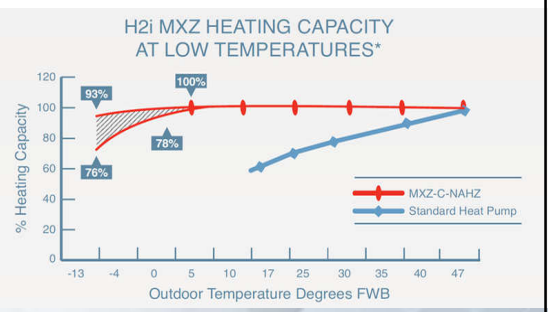
Cold Climate Air Source Heat Pump Strategies

12-01-2020

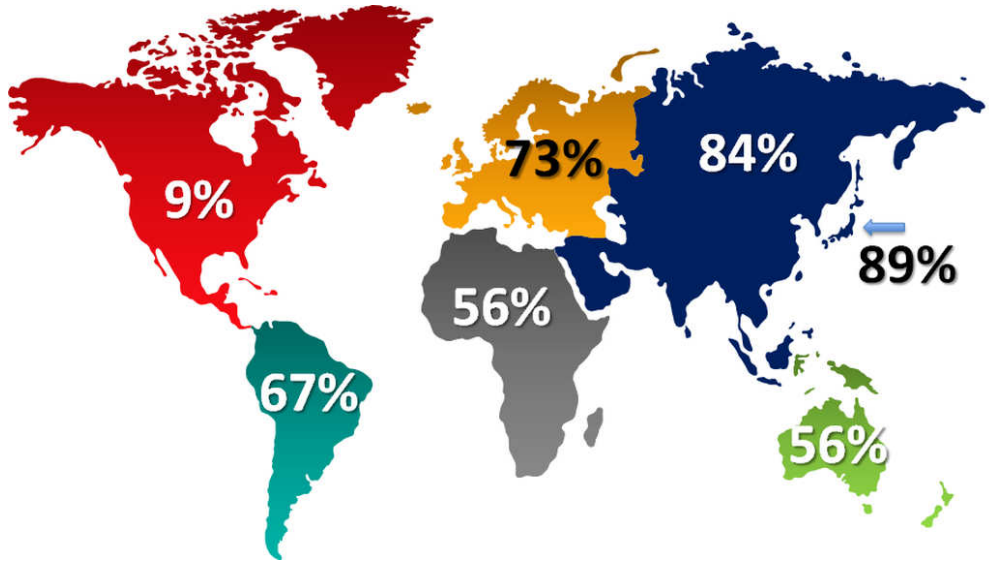
Shawn LeMons

Performance Construction Mgr.

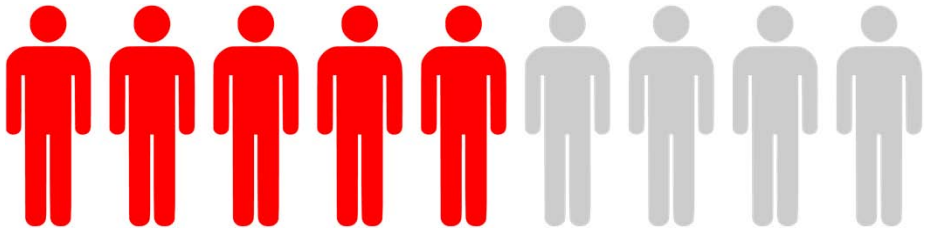
(Former IECC, RESNET, LEED, PHIUS)



