

Engineering for Extremes: Powering a Science Station in Greenland with Renewable Energy



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Principal

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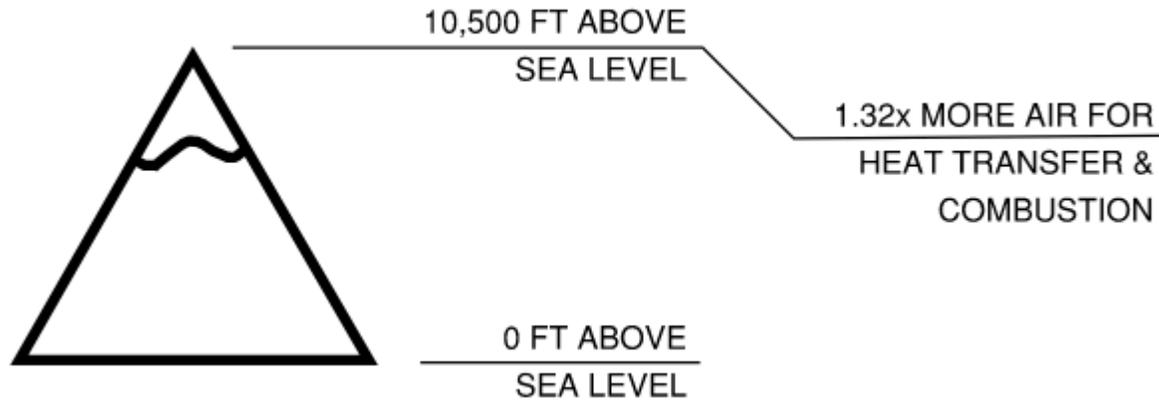
LEARNING OBJECTIVES

1. Understand the unique design challenges associated with constructing a modernized Arctic science station in extreme environmental conditions.
2. Analyze the strategies and technologies used to achieve operational resiliency, including power automation relaying for grid outages and equipment maintenance.
3. Evaluate the integration of renewable energy systems and their role in reducing the facility's carbon footprint while supporting net-zero operation.
4. Discuss the implications of custom and semi-custom engineering solutions for ensuring reliable and efficient power and heating in remote research facilities.

