Air Source Heat Pump and Internal Heat Gains in the Context of a Super-Efficient Building Envelope

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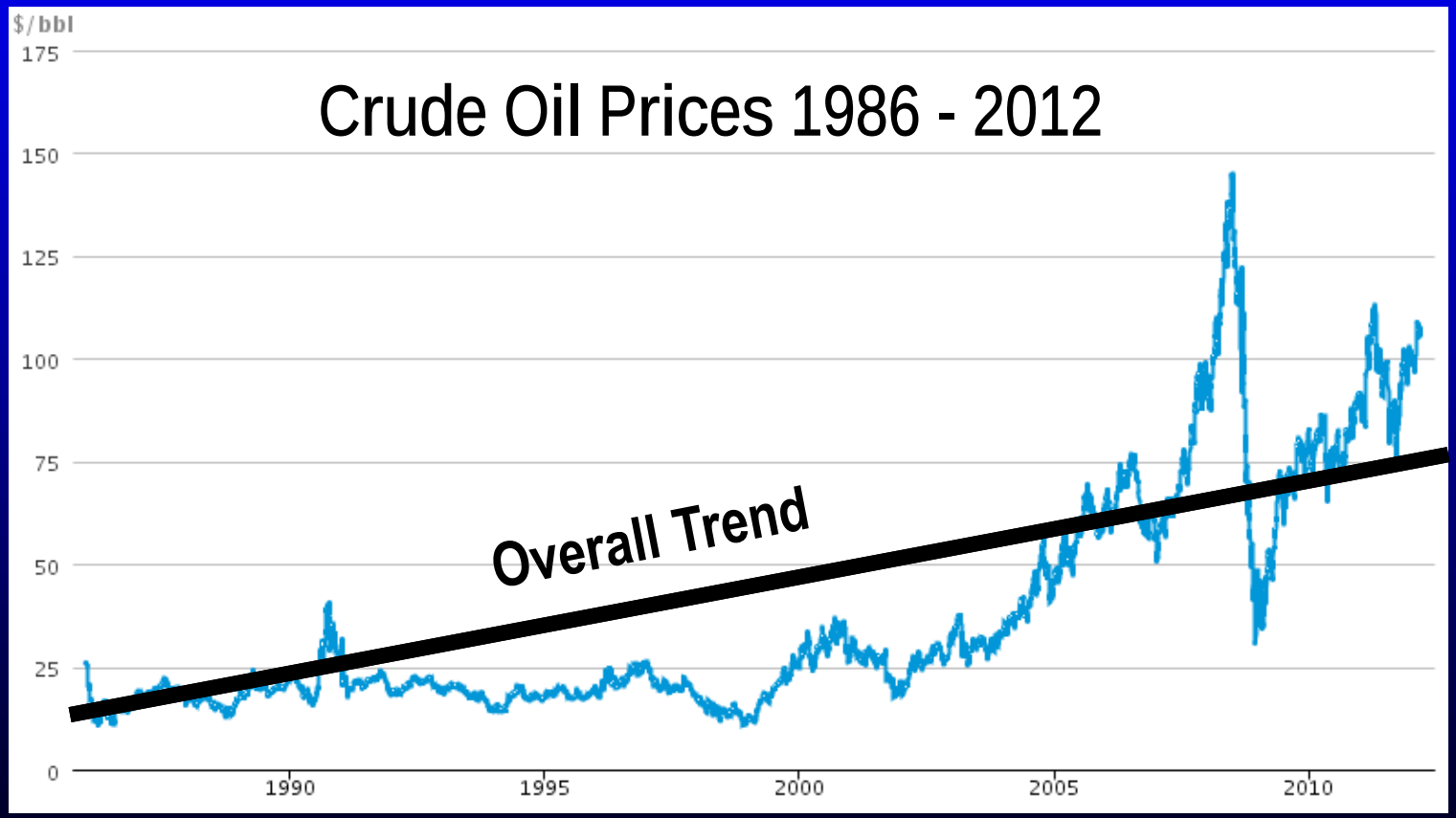
Reasons for energy efficient buildings

- Reduce energy use (save money, environment, etc.)
- Increase value of property
- Get ready for the long-term future

