

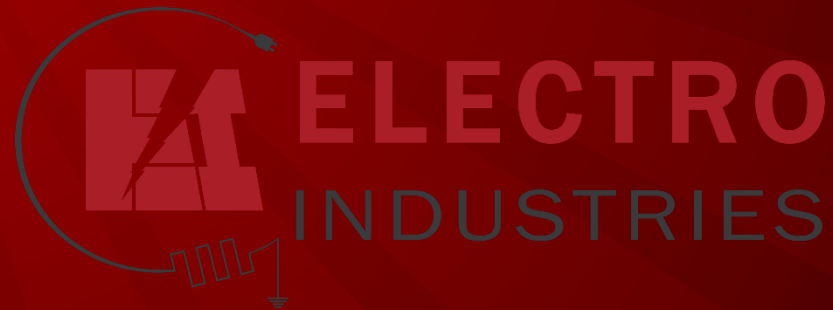
In accordance with the Department of Labor and Industry's statute 326.0981, Subd. 11,

“This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 hours** of credit toward **Building Officials and Residential Contractors code /1 hour energy** continuing education requirements.”

For additional continuing education approvals, please see your credit tracking card.

# AIR TO WATER HEAT PUMP SYSTEMS

Dennis Schramel  
Electro Industries Inc.  
National Sales Manager  
[dschramel@electromn.com](mailto:dschramel@electromn.com)



# QUESTIONS WE WILL ANSWER

- Efficiency standards in today's heating equipment
- Why the push to heat pumps?
- Types of air to water systems
  - Is one type more efficient than the other?
- What are the energy performance results?
- Where is the market for these systems and what are obstacles to growth?

# EFFICIENCY... IT'S WHAT CONSUMERS EXPECT

## Various COP's

Old Oil Boiler	0.50
Open Flame Flue	0.75
Direct Vent Gas	0.87
Condensing Gas	0.95
Electric Heat	1.00



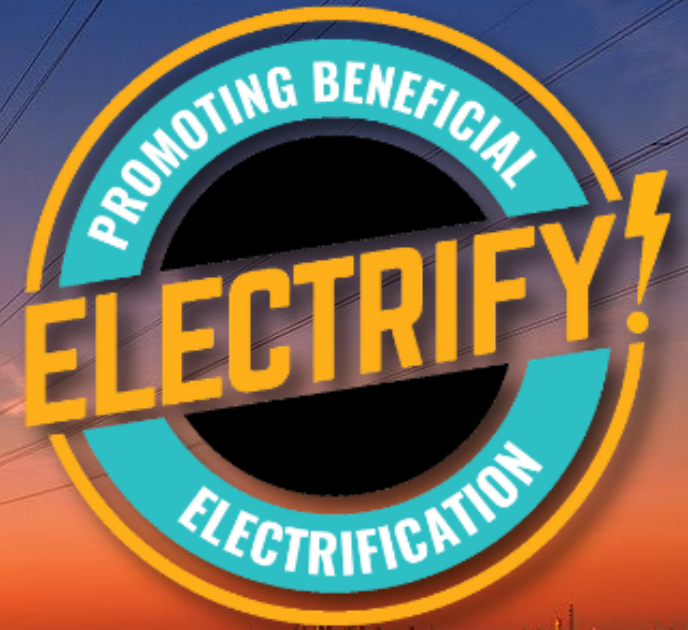
# TODAYS EFFICIENCY STANDARDS



- Efficiency continues to remain a top concern for today's homeowner and electric utilities
  - While 100% is good, its simply not good enough
- Geothermal 350 - 400% efficiency
  - Great choice... however its expensive
  - What is the impact when the federal tax credits goes away?
- Air Source Heat Pump 200% and higher
  - Not your same air source heat pumps of yesterday
  - Inverter driven and cold climate technology is a game changer



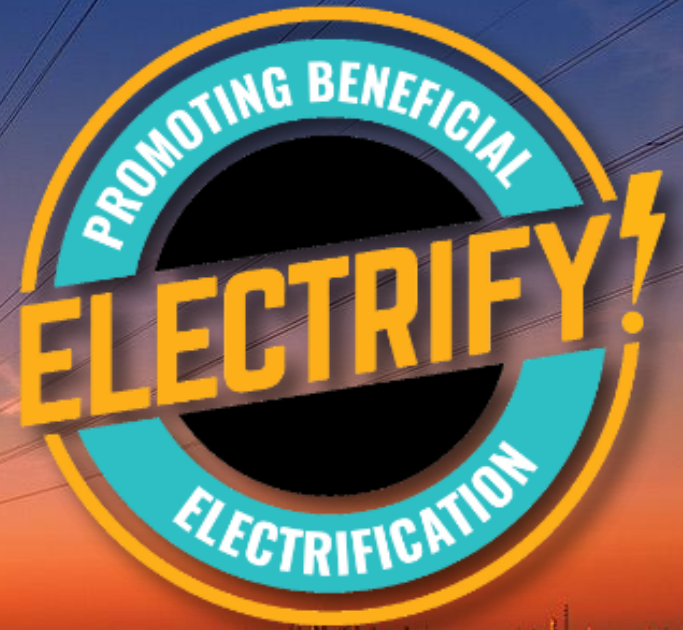
# Beneficial Electrification



If it meets one of more of three criteria, without adversely affecting the other two:

1. Saves consumers money over the long run;
2. Reduces environmental impacts; and
3. Enables better grid management.

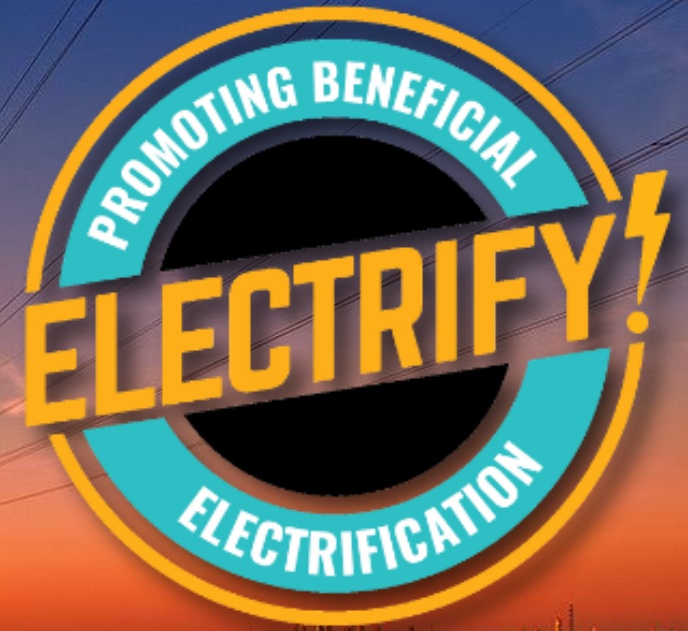
# Electric Heating Has Always Been Beneficial



- **Reliable and Stable Energy Source**
- **Efficient and Effective**
- **Simple and Safe**



# Push for electric heating...its BACK



- 11 cities in California ban Natural Gas
- Vancouver banning gas in new construction.
  - 2050 -existing homes must be converted to heat pump technologies
- New York City decarbonization plans to ban natural gas
- Air Source Heat Pump technology will be at the forefront that will create a winning proposition for end use consumers