ASHP International Market



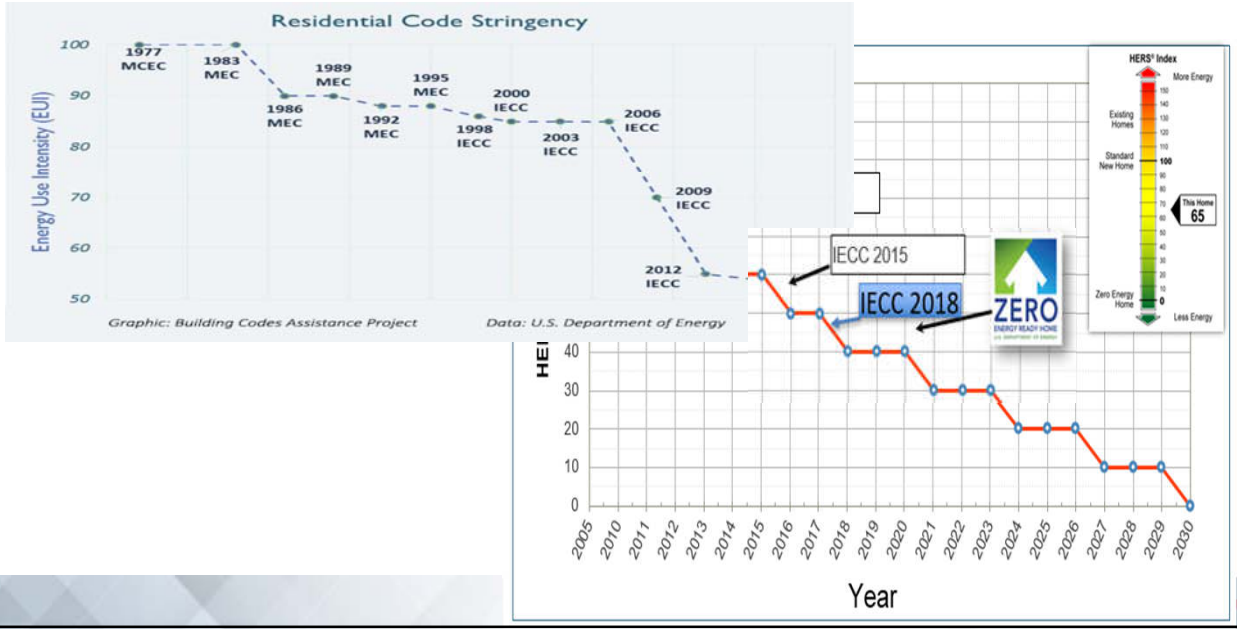
Did you know?



Well over 50% of U.S. HVAC contractors do not size heating & cooling correctly.

source: U.S. Department of Energy - 2016

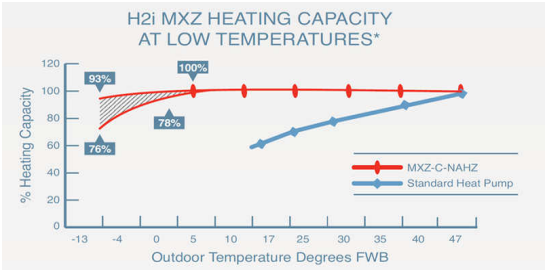
Performance Changing Over Time



What is a "Cold Climate" ASHP?

