Northern Sustainable Housing Project

Inuvik, 2010

ARCTIC ENERGY ALLIANCE

NORTHWEST TERRITORIES HOUSING CORPORATION

Background

- In February of 2009, CMHC approached the NWTHC and expressed interest in partnering on the design and construction of a Northern Sustainable Housing Project for the NWT
- Concerned with climate change and rising energy costs, the NWTHC saw an opportunity to explore and improve new housing designs for the future.
- The objective of the project was to design and build energy efficient housing that meet the needs of the community.

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Objectives

- To design and build a northern housing prototype that will consume 50% less energy than the present Model National Energy Code of Canada.
- To develop a design that will meet or exceed a target **EnerGuide rating of 85**.
- To develop designs and components that could be implemented in projects in other communities throughout the NWT with relatively minor modifications.
- To produce a design that is economical, reasonably easy to maintain, and can be constructed locally.

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Design

- The NWTHC conducted a series of design charrettes and workshops to engage and encourage stakeholders to participate in the design process, which would help determine the needs, wants, concerns and aspirations held by the community.
- The design then took shape from the following:
  - Charrette and Workshop Information
  - NWTHC Spatial Design Standards
  - National Building Code _ Section 9
  - Community Bylaws
  - Visitable Design Features (1)_ zero step entry, (2) _min 32” doorways, (3) _bathroom main floor)

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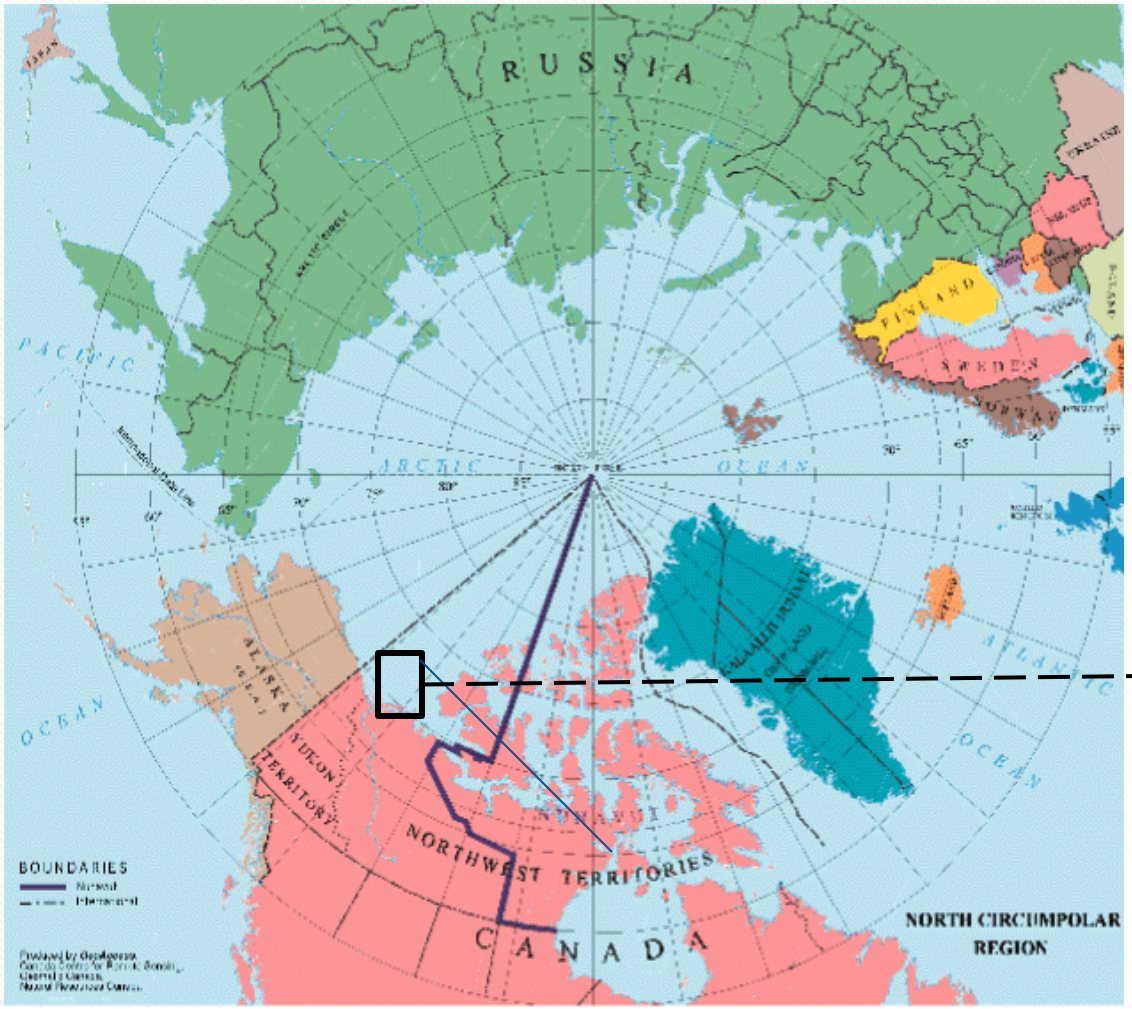
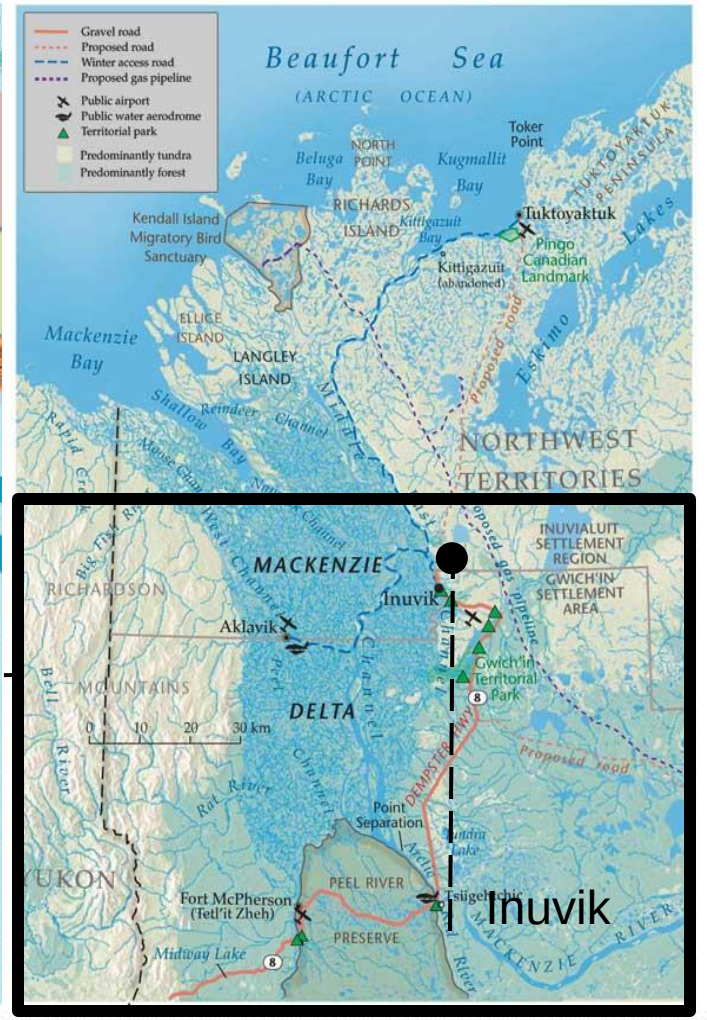
LOCATION





Inuvik is the location for this project, challenging our objective to meet the EGH 85 rating, with its extreme northern climate. Inuvik is situated north of the Arctic Circle @ 68° 18' N 133° 29' W

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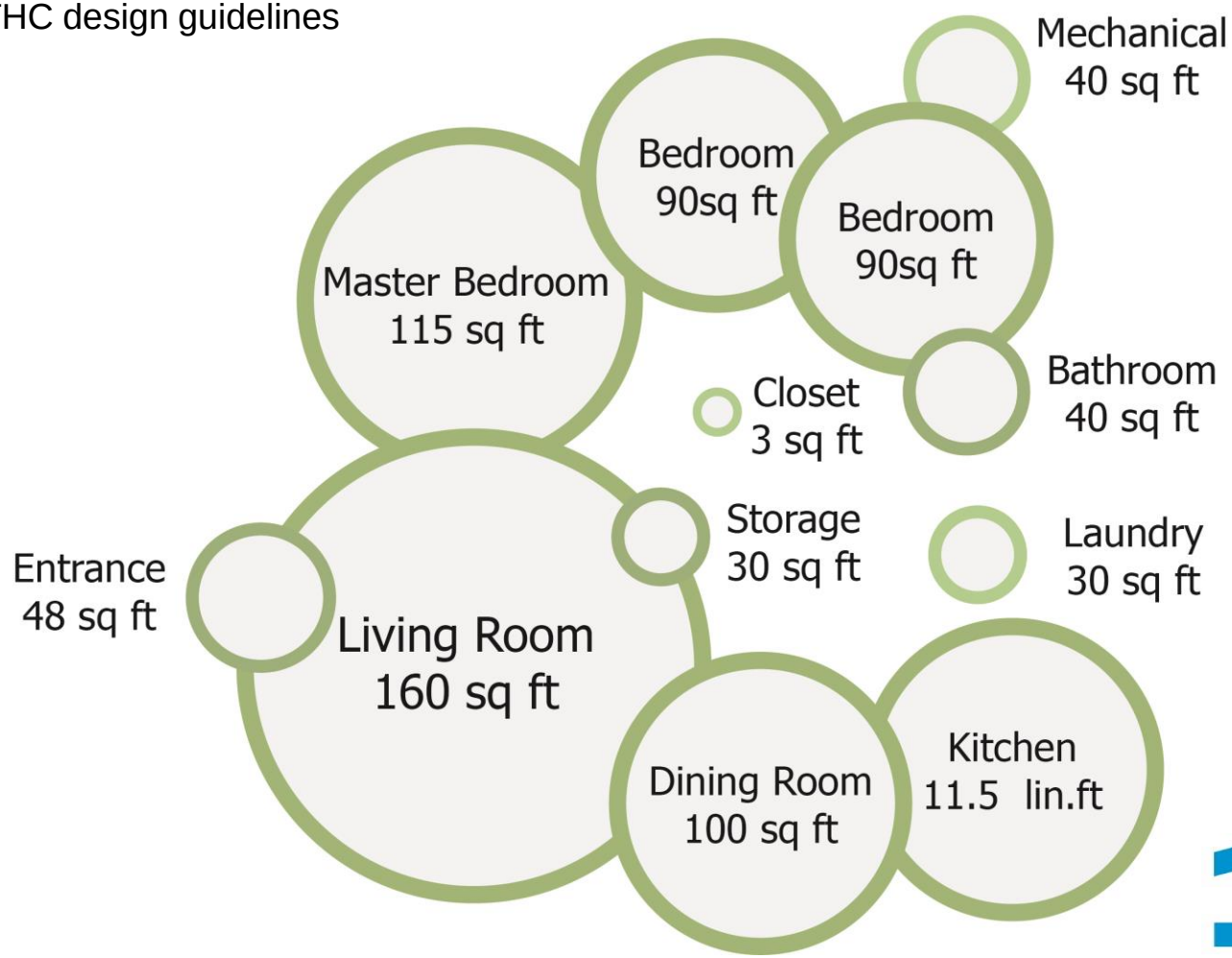
Space Design Guideline