HOW DO THEY WORK

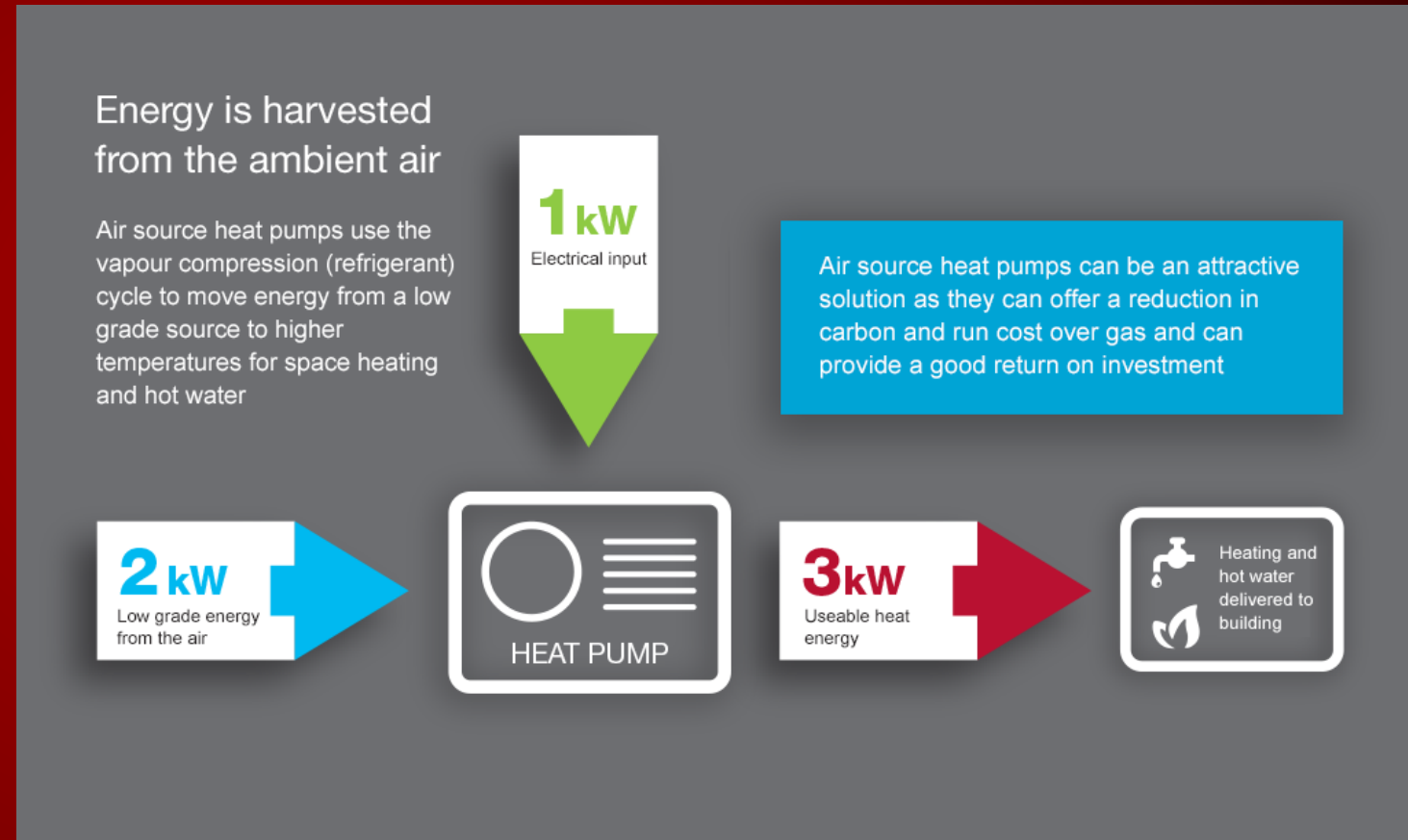
# HARVESTING ENERGY FROM THE AIR



Air to Water systems operate on the same principles as their forced air cousins in moving or transferring heat

## Low temp applications

- Radiant floors
- Low temp Radiators/baseboards,
- Fan coils
- Domestic water heating \*



# WHAT WE ALREADY KNOW ABOUT ASHP PERFORMANCE?

- ASHP heat output capacity is reduced as the outdoor temperature drops
  - Cold climate heat pumps gaining ground
  - Move heat well below zero
- Heat Pumps balance point
  - Below the balance point the system needs a little help for just a brief period of time
  - Depending on geographic location, few heating hours below the heat pumps balance point



## WHAT WE ALREADY KNOW ABOUT ASHP



- Flexible to be installed in both new or retrofit applications
  - Challenges with large applications
    - Multiple systems
- Significantly lower up front cost than Geothermal
  - ASHP deliver high COP and provide quick ROI
- Can provide both heating & cooling



# WHY AIR TO WATER SYSTEMS

# WHY THE FOCUS ON AIR TO WATER TECHNOLOGY?



- Energy source flexibility
- Application use flexibility
- Reliability, emissions reductions
- Integration of renewables with solar and wind
- Better economics

# WHY THE FOCUS ON AIR TO WATER TECHNOLOGY?

- Move away from natural gas
  - large source of GHG emissions
  - efficiency that closely resembles NG operating costs
- Focus on renewable sources such as wind or solar
- Less expensive alternative to Geothermal

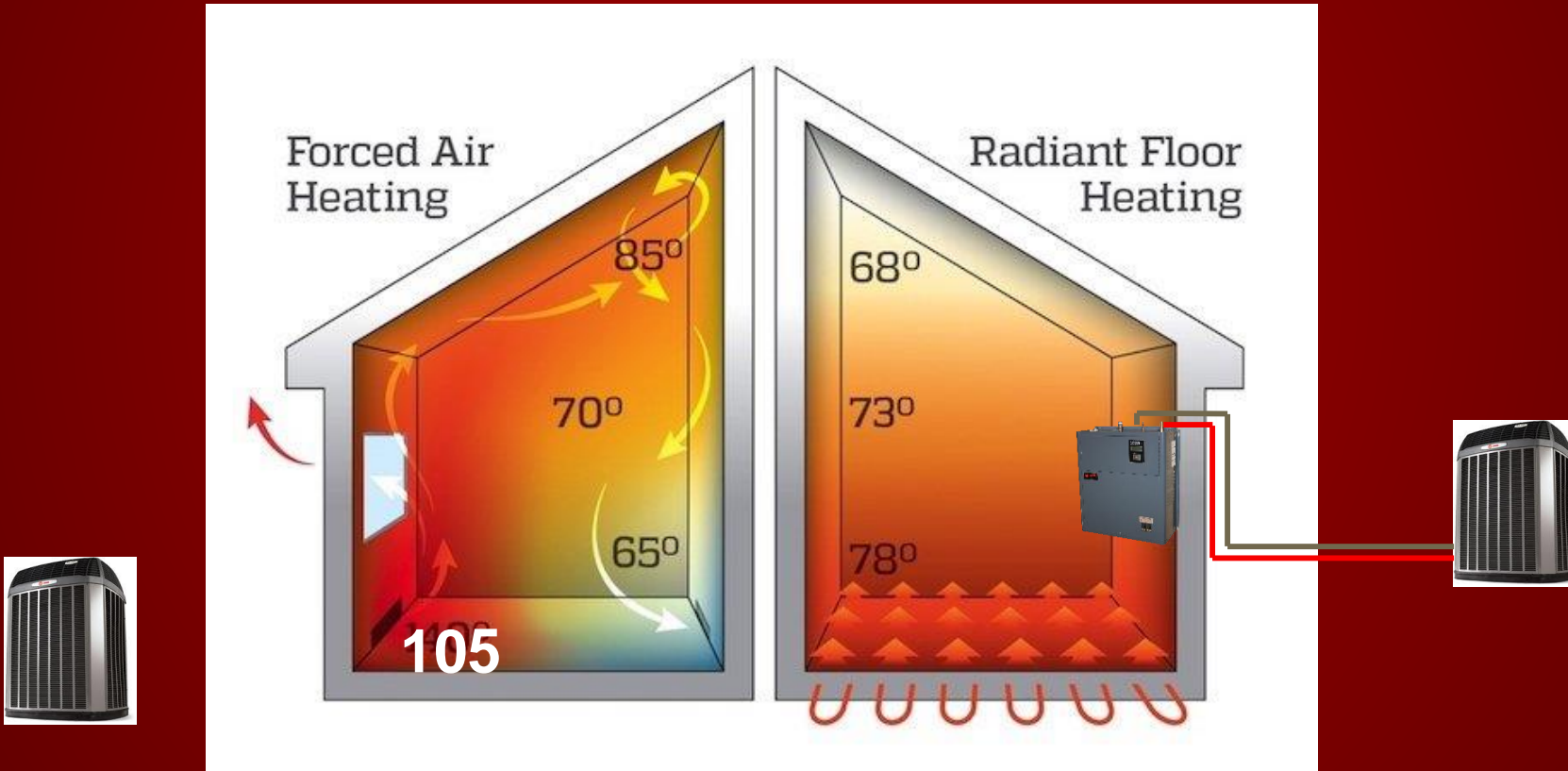
# PUSHING THE COMFORT METER



- Heating water will certainly deliver unsurpassed comfort
- Heating with air will never achieve total homeowner satisfaction
  - Cold floors
  - Noise levels
  - Dust and allergies
  - Temperature stratification from floor to ceiling



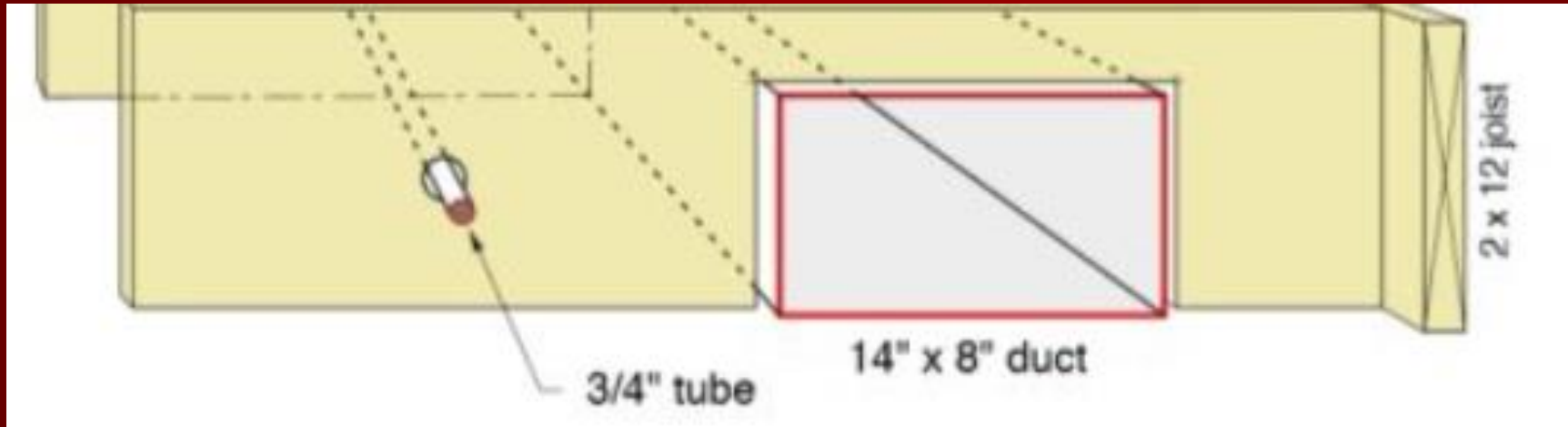
# HOW HEAT IS DELIVERED MAKES A BIG DIFFERENCE IN COMFORT!



