

The *Passive House* Standard

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Purpose

- Reduce the need for *active* temperature control.
- Use 90% less fuel

Focus

- Since it's winter, focus is on winter performance.

Why Heat Your House in Winter?

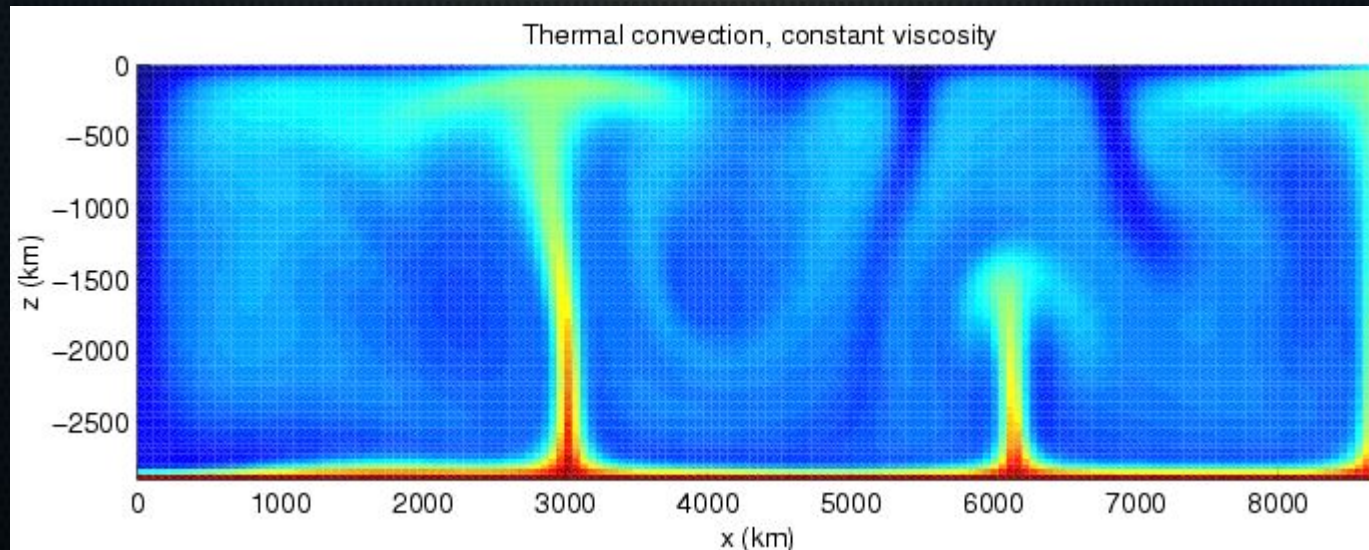


Thermodynamics

- 3 ways for outside temperature to affect inside temperature:
 - Convection
 - Conduction
 - Radiation

Convection

- In this context, cold air (outside) mixes with warm air (inside).
 - E.g. standing next to a leaky fireplace vent



blue = outside air; red = inside air

Conduction

- Direct contact of substances of different temperatures.
 - E.g. touching a cold wall



Radiation

- Transfer of heat via EM waves
 - Sun → Earth
 - What thermal imaging cameras pick up
 - E.g. standing near a cold wall



Nature Wants You Frozen

- Exterior wall **conducts** heat to cold outside air at the interface.
- Warmed outside air replaced with cold air via **convection**, keeping the cycle going.
- Inner wall **conducts** heat to cold outside wall.
- You lose body heat to the cooled wall via **radiation**.

Nature Wants You Frozen

- Leaks
 - lose hot air
 - allow cold air to cool interior via **convection**

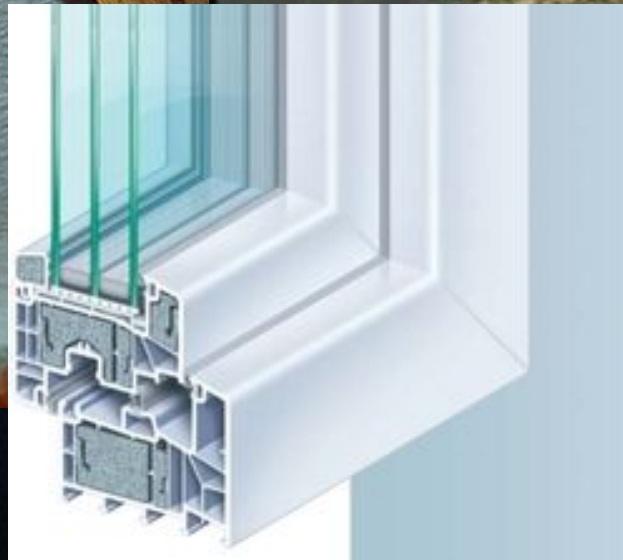
How to Improve This?

- Assume this is the worst house design. How do we reduce heat transfer?



Convection

- Seal air leaks



Conduction

- Insulate
- Reduce “thermal bridges”

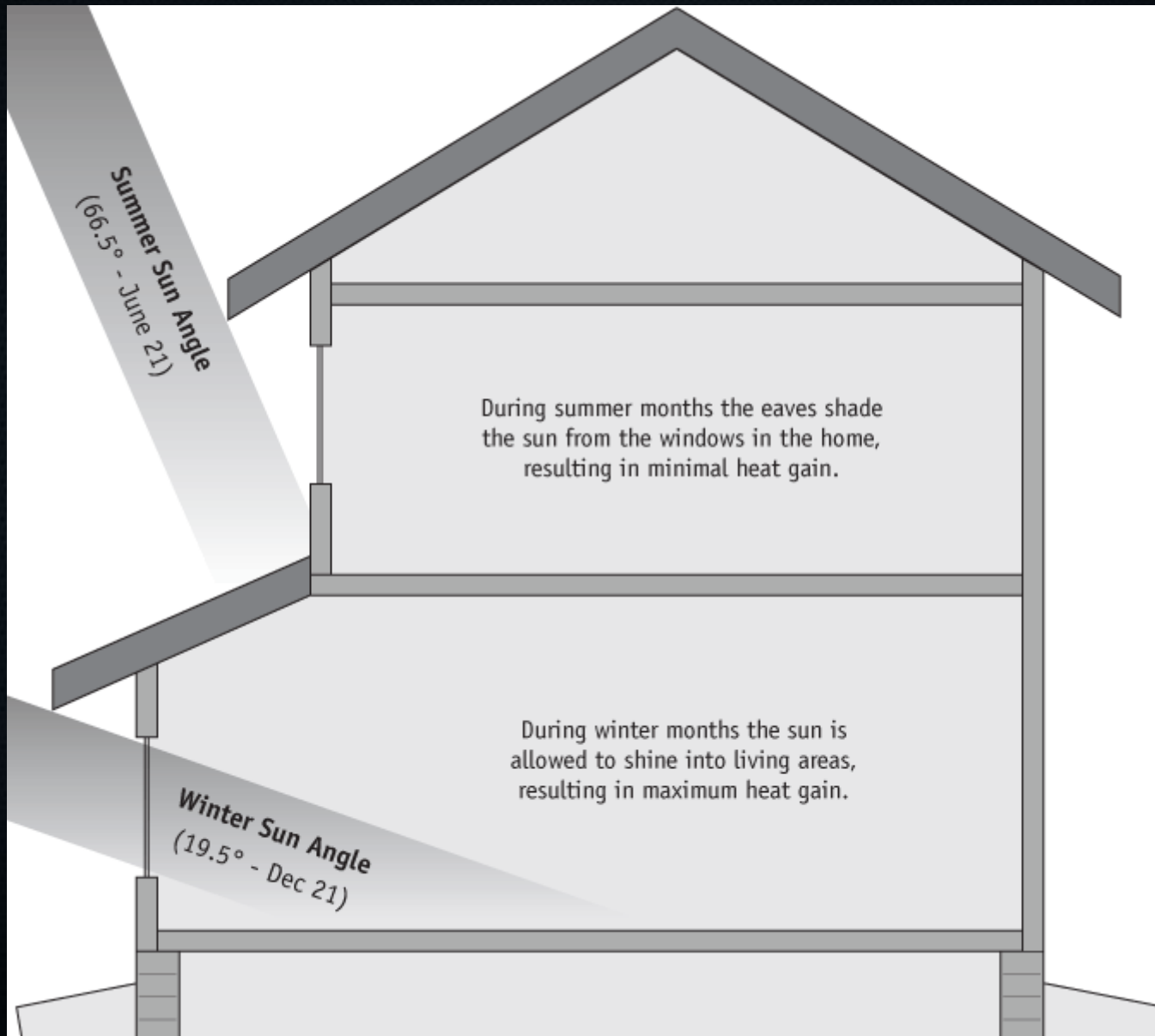




Radiation

- *Prevent* direct sunlight into living space in summer
- *Encourage* direct sunlight into living space in winter
- *AKA Passive Solar*

Radiation



Radiation

- Use exterior materials that reflect radiation



More on Conduction

- *Large* amounts of insulation
 - Up to R-100 roof, R-75 walls
 - vs UCC: R-35 roof, R-20 walls
 - walls, ceilings, basements/slabs

More on Radiation

- Floors act as thermal mass



More on Convection

- A Passive House is sealed up as tightly as possible.
 - Slightly looser than a submarine or spaceship
 - A lot of heat is lost through convection.



But Now Everyone Suffocates

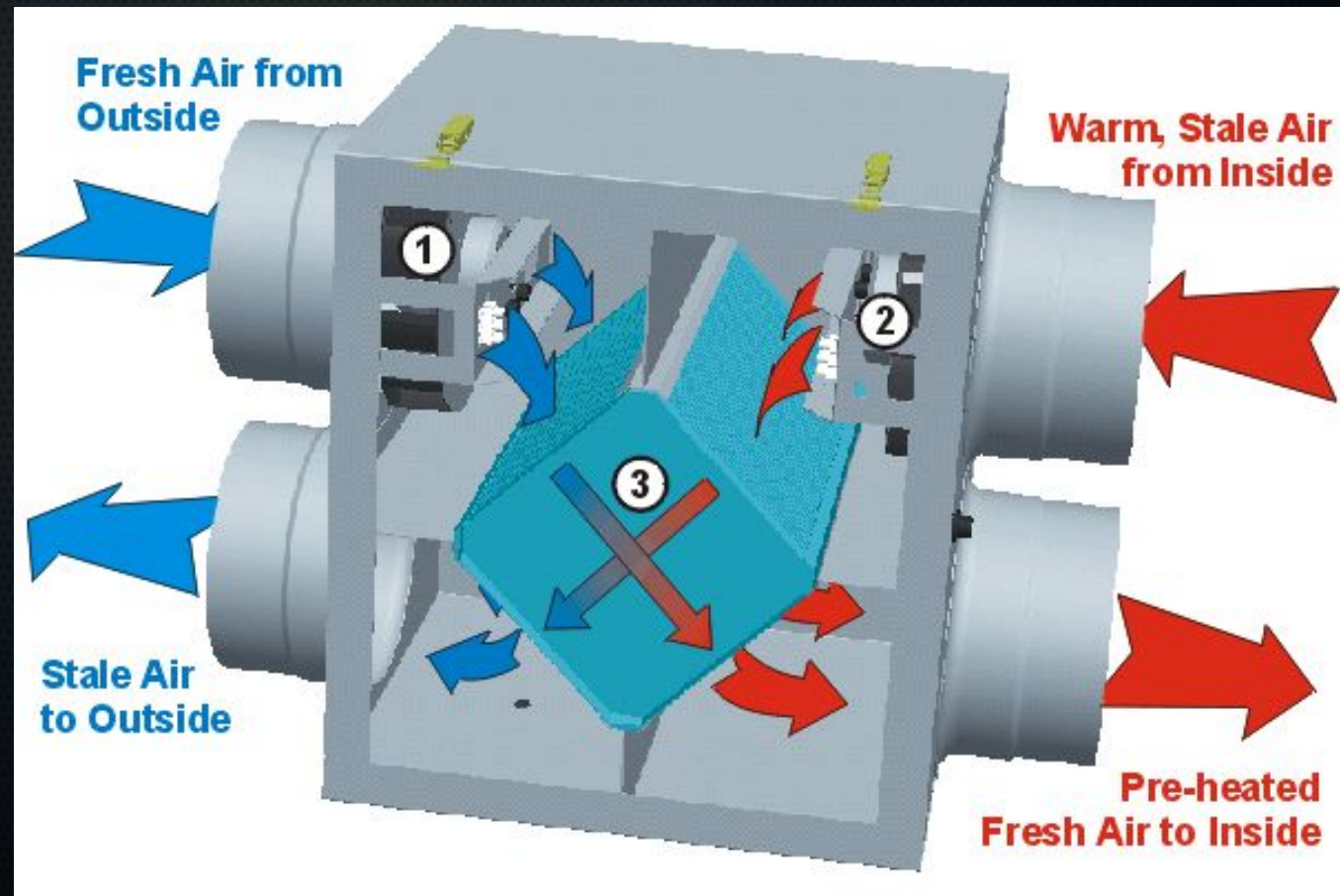
- How does your house get fresh air *when the outside conditions are bad?*
 - Briefly open doors during entrance/exit
 - Air leaks: walls, windows, vents, chimneys
- Seal those all up, and where does your fresh air come from?

Putting the Active in Passive

- An *active* system manages air intake and exhaust, but it is better than haphazard air leaks.
 - HRV (Heat Recovery Ventilator)
 - ERV (Energy Recovery Ventilator)

HRV

- Brings filtered, warmed exterior air inside.
 - Resulting temp ~between interior & exterior temps.



HRV

- If 68F inside and 32F outside, HRV brings in ~50F fresh air.
 - Much easier to warm 50F air than 32F air.
 - Humans react better to “drafts” of 50F air than 32F air.

HRV

- Flow rate is also managed
 - Too high, and it's like having a leaky house
 - Too low, and you die from CO₂ buildup

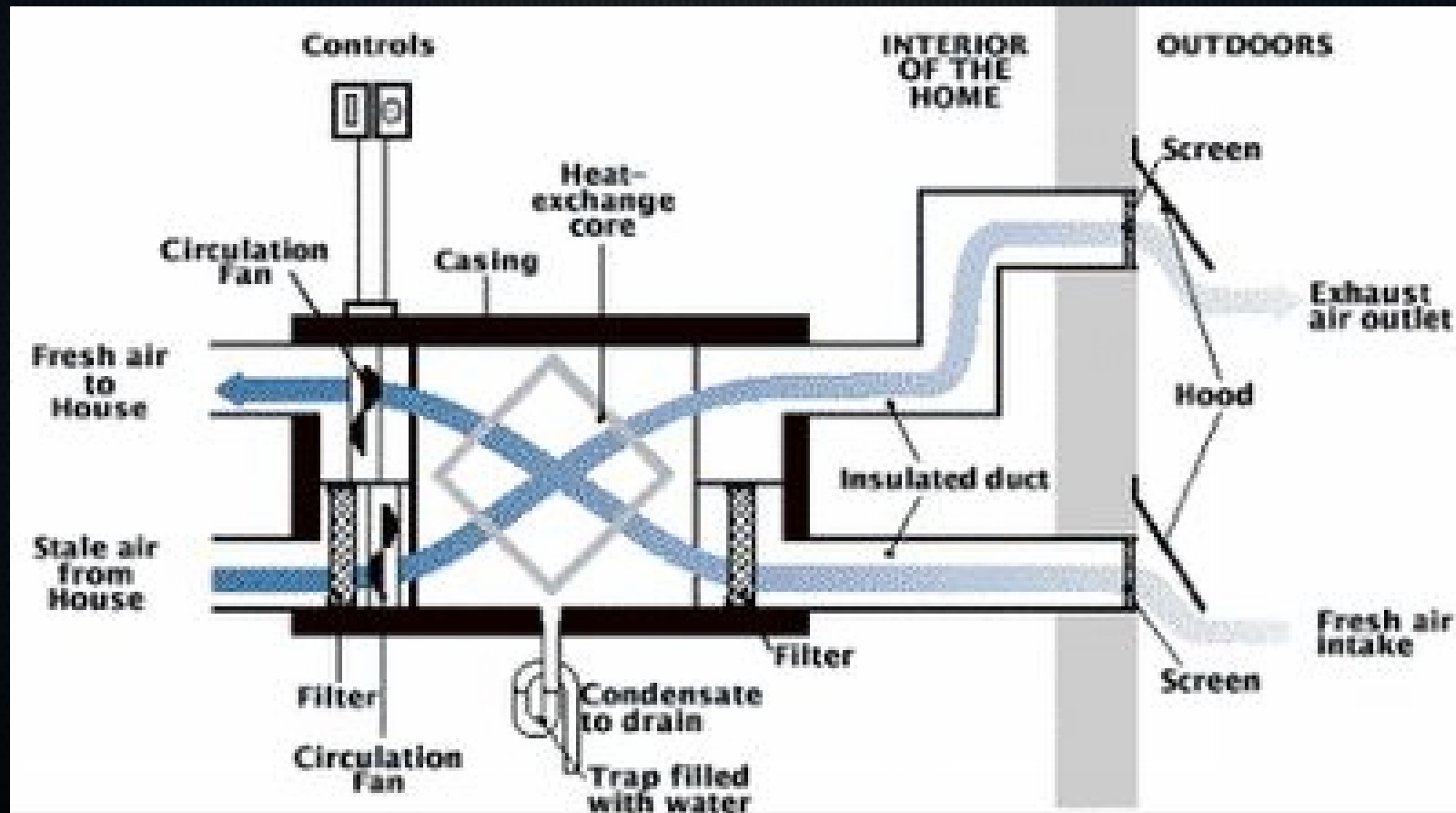
HRV (Bonus Summer Slide)

- Some can cool house on summer nights.
 - Same mechanism, minus heat exchange.



ERV

- An HRV that also averages humidity



Can I Open Windows?

- Yes



Heating The House

- Sub-floor heating alone is common.



Vents

- A traditional house has vents for
 - Kitchen
 - Bathrooms
 - Laundry
 - Drains
 - Gas appliances
 - Furnace, water heater, etc.



Vents?

- A Passive House prefers venting to go through the HRVs/ERVs
- In a Passive House, some exhaust could de-pressurize it and reduce the HRV's abilities.
- Also compromises seal

Vents?

- HRV limitations:
 - Temperature range (nothing too hot)
 - Air volume (~200cfm per unit is max)
 - grease, lint, smoke clog/break them

Vents :(

- From inside the sealed space, you can't vent your
 - Dryer
 - Air volume too high
 - Air temperature too high
 - Air too dirty (lint)
 - Kitchen hood
 - Grease and smoke

Don't Cheat



Vents :)

- You can have a dryer
 - put your dryer outside the sealed space
 - get a crappy condenser dryer
 - wait a few years for dryers with heat exchangers to hit the US market

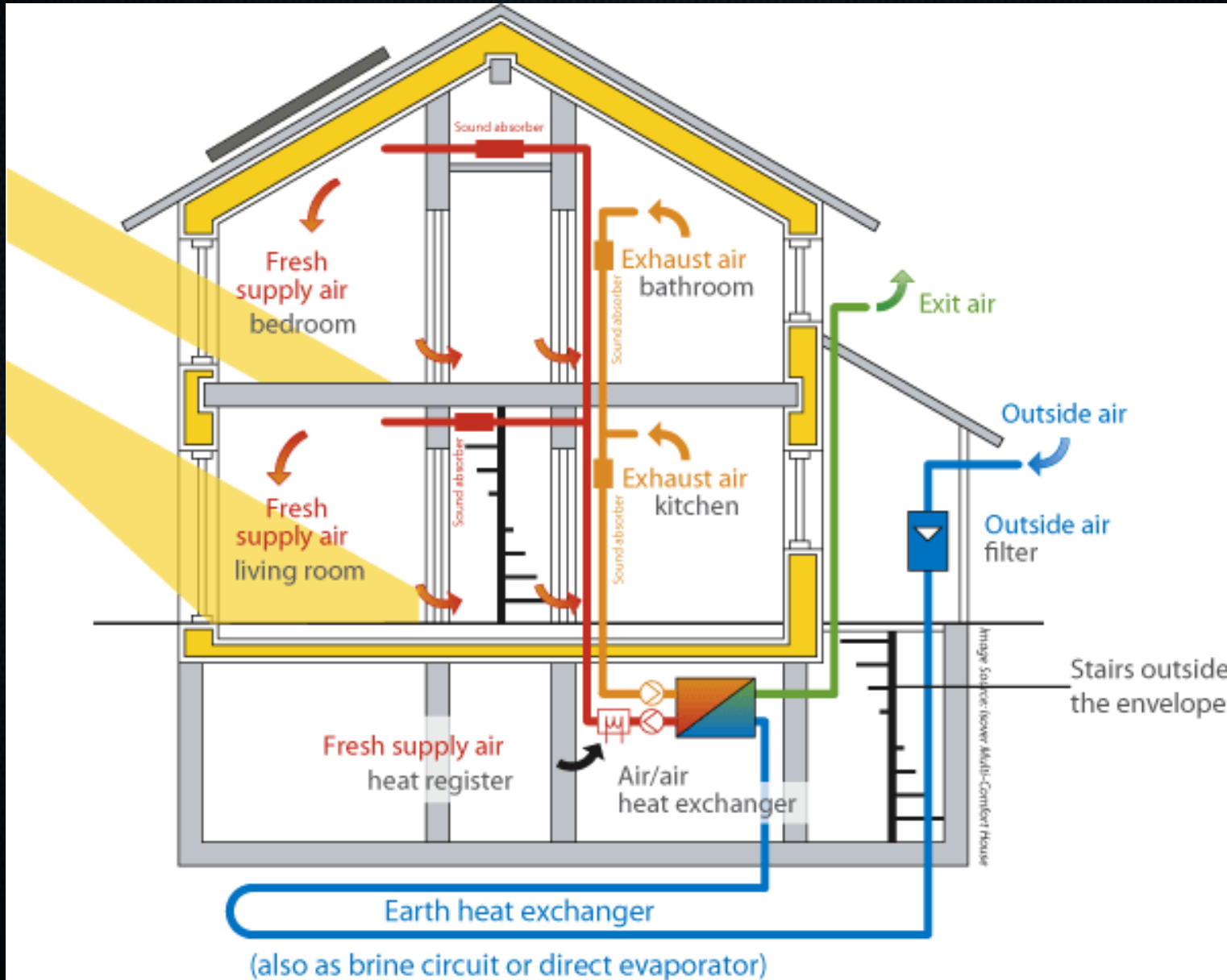
Vents :)

- You can have a cooktop
 - gas cooktop CO₂ production can be handled by HRVs
 - recirculating hood instead of venting hood
 - filter out grease and smoke, then allow HRV to do its job

Vents :)

- You can have a gas water heater
 - Electric is more suitable, but gas can work

All Together Now



Example Passive Houses



Example Passive House



Example Passive House



References

- German Passivhaus site
 - <http://passiv.de/en>
- US Passive House Institute site
 - <http://www.passivehouse.us>