Northern Arapaho Tribe

Appendix C: Technical Appendix

<u>Create New DOE "Zero Energy Ready" Level Homes for Tribal Members</u>

Description

The Northern Arapaho Tribe manages affordable housing for Tribal members via the Northern Arapaho Tribal Housing. Under the proposed plan, residents will continue to be responsible for their utility bills, but the new homes will be designed to significantly reduce these costs. The Tribe proposes developing new, highly insulated, high-performance, affordable homes for tribal members. These new homes will follow the US Department of Energy's Zero Energy Ready Home Program[1]. Zero Energy Ready Homes are high-performance homes that are so energy efficient that a renewable energy system could offset most or all the home's annual energy use. To achieve the level of high performance required to achieve this level, the home designs will follow Passive House principals for thermal, air, radiation, and moisture control[2]. This level of design will also bring a level of resiliency to residents where the home's performance will protect occupants from harsh environmental conditions in the event of prolonged power outages.

One key factor to consider is that the Wind River Reservation is located within the Rocky Mountain Power Area (RMPA) eGRID Subregion. This subregion heavily relies on fossil fuels (62.6%) for electricity generation, resulting in a significant carbon footprint of 1166.15 lbs. of CO2e per MWh, as reported by the EPA. Simply electrifying home HVAC systems will not be sufficient to offset greenhouse gas emissions, as using propane for heating in this region has a smaller carbon footprint. Therefore, the strategy to reduce a home's carbon footprint must also include the generation of on-site renewable electricity, in addition to the local utility providing cleaner electricity.

One of the key aspects of this proposal is the adoption of a communal approach to energy generation and distribution. The plan includes a fossil-fuel-free district energy system for heating and cooling and a community-scale photovoltaic (PV) array. This array will distribute power via a local microgrid, providing carbon-neutral electricity to a new 20-home community on the Reservation. By building the homes within a community where power and heat generation assets are shared among all the properties, we can maximize the use of communal renewable energy and a fossil fuel-free district energy system to meet all the home's power, heating, and cooling needs.

A microgrid is a group of interconnected loads and distributed energy resources that act as a single controllable entity to the primary utility grid. It can connect and disconnect from the grid to operate in grid-connected or island mode. Microgrids can improve customer reliability and resilience to grid disturbances and enable local power generation assets, such as renewables and battery storage, to keep the local grid running even when the larger grid experiences interruptions. In addition, microgrids allow local assets to work together to save costs, extend the duration of energy supplies, and produce revenue via market participation. Microgrid projects continue to gain prominence in the energy sector due to the increased resilience, flexibility, and efficiency these localized energy systems offer, incentivized further by

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[1] https://www.energy.gov/eere/buildings/zero-energy-ready-home-program

[2] https://www.phius.org/passive-building/what-passive-building/passive-building-principles

federal and state support for their development. Microgrid installations are expected to grow dramatically as distributed energy prices drop, and worries heighten about electric reliability because of severe storms, cyberattacks, and other threats.

The microgrid envisioned will serve the residential loads behind a point of standard coupling with the local electric distribution grid and distribute power across the community via underground electrical cabling for added resiliency against weather events. An initial feasibility study conducted as part of this project will determine total electrical loads, appropriate asset mix of PVs and storage, and approaches to ride through an extended grid outage to meet community needs and be in compliance with local utility and state regulations, which the team will use to develop the final budget and implementation schedule.

A district energy system utilizes a site-wide ground-coupled (aka “geothermal”) wellfield and heat pump system for heating and cooling needs. This ground-coupled condenser water system transfers heat between buildings and various system components. The primary benefits of this approach are the inherent energy efficiency benefit of moving thermal energy rather than creating it, and the flexibility to add both sources and sinks of thermal energy to the same shared infrastructure, with each drawing or rejecting heat to the central loop at any time as needed.

The geothermal system is a centralized heating and cooling infrastructure that allows heat exchange with Earth's relatively constant temperature throughout the year. It uses the earth, without any intermittent heat source (in the winter) or a heat sink (in the summer). The average annual effect on the ground temperature is minimal because of the cyclical nature of the seasons, and an ideal design will generally result in a seasonal balance of total heat extraction and total heat injection.