The Beaufort Delta District had a program requirement for a 3 bedroom duplex

NWTHC design guidelines



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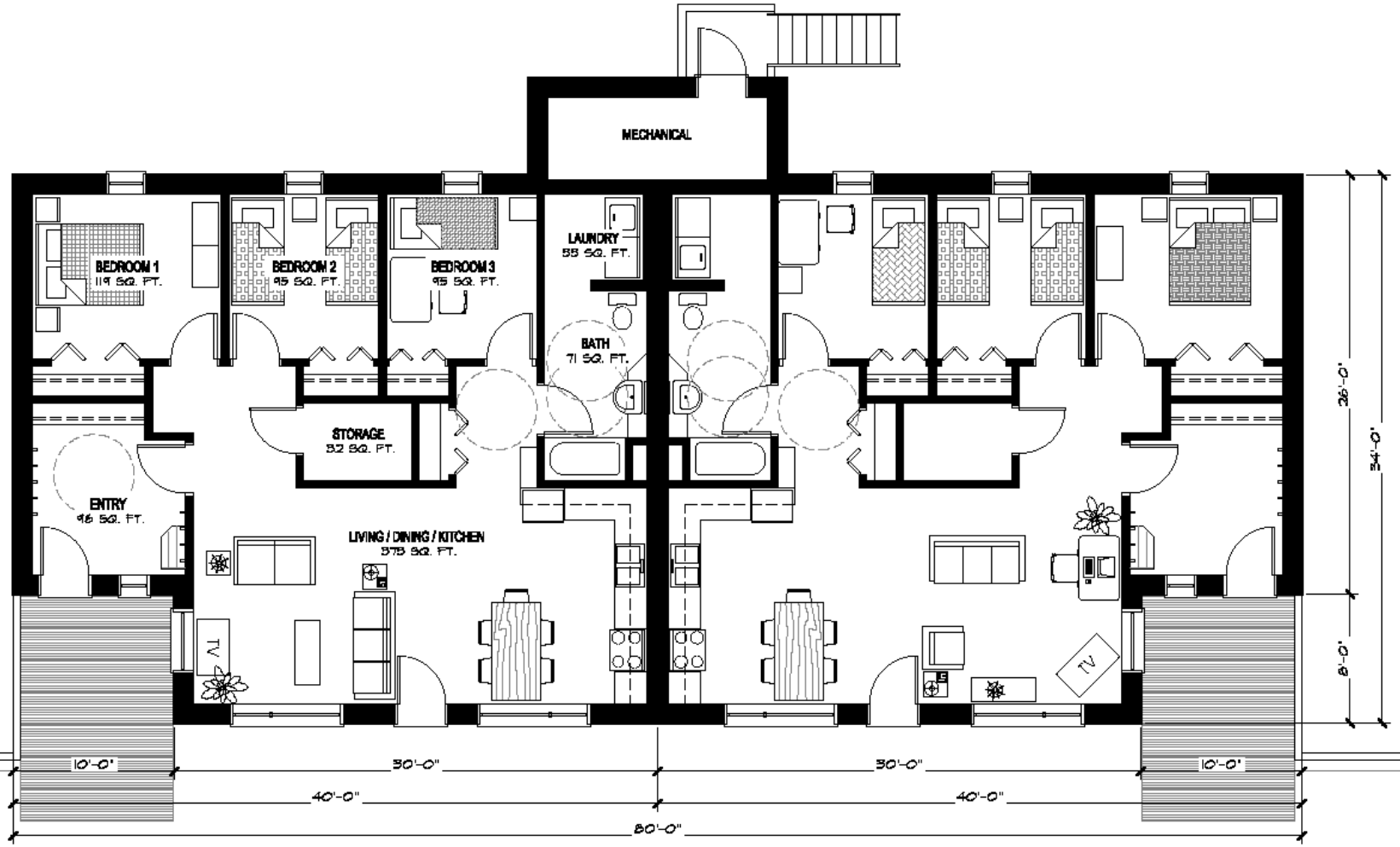

PLAN

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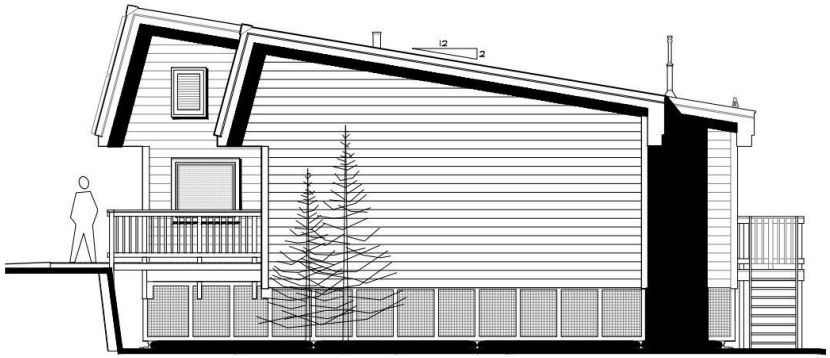
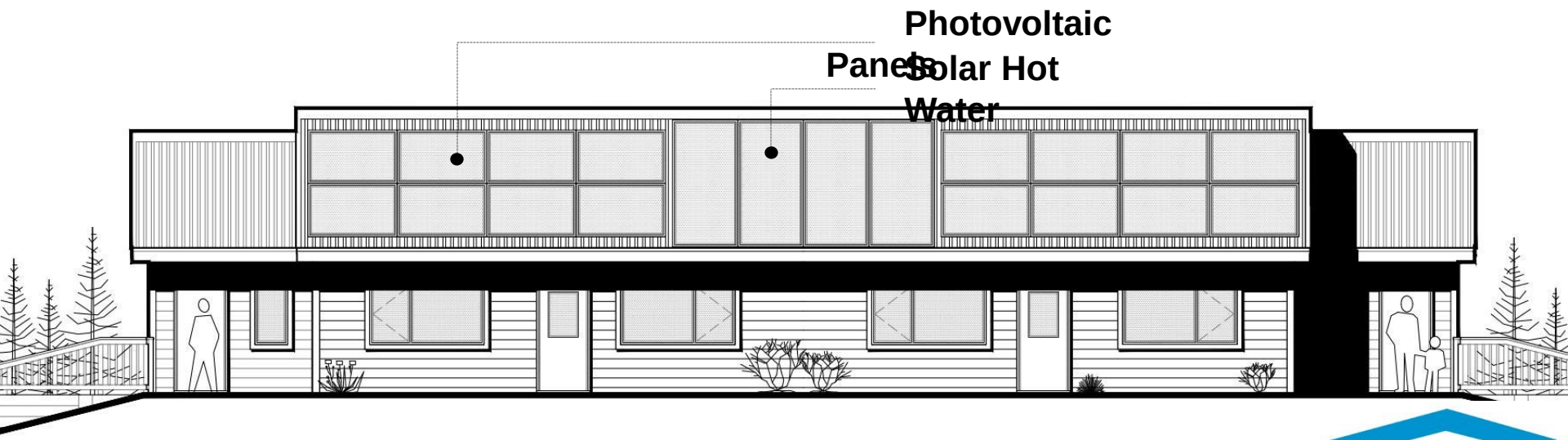
EAST ELEVATION



WEST ELEVATION



SOUTH ELEVATION

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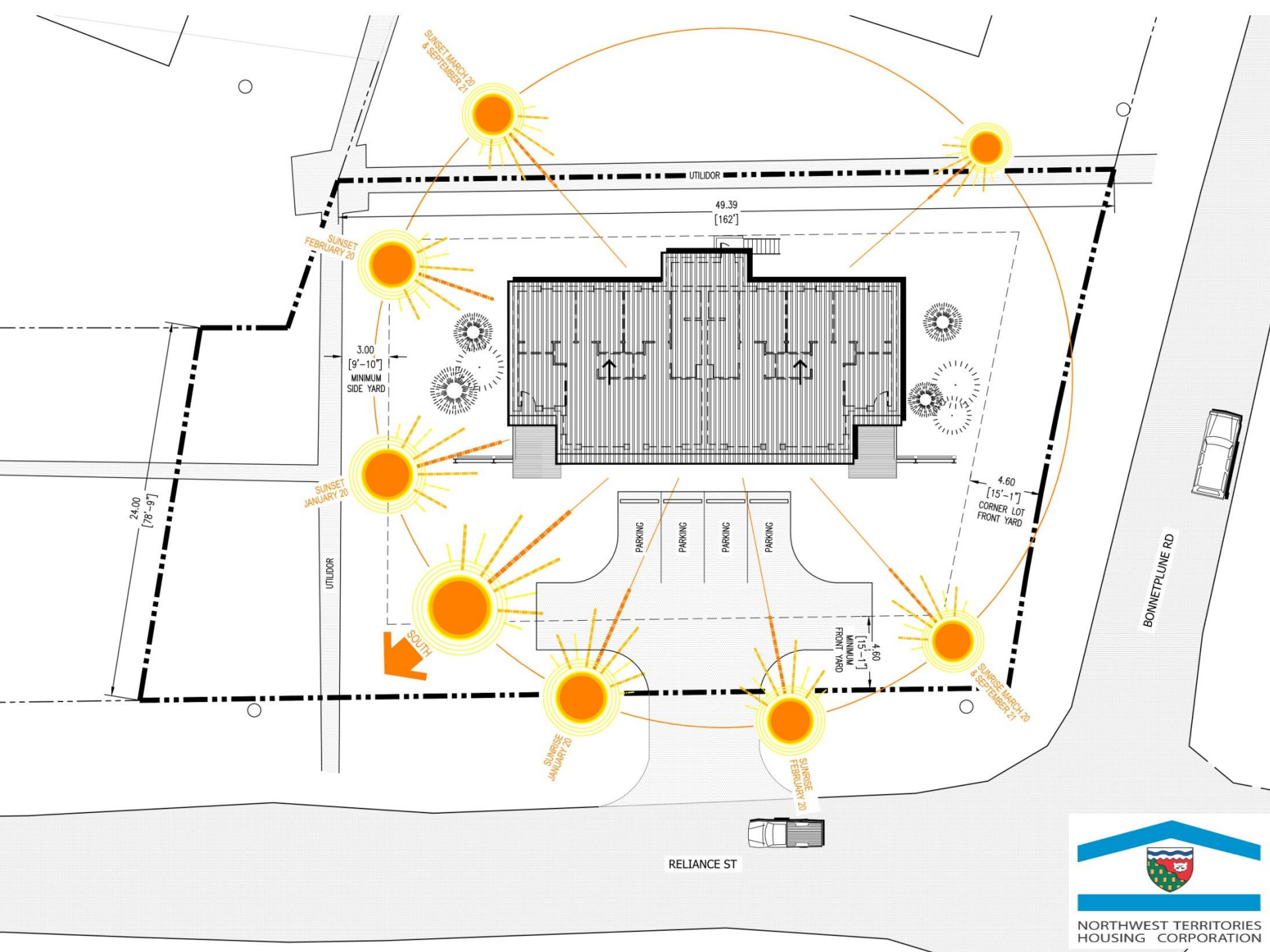

