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What are the Best HVAC Solutions for Low-Load, High Performance Homes?

Context: Low-load Definition(s)

- Residence that requires a heating capacity of less than 15-25 kBtu/hr or cooling / heat-pump system capacity of less than 1.5 to 2 tons
 - Standard cooling equipment available in 1.5-2 ton and up
 - Standard heating equipment available in 40 kBtu/hr and up
- Peak load intensity per unit floor area (w/m² or btu/(h*sq.ft.)) less than about 12 Btu/hr per sq ft and cooling under one ton per 1200-1500 sq ft
 - Different rules for distribution, mixing, duct sizes apply at these low loads
- Less than ½ or 1/3 equivalent code-built home

Context

- 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 kBtu/hr to meet 2-3 GPM draw
 - This is significantly more than peak power demand for cooling or heating

Problem

- Over-sized AC means poor latent control, short cycling reduces durability and comfort
- Over-sized heating (2x or more) requires much larger ducts and vents for no benefit
- Short-cycling can limit comfort
- Small modulating condensing gas furnaces should be available in 12-24 kBtu/hr. No technology issues. Pure manufacturing issue.
- PS Cost is usually not a limit. Standard units are cheap

Recommendations

- No perfect solution for all
- Major question:
 - all electric or
 - Gas+ electric
- Cooling important or not
 - Pacific North-west?
 - Dry northern areas?

Pros & Cons of existing solutions

- **Condensing furnace + nat gas hotwater heater**
 - Furnace too large, hotwater heater not very efficient
 - 2 ton AC often too large
- **Air-source heatpump + nat gas hotwater heater**
 - 2 ton unit may be over-sized for cooling in cold climates
 - Hotwater heater not too efficient
- **Tankless combo system with small air handler**
 - Can be tweaked and tuned to meet heating needs
 - 2 ton AC is often too large
 - Not an all-electric solution, installation requires care

Pros and Cons of Possible Solutions

- New technology Heat pumps
 - Allow all electric, heating+cooling solution in one unit
- Air-to-water HP look good if expensive, but ...
 - Getting 120-140° F or more water for DHW is not very efficient (source energy vs gas)
- Air-to-Air HP look good, small capacities
 - Cost effective, HSPF>11, SEER>20, modulating output
- Meeting peak loads in cold climates is challenging
 - Air-to-air HP now down to -5F reliably
 - Air-to-water perhaps 10F, but DHW?

Ventilation, Filtration, Mixing

- Central air-based systems allow for ventilation mixing, and filtration
- Ductless mini-splits don't help this!
- Only some water-based heat pumps do this
- Can integrate HRV/etc. into combo systems

Recommendation

- **Better Integrated packages needed**
 - Heating, cooling, humidity, ventilation, filtration, mixing
- **Gas:Combo systems should be further developed**
 - Better understanding needed for cold sandwich
 - Missing a small AC to attach to duct (or accept separate ductless mini-split)
- **Electric: Ductless mini-splits + DHW**
 - Have great promise, but aesthetics and distribution is a challenge
 - Need efficient DHW- heat pump? Solar?

Value

- Current mass-produced furnace + 3 ton AC + supply ventilation is relatively inexpensive
- Essentially all alternate systems cost more
- Value will have to be found in
 - better comfort, less noise,
 - easier installation,
 - smaller ducts, etc.

Market Readiness

- Growth in airtight well-insulated small homes, row houses, apartments means a significant need for lower capacity today
- The bigger problem is suppliers are not providing central ducted
 - Condensing multi-stage NG furnace of 20 kBtu/hr
 - Hi SEER 1 ton AC
 - Variable output, 0.5 to 3 ton air-source heat pump
- Technology not ready for air-source DHW HP from exterior temperatures of 30F and lower

