12 Buildings

Cooling

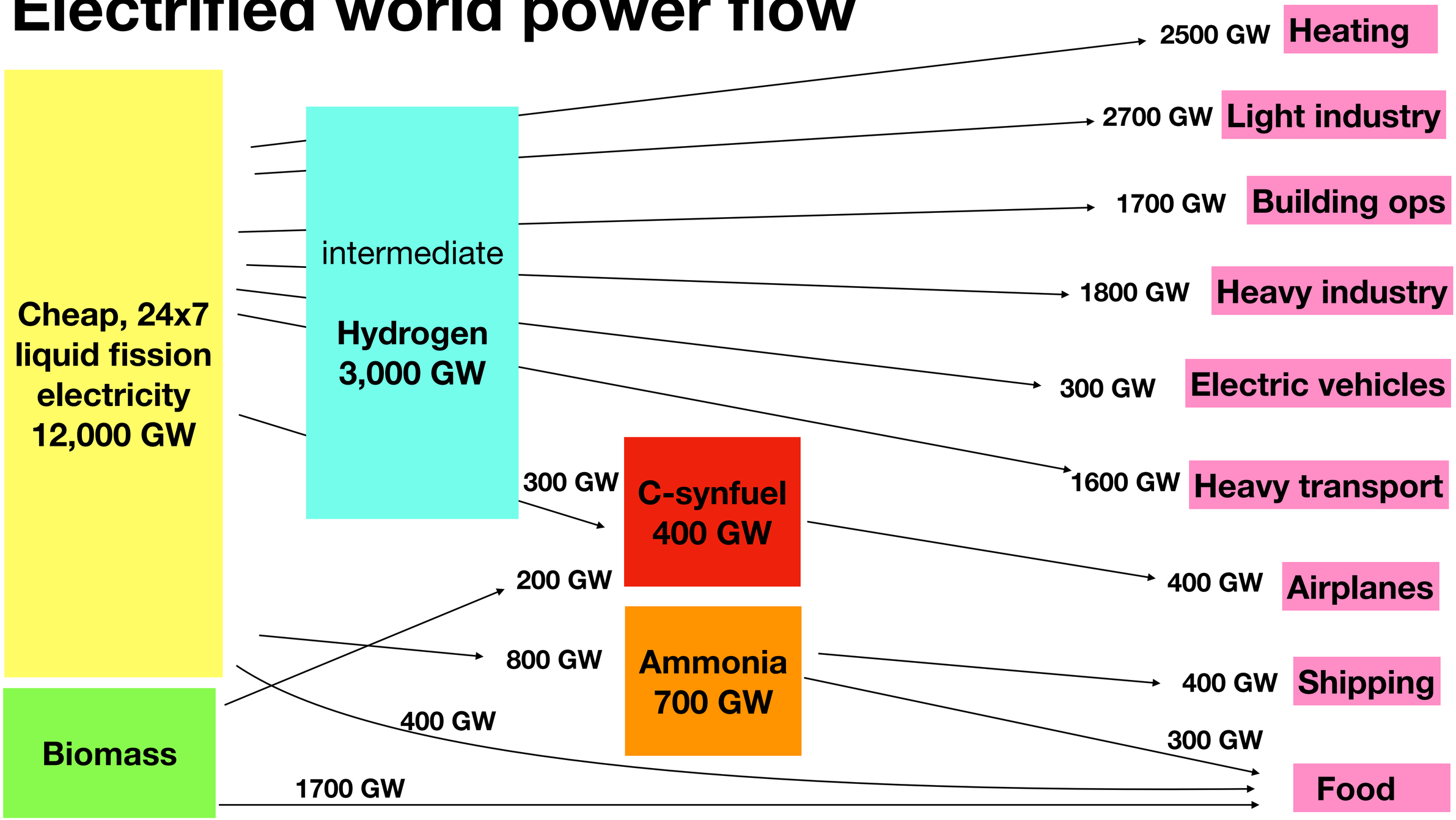
Heating

Insulation

Co-generation

Fission is in Fashion

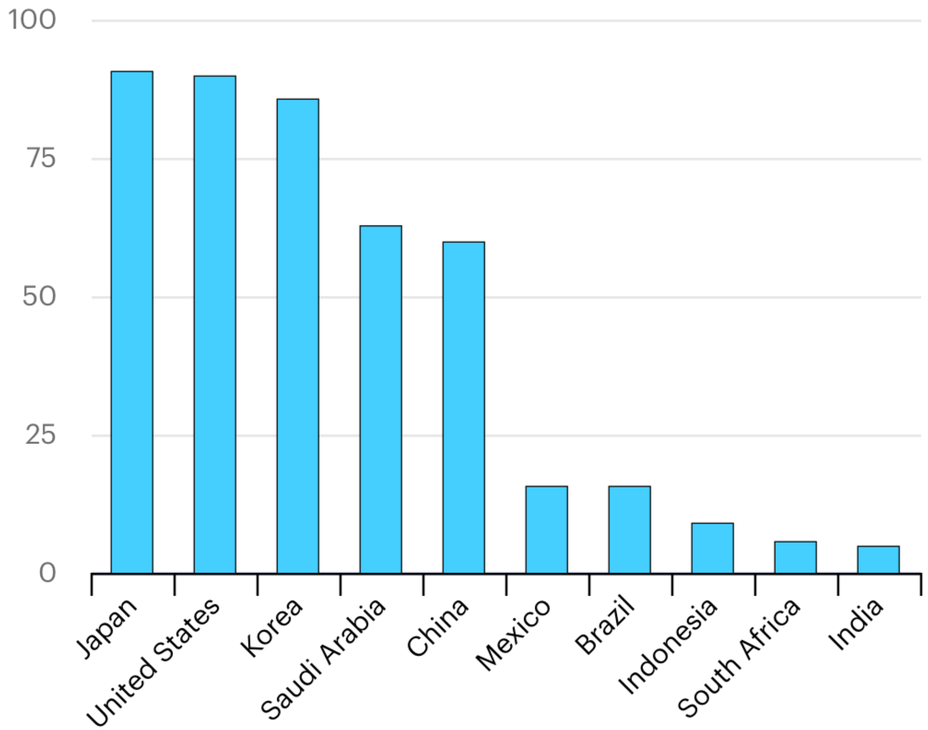
Electrified world power flow

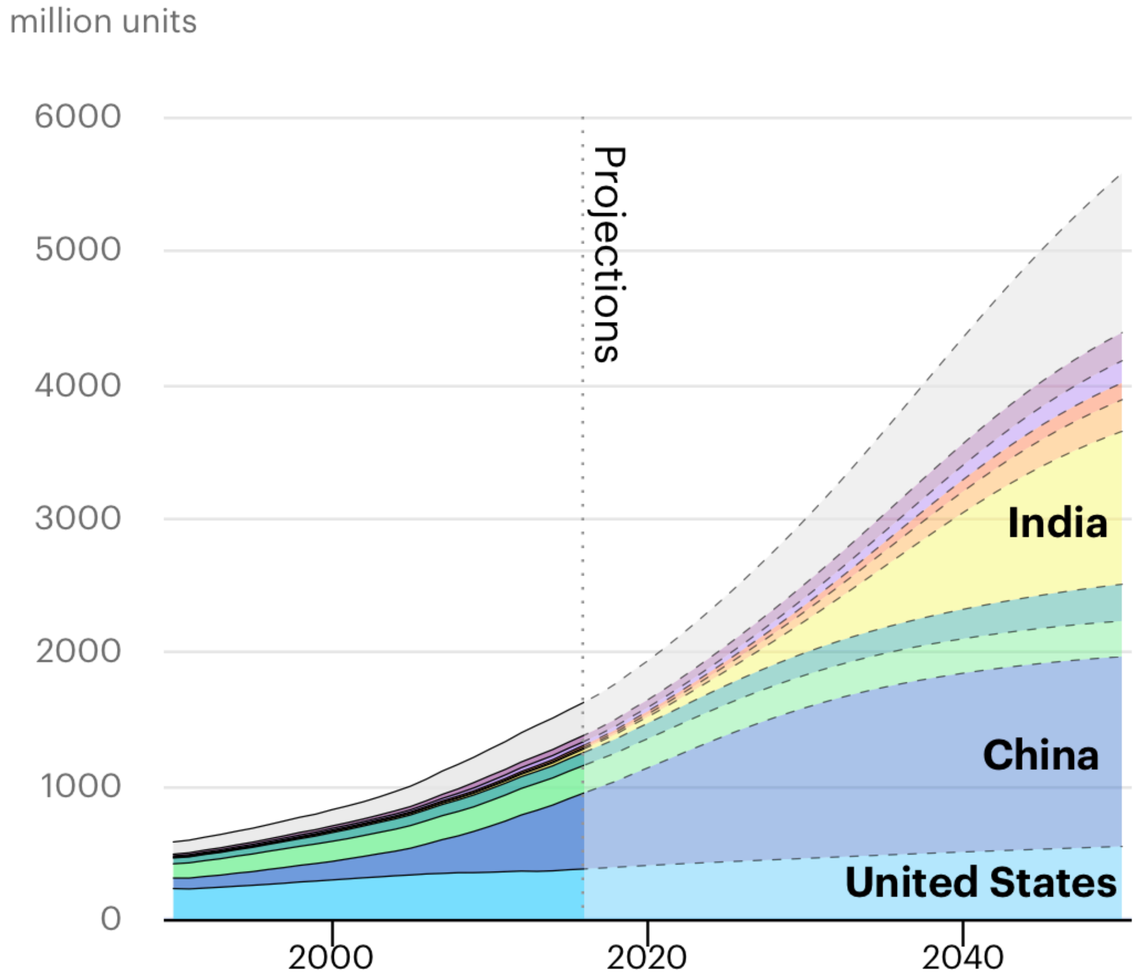


Cooling consumes > 8% of all electricity.

Responsible for 1 Gt CO2 emissions.
2 billion units in operation use **250 GW.**
Unit sales increasing 10-15% per year.
Ave COP efficiency could double, to 6.

Air conditioning units will triple, with electricity consumption of **700 GW** by 2050.