Project Overview



Project Overview



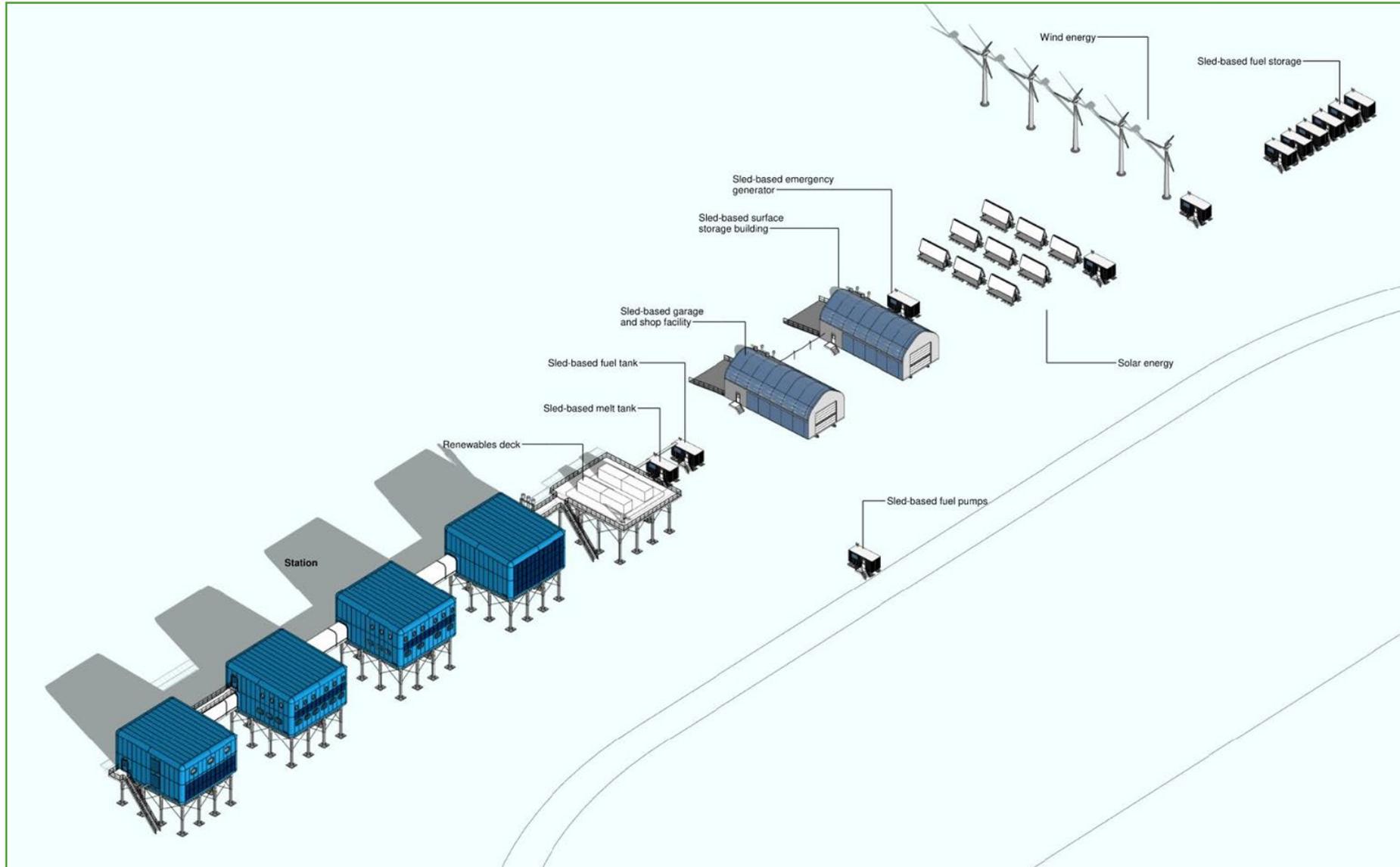
RECOMMENDATION - USE FLUID TO MOVE HEAT RATHER THAN AIR

\$1/ 1,026
BTU/H

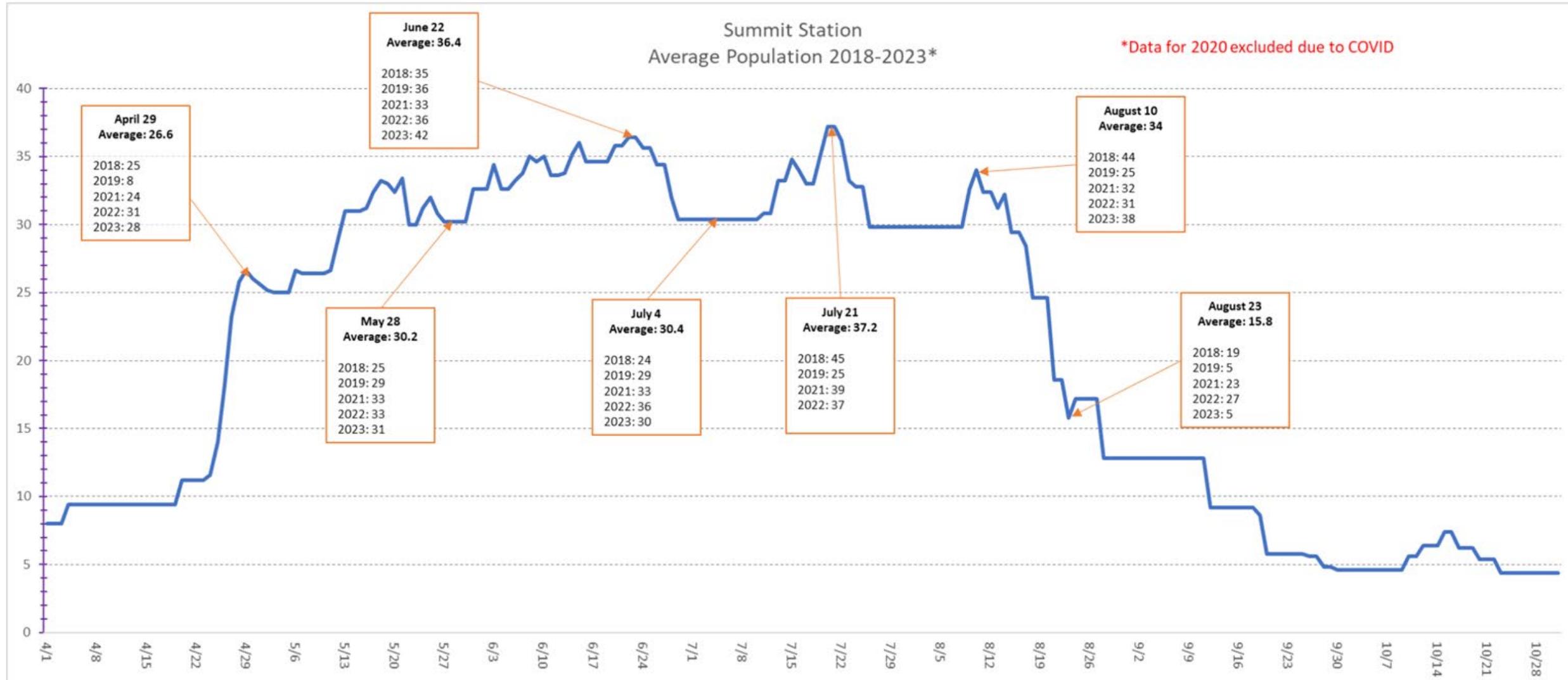
RECOMMENDATION - REDUCE CONSUMPTION AS MUCH AS POSSIBLE

ASSUMPTION - COST OF TRANSPORTING 1 GALLON OF FUEL TO THE
SUMMIT \$35/GAL

Project Overview



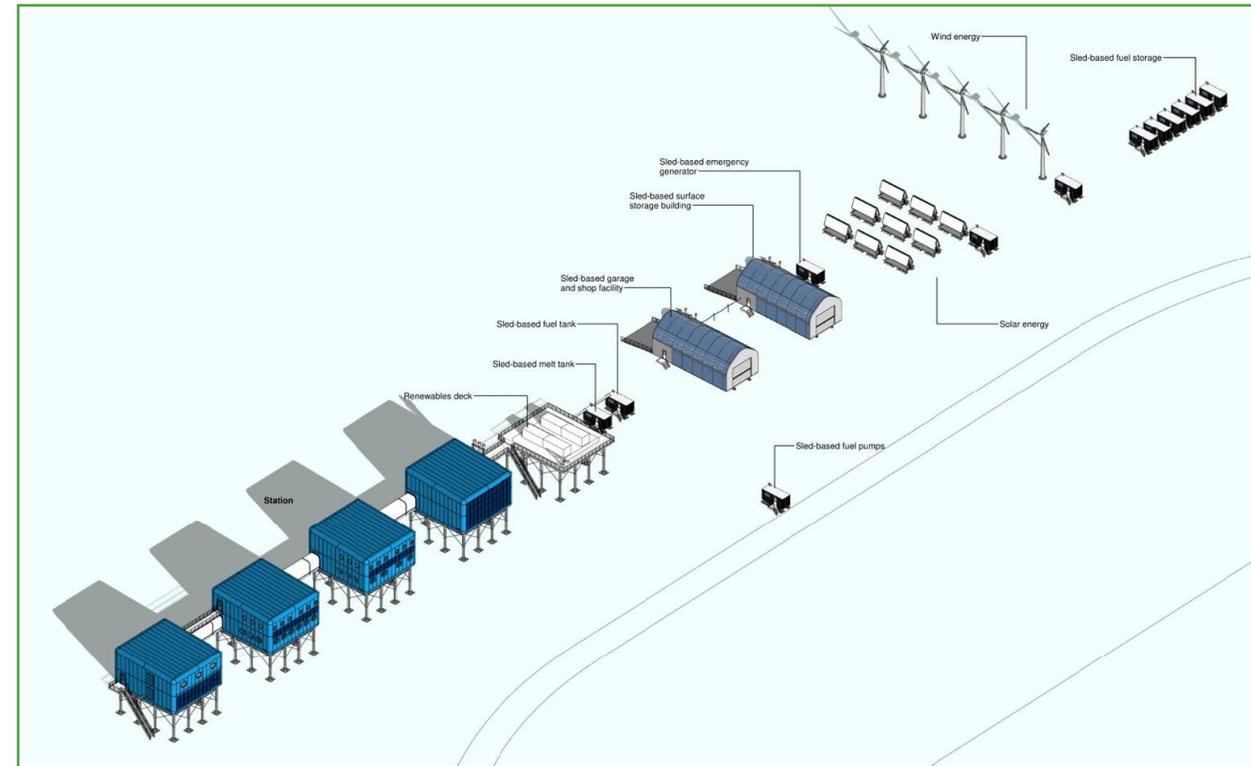
Project Overview



Project Overview

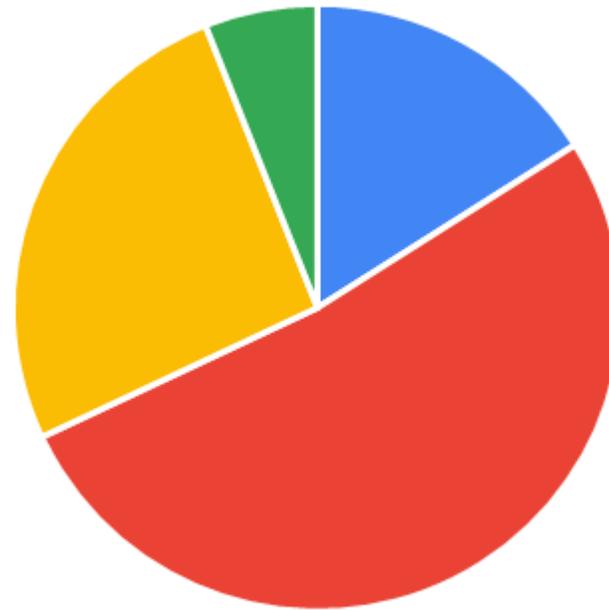
PROJECT OBJECTIVE
ENABLE WORLD CLASS SCIENCE*
LIFE SAFETY
RESILIENCY (FIRESAFE)
HEALTH AND WELLBEING
INCLUSION AND EQUITY
REDUCED EMISSIONS: CLEAN AIR AND SNOW*
EFFICIENCY: ENERGY SPATIAL /FUNCTIONAL
FLEXIBILITY/ADAPTABILITY
SCALABILITY (PARTITIONING FOR WINTER OPERATIONS)
CONSTRUCTABILITY
AUTONOMY*
STEWARDSHIP OF FINANCIAL RESOURCES FIRST COSTS LIFE CYCLE COST
DURABILITY/LOW MAINTENANCE
IMAGE REFLECTIVE OF NSF (SIMPLE, ICONIC)

