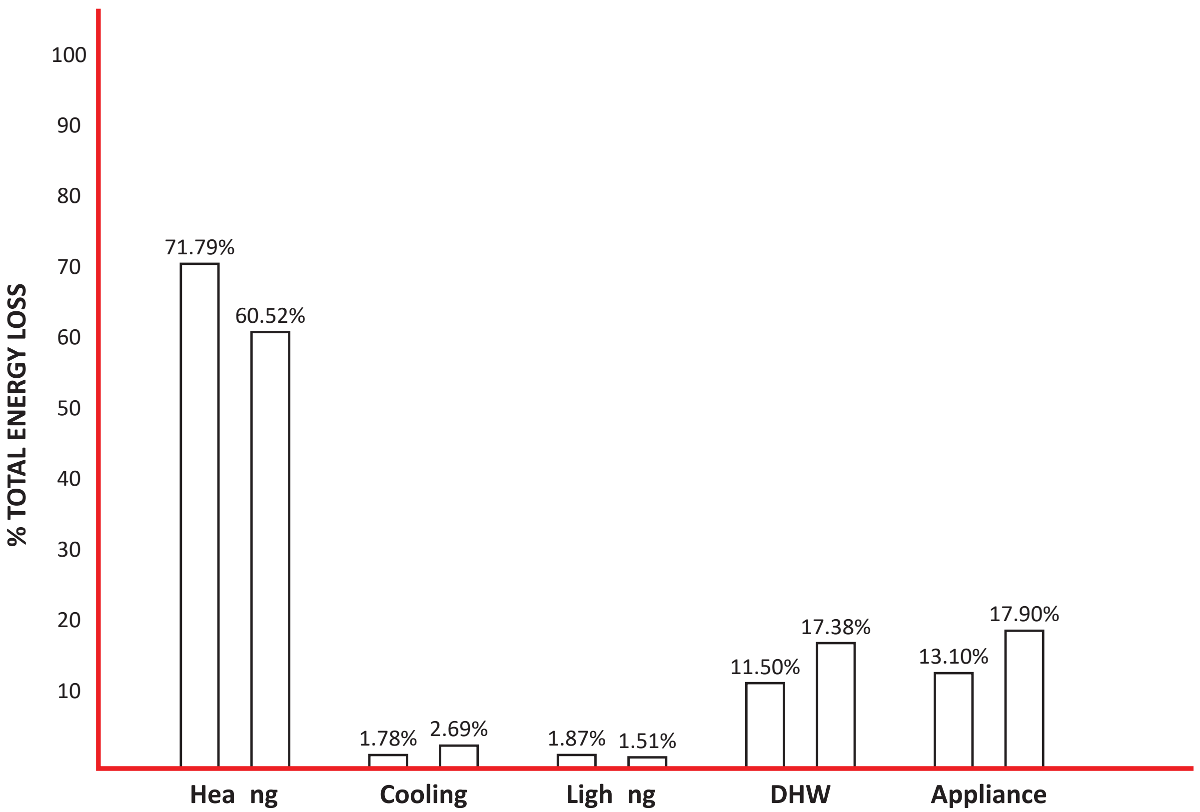
PREVIOUS LOAD SUMMARIES

	HEATING	COOLING	LIGHTING	DHW	APPLIANCE	TOTALS
annual kwh	37070.02	920.57	967.68	5941.98	6735.48	51691.90
annual mmbtu	126.52	3.14	3.30	20.28	22.98	176.42
% of total energy	71.79%	1.78%	1.87%	11.50%	13.10%	100%

RETROFIT LOAD SUMMARIES

	HEATING	COOLING	LIGHTING	DHW	APPLIANCE	TOTALS
annual kwh	20691.47	920.57	516	5941.98	6119.25	34189.28
annual mmbtu	70.62	3.14	1.76	20.28	20.88	116.68
% of total energy	60.52%	2.69%	1.51%	17.38%	17.90%	100%

LOAD SUMMARIES CHART



D-09 Retrofit: Load Summary

The retrofit load summaries are based on the assumption that all eight retrofits are applied.

The eight retrofits are chosen to minimise the costs in heating and appliances, which also redistributes the load. An increase in the percentage of the total energy does not mean more money is spent on that load.

[e]

passive solar heating

calculations to determine window square footage required for passive solar heating
retrofits to aid passive solar heating

A_g		variable (area of S glazing) to be solved
UA home	998.86 Btu/hr°F	total UA before considering S windows and S wall UAs
UA_h	770.17 Btu/hr°F	UA of whole house after energy retrofit, not including S windows and S wall UAs
U_g	0.33	U value of S glass (including window quilt night insulation)
U_{sw}	0.084	U value of S wall construction after retrofit
A_{tw}	769.11 ft²	area of S (674.84 ft²) and window area (94.27 ft²)
t_i	65°F	desired interior design temperature
t_o	30°F	12 noon outdoor temperature in January
I_s	69.02 Btu/h ft²	12 noon average hourly solar radiation in january
	43.6°	YYZ Latitude
	254 Btu/h ft²	12 noon totals for S direction in January
	932	half day totals for SSE direction in January
	561	half day totals for SSW direction in January
	1747	half day totals for January
	14.5%	noon hour % of days energy
	680*	global average incident solar radiation in January
	98.6 Btu/h ft²	noon hour for SSE surface glass
	0.7	solar heat gain coefficient (SHGC)
	69.02 Btu/h ft²	energy permeating through glass to interior

$[UA_h + U_gA_g + U_{sw}(A_{tw}\text{-}A_g)]*(t_i\text{-}t_o) = I_sA_g$

$[770.17 + (0.33)A_g + (0.084)(769.11\text{-}A_g)]*(65\text{-}30) = 69.02A_g$

$770.17 + 0.33A_g + 64.60 - 0.084A_g = 1.972A_g$

$834.77 = 1.726A_g$

$A_g = 483.65$ ft²

Remaining area of glazing required:

(A_g) - (current area of S window area)

483.65 ft² - 94.27 ft² = 389.37 ft²

% Wall Coverage:

$(A_g)/(A_{tw})$

(483.65 ft²) / (769.11 ft²) = 62.88%

E-01 Solar Calculations: Suntempering

The solar facade has a SSE orientation, which means the houes is not oriented directly north and so the half day total is not doubled. The half day totals for SSE and SSW are added to the half day total for the S direction. However the SSE wall is not included in the A_{tw} value because of the garage and the neighbouring house.

Based on calculations, approximately 63% of the solar facade needs to be glazed.

A_g		variable (area of S glazing) to be solved
UA home	998.86 Btu/hr°F	total UA before considering S windows and S wall UAs
UA_h	770.17 Btu/hr°F	UA of whole house after energy retrofit, not including S windows and S wall UAs
LCR	40	load collector ratio
	direct gain (DGA3)	passive solar system type
	30 btu/ft² °F	thermal storage capacity
	11090.4 btu/ft² °F	thermal storage required [(capacity)*(A_g)]
	2	mass thickness (inches)
	6:1	mass : glazing area
	2218.08 ft²	surface area of thermal mass required (based on 6:1 ratio)
	2	amount of glazing elements
	yes	night insulation
	18%*	SSF (solar savings fraction) goal

$LCR = (24)(UA_h)/(A_g)$

$40 = (24)(770.17)/(A_g)$

$A_g = (18484.08)/(40)$

$A_g = 462.10$ ft²

Remaining area of glazing required:

(A_g) - (current area of S window area)

462.10 ft² - 94.27 ft² = 367.83 ft²

% Wall Coverage:

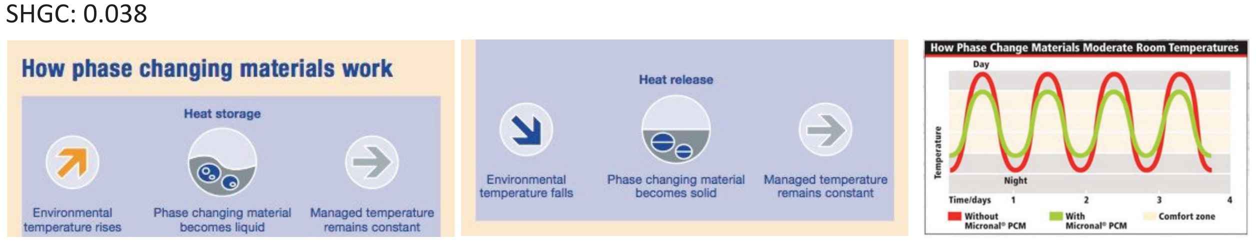
$(A_g)/(A_{tw})$

(462.10 ft²) / (769.11 ft²) = 60.08%

E-02 Solar Calculations: Passive Solar Heating

Based on calculations, approximately 60% of the solar facade is required to be glazed in order to achieve passive solar heating through direct gains.

KNAUF Phase Change Material Smartboard
SHGC: 0.038

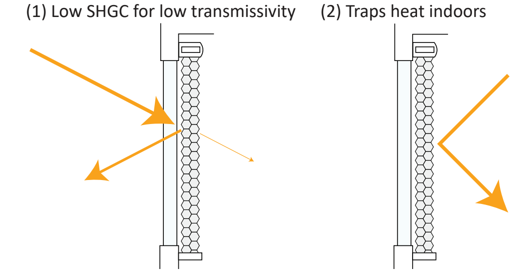


E-01 Solar Redesign: Passive Solar Heating

To achieve direct gain for passive solar system, windows should be redesigned to be taller and wider or to add skylight at the double height entrance of the house (marked with dashed line).

Thermal massing can be achieved by using KNAUF PCM Smartboards that'll absorb heat energy along the SSE and SSW walls during the day (when the house is vacant) and releases it during night. Based on calculaons from E-02, ~2218 ft² of thermal mass is required. However, with a greater window surface area on the solar facade, the heat that enters the room can immediately be used, so the 6:1 ratio for determining thermal mass is not needed to be exact. The walls highlighted in yellow are where the drywalls should be used on interior walls that face the room where solar heat is transmitted through. 2 inch thickness of the thermal mass is not required since the PCM smartboard has 10 times the capacity of concrete.

Benefits of Cellular Shades:
(1) Low SHGC for low transmissivity (2) Traps heat indoors



Cellular Shades Specs:

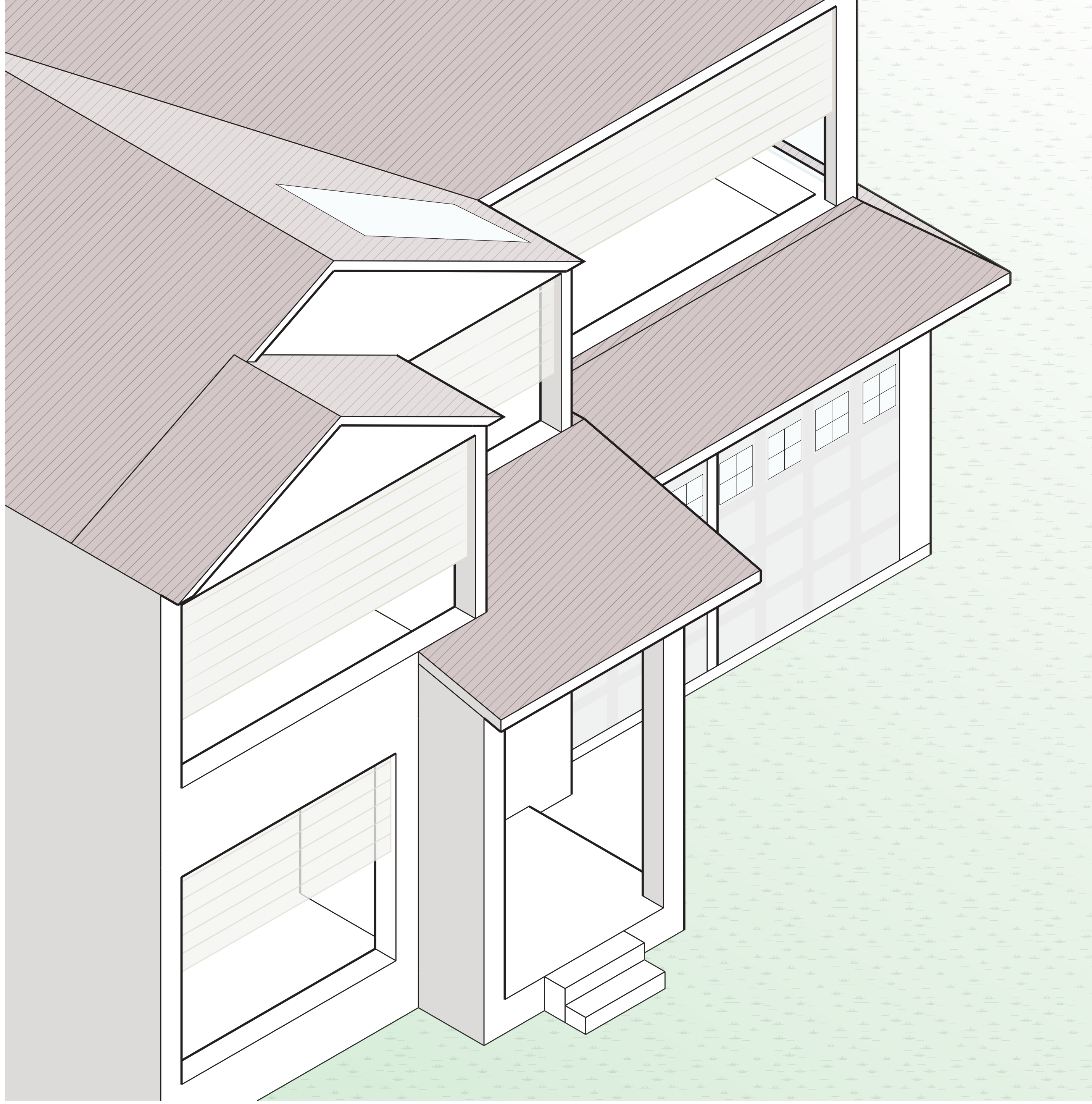
Double Cell Light Filtering ComforTrack with Side Tracks
- 3/8” Thickness
- 2.8 R-Value (shades only)
- 5.1 R-Value (shades, side tracks, window)

Standard Double Cell Room Darkening Shades with Side Tracks
- 3/8” Thickness
- 4.7 R-Value (shades only)
- 6.5 R-Value (shades, side tracks, window)
- 0.12 SHGC