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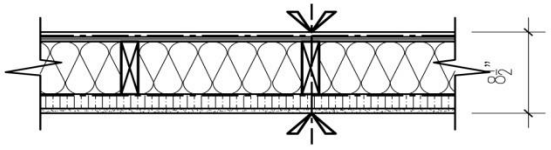
Wall Section Detail Analysis

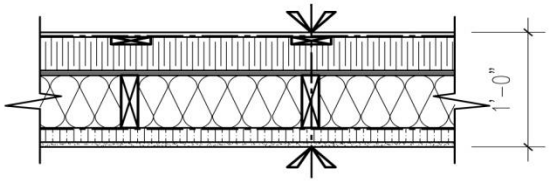


CONVENTIONAL WALL ASSEMBLY

EXTERNAL WALL ASSEMBLY (R-22)

¾" SIDING (AS SPECIFIED)
TYVEK WEATHER BARRIER
½" PLYWOOD
2x6 STUDS @ 24" O.C
6 MIL VAPOUR BARRIER
BATT INSULATION (R-20)
1-1/2" STRAPPING (HORIZONTAL)
FILLED WITH SEMI RIGID INSULATION
½" GYPSUM

UNIT 1

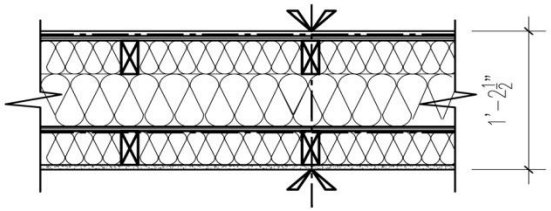


CONVENTIONAL WALL ASSEMBLY (UPGRADE)
NOTE: NBC A-9.25.1.2

EXTERNAL WALL ASSEMBLY (R-38)

¾" SIDING (AS SPECIFIED)
TYVEK WEATHER BARRIER
3.5" RIGID INSULATION (R-16) 2 LAYERS
2" VERTICALLY SHIP LAPPED
1-1/2" HORIZONTALLY SLOTTED
½" PLYWOOD
2x6 STUDS @ 24" O.C
6 MIL VAPOUR BARRIER
BATT INSULATION (R-20)
1-1/2" STRAPPING (HORIZONTAL)
FILLED WITH SEMI RIGID INSULATION
½" GYPSUM

UNIT 1.247

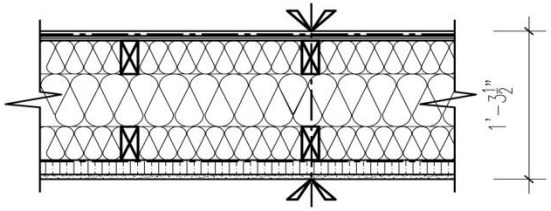


DOUBLE WALL SECTION

EXTERNAL WALL ASSEMBLY (R-50)

¾" SIDING (AS SPECIFIED)
TYVEK WEATHER BARRIER
½" PLYWOOD
2X4 STUDS @ 24" O.C
BATT INSULATION (R-14) ROXUL
5-1/2" BATT INSULATION (R-22) ROXUL
½" PLYWOOD
6 MIL VAPOUR BARRIER
2X4 STUDS @ 24" O.C
BATT INSULATION (R-14) ROXUL
½" GYPSUM

UNIT 0.975

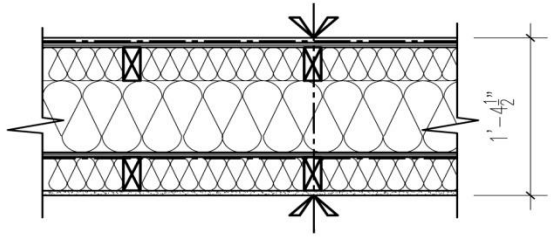


NWTHC EXTERNAL WALL SECTION

EXTERNAL WALL ASSEMBLY (R-47)

¾" SIDING (AS SPECIFIED)
TYVEK WEATHER BARRIER
½" PLYWOOD
2X4 STUDS @ 24" O.C
BATT INSULATION (R-12)
5-1/2" BATT INSULATION (R-20)
2X4 STUDS @ 24" O.C
BATT INSULATION (R-12)
6 MIL VAPOUR BARRIER
1-1/2" STARPING (HORIZONTAL)
WITH SEMI RIGID INSULATION
½" GYPSUM

UNIT 1.105

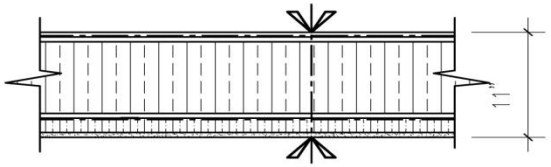


DOUBLE WALL SECTION (TYPE 2)

EXTERNAL WALL ASSEMBLY (R-50)

¾" SIDING (AS SPECIFIED)
TYVEK WEATHER BARRIER
½" PLYWOOD
2X4 STUDS @ 24" O.C
BATT INSULATION (R-12)
7-1/2" BATT INSULATION (R-28)
½" PLYWOOD
6 MIL VAPOUR BARRIER
2X4 STUDS @ 24" O.C
BATT INSULATION (R-12)
½" GYPSUM

UNIT 0.995



SIP WALL WITH STRAPPING

EXTERNAL WALL ASSEMBLY (R-43)

¾" SIDING (AS SPECIFIED)
TYVEK WEATHER BARRIER
8-1/2" SIP
6 I
1-
FIL
½"

UNI

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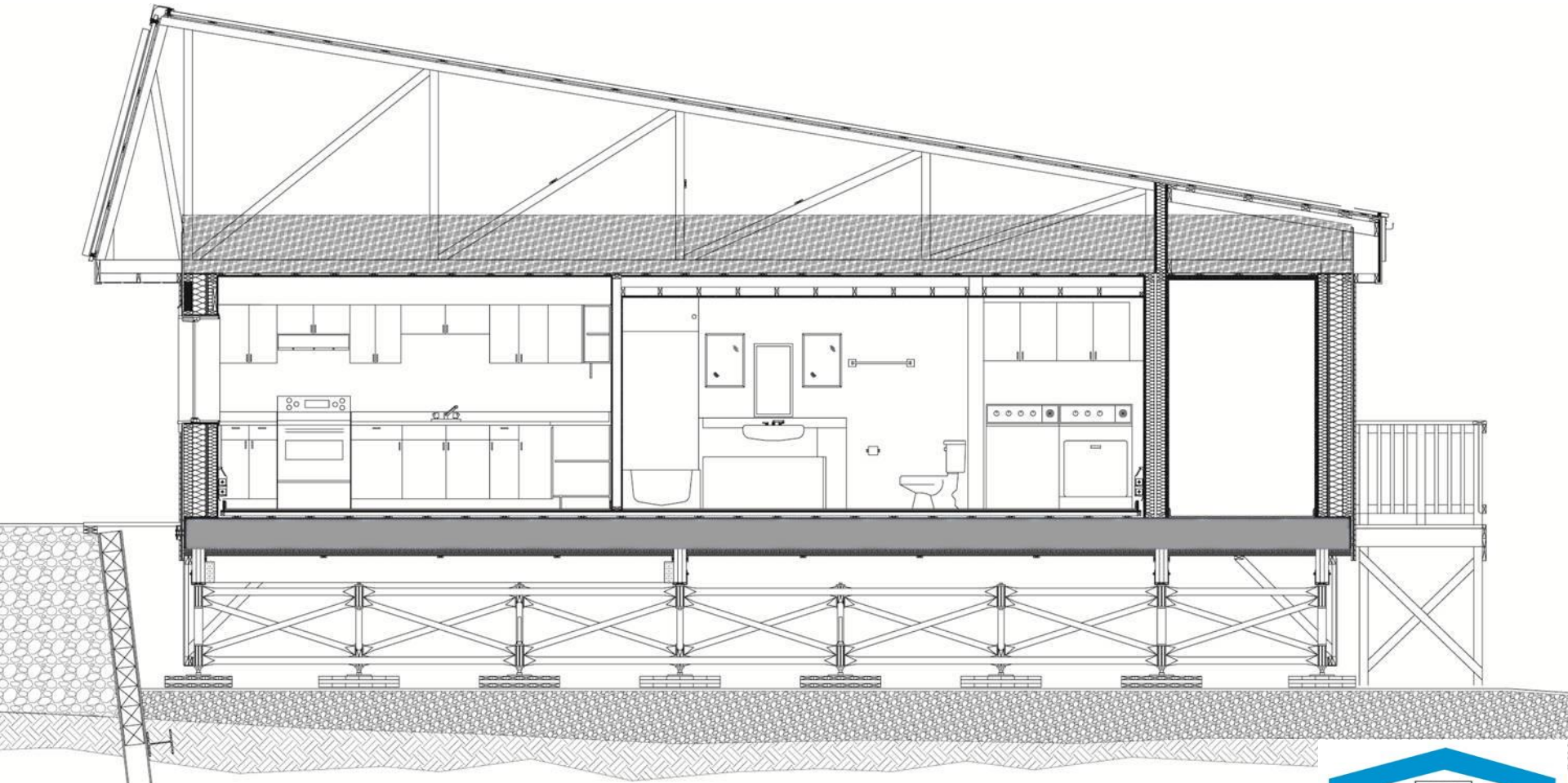
Section



