

Investigation of A Ground Source Heat Pump System Integrated with Renewable Sources

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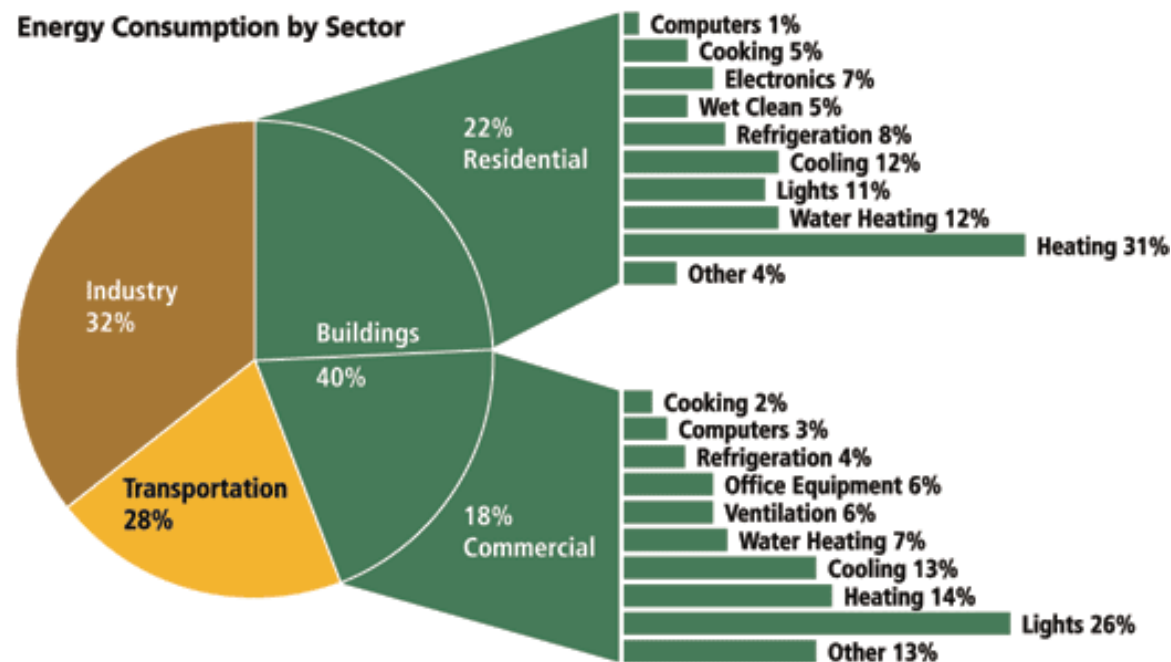
July 11 -14, 2016



Introduction



- Building consumed 40% of the energy in the U.S.

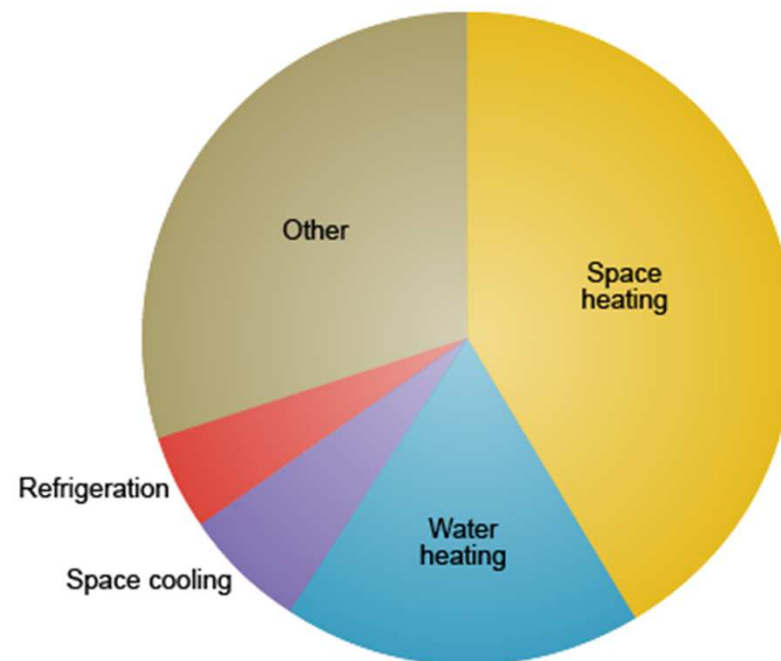




Introduction

- Majority of the energy was used for space heating, cooling and water heating in the buildings.

Residential Energy Consumption by End Use, 2009



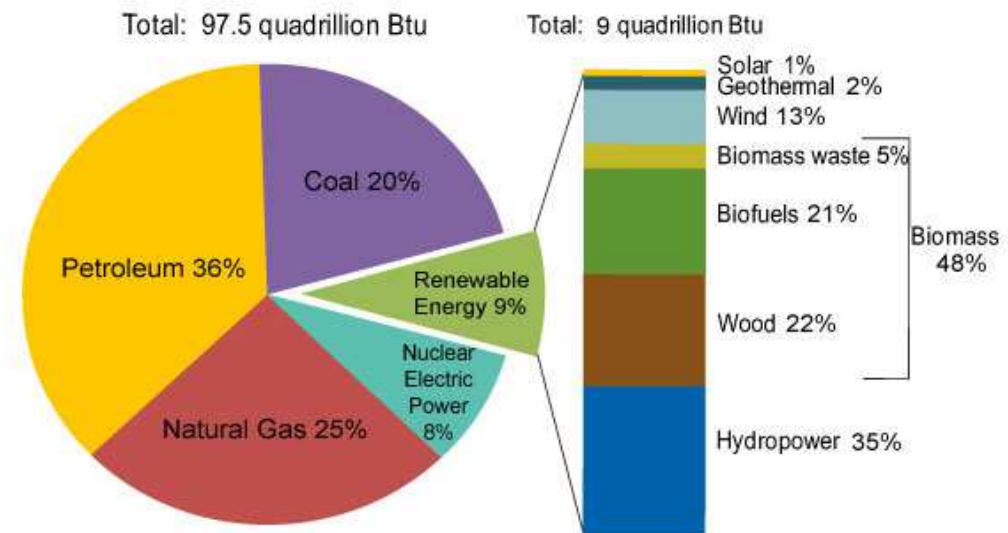


Introduction



- Relative contributions of energy sources

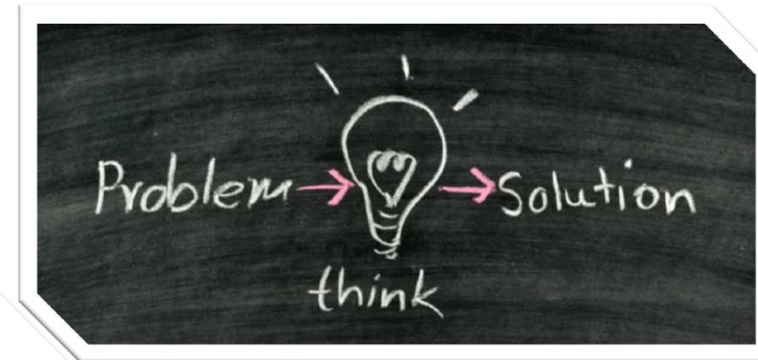
U.S. Energy Consumption by Energy Source, 2011



Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 10.1 (March 2012), preliminary 2011 data.

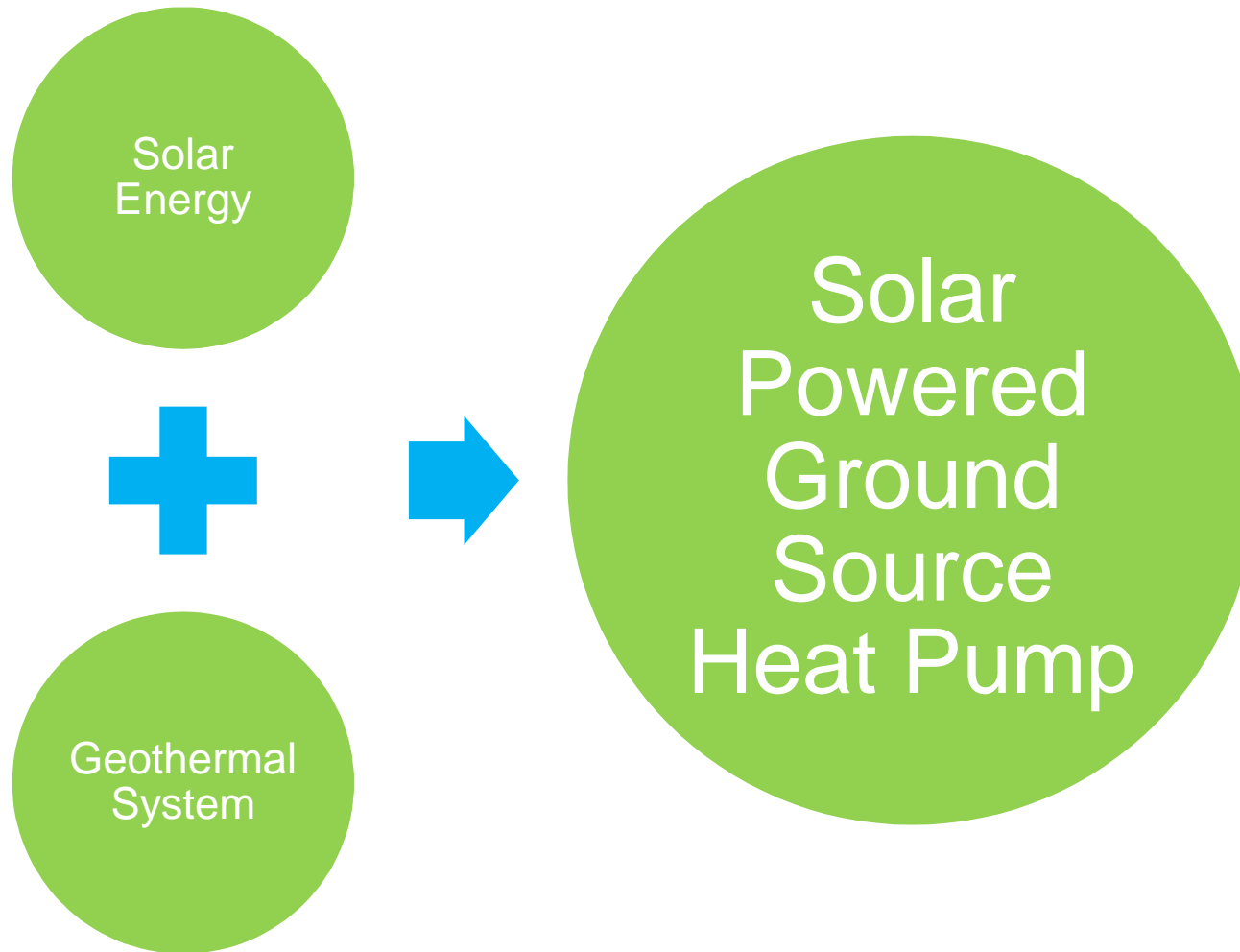


Introduction





Introduction

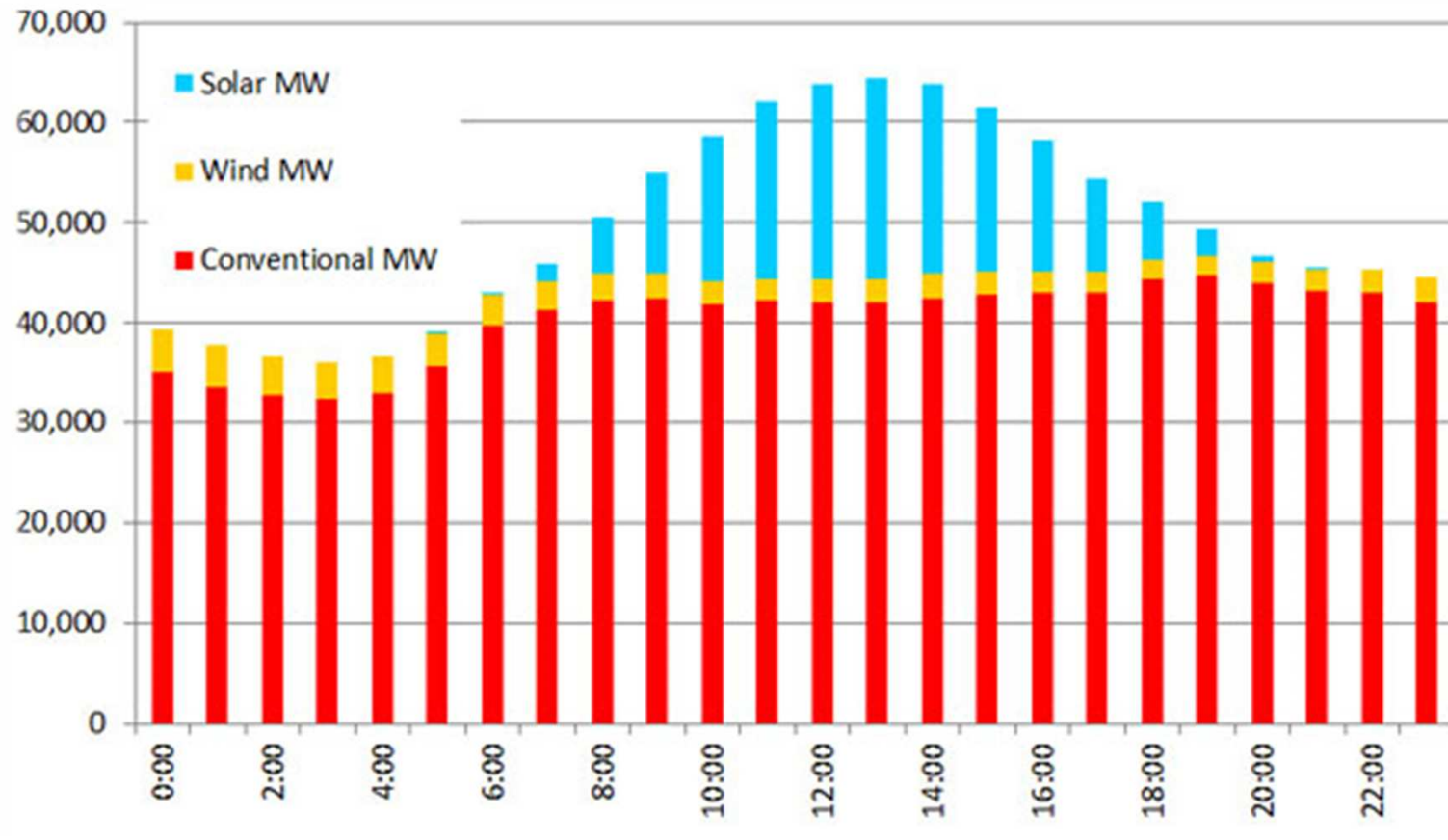




Goals and Benefits



1. Reduce the electricity peak demand

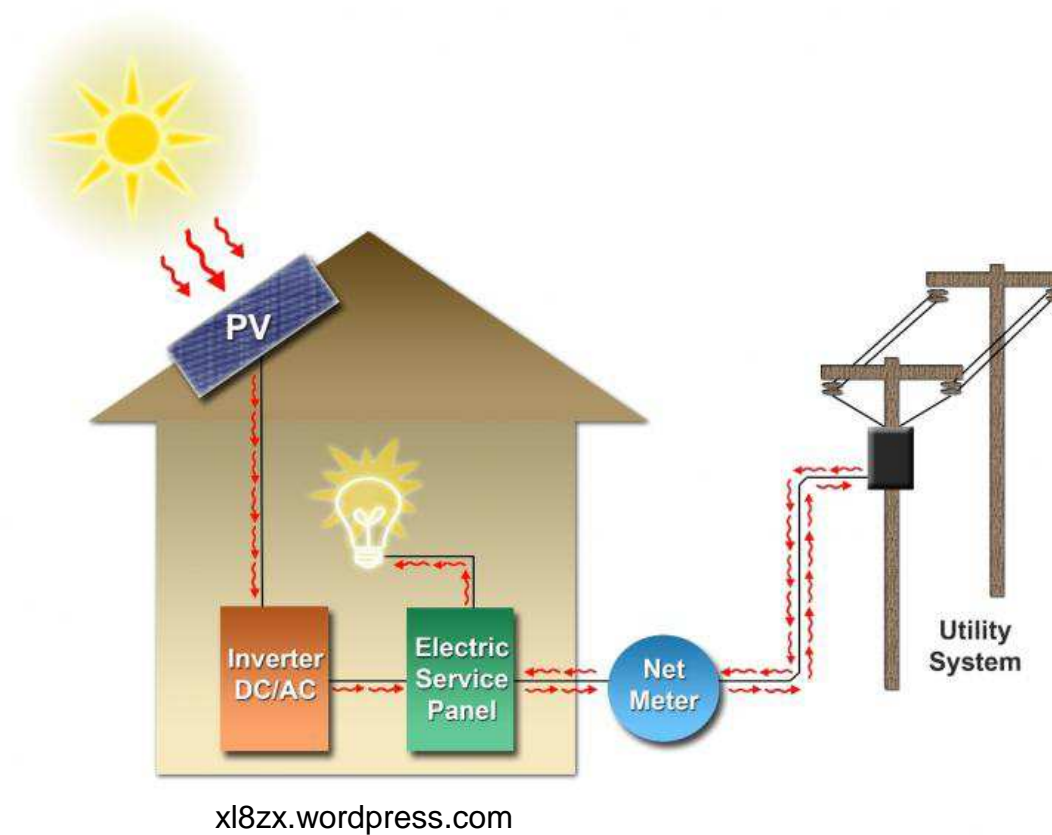




Goals and Benefits



2. Net-Zero Energy Building

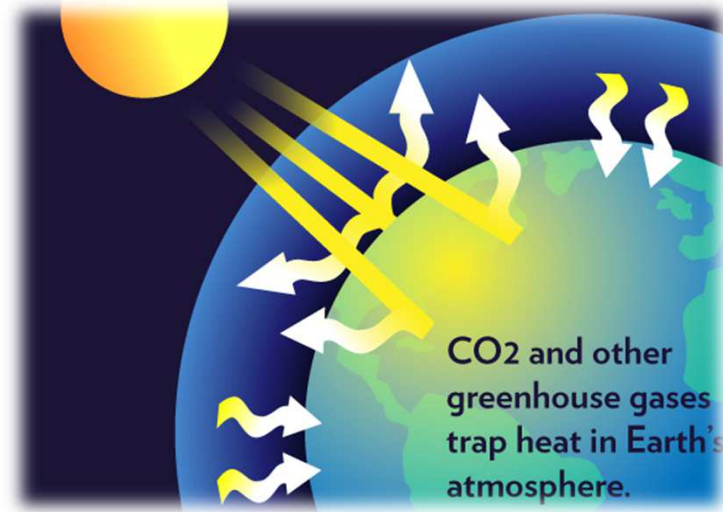




Goals and Benefits



3. Reduce Greenhouse Emissions

