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KUUGALAK CULTURAL WORKSHOP ENERGY MODEL REPORT UPDATE

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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 and therefore the highest expected energy use intensities (EUI) for buildings. According to a report by ENERGY STAR® Portfolio Manager, Energy Benchmarking Data Snapshots for All Building Types, the annual site Energy Use Intensity (EUI) benchmark could be from 1.53 to 2.1 GJ/ m^2 (425.00 to 583.33 kWh/m^2, Top 15% Canadian Energy Load of F3 building with similar area to the workshop) for the workshop building type built through typical construction practice in the region. To evaluate the expected energy performance of the building design, an energy analysis was completed using 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.

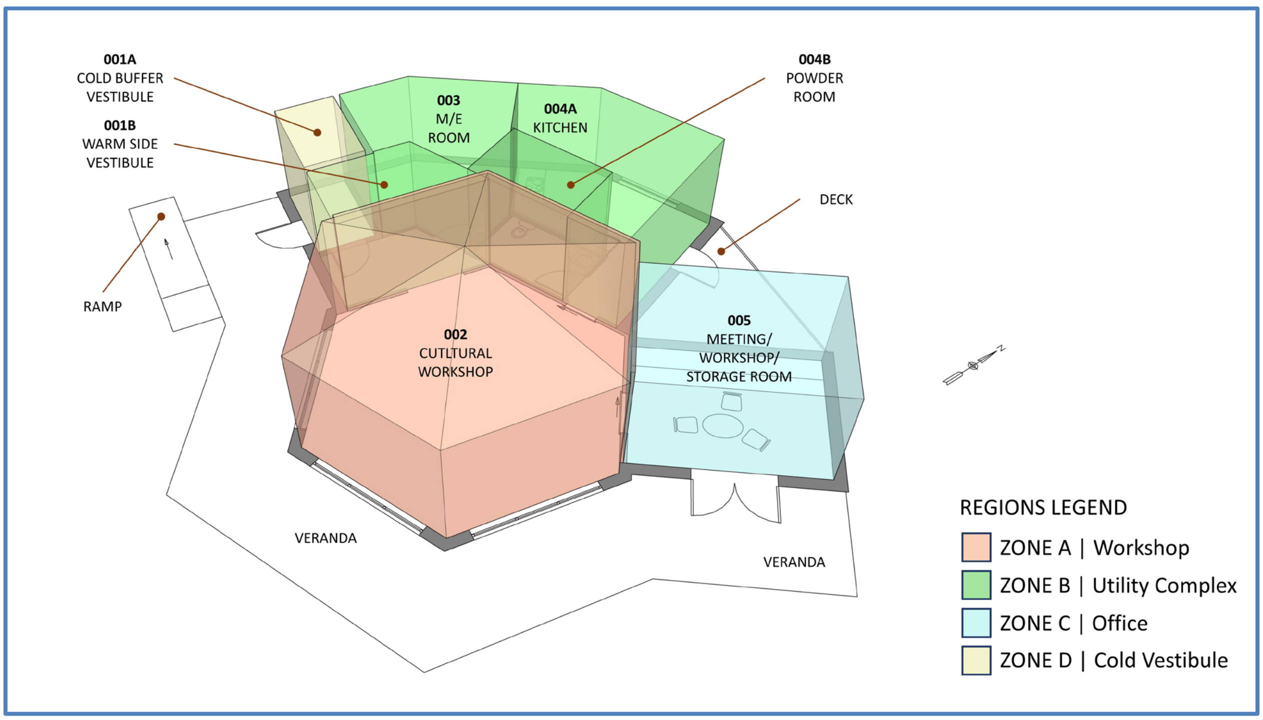

Figure 1: Building Form and Room Types

Occupant Loads

The average occupant load used for the majority of scheduling in the model is 6 persons in the entire building at the same time.

Modelling Principles

Identical geometry (dimensions), occupant loads, and room usage are applied on both base and proposed cases. Under the mentioned condition, the assumed base case is modelled with building envelope parameters consistent with conventional wood stud frame structure and has diesel-powered mechanical systems; whereas the proposed case is modelled with the features illustrated in the following paragraphs.

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. According to the ZS2 Structural Drawing, all the basic units assembling the envelope are structural insulated panels (SIP) produced by ZS2 Technologies.

Mechanical Systems

The expected typical hot water heater in the region uses diesel fuel and generally converts fuel into the heat in water at an efficiency of only 53-60%. To improve the efficiency of hot water supply, an electrical hot water heater will be introduced for the daily demands. It may not only have a higher conversion efficiency of 99%, but also may be powered by renewable electricity sources in the future.

The local climate results in the importance of heat conservation technologies to reduce the direct exchange of air and water across the thermal barrier of the building. The proposed case 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, the integration of a DryAbove In-floor heating layer may prevent the heat loss through the high-raised floor system. The heating loop could provide 37,463 and 28,188 Btu/hr loads in workshop core and meeting/ storage room pods respectively.

Electrical Systems and Lighting

Both proposed and base cases have identical electrical appliance loads. The luminance supplied by conventional measures in each room of the base case differs in the proposed case. Lower wattage LED lighting fixtures are specified for the proposed design.

Renewable Energy System

There are 16 solar panels with 6.7 kW capacity designed to be installed on the roof or serving as a solar awing. It is the most direct reduction of the demand from the municipal electrical grid. The 12 of 16 panels were designed as an awing system to regulate direct solar incidence from the windows on the south elevation in different seasons. The effect also helps to regulate energy consumption.

SUMMARY OF PERFORMANCE

Under the assumptions mentioned above, the results illustrated the site EUI of the base case would be 822 kWh/m^2. This result is higher than that of assumed benchmark range (425.00 to 583.33 kWh/m^2) and proposed high-performance design of 411 kWh/ m^2 even before any renewable energy compensates partial energy consumption in the building. Among every investigated category in this modelling report, the majority of the energy savings is attributed to more efficient mechanical systems and the thermal resistance of the envelope (55% reduction of space heating from base case to proposed case). It is also the most carbon footprint contribution during building operation by direct diesel consumption. Electrical loads in different aspect of the building have less discrepancy between proposed and base cases; however, the on-site electricity generation, especially through renewable resource, would reduce the reliance on the municipal gird network. With the electrical supply by solar PV panels, the overall performance of the centre could be further reduced to 345 kWh/ m² of annual EUI, which would be 58% more energy efficient than the speculated general Nunavut building with the same occupancy class. Refer to Table 1 below for a summary of results.

Table 1: Summary of Modelled Annual Energy Performance

	Fuel Load Distribution (kWh)		Description		
	Base Case	Proposed Case			
Space Heating	67,264.00	29,608.00	The space heating through HVAC and radiator loops		
Heat Trace	548.00	69.80	Plumbing system pipe heat trace		
Mechanical Units	5,298.00	4,388.00	Heat Recovery Ventilation Unit		
Fans	5,227.30	2,790.33	Inlet, exhaust and circulation fans of HVAC		
DHW	145.20	84.80	Domestic hot water supply		
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 Essentials and Kitchen, Washroom Exhaust Fan		
EUI (kWh/m²)	822.02	411.09	Building Footprint Area	103	m²
Electricity Grid	16,711.30	12,664.23	Carbon Factor	0.795	kg-CO_2/kWh
Fuel-Diesel	67,957.20	29,677.80	Carbon Factor	0.253	kg-CO_2/kWh
$CO_{2e,equ}$ (Tonne)	30.48	17.58	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)	84,668.50	35,625.03	Annual Net Total Energy in Fuels Consumption		
EUI (kWh/m²)	822.02	345.87	Annual Energy Use Intensity		
$CO_{2e,equ}$ (Tonne)	30.48	**12.24**	Net equivalent mass of carbon dioxide emission		

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. 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.