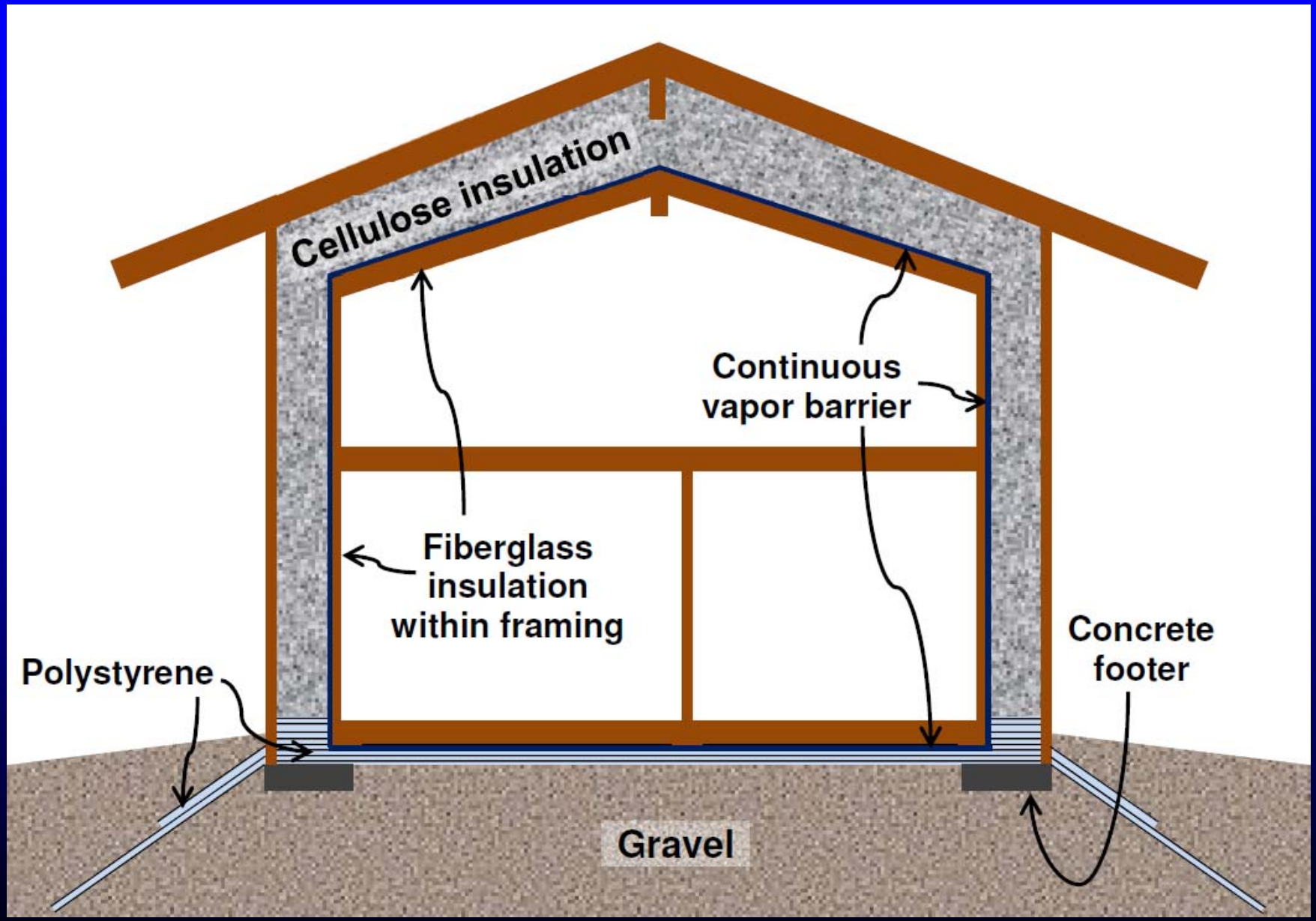


Source: Energy Information Administration (www.eia.gov)