Chicago, January 29, 2019, with 3 days below -20F

https://drive.google.com/file/d/1QBgBd4JcVBpNpafsI4IeWH24GcurEa9b/view



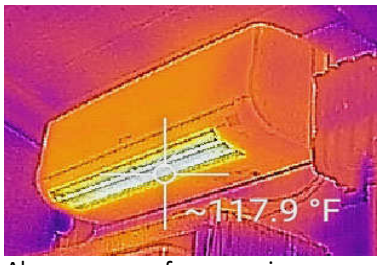
100% capacity at 5 F

76%-93% capacity at -13 F*

Operation down to -18 F and lower*

* Varies by outdoor model

VCHP systems - North Pole, AK



Above spec performance is common

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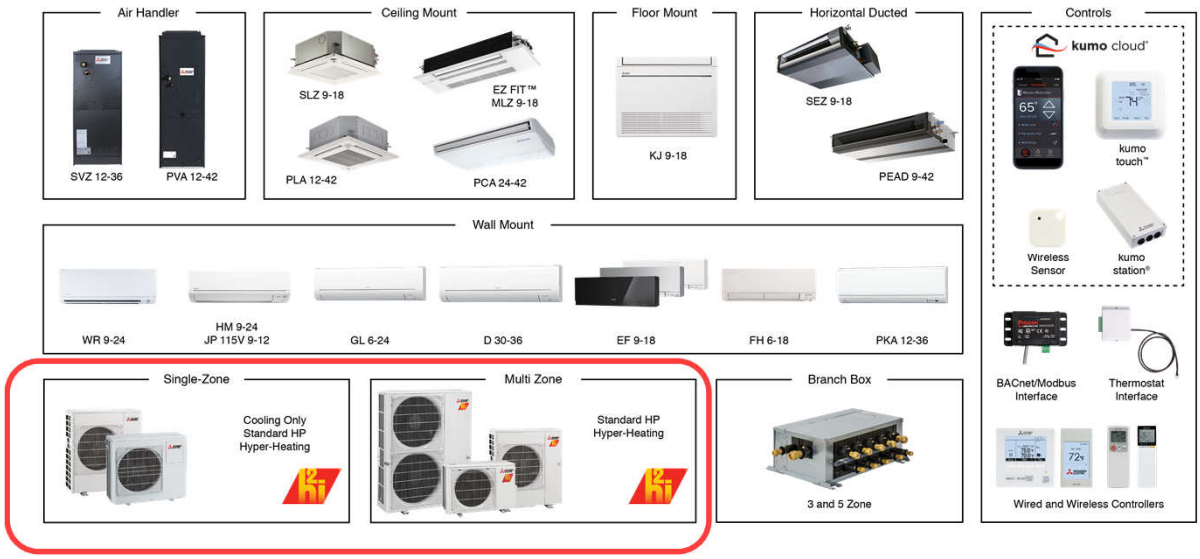
Heat Pumps Have Evolved



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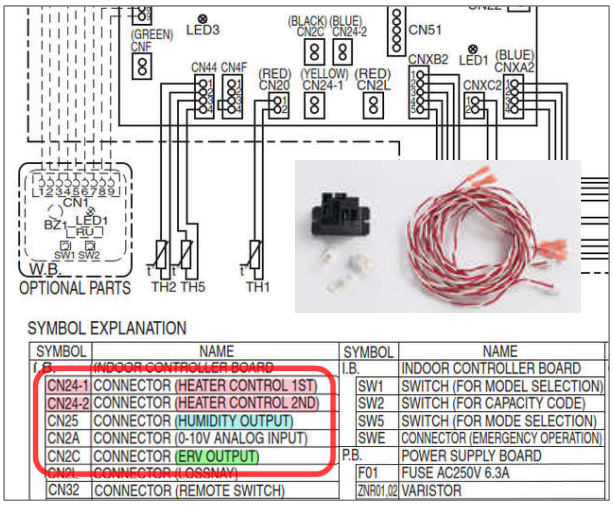
Integrate Other Equipment

3rd Party Thermostats, ERV/HRV and Humidity Fan Integration



SYMBOL EXPLANATION

SYMBOL	NAME	SYMBOL	NAME
~~I.B.~~	~~INDOOR CONTROLLER BOARD~~	I.B.	INDOOR CONTROLLER BOARD
CN24-1	CONNECTOR (HEATER CONTROL 1ST)	SW1	SWITCH (FOR MODEL SELECTION)
CN24-2	CONNECTOR (HEATER CONTROL 2ND)	SW2	SWITCH (FOR CAPACITY CODE)
CN25	CONNECTOR (HUMIDITY OUTPUT)	SW5	SWITCH (FOR MODE SELECTION)
CN2A	CONNECTOR (0-10V ANALOG INPUT)	SWE	CONNECTOR (EMERGENCY OPERATION)
CN2C	CONNECTOR (ERV OUTPUT)	P.B.	POWER SUPPLY BOARD
~~CN2L~~	~~CONNECTOR (LOSSNAY)~~	F01	FUSE AC250V 6.3A
CN32	CONNECTOR (REMOTE SWITCH)	ZNR01,02	VARISTOR

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Backup Heat

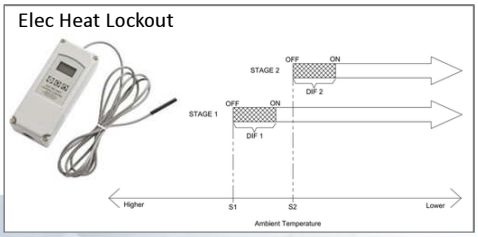
Onboard logic to manage electric heat when needed.