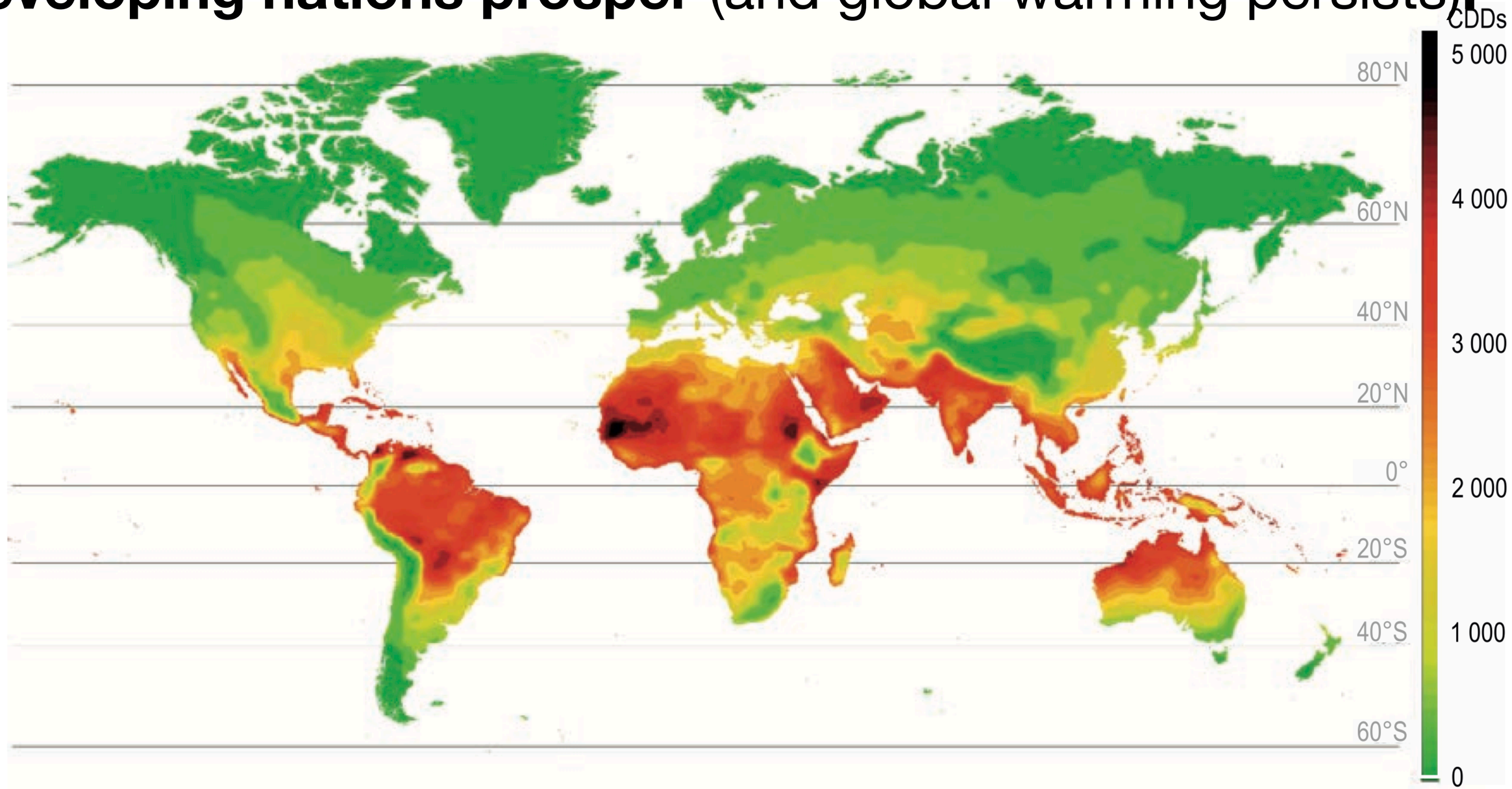




https://www.iea.org/reports/the-future-of-cooling

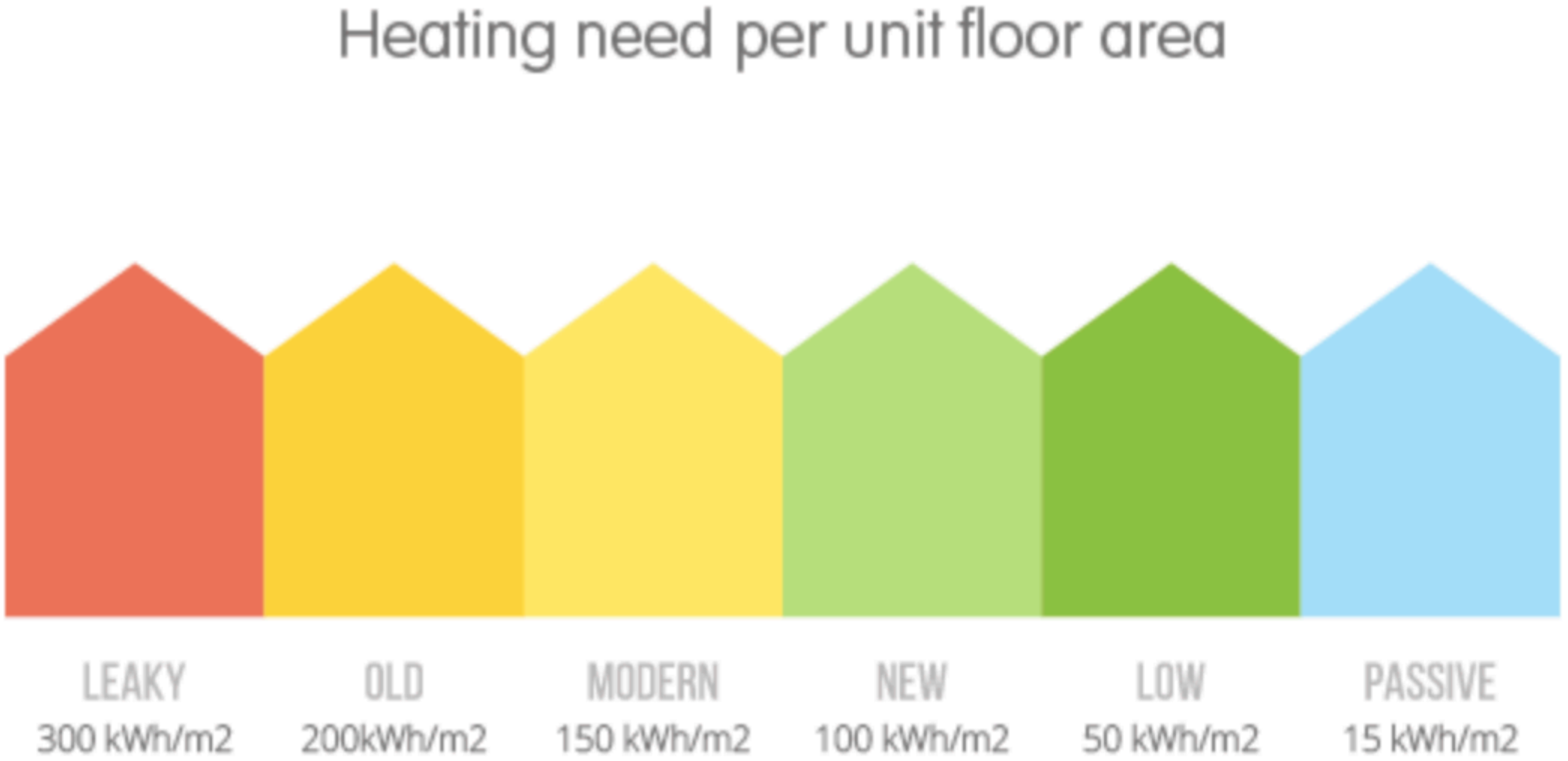
https://www.technologyreview.com/2020/09/01/1007762/air-conditioning-grid-blackouts-california-climate-change/

