Efficiency Vermont



Heat Pump Technology

Capturing the HVAC Market in the Coming Decade

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Our Roadmap

- Brief technology overview
- Customer Economics
- Case Study
- Market potential
- Programs to accelerate progress
- Future State – even more compelling

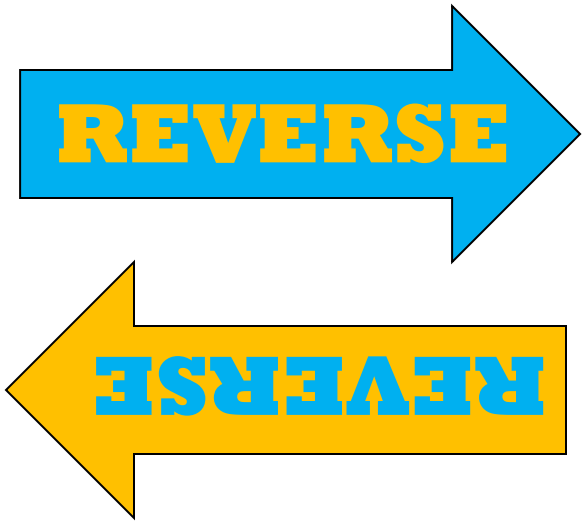
Benefits of Heat Pumps

- Heating and cooling from same piece of equipment
- Cheaper heat than most conventional combustion and resistive heating systems
- Also efficient cooling with SEERs >25
- Ductless heat pumps are a quick and non- invasive retrofit installation
- New construction - reduced need for heating and cooling infrastructure
- Can be completely sustainable if powered by renewables

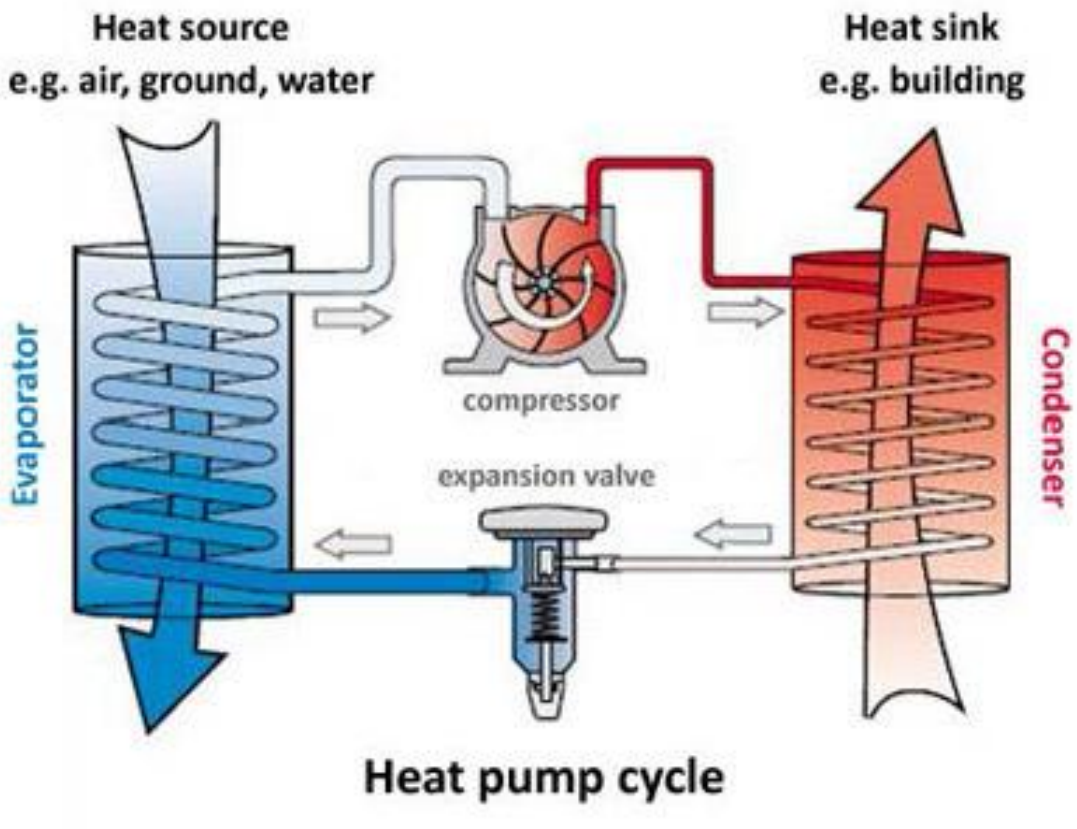
A Quick Technology Primer

What IS a heat pump, anyway?