DID YOU KNOW...

WATER DELIVERS 3500 TIMES MORE HEAT ENERGY THAN AIR

THE LOWER THE WATER TEMP THE BETTER, GONE ARE THE DAYS OF HIGH WATER TEMPS W/ RADIANT FLOOR



# TYPES OF AIR TO WATER SYSTEMS

# AIR TO WATER SYSTEMS

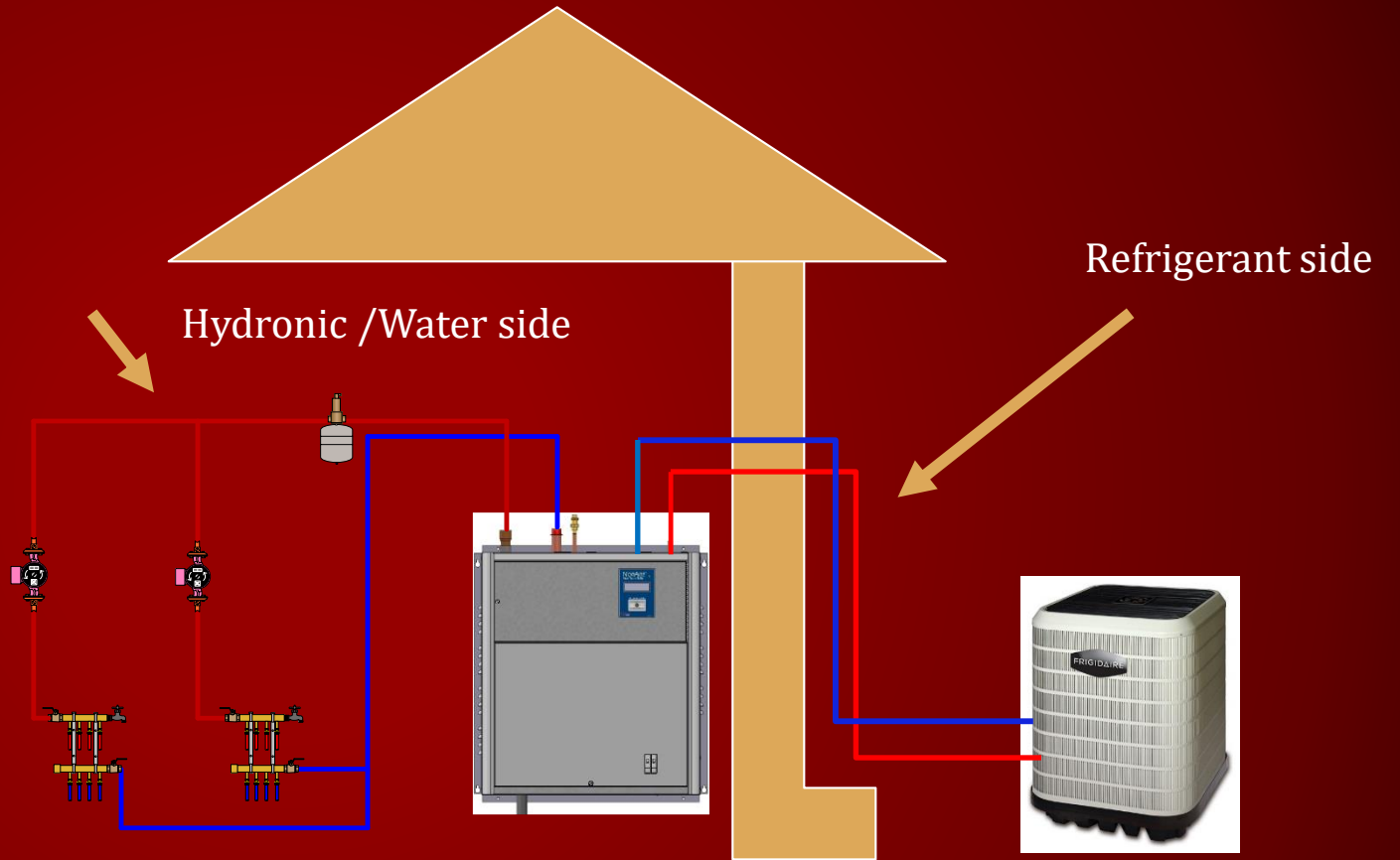
Split Systems

Mono Bloc

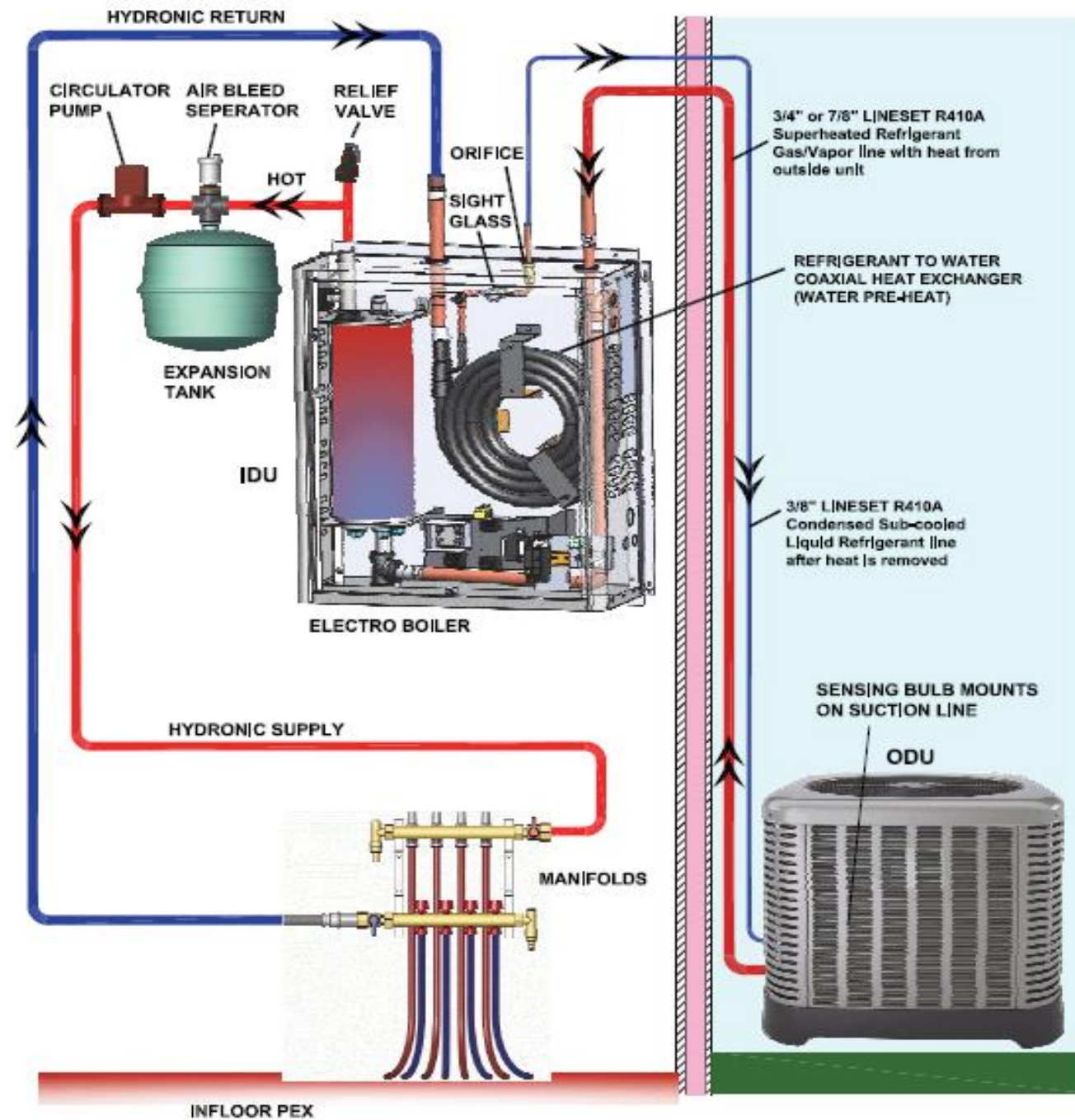


# SPLIT HEAT PUMP SYSTEMS

- Standard high efficiency air source heat pump
- Requires both HVAC and plumbing contractors



