April 2015

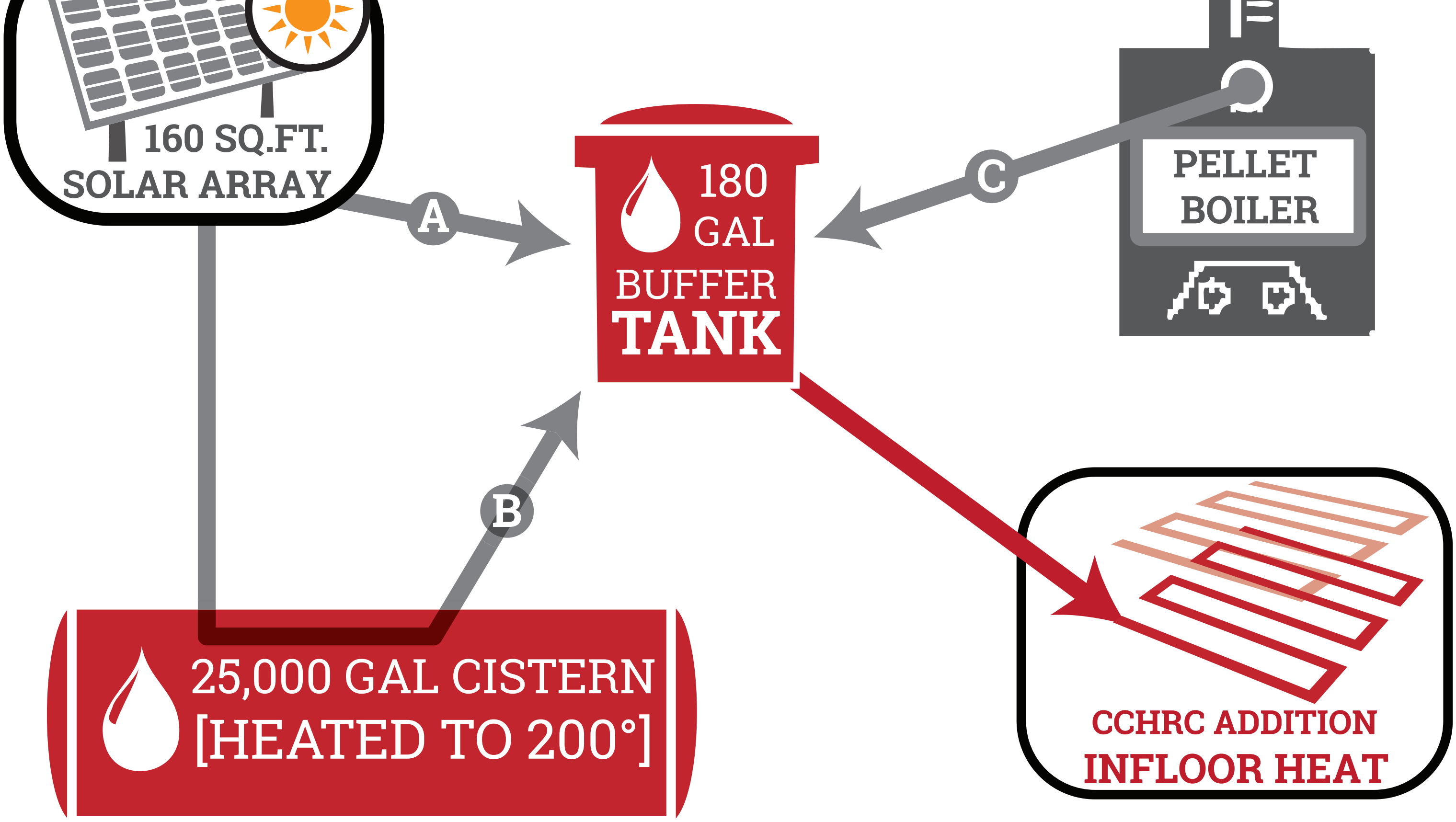
Solar Hybrid System with Seasonal Thermal Storage

An Economic and Environmental Case Study

What is the best heating system for the addition at CCHRC?