E-04 Solar Redesign: Passive Solar Heating

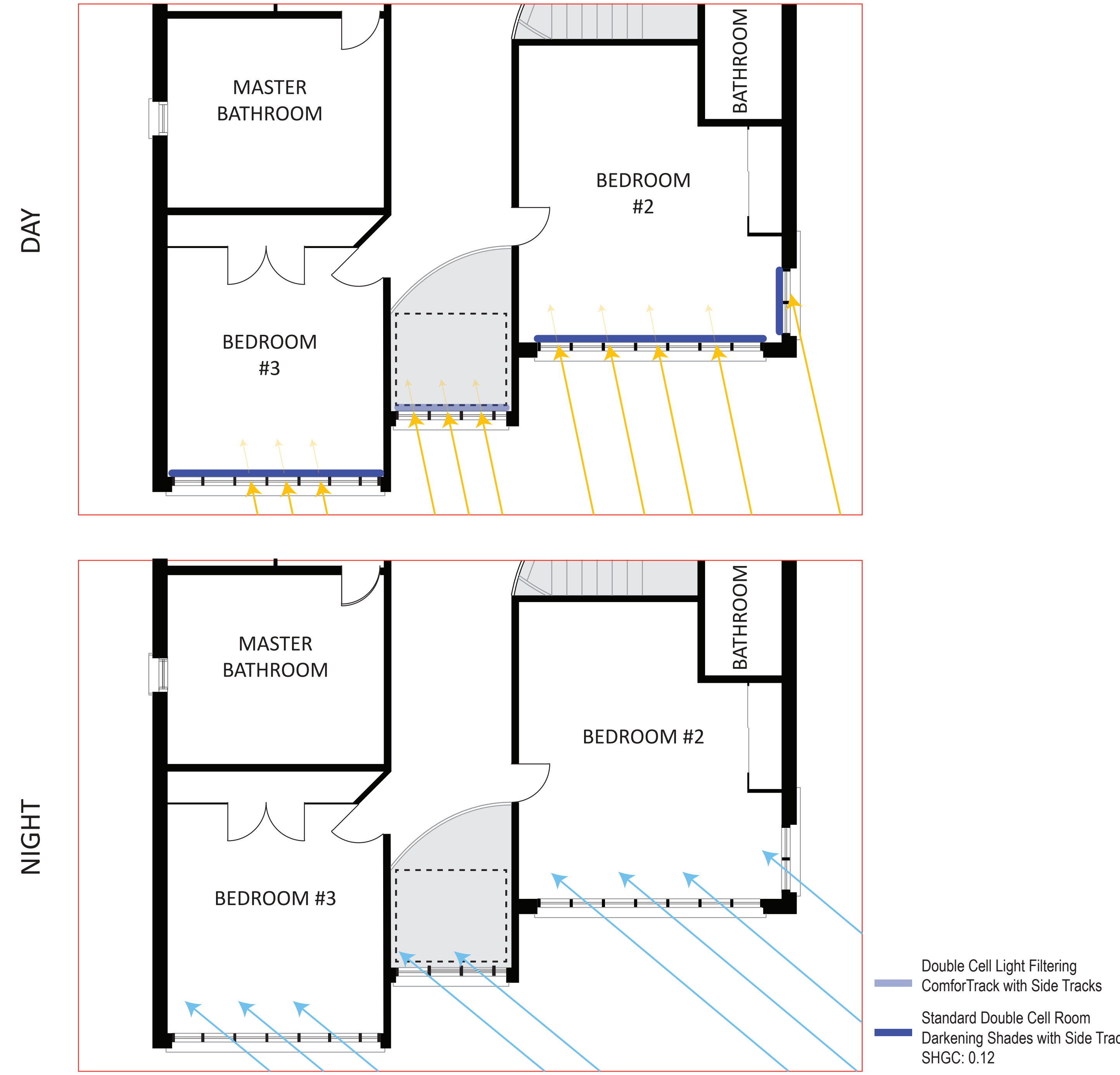
The windows marked with lighter blue can use the light filtering cellular shades. Having solar radiation completely blocked is not ideal for this house since it is the only primary opportunity for daylight. However, since the windows should expand in size to allow for passive solar heating, shading may be required during certain hours of the day. So this light filtering shading device would be useful for shading while having a R value high enough to resist heat transfer to the exterior (from D-05).

Bedroom #2 and #3 can use darkening/blackout shade that has a thin, flexible foil that traps heat, which is desired during winter nights to reduce heating loads. During the winter days, the shading device should be opened to allow for solar radiation to be converted to stored energy within the PCM drywall. During the summer days, this would be beneficial as it blocks out sunlight to reduce cooling loads.



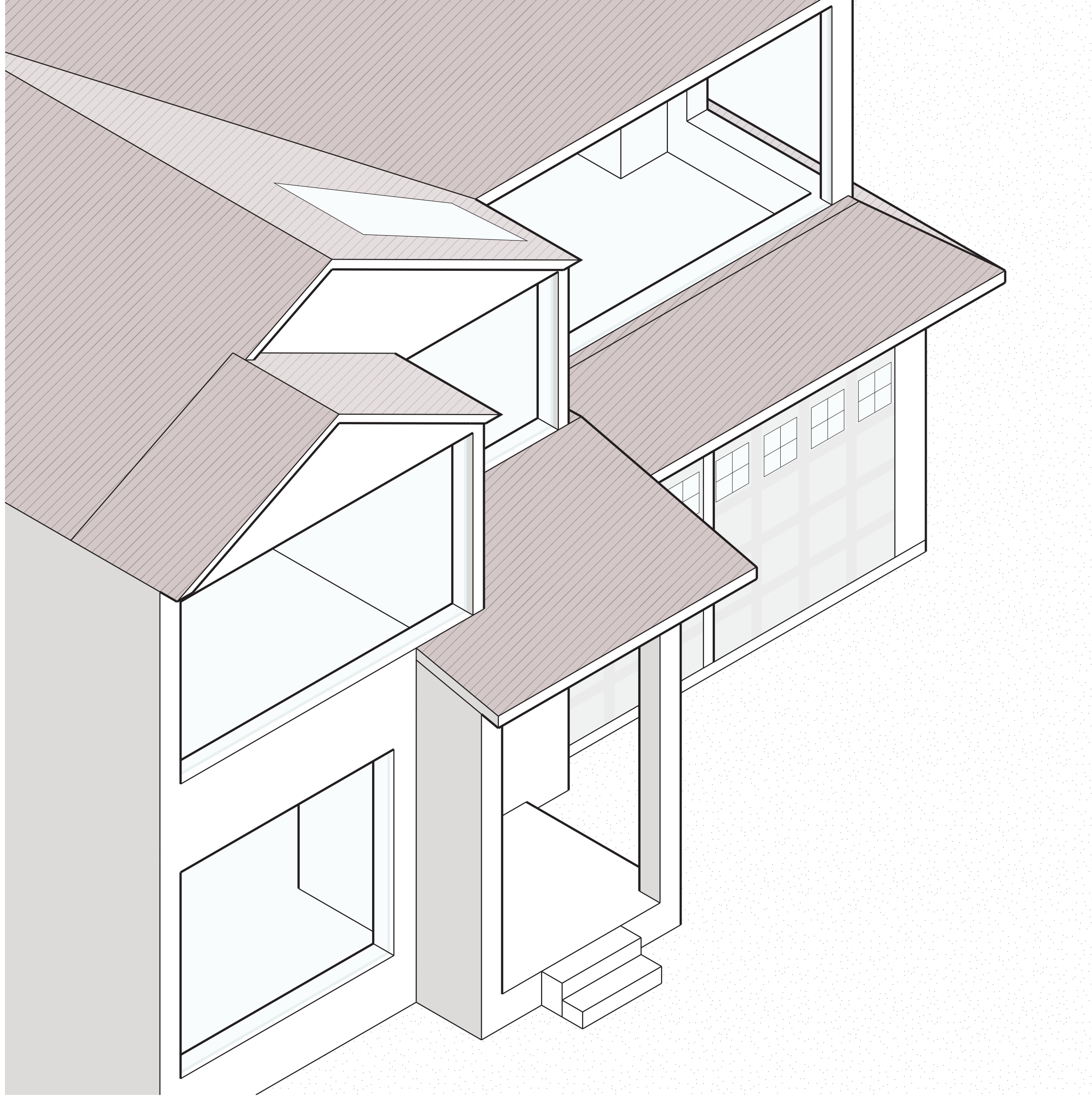
E-05 Solar Redesign: Axonometric [summer day]

The increased window area on the solar facade requires shading in the summer to prevent from glare and overheating. Despite closed, the light filtering cellular shades will allow for light to still enter the shared, public spaces of the house. The blackout cellular shades would be opened or closed depending on the occupant's comfort regarding privacy, glare, and temperature.



E-06 Solar Redesign: Floor Plan [summer]

Cellular shades can be opened or closed during the day depending on the comfort of the occupants. It can be closed if there is too much glare or the interior temperature is too high. The shades and window can be opened to allow for natural ventilation.



E-07 Solar Redesign: Axonometric [winter]

During the winter, the increased window area would allow for passive solar heating. Throughout the day, the cellular shades should be opened to allow for the heat from the sunlight to enter the house and be absorbed into the PCM smartboard on the walls. At night, the cellular shades should be closed to trap heat within the house.

E-08 Solar Redesign: Floor Plan [winter]

Cellular shades are opened during the day to invite solar heat and closed during the night to prevent heat loss through glazing.

[f] conclusion

this booklet provides analysis on this residence that offer design changes to:

(1) improve quality of life
(2) reduce heating/cooling loads
(3) reduce costs towards those loads
(4) maintain an environmentally-friendly house
(5) provide long term considerations for the house