Mode Change	Condition								
	(To -T_{RA}) > 2.7 °F [1.5 °C]	AND	T_{RA} has not increased by 0.9 °F [0.5° C] in X min	EH1 ON for > 7 min	AND	(To -T_{RA}) > 2.7 °F [1.5 ° C]	AND	T_{RA} has not increased by 0.9 ° F [0.5° C] in 7 min	(To -T_{RA}) < 0.9 °F [0.5° C]
EH1 ON	○	AND	○						
EH2 ON				○	AND	○	AND	○	
EH1 OFF									○
EH2 OFF									○

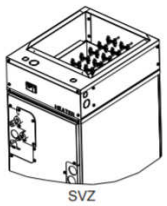
KEY
- EH1: Electric Heater 1
- EH2: Electric Heater 2
- To: Set point temperature
- T_{RA}: Return Air temperature
- X: Time delay (Selectable. Default is 24 min. Selectable to 14, 19, or 29 min)

Can used with any heat source control

Elec Heat Lockout



Heat Kit



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CEE Case Study 2 (MN, June '18)

Table 1. A comparison of the weather normalized annual performance for several heating systems in this Minneapolis home.

	Heating Load	Annual COP	Electric Use	LPG use	Natural Gas Use	Total Energy Use	Annual Operating Costs[1]	Emissions[2] CO_2
	mmBtu	-	kWh	therms	therms	mmBtu	$	eqiv lbs
ccASHP w/ ER boost	63.1	1.84	10,075	0	0	34.3	$1,310	11,499[3]
Electric Resistance	63.1	0.99	18,491	0	0	63.0	$2,404	21,104
LPG Furnace	63.1	0.79	503	747	0	76.4	$1,404	11,650
Natural Gas Furnace	63.1	0.79	503	0	747	76.4	$807	9,699

1. Average residential pricing in 2017 for propane, natural gas, and electricity from Energy Information Administration were $0.13/kWh for electricity, $1.57/gallon for LPG, and $0.95/therm for natural gas.
2. Monthly average emissions in 2017 monthly were used. For electricity, 1.14 equivalent lb/kWh, 11.7 lb/therm for natural gas, and 13.0 lb/gal for LPG. (See Edwards et al 2018).
3. Using the NSP value of 0.894 lbs/kWh[1] the ccASHP with ER booster annual emissions would be 9,007 equiv. lbs, a 2% reduction over the natural gas furnace.

PVA-A36

PUZ-HA36NHA5

Site Characteristics

- 2 bedroom, one bath, 1.5 story single-family home
- 1924 Bungalow, 1600 sqft, with efficiency upgrades
- 50,000 btu/hr heating load calculation at -11°F
- 26,000 btu/hr measured heating load at -11°F
- 18kW electric resistance ducted heat strip

https://www.mncee.org/MNCEE/media/PDFs/ccashp-Study-2-MPLS.pdf

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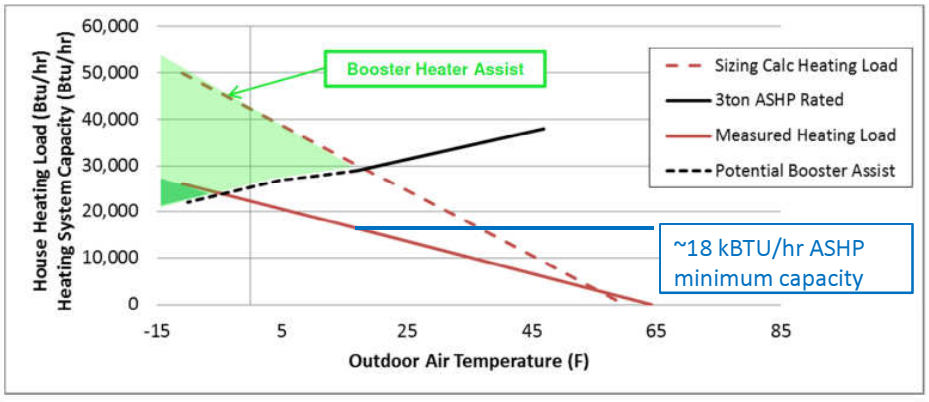
CEE Case Study 2 (MN, June '18)

Figure 3. Capacity vs. Outside Air Temperature



PVA-A36

PUZ-HA36NHA5

Site Characteristics

- 2 bedroom, one bath, 1.5 story single-family home
- 1924 Bungalow, 1600 sqft, with efficiency upgrades
- 50,000 btu/hr heating load calculation at -11°F
- 26,000 btu/hr measured heating load at -11°F
- 18kW electric resistance ducted heat strip

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MITSUBISHI ELECTRIC TRANE HVAC US

CEE Case Study 2 (MN, June '18)

SPECIFICATIONS: PVA-A36AA7 & PUZ-HA36NHA5

Heating at 47°F[2]	Maximum Capacity	BTU/H	40,000
	Rated Capacity	BTU/H	38,000
	Minimum Capacity	BTU/H	18,000
	Maximum Power Input	W	3,360
	Rated Power Input	W	3,040
	Power Factor	%	88.7
Heating at 17°F[3]	Maximum Capacity	BTU/H	38,000
	Rated Capacity	BTU/H	29,000
	Maximum Power Input	W	5,400
	Rated Power Input	W	3,230
Heating at 5°F[4]	Maximum Capacity	BTU/H	38,000
	Maximum Power Input	W	6,100
	SEER		17.8
	EER[1]		12.5
			11.0
			3.66
			2.06
			1.82
	ENERGY STAR® Certified (ENERGY STAR products are third-party certified by an EPA-recognized Certification Body)		Yes

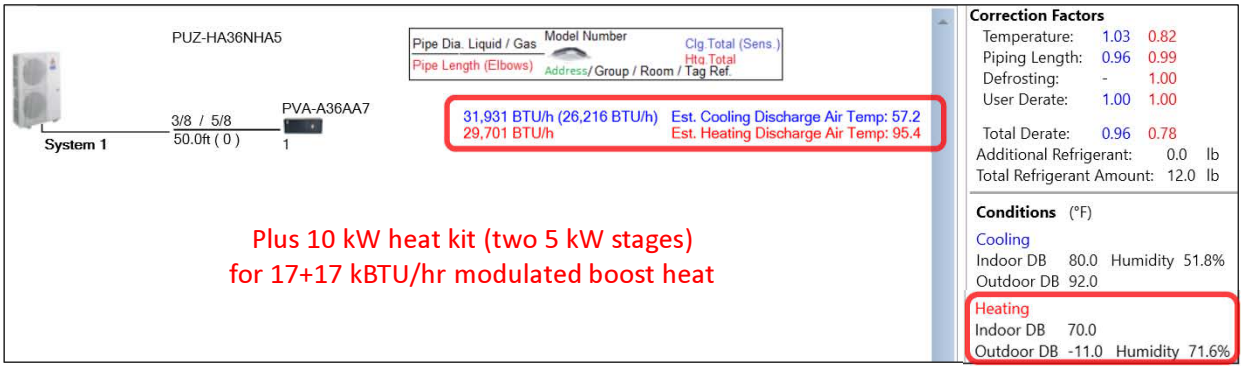
Site Characteristics

- 2 bedroom, one bath, 1.5 story single-family home
- 1924 Bungalow, 1600 sqft, with efficiency upgrades
- 50,000 btu/hr heating load calculation at -11°F
- 26,000 btu/hr measured heating load at -11°F
- 18kW electric resistance ducted heat strip

CEE Case Study 2 (MN, June '18)

If the Manual J was closer to the 26 kBTU/h heat load…

DIAMONDSYSTEM BUILDER



Plus 10 kW heat kit (two 5 kW stages)
for 17+17 kBTU/hr modulated boost heat

Verify system combination and capacity at design conditions.