Annual cooling degree days portend high GW demand as developing nations prosper (and global warming persists).



https://webstore.iea.org/download/direct/1036

Home heating demand varies by 20:1



https://www.ovoenergy.com/guides/energy-guides/how-much-heating-energy-do-you-use.html

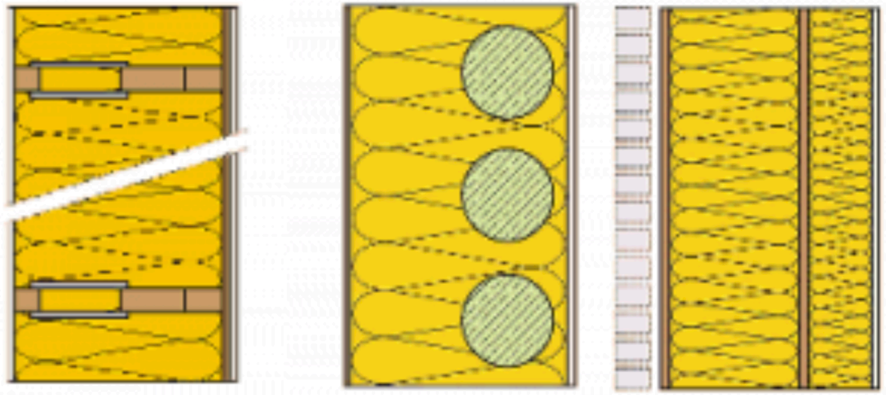
Well insulated buildings are #1 priority to reduce heat demand.

Example specification: well sealed, well insulated Vermont 2000 sq ft home)

- Passive solar features
- R40 walls
- R60 ceiling
- R20 basement
- R7 triple-glazed windows
- R8 doors
- Air in-leakage less than 1.0 air changes per hour at 50 pascal.
- HVAC whole-house, forced-air ventilation of 0.5 air changes per hour.
- Air-to-air heat recovery exchanger.
- Space heating demand at -10°F, 6 kW(t).

LEED, Passivehaus can be $$$ certification regimes.

Making Passive House homes affordable



Examples of super-insulated external wall superstructures suitable for Passive Houses

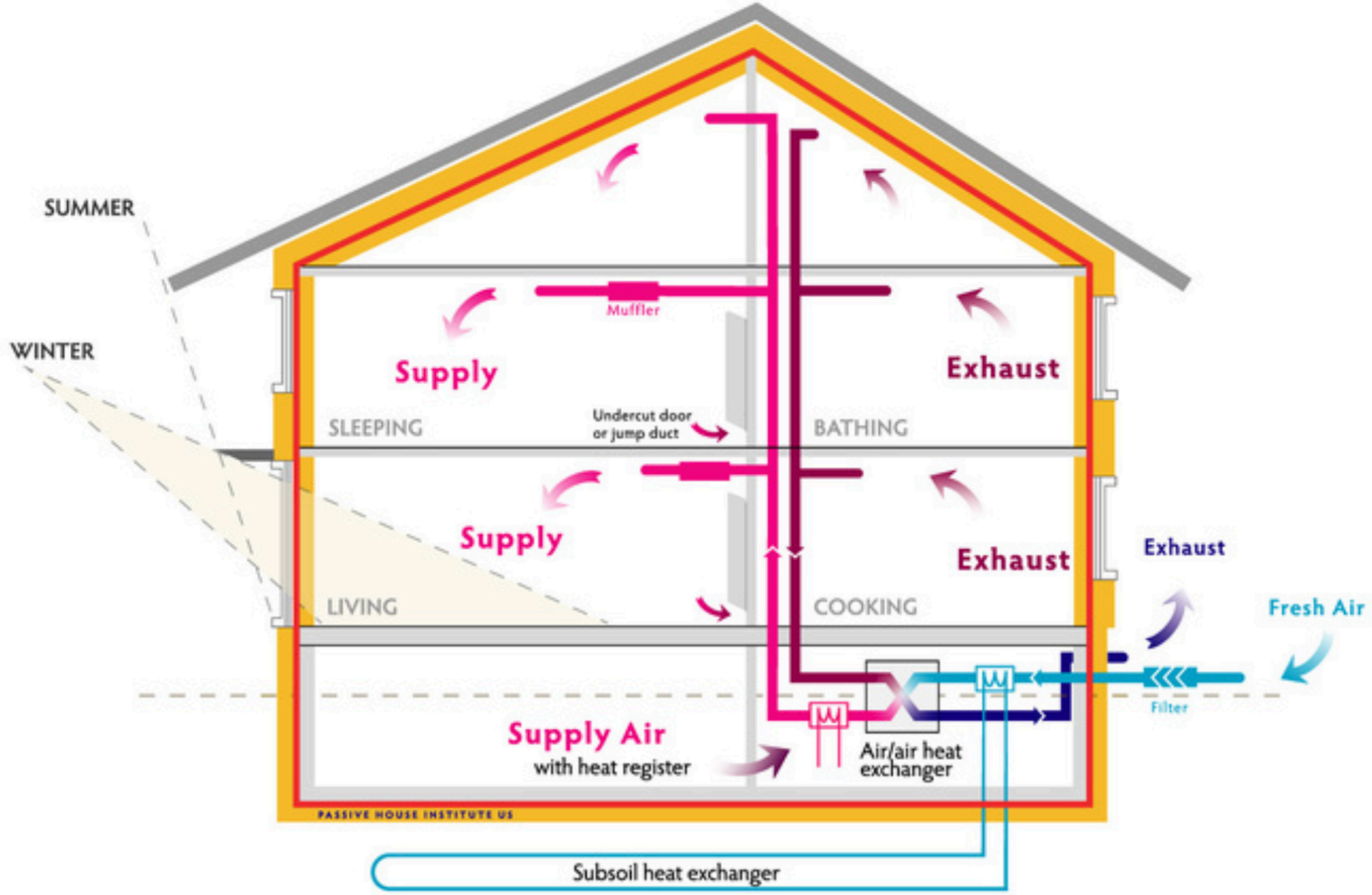
https://passipedia.org/planning/thermal_protection/integrated_thermal_protection

THE UN-CERTIFIED BUT 'DAMN NEAR' PASSIVE HOUSE.