There is no simple answer to this question. Here at the Cold Climate Housing Research Center's facility in Fairbanks, researchers weighed the advantages and disadvantages of various heating systems before installing a hybrid solar thermal and pellet boiler system in the new building addition in 2014. The goal was to minimize costs and environmental impacts, and learn about system design and performance.

CCHRC HYBRID SYSTEM DIAGRAM



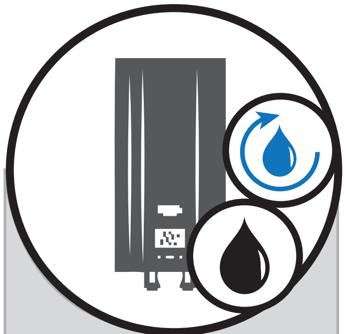
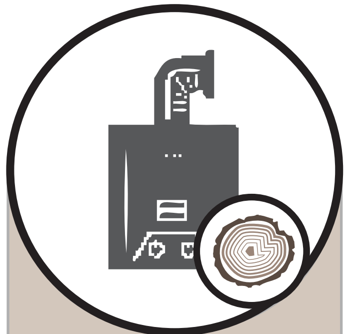
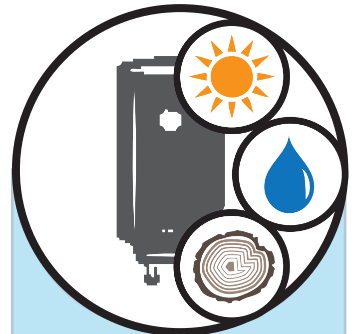
The following analysis compares four heating systems:

86% EFFICIENT NON-CONDENSING OIL BOILER	96% EFFICIENT CONDENSING OIL BOILER	PELLET BOILER	CCHRC HYBRID SYSTEM: PELLET BOILER + 640 SQ.FT. SOLAR COLLECTORS + 25,000GAL WATER THERMAL STORAGE
ANNUAL FUEL USE: 1,093 GAL FUEL OIL	ANNUAL FUEL USE: 1,014 GAL FUEL OIL	ANNUAL FUEL USE: 9.63 TONS OF PELLETS	ANNUAL FUEL USE: 7.35 TONS OF PELLETS

TOTAL ANNUAL HEAT LOAD FOR CCHRC BUILDING ADDITION: **131 MBTU/YR**

Economic Comparisons

The following analysis uses the oil boiler as the standard for comparison; each of the systems are compared to it using payback* and net present value (NPV)**

86% EFFICIENT NON-CONDENSING OIL BOILER	96% EFFICIENT CONDENSING OIL BOILER	PELLET BOILER	CCHRC HYBRID
CAPITAL COST **$2,300 (CONTROL)**	CAPITAL COST **+$2,539**	CAPITAL COST **+$5,865**	CAPITAL COST **+$56,840**
	PAYBACK **25+ YEARS**	PAYBACK **4 YEARS**	PAYBACK **25+ YEARS**
	NET PRESENT VALUE **< $0**	NET PRESENT VALUE **$18,977**	NET PRESENT VALUE **< $0**
	ECONOMIC APPEAL **LOW**	ECONOMIC APPEAL **HIGH**	ECONOMIC APPEAL **LOW**

Alternate scenario: What if the building were less energy efficient and instead had double the heating load?