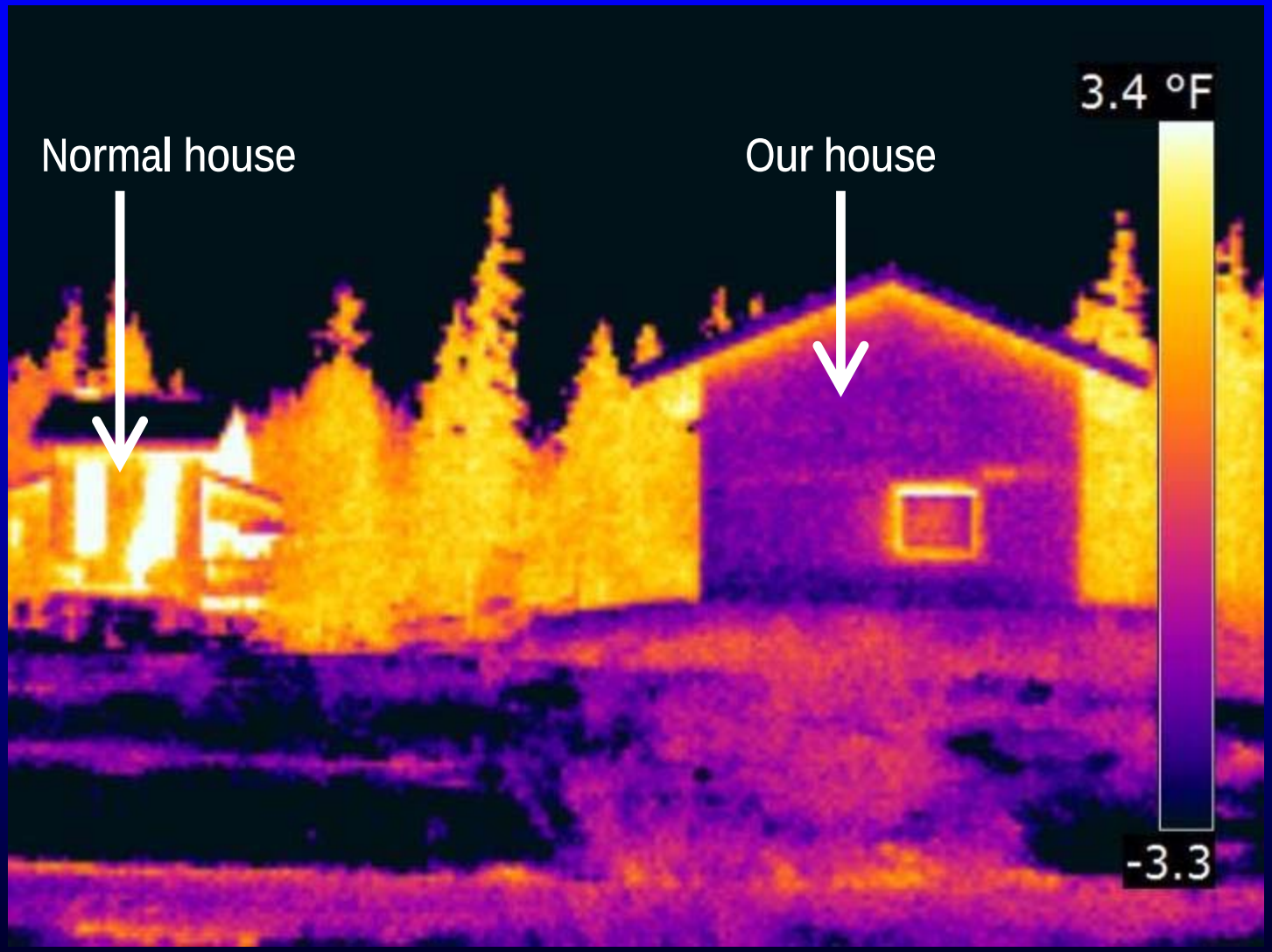
Our house – basic characteristics

Location - Dillingham, AK
24’x24’ outside dimensions, 2 story envelope
28” thick walls
1,150 sf gross living area, 590 sf net living area
2 bedrooms, 1 bathroom

Keep it simple!



Super-insulation works!



Our house – energy features

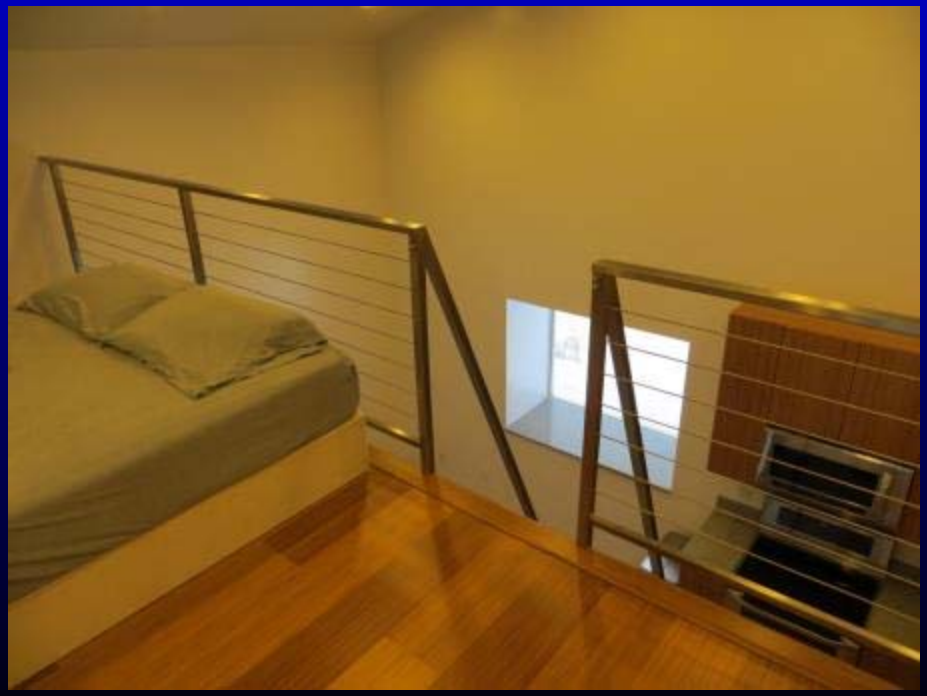
(approximate values)

- Largely (but not completely) based on the Passive House standard
- Walls: R-90; Ceiling: R-140; Floor: R-35 + R-20 outside along perimeter
- Design heating load (@ -22 F) of 1.4 kW
- Air-tightness: 0.05 ACH @ 50 Pa - Tightest known house in the world!

Our house – energy features – Cont'd

- Triple-pane, argon-filled, double low-e, fiberglass-frame windows
- Heat Recovery Ventilator (HRV)
- Heat pump water heater
- Low-flow plumbing fixtures
- ENERGY STAR appliances
- Entirely electric (no oil, no propane, no wood)

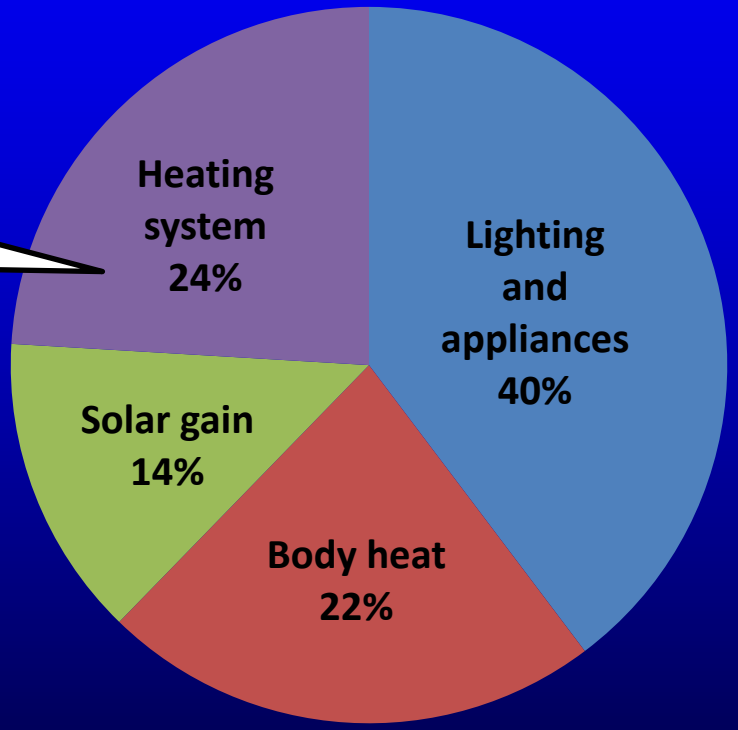

WERNER



Where is the heat coming from?

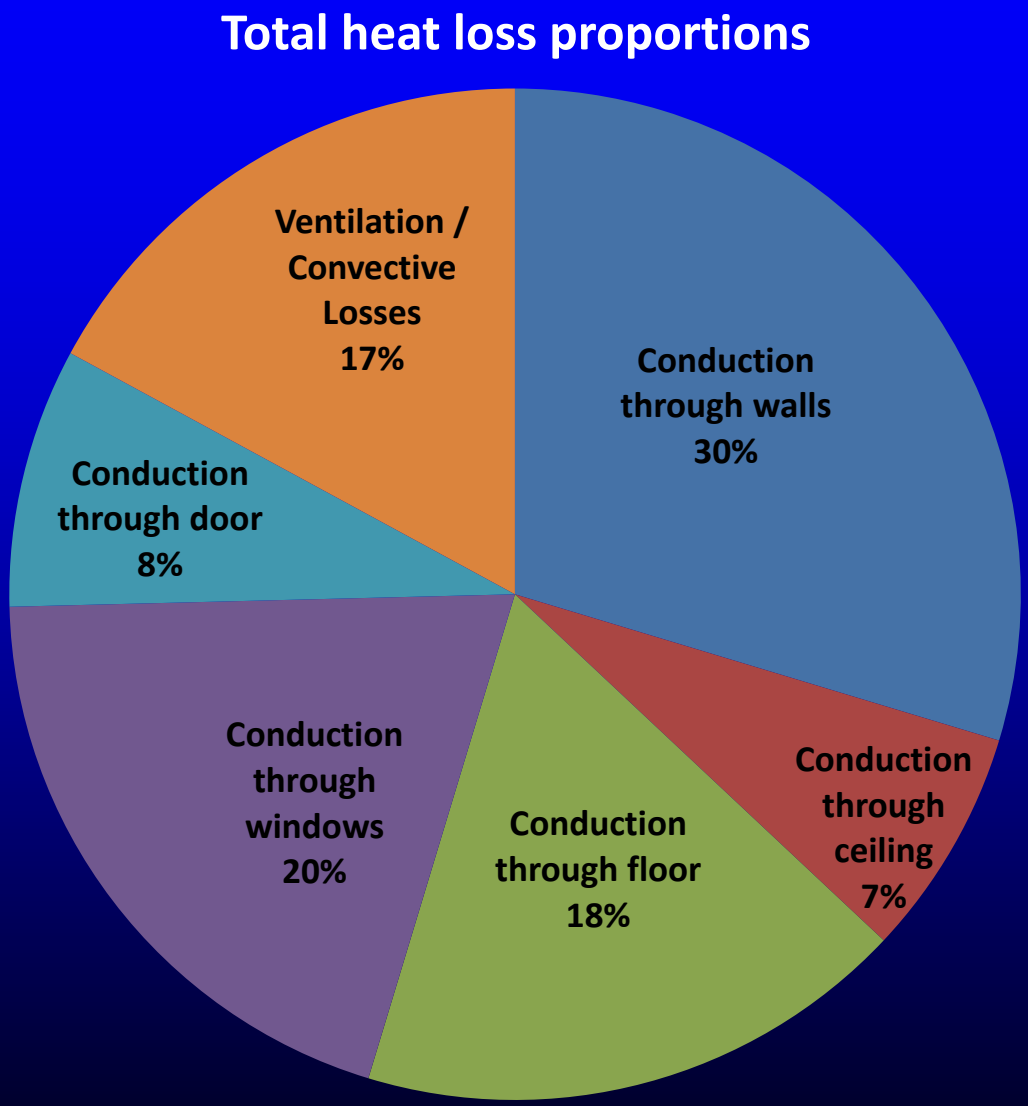
Total annual heat demand:
15,900 kBtu (100%)

~3,800 kBtu
or
~35 gal if heated with oil*



* Note:
35 gal of heating oil is stated just for perspective.
The house is heated with an air-source heat pump, which uses ~600 kWh of electricity annually.

Where is the heat going?



Total annual electricity use

Based on simulation for typical year: 3,200 kWh
Total electricity actually used in 2013: 2,930 kWh

Annual energy cost for typical year

	Electricity	Heating fuel	Total
Average house in Dillingham	(5,930 kWh) $1,200	(700 gal of oil) $4,200	$5,400
Our house	(3,200 kWh) $770	None	$770

Notes:
$0.16/kWh (after PCE) plus service fees
$6 per gallon
700 gallon of oil per year is average for rural Alaska; data for Dillingham not available

Material cost

Category	Cost	What is included
Land and gravel	$42,900	Land, gravel, well, sewage system
Unequipped building	$57,500	Foundation, roof, windows and door, walls (siding to sheetrock), insulation
HRV and accessories	$1,300	HRV, weather hoods, ducts
Space heating system	$3,100	Air-source heat pump, plus an electric heater backup
Water heating system	$1,400	Heat pump water heater
Plumbing and electrical	$8,800	Rough plumbing and electrical, pressure tank, water softener, lighting
Interiors	$61,600	Kitchen, flooring, plumbing fixtures, appliances, interior doors
Total	$176,600	

Labor cost: ???

Heating System (Experimental)

Air-source heat pump

More detailed monitoring needed to better understand the system's performance in cold climates.

Air Source Heat Pump (ASHP) Basics

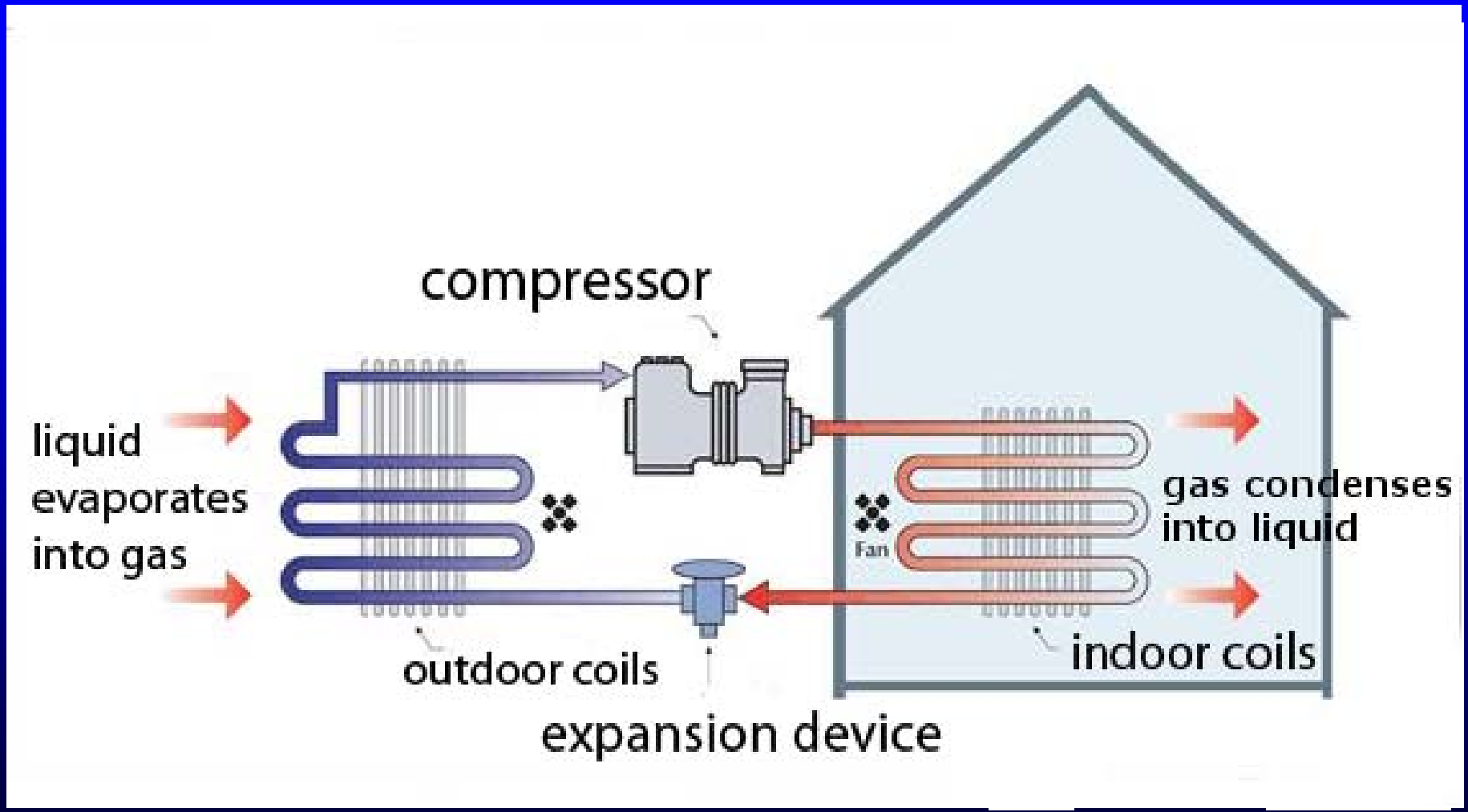
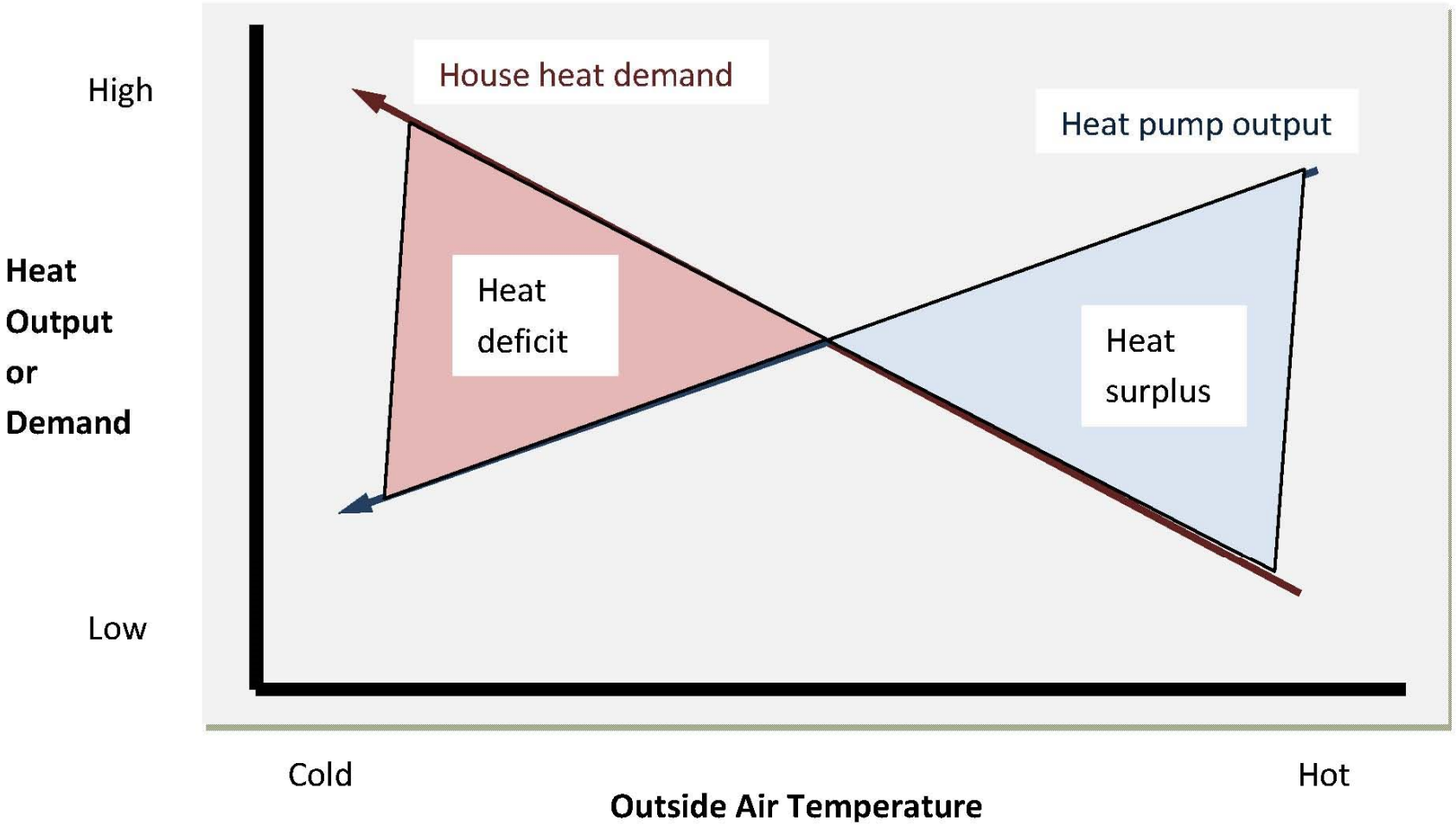
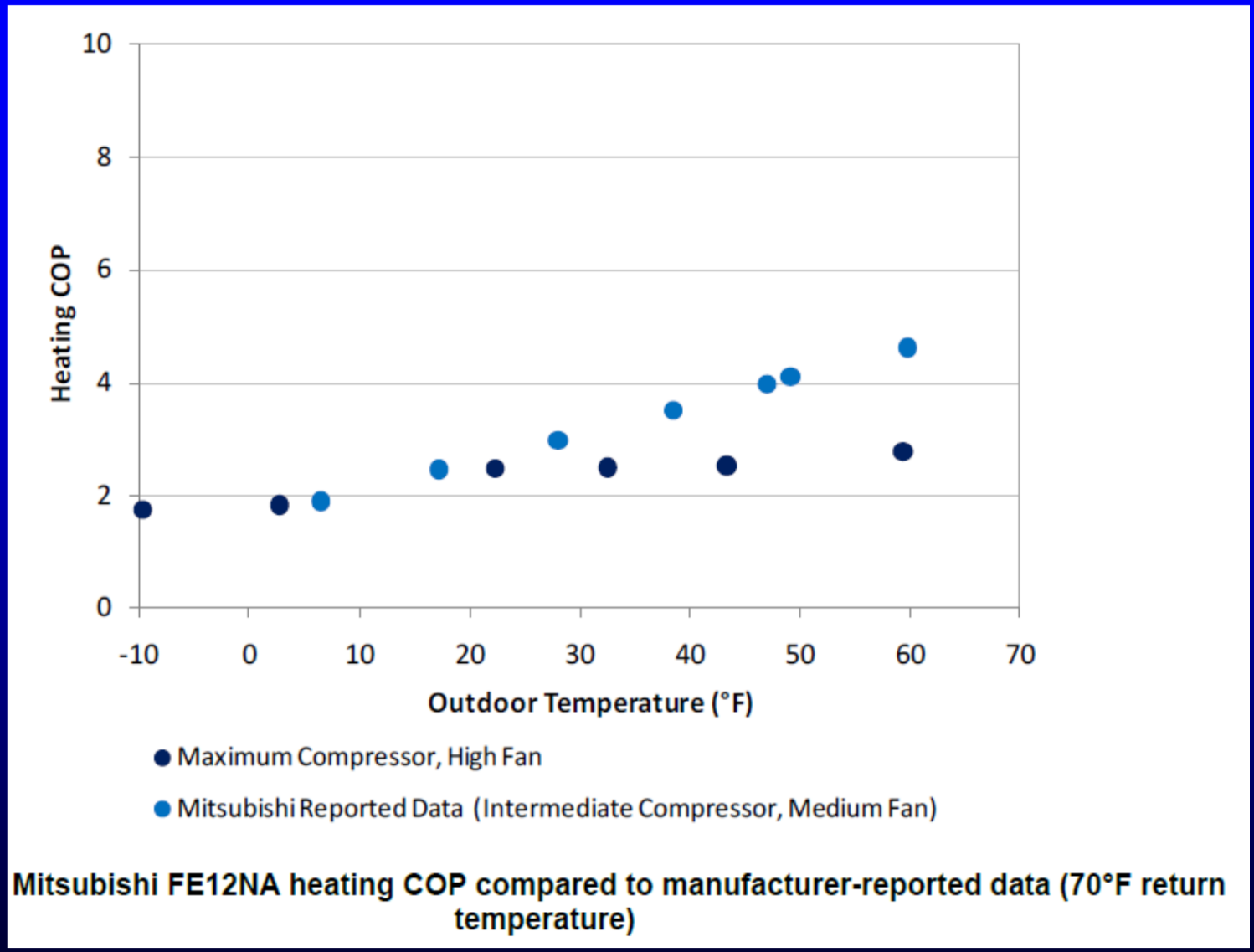


Image courtesy of RETScreen

Fundamental Challenge of ASHPs



ASHP Coefficient of Performance (COP)



Mitsubishi FE12NA heating COP compared to manufacturer-reported data (70°F return temperature)

Source: NREL – Laboratory Test Report

ASHPs – Special Considerations

- Need for a backup heat source in cold climates
- What is the source of electricity and its efficiency?
- Air-to-air versus air-to-water
- For air-to-air: ducted versus ductless

ASHPs in Context of Super-Efficient Building Envelope

- Inexpensive backup heat source (electric space heater)
- Possibility to span colder parts of day with no heating
- Lower seasonal COP because heating is needed only when it is cold

Emerging Energy Technology Fund Grant
- Air Source Heat Pump Potential in Alaska -

Partnership of CCHRC and UAF Bristol Bay Campus

Main Objectives

- Study the field performance of ASHPs in Alaskan conditions
- Study the behavior of ASHPs around cut-off temperatures
- Study the potential of using ASHPs as an electrical demand management tool by replacing resistive heating systems (primarily on south-east Alaska)

Credits

Individuals:

William Donaldson
Gorden Isaacs
Chet Chambers
Fergus Hickling
Dave Northup
Mike Favors
Dagen Nelson
Kent Winship
Jack Brown
Tran Smyth
Mike Davis
Todd & Michele Radenbaugh
Paul Liedberg
Rick Lind
Bryan Reed
Jiri Marsik
Russell Nelson
Anthony Jett
and many others …

Organizations:

UAF Bristol Bay Campus
Alaska Building Science Network
Cold Climate Housing Research Center
Bristol Bay Housing Authority
Alaska Energy Authority

THANK YOU!

For more information

Go to the web

energy-alaska.wikidot.com/nzer-Dillingham

www.cchrc.org

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