One of the first steps was to convince people to pay more for the construction of the building, instead of a cheaper building with higher energy bills.

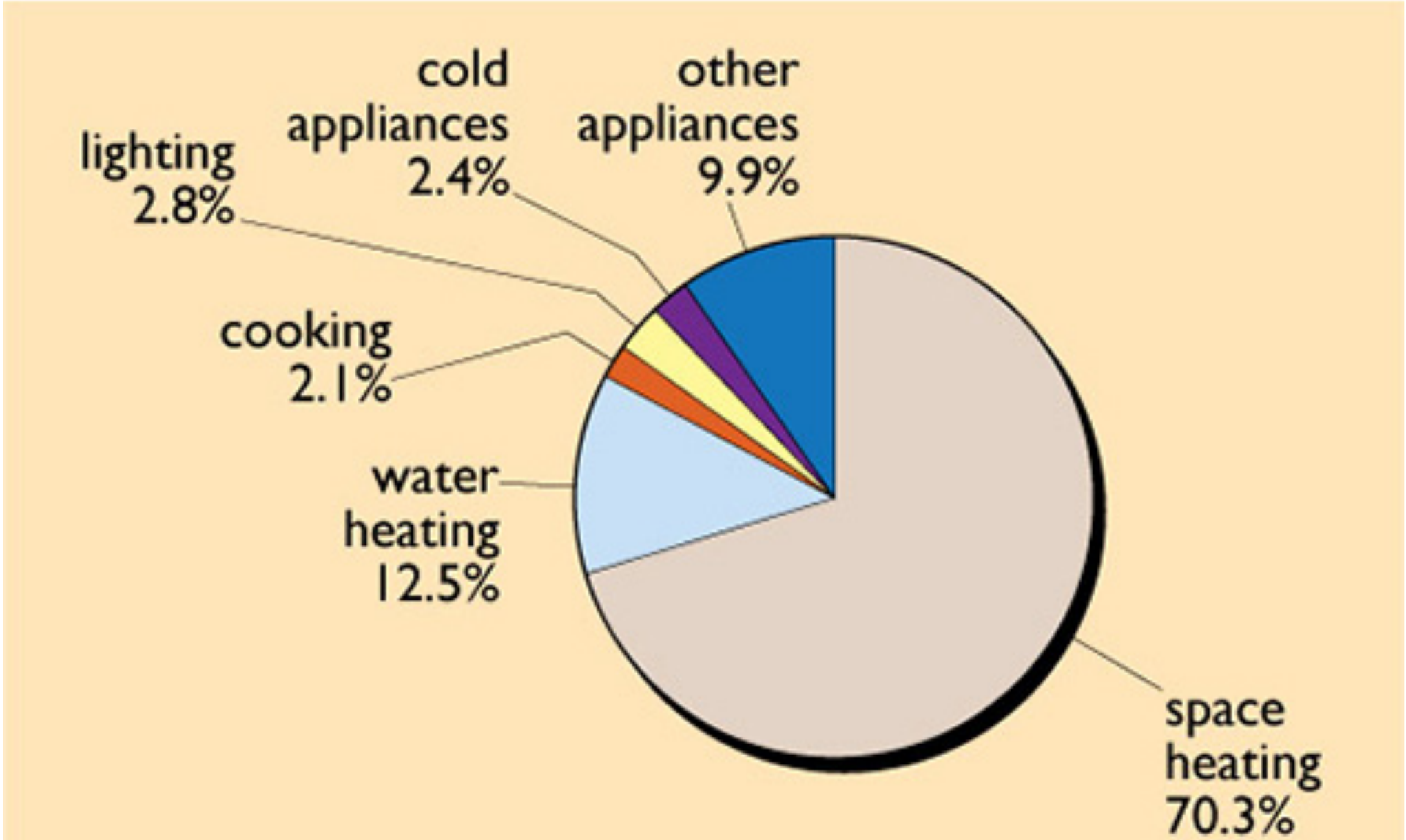
https://www.ecohome.net/guides/1482/the-un-certified-but-damn-near-passive-house/

Ground source heat pump, air/air heat exchanger in air-tight home.