* ADDED FROM KICKOFF MEETING



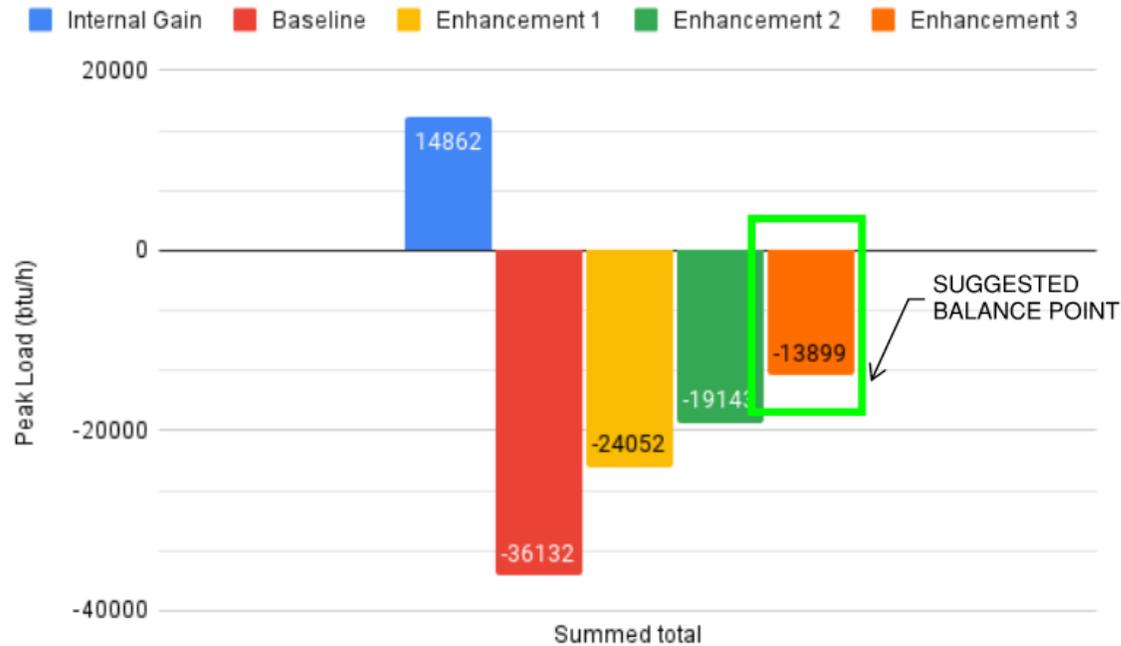
Project Overview

Energy Usage Breakdown



■ Building Heating ■ Snowmelting ■ Domestic Hot Water ■ Interior Usage

Reduction



IN THIS COMPARISON, THE TEAM EVALUATED THE BALANCE POINT BETWEEN THE INTERNAL GAIN OF A DORMITORY AND THE HEAT LOSS OF THE ENVELOPE ACROSS THE ENTIRE YEAR.

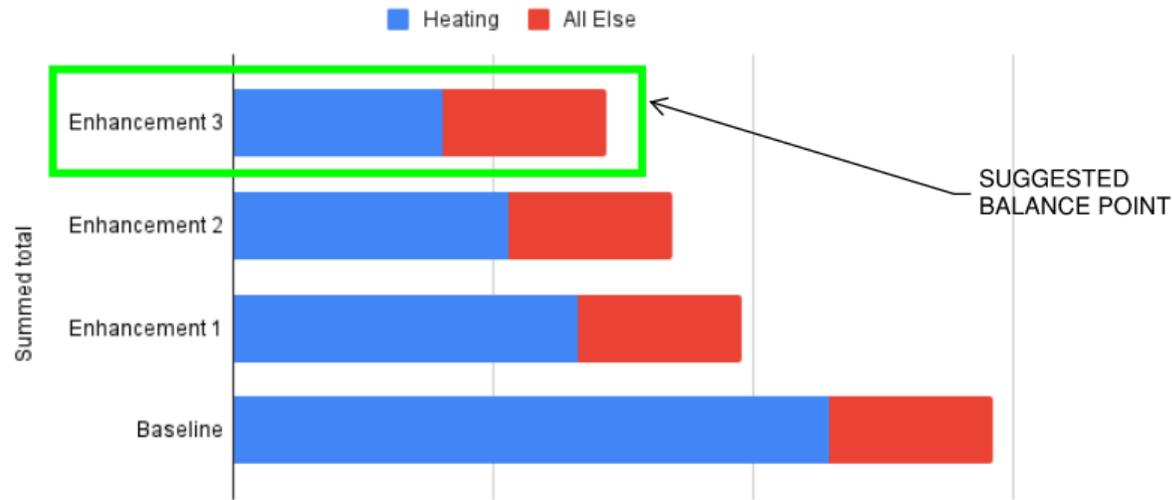
AT THIS POINT, NO MECHANICAL HEATING IS REQUIRED TO HEAT THE SPACE. HEAT GENERATED INTERNALLY TO THE BUILDING IS ENOUGH TO OVERCOME THE HEAT LOSS IN THE BUILDING.

THE OPTIMAL BALANCE POINT IS WHERE THE AMOUNT OF HEAT GAIN IN THE SPACE EQUALS THE AMOUNT OF HEAT LOSS IN THE BUILDING.