An air conditioner in reverse

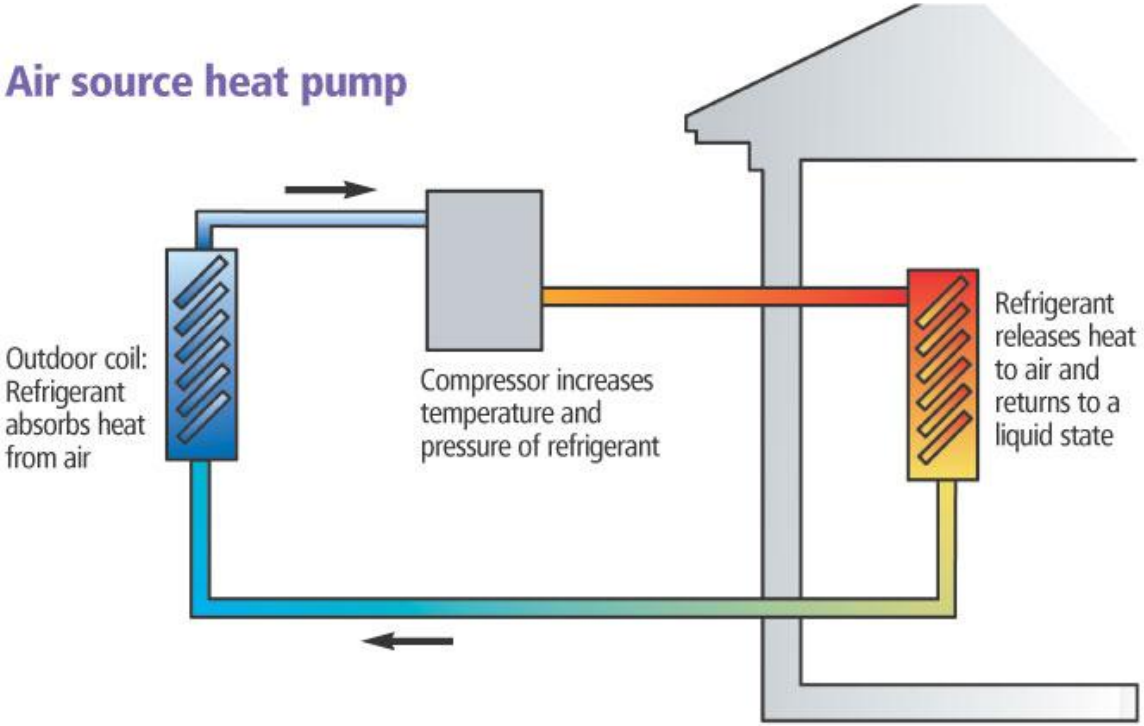


Heat Source → Heat Sink



Heat Source

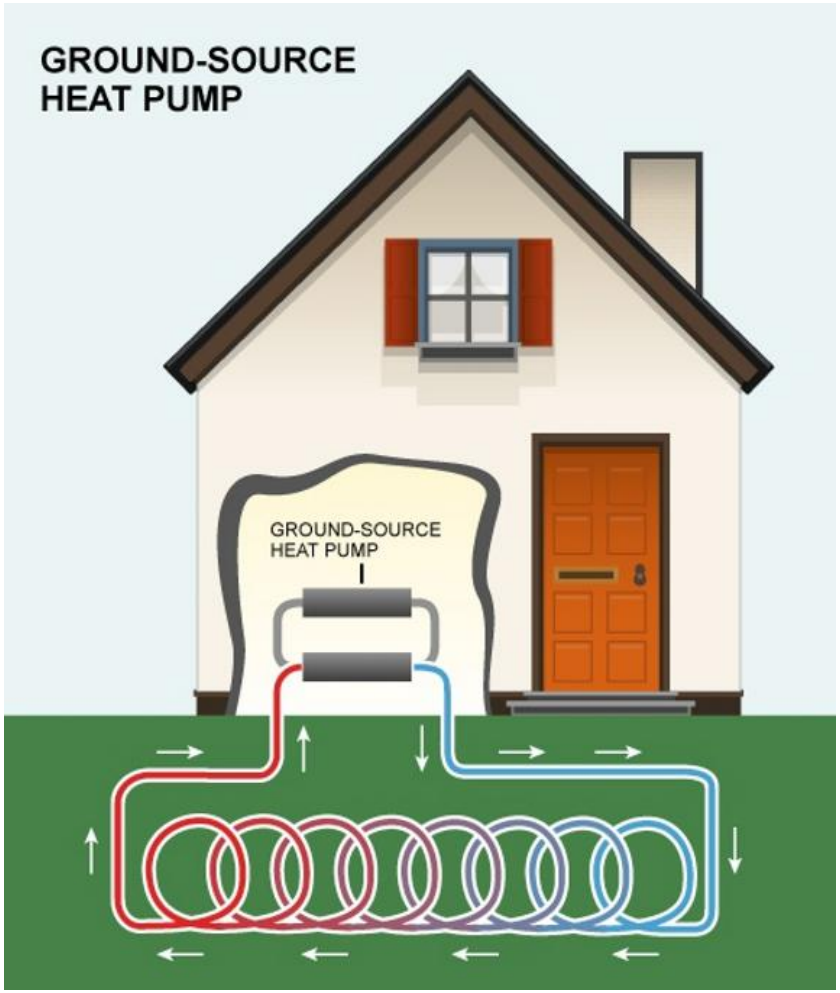
Air (Air Source Heat Pump)