Use this capacity and other spec sheet details for Manual S & Manual D compliance.

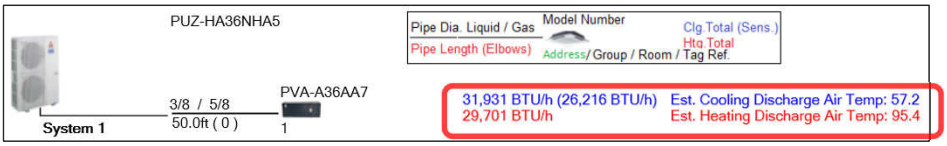
CEE Case Study 2 – Manual S Decision

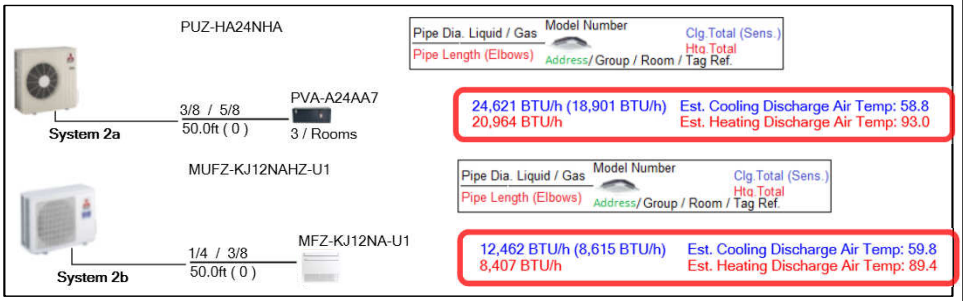
1 outdoor
1 ducted indoor
18 kBTU/hr min heat
~1400 watts at ~20°F

or…

2 separate systems:
Ducted for rooms
Ductless for Liv & Kit
2.9 kBTU/hr min heat
~200 watts at ~60°F

Cooling minimums are similar.





High Altitude Example

Design Conditions
- 26 kBTUh heating / 13 kBTUh cooling loads
- -11°F / 95°F design temps **@ 10,000 ft elevation**

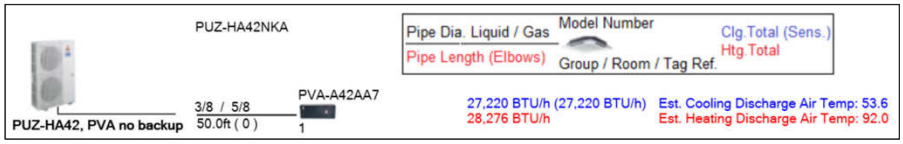
1 outdoor with 1 ducted indoor

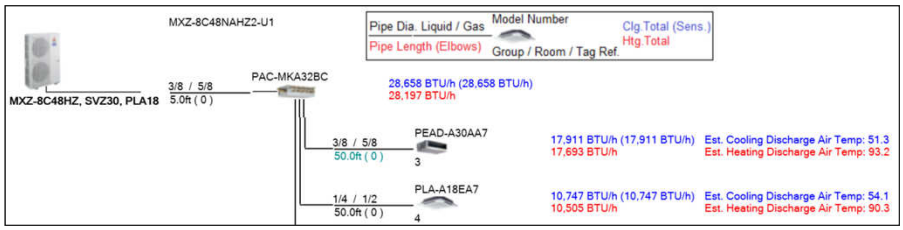
or…

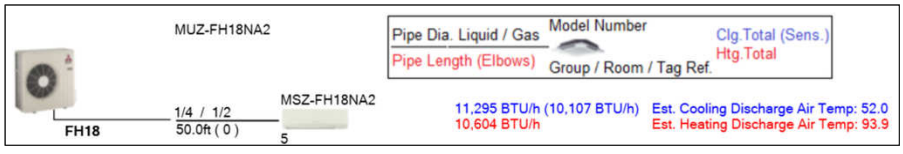
1 outdoor with ducted + ductless indoor units

or…

2 separate systems

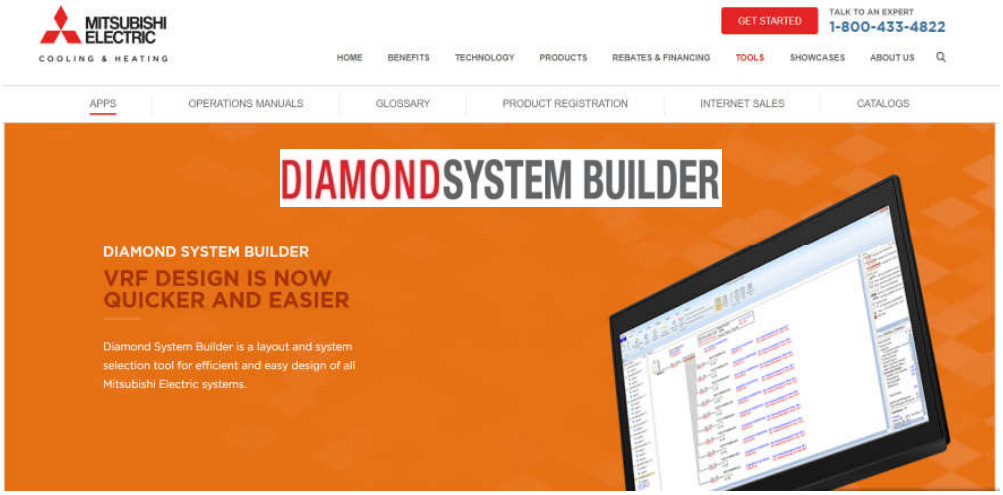




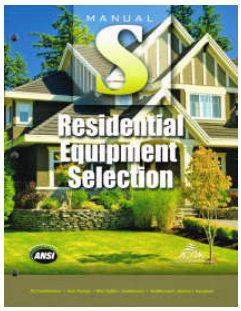


Design Resources

Extensive tools for Architects, Builders, Designers, Installers, and Homeowners



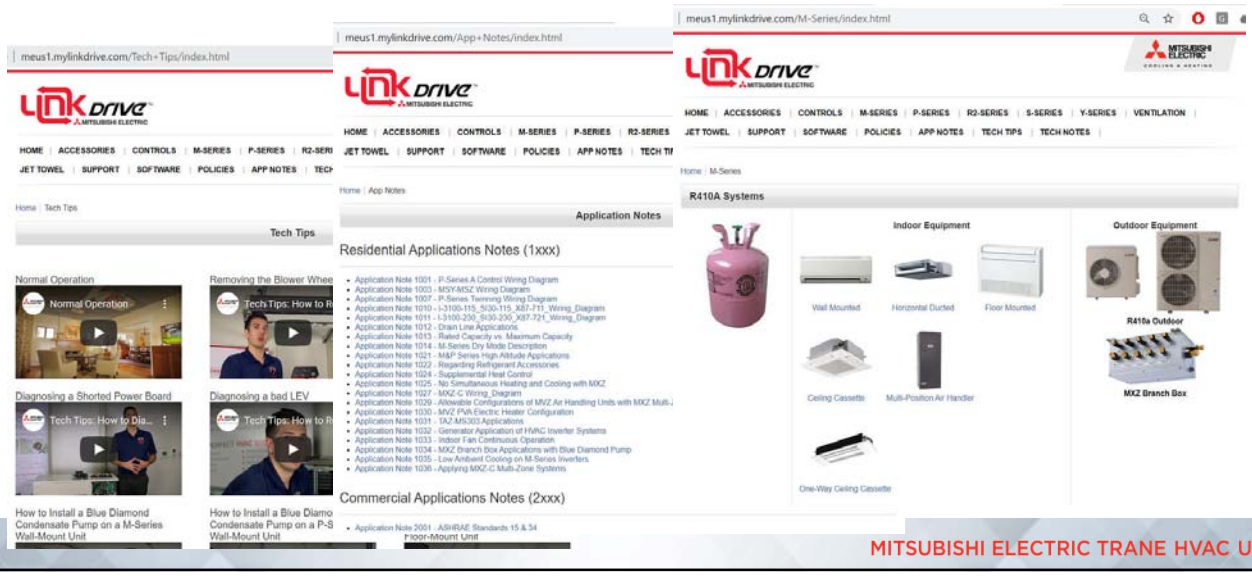
Use DSB with Manual S equipment selection