	BASELINE	ENHANCEMENT 1	ENHANCEMENT 2	ENHANCEMENT 3
WALLS	R-30	R-40	R-50	R-60
ROOF	R-40	R-60	R-80	R-100
FLOOR	R-30	R-60	R-80	R-100
GLAZING	U-0.35	U-0.27	U-0.18	U-0.10
INFILTRATION	0.1 CFM/SF FACADE	0.1 CFM/SF FACADE	0.1 CFM/SF FACADE	0.1 CFM/SF FACADE

Reduction

Comparison Insulation Values



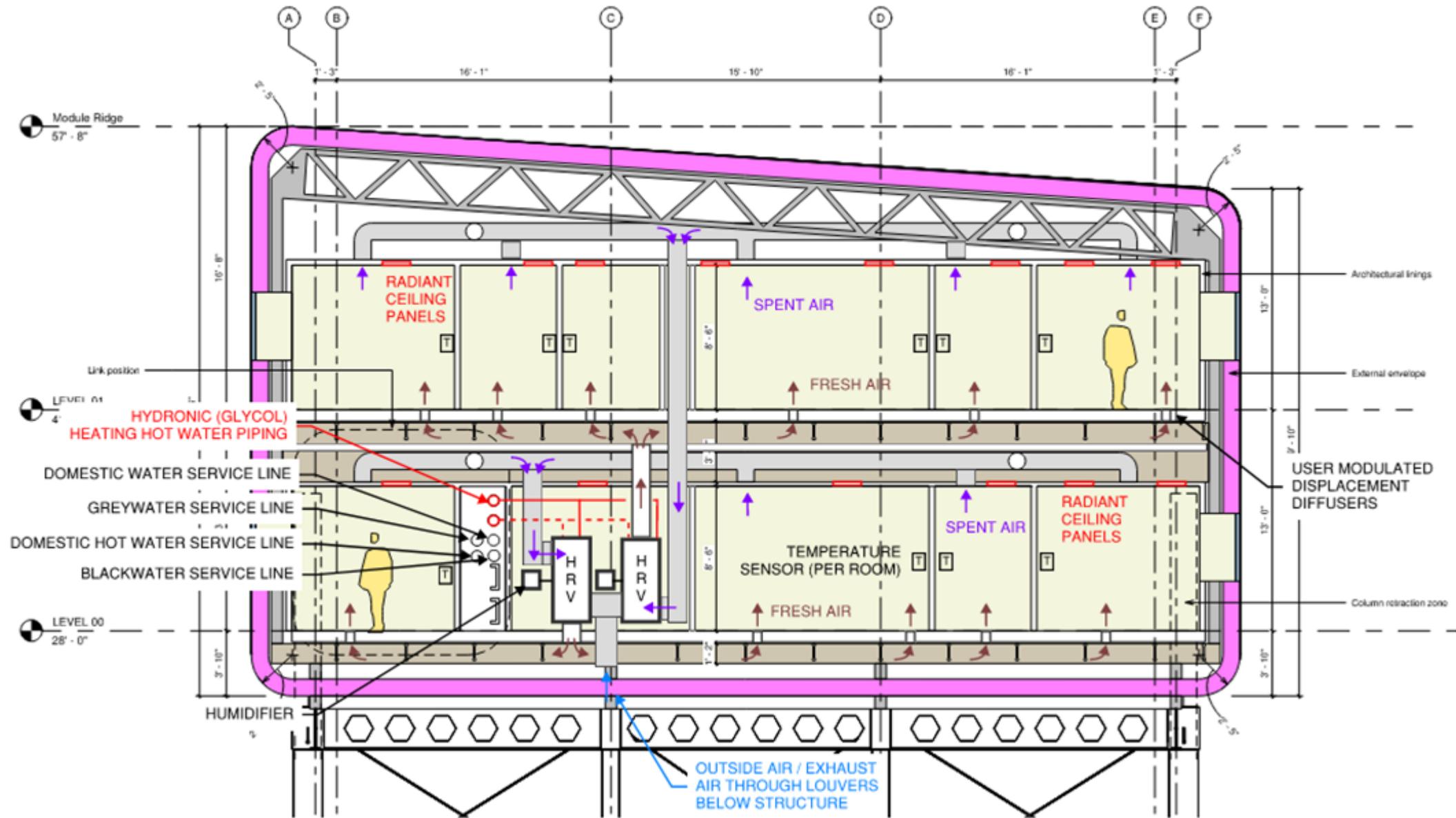
THE OPTIMAL BALANCE POINT, AS INDICATED IN THE PREVIOUS SLIDE, IS WHERE THE AMOUNT OF HEAT GAIN IN THE SPACE EQUALS THE AMOUNT OF HEAT LOSS IN THE BUILDING.

THIS WILL RESULT IN THE LOWEST ENERGY USAGE FOR THE BUILDING.

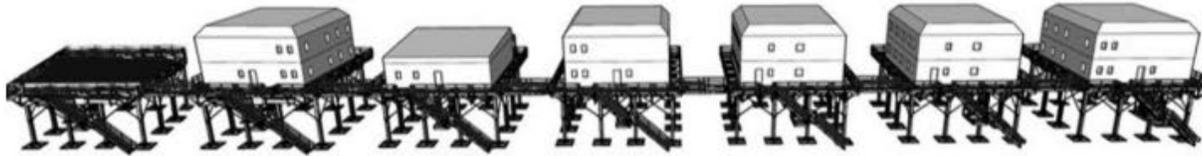
SUGGESTED BALANCE POINT

	BASELINE	ENHANCEMENT 1	ENHANCEMENT 2	ENHANCEMENT 3
WALLS	R-30	R-40	R-50	R-60
ROOF	R-40	R-60	R-80	R-100
FLOOR	R-30	R-60	R-80	R-100
GLAZING	U-0.35	U-0.27	U-0.18	U-0.10
INFILTRATION	0.1 CFM/SF FACADE	0.1 CFM/SF FACADE	0.1 CFM/SF FACADE	0.1 CFM/SF FACADE

Reduction



Reduction



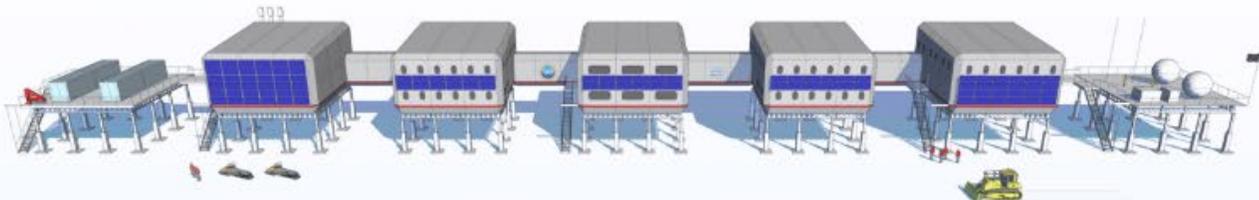
EXTERIOR WALKWAYS

INFILTRATION ESTIMATED
OPERATIONAL COST

\$368,974
/YR

OPERATIONS &
MAINTENANCE
ESTIMATED COST

\$22,000
/YR

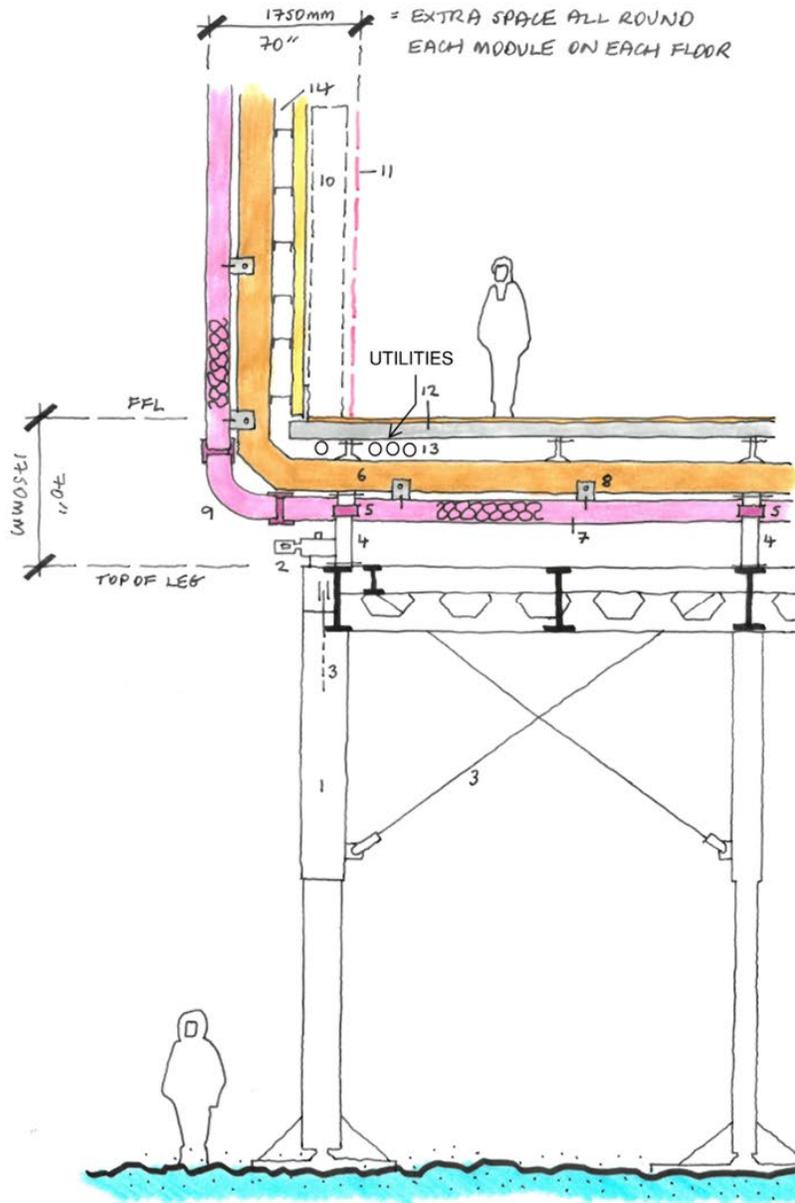


ENCLOSED WALKWAYS

\$3,000
/YR

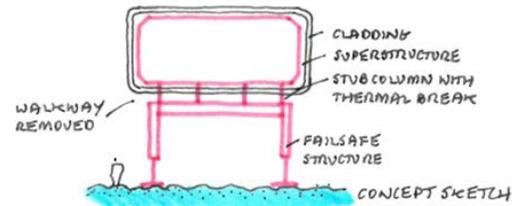
\$1,500
/YR

Reduction



KEY

- 1 FAILSAFE FRAME & LEG STRUCTURE
- 2 ELECTRIC MOTOR
- 3 BRACING CABLES
- 4 CHS STUB COLUMN LIFTS FLOOR/MODULE ABOVE MOTORS
- 5 THERMAL BREAK - HIGH DENSITY NYLON OR OTHER
- 6 SUPERSTRUCTURE - STEEL OR GLULAM - SUPPORTED ON STUB COLUMNS
- 7 CLADDING - METAL FACED SIP6 OR METAL COMPOSITE PANELS
- 8 CLADDING FIXINGS TO SUPERSTRUCTURE
- 9 GLASS FIBRE COMPOSITE CORNERS
- 10 EXTENDED LEG DURING CONSTRUCTION
- 11 EXTERNAL FACE IF MODULE BUILT WITHIN WELL IN FAILSAFE FRAME
- 12 HONEYCOMB ALUMINIUM FLOORING WITH FINISH - VINYL, RUBBER, CARPET
- 13 FLOOR SUPPORTED OFF SUPERSTRUCTURE
- 14 FIRE PROTECTION / WALL LININGS

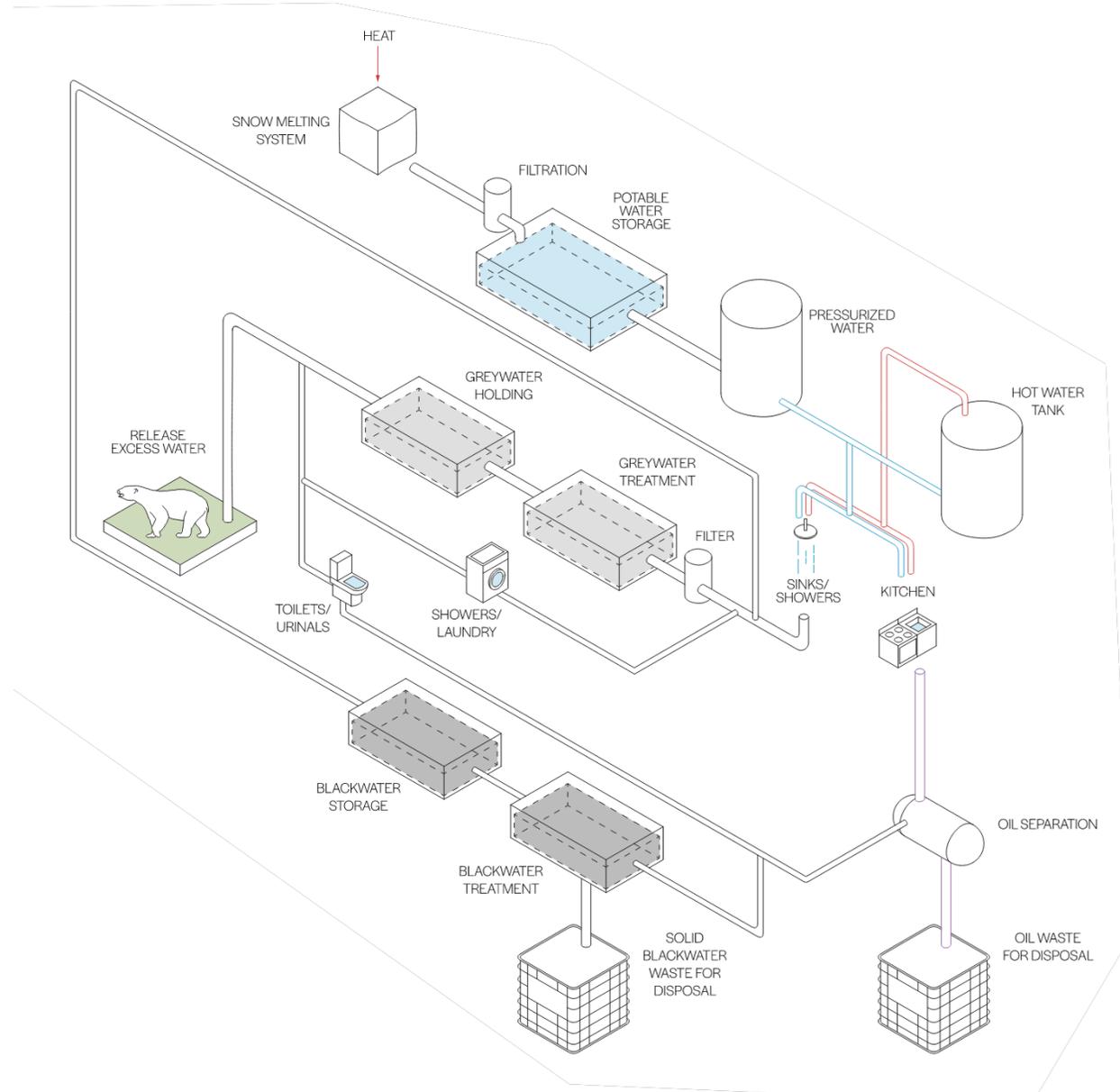


SUMR ENVELOPE CONCEPT

CANTILEVERING MODULE OVER STRUCTURE EDGE
 JULY 23RD 2024

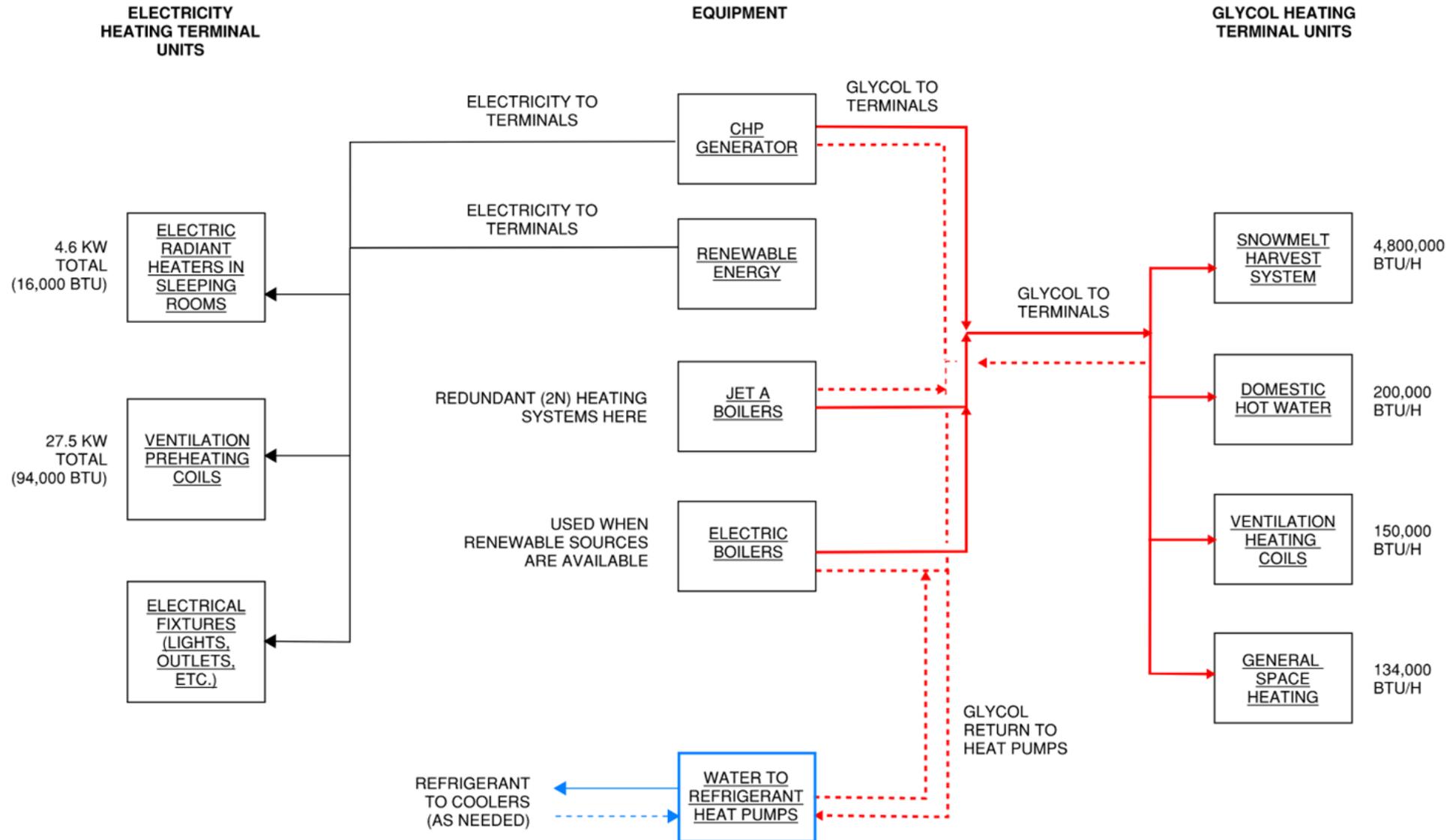
OZ ARCHITECTURE / HUGH BROUGHTON ARCHITECTS

Reduction - Water

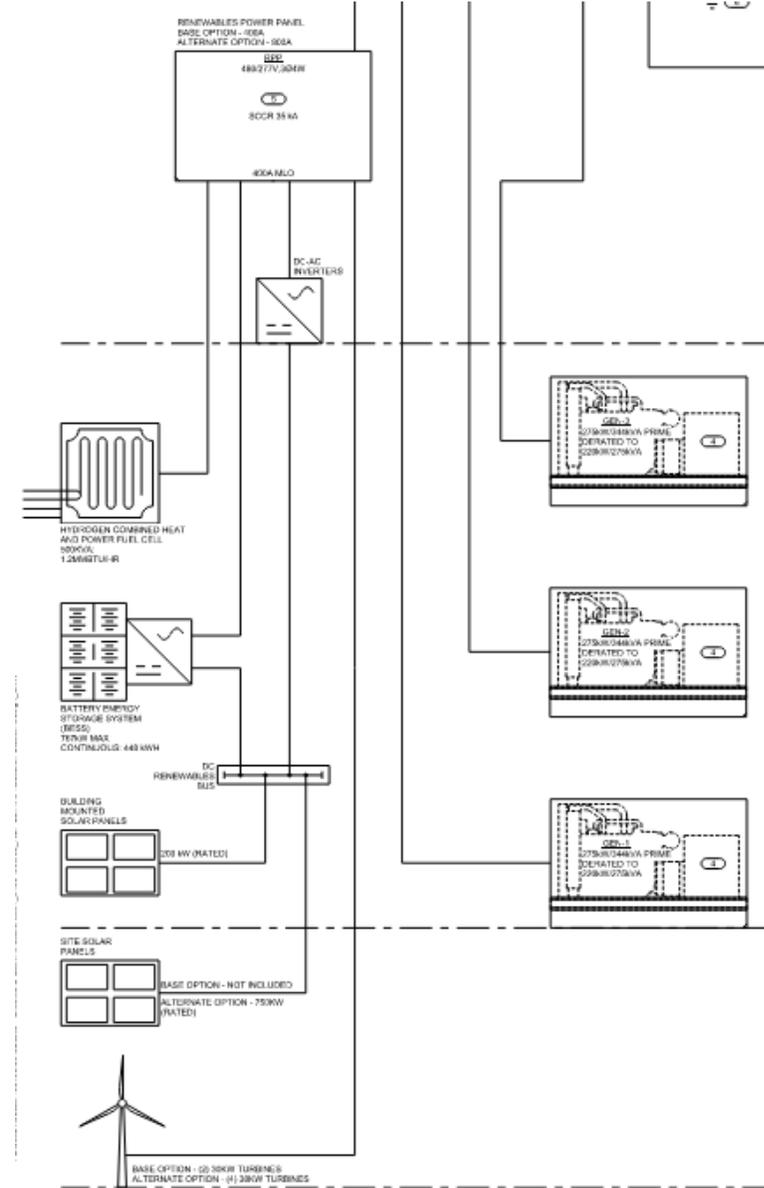
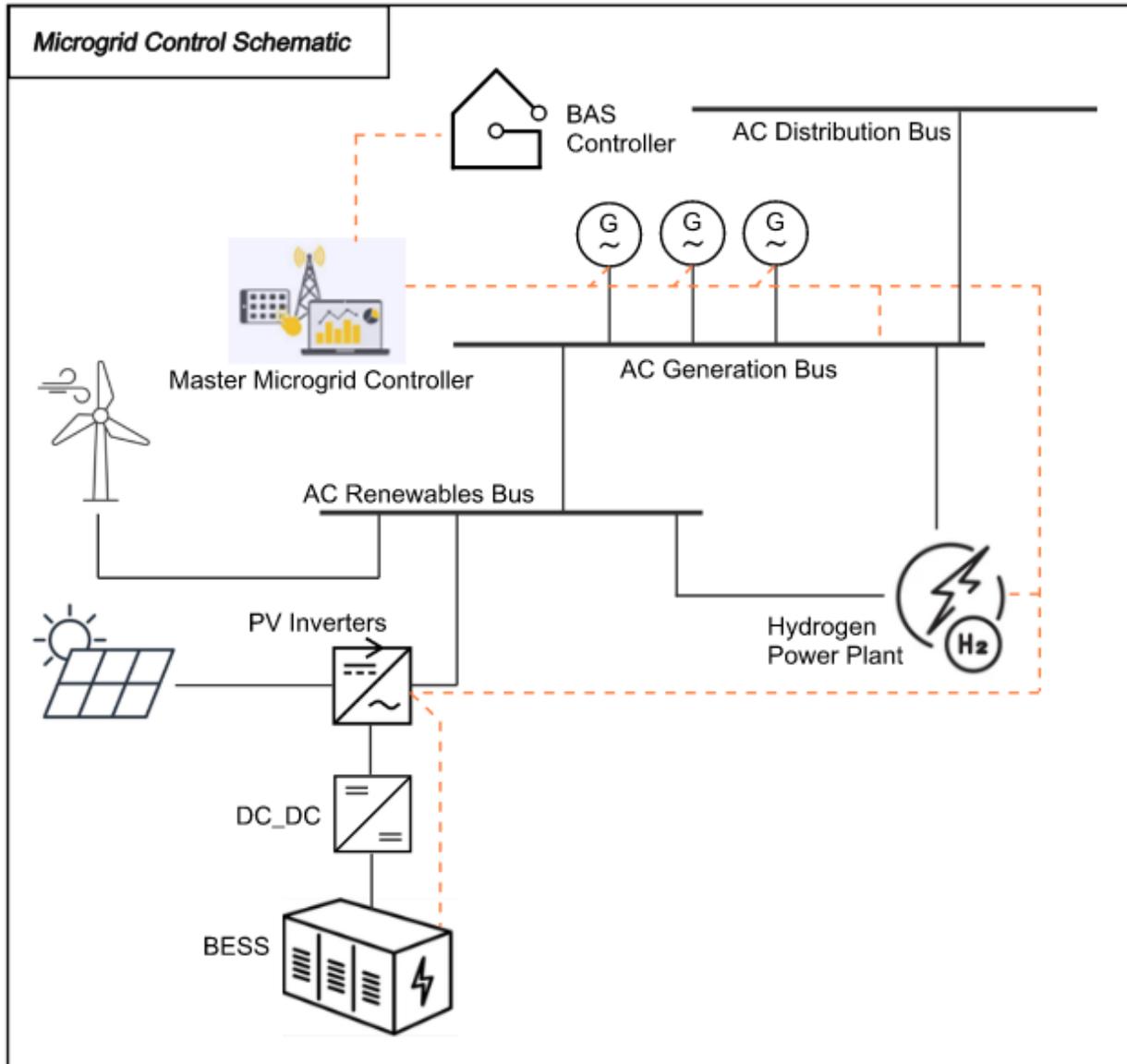


Reduction - Mechanical

MECHANICAL SYSTEMS - PLANT LEVEL



NSF Summit Station - Greenland



NSF Summit Station - Greenland



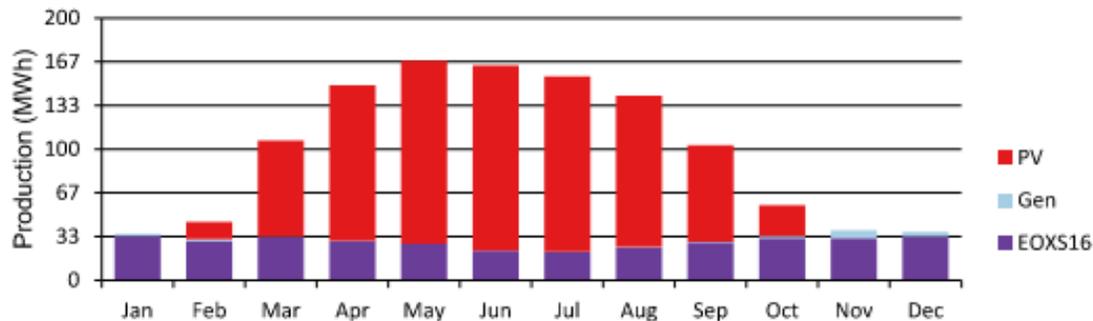
PROPOSED SYSTEM



We propose adding 600 kWh of battery capacity and 90 kW of wind generation capacity. This would reduce your operating costs to \$601,089/yr. Your investment has a payback of 0.361 years and an IRR of 282%.