MITSUBISHI
ELECTRIC
Mr.SLIM
R410A

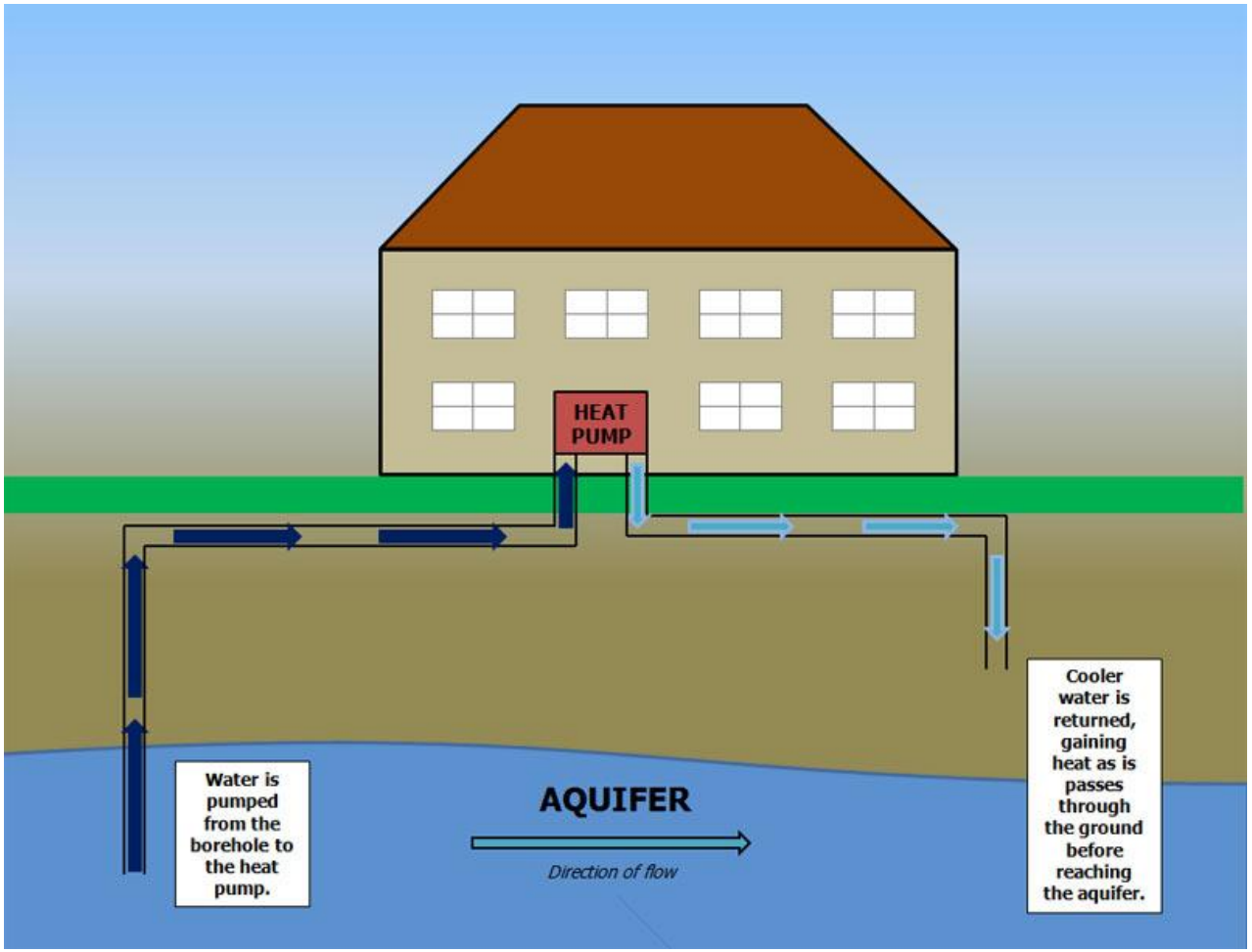
Ground (Ground Source or Geothermal Heat Pump)

- Earth



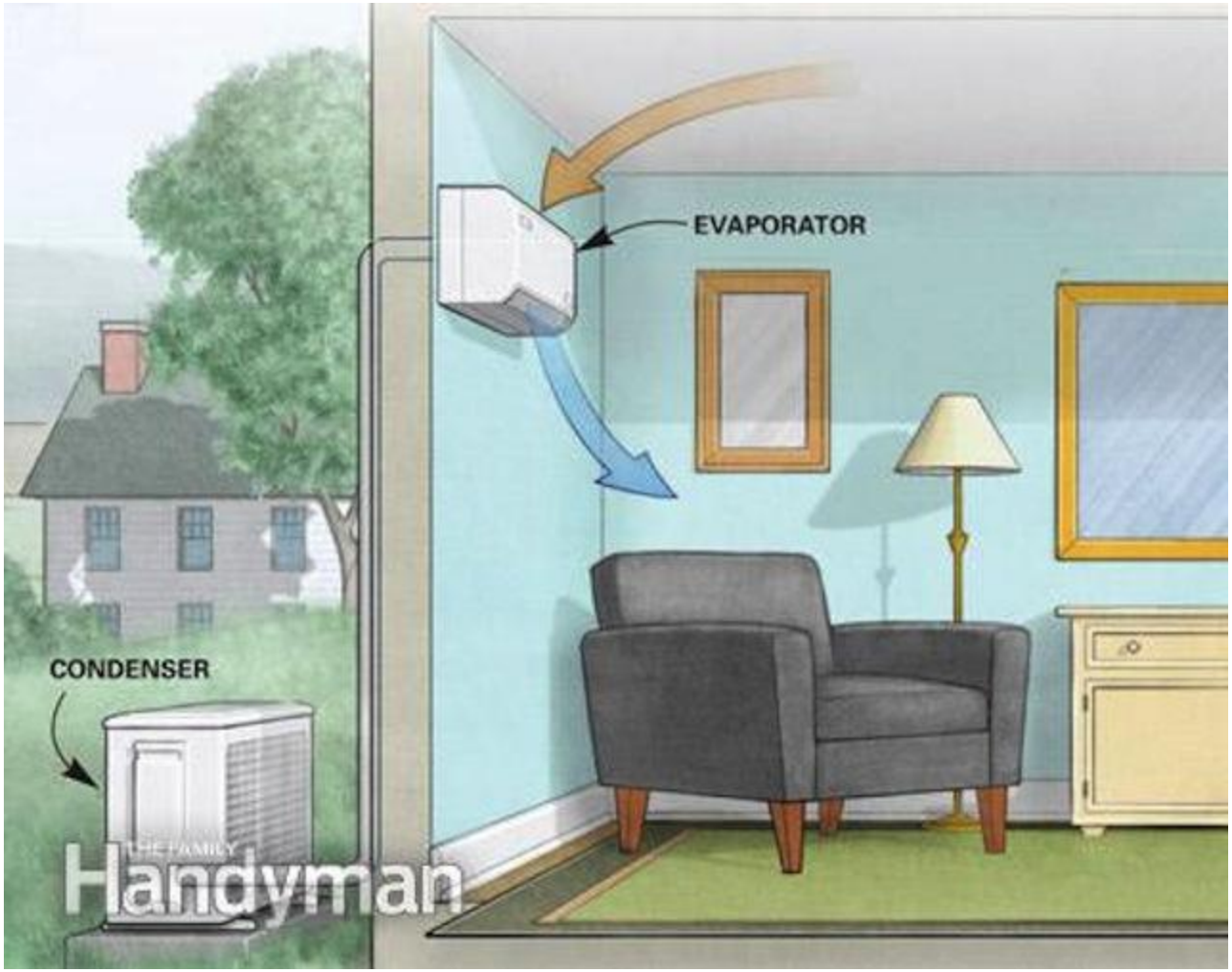

CliTech

➢ Water


HEAT PUMP
Water is pumped from the borehole to the heat pump.
AQUIFER
Direction of flow
Cooler water is returned, gaining heat as is passes through the ground before reaching the aquifer.

Heat Sink – Space Heat

Air Delivered



Heat Sink – Space Heat

Water Delivered

Heat Sink – Domestic Hot Water

Heat Pump Water Heaters

- Air → Water
- 1/3-1/2 the electricity as a standard electric water tank (saves 50-66%)
- Incentive programs in 28+ states
- New federal standards in 2015 will require electric DHW>55 gal to be a heat pump water heater

Source/Sink Variations

Air – Air

- Example is ductless mini-splits

Air – Water

- Daikin Altherma or heat pump water heaters

Water – Water

- “Geothermal” or ground source feeding hydronic distribution

Water – Air

- Ground (water) source feeding into ducted air handler

World of Heat Pumps

Many Applications and Forms

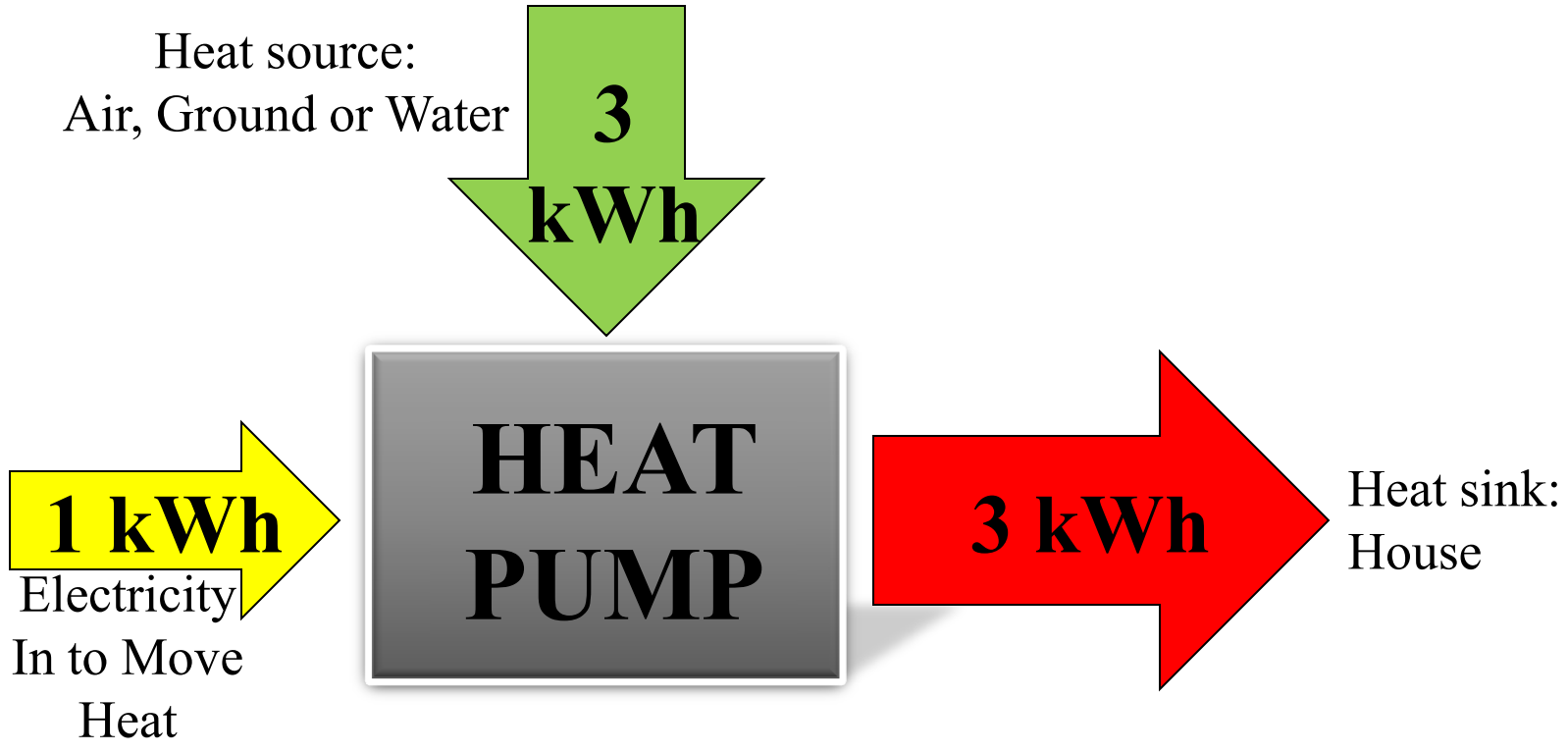
- Space Heat
- Water Heat
- Cooling
- Dryers
- More?

Are they efficient?

- They *Move* Heat, rather than *Generate* Heat
- Leverage heat existing in the environment rather than burn fuel to release energy
- COPs of 2.0-4.0+
  - What is COP?
  - COP (Coefficient Of Performance) = Energy Out/Energy In
- High SEER (Seasonal Energy Efficiency Ratio) – Cooling
- High HSPF (Heating Season Performance Factor) - Heating

So… A COP of 2-4 is equivalent to 200-400% efficiency!

