Residential Mechanical Systems

Net Zero Homes Workshop

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Sustainable Solutions™

Getting Started

- The loads have been reduced, the systems modeled… now what?

Barriers

- Many net-zero homes are unique
- Look at constructability for the masses
- Remember how we get there
  - paying attention, watching energy use
  - Highly dependant on occupant use patterns

Systems

- Helping the cause.
  - Simplicity
  - Repeatability
  - Work with the environment not against.
- Some key system elements
  - Renewable energy storage – geo, mass, solar
  - Very high efficiency
  - Right sizing
  - Load tracking
  - Air sealing
  - Distribution systems within envelop
  - Zoned

Systems for energy efficiency

- Daylight Savings Time saves energy
  - Better use of the natural light of the sun, rather than the extra fuel.
  - 1% US DOT study to 3.5% (New Zealand)

"A penny saved is a penny earned"

Thermal Comfort

- Thermal Comfort Equation [P.O.Fanger] combines the effect of 6 parameters*:*
  - Metabolism [MET] (Activity Level)
  - Clothing level [Clo]
  - Air Temperature
  - Air Velocity
  - Air Humidity
  - Mean Radiant Temperature

Systems – Energy

- Fuel Choices
  - Electric
  - Gas
  - Propane
  - Fuel Oil
  - Coal
  - Renewables (wood, bio fuels)
- Factors
  - Energy Content
  - Price
  - Efficiency
  - Emissions

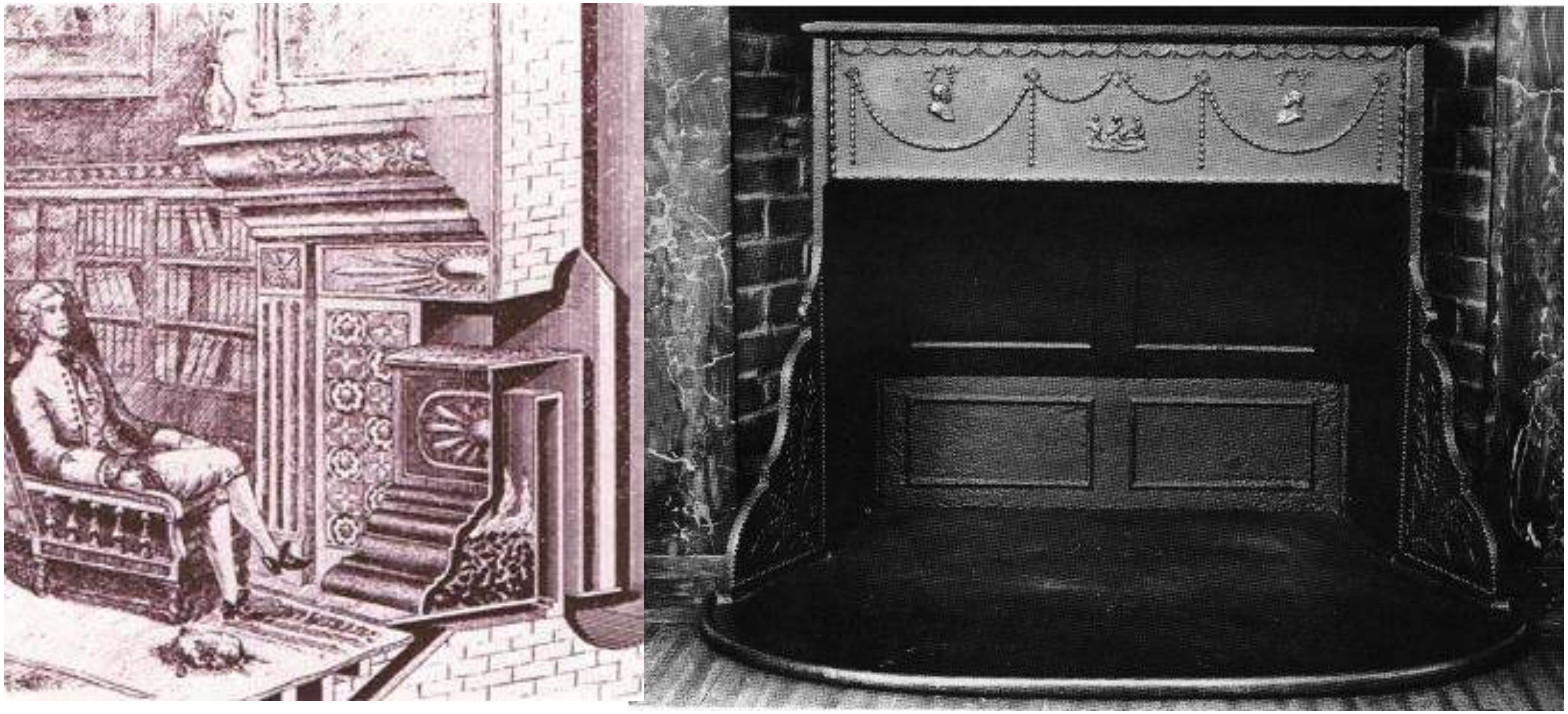
Source energy key consideration – fuel neutral

Differing source produce different emissions and energy cost on source level.

Systems

- Forced Air
- Hydronic
- Domestic Water
- Combination Systems
- Ventilation / Exhaust

Systems



Pennsylvania fire place

(iron furnace stove)

Systems – Solid Fuel Stoves

- Wood Stoves
  - Renewable resource?
  - Hazardous pollutant POC
  - Avg. Efficiency: 72%
  - OK where wood fuel plentiful
- Pellet Fuel
  - Recycled/biomass products
  - Fans increase energy consumption
  - Clean burning
  - Avg. Efficiency: 78%

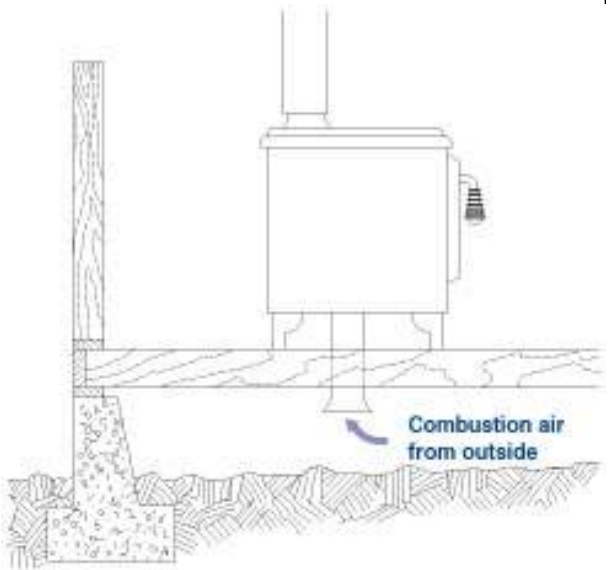
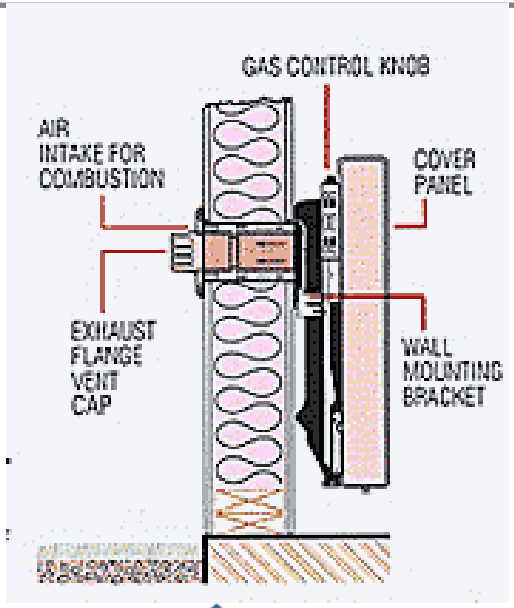
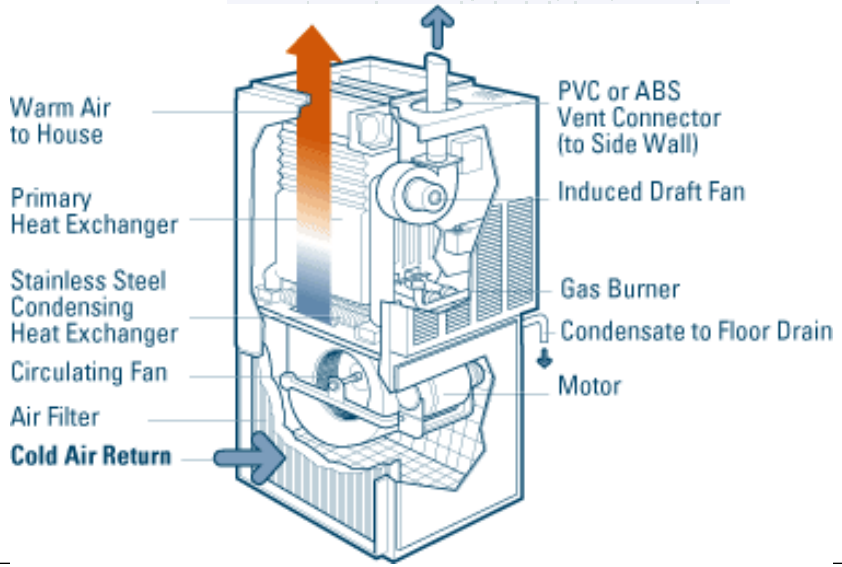