https://www.mitsubishicomfort.com/diamond-system-builder

Design Resources

Extensive tools for Architects, Builders, Designers, Installers, and Homeowners

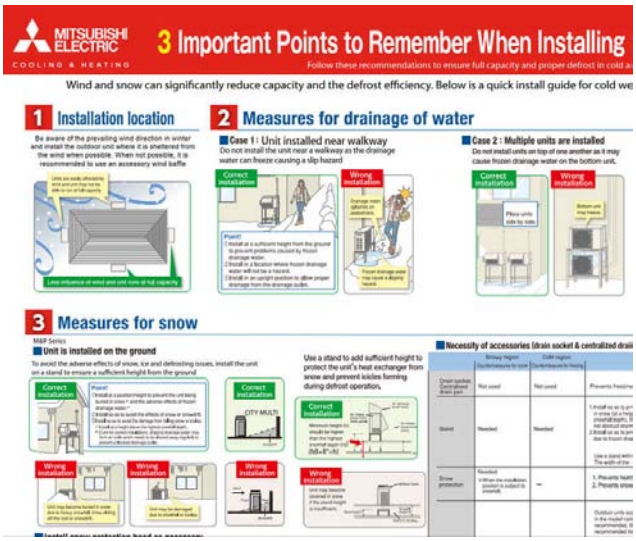


Cold Climate Installation Guidelines

Need to managing drainage, ice, and snow level

Good, but…

Better

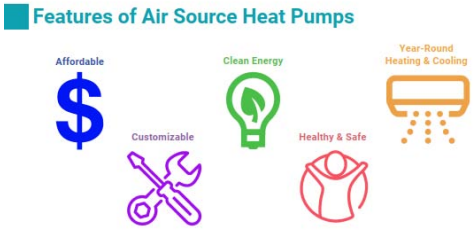


Cold Climate Installation Guidelines - https://tinyurl.com/y6blz8uz

NEEP - ASHP Guides

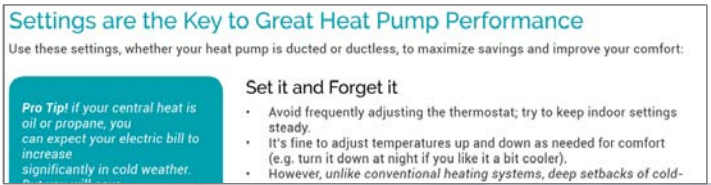
Part 1: Air Source Heat Pumps - The Basics

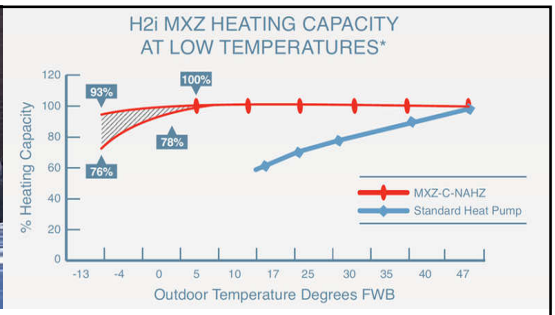
https://neep.org/sites/default/files/resources/ASHP_buyingguide_5.pdf



Getting The Most Out of Your Heat Pump

https://neep.org/sites/default/files/GettingTheMostFromYourHeatPumpConsumerGuideFINAL.pdf





Questions?

Shawn LeMons

Performance Construction Mgr.

(Former IECC, RESNET, LEED, PHIUS)

slemons@hvac.mea.com

720-648-0505