## CLOSER LOOK AT SPLIT TYPE SYSTEM



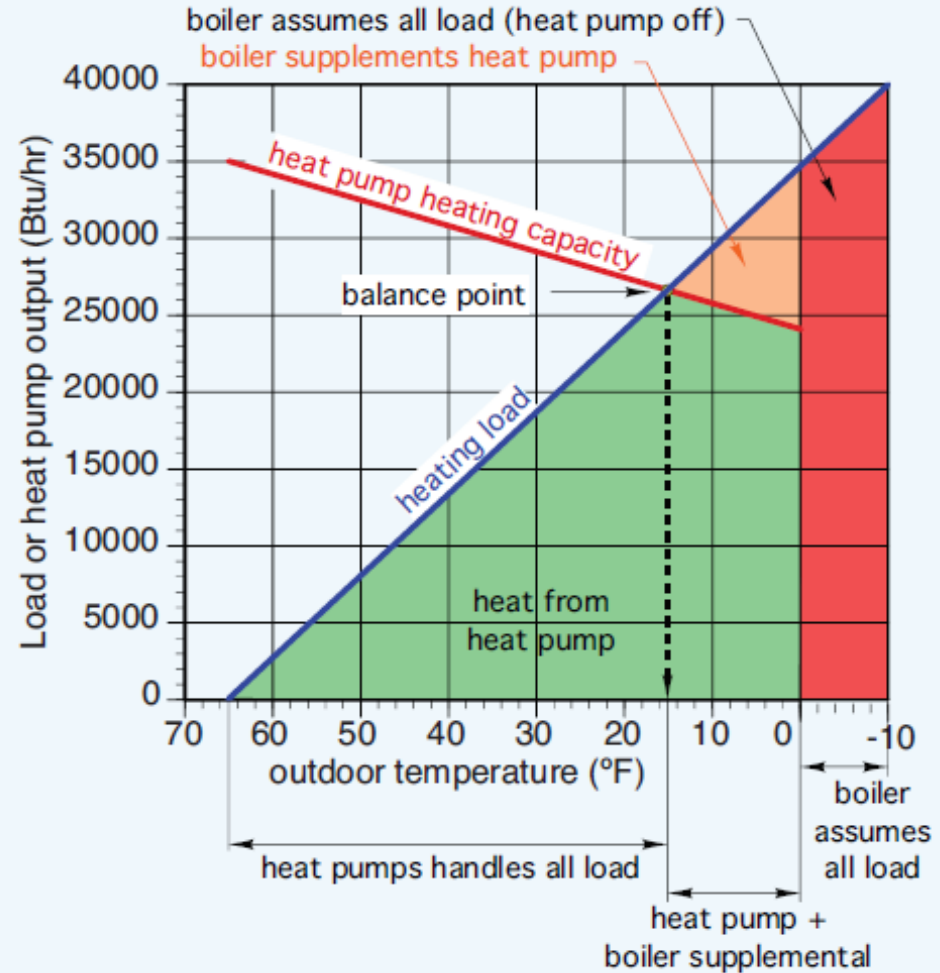
# DELIVERS HIGH EFFICIENCY

- Average annual efficiency is 200%
  - Higher efficiency in warmer regions/marine states
- Heat pumps are still very efficient at cold temperatures
  - Even in cold Minnesota!
  - Low temperature water delivery
    - Properly design systems don't need high temps
- Integrated electric boiler will ensure comfort and efficiency

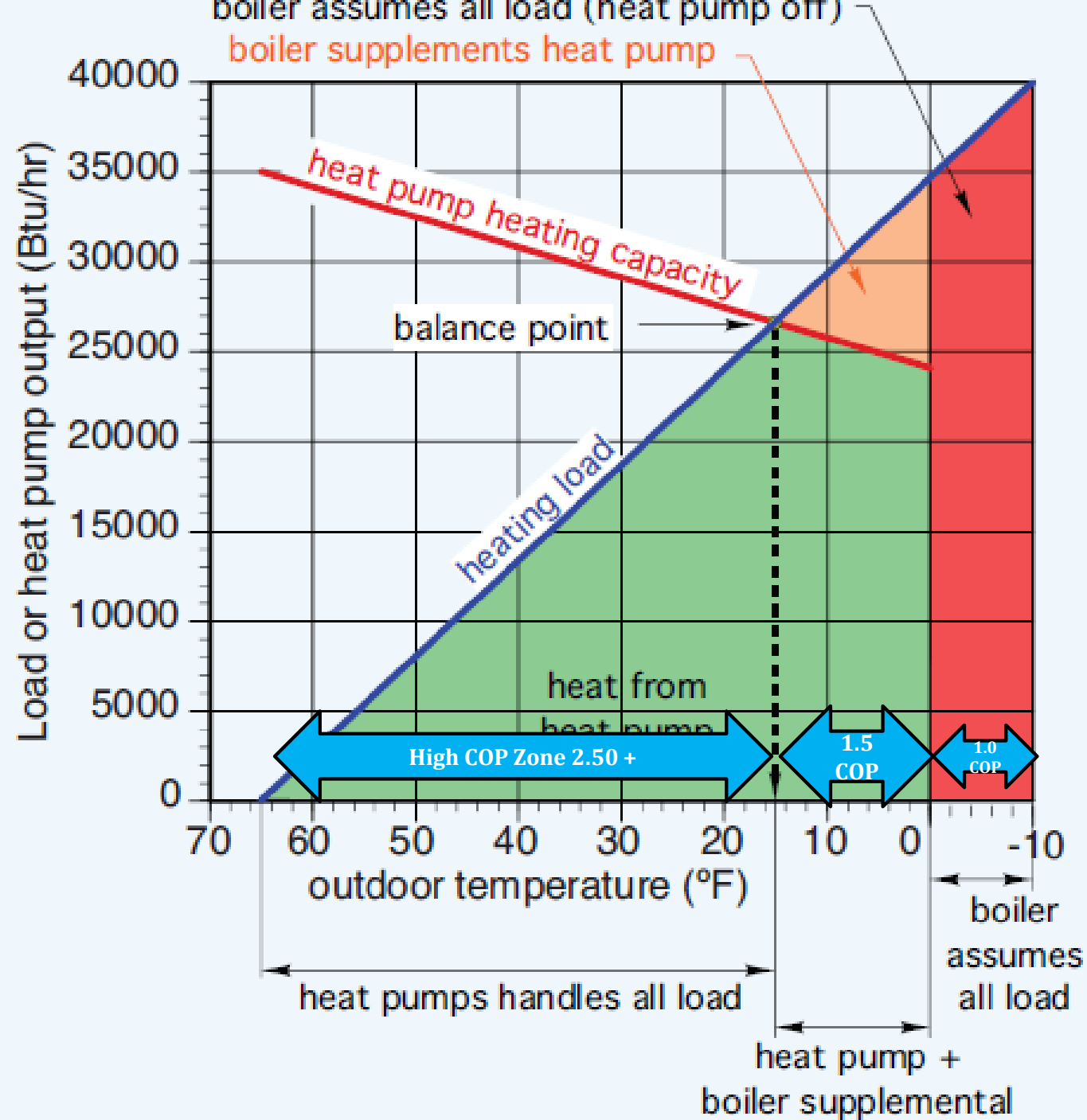


# THE BALANCE POINT

- Heat Pump operation alone
- Heat Pump and Electric Boiler working in combination to achieve BTU output required
- Below lockout temperature
  - Electric boiler takes over with own set point, target temperature
- Never will the system fall below 1.0 COP







# SPLIT SYSTEMS

- Capacity Sizes range from 24,000 – 68,000 BTU/h
  - 2, 3, 4 and 5 ton units
- Electric boiler is optional
  - Coastal areas will not need an electric boiler boost
  - omit if BTU/hr. load at design conditions can be met



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# OUTDOOR UNIT (ODU)

- Big benefit of split type systems is the installer can use most brands of heat pumps
  - No 2 or 3 wire communication capability
- No ARI listing or category is currently available for split type systems
  - Some utilities will go off HSPF or COP



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# Operation modes provides the homeowner choices

- Heat Pump only (**2.0 plus COP**)
- Heat Pump and Boiler Blended (**1.5 COP avg**)
- Internal Electric boiler only (**1.0 COP**)
- Gas Boiler only (**.94 COP**)



# HEATING AND COOLING WITH SPLIT TYPES

- Provides both high efficiency radiant heating and forced air cooling
- Chilled water 40°F from the heat pump provides the cooling to water coil
- Some parts of the country are floor cooling
  - Caution on dewpoint, good controllers
  - Experience is **absolute must**