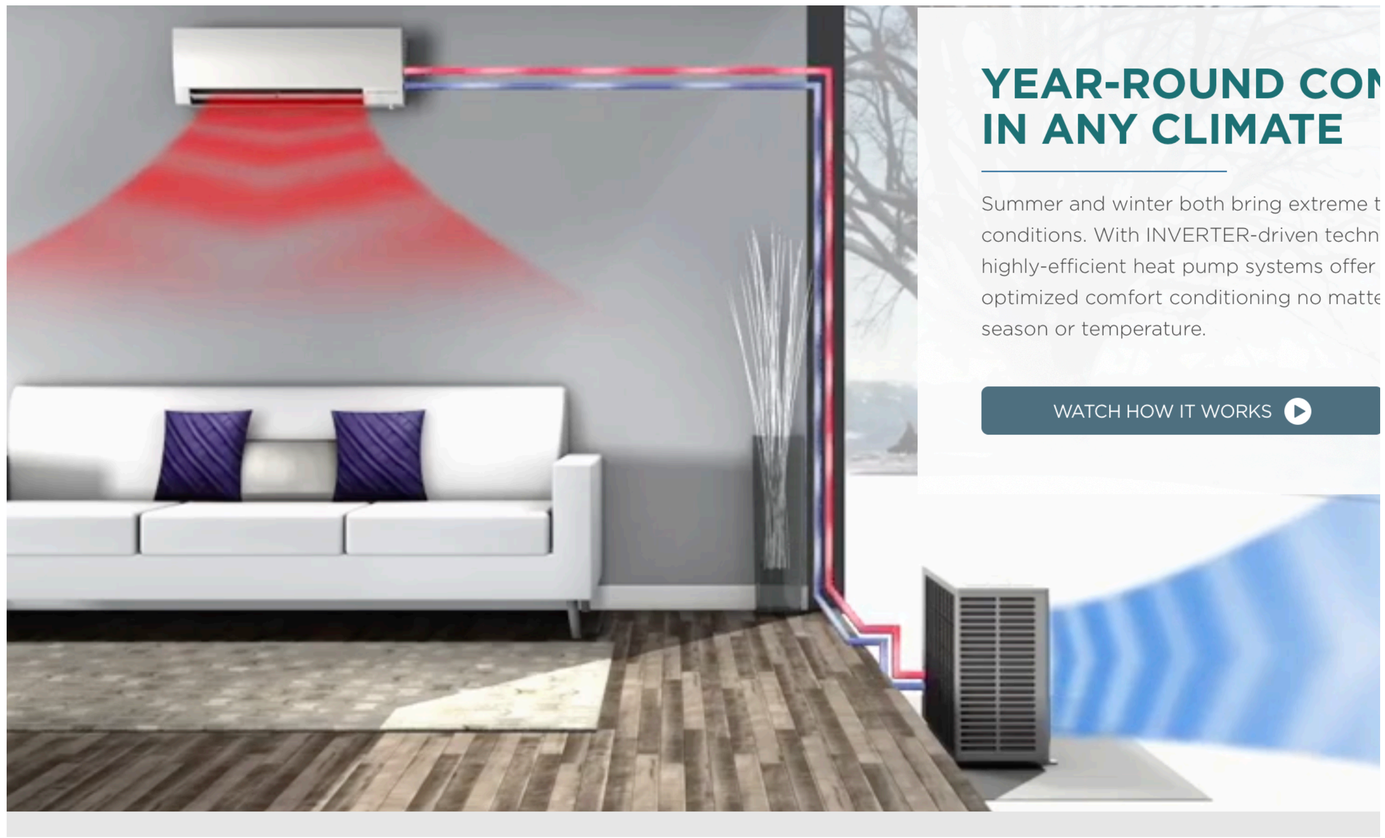
https://www.phius.org/what-is-passive-building/passive-house-principles

Electric resistance heating is common in UK (and Quebec).



https://www.open.edu/openlearn/ocw/mod/oucontent/view.php?printable=1&id=21281

Air source heat pumps can do both heating and cooling.



Coefficient of Performance
= kW(t) output / kW(e) input

Gov't: HSPF (BTU/Wh) = 3.41 x COP

Heating COP drops with temperature.

Utilities burn more natural gas as electricity demand goes up.

Below 20-35°F home furnaces use less natural gas than utility would.

Near 0°F COP ~1, like resistive heat.

Hybrid heating: keep gas or oil furnace for backup, for lower CO2.

https://www.linkedin.com/pulse/lets-run-towards-hybrid-heat-pumps-benefits-climate-harvey-michaels/

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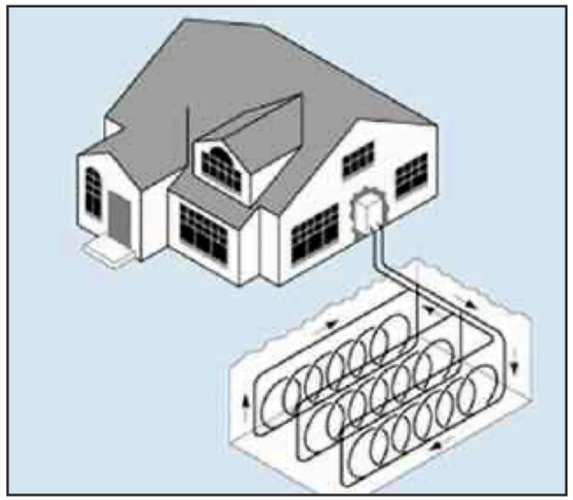
- Air-to-air heat recovery exchanger.
- Space heating demand at -10°F, 6 kW(t).

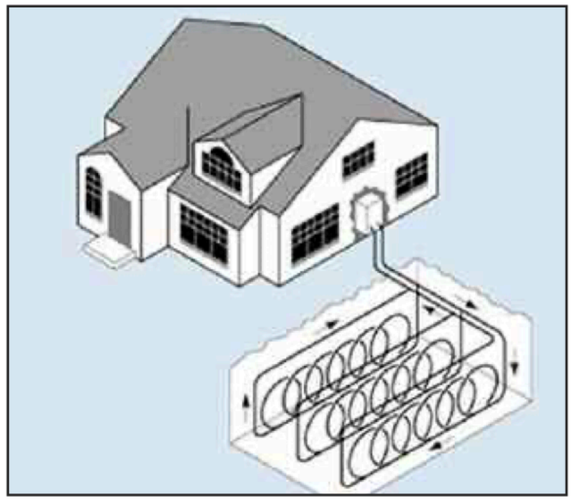
Caveats for air source heat pumps in Vermont:

- At 44°F Mitsubishi heat pump delivers 6 kW(t), uses < 2 kW(e); but at -10°F delivers nil.
- Home might survive -10°F with 6 kW(e) resistive heating (2 stovetop burners plus oven).
- Propane heater and tank are rational backup for power failure or extreme cold.

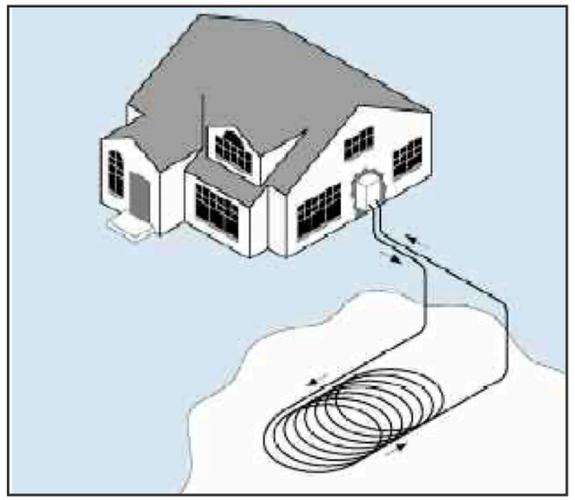
Ground source heat pumps cost more.