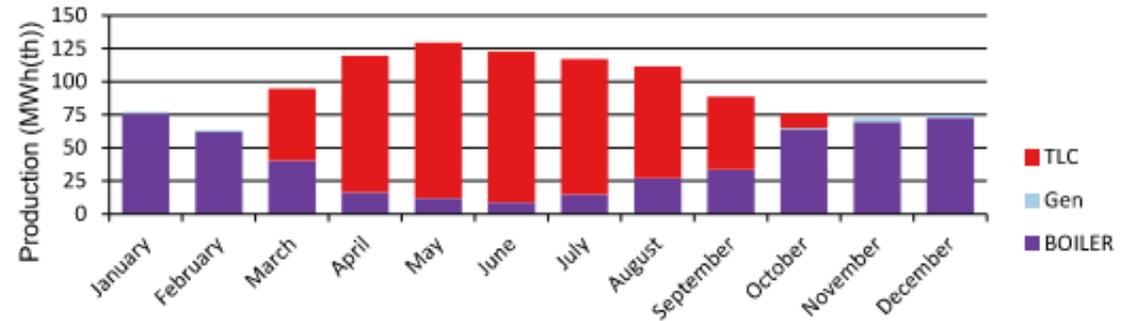
Electric Consumption

This microgrid requires 1483 kWh/day and has a peak of 537 kW. In the proposed system, the following generation sources serve the electrical load.

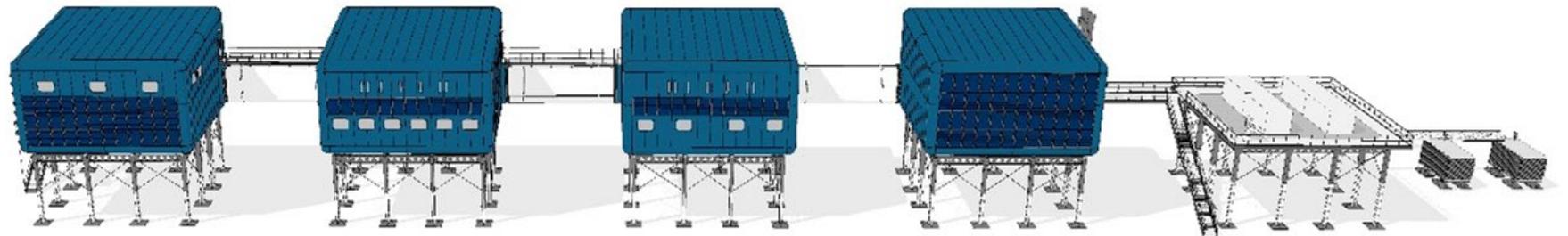
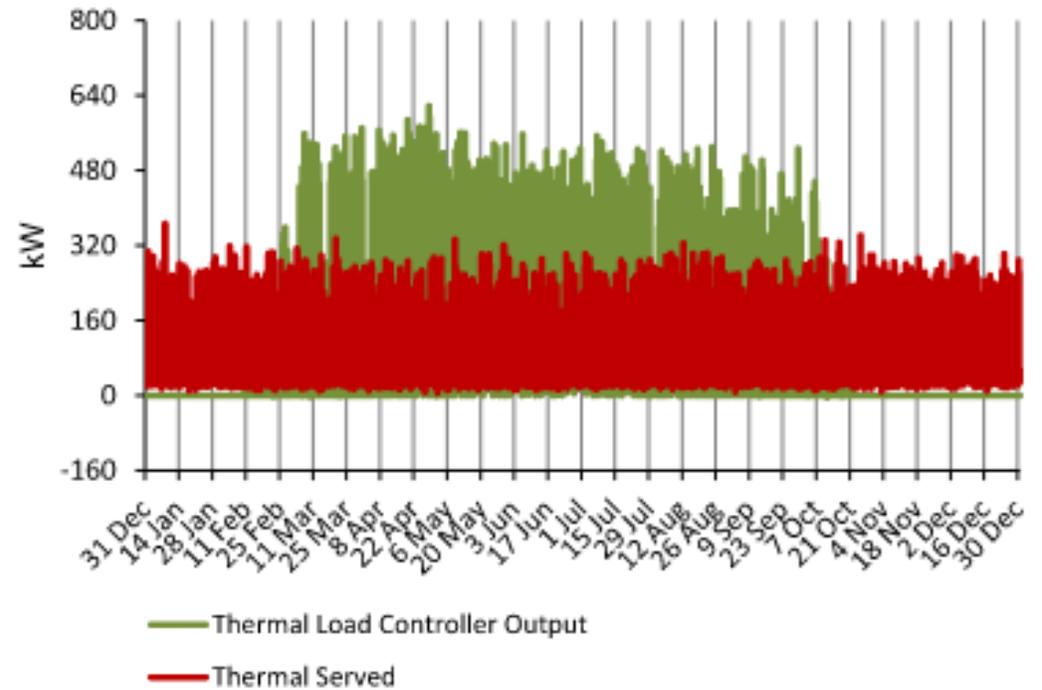
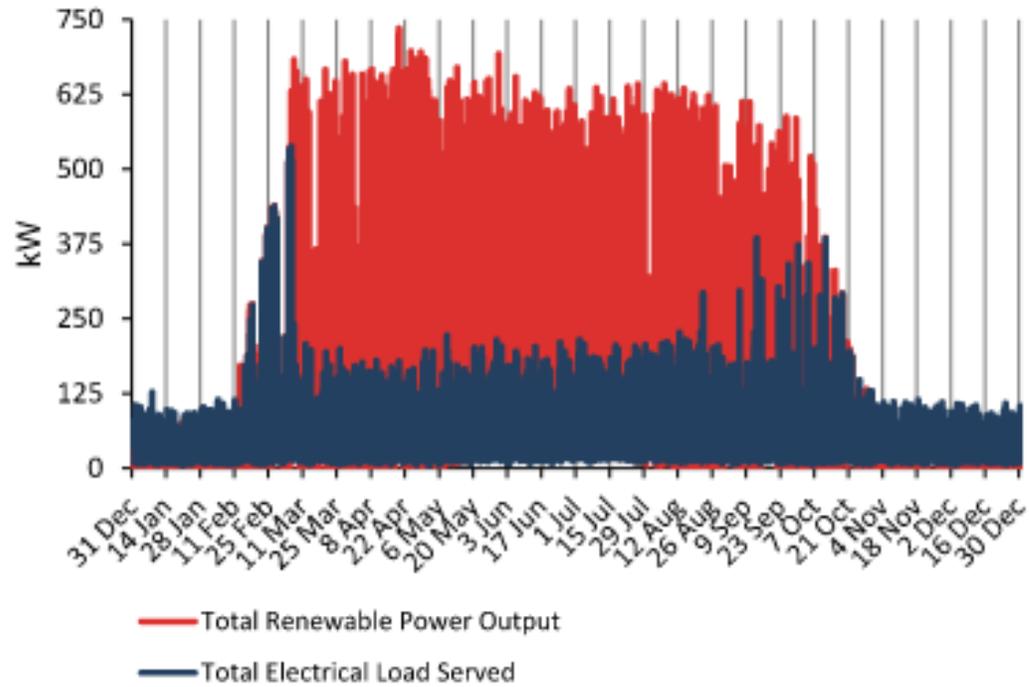


Thermal Consumption

This microgrid requires 2424 kWh(th)/day and has a peak of 366 kW. In the proposed system, the following generation sources serve the thermal load.



NSF Summit Station - Greenland



Questions/Discussion



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