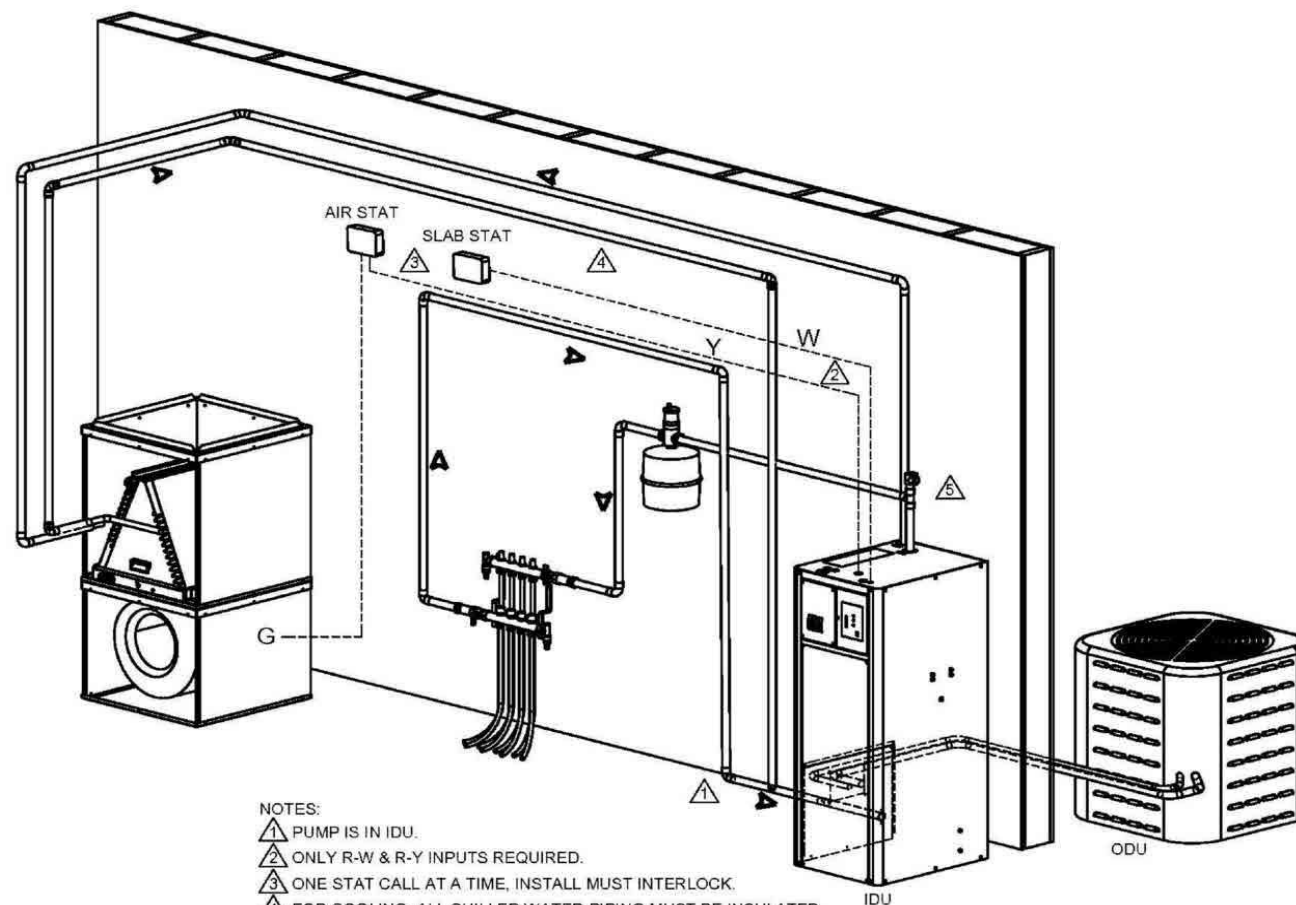




# HEAT/ COOL LAYOUT

## AIR TO WATER HEAT PUMP

- Add cooling forced air water coil, see sheet 1
- Must size to match heat pump BTU/h
- Water coil **not** configured for heating, water coil heating see sheets 9 & 10



### NOTES:

1. PUMP IS IN IDU.
2. ONLY R-W & R-Y INPUTS REQUIRED.
3. ONE STAT CALL AT A TIME, INSTALL MUST INTERLOCK.
4. FOR COOLING, ALL CHILLED WATER PIPING MUST BE INSULATED.
5. SEE P.1 FOR RELIEF VALVE.

HX103  
Rev. 06 10/18/2011  
Sheet 2 of 12

# SPLIT TYPE SYSTEM PICS

# DUAL SYSTEM INSTALLATION

- This application will require 2 qty. ASHP
- Radiant heating zones
  - Basement
  - Garage



# RADIANT HEATING INSTALLATION - WAREHOUSE

- Electric Cooperative in South Dakota
- 10 ton heating system utilizing 2 qty Air to Water units
- Each unit has integrated 20kW auxiliary boiler for boosting temperature below ASHP balance point





# PROS AND CONS OF SPLIT TYPE



## Pros

- Efficiency to install cost ratio is far less than geothermal
- Can deliver heat to radiant systems and chilled water for A/C
- Heat pump can be sized to the heating load
- Freeze proof
- Lowest cost of Air to Water types

## Cons

- Few manufacturers
- Relatively new to the US market
  - Big in Europe and Asia markets
- Lack of awareness
  - contractor training is needed
- Need both a plumber and HVAC contractor
- Don't recommend domestic water heating

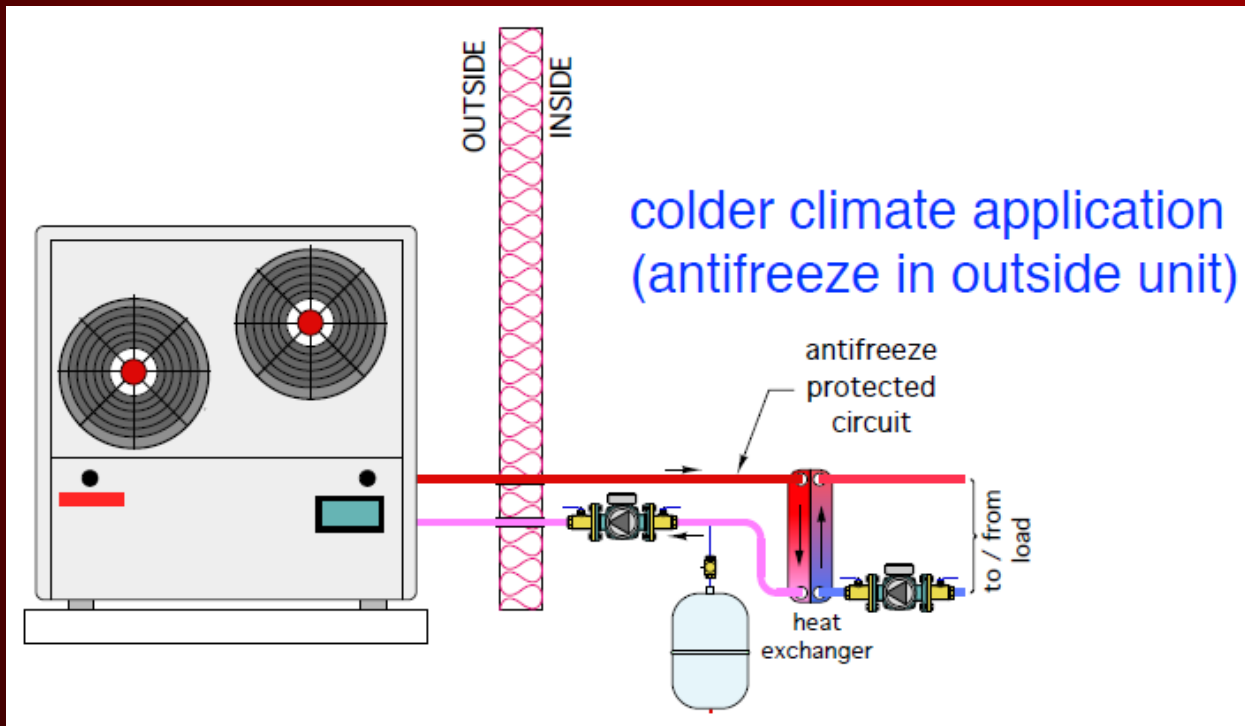


# MONO BLOC SYSTEMS

# MONO BLOCK

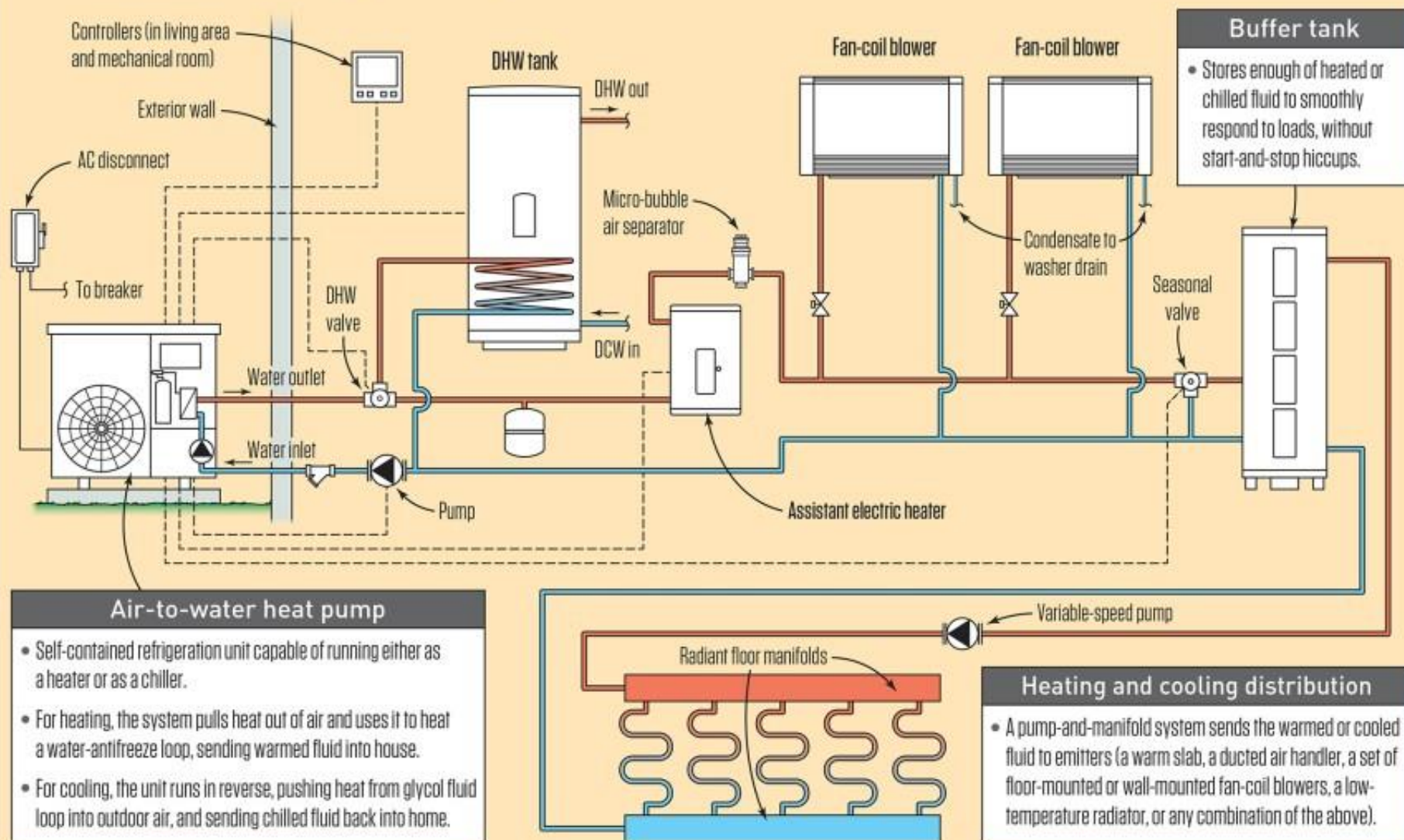


# MONO BLOC SYSTEMS



- Self contained system
- All components are housed in an outside cabinet
  - Must use propylene glycol antifreeze
- Hydronic systems still required inside