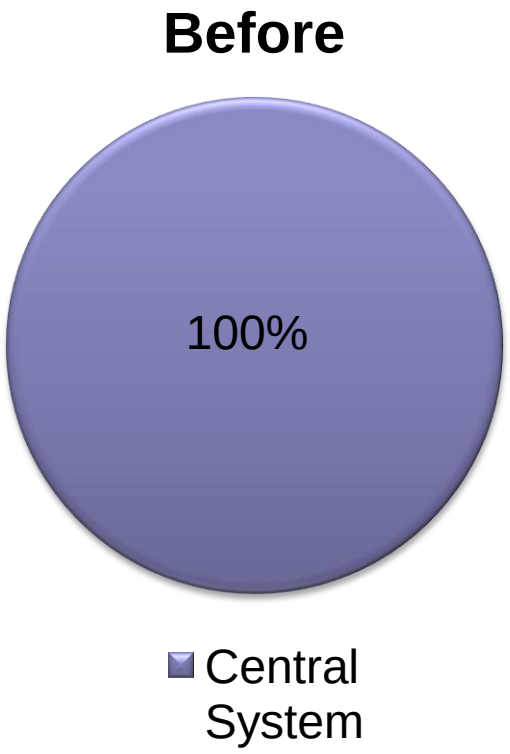
More Out than In (COP of 3)?

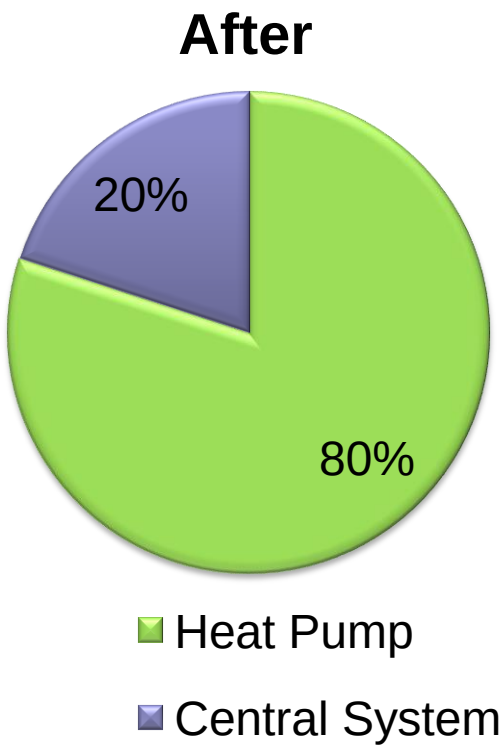


Customer Economics

Ductless Mini Splits

The Displacement Model





Play with Numbers

House before:

- 850 gallons fuel oil ($4/gal)
- $3400/yr for heat (117 MMBtu)

House after:

- 170 gallons oil + 7300 kWh electricity ($0.15/kWh)
- $680 (oil) + $1100 (electric) = $1780/yr for heat (48 MMBtu)
- Net Savings - $1620/yr (69 MMBtu – 59% Reduction)

A Comparison of Heating Fuels

Fuel Type	Unit	Btu/Unit	Efficiency	$/Unit	$/MMBtu
Wood	Cord	22,000,000	60%	$193	$14.62
Natural Gas	Therm	100,000	90%	$1.55	$17.22
Pellets	Ton	16,400,000	80%	$247	$18.83
Fuel Oil	Gallon	138,200	85%	$3.72	$29.91
Kerosene	Gallon	136,600	85%	$4.19	$34.08
Propane	Gallon	91,600	90%	$2.96	$35.90
Electricity	kWh	3,412	300%	$0.15	$14.65

Typical Residential Heating Fuel Costs (75 MMBtu/Yr)

Fuel	Volume	Unit	$/Unit	$/Year
Wood	5.7	Cords	$193	$1,100
Natural Gas	833	Therms	$1.55	$1,291
Pellets	5.7	Tons	$247	$1,407
Fuel Oil	603	Gallons	$3.72	$2,243
Kerosene	610	Gallons	$4.19	$2,556
Propane	910	Gallons	$2.96	$2,694
Electricity	21,981	kWh	$0.15	$3,297

- Without Natural Gas (or biomass), heating costs run $2000-$3000+ per year

Heating Fuel Cost Savings with an ASHP (COP 3.0)

Fuel	Unit	50 MMBtu/Yr	75 MMBtu/Yr	100 MMBtu/Yr
Wood	Cords	$28	$41	$55
Natural Gas	Therms	$(136)	$(204)	$(272)
Pellets	Tons	$(194)	$(291)	$(388)
Fuel Oil	Gallons	$(800)	$(1200)	$(1601)
Kerosene	Gallons	$(985)	$(1478)	$(1970)
Propane	Gallons	$(1218)	$(1827)	$(2435)
Electricity	kWh	$(1744)	$(2616)	$(3488)

- Savings ~$1,000-$2000/yr+
- Assuming 90% heating fuel offset and no cooling effects

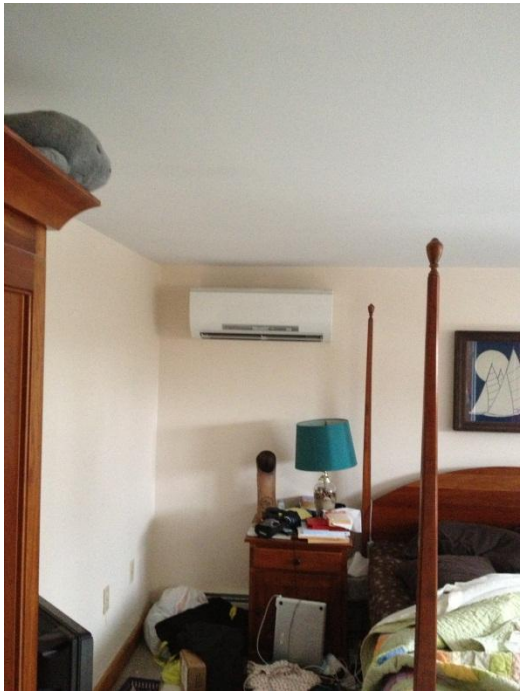
Case Study

Building Description

- 2 Story, 3 Bedroom home in Burlington, VT
- 2280 ft2 CFA
- Some weatherization (primarily in the attic)
- Modeled design heat load ~54,000 btu/h
- Existing oil boiler – 680 gallons/yr ($2600)