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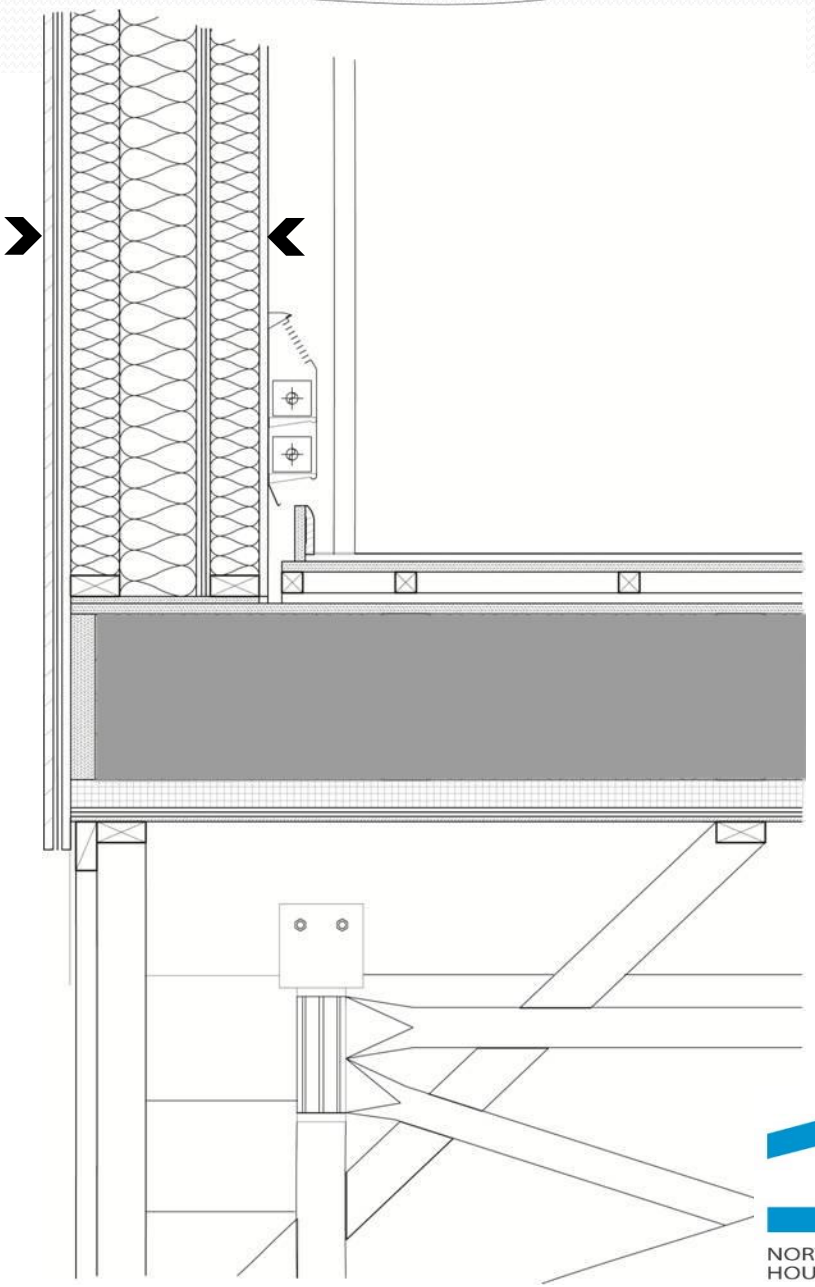
Exterior Wall Construction

-½” Abuse Resistant Gypsum Board
-2x4 Studs @ 24” o.c.
-R 14 (3 ½”) Mineral Fiber Insulation
-6 mil Poly. Vapour Barrier
-3/8” OSB Sheathing
-R 22 Mineral Fiber Insulation
-2x4 Studs @ 24” o.c.
-R 14 Mineral Fiber Insulation
-3/8” OSB Sheathing
-Air Barrier
-Siding



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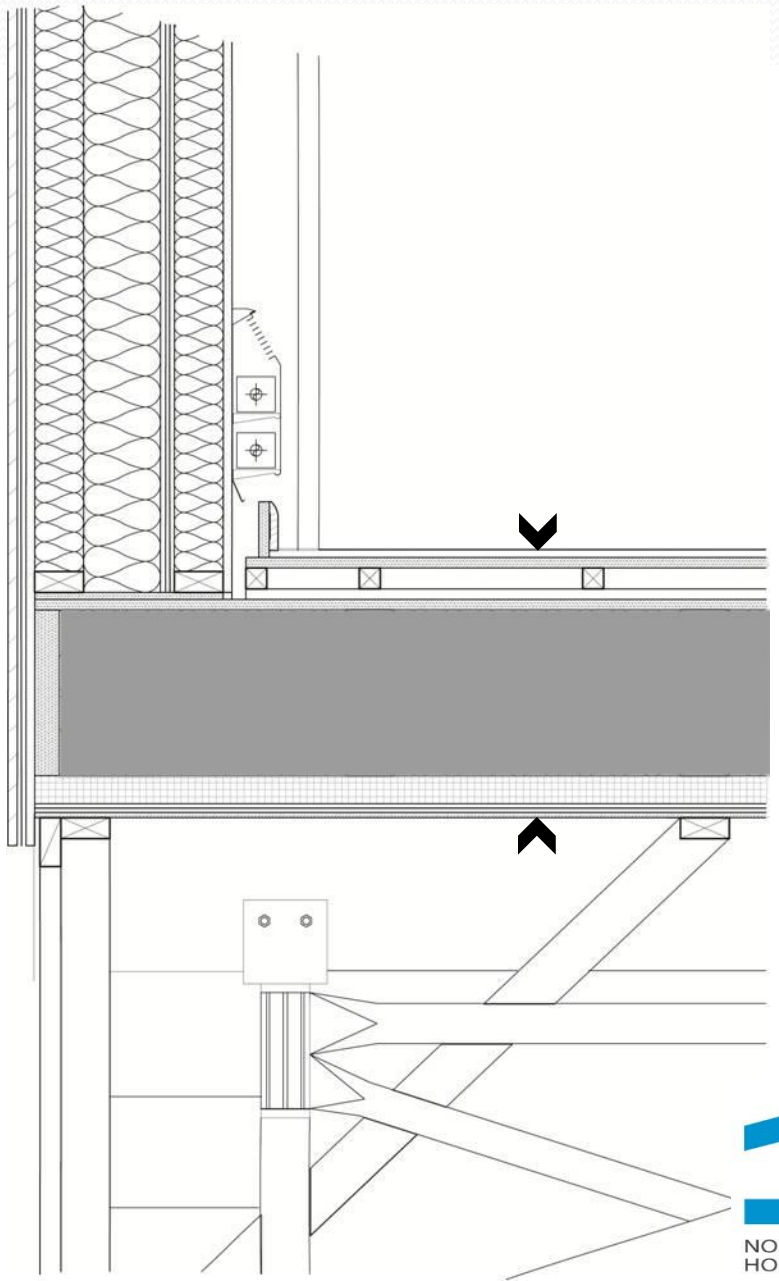
Floor Construction

-V.C. Tile
-Underlay
-¾” T&G Plywood
-2x2 False Floor Framing @16” o.c. on 1x4
-Structural Insulated Panel
-Air Barrier
-5/16” Plywood Soffit



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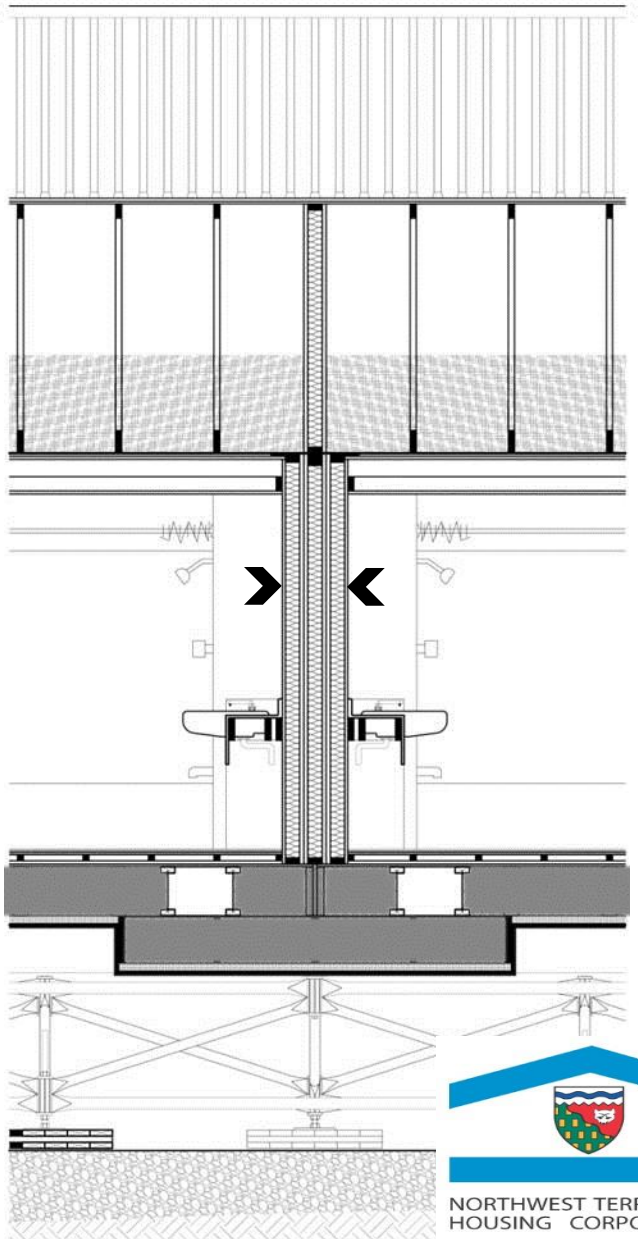
Party Wall

-½” Abuse Resistant Gypsum
-2x4 Studs @ 16” o.c. Plumbing Wall
-3 1/2” Acoustic Batt Insulation
-1” Air Space
-5/8” Type “X” Gypsum BD.
-2x4 Studs @ 16” o.c.
-3 1/2” Acoustic Batt Insulation
-5/8” Type “X” Gypsum BD.
-1” Air Space
-2x4 Studs @ 16” o.c. Plumbing Wall
- 3 1/2” Acoustic Batt
-5/8” Type “X” Gypsum BD.