Figure 15 - Wood stoves should have outdoor combustion air intakes to avoid backdrafting and to reduce air leakage

Systems – Air - Heating

- Furnace
  - 78%-97% AFUE
    - Atmospheric
    - Sealed Combustion
    - Condensing, Pulse
  - Variable speed fan
  - Multi-stage heat



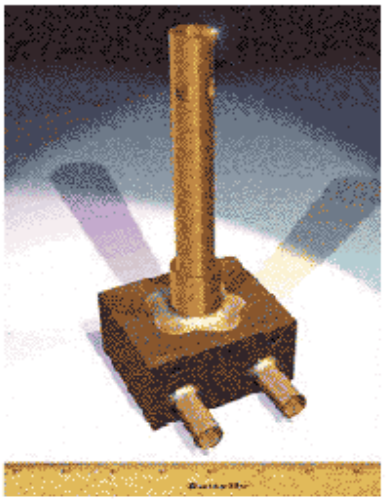


Systems – Furnace of the Future

- Decentralized, Distributed
- 4-120 MBH capacity - incorporate into baseboard heaters

Figure 3: MicroHeater

The MicroHeater, developed by researchers at the DOE's Pacific Northwest National Laboratory, is 10 times smaller and lighter than conventional combustors. An array of modules can heat a house efficiently and could reduce ducting and zoning energy losses by 45 percent.



Source: Pacific Northwest National Laboratory

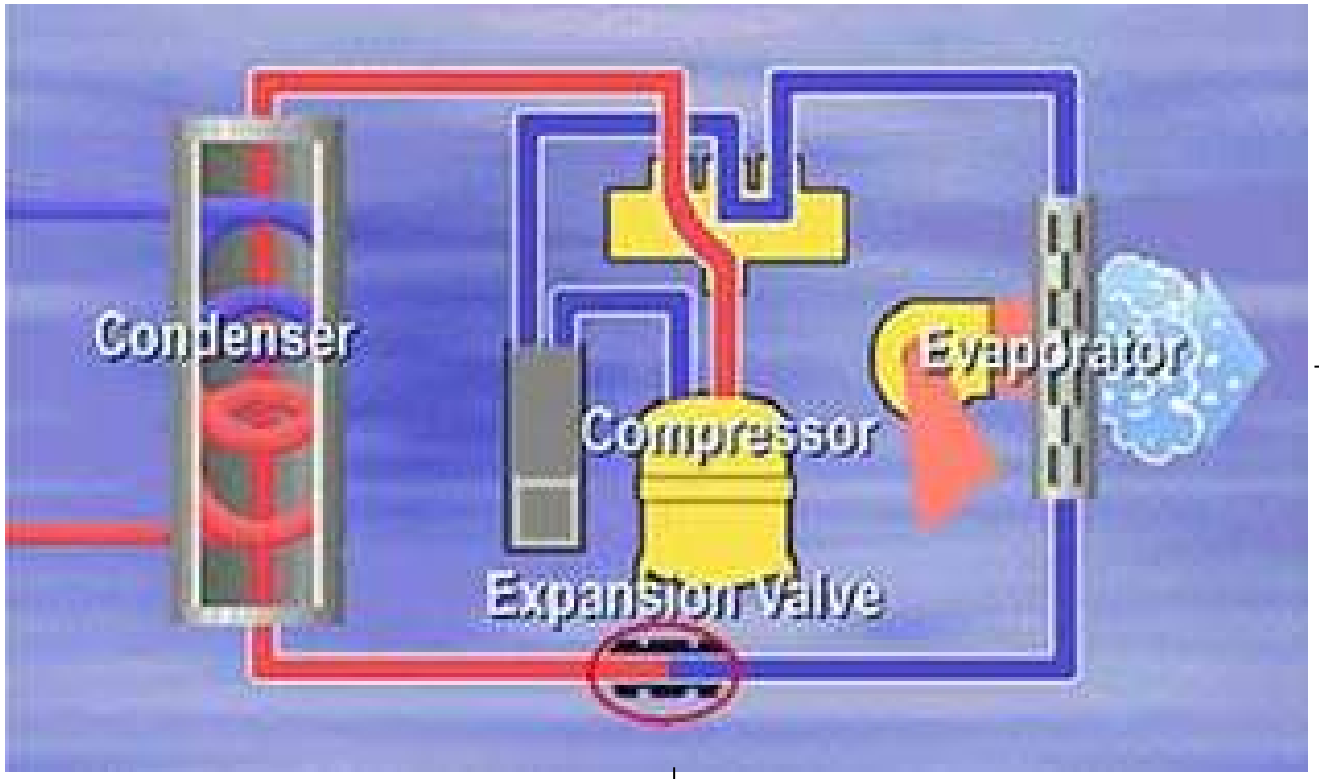
Systems – Air Cooling – Split System

- SEER of 10-19.5
- Refrigerant options
- Variable speed motor
- Multi-stage compressor
- Must combine right system of components to get peak performance

SEER = Btus out/W in

Systems – Air Conditioner

- How it works



Systems – Air - Heat Pump (Air Source)

- Compressor to pump heat
- 10-18 SEER
- 6.8-9.85 HSPF
- Lose output at 35 Deg F
  - Backup heat required

HSPF = Btus out/kWh in

SEER = Btus out/W in

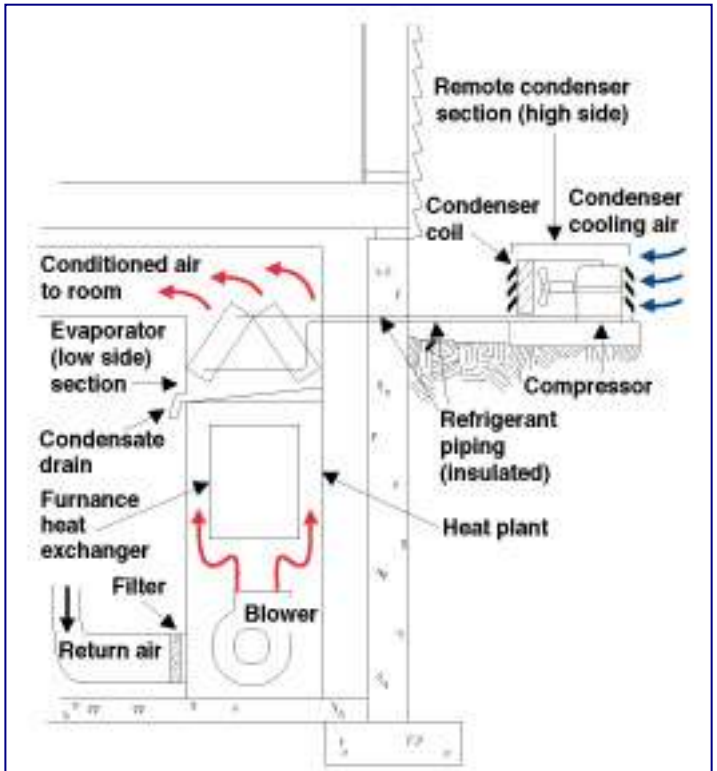


Figure 5 - Schematic of air-to-air heat pump

Systems – Air - Geothermal Heat Pump

- More efficient than air-source (13-23 EER)
- COPs of 2.7-4.0
- "Free" DHW
- Open or closed loop
- Vertical or horizontal
- Heating & cooling loads should be present

COP = watts out/watts in

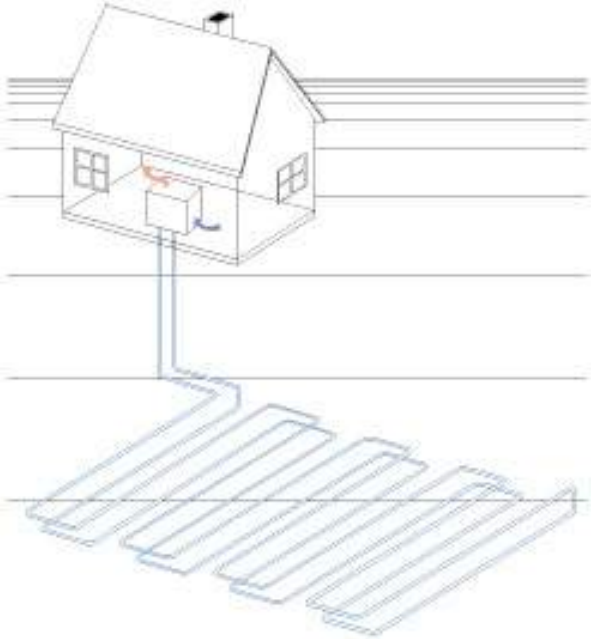


Figure 6 - Ground source heat pump

Systems – Evaporative Cooling

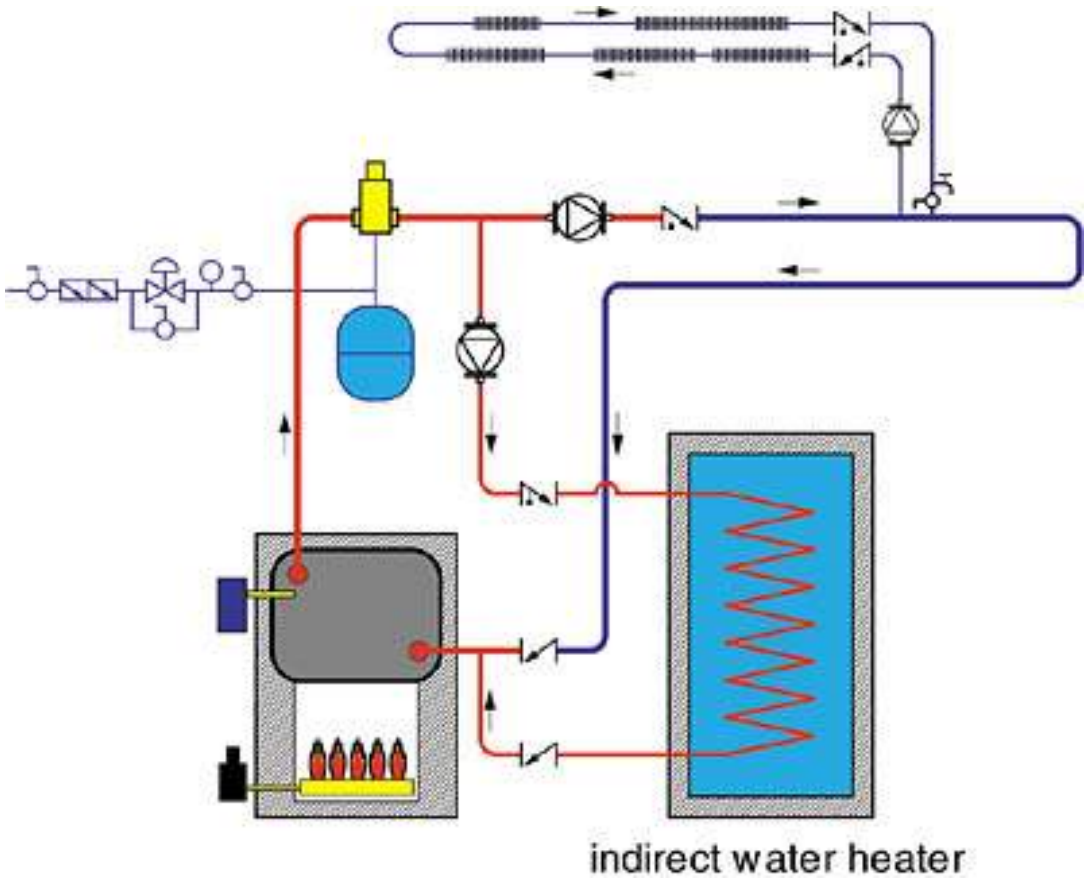
- EER of 40+
- Higher volumes of outdoor air
- No CFCs
- Water use
- Direct vs. Indirect

Systems – Ductwork

- Supply and returns in conditioned space
- HVAC system as source of contaminant
- Filtration

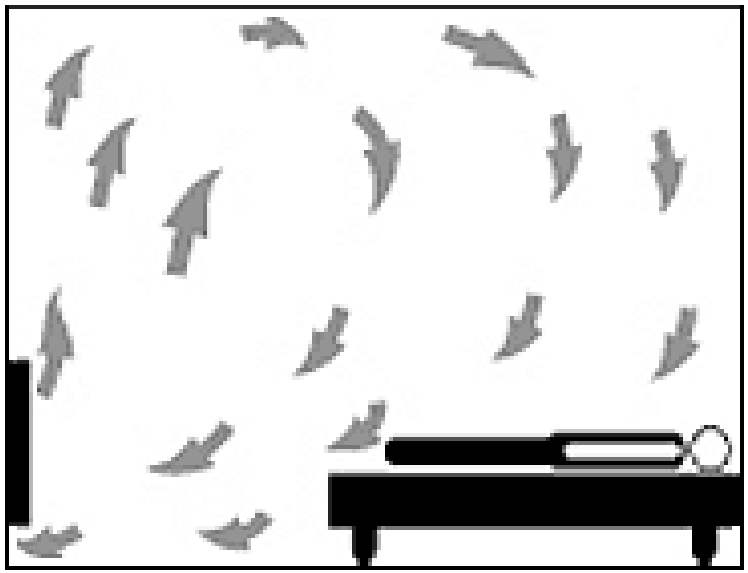
Systems – Hydronic

- One source – multiple loads



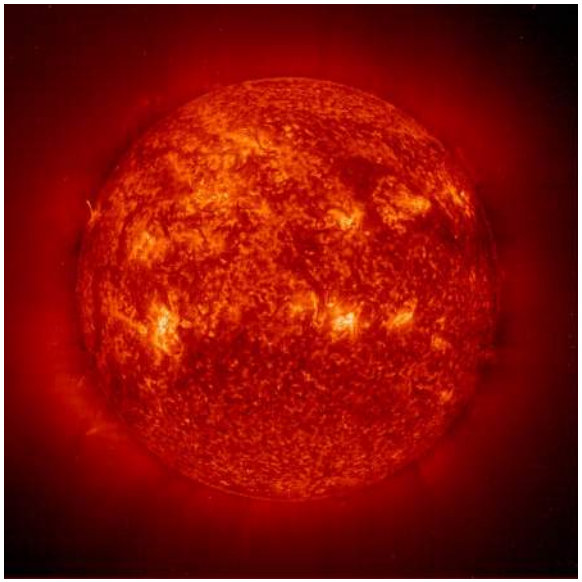
Systems – Hydronic (Convection)

