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SSRIA- No Demo NZE

Energy Consumption and Utility Cost Analysis Report

Context of the case study:

Amelie has been in the energy efficiency world since 2001. In the past 20 years, the only message she had heard in regards to making houses NetZero Energy (NZE) was to "add more insulation" to reduce the heating requirements for the house. This would then reduce the sixing of mechanical systems required to keep the house warm in winter. She even did her Masters in Austria where she took the Passivhaus course with its emphasis on insulation.

When she returned to Canada, she met a mechanical engineer who suggested that an active approach with a ground source heat-pump (geoexchange) would be a more cost-effective approach than adding Passivhaus levels of insulation.

The other idea that poked her interest in approaching NZE the way she did is the larger carbon footprint attached with the renovation of existing homes. Why would a homeowner want to demolish a house that isn't ready for landfill JUST to get to an energy target? Not only is this very invasive, but it also doesn't make any sense carbon-wise.

There were also some very specific legal bylaws (clearance to neighboring homes) that prevented her from insulating the outside of the house nearest the neighbors. So, after MUCH analysis and projections, Amelie decided to try the mechanical engineer's theory. I set out to find an existing home and test this very interesting approach.

The house was purchased in August 2021, and the retrofitting took place between Sept 2021 and Sept 2022.

The second part of this case study was the monitoring and analysis of data collected for the following 12 months period.

Date Range:

- Before Renovations: Sept 21, 2021, to September 21, 2022
- After Renovations: September 21, 2022, to September 21, 2023

Summary:

This report provides a comprehensive analysis of energy consumption, CO2 emissions, and utility costs before and after a renovation project. The data represents two key categories: "Modelled H2K" and "Total actual energy usage (all energy sources)." The renovation project aimed to enhance energy efficiency and reduce CO2 emissions. The results demonstrate significant improvements in energy efficiency and cost savings.

Data Overview:

The following table presents data for two key categories: "Modelled H2K" and "Total actual energy usage (all energy sources)." The data is divided into two periods: before renovations (from Sept 21, 2021, to September 21, 2022) and after renovations (from September 21, 2022, to September 21, 2023). The key metrics analyzed include energy consumption, CO2 equivalent emissions (CO2e), energy production, energy reduction, and cost of utilities.

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Item	Total Consumption before renos (Aug 21 21-Sept 21 22)	kg CO2e	Total consumption After renos (Sept 21 22 to Sept 21 23)	Energy Production	After renos kg CO2e	Energy reduction	Kg CO2e savings
Modelled H2K	143 GJ (39722 kWh)- 116 GJ Nat gas, 28 GJ elec	9296	61 GJ (16945 kwh)	39 GJ (10833 kWh)	2200	**-100 GJ**	**-10000**
Total actual energy usage (all energy sources)	137 GJ /year (38098 kwh)- 89 GJ Nat. gas, 48 GJ Elec	9784	75 GJ/ year - 100% electric (20881 kwh)	46.5 GJ (12927 kWh)	2850	**-121.5 GJ**	**-12150**

Kg CO2e metrics: (averages)-no specific source-set as a reference

- Emissions from natural gas: 56 kg CO2e/GJ
- Emissions from electricity: 100 kg CO2e/GJ

Key Findings:

1. **Modelled H2K:**

    - Estimated Energy consumption significantly decreased from 143 GJ to 61 GJ (39,722 kWh to 16,945 kWh) after renovations.
    - CO2e emissions decreased by 6100 kg.
    - Energy production increased from 0 GJ to 39 GJ (0 kWh to 10833 kWh), further reducing CO2e emissions.
    - The energy reduction achieved is -100 GJ, resulting in substantial CO2e savings of -10,000 kg (all electric).

2. **Total Actual Energy Usage (All Energy Sources):**

    - Total energy consumption decreased from 137 GJ/year (38,098 kWh) to 75 GJ/year (20,881 kWh).
    - CO2e emissions decreased by 7500 kg.
    - Energy production after renovations increased to 46.5 GJ (12,927 kWh), further reducing CO2e emissions.
    - The energy reduction achieved is -121.5 GJ, leading to CO2e savings of 6934 kg.

3. **Life time savings in energy usage and kg CO2e**

A 25 year “life span” saving has been selected, as 25 years is a conservative life expectancy for geo-exchange heating/ cooling system and solar PV array. With this in mind, it is estimated that the house will have saved **3025 GJ of energy and 173,350 kg CO2e over a 25 year period.**

Conclusion:

The renovation project has been highly successful in improving energy efficiency and reducing CO2 emissions, resulting in significant cost savings. The data demonstrates the environmental and financial benefits of the renovations, making this a commendable effort in promoting sustainability and reducing the carbon footprint.

The findings from this analysis can serve as a valuable reference for future energy-efficient renovation projects, underscoring the importance of making environmentally conscious decisions to benefit both the planet and your budget. Further efforts can be made to monitor and improve these results in the future to continue the positive trend of reduced energy consumption and emissions.

Difference between H2K modelling and actual can be explained by the baseloads defaulted in Hot2000 software. The defaults are not representative of our family dynamics:

Hot2000 baseloads and occupancy vs actual baseloads and occupancy

Hot2000	**Actual**
Solar absorptivity: 0.4	**Same**
Thermal Mass (MJ/m2C): 0.06	**same**
Daytime heating set point: 21C	**20.5 C**
Night time Heating Set Point: 18C	**20.5 C**
Cooling set point: 25C	**21 C**
Basement heating set point: 19C	**20 C**
Heating set Point: 22C	**20.5 C**
2 Adults at Home 50% of the time	**3 Adults at Home 100% of the time**
2 children at home 50% of the time	**1 child at home 50% of the time**
Internal gain fraction: 0.15	**same**
Electrical load appliances: 7.82 kwh	**Estimated much higher**
Lighting: 2.6 kwh	**Estimated similar**
Other electrical load: 9.7 kwh	**Home Office- 6 screens, 2 lap tops-reptile tank**

Section 4 – Project Specific Results and Report:

<u>Summary: Performance Metrics for GSHP and DHW.</u>

This section presents an analysis of the performance metrics related to the Geo Field, Ground Source Heat Pump (GSHP), and Domestic Hot Water (DHW) systems. The data covers various aspects, including incoming water temperatures, electric consumption

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for heating and cooling, and the energy balance towards achieving Net Zero Energy (NZE). The findings provide insights into the system's efficiency, energy usage, and the potential for achieving NZE status.

Geo Field incoming water T in Heating	MIN 0C monitored, expected -1.5C
Geo field incoming water T in Cooling	MIN 2C to 3C
GSHP electric consumption- Heating 20 C (average)	27.4 GJ (7617 kWh) (November to April)
GSHP electric consumption-Cooling 22.5 C (average)	8.4 GJ (2343 kWh) (May to October)
Total GSHP electric consumption 12 months	9961 kWh (35.8 GJ)
DHW Electric consumption – heating season	4.2 GJ (1159 kWh) (November to April)
DHW Electric consumption- Cooling season	5 GJ (13888 kWh) (May to October)
Energy balance to NZE	Usage: 20881 kWh, production: 12927 kWh, balance of 7954 kWh (short 38%)

Data Overview:

The data in the chart includes several key performance metrics:

1. **Geo Field Incoming Water Temperature in Heating:**
    - Minimum Monitored Temperature: 0°C
    - Expected Temperature: -1.5°C
2. **Geo Field Incoming Water Temperature in Cooling:**
    - Minimum Temperature: 2°C to 3°C
3. **GSHP Electric Consumption - Heating (20°C average):**
    - Total Consumption (November to April): 27.4 GJ (7,617 kWh)
4. **GSHP Electric Consumption - Cooling (22.5°C average):**
    - Total Consumption (May to October): 8.4 GJ (2,343 kWh)
5. **Total GSHP Electric Consumption - 12 Months:**
    - Total Consumption: 9,961 kWh (35.8 GJ)
6. **DHW Electric Consumption - Heating Season:**
    - Total Consumption (November to April): 4.2 GJ (1,159 kWh)
7. **DHW Electric Consumption - Cooling Season:**
    - Total Consumption (May to October): 5 GJ (13,888 kWh)
8. **Energy Balance to NZE:**

- Usage: 20,881 kWh
- Production: 12,927 kWh
- **Balance: 7,954 kWh (short 38%)**

Key Findings:

1. **Geo Field Incoming Water Temperature:**
   - The monitored minimum temperature in heating season is 0°C, which closely aligns with the expected temperature of -1.5°C. This indicates effective system operation.
2. **GSHP Electric Consumption:**
   - During the heating season (November to April), the GSHP consumes 27.4 GJ (7,617 kWh).
   - During the cooling season (May to October), the consumption is 8.4 GJ (2,343 kWh).
   - The total electric consumption for 12 months is 9,961 kWh (35.8 GJ).
3. **DHW Electric Consumption:**
   - The DHW system consumes 4.2 GJ (1,159 kWh) during the heating season and 5 GJ (13,888 kWh) during the cooling season.
4. **Energy Balance to NZE:**
   - The energy balance towards achieving Net Zero Energy (NZE) indicates that 38% of the energy requirements are not being met. The system produces 12,927 kWh while consuming 20,881 kWh.

Conclusion:

The performance metrics presented in this report highlight the effective operation of the GSHP, and DHW systems. The close alignment between monitored and expected temperatures in the Geo Field demonstrates the system's reliability. However, the energy balance data suggests that further optimization is needed to achieve Net Zero Energy status, as 38% of the energy requirements are not being met. This could involve improvements in energy production, storage, or more efficient energy use.

Overall, the data provides valuable insights into the system's performance, which can be used to identify areas for improvement and ensure energy efficiency and sustainability goals are met.

Peak load analysis:

Summary:

This section provides an analysis of the peak current consumption data for the house and the Ground Source Heat Pump (GSHP) for the period from September 21 2022 to September 21, 2023. The data includes peak usage and peak kickstart currents for both the house and the GSHP, along with Domestic Hot Water (DHW) consumption. The findings in this section aim to shed light on electricity usage patterns and the efficiency of the GSHP system during this time frame.

	Total house Peak-usage (A)	Total house peak-kickstart** (A)	GSHP-usage (A)	GSHP kick start** (A)	DHW (A)
Sept 21 2022 to Sept 21 2023	82.8	89.7	19.7	76.9	19.7

** The term “kick-start” indicates the nano-second when the heat pump turns on.

Data Overview:

The data in the chart presents peak current consumption values for the house and the GSHP, as well as DHW consumption, for the specified period:

- **Total House Peak Usage (A):** 82.8 A
- Total House Peak Kickstart** (A): 89.7 A
- **GSHP Usage (A):** 19.7 A
- GSHP Kickstart** (A): 76.9 A
- **DHW (A):** 19.7 A

Key Findings:

1. **Total House Peak Current Consumption:**
    - During the specified period, the total house peak current usage was 82.8 A.
2. **GSHP Current Consumption:**
    - The GSHP's current consumption during this time was 19.7 A.
3. **DHW Current Consumption:**
    - The Domestic Hot Water system drew 19.7 A of current during this period.

Conclusion:

The house's total peak current consumption is relatively consistent with a slight increase during the peak kickstart phase. This indicates that the house's electricity usage patterns are relatively stable, with occasional spikes in current demand.

Indoor air quality:

Summary:

This section provides an overview of indoor environmental metrics, including temperature, relative humidity (RH), volatile organic compounds (VOC), and radon levels in different areas of the building, specifically the Basement, Main, and Upper floors. The data is divided into two categories: Heating and Cooling conditions. The findings aim to assess the comfort and air quality within the building, and to highlight any areas that may require attention or improvement.

Metric	Basement	Main	Upper
Heating average T (C)	21	21	21
Heating average RH (%)	47.3	42.6	43.6
Heating average VOC (ppb)	N/A	139	165
Heating Basement radon (Bq/m3)	323.65		
Cooling average T (C)	21	22	23
Cooling average RH (%)	51	43	42

Cooling average VOC (ppb)	N/A	140	146
Cooling Basement Radon (Bq/m3)	314		

Data Overview:

The data in the chart represents several key indoor environmental metrics for each of the three building areas during both Heating and Cooling conditions:

Heating Conditions:

- **Heating Average Temperature (°C):** 21°C in the Basement, Main, and Upper floors.
- **Heating Average Relative Humidity (RH) (%):** 47.3% in the Basement, 42.6% in the Main floor, and 43.6% in the Upper floor.
- **Heating Average VOC (ppb):** Not available (N/A) in the Basement, 139 ppb in the Main floor, and 165 ppb in the Upper floor.
- **Heating Basement Radon (Bq/m³):** 323.65 Bq/m³.

Cooling Conditions:

- **Cooling Average Temperature (°C):** 21°C in the Basement, 22°C in the Main floor, and 23°C in the Upper floor.
- **Cooling Average Relative Humidity (RH) (%):** 51% in the Basement, 43% in the Main floor, and 42% in the Upper floor.
- **Cooling Average VOC (ppb):** N/A in the Basement, 140 ppb in the Main floor, and 146 ppb in the Upper floor.
- **Cooling Basement Radon (Bq/m³):** 314 Bq/m³.

Key Findings:

1. **Heating Conditions:**
    - Temperature: All floors maintain a consistent temperature of 21°C during heating.
    - Relative Humidity (RH): The Basement has the highest RH at 47.3%, while the Main and Upper floors have slightly lower RH levels (42.6% and 43.6%, respectively).
    - VOC Levels: VOC levels are highest in the Upper floor (165 ppb) and lower in the Main floor (139 ppb). The Basement is not available (N/A).
    - Radon Levels: The Basement exhibits a radon level of 323.65 Bq/m³ during heating.

2. **Cooling Conditions:**
    - Temperature: The cooling temperature differs slightly between floors, with the Basement at 21°C, the Main floor at 22°C, and the Upper floor at 23°C.
    - Relative Humidity (RH): The Basement has the highest RH at 51%, while the Main and Upper floors maintain lower RH levels (43% and 42%, respectively).

- VOC Levels: VOC levels are higher in the Upper floor (146 ppb) and the Main floor (140 ppb), with N/A levels in the Basement.
- Radon Levels: During cooling, the Basement shows a radon level of 314 Bq/m³.

Cost Analysis:

The overall budget of the project is as follows:

- geo-exchange $68000 ($40000 on drilling, $28000 for swapping of HVAC and bringing geo exchange field pipes within the house.); no secondary heating required
- solar $28000
- Aerobarrier $4500: please note that this is ONLY the fees for Aerobarrier, the prepping of the house was done by myself. It took about 35 man hours to prep the entire house.
- miscellaneous $5800 in (permits, panel upgrade etc)

Total of $106000

Utility cost prior to reno (Gas and Electric)	Monthly average- pre reno	Utility cost after reno (all electric)	Monthly average- after renos	Total cost of project	Monthly cost over 25 years + utilities	Monthly utility- Break even
$5309	$442	$3572	$152	$106000	$368 + $152 = $520	**$598**

Utility costs decreased from $5,309 to $3,572 after the renovations, resulting in cost savings of -$1,737 (-32%).

Return on investment over 25 years (solar module warranty and typical mortgage):

- $106000 would equal to $4236 per year.
- Aeroseal and upgrades appliances: extra of $156 per year (same time period)
- Currently still paid $1835 in utilities.

Break even amount on a yearly basis (renos + utilities) is: $6227 per year (aver. $520 per month)

Pre-reno annual utility bills: $5300/year ($442 aver. per month- based on aver. total electrical rate of 0.32$ /kwh and aver. total price of Natural gas $15/ GJ)

If we still had our gas and electrical energy sources, we see a savings when the combined price of utilities increases our monthly bills by $78 per month on average or more!

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Conclusion:

The data provided in this report offers valuable insights into the indoor environmental conditions within the building during heating and cooling periods. Overall, the temperature and relative humidity levels remain within a comfortable and reasonable range. However, some variations exist between the different floors, which may be due to occupant behavior.

The presence of radon in the Basement during both heating and cooling conditions suggests that radon mitigation measures may be needed to maintain a safe indoor environment.

Regular monitoring and assessment of these metrics can help in maintaining a healthy and comfortable indoor environment and addressing any potential issues related to air quality and radon exposure. Further actions may be required to optimize air quality and safety within the building.

NetZero Energy Remediation Strategy:

1. **Upgrading Washing Appliances:**
   - Replacing the current cloth washing appliances with a more efficient washing machine and ASHP (Air Source Heat Pump) dryer is a significant energy-saving measure, (Nov 7 2023)
   - New dryer annual usage: 1200 kWh (compared to 5600 kWh)
   - Increase in usage (from 4 hours to 6 hours per week) should be monitored to ensure overall energy savings.
2. **Heating System Duct Cleaning and Aeroseal:**
   - Cleaning and Aerosealing heating system ducts can lead to a significant reduction in heating demand.
   - Scheduled installation on October 23, 2023.
   - After installation, energy consumption data should be monitored to confirm the reduction in heating demand. Aeroseal claims a 30% reduction on the energy usage of the house, which would be a reduction of 3900 kWh over the next 12 months period (sept 21 2023 to Sept 21 2024)

Indoor Air Quality (IAQ) Improvement:

- **Radon Mitigation:**
  - High radon levels in summer conditions indicate the need for mitigation.
  - Installing a radon mitigation pipe in the mechanical room will help reduce radon gas levels, improving IAQ.
  - Regular monitoring of radon levels is crucial to ensure the effectiveness of the mitigation system.

By implementing this remediation strategy and paying attention to energy usage, Amelie is on the right path to achieving NetZero Energy while also addressing indoor air quality concerns. Regular monitoring and maintenance will be key to achieving her sustainability goals.

I have completed the results from data collected via all our monitoring systems and too the best of my ability, and have used an average CO2Eq emissions to keep the report simple. Some sources will differ than others depending on their time of creation as the Alberta Utility grid is constantly improving.

I welcome any feedback on this report .

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