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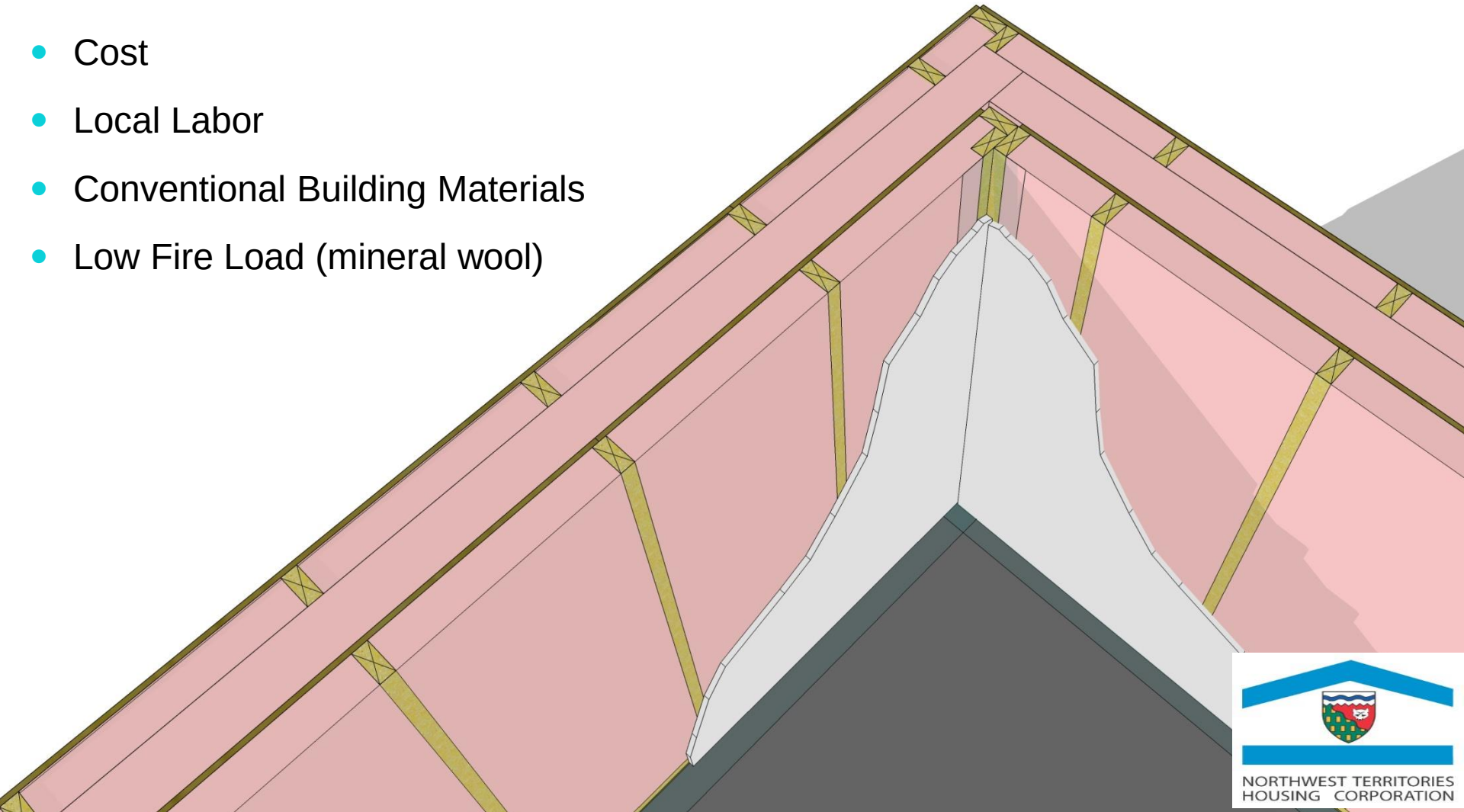
Advantages of our double stud wall

- Thermal Performance
- Cost
- Local Labor
- Conventional Building Materials
- Low Fire Load (mineral wool)



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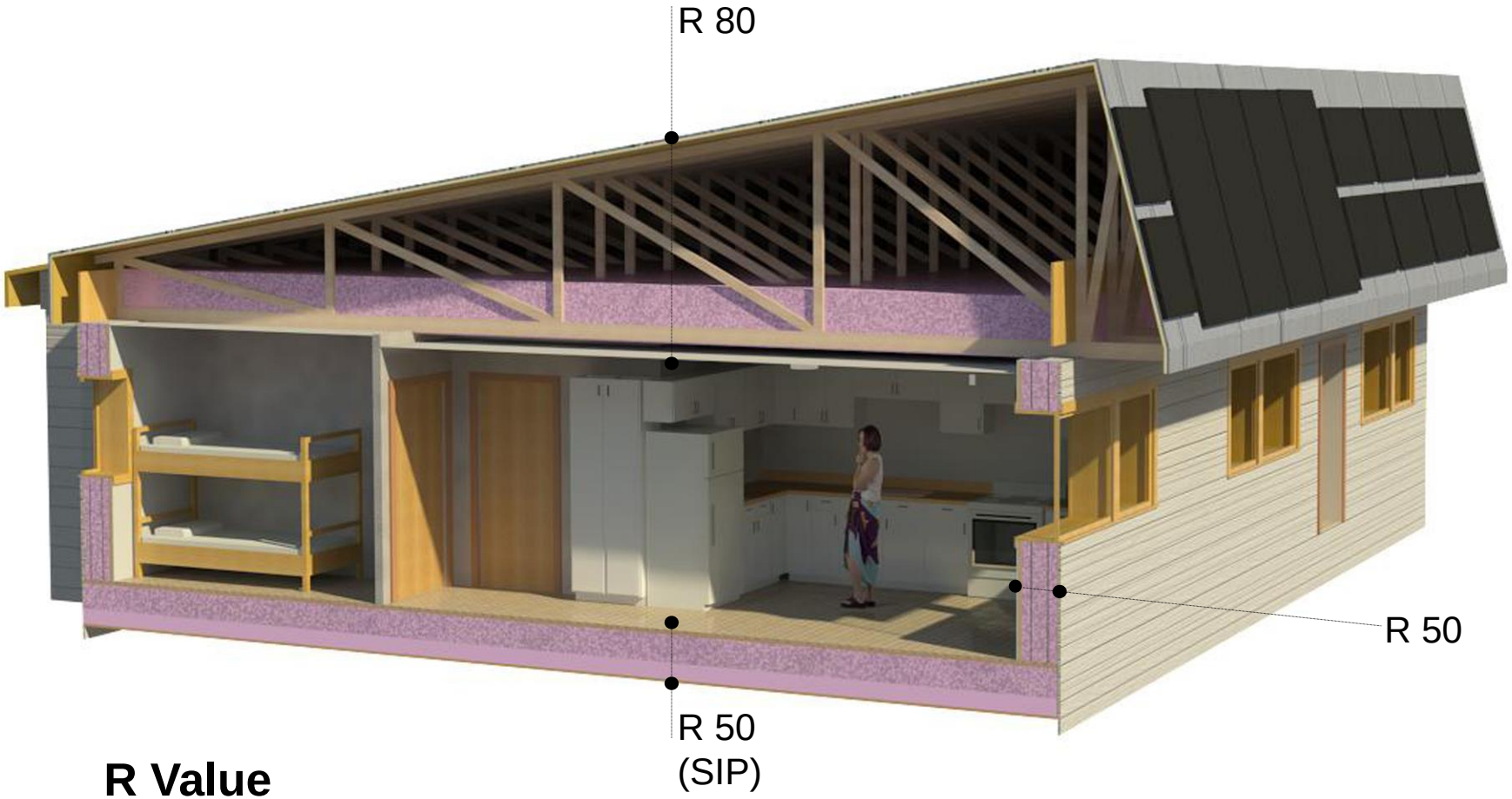

R Value

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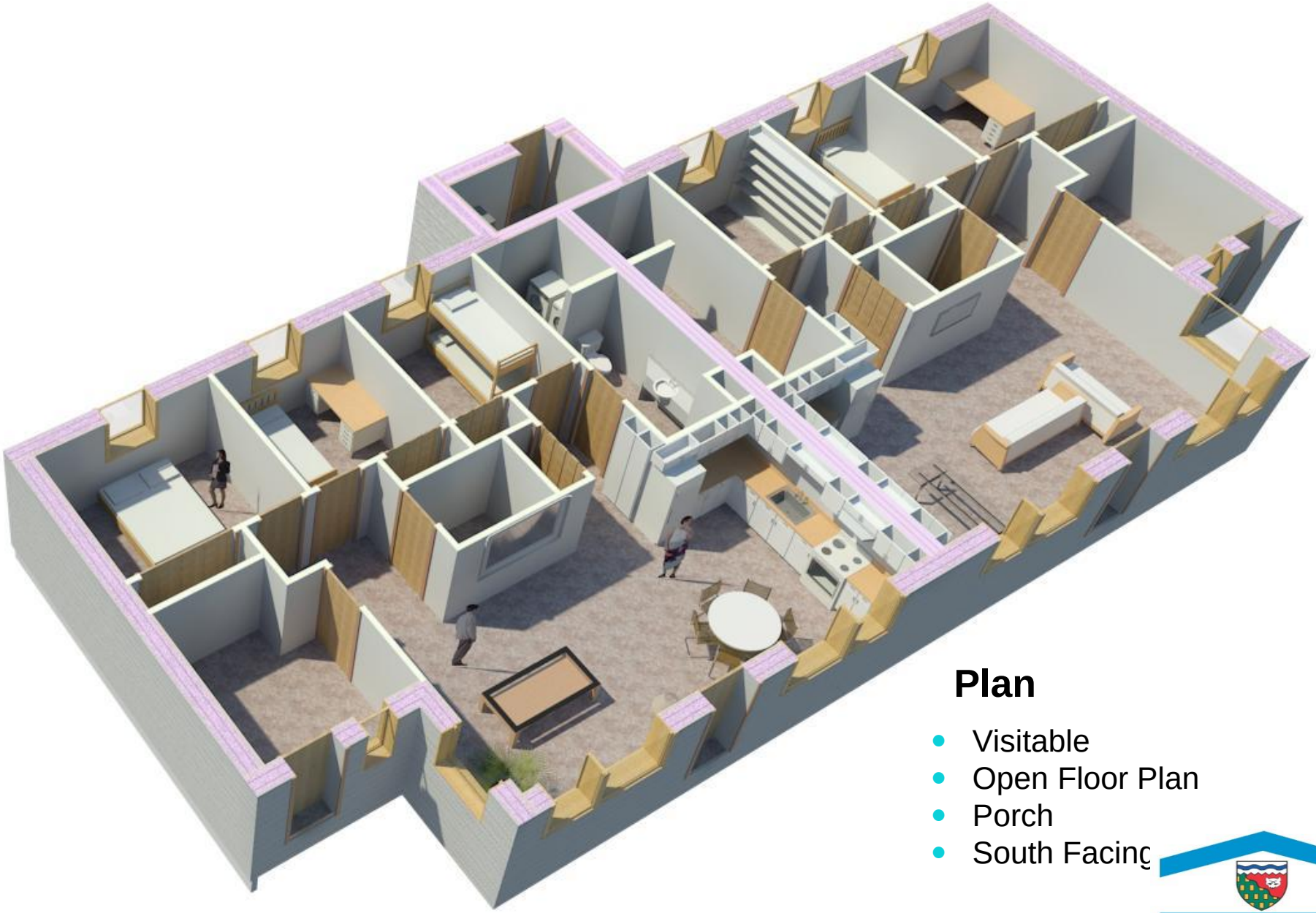

Plan

- Visitable
- Open Floor Plan
- Porch
- South Facing

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Rendered Model & Avatar

NORTHWEST TERRITORIES
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Rendered Model & Avatar

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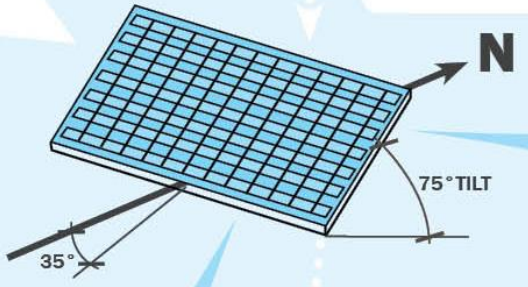
SOLAR PHOTOVOLTAIC (SOLAR PV)

Solar PV panels make electricity from sunshine. The NSH's solar photovoltaic units are grid-tied & installed at 75° tilt facing 35° east of due south. Each unit's system consists of eight 224W Sharp Solar Photovoltaic Modules (a 1.7kW system) & a Sunnyboy 3000US grid-tied inverter (DC to AC).

Performance:

The as-built size of the photovoltaic array is rated 1.7kW at 8 panels of 13.4m2 for each unit. Each system offset about 1,350 kWh of purchased electricity annually.



1ST YEAR EARNED
(+) $81/$142

1ST YEAR SAVINGS
(-) $681/$469

Maintenance:

This solar PV system requires very little maintenance because it is grid tied (connected to the large electrical grid that supplies Inuvik). Because it is a grid tied system, it requires NO batteries and batteries DO require maintenance. At Inuvik's latitude, these panels start to produce at the end of Feb and should be kept clear of snow and the dust washed off as required. They were quite dirty when we commissioned the system and production improved by 30% after washing.

Northern Sustainable House (NSH)

SOLAR HOT WATER

Monitored Annual Energy Used for Domestic Hot Water:

Typical Domestic Use	Unit A	Unit B
	33%	27%

COLD → SOLAR PANEL → WATER STORAGE → BOILER

Maintenance:

Solar Hot water performs best in summer months.

Performance:

These systems involve pumps that need to be serviced or replaced occasionally and glycol that needs to be maintained and should be changed every 3 years.

Solar Hot Water (SHW) systems heat water using radiation from the sun. In the case of the NSH the SWH systems for each unit are to supplement the natural gas boiler in providing the domestic hot water supply. The hot water produced by the SHW in turn reduced gas consumption & Greenhouse Gas (GHG) emissions. 27 - 33% of the domestic hot water supply was met by the Solar Hot Water system.

Northern Sustainable House (NSH)

HEAT RECOVERY VENTILATOR (HRV)

A Heat Recovery Ventilator (HRV) is a fan in a box with filters & a heat exchanger. It brings in the correct amount of fresh air to keep everyone healthy as well as recovers heat from the warm exhausted air as it exits the home. The NSH uses Two VanEE 90H-V ECM which are ENERGY STAR® rated with an apparent sensible effectiveness of 83% at 0°C and 89% at -25°C. Therefore when the NSH is heated to 20°C instead of bringing in -25°C fresh air you would be bringing in about 12°C fresh air.

Maintenance:

This is mechanical equipment & requires maintenance. It has filters & a heat exchanger to clean on a regular basis. Read the operating manual carefully & follow directions. To view a maintenance schedule sheet & instructional video, go to: http://www.cmhc-schl.gc.ca/en/co/grho/grho_003.cfm

Performance:

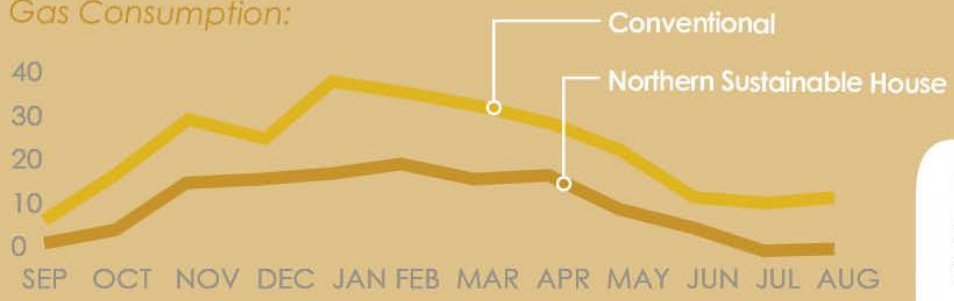
HRVs have been used for many years & although our northern climate does present challenges, they have improved greatly over the past 30 years. This house has provided an opportunity, not only to test how this equipment works in Inuvik, but has allowed maintainers & installers to get more familiar with this new technology. These units have been providing fresh air effectively according to our CO2 readings but due to technical challenges, the inconsistent performance has not allowed us to accurately measure the energy savings from this device.

HIGH EFFICIENCY BOILER

The NSH has one high-efficiency, condensing, & modulating natural gas boiler. The NSH's boiler is an IBC VFC-15-150 with a maximum input of 150,000 Btu/h & Annual Fuel Utilization Efficiency (AFUE) of 92.6%. This boiler meets the space heating needs & some of the domestic hot water demand of both units.

Annual Heating Consumption of Individual Units:

Gas Consumption:



Maintenance:

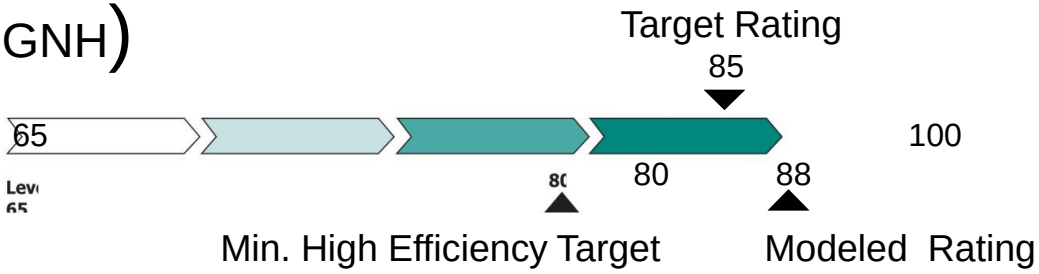
There have been some maintenance issues with this heating system as a whole but most of these seem to be pump, glycol & pressure related issues. There are many high efficiency, condensing gas furnaces & boilers in Inuvik & local installers & maintainers should be able to deal with service issues.

Performance:

NSH units use about 50% less gas than a conventional house. The high efficiency boiler significantly reduced the NSH's gas consumption, however it needs to be taken into account that the HRV, Boiler, & Building Envelope all work together to reduce the gas consumption. The much lower gas consumption of the NSH in the summer months shows that the Solar Hot Water Heater (SWH) is reducing the operation time of the boiler for hot water purposes (See Solar Hot Water Report for more info).

EnerGuide Rating (EGNH)

Northern Sustainable House_Project
Design Development Rating EGNH 85



OVERALL BUILDING COST - $815,000 ($310/ft2)
NWTHC – funded $690,000 for construction
CMHC – funded $75,000 for incremental cost
ENR – funded $50,000 for solar

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	PROS	CONS
High Insulation Values	Best bang for buck for life cycle costing	Higher capital cost
Solar PV	Easy maintenance & installation	Grid-tied issues (NWTHC to explore other means to utilize this excess seasonal power)
Solar Hot water	Savings on heating water	Higher maintenance
Secondary Door	Supersedes NBC on access to egress	No Arctic entry or double door thus compromised heating
High Efficiency Heat Boiler	Lower heating costs	Higher maintenance, requires gas (not all communities provide gas)
HRV	Recovery of heat back into the unit	Higher Maintenance, requires calibration,
“Tekmar”	Sensing outside temperature to avoid freeze-up	Higher Maintenance
Siting & Land selection	Some solar gain	Could not optimize on site. Quality & shape of site impact benefits of sustainable design
Quad Glazing	Higher R-value	Higher cost with minimal payback

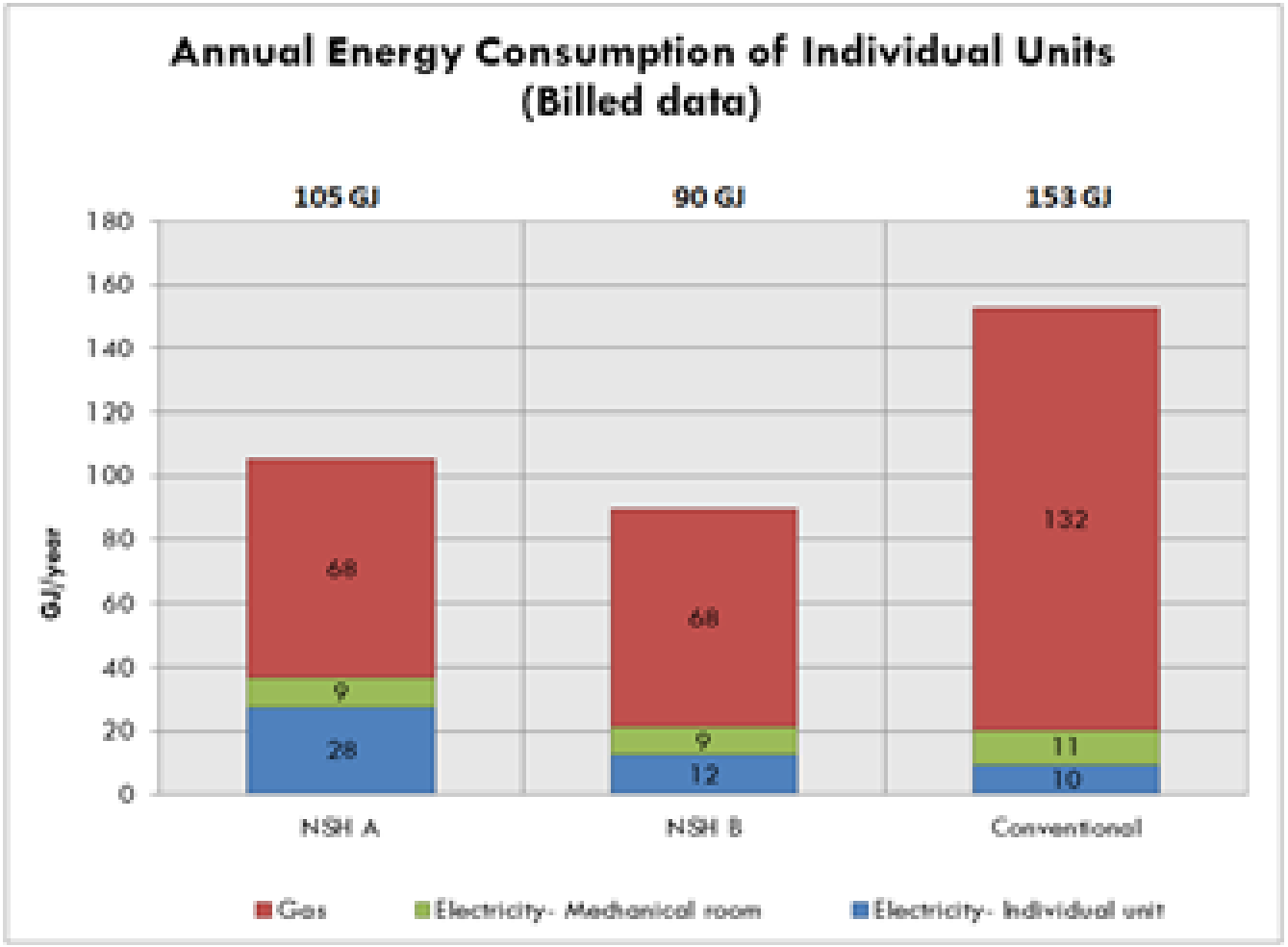
Monitoring

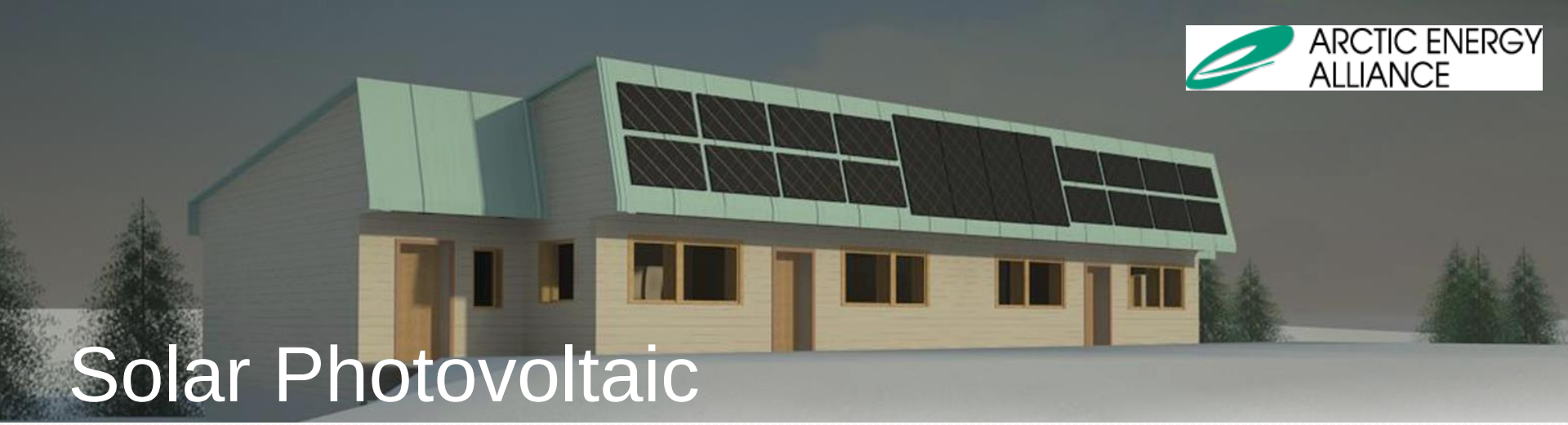
Quantitative and Qualitative Approach

1. Electrical
2. Solar Photovoltaic
3. Gas
4. Heating
5. Hot Water
6. Solar Hot Water
7. Water Consumption
8. Indoor Air Quality
9. Ventilation
10. Occupant Surveys

Overall House Performance Year 1

Based on billed data the NSH unit uses 31 – 41% less energy than the conventional NWTHC unit. The NSH duplex uses 48% less gas than the conventional duplex based on billed data.





Solar Photovoltaic

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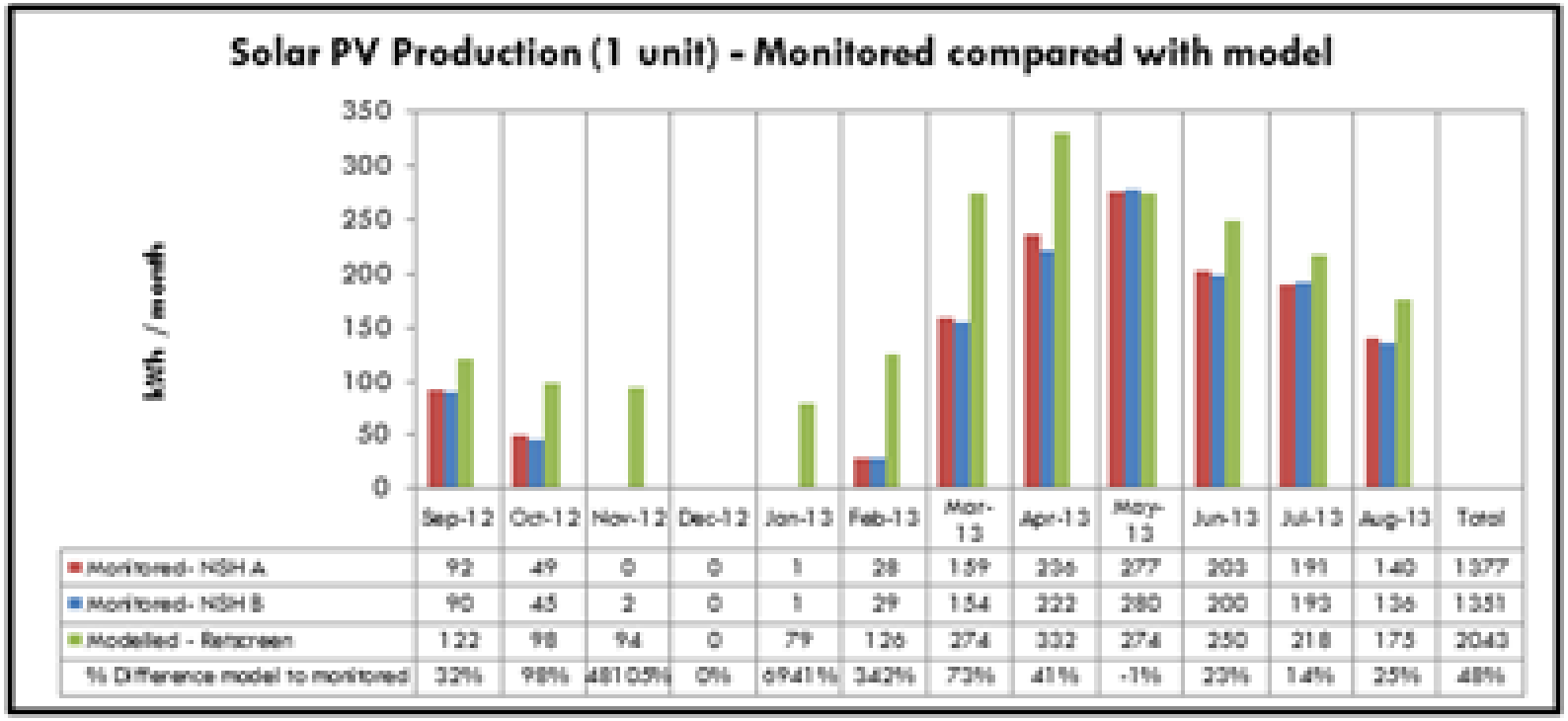
Solar Photovoltaic



	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Total
Monitored- NSH A	92	49	0	0	1	28	159	236	277	203	191	140	1377
Monitored- NSH B	90	45	2	0	1	29	154	222	280	200	193	136	1351
Modelled - Retscreen	122	98	94	0	79	126	274	332	274	250	218	175	2043
% Difference model to monitored	32%	98%	4810%	0%	6941%	342%	73%	41%	-1%	23%	14%	25%	48%

The PV output for the year was about 1350 kWh for each 1.7 kW unit.

The modelled PV production was overestimated by nearly 50% when compared with the monitored results. Losses of 35% would need to be included in the model in order to match the annual production numbers. In this case the winter months would still be overestimated and the summer months would underestimated.