- Baseboard / Coils



Systems – Hydronic (Radiant)

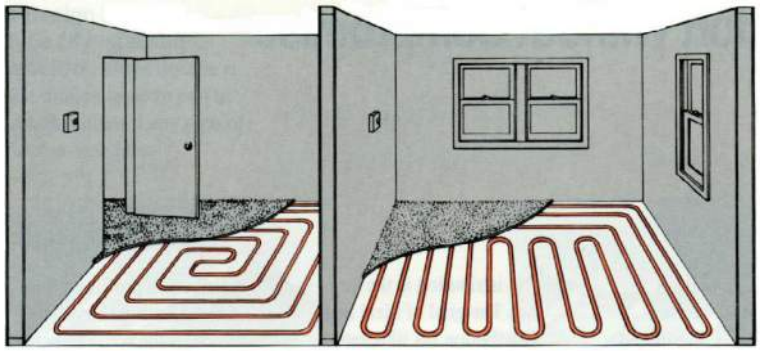
- Radiant Renaissance
  - Panels
  - Tubing

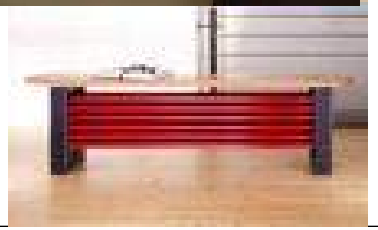


Ancient radiant systems

Systems – Radiant

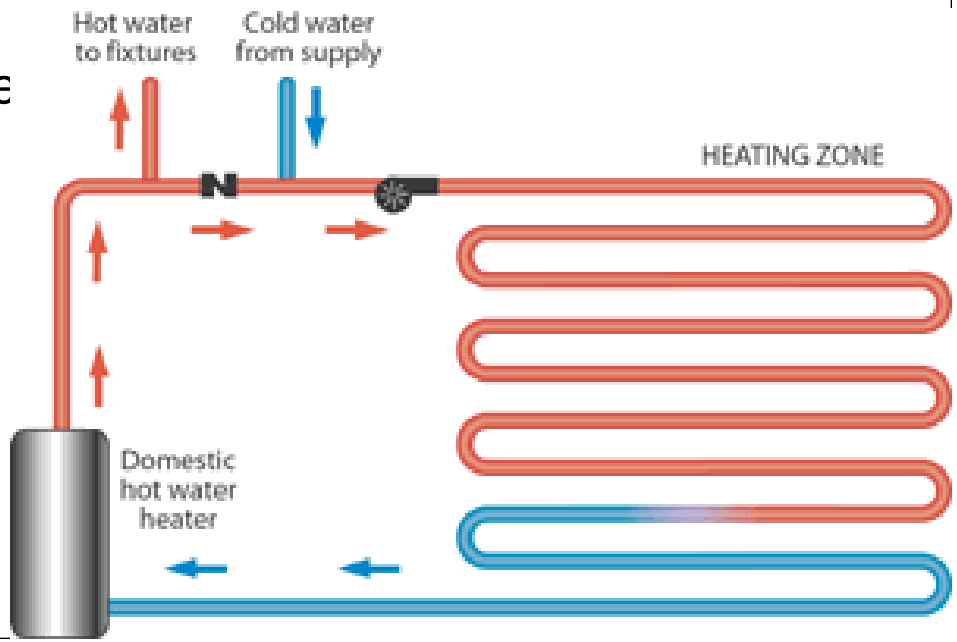
- Benefits
  - Comfort (MRT)
  - Clean, quiet & draft-free
  - Aesthetics
  - Efficiency - SWT
  - Zoning
  - Heat source independent
    - DHW heater
    - Solar
    - Boiler
    - Geo





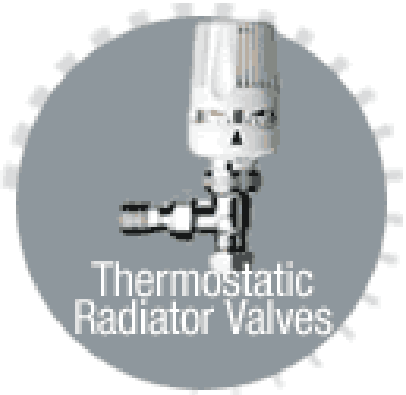
Systems –Hydronic (Radiant)

- Open System vs. Closed?
- Considerations
  - Efficiency of operation
  - Cost Effective
  - Simplicity in installation and maintenance
  - Longevity
  - Solar heat compatible
  - Safety



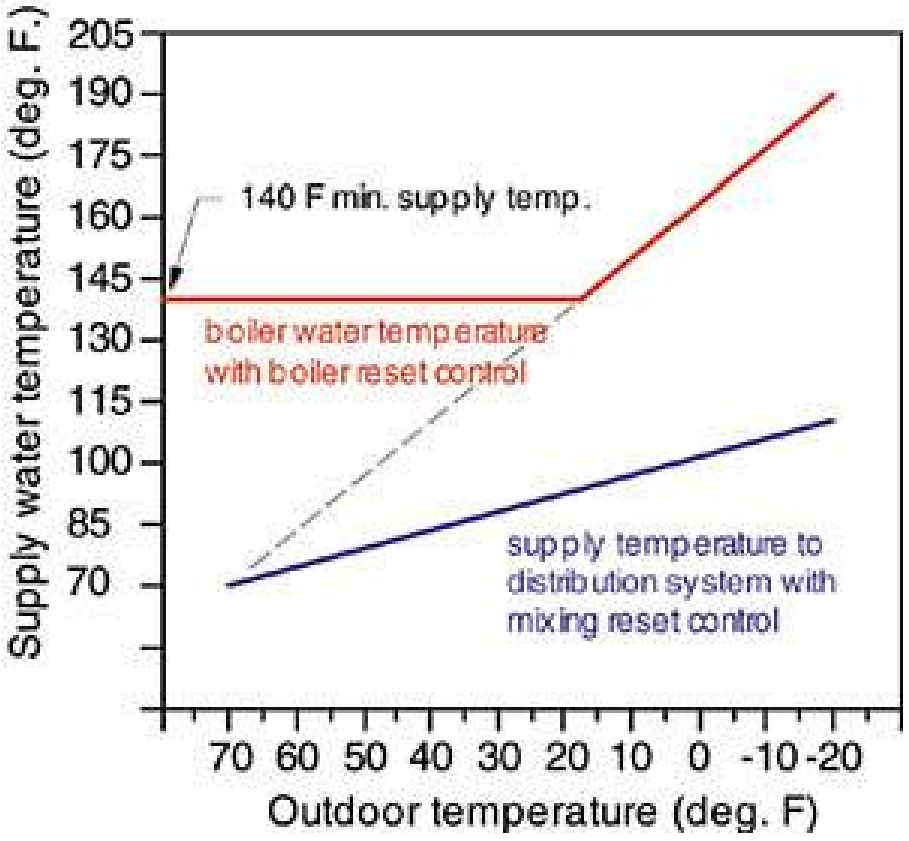
Systems –Hydronic

- Controls: Electric vs. Non-Electric?
- Considerations
  - On-off vs. modulating control
  - Individualized control
  - Continuous, centralized circulation

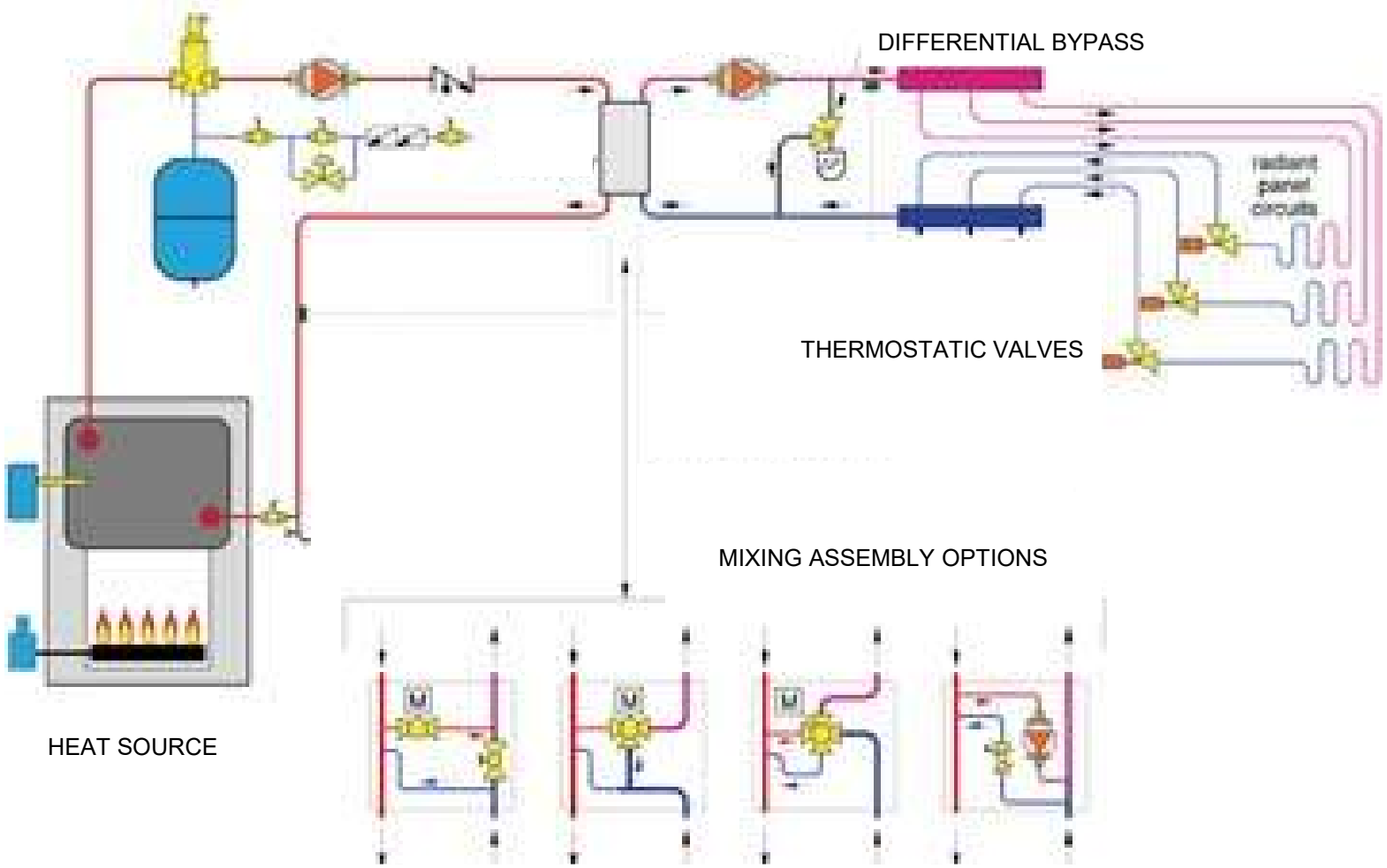


Systems – Hydronic

- Outdoor Reset
- Check your boiler type

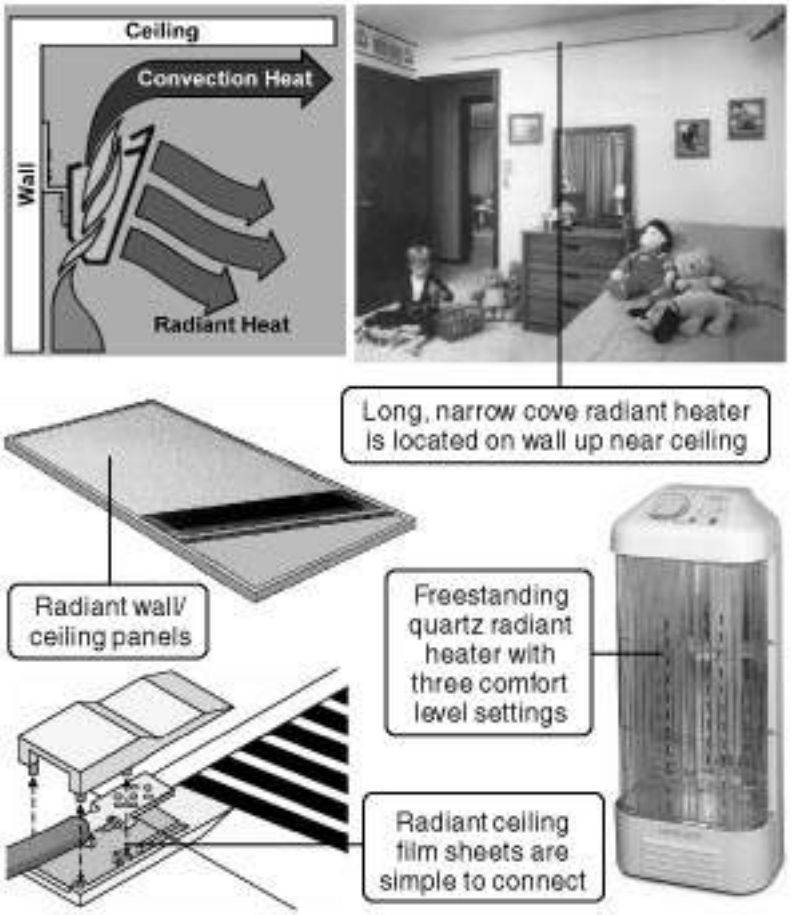


Systems – Hydronic



Systems – Radiant

- Choices
  - Electric or Hydronic?
    - Installation size
    - Backup or Primary?
    - Anticipated use patterns
    - Source flexibility desired



Systems – Boilers

- How low can you go?
- Delta T
- Similar to furnaces in types
- Size for largest load
  - space or DHW