## Heating, Cooling, and DHW With an Air-to-Water Heat Pump



# PROS AND CONS OF MONO BLOC



## Pros

- Single outside unit
  - Fully pre-charged refrigerant
  - Two pipe system to indoors
- Plumbers can install
  - no HVAC contractor needed
- Efficient system
  - Operate well below zero
- Heating domestic water and A/C
  - Lower COP delivery for domestic hot water

## Cons

- More expensive \$\$\$ than split types
- Size circulating pump for entire system
- Risks of freezing
  - Insulate water lines!
  - Propylene glycol needed in the entire system
  - Plate heat exchanger adds cost/insurance
- Lack of awareness
  - contractor training is needed
- Electric resistance needed
  - Some units have small integrated electric boilers



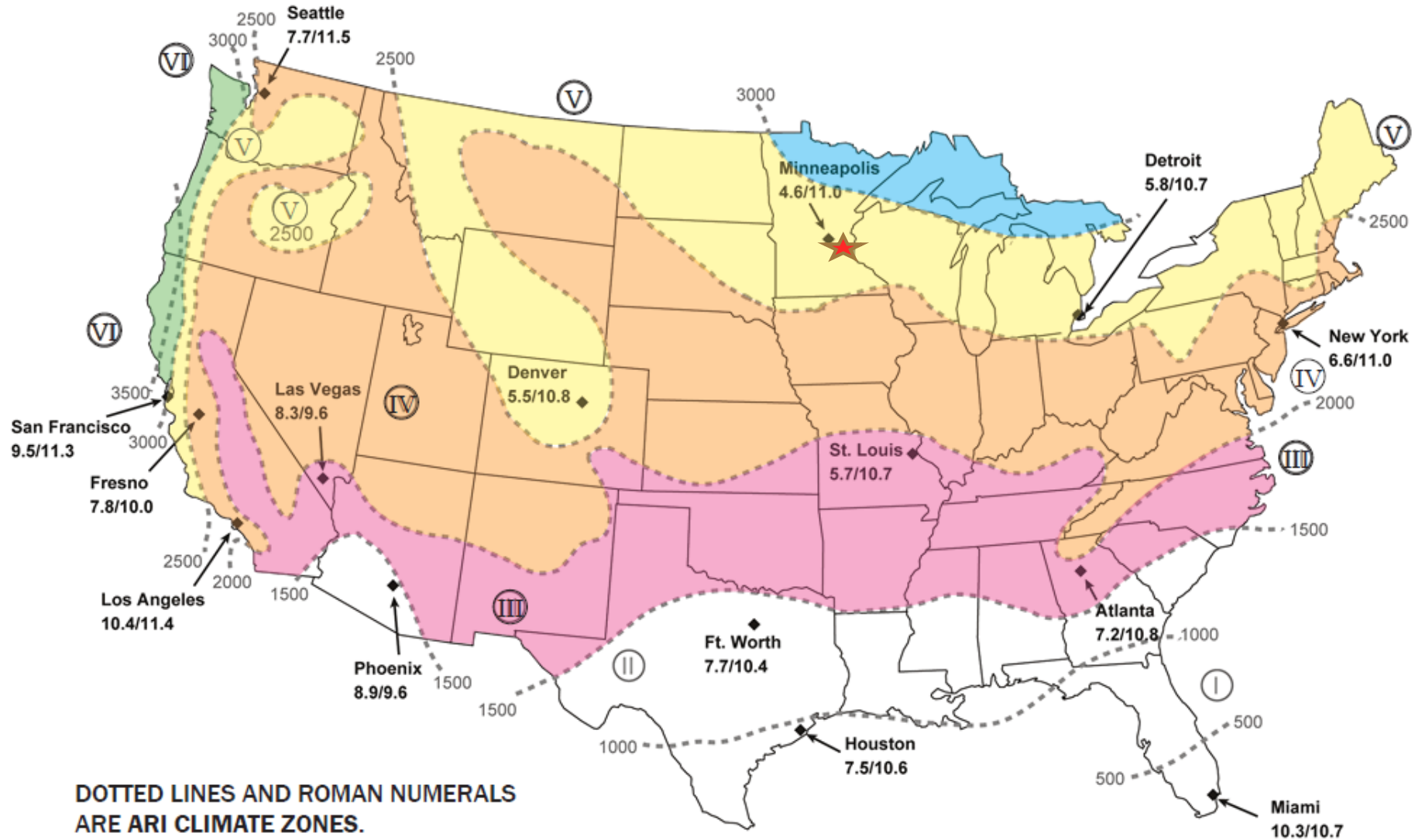
# WHAT ARE THE LIMITATIONS OF ANY AIR TO WATER SYSTEMS?

- High temperature output is limited
  - Baseboard heating is questionable unless changes to low temp emitter
  - Limited fan coil
- Heating domestic water
  - Some can systems can achieve high enough temperature and still deliver COP above 1.0

ENERGY PERFORMANCE  
SPLIT TYPE - AIR TO WATER HEAT PUMP  
SYSTEM

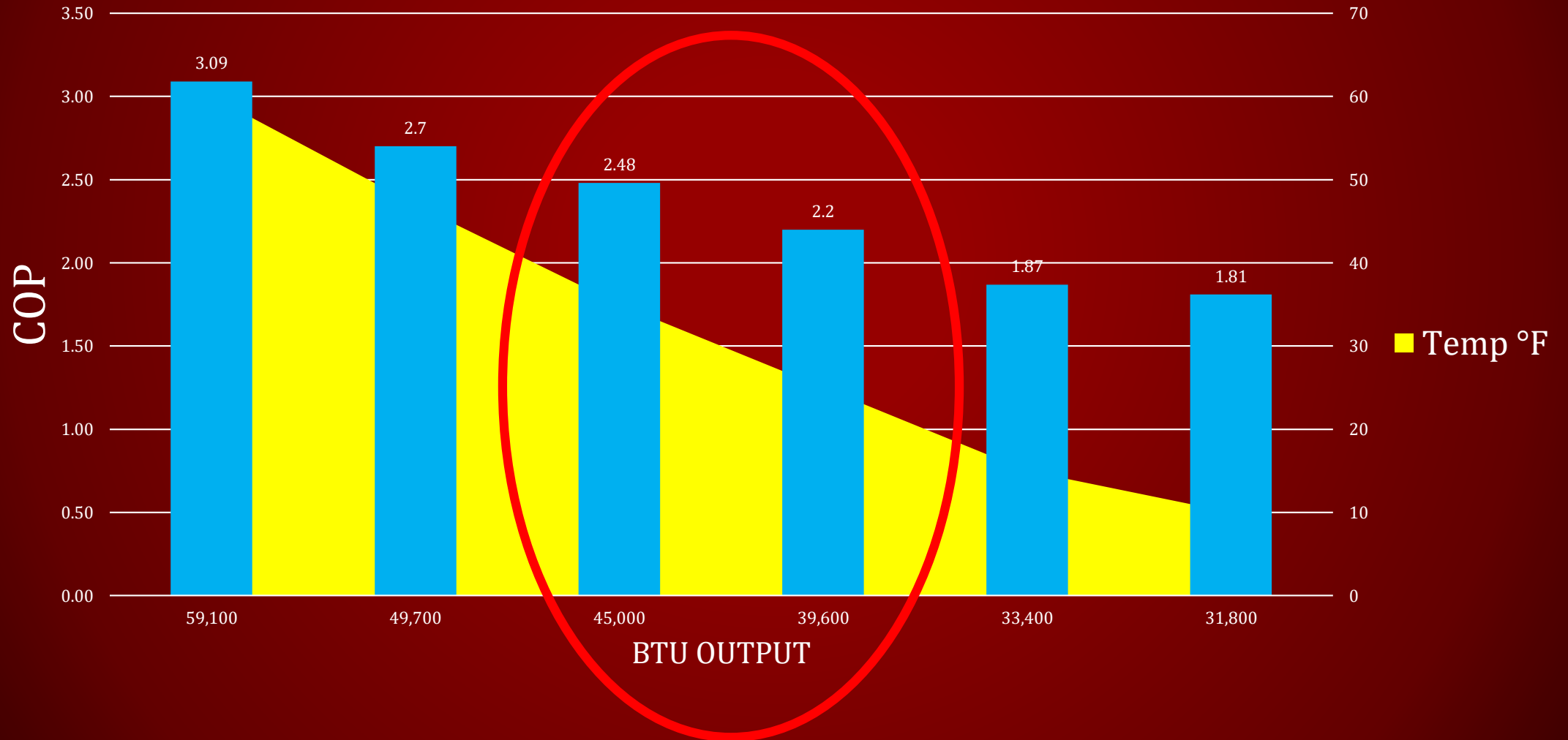
ARI REGION	EXAMPLE CITY	DESIGN TEMP	AVERAGE WINTER TEMP
V	MINNEAPOLIS, MN	-15°	12°
IV (N)	OMAHA, NE*	-3°	20°
IV (S)	SANTA FE, NM	10°	20°
III	KANSAS CITY, MO	6°	34°
VI	SEATTLE, WA	26°	37°

\*COULD BE DES MOINES, CLEVELAND, PITTSBURGH



DOTTED LINES AND ROMAN NUMERALS  
ARE ARI CLIMATE ZONES.

