Petersen Engineering, Inc.
Building Mechanical Systems Consultants

Basis of Design – DD

Job Name:	Green Woodlands
Job #:	0551
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Overall Goals and Objectives
The contents of this document are based on our communication to date with the Greens and the project team.

We understand the following to be goals and objectives of this project:

- High standards for energy efficiency and resource conservation.
- Use of renewable energy sources to the greatest extent possible.
- High standards for indoor air quality.
- LEED and Energy Star certification.

Project Summary
The Green Woodlands house will be off the electric grid. Electrical power will be generated by hydro power and photovoltaic solar panels with an LP generator as backup. Space heating and domestic hot water heating will be provided by renewable electrical power, a wood boiler and heat rejected from the generator (when it runs to recharge the batteries) with an LP boiler as backup. Additionally, a masonry stove in the first floor living space will provide the majority of the house heating when it is used. Shower drain heat recovery units will be used to pre-heat domestic hot water.

Occupancy & Setpoints
When the house is occupied, the setpoints for the four heating zones (living space, master bedroom, two second floor bedrooms) will be approximately 70°F. The house will be unoccupied for extended periods of time. During unoccupied times, the setpoints will be lowered to 50°F for freeze protection.

Codes and Standards
The following codes will be used for the design of mechanical systems:

- Building Code - International Building Code 2000
- Mechanical Code - International Mechanical Code 2000
- Plumbing Code – International Plumbing Code 2000
- Ventilation - ASHRAE 62.2-2004

Heating and Domestic Hot Water Systems
The systems providing space heating and domestic hot water production will be designed to use renewable energy sources to the greatest extent possible. Fossil fuels (LP) will only be used as a backup to the renewable energy sources.

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Heating
Heat loss values were calculated using outdoor weather data from 2005 ASHRAE Fundamentals Handbook for Lebanon, NH, the closest city with weather data. The following design conditions were used:

Outdoor - Winter Design Conditions: -8.0ºF db
Summer Design Conditions 88.5ºF db, 71.0ºF wb

- The summer outdoor design conditions are expected to be exceeded (i.e. hotter) only 0.4% of the year (35 total hours annually). Similarly, the winter outdoor design conditions are expected to be exceeded (i.e. colder) only 0.4% of the year (35 total annual hours).

Indoor - Winter Design Conditions: 70ºF db Occupied, 50ºF Unoccupied
Summer Design Conditions: Natural Ventilation

- The indoor conditions are typically agreeable to occupants according to ASHRAE Standard 55-2004 – Thermal Environmental Conditions for Human Occupancy.

Water Storage Tank
A water storage tank will be used to accept heat from the various sources. This tank will accept heated water from the wood boiler, generator exhaust and LP boiler. The tank will also have an electric element to accept heat from the renewable electrical sources. The electric element will be sized to match the anticipated renewable electrical energy available.

The temperature of the tank will be allowed to swing over a wide range when renewable energy is available. When the tank is heated to its maximum allowable temperature, it can provide approximately 12 hours of building heating on the coldest day with no additional heat input simply by letting the tank temperature be reduced to its minimum.

Domestic Hot Water
The following are estimates of domestic hot water usage. The 2003 ASHRAE Applications Handbook, Chapter 49 – Service Water Heating was used as a guideline.

Method #1
The following table summarizes the hot water demand per fixture for private residences (2003 ASHRAE Applications Handbook, Ch. 49, Tables 2 and 8). Table 2 lists representative hot water temperatures at each fixture. Table 8 prescribes the gallons per hour for each fixture at a storage temperature of 140ºF. For example, a lavatory uses 2 gallons of 140ºF water mixed to a final fixture temperature of 105ºF.

	Qty	Delivery Water Temp.	Unit GPH of 140ºF	Total GPH of 140ºF	Total GPH of 120ºF
Lavatory	3	105	2	6	7.5
Tub/shower	3	110	30	90	112.5
Dishwasher	1	120	15	15	18.8
Kitchen sink	1	105	10	10	12.5
Laundry	1	120	20	20	25.0

	Totals:	141	176.3

Domestic hot water will be stored at a minimum temperature of 120ºF. The "Total GPH of 120ºF" column is a calculation of the required number of gallons per hour of 120ºF water before mixing down to the final fixture water temperature (176 gph). Applying a demand factor of 0.3 for private residences gives a probable maximum demand of 53 gph.

Method #2

Showers

- Per ASHRAE, the average length of a shower is 7.5 minutes. Assuming 110ºF water, 1.5 GPM shower heads (low flow), and one shower per person per day, the total "shower" gallons of 120ºF water is 40 gallons per day.

(4 showers/day)(1.5 gal/min)(7.5 min/shower)(0.875 ratio of 120ºF) = 40 gal/day

Dishwashers

- According to www.energystar.gov, the average usage for dishwashers is 215 loads per year. Per ASHRAE, one dishwasher load consumes 15 gallons of hot water. The total "dishwasher" gallons of 120ºF water is 9 gallons per day.

(215 loads/yr)(15 gal/load)(yr/365 days) = 9 gal/day

Laundry

- Assume 3 loads of laundry per week. Per ASHRAE, a load of laundry consumes 21 gallons of hot water. The total "laundry" gallons of 120ºF water is 9 gallons per day.

(3 loads/week)(1 week/7 days)(21 gal/load) = 9 gal/day

Miscellaneous

- Assume that each person will wash his or her face and hands on average twice a day with hot water (2 gallons per task), and that on average two meals per day will be prepared (3 gallons per task). The total "miscellaneous" gallons of 120ºF water is 22 gallons per day.

(4 ppl)(2 washs/ppl/day)(2 gal/wash) + (2 meals/day)(3 gal/meal) = 22 gal/day

The probable maximum hourly demand can be estimated by multiplying the aggregate daily hot water usage (total of 80 gal/day) by a demand factor of 0.3 to get 24 gallons per hour.

Therefore, based on methods 1 and 2, the probable maximum demand of domestic hot water will be in the range of **24 to 53 gph** of 120ºF water.

Domestic Hot Water Tank

The house will be served by an indirect domestic hot water tank with an electric element. Because hot water tank manufacturers do not stock indirect hot water tanks with an electric element backup, this tank will be custom. The electric element will be sized to match the anticipated renewable electrical energy available.

The temperature of the tank will be allowed to swing over a wide range when renewable energy is available.

Natural Ventilation System
The house will not have mechanical cooling, but will have natural ventilation through operable windows.

Ventilation
Per ASHRAE Standard 62.2-2004, *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*, the ventilation requirement for private residences is based on total floor area and number of bedrooms. A heat recovery ventilator (HRV) will be used to provide fresh air, preheated by exhaust air. The HRV will have a manual wall switch, designed to run when the house is occupied.

Humidification
Mechanical humidification and dehumidification will not be provided for the house.

Water Conservation
Water conserving fixtures will be used throughout the house. Composting toilets will be used. Showers will use 1.5 gpm heads. Lavatories and kitchen sinks will have 0.5 gpm flow restrictors.