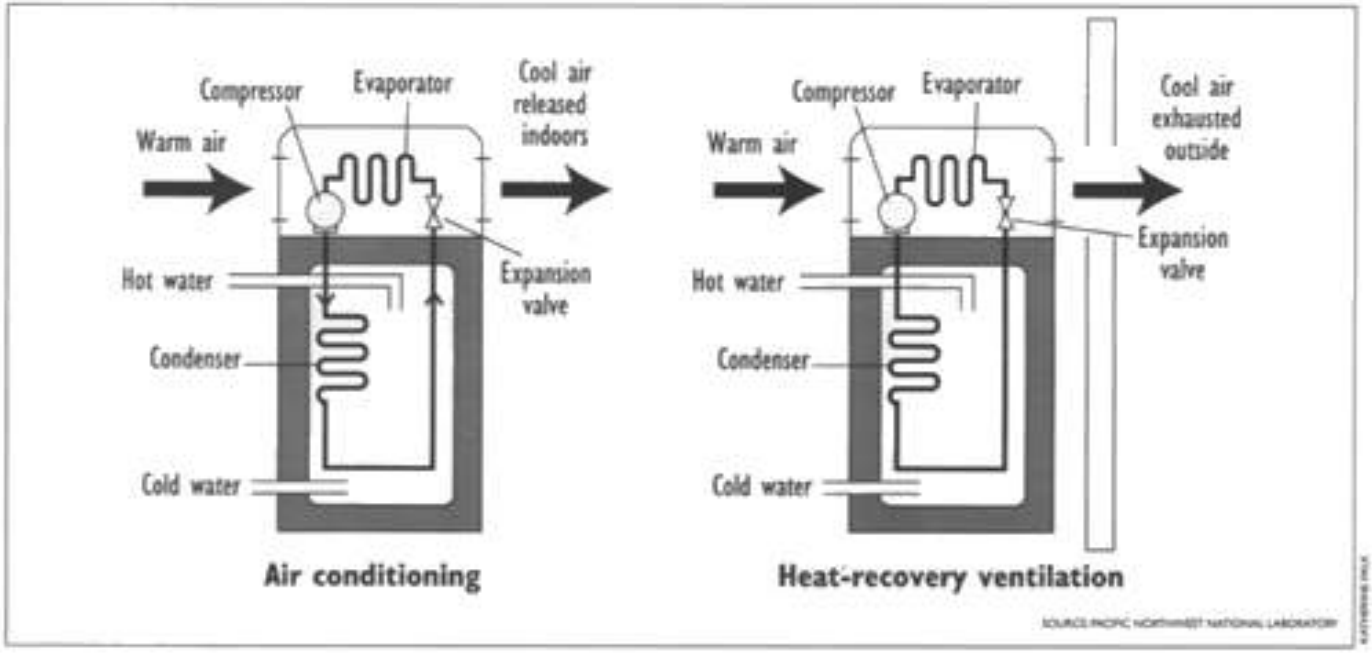
Systems – Domestic Water

- Tanks vs. Tankless
- Tanks
  - EF gas =.43-.8 (std. ~.59)
  - EF elec. = .7-.95 (std. ~.86)
- "It's a tankless job"
  - Central or point of use
  - Longevity
  - EF gas = .69-.85
  - EF elec. = .98-.99+
  - Great as backup source

EF = portion of energy that gets turned into useable hot water under avg. conditions

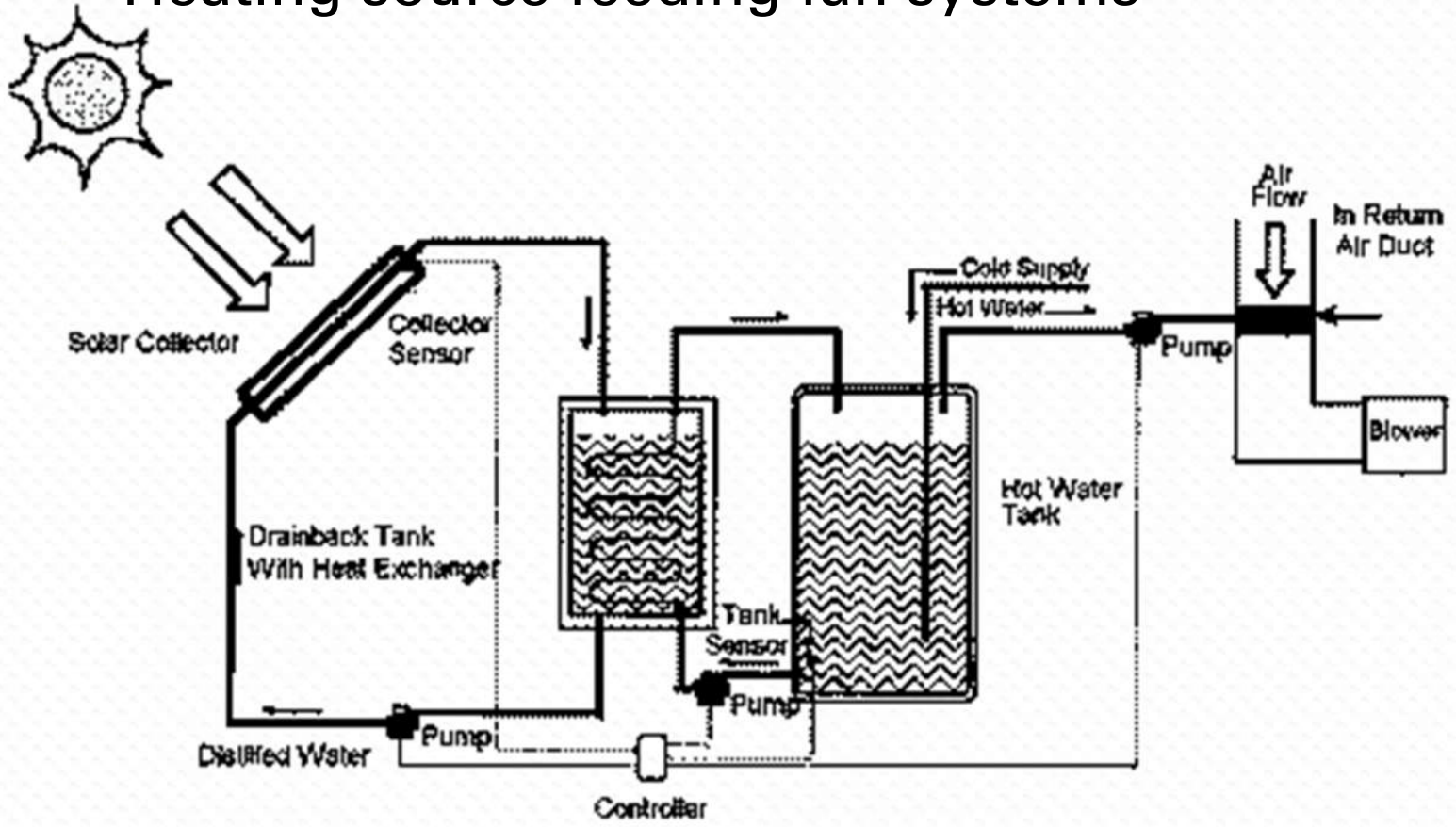
Systems – Domestic Water

- Heat Pump Water Heaters
  - 2-3 more efficient than electric
  - Limited application
  - EF 1.5-2.0



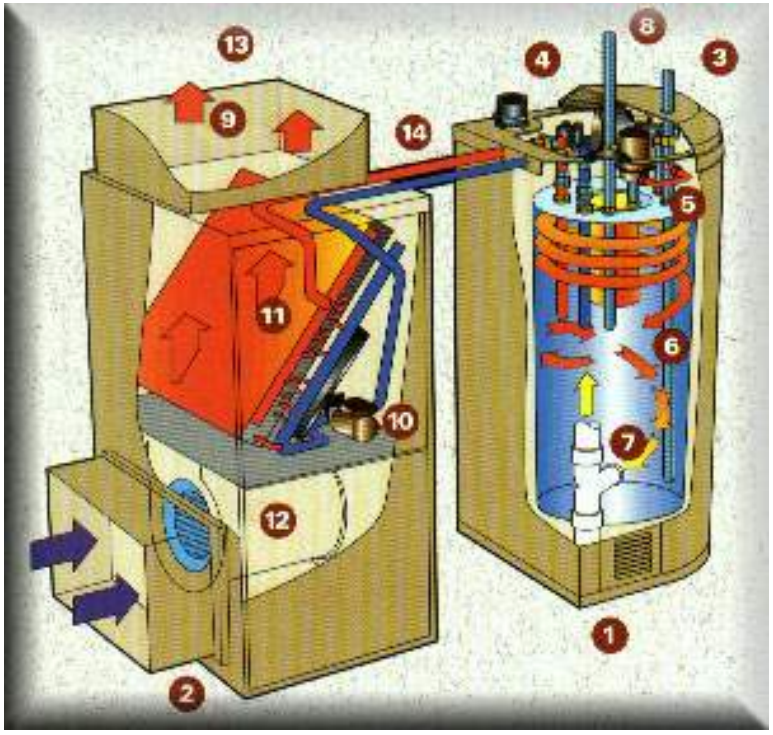
Systems – Combination

- Air-Water
  - Heating source feeding fan systems



Systems – Combination

- Air-Water
  - Packaged combination systems



  - Geothermal feeding radiant heating/air-side cooling

Systems – Ventilation

- Meeting air change rates
  - Upgraded bath fan
  - Dedicated fans
  - Furnace cycling
  - Energy recovery ventilators
    - Supply to living, exhaust near source of contamination
- Exhaust
  - Low sone <1.0

Systems – Ventilation

- Crawl Space Ventilation
  - Req. established 1942 -No technical basis
  - Passive
  - Mechanical
    - Consider Conditioned/pressurized space
    - Well sealed and insulated

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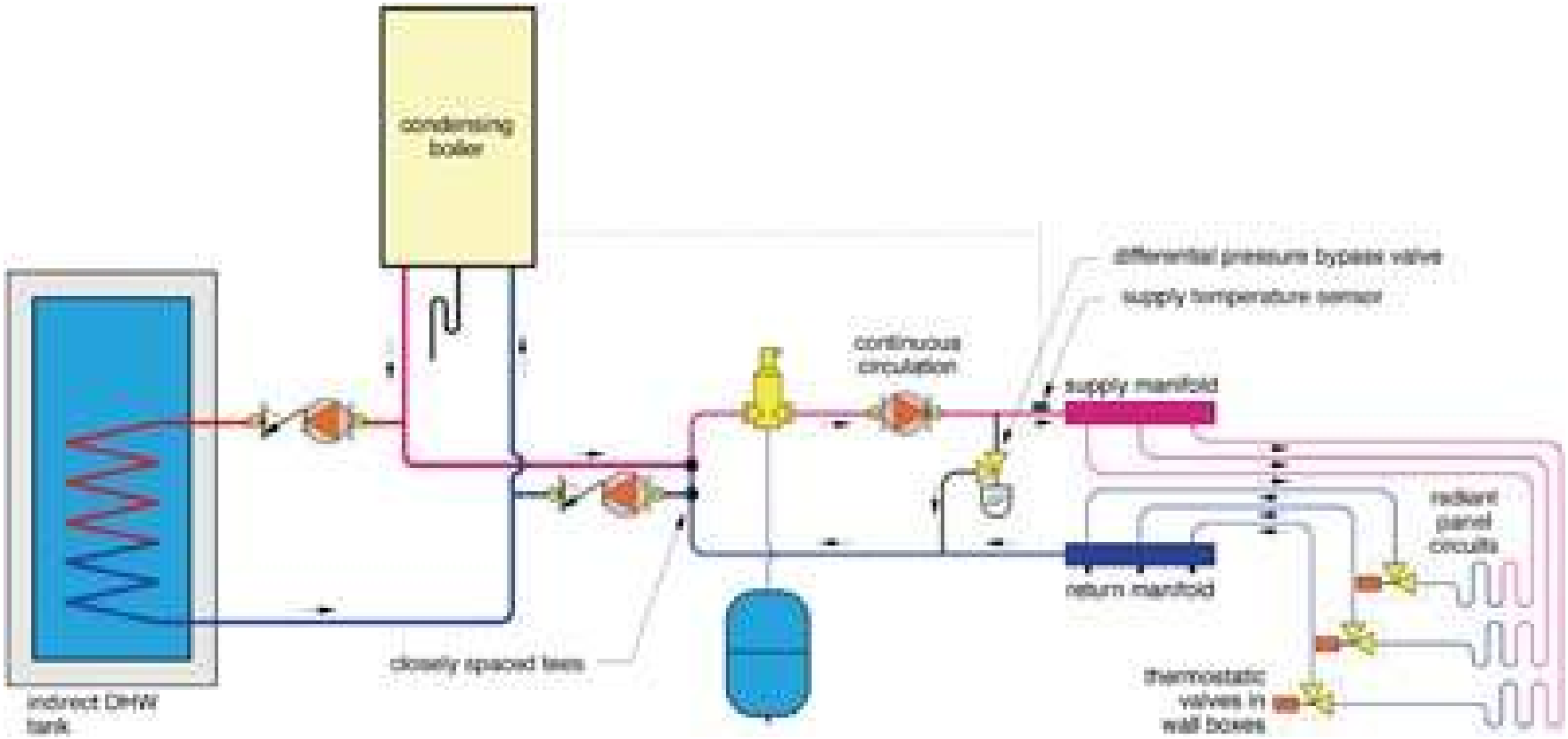
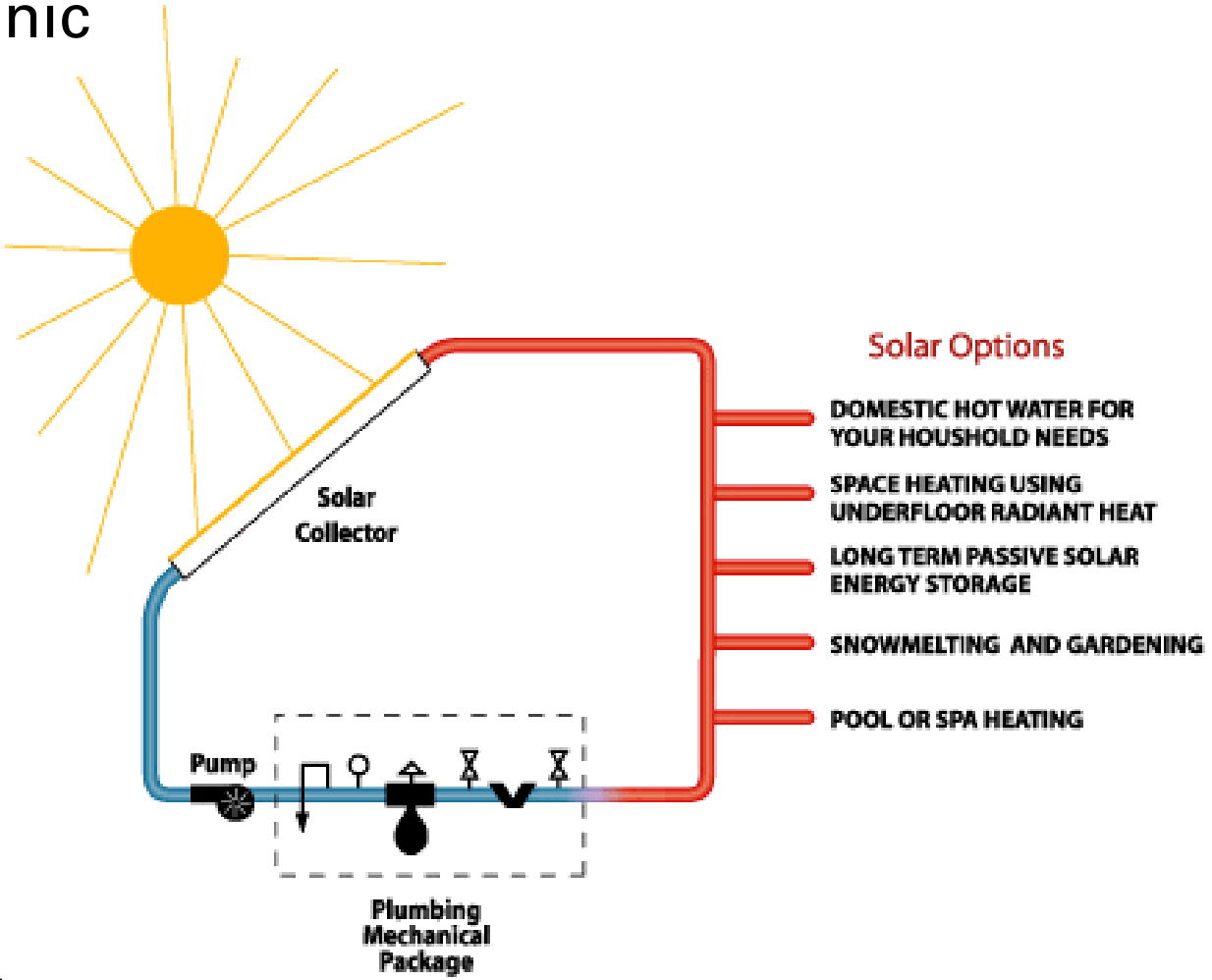
Systems – Hydronic



Systems – Solar Connection

- Many options
  - Hydronic
  - Air

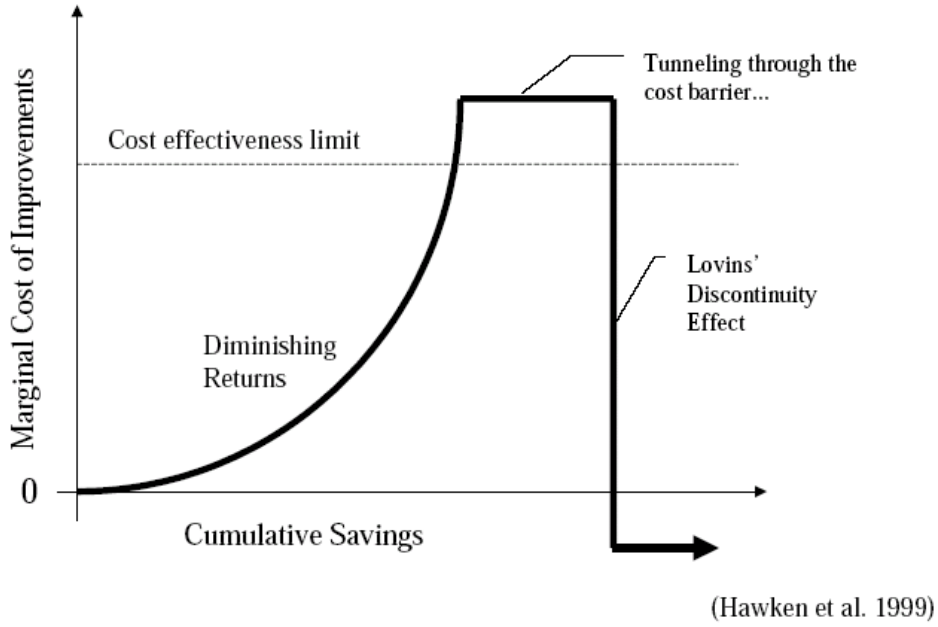


Wasted Energy

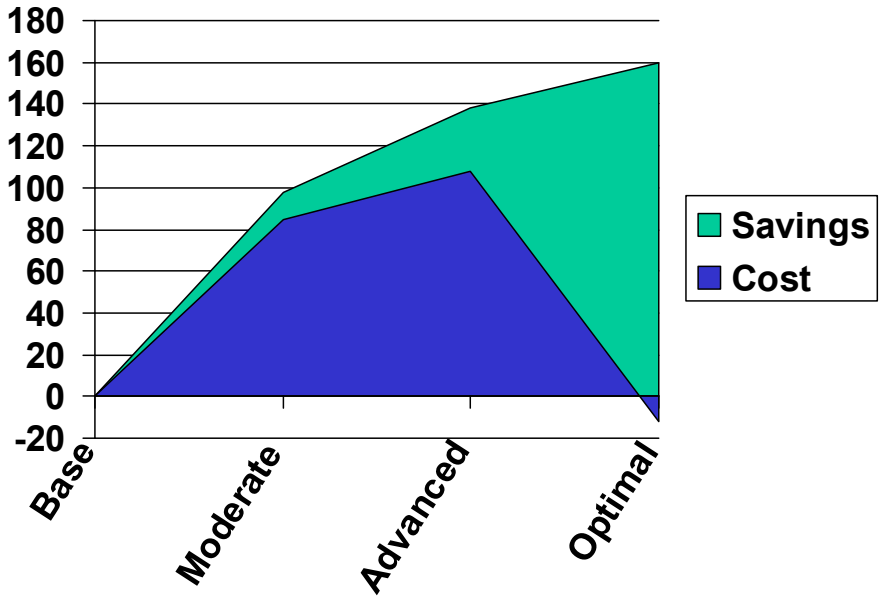
Strategies for Success

Whole System Thinking

- Multiple duty out of building elements
- Tunneling through the cost barrier
  - (A. Lovins)



(Hawken et al. 1999)



Strategies for Success

Embrace Integrated Design

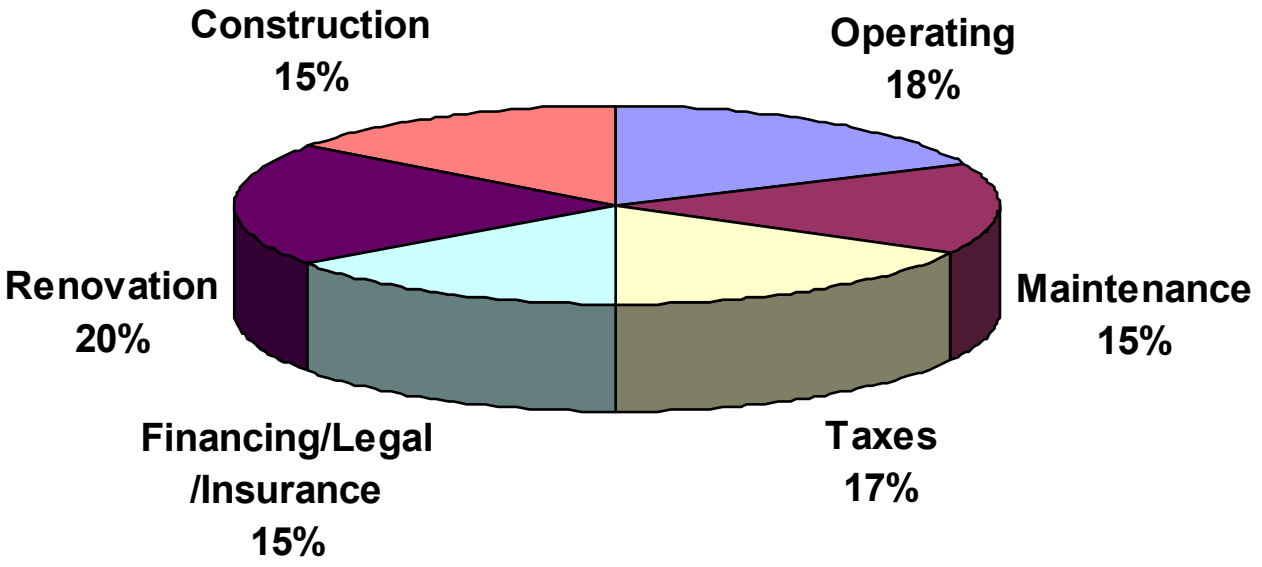
- Front-loaded design process
- Early involvement of all stakeholders
- Team selection
- Goal setting of environmental targets
- System optimization (computer modeling)
- Commissioning
- Maintenance, monitoring and reporting for ongoing results

Strategies for Success

Consider Life Cycle Cost

5% increase in construction (first cost) = <1% over life of building

"Green designed buildings have lower cost of ownership than conventionally designed buildings"



Strategies for Success

Rules of Thumb

- **Cooling 250-> 500 sf/ton**
- **Lighting 1.2-> 0.7 W/sf**
- **Plugs < 0.5 W/sf**