Split Type Air to Water Heat Pump  
5 ton Single Stage Heat Pump  
8 GPM, 90°F Return



# EFFICIENCY

- Single Stage ASHP will average 200% efficiency and higher



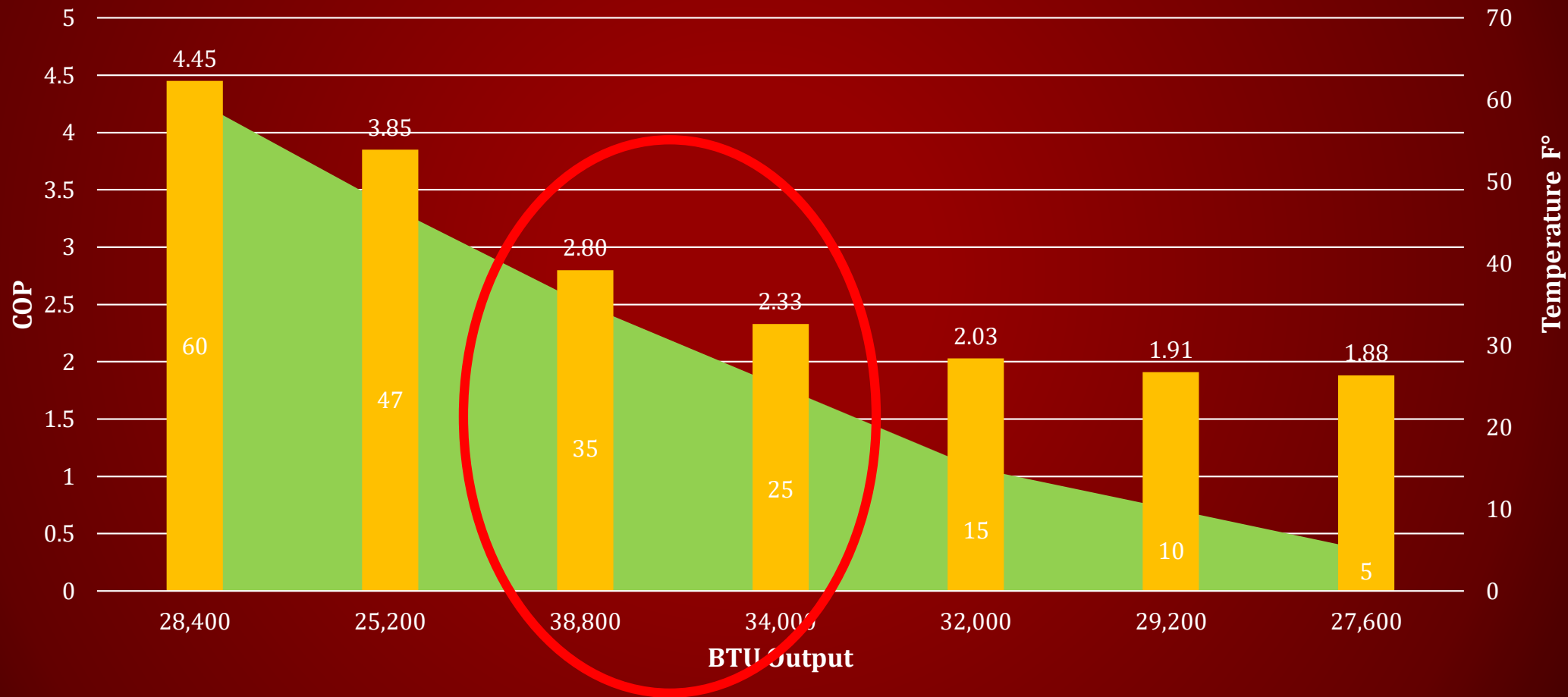


# INVERTER DRIVEN HEAT PUMPS



- Think cruise control for heating
- Analyzes the temperature and conditions
  - adjusts its output
  - maximize efficiency and comfort
- Best technology w/ split systems
- Make sure they can communicate with the indoor unit

**Split Type- Air to Water Heat Pump**  
**5 Ton Inverter Driven Heat Pump**  
**8 GPM, 90°F Return**



# ENERGY MODELING

Location – Minnesota

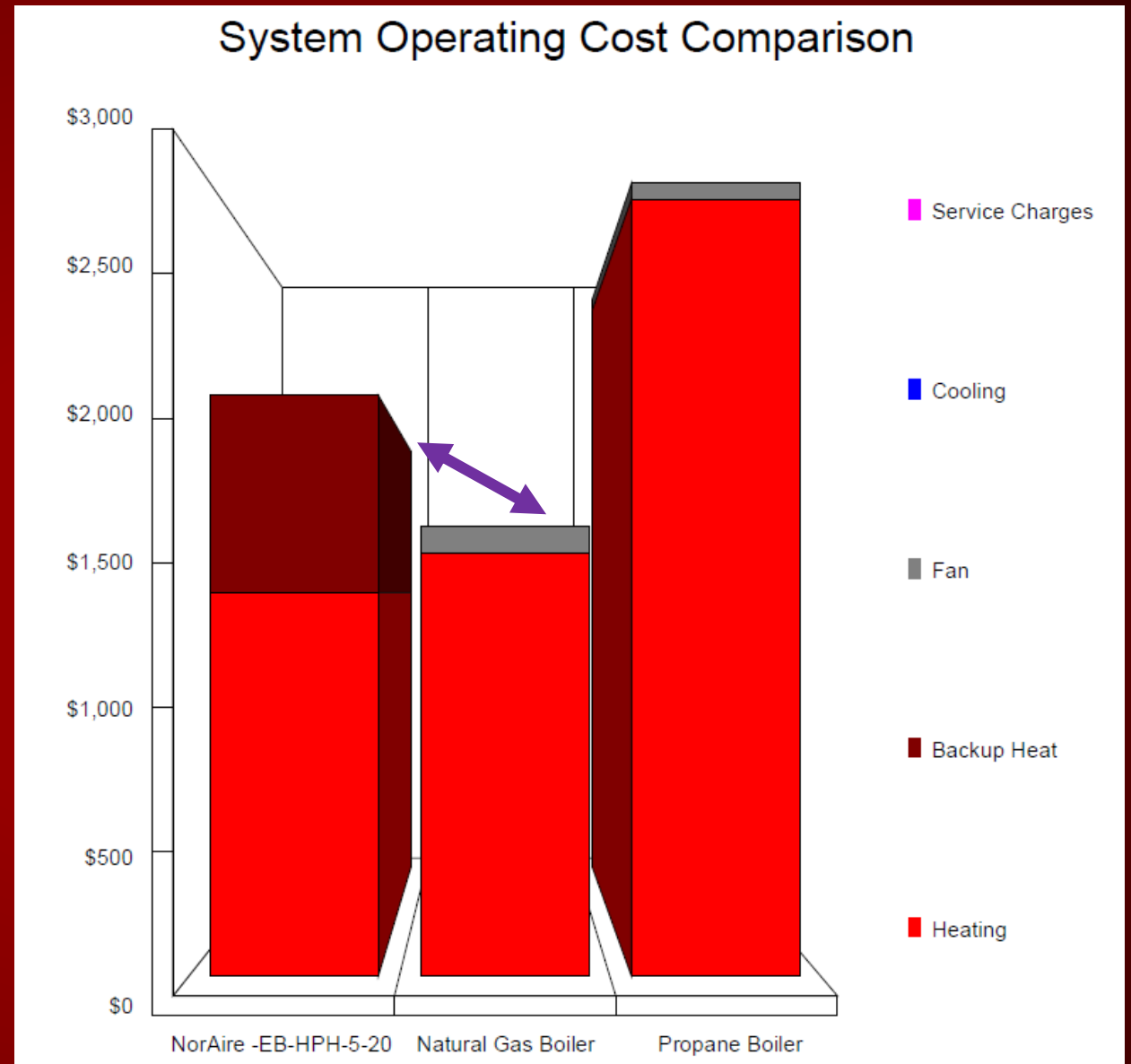
- 64,000 BTU/Hr. Heat Loss
  - 5°F Cutoff Temp
  - 5 Ton Inverter Heat Pump
  - MN Power Electric Rate \$.080/kWh
  - Natural Gas - \$.94/therm
- Propane Gas - \$1.85/Gl.