-> A higher heat load in the building would mean that the renewable systems have shorter payback times

-> This is a reason CCHRC chose to consider cost as only one of many decision factors

86% EFFICIENT NON-CONDENSING OIL BOILER	96% EFFICIENT CONDENSING OIL BOILER	PELLET BOILER	CCHRC HYBRID
CAPITAL COST **$2,300 (CONTROL)**	PAYBACK **10.8 YEARS**	PAYBACK **2 YEARS**	PAYBACK **17.2 YEARS**
	NET PRESENT VALUE **$1,277**	NET PRESENT VALUE **$43,819**	NET PRESENT VALUE **$11,357**
	ECONOMIC APPEAL **MEDIUM**	ECONOMIC APPEAL **VERY HIGH**	ECONOMIC APPEAL **MEDIUM**

*Payback: Difference in capital cost divided by energy savings; i.e. the amount of time it takes to recover the initial capital investment
** NPV: The 25-year value of the system accounting for capital costs, operations and maintenance costs, and energy savings

Environmental Costs

We also considered the environmental impact of each heating system. This life cycle assessment accounts for the material sourcing and manufacturing of the systems, 25 years of operation, and the final disposal of the systems. The output is separated into four categories to describe the type and magnitude of environmental impacts.

	RESOURCE USE	HUMAN HEALTH	ECOSYSTEM	CLIMATE CHANGE
OIL BOILERS	Higher impact than the other systems due to the use of a non-renewable resource (heating oil) for fuel	Lower impact relative to the biomass heating systems because emissions from fuel combustion are relative clean	Damage to ecosystems is considered relatively low for this heating scenario	Significantly greater impact than other heating systems due to carbon dioxide emissions from non-renewable resources; high carbon footprint
PELLET BOILER	Relatively low impact in the resource category because pellets, made from wood by-products, are a renewable resource	The highest impact of the heating systems due to PM2.5 emissions from fuel combustion	There is some ecosystem impact due to aluminum and zinc in the ash waste from combustion, but the overall impact to ecosystem is relatively low	Relatively low impact compared to the other heating systems since carbon dioxide emissions are from a renewable fuel resource; medium carbon footprint
CCHRC HYBRID	Similar to the pellet boiler heating scenario because this system also relies on pellets for fuel.	Adding solar thermal heating greatly reduced the human health impact due to less reliance on the pellet boiler for heat, meaning less PM2.5 emissions into the air.	Relatively low impact, very similar in magnitude to the pellet boiler heating scenario	PELLETS: Relatively low carbon footprint which uses renewable fuel resource SOLAR: minimal carbon footprint

Installed System Summary; CCHRC Hybrid System

The purpose of the CCHRC hybrid system was to demonstrate renewable technologies in a new context, leveraging available resources, like solar and biomass, with relatively emerging systems like thermal storage, all in the extreme climate of interior Alaska.

Why a hybrid system?

To demonstrate using renewable energy technologies in a severe climate.
To measure how much solar thermal energy can be stored for the dark days of winter.
To gain knowledge, experience, and perspective on using seasonal thermal storage, which complement a wide variety of renewable energy systems.
To achieve LEED Platinum status for the CCHRC building addition.

System specs:

16 fixed, flat plate solar thermal panels; south-facing, tilted at 85° from horizontal
25,000 gallon water storage tank (recycled from a fuel storage plant)
113,900 BTU pellet boiler
Radiant floor heating distribution system; low temperature
180 Gallon buffer tank

CCHRC building addition specs:

8,024 square feet
113.8 MBTU annual heat load
73,033 BTU/hr design heat loss
0 Domestic Hot Water load
R-44 REMOTE walls, passive solar heating, HRV, built to LEED Platinum standard

More resources

Trying to choose between different heating systems for your own home? The following may help you:

Thermal Storage Technology Assessment; Includes information about using thermal storage in Alaska
http://www.cchrc.org/sites/default/files/docs/thermal_storage.pdf

Life Cycle Assessment for the Built Environment; Includes links to websites to help conduct economic and environmental assessments for buildings
http://www.cchrc.org/life-cycle-assessment-built-environment

The Alaska Consumer Guide to Home Heating;
http://www.cchrc.org/alaska-consumer-guide-home-heating

REFERENCED HEATING SYSTEMS [#1] Viessmann Vitola 200 (86% Efficient Non-Condensing Oil Boiler)
[#2] FCX 22 (96% Efficient Condensing Oil Boiler) [#3] Harmann PB 105 (Pellet Boiler)