Electrical Consumption

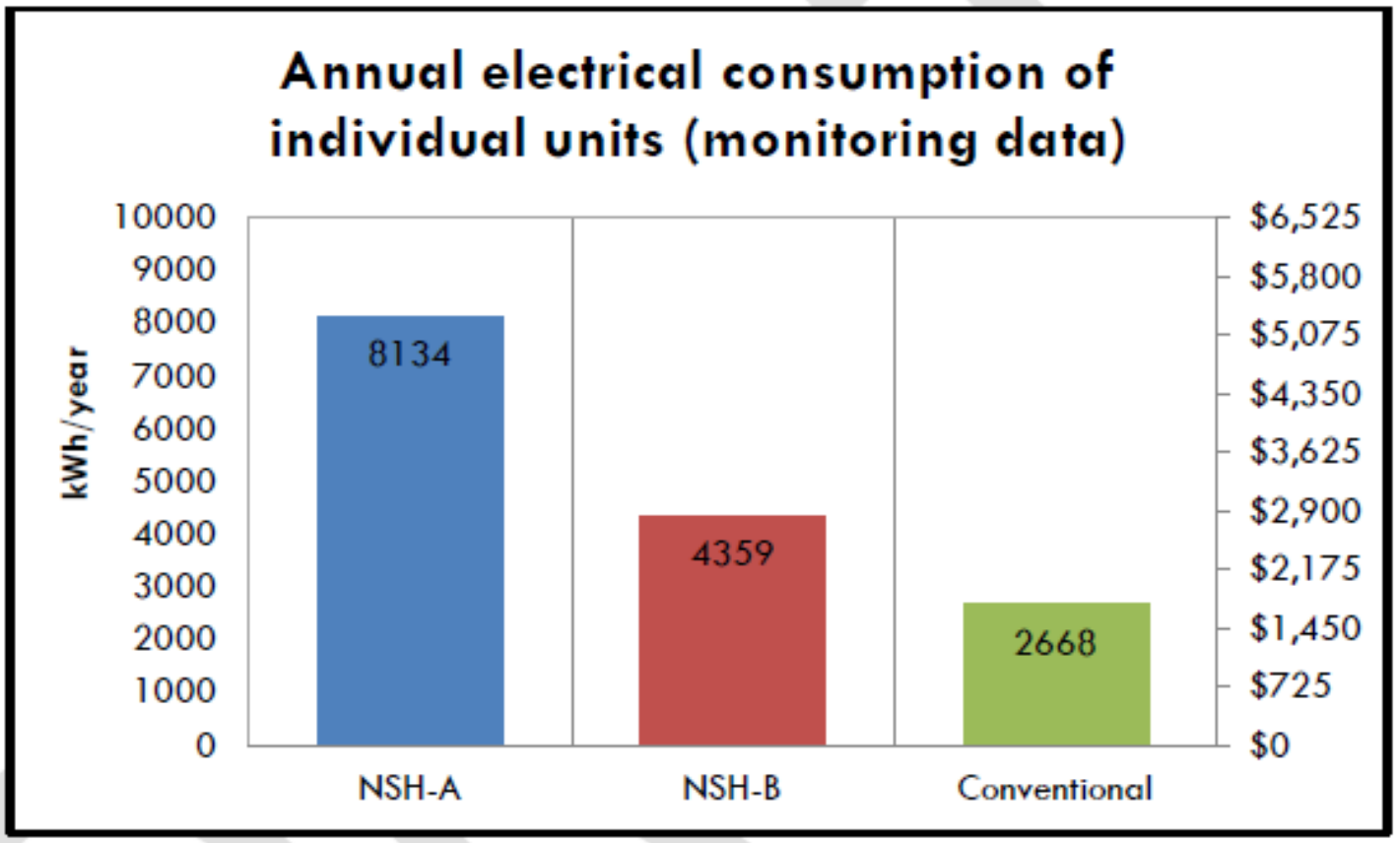
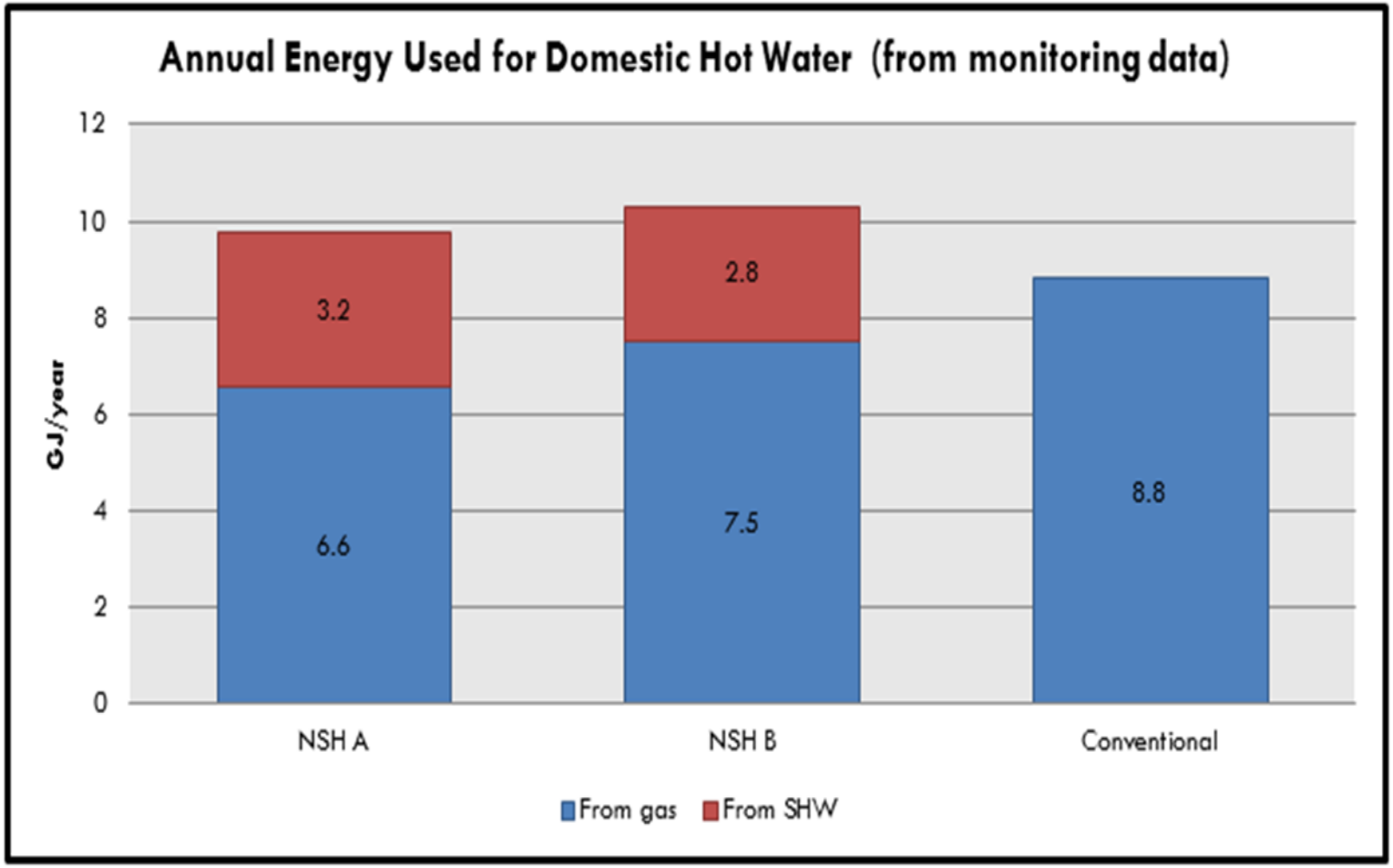


FIGURE 5.1: ANNUAL ELECTRICAL USAGE OF EACH UNIT

Solar Hot Water



Gas Consumption

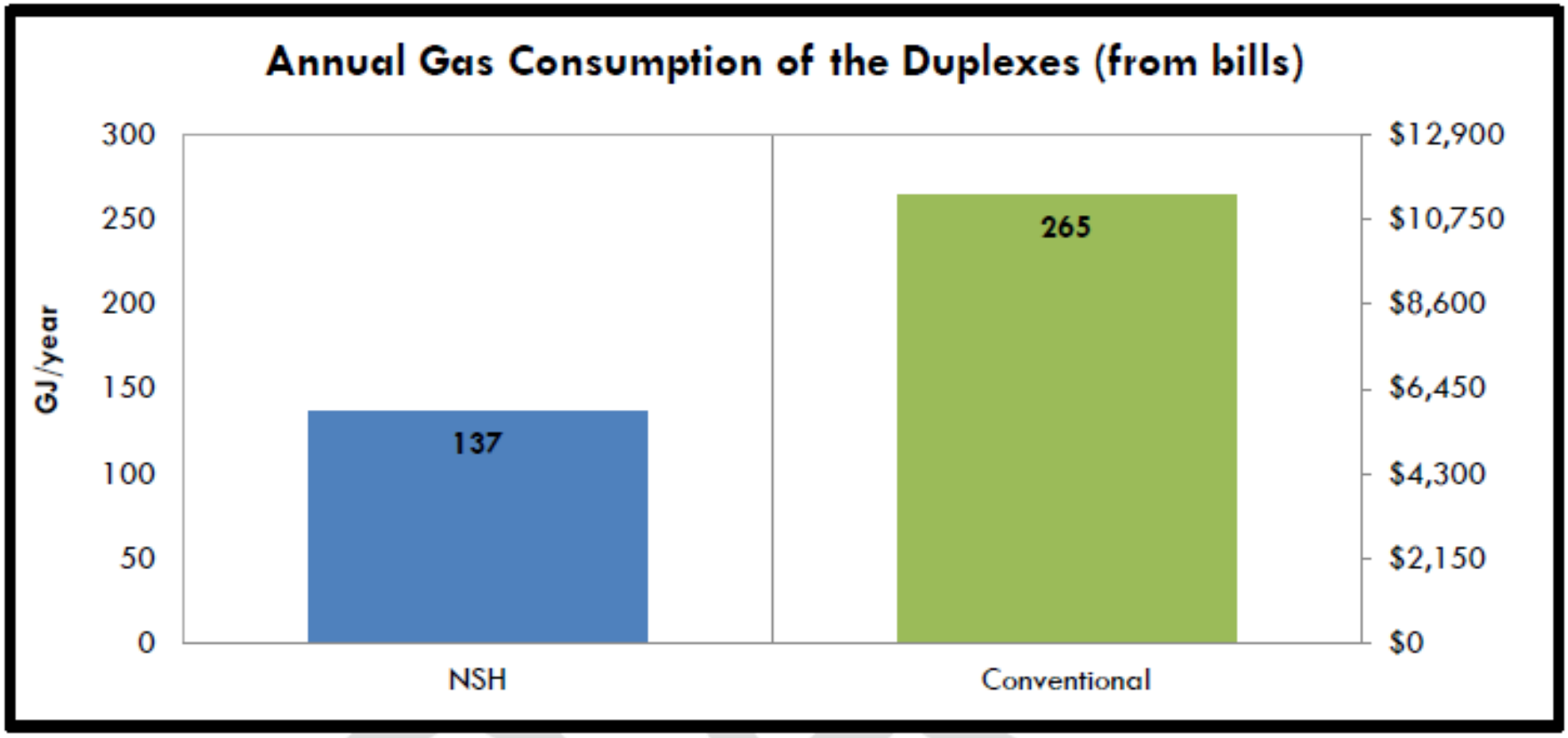


FIGURE 4.1: ANNUAL GAS CONSUMPTION OF NSH COMPARED WITH CONVENTIONAL DUPLEX BASED ON BILLS

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Thank You

Questions?