Case Study - Heat Pump Installation

- 2 Mini-splits installed in November, 2012
- One Mitsubishi FE18 in dining/kitchen and one FE12 in master bedroom



Case Study - Fuel Use Data

	Pre-Installation Use	Adjusted Pre-Use (for DHW)	Post-Installation Use (adj)	Difference	Savings ($/year)
Oil (gal)	684	584	188	-396	$1,464
Electric (kWh)	6910	NA	12,056	+6200	$(870)

Net Savings = $594

Some considerations

- 73% displacement
- All things equal, COP = 2.2 (assumes all added electric went to heat)
- Annual increase in kWh is not necessarily heating-only

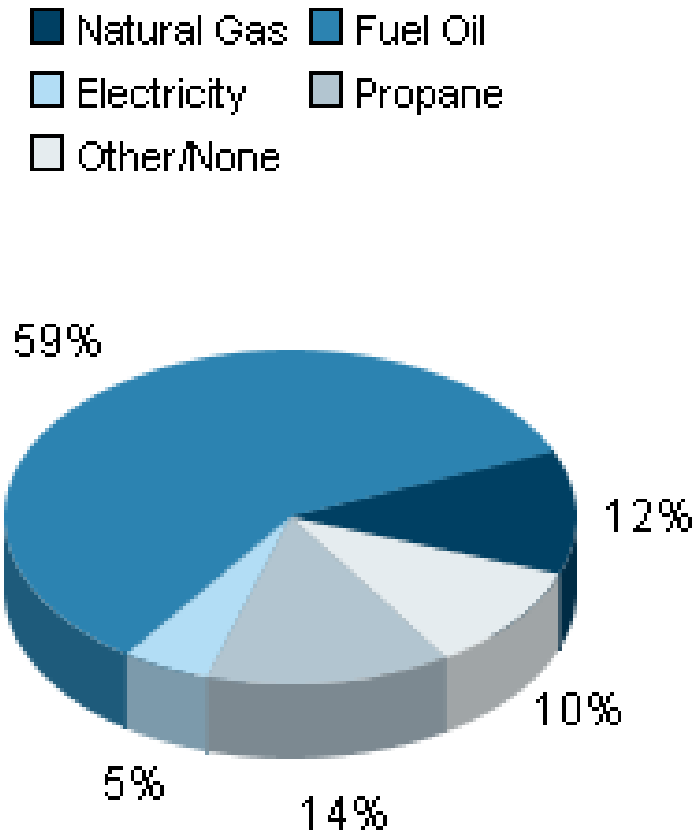
Lessons Learned, Next Steps

- DHW disaggregation a wild card
- Accurate billing analysis difficult with unregulated bulk fuel deliveries
- Sub-metered data necessary for accurate evaluation

- 13 Homes where sub-metering is installed
- 9 of these have an experimental COP metering
- Beginning to gather data, analysis in late spring/early summer
- Developing better tools for calculating bulk fuel use

Economics for Vermont and Beyond

Heating Fuels for Vermont Homes



Source: US DOE, 2000 Census

Potential Savings for Vermont

Fuel Displacement %	Space Heating (Gal Oil + LP)	Water Heating (Gal Oil + LP)	Cost Savings ($/Year)
10%	9,250,000	1,850,000	$20,000,000
20%	18,500,00	3,700,000	$40,000,000
30%	27,750,000	5,550,000	$60,000,000
40%	37,000,000	7,400,000	$80,000,000
50%	46,250,000	9,250,000	$100,000,000

Source: Hyper-Efficient Devices: Assessing the Fuel Displacement Potential in VT of Plug in Vehicles and Heat Pump Technology, Letendre 2013

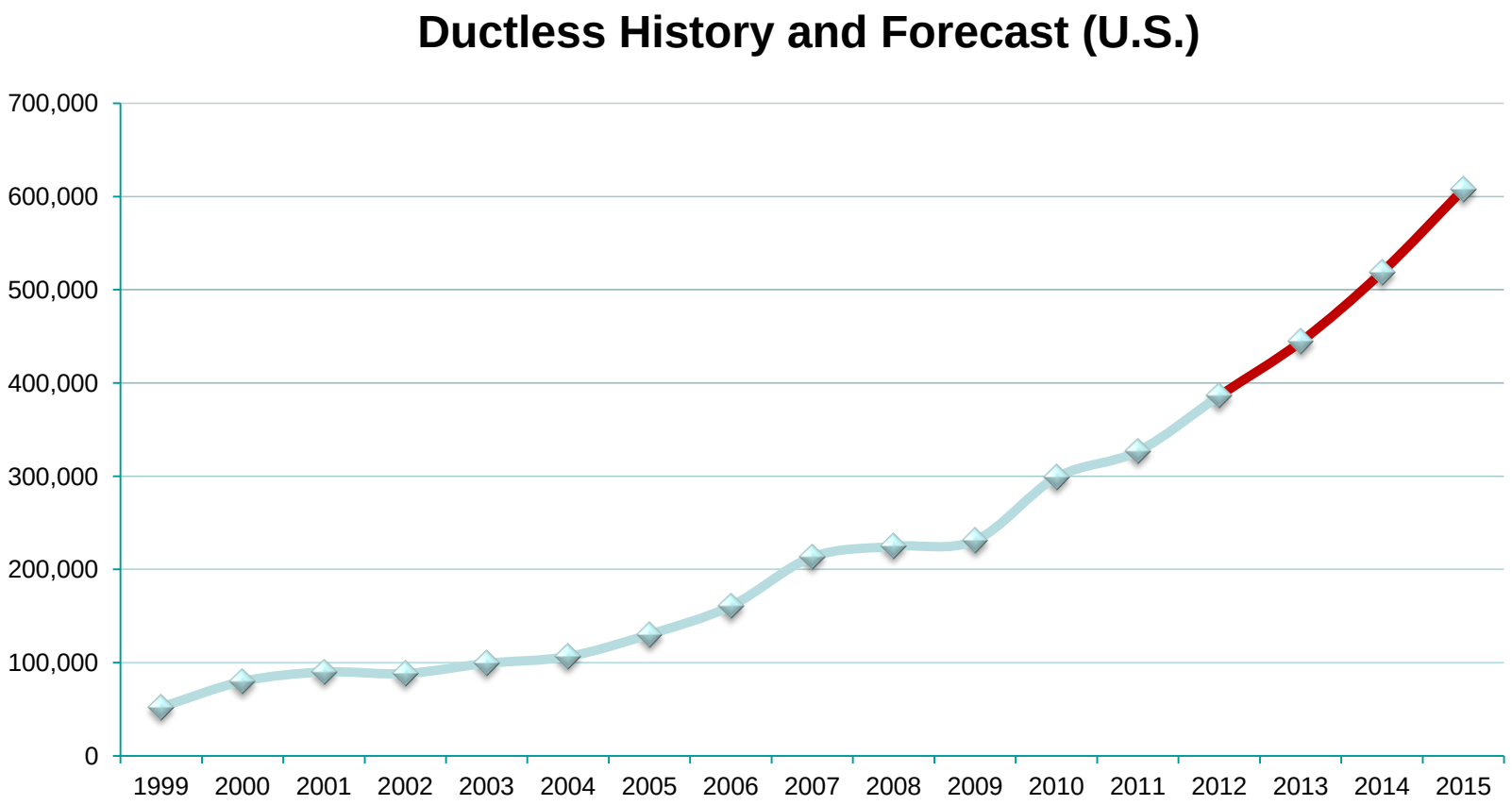
- Assuming fuel oil at $3.99/gal, LP at $2.99/gal, electricity at $0.14615/kWh

Theoretical Maximum Efficiency (COP)

	Technology		
	Combustion	Resistive	Heat Pump
Present Peak Efficiency	0.95	1.0	2.0-4.0
Theoretical Maximum	1.0	1.0	6.0-17.0

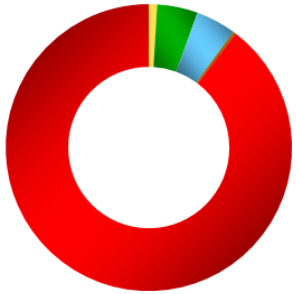
- Combustion Technology is near maximum
- Heat Pumps still present huge potential

National Sales – Ductless Heat Pumps

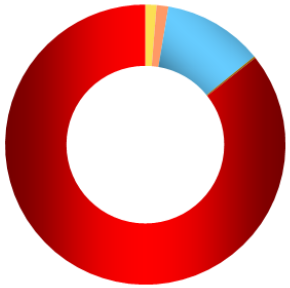


Mitsubishi Electric "Market Data"

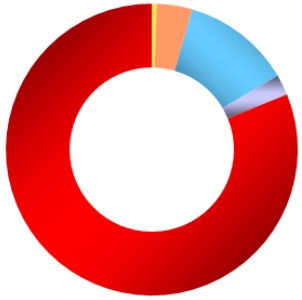
Worldwide Adoption



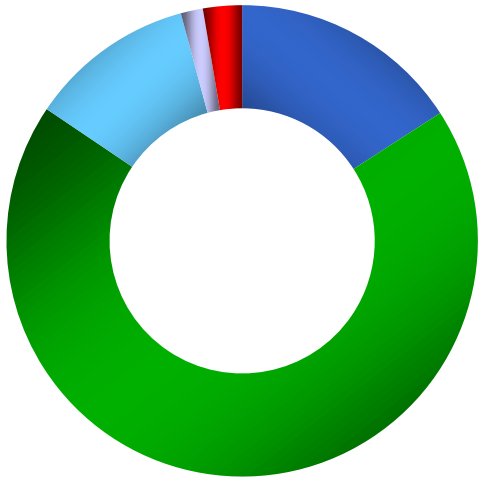
Japan
90%
7.2M Systems



China
86%
16.7M Systems



Europe
81%
7.6M Systems



USA
4%
0.4M Systems

Ductless is a small percent of the U.S. HVAC market but current building and energy usage trends indicate a large growth opportunity

Mitsubishi Electric "Market Data"

Vermont Market – Residential Splits

2011-2012 Sales:

- Close to 35% growth over previous year
- ~1720 Units

2012-2013 Sales:

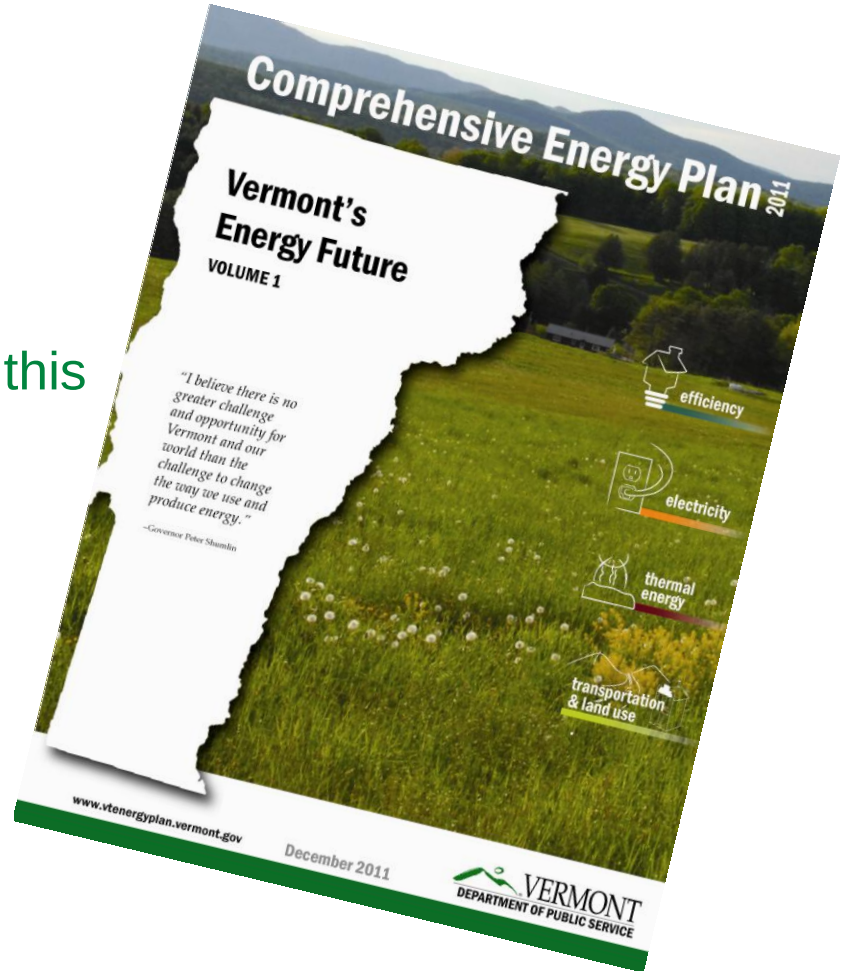
- Major manufacturers saw over 40% growth
- ~2400 Units