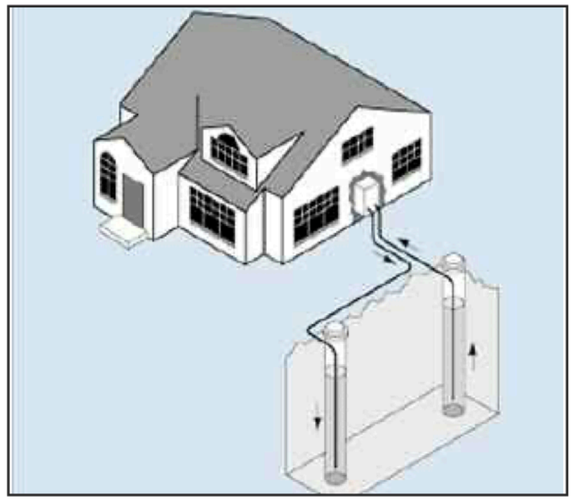
Closed Loop Systems
Horizontal



Closed Loop Systems
Vertical



Closed Loop Systems
Pond/Lake



Open Loop Systems

HDPE tubing has ~50 year lifetime.

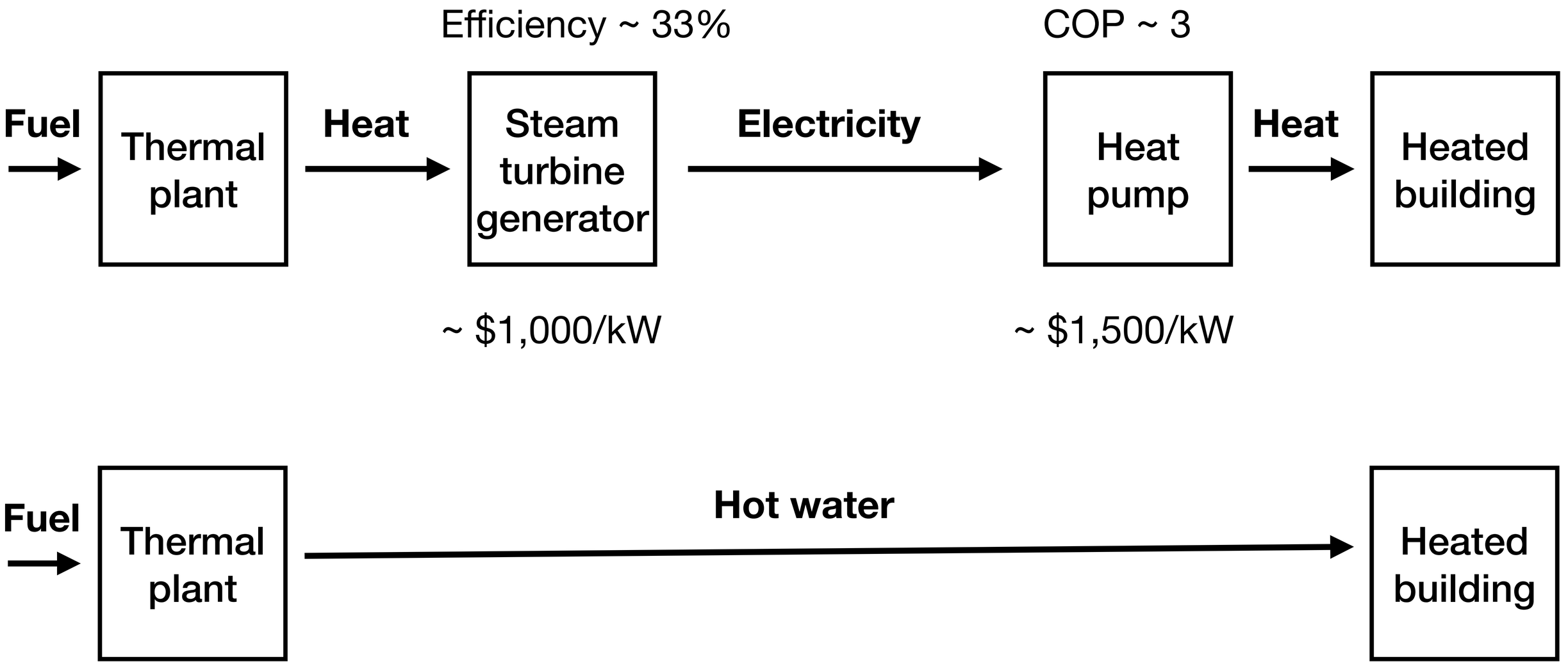
Suited to college campuses.

Harvard's 19, 1500-foot-deep wells provide partial heating/cooling for 6 buuildings.

Economics? "…'simple payback' is often a misleading metric…"

https://www.nwf.org/~/media/PDFs/Campus-Ecology/Reports/Geothermal%20Guide%20FINAL%203-1-11.ashx

District heating can bypass thermal-electric, electric-thermal conversions.



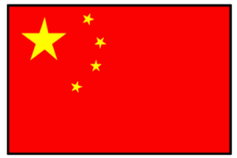
District heating reactors will be located in China cities.

CGN – The NHR200-II reactor is a low-temperature district heating reactor. Its design is described by CGN as “mature”, having passed National Nuclear Safety Administration review in the 1990s. In February 2018 it was announced that CGN and Tsinghua University were carrying out a feasibility study on constructing China’s first district heating nuclear plant using the NHR200-II design.

CNNC – The District Heating Reactor-400 (DHR-400) or ‘Yanlong’ is a low-temperature **400 MW pool-type reactor**. It is designed to provide **heat at 90°C for up to 200,000 three-bedroom apartments.** The reactor prototype achieved 168 hours of continuous heat supply in November 2017 – seen by its developers, CNNC, as the first major step towards commercialization of the design.

SPIC – The Advanced Happy200 is similar to the Yanlong, **200 MW and producing hot water at 110°C**. Pre-feasibility studies suggest first commissioning in 2022. In February 2019, SPIC contracted to build the Baishan Nuclear Energy Heating Demonstration Project in Jilin province.

