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KUUGALAK CULTURAL WORKSHOP
ENERGY MODEL REPORT UPDATE

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June 14, 2023

ENERGY MODEL OVERVIEW

The Kuugalak Cultural Workshop is a pilot building which has been designed to be constructed in Cambridge Bay, Nunavut as a living lab; situated within Climate Zone 8 as defined by the National Energy Code of Canada for Buildings (NECB). Climate Zone 8 is the most northern zone in Canada with the highest number of heating degree days (highest heating energy demand). Based on data from a report by ENERGY STAR® Portfolio Manager, *Energy Benchmarking Data Snapshots for All Building Types*, the annual site Energy Use Intensity (EUI) benchmark is expected to range from 1.53 to 2.1 GJ/ m² (425 to 583 kWh/m²). The energy analysis outlined in this report was completed using the RETScreen® Clean Energy Management Software. The energy model described as the proposed case in this report is based on available information from the *Issued for Building Permit* set of design documents. The baseline energy modelling case is based on what would be expected as typical construction practice in the region and is provided for relative comparison only.

METHODOLOGY

Building Geometry and Room Usages

An overview of the building form and room types is shown in Figure 1 below. The workshop has a hexagonal core and two attached pods with different room usages. The cultural workshop core would be the primary occupied area, and the pod areas include supporting services and meeting/storage space. The entrance of the building was divided as cold and warm vestibules to serve as a conditioning buffer zone in the extreme cold climate of Nunavut.

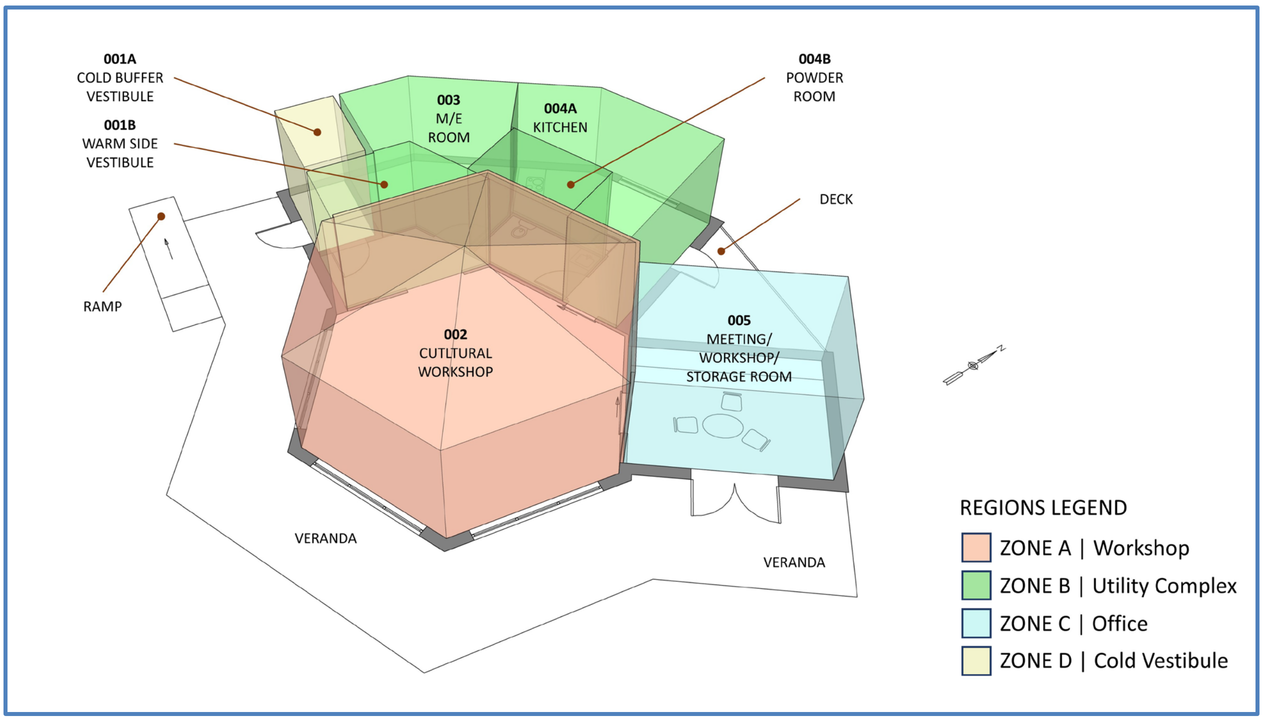

Figure 1: Building Form and Room Types

Occupancy Loads

The average occupancy load within the facility for most of the building's operation schedules is assumed to be six persons simultaneously.

Modelling Principles

As mentioned in the Energy Model Overview, there are two cases examined: the base case and proposed case. Both cases utilize identical geometry, dimensions, occupancy loads, and room usage. However, the main differences are the type of building envelope construction, conditioning system, lighting and renewable source integration.

THE ENERGY EFFICIENT DESIGN OF THE WORKSHOP

Building Envelope

The designed building envelope maximizes its thermal barrier continuity and airtightness between the R40 wall and R60 Roof and R45 Floor against the mentioned challenge. In accordance with the ZS2 Structural Drawings, all the basic units assembling the envelope are structural insulated panels (SIP) produced by ZS2 technologies.

Mechanical Systems

The local climate is a crucial factor in consideration for heat conversion technologies. Systems have been selected to reduce the direct exchange of air and water across the thermal barrier of the building. The proposed design has a more efficient boiler (87% efficient compared with 80% for the base case) which serves the air heating and glycol loop (radiators and in-floor heating). The heat recovery ventilator (HRV) has a 62% recovery rate instead of just 55% in the base case. Moreover, integrating a DryAbove In-floor heating layer may prevent heat loss through the high-raised floor system. As a result, the heating loop could provide 37,463 and 28,188 Btu/hr loads in the workshop core and meeting/ storage room pods, respectively.

The mechanical design includes an electric hot water heater. Compared to diesel-fuelled water heaters which are more common in the region and have efficiencies ranging from 53-60%, electric water heaters have higher efficiencies reaching 99%. In addition, this energy demand can also be sourced through renewable energy, such as solar photovoltaic (PV) panels. Solar PV generation capacity can be expanded in the future, reducing the environmental impact of the operational energy requirements.

Electrical Systems and Lighting

Both base and proposed cases have identical electrical appliance loads. The lighting design of the proposed building includes lower wattage LED lighting fixtures compared with the base case assumptions, which means the proposed lighting design is expected to use less energy.

Renewable Energy System

There are 16 solar PV panels with a 6.7 kW capacity designed to be installed on the roof or serve as a solar awing. The electrical energy generated from the solar PV is calculated in the energy model to quantify how much of the building’s operational electricity needs can be offset. Twelve of the 16 panels were designed as an awing system to regulate natural solar incidence from the windows on the south elevation in different seasons, providing further benefit to keep the space cooler during warmer months.

SUMMARY OF PERFORMANCE

Under the analysis with the conditions mentioned above, the energy model is simulated for one year thoroughly. The base case resulted in a site Energy Use Intensity (EUI) of 857 kWh/m², which exceeds the assumed benchmark range of 425 to 583 kWh/m². The proposed case has a site EUI of 441 kWh/ m² before any renewable energy generation is accounted for. Among every investigated category in this modelling report, most of the energy savings are attributed to more efficient mechanical systems and improved thermal resistance of the building envelope (49% reduction of space heating from base case to proposed case). With the additional electrical supply by solar PV panels, the Kuugalak Cultural Workshop's overall performance is further reduced to 376 kWh/ m² of annual site EUI, which would represent overall performance of 56% more energy efficient than the base building assumptions.

Direct diesel consumption during building operations significantly contributes to the overall carbon footprint. However, the electricity loads have a minor discrepancy in carbon footprint between the two cases. Electrical loads in different aspects of the building have less distinction between proposed and base cases. Furthermore, the on-site electricity generation, primarily through renewable resources, would reduce the reliance on the municipal grid network in advance. Refer to Table 1 below for a summary of the results.

Table 1: Summary of Modelled Annual Energy Performance

	Fuel Load Distribution (kWh)		Description		
	Base Case	Proposed Case			
Space Heating	67,264.00	29,663.00	The HVAC Air Heating for conditioning space		
Heat Trace[1]	3,947.00	3,043.00	Heat trace pipe around plumbing system		
Mechanical Units	5,298.00	4,388.00	The electrical load at furnace, unit heaters under their assumed duty cycles.		
Fans	5,195.00	2,761.80	Heat recovery fan units and kitchen range exhaust fans		
DHW	363.30	194.00	Domestic hot water supply without heat recovery design		
Lighting	1,154.00	404.10	General interior lighting		
Water Pump	459.00	424.00	Pump for all water uses in the building		
Appliances	4,573.00	4,573.00	Arctic Living Requirements and Kitchen		
EUI (kWh/m²)	856.83	441.27	Building Footprint Area	103	m²
Electricity Grid	16,679.00	12,744.90	Carbon Factor[2]	0.795	kg-CO_2/kWh
Fuel-Diesel	71,574.30	32,706.00	Carbon Factor[2]	0.253	kg-CO_2/kWh
CO_{2eq} (Tonne)	31.37	18.41	Net equivalent mass of carbon dioxide emission		
Renewable Source Generated Energy (kWh)					
Solar (kWh)	0.00	6,717.00	On-site electricity generation by 16 solar panels		
$CO_{2e,Saving}$ (Tonne)	0.00	5.34	Net equivalent saving mass of carbon dioxide emission		
Net Total					
Total (kWh)	88,253.30	38,733.90	Annual Net Total Energy in Fuels Consumption		
EUI (kWh/m²)	856.83	376.06	Annual Energy Use Intensity		
CO_{2eq} (Tonne)	31.37	**13.07**	Net equivalent mass of carbon dioxide emission		

[1] This item indicates the reheat fuel consumption in the heat trace looping around the sewage tank preventing the liquid wastes in the tank from freezing. The proposed case was assumed to have dynamic operation schedule and better insulation around the trace tubes than base case assumption.

[2] An equivalent carbon factor per unit of energy consumed from the electricity grid of Nunavut or a specific type of fuel. The factors referenced by the RETScreen software were checked against the data reported in Canada's National Inventory Report (2020 data): https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/inventory.html

https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/index.html

LIMITATIONS OF USE

This report has been prepared for the exclusive use of Pitquhirnikkut Ilihautiniq/Kitikmeot Heritage Society for the purpose of understanding the energy performance expectation for the proposed building. Energy modelling assumptions are conservative in nature, as is consistent with modelling best practice, which may result in overestimating energy use in some areas. The modelling outcomes are given under the convenience to NASA climate data, uniformity of building envelope and averaged mechanical and electrical performance under a fixed schedule. Any dynamic and human factors were not under the consideration of the model. In reality, there are many reasons that actual measured energy performance will differ from modelled performance which include, but are not limited to, actual weather and temperatures, occupant behaviour, building use, construction practices, and mechanical equipment operation.