See a trend?

Programs

VT Comprehensive Energy Plan

- 90% Renewable by 2050
- Renewable thermal energy?
- Biomass and electrical
- Heat pumps are a big piece of this energy puzzle
- Programs being put in place to support this ambitious goal



Programs – CEED Cold Climate Heat Pump Program

What is it?

- Collaboration between Efficiency Vermont, Green Mountain Power, and Neighborworks of Western Vermont
- Incentive program for installing heat pumps in residential and commercial buildings
- Both ductless and central systems – All air source
- Fossil fuel displacement

COLD-CLIMATE
HEAT PUMP

Programs – CEED Cold Climate Heat Pumps Eligible Equipment

The world's first cold climate heat pump standard:

	DUCTLESS	CENTRAL
Definition	A split-system heat pump unit that heats (or cools) directly into the room without ducts	A split-system heat pump unit connected to whole house distribution systems
Capacity	100% of Nominal Capacity at 5°F	Maximum heating capacity at 5°F >50% rated capacity
Heating Efficiency	COP >1.75 @5°F maximum capacity rating; HSPF > 9	COP >1.75 @5°F maximum capacity rating
Cooling Efficiency	>20 SEER	>SEER 13

Programs – CEED Cold Climate Heat Pumps Customer Eligibility

- Must be Legacy CVPS customer
- Must use fossil fuels
  - 300 gallons of fuel oil/kero
  - 450 gallons of LP
- Building must be weatherized
  - Avoid putting heat pumps in “leaky old farmhouses”

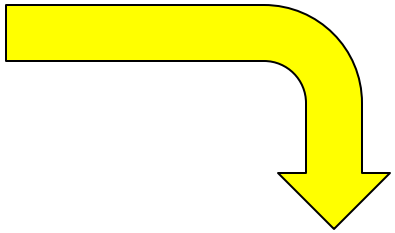
Programs – CEED Cold Climate Heat Pumps
Customer Incentives

	DUCTLESS*	CENTRAL
First Indoor Unit	$750	$500/ton
Second Indoor Unit	$500	
Integrated Controls	$250	$250
Integrated DHW System		$500

Programs – Cold Climate Heat Pump
Electric Heat Retrofit

What is it?

- EVT program directed at electric resistance displacement
- NOT a fuel switch program
- Targeting residential customers with primary electric heat



Programs – Cold Climate Heat Pump Electric Heat Retrofit

- Equipment Eligibility- Same as CEED CCHP (ductless only)
- Customer Eligibility- State-wide residential electric customers who use primarily electric resistance heat
- Incentives- $1,000 for each home
- Official rollout…Today!

Lease Programs – GMP

- August 1, 2013 Rollout
- Only for GMP customers
- 600+ calls in the first few days
- So successful, had to stop taking new calls
- 447 homes have been visited
- Around 100 ductless units installed
- Plans to go State-wide

Lease Programs – Glow (www.glowheat.com)

- Monthly costs $52-$57, no money down
- Private 15 yr. lease arrangement
- Installing similar equipment to CEED/HiPER

Three unit sizes are available

Size (btu)	12,000	15,000	18,000
Monthly Cost*	$51.95	$53.95	$56.95
Net Savings**	$517	$751	$985

* Cost estimate for Mitsubishi FE Series heat pump lease (taxes not included)

**Estimating annual savings for an average 2500 sq ft home currently using 850 gallons of oil per year for heating

Programs- Other States

Maine

- $600 unit, optional on-bill financing (7.75%)
- 1350 homes – low income
- 660 homes – open market

Connecticut

- 3576 heat pumps – low income
- 490 heat pumps – open market

Other Programs

- Massachusetts, New York, New Hampshire, Pacific Northwest

A Look Forward

Technology to Look Out For

Near Term

- 30+ SEER ductless
- Multi-zone cold climate optimized ductless
- Integrated water heating
- More customer options all around

Long Term

- Constantly improving efficiencies
- CO2 Refrigerant Systems
- No need for back-up systems (true replacement)

Other Upcoming Factors

- Most models forecast significant natural gas cost increases over the next decade
- Increased adoption of renewable generation is constantly improving the source factor (decrease in CO2)
- Demand response as AMI (smart grid) improves, possible time of use rates provide added support for electrification

Not Without Challenges

- Program support is challenging for fossil fuel displacement. Concerns about load/peak building
- Current source factors make carbon reduction minimal for much of the US
- Added strain on an aging electrical infrastructure
- Creates even more need for efficiency and renewables
- Installation and service contractor training
- Supply chain disruptions

Take Away

Challenges do exist, however…

- Technology is currently very economically compelling
- Future developments and technology potential make this even more compelling
- Opportunity for market growth is tremendous
- Provides important strategy for carbon reduction solution
- Programs being put in place are accelerating adoption

Let's Talk