District heating reactor



DHR (CNNC, China)

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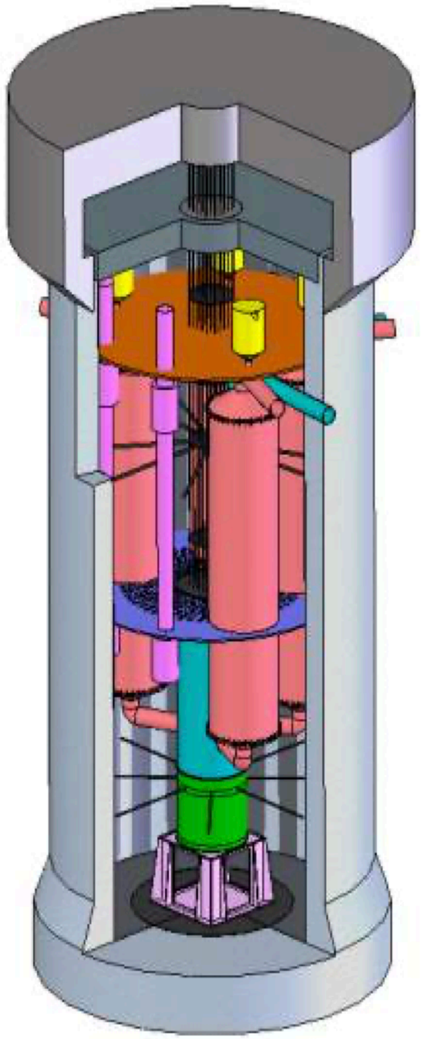
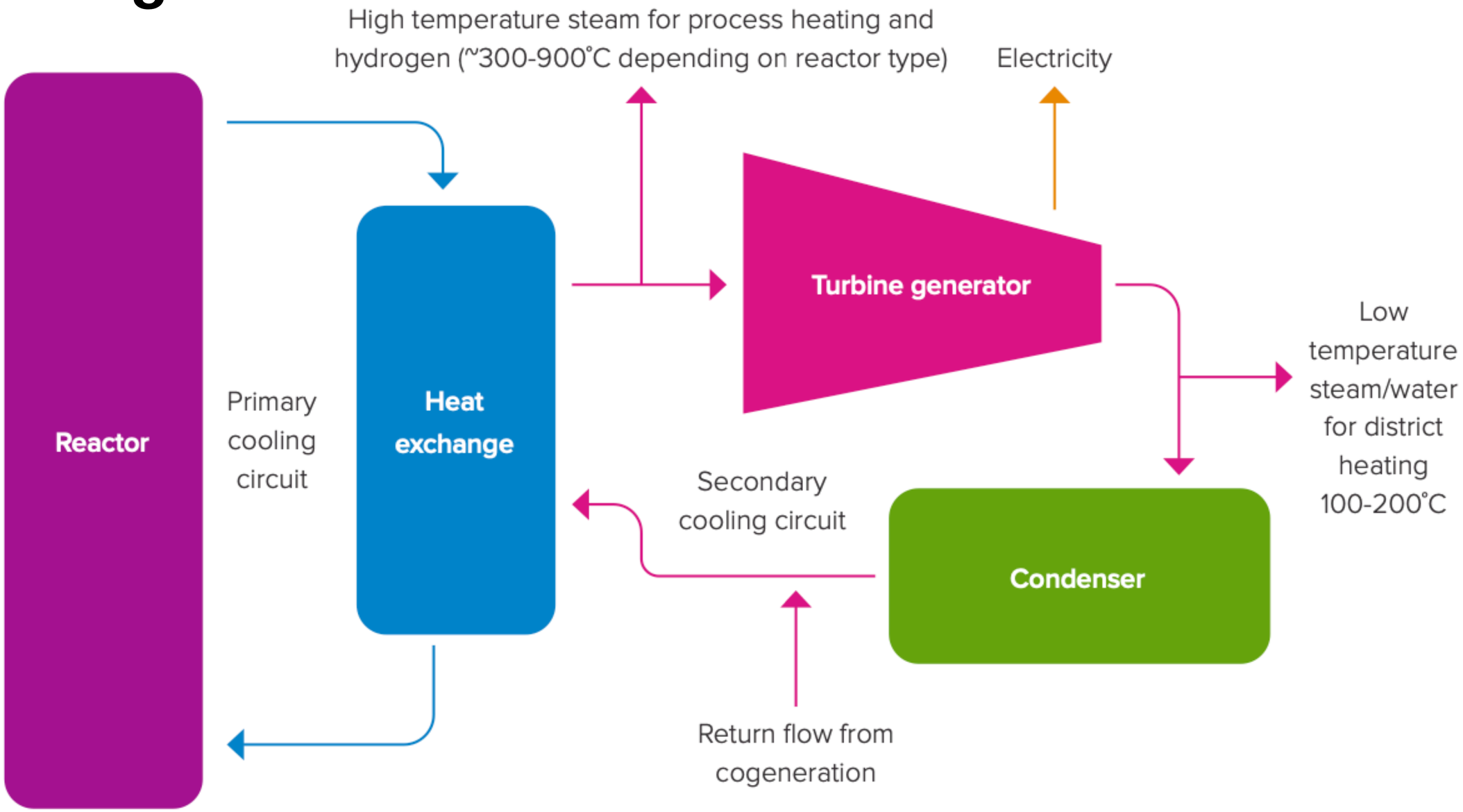


MAJOR TECHNICAL PARAMETERS	
Parameter	**Value**
Technology developer, country of origin	China National Nuclear Corporation (CNNC), People's Republic of China
Reactor type	Pool type reactor
Coolant/moderator	Light water / light water
Thermal/electrical capacity, MW(t)/MW(e)	400/none
Primary circulation	Forced circulation
Core inlet pressure (MPa)	0.3
Core inlet/outlet temperatures (°C)	68/98
Fuel type/assembly array	UO_2 pellet/17x17 square
Number of fuel assemblies	69
Fuel enrichment (%)	<5.0
Fuel burnup (GWd/t)	30
Fuel cycle (months)	10
Main reactivity control mechanism	Control rod driving mechanisms
Design life (years)	60
Plant footprint (m^2)	40000
Pