

Kohta Ueno

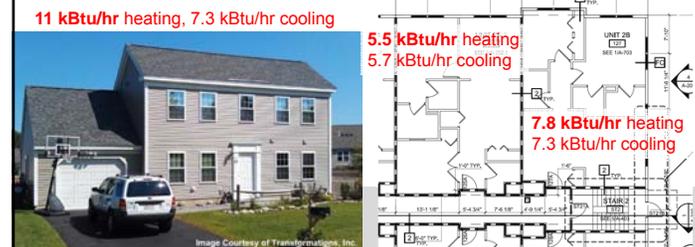
## Low-Load, High Performance Homes: Introduction and HVAC Solutions




CONFERENCE + TRADE SHOW FOR RENEWABLE ENERGY AND GREEN BUILDING PROFESSIONALS

### 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



### Context: Low-load Definition(s)

- 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 ( $W/m^2$  or  $Btu/(h \cdot sf)$ ) 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 1/2 or 1/3 equivalent code-built home



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### Low Load Building Anomalies

- Internal / solar gains have a BIG impact on space temperature
  - Eg. SHGC (g)=0.60
  - 6'0" x 6'8" patio door with 80% glass
  - 6000 Btu/hr in bright sun! (1/2 ton AC in one room)
  - Occupancy example
- Better zoning may be needed
  - Room by room
  - Mixing between rooms
  - Or better enclosure? (lower SHGC glazing)



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## 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)


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## 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


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## 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


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## 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



**REDACTED** Gas Furnace 46,000 BTU  
 BYU Furnace, 2-Stage Burner, 2-Stage Burner, 1,200 CFM Multi-Speed Blower, Upflow / Horizontal Flow

**REDACTED**

MPN: GMH90453BX  
 SKU: GMH90453BX  
 Fuel Source: Natural Gas  
 Price: \$697.00  
 This item is in stock

Quantity: 1


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  - 1.5/2 ton AC (18-24 kBtu/hr)
    - 2 ton is the smallest efficient model
- 30 kBtu/hr system with 5 to 10 kBtu/hr load?
  - Runs for 10 to 20 min/hour (two fires/hour?) at **peak**
  - Short cycling (wear & tear, inefficiency)
  - Must provide ductwork for 40 kBtu/hr (~1000 CFM)

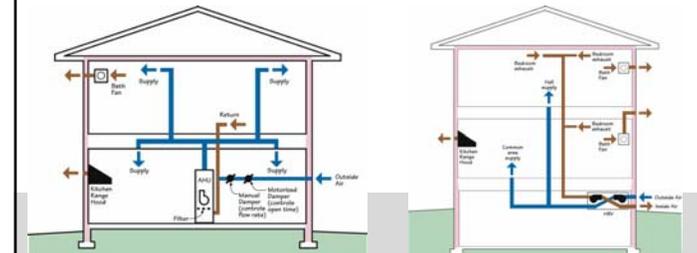


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## Ventilation, Filtration, Mixing

- 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 kBtu/hr to meet 2-3 GPM draw (instantaneous)
  - This is significantly more than peak power demand for cooling or heating
- 30-40 kBtu/hr with a storage tank → losses



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## 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



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## Choosing HVAC Systems

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



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## Questions?

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Kohta Ueno (kohta@buildingscience.com)

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