The network of underground piping is a closed loop system consisting of individual boreholes, piping loops, and interconnecting piping acts as a large heat exchanger, allowing the HVAC systems (primarily water source heat pumps) to take advantage of the moderate year-round ground temperatures to boost efficiency and reduce operational costs. Water is circulated through the well-field network to exchange heat between the earth and the buildings on the site. The entire piping system (vertical loops and horizontal interconnecting piping) is located below ground and provides excellent resiliency to weather events, as only the pumping stations are above ground.

Building energy efficiency will thus be a primary driver of reducing consumption. Homes will follow the Passive House design standards to perform up to 85% better than average homes. Initial concepts include utilizing an offsite prefabricated structure manufactured from Fiber-Reinforced Polymers (FRP) to meet required efficiency and air tightness standards and aid in scheduling construction around the harsh Wyoming winters. In addition to increased thermal properties, this system provides an additional layer of resiliency due to its inherent properties to withstand high winds and impact.

However, efficiency is not limited to building design and high-performance envelopes and systems. Building user behavior can increase the efficiency of the energy used in the buildings. Different strategies will be needed to address and support this issue. Achieving and maintaining energy-efficient behavior without decreasing the comfort of building occupants will remain a primary focus.

The benefits of utilizing a communal renewable and district energy approach and their inherent efficiencies allow residents to minimize, even eliminate, utility bills, further incentivizing living in this community and influencing occupant behavior.

GHG Reduction Estimate

During the design phase, the team will perform calculations to estimate both (1) the energy use of the proposed design and (2) that of a typical existing home, quantifying the annual electrical and fossil fuel savings of the proposed design and its GHG reduction. Before the design, GHG reductions relied on the strategy below to estimate potential savings.

Estimating the GHG reduction measures for this Priority Action is difficult to quantify for many reasons. Residential GHG emissions vary among individuals depending on the home's location, number of occupants, their habits, and personal choices. For example:

- The quantity of GHG gas emissions from home electricity use depends on the types of fuel utilized by the local electrical grid power plant to generate the electricity and the amount the home uses.
- The quantity of GHG emitted from heating the home depends on the fuel source, the equipment efficiency, and the home's size and exterior envelope insulation factor.
- The total number of occupants and their behavior far outweigh any other factors.

The below estimated GHG emission calculations utilize the EPA's Household Carbon Footprint Calculator[3] to provide a baseline GHG emissions factor. The inputs include home location, number of people, fuel for primary heating source, and average monthly natural gas, electricity, fuel oil, and/or propane usage.

Based on the utility data gathered for the Priority Climate Action Plan GHG Inventory, the primary residential utilities in this geographic area are electric and propane for heating. To provide baseline usage, the calculations utilize data via the US Energy Information Administration (EIA) for Wyoming's average US residential electrical and propane usage.

<u>Baseline:</u>

Based on the above, the EPA Household Carbon Footprint Calculator includes the following inputs to create the baseline:

- *Location*: 82501 zip code for Riverton, WY – proposed location for the proposed housing within the Wind River Reservation.
- *Number of People in the Household*: Six (6). Based on information provided by the Northern Arapaho Tribal Housing Authority, Tribally managed housing is multigenerational. The figure is an assumed average that includes a family of 4, plus either parents and/or extended family.
- *Electricity*: 891 kWh/month, or $98.78/month[4], per 2022 EIA data for Wyoming.

[3] https://www.epa.gov/ghgemissions/household-carbon-footprint-calculator

[4] In calculating the average use/cost per state for both electricity and propane, the EIA's information is unclear as to the average number of occupants per household that contributed to the calculation. This provides a variable to the overall GHG calculations.

2022 Average Monthly Bill- Residential

(Data from forms EIA-861- schedules 4A-D, EIA-861S and EIA-861U)

State	Number of Customers	Average Monthly Consumption (kWh)	Average Price (cents/kWh)	Average Monthly Bill (Dollar and cents)
Montana	540,745	908	11.33	102.94
Nevada	1,270,155	939	13.78	129.35
New Mexico	921,109	659	13.84	91.21
Utah	1,207,878	783	10.84	84.87
Wyoming	281,464	891	11.09	98.78

- *Propane*: 84.9 MBtu/household annually[5] or 7.08 MBtu/month per 2020 EIA data for Wyoming (note 2020 is the latest data available, released on June 23, 2023). The EPA calculator requires propane usage in gallons. Thus, using a conversion factor of 91,452 Btu/gallon, this equates to 77.36 gallons/month.