## Operating Cost/Year

Air To Water- \$2114.00  
Including 20 Kw Aux. Boiler

Natural Gas Boiler \$1640.00

Propane Boiler \$2885.00



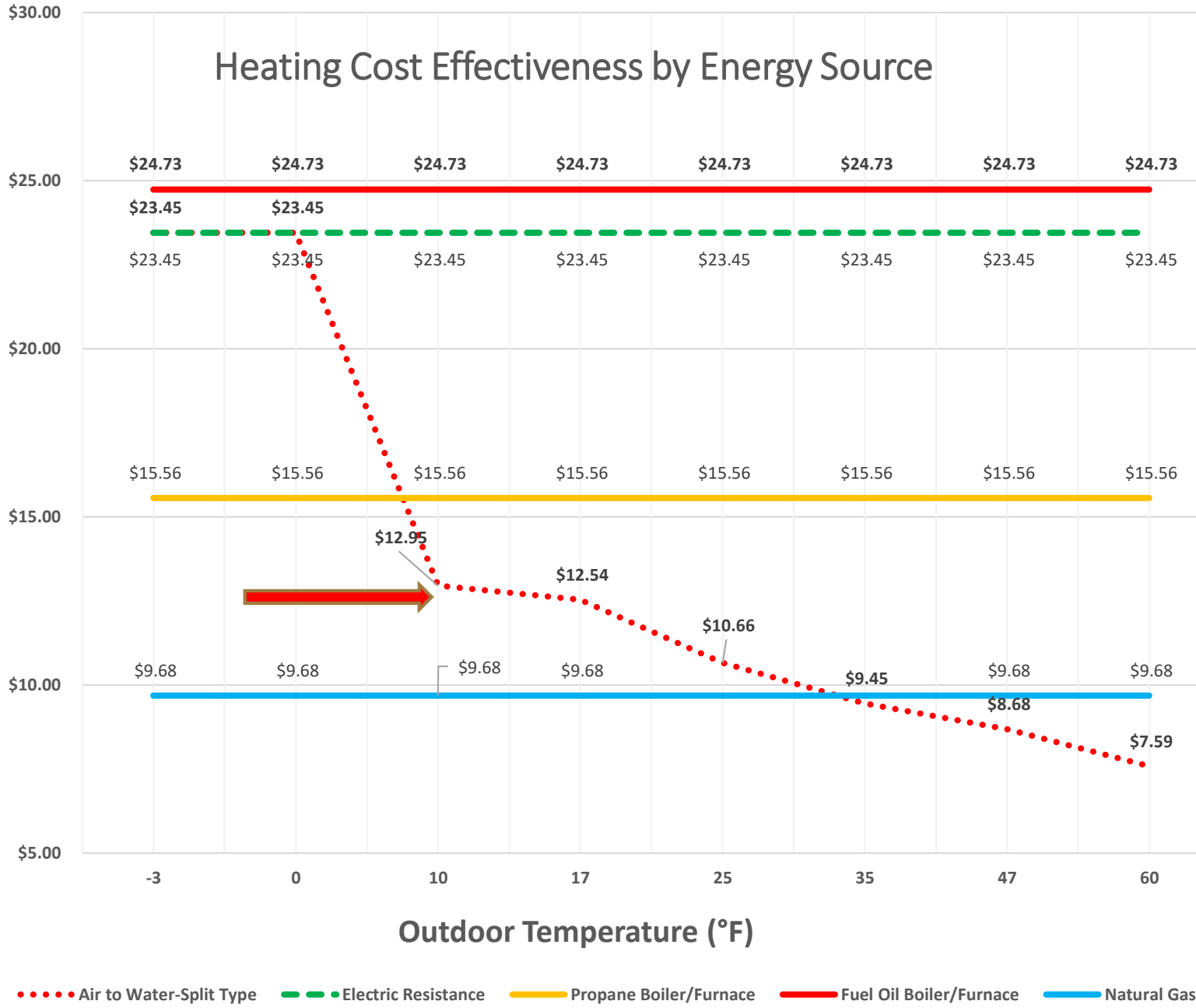
Source: Elite Software - Energy Audit Software  
[www.elitesoft.com](http://www.elitesoft.com)

# BLENDING ASHP AND BOILER

Bin Temp Ranges Degree F	Hours Per Bin	Heating Load Btuh	Adjusted Load (x 0.77)	Heat Pump Output Btuh	H. Pump Run Time Fraction	Backup Output Btuh	H.Pump Heating Cost	Backup Heating Cost	Total Heating Cost
-35 to -30	3	76,364	58,800	0	0.000	58,800	0.00	4.13	4.13
-30 to -25	9	72,727	56,000	0	0.000	56,000	0.00	11.81	11.81
-25 to -20	21	69,091	53,200	0	0.000	53,200	0.00	26.19	26.19
-20 to -15	45	65,455	50,400	0	0.000	50,400	0.00	53.16	53.16
-15 to -10	87	61,818	47,600	0	0.000	47,600	0.00	97.07	97.07
-10 to -5	99	58,182	44,800	0	0.000	44,800	0.00	103.96	103.96
-5 to 0	136	54,545	42,000	0	0.000	42,000	0.00	133.89	133.89
0 to 5	263	50,909	39,200	0	0.000	39,200	0.00	241.65	241.65
5 to 10	282	47,273	36,400	31,343	1.000	5,171	115.56	33.43	148.98
10 to 15	375	43,636	33,600	32,513	1.000	1,229	155.54	9.55	165.10
15 to 20	560	40,000	30,800	30,800	0.901	0	211.53	0.00	211.53
20 to 25	618	36,364	28,000	28,000	0.737	0	191.85	0.00	191.85
25 to 30	642	32,727	25,200	25,200	0.611	0	166.03	0.00	166.03
30 to 35	703	29,091	22,400	22,400	0.510	0	152.43	0.00	152.43
35 to 40	528	25,455	19,600	19,600	0.424	0	95.69	0.00	95.69
40 to 45	612	21,818	16,800	16,800	0.349	0	91.73	0.00	91.73
45 to 50	639	18,182	14,000	14,000	0.278	0	76.81	0.00	76.81
50 to 55	645	14,545	11,200	11,200	0.207	0	58.79	0.00	58.79
55 to 60	699	10,909	8,400	8,400	0.146	0	45.42	0.00	45.42
60 to 65	684	7,273	5,600	5,600	0.091	0	28.23	0.00	28.23
Totals:	7,650						\$1,396.73	\$716.85	\$2,113.58

Fuel Type	Fuel Unit	Fuel Price Per Unit (dollars)	Fuel Heat Content Per Unit (Btu)
Electricity	kWh	\$ 0.080	3,412
Propane	Gallon	\$ 1.35	91,333
Natural Gas	Therm	\$ 0.92	100,000

Energy Cost (per million Btu)





# CALCULATED ANNUAL COP

City	State	Heating Degree Days	Outside DB	\$/ kWh	Heatloss	Air to Water Annual Cost	Electric Boiler Annual Cost	Air to Water kWh	Electric Boiler kWh	Annual COP
Minneapolis	MN	7958	-12	0.08	64,000	\$ 1,672.00	\$ 3,250.88	20,909	40,636	1.94
Duluth	MN	9251	-18	0.08	69,000	\$ 2,114.00	\$ 3,678.60	26,445	45,945	1.74

# THE MARKET FOR AIR TO WATER HEAT PUMPS

# ENERGY STAR



- The ENERGY STAR® Emerging Technology Award (ETA) is given to innovative technologies that meet rigorous performance criteria to reduce energy use and lower greenhouse gas emissions. The U.S. Environmental Protection Agency (EPA) is pleased to recognize Air-to-Water Heat Pumps for the ENERGY STAR Emerging Technology Award for 2019.
- Products must demonstrate  $>1.7$  COP at 5°F with a leaving water temperature at 110°F

# NORTH AMERICAN MARKET

- Modest number of installations
- Contractor training and lack of awareness in the industry
- Utilities focusing on this technology to increase efficiency and reduce kW demand and lower GHG emissions

# THE CURRENT MARKET

- Global market is 1,745,000 sold in 2014 (JARN - Aug 2015)
  - China leads followed by European markets
  - US Market = thousands, this is about to change
  - Best markets currently are in coastal regions:
    - Washington state
    - Vancouver
    - Kodiak Island, Alaska
    - California



# EMERGING AIR TO WATER MARKET INDICATIONS

- Air to Water systems are far less expensive in front end costs compared to geothermal
- Better construction leads to:
  - small Btu/hr. heating systems
  - Air to water is ideal

# IN SUMMARY

- Efficiency continues to be on homeowners minds
  - Electricity is **Greener** then ever before
  - Focus on renewables
  - Air to Water systems will be at the forefront of delivering heat, cool or heating domestic water

Air to Water Heat Pump System offer a great value in delivering:

- Beneficial Electrification
- Win –Win – Win for customers/member owners, utilities and environment
- Excellent alternative to more expensive Geothermal - Low cost/COP

# IN SUMMARY

- Air to Water types - More expensive than Air to Air but...
  - More applications
  - Deliver unsurpassed comfort in heating water
- Good practice to utilize auxiliary back up electric boiler based on climate
- Air to Water Heat Pump System are not AHRI rated
  - Manufacturers working toward certifications
- Air to Water systems make up a very small market share.
  - Push from consumers and utilities will change this
  - Training and awareness for a responsive supply chain

Questions?

Thank you





Dennis Schramel  
Electro Industries Inc.  
National Sales Manager  
[dschramel@electromn.com](mailto:dschramel@electromn.com)