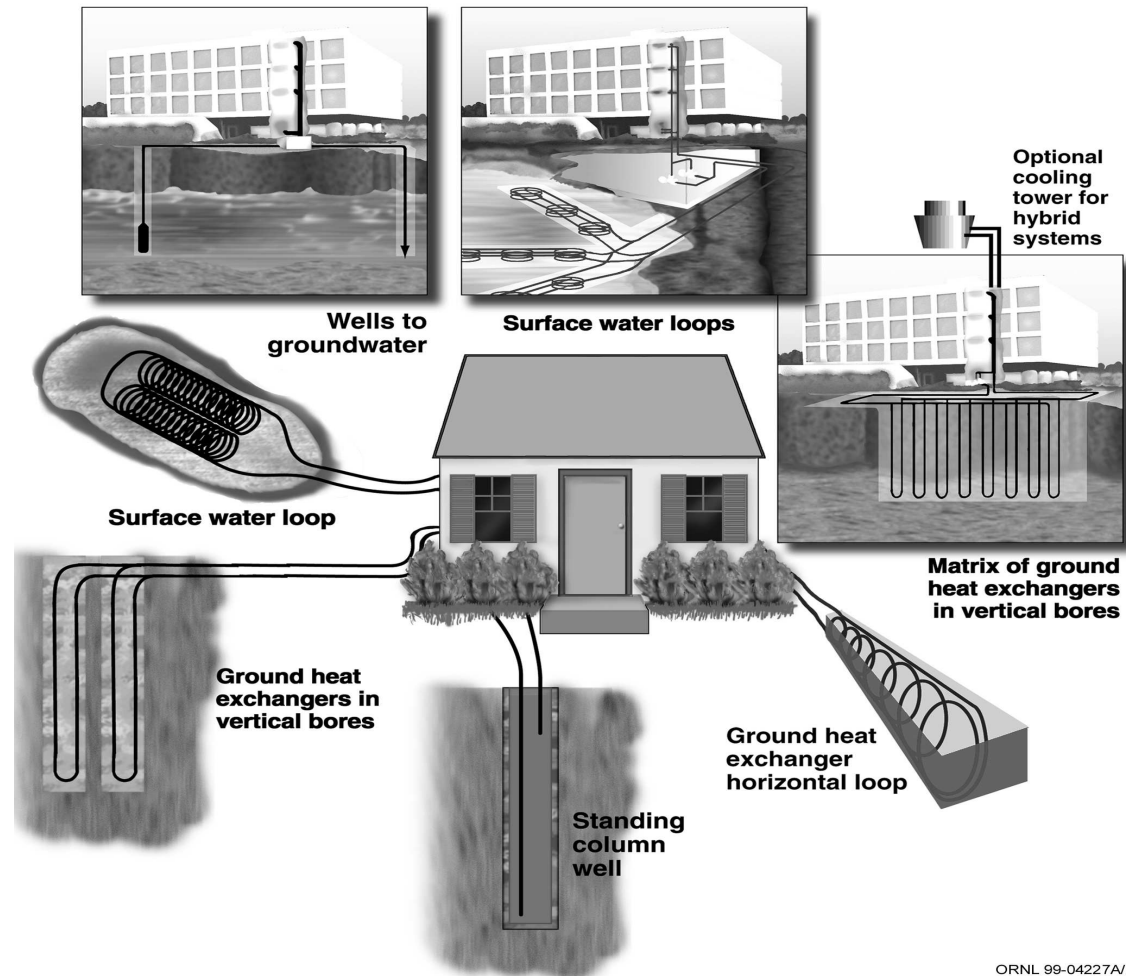




Ground Source Heat Pump System



- Most efficient system in the market
- Ground Coupled
- Surface Water
- Ground Water
 - » Close-loop
 - » Open-loop



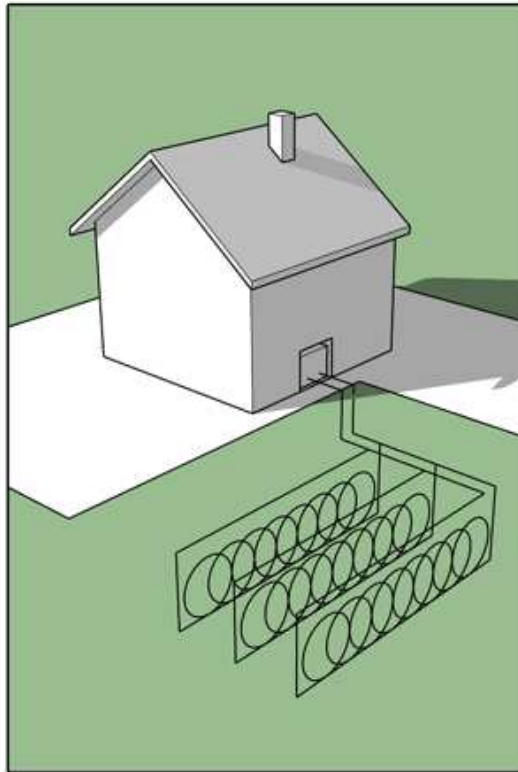
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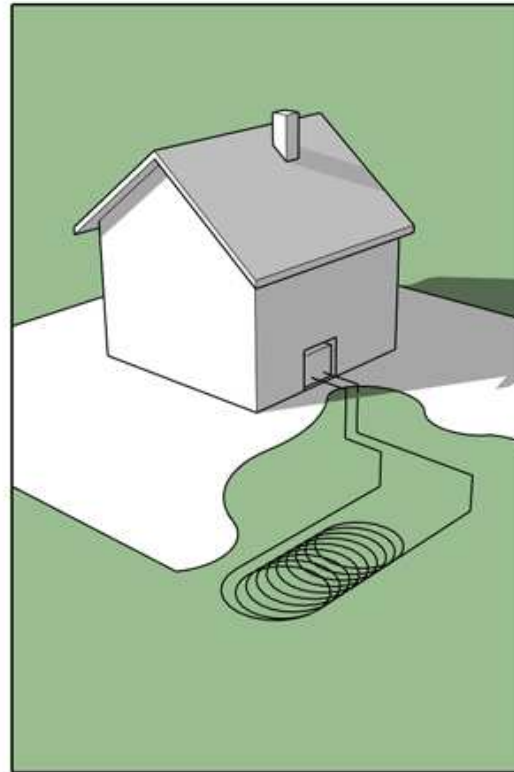
Ground Source Heat Pump System



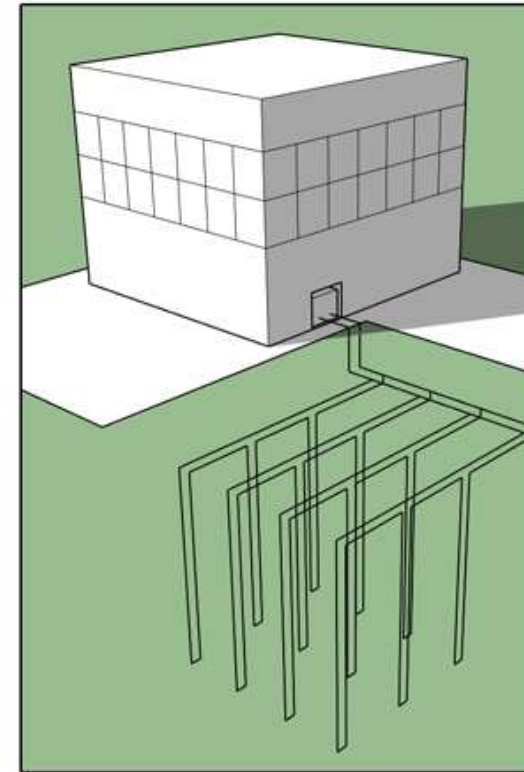
Horizontal



Pond/Lake



Vertical



<http://www.widsethsmithnoalting.com/a>

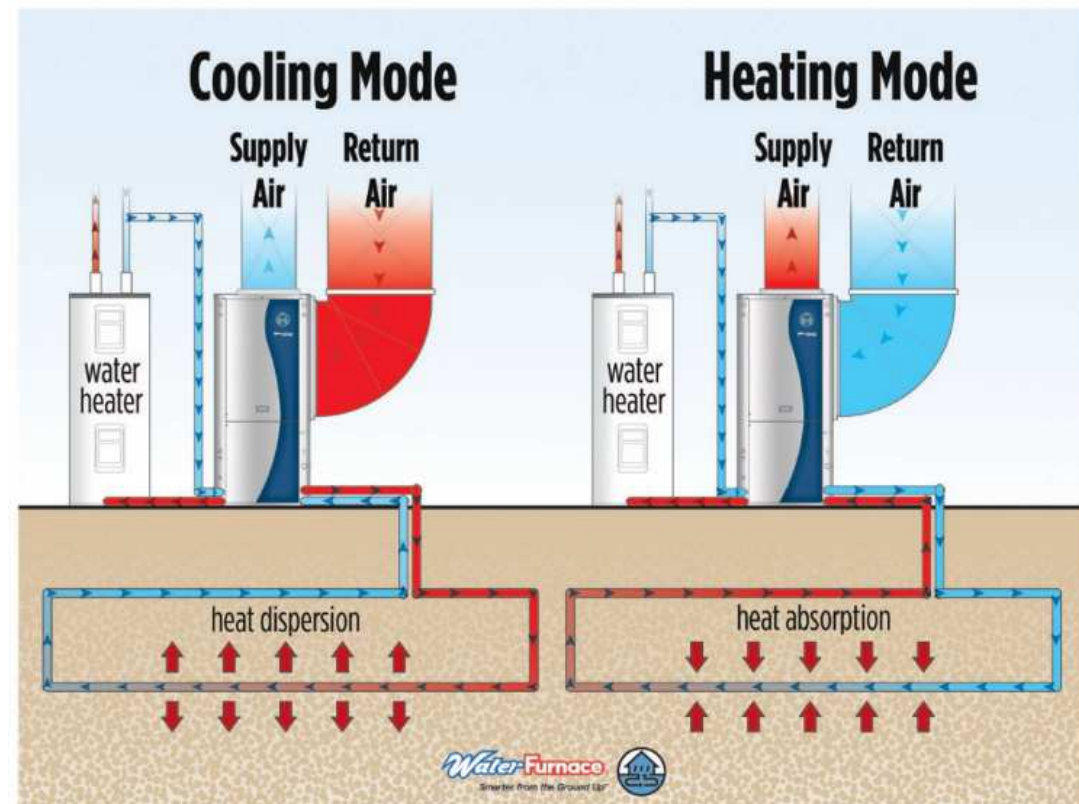


Ground Source Heat Pump System



How it works?

- Ground water temperature is steady over the year
 - » 68 °F at Tuscaloosa area
- Cooling mode
 - » Dissipate the heat to the ground water
- Heating mode
 - » Extract heat from the ground water

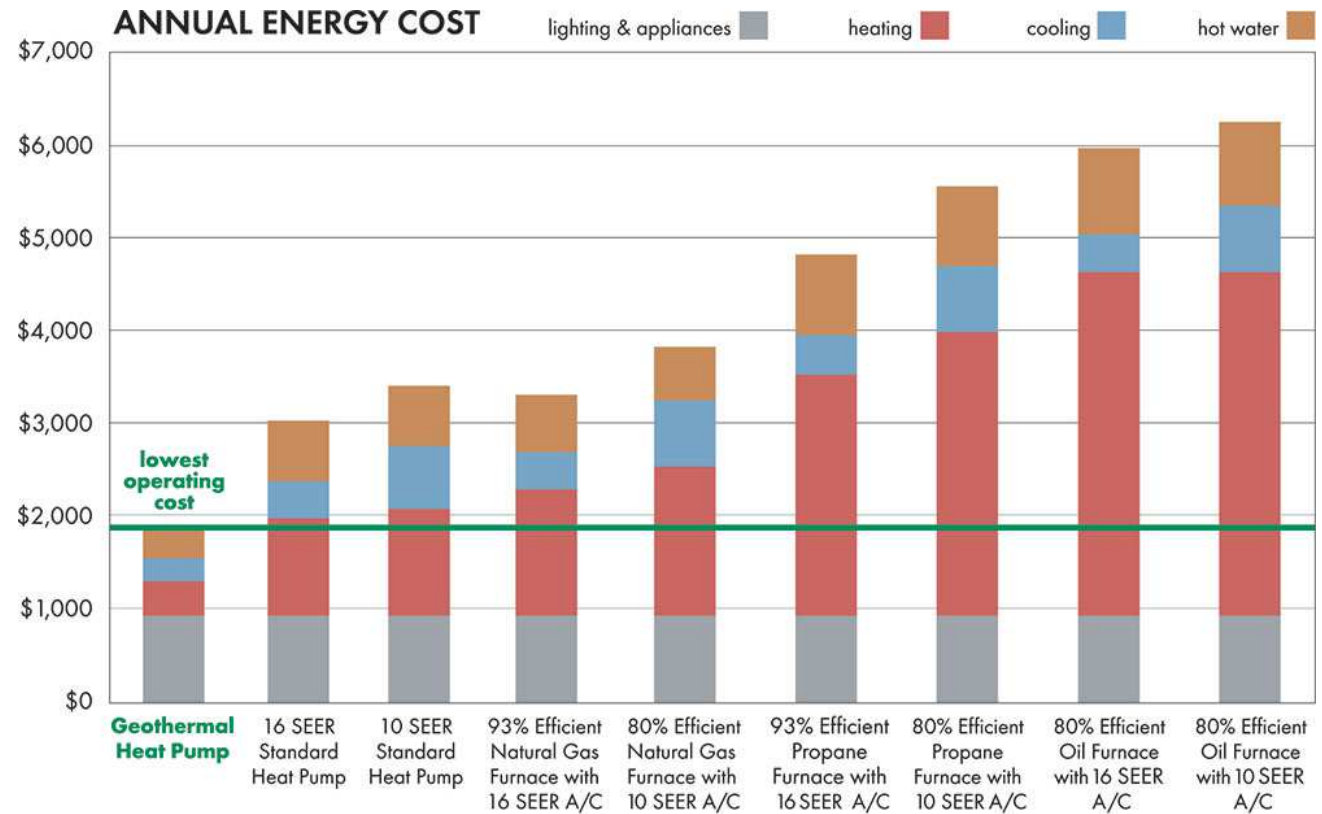




Ground Source Heat Pump System



- High Efficiency
- Low Annual Energy Cost



Calculations are based upon current utility costs for a typical home in the U.S. Midwest.

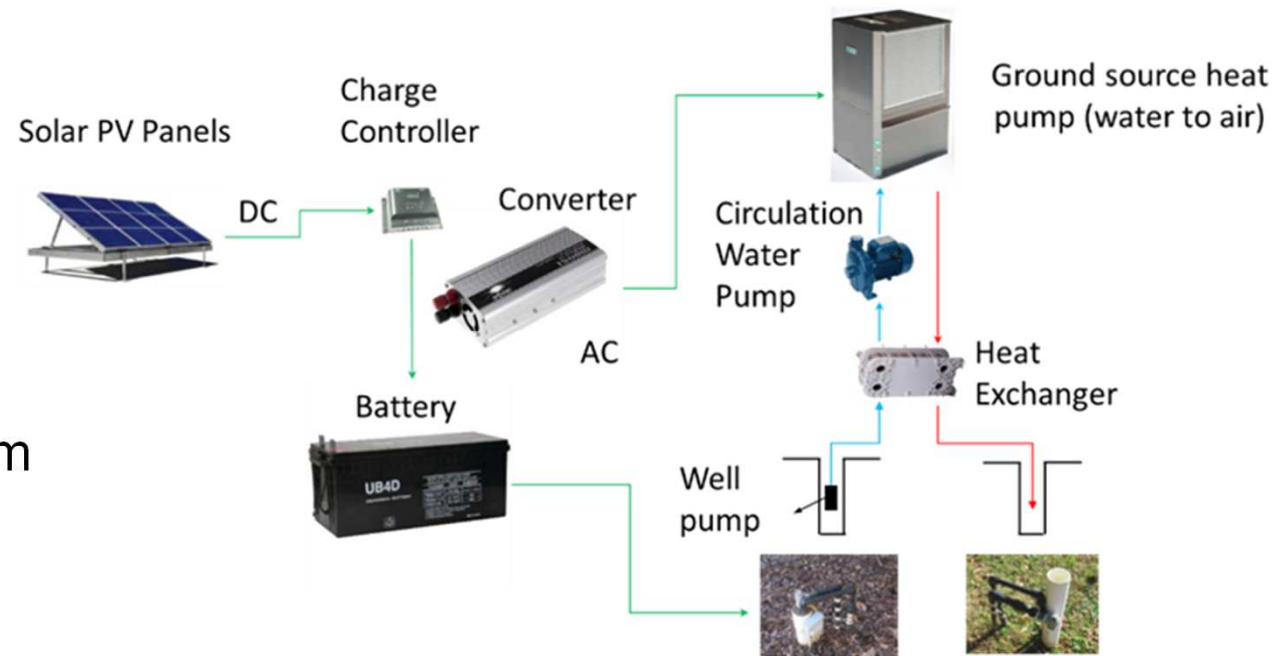


Ground Source Heat Pump System



System Setup

- Heat Pump
 - » ¾ tons
- Geothermal System
 - » Two wells of 60 feet
 - » Close-loop
- Solar Panels
 - » 800 Watts for heat pump
 - » 320 Watts for well pump

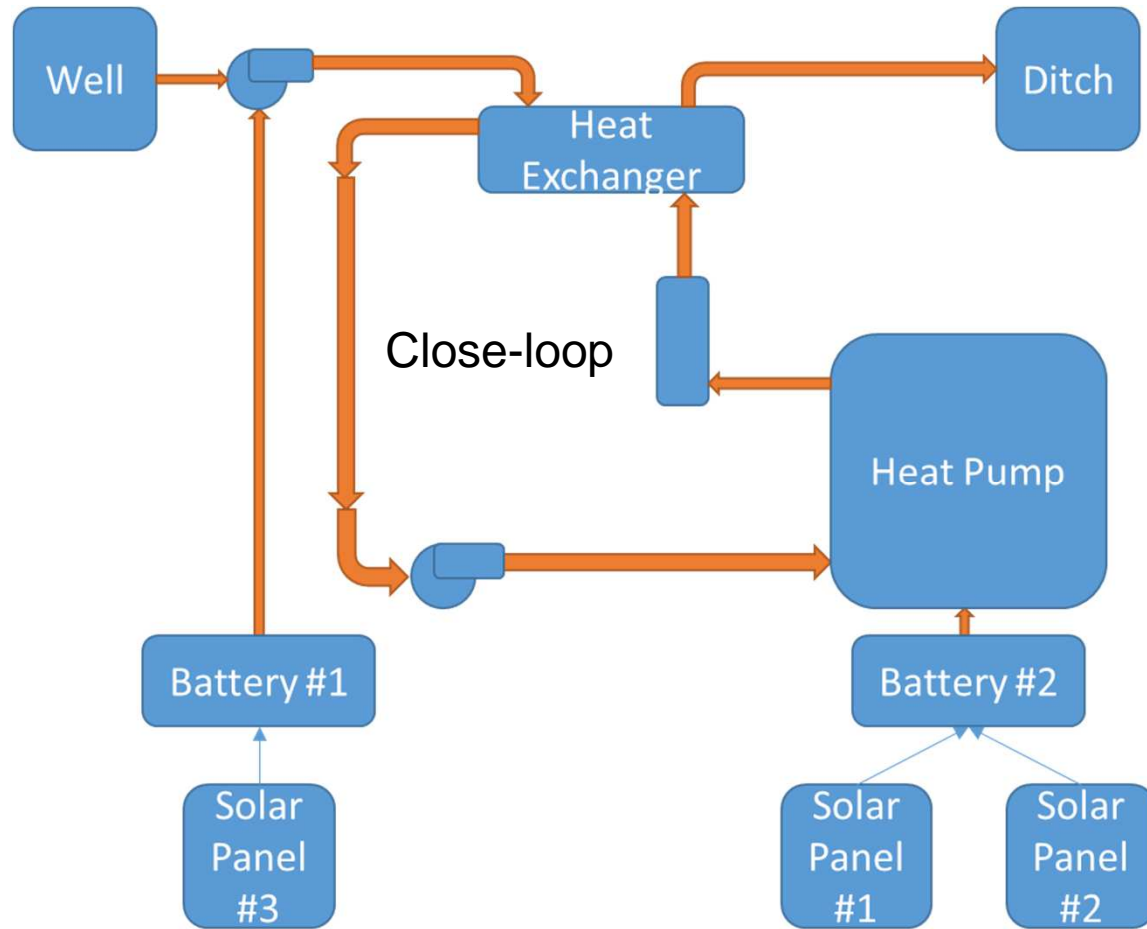




Ground Source Heat Pump System



General Sketchup





Experimental System



Solar Panels



Weather Station

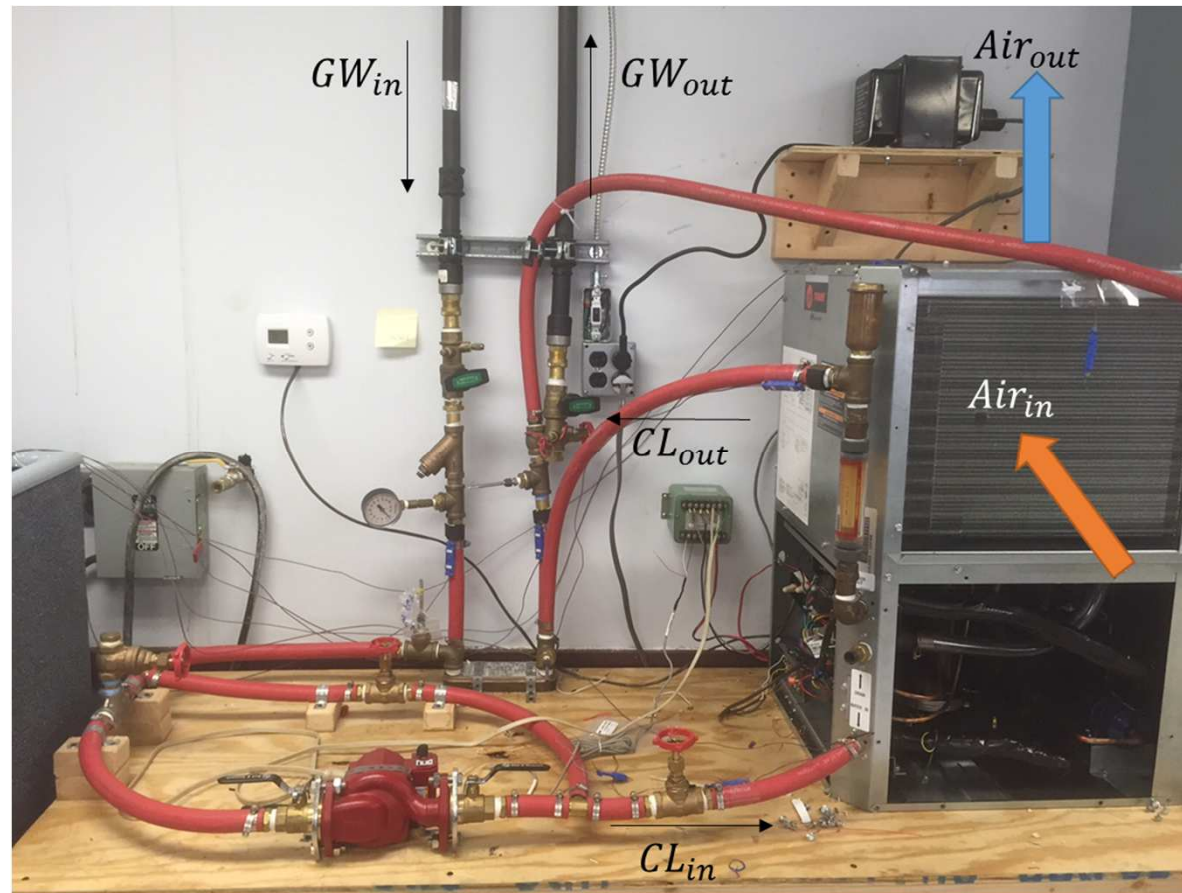




Ground Source Heat Pump System



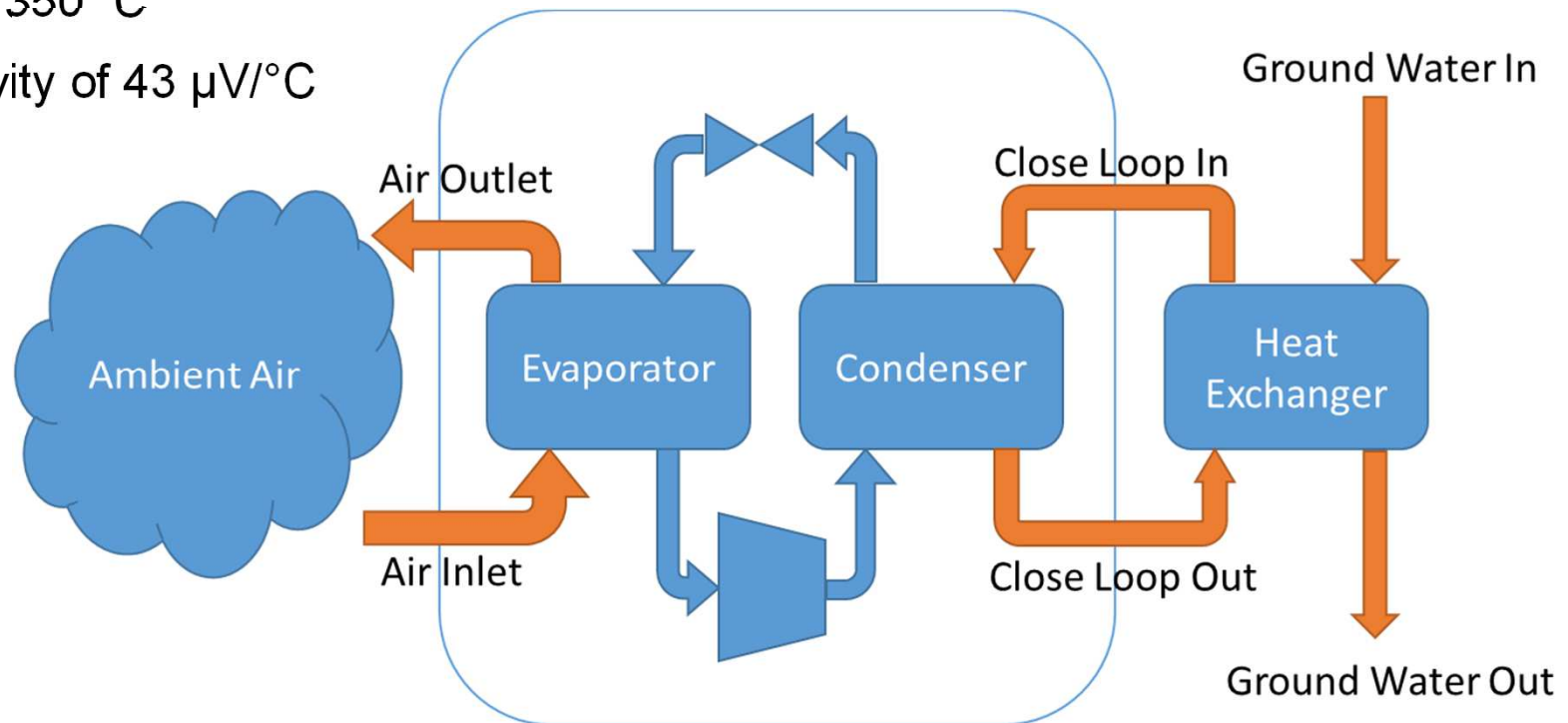
Actual Test Rig





Temperature Sensors

- T-Type Thermocouple
- -200 to 350 °C
- Sensitivity of 43 $\mu\text{V}/^\circ\text{C}$

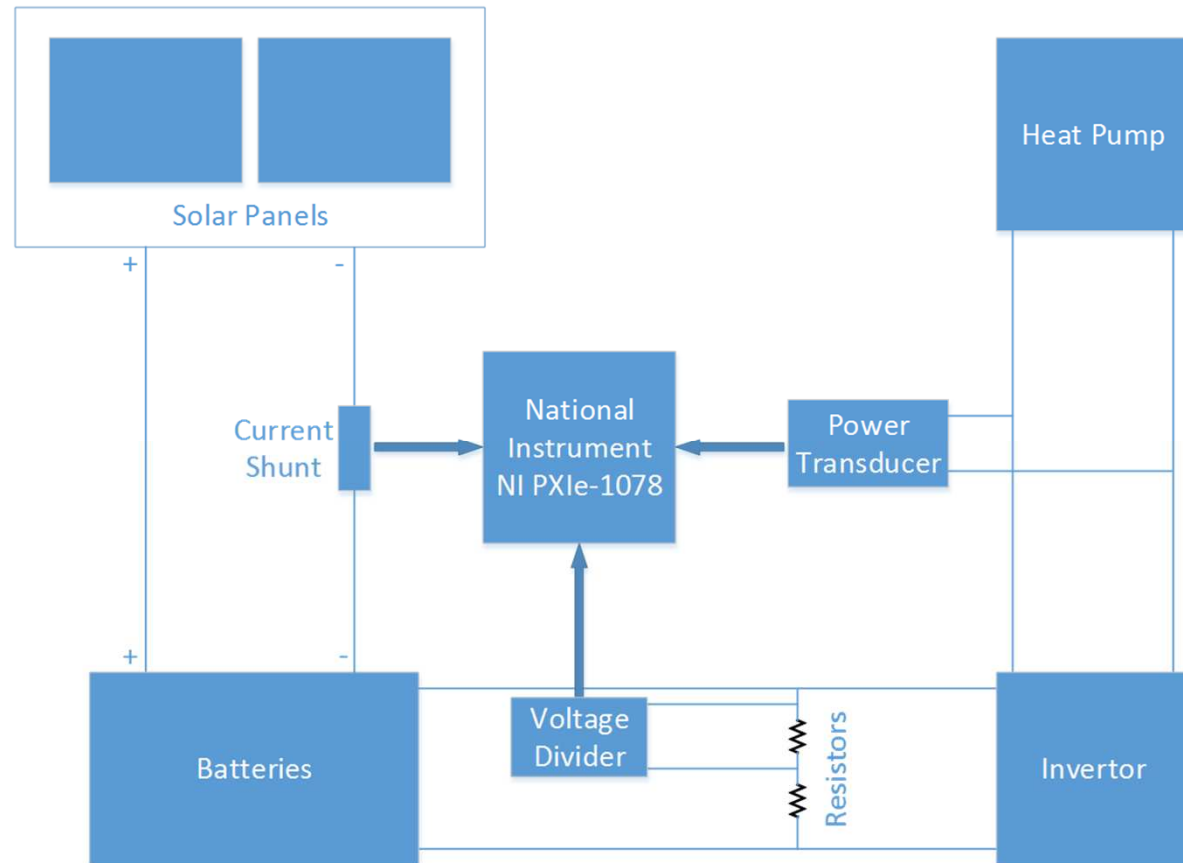




Solar Panels and Power Sensors

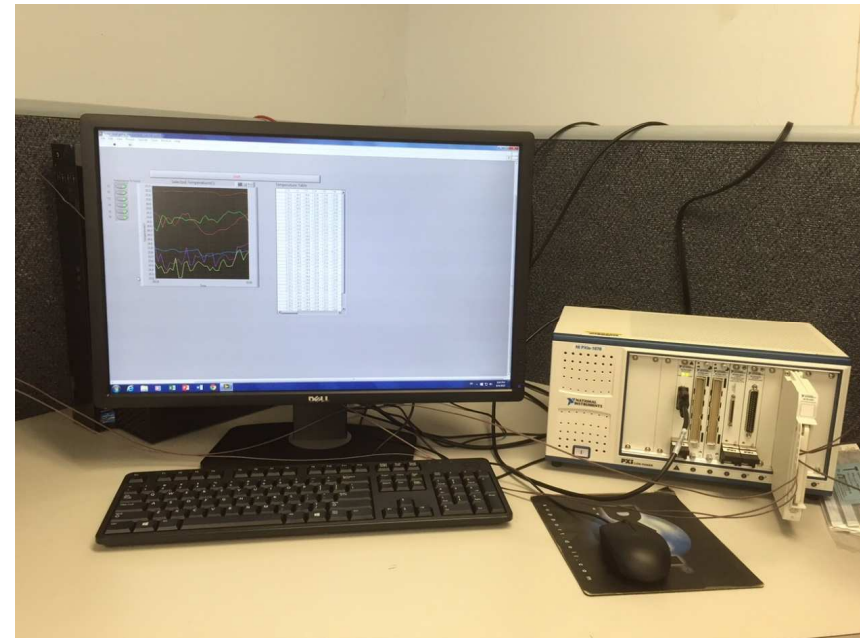
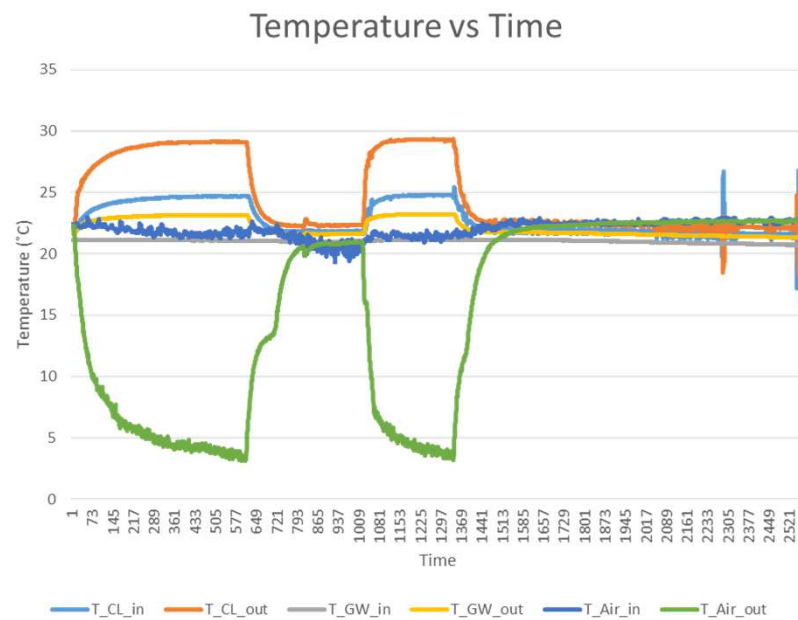


- Collect the solar energy
- Supply the system when on demand
- Sensors were installed to monitor the energy collections and consumptions





Data Acquisition System

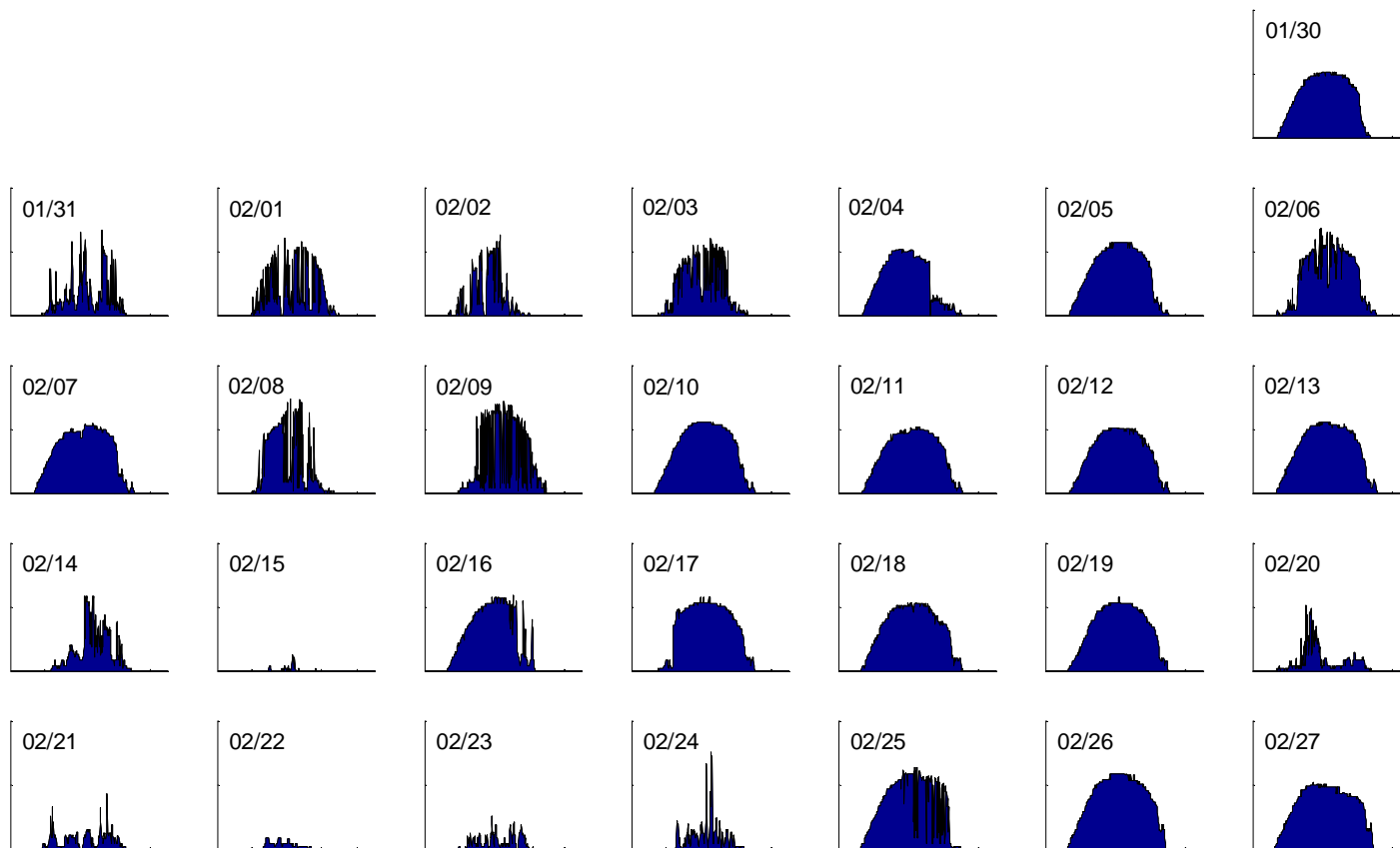




Results

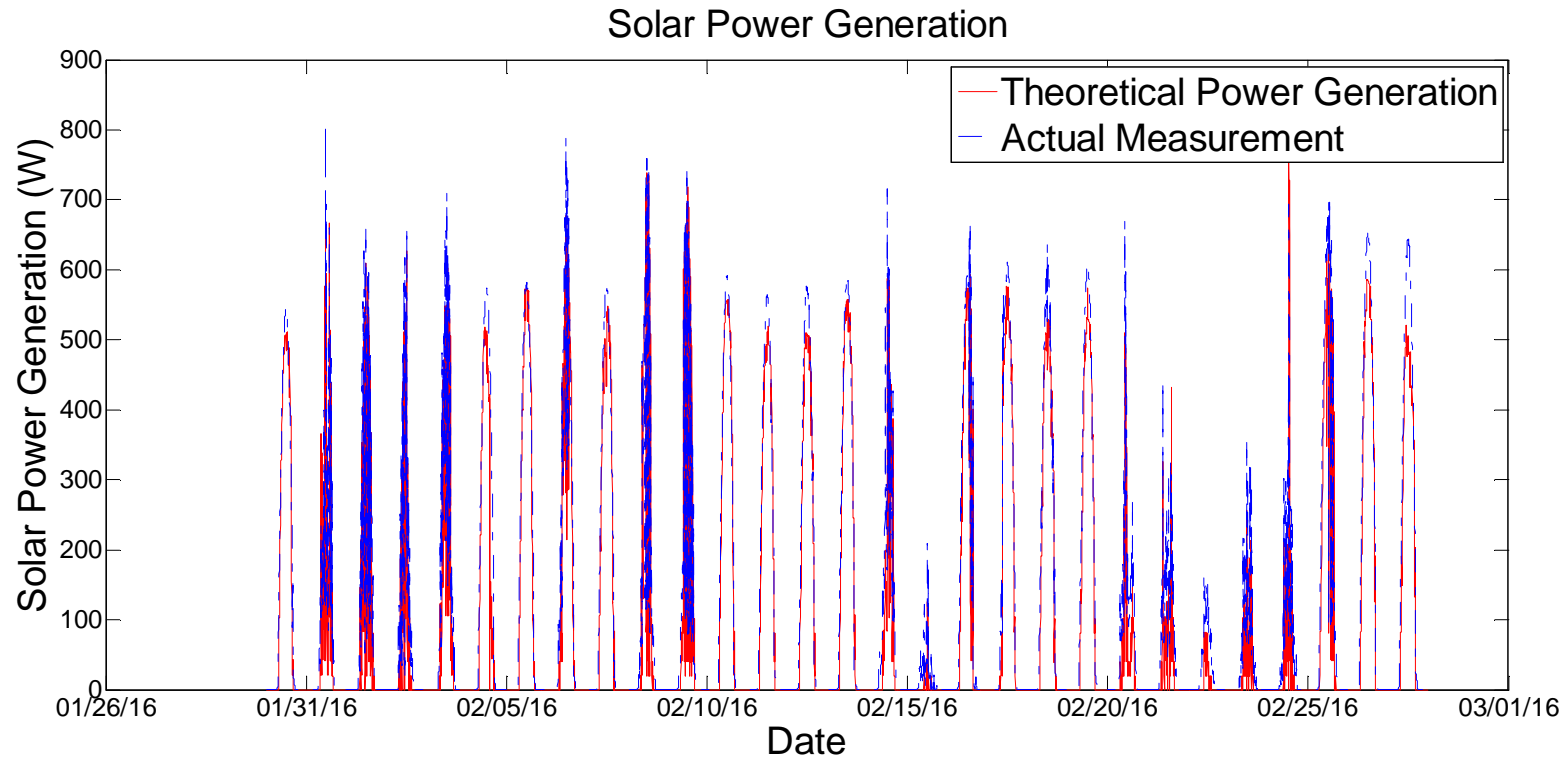


Solar Power Generation





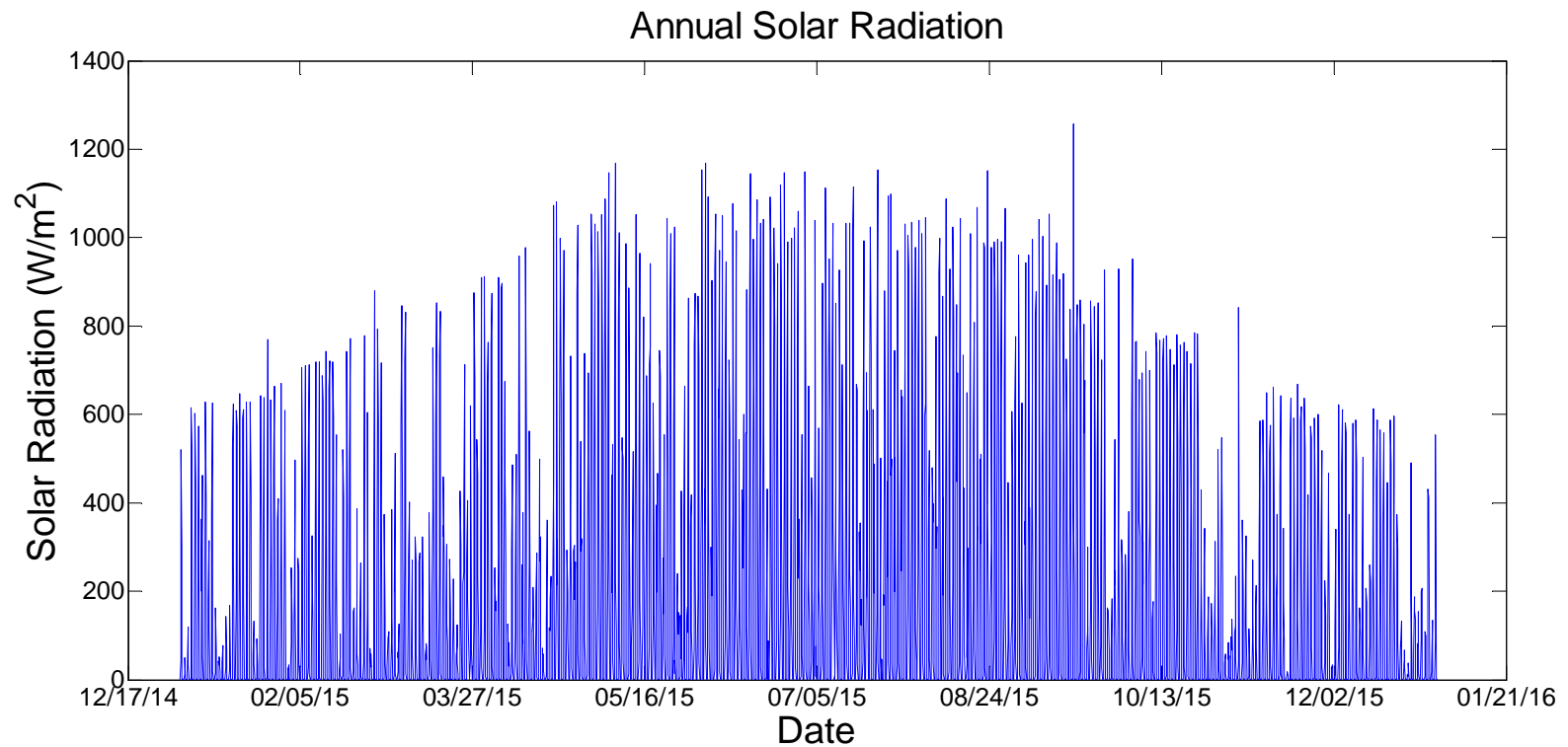
Results



- Theoretically, the solar panels will generate 297 MJ during the testing period
- Actual measurement was 242 MJ



Results





Problems and Future Works



- Small Battery Capacity
 - » Two 800Ah battery banks can support the system for 9.5 hours
- Charging Rate
 - » Actual charging rate depends on the state of charge (SOC) of the batteries
- Old Solar Panels
 - » Part of the solar panels had used for more than 20 years, and there is a performance degradation occurs



Problems and Future Works



- Extend Battery Capacity
- Extra Solar Panels
- Modelica-Based Model
 - » Validation of the model
 - » Advanced control design of a solar power GSHP for batter building to grid integration



Questions?



Thank You