CE4.6.LP.ST Annual household site propane end-use consumption in the United States by state—averages, 2020

	Number of housing units (million)	Average site propane consumption (million Btu per household using the end use)			
	Total U.S.[a]	Total	Space heating[b]	Water heating	Other[c]
Wyoming	0.23	84.9	83.4	Q	Q

The baseline carbon emissions per the EPA Household Carbon Footprint Calculator is **31,921 pounds CO_2e/year (14.5 MT CO_2e/year)**.

<u>Proposed</u>

To determine potential GHG reductions, the below calculations are organized to reflect project development milestones that provide a gradual reduction in GHG emissions. The schedule milestones include 1) immediate post construction where each home will remain grid-tied for all electrical needs, 2) after the microgrid comes online to provide 100% renewable electricity to the development.

GHG Reductions 2025-2030 (Grid Tied):

During initial home occupancy after construction of the homes and district energy system is complete, but while the renewable microgrid is still in development, the homes will utilize the utility electrical supply to provide all electrical needs, including heating.

As the project has yet to be designed to determine equipment efficiencies and strategies, it is impossible to determine an accurate reduction in energy use from the baseline. However, for these calculations, the

[5] See above.

proposed reductions utilize the Passive House stated performance efficiency of up to 85% better than average homes[6].

As the proposed development will utilize electricity as the primary heating source, the calculations include converting the baseline propane consumption into an equivalent kWh and adding it to the total baseline electrical consumption to determine an overall kWh energy usage for comparison.

Baseline in kWh:

- Propane: 7.075 MBtu/month * 0.000293071 kWh/Btu = 2073.48 kWh/month
- Electricity: 891 kWh/month
- Total: 2964.48 kWh/month total

As noted above, assuming an 85% efficiency factor for designing to Passive House standards, utilizing the EPA's Household Carbon Footprint Calculator with the same zip code and home occupancy, the proposed reductions are as follows:

Reduction of Home Energy GHG emissions:

- 2964.48 kWh * 85% = 444.67 kWh/month
- Carbon emissions: 10,172 pounds CO_2e/year (per the EPA Household Carbon Footprint Calculator)
- Reduction: 31,921 pounds CO_2e/year (*baseline*) - 10,172 pounds CO_2e/year = **21,749 pounds CO_2e/year per home (9.9 MT CO_2e/year).**

As the proposed development is for 20 new homes, **there is a potential GHG reduction of 434,980 pounds CO_2e/year (197.3 MT CO_2e/year)**.

GHG Reductions 2025-2050 (100% Renewable Microgrid)

When the proposed affordable home development is paired with the renewable microgrid after it comes online, the assumption is that this would supply 100% of the development's electrical needs with renewable electricity. With this assumption, the proposed housing will achieve Net-Zero energy and carbon, resulting in a **potential annual GHG reduction of 638,420 pounds CO_2e/year (289.6 MT CO_2e/year)** in total for the entire development (31,921 pounds CO_2e/year (*baseline*) * 20 homes).

[6] https://www.phius.org/passive-building/what-passive-building/passive-building-principles

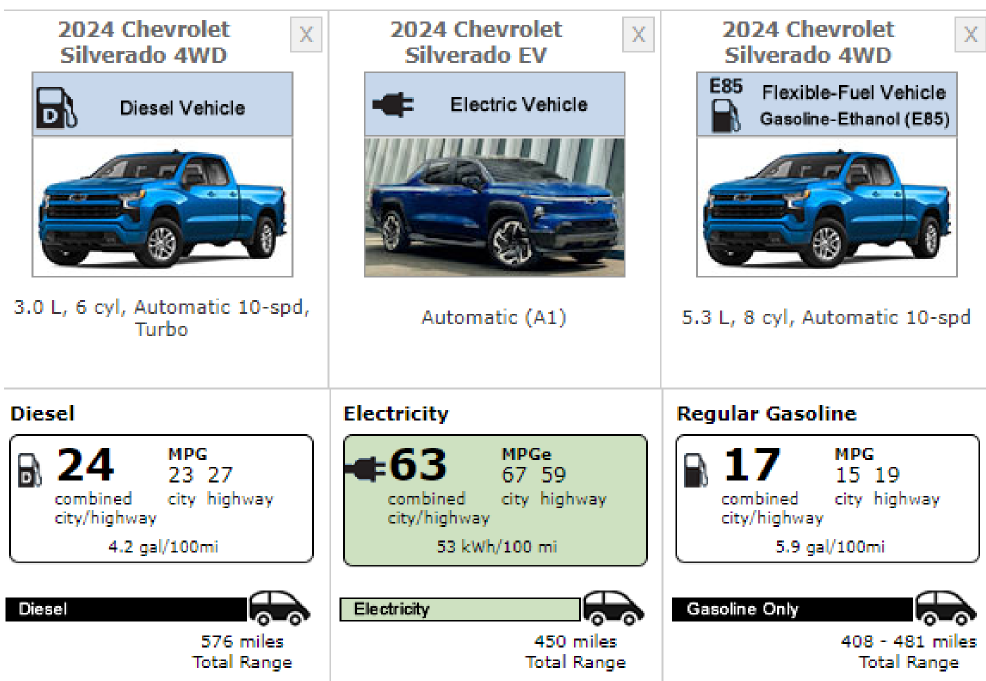
GHG Reduction Through Vehicle Replacement

Description

In 2022, the fleet had 34 diesel vehicles, which accounted for an estimated 340,738 miles, and 190 gasoline-powered vehicles, which accounted for an estimated 2.1 million miles. See attached "*2024 EPA CPRG - N.Arapaho - GHG Asset Inventory.xlsx*" and "*2024 EPA CPRG - N.Arapaho - GHG Calculator*" for details".

During this time, diesel vehicles consumed an estimated 25,740 gallons of diesel fuel, while gasoline vehicles consumed an estimated 112,089 gallons. This yields a fleet average fuel economy of 13.2 mpg for diesel vehicles and 18.8 mpg for gasoline vehicles.

With EPA's[1] published statistics as 8,887 grams of CO_2/gallon (19.6 lbs. of CO_2/gallon) of gasoline and 10,180 grams of CO_2/gallon (22.4 lbs. of CO_2/gallon) of diesel, we can conclude diesel CO_2 emissions of 576,576 lbs. and gasoline CO_2 emissions of 2,196,944 lbs. totaling 2.77 million lbs. When factoring in well-to-pump emissions, or those associated with the extraction, refining, and transportation processes[2], this number increases to about 3.57 million pounds annually by this fleet or 28,798 lbs./vehicle/year.



From fueleconomy.gov

Table 1. Fuel efficiency and CO_2 emissions for Chevy Silverado's of differing fuels.

	Fuel efficiency[6]	CO_2 emissions	CO_2 emissions reduction
Diesel	0.042 gal/mile	1.17 lbs./mile	0%
Renewable Diesel	0.042 gal/mile	0.29 lbs./mile	75%
Gasoline	0.059 gal/mile	1.50 lbs./mile	0%
Electric	0.53 kWh/mile	0.97 lbs./mile	28% (avg for gas/diesel)
Electric - Hydro/Solar	0.53 kWh/mile	0.00 lbs./mile	100%

According to the U.S. Energy Information Administration5, Wyoming's average CO2 emissions per kWh of electricity generation are 1.833 lbs. Based on Table 1, replacing an "average" fleet vehicle with an electric equivalent would yield a per-vehicle reduction of 0.385 lbs./mile (28%).

In addition to crude oil and natural gas production, the Wind River Reservation has two hydroelectric dams producing almost 18 megawatts of electricity[3]. It has been touted as one of the top reservations in the nation with the best potential to generate electricity from solar[4]. If we replace the Wyoming average CO_2 emissions per kWh of electricity generation with a "zero" for hydroelectric or future solar electricity generation, EVs will reduce vehicle emissions to zero or by 100%. Using Renewable Diesel could reduce life cycle CO2 emissions by up to 75% compared to petroleum diesel for diesel vehicles. Comparing the CO2 emissions of Renewable Diesel to those of EVs charged by average Wyoming grid power, this is a great option that can be deployed immediately with no need for infrastructure improvements.

[1] https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references

[2] https://innovationorigins.com/en/producing-gasoline-and-diesel-emits-more-co2-than-we-thought/

[3] https://www.eia.gov/state/analysis.php?sid=WY

[4] https://www.nrel.gov/docs/fy18osti/70807.pdf

[5] https://www.eia.gov/electricity/state/wyoming/

[6] www.fueleconomy.gov