Context: Low-Load Houses/Units

- Heating / cooling loads shrinking!
- Better insulation, airtightness, windows
- New programs: NZE, PH, E-Star V3+
- Smaller homes, townhomes
- Multi-unit = small exterior enclosure area

Residence that requires a heating capacity of less than 15-25 kBtu/h or cooling / heat-pump system capacity of less than 1.5 to 2 tons

Peak load intensity per unit floor area (W/m² or Btu/(h·sf)) less than:
- ~12 Btu/h·sf heating
- 1200-1500 sf per ton (or more) cooling

Different rules for distribution, mixing, duct sizes apply at these low loads

For reference—PassivHaus recommends 3.2 Btu/h·sf

Less than ½ or 1/3 equivalent code-built home
HVAC Constraints

- Safety
  - Combustion, explosion, scalding
- Health (air quality)
- Comfort
  - Temperature, humidity, air speed, noise, light
- Reliability
  - Maintainable, long term performance
- Efficiency
  - Minimum of additional energy
- Economy (Builder can afford)

HVAC Functions

Five Critical functions are needed

- Heating
- Cooling
- Ventilation
  - “fresh air”
  - dilute / flush pollutants
- Air filtration / pollutant removal
  - Remove particles from inside and outside air
  - Remove pollutants in special systems
- Humidity Control

Equipment Limitations

- Peak design loads are smaller than smallest commodity central units
  - E.g. 25-30 kBTU/hr furnace
  - Smallest condensing furnaces are 40 kBTU/hr
  - Two-stage furnaces allow for low stage fire at 30 kBTU/hr
  - 1.5/2 ton AC (18-24 kBTU/hr)
    - 2 ton is the smallest efficient model

Condensing Furnace

- Simple, reliable, lots of service available
- Cheap
- Usually works at near rating condition
  - E.g. 95% efficiency
- Spec efficient fans
- Cost of ductwork
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- 1.5/2 ton AC (18-24 kBu/hr)
  - 2 ton is the smallest efficient model
- 30 kBu/hr system with 5 to 10 kBu/hr load?
  - Runs for 10 to 20 min/hour (two fires/hour?) at peak
  - Short cycling (wear & tear, inefficiency)
  - Must provide ductwork for 40 kBu/hr (~1000 CFM)

Ventilation, Filtration, Mixing

- Central air-based systems allow for ventilation mixing, and filtration
- Ductless mini-splits don’t help this!
- Fully ducted HRVs and mini splits? Cost ↑

Context-Domestic Hot Water

- New low-load houses consume almost as much DHW energy as space-conditioning
- Hard to address HVAC without considering DHW
- Required power output for DHW is around 75-125 kBu/hr to meet 2-3 GPM draw (instantaneous)
  - This is significantly more than peak power demand for cooling or heating
- 30-40 kBu/hr with a storage tank → losses

Interactions, interactions…

BEWARE:

- “Perfect” solution for heating may not solve cooling
- “Perfect” cooling solution may not solve DHW supply
- Perfect heating + cooling + DHW may do nothing for ventilation!
- We need
  - Heat + cool + DHW + vent + filtration + humidity
Choosing HVAC Systems

- No perfect solution
- Depends on building size, shape, etc.
- New or retrofit?
- Gas available or all-electric?
- Trades and equipment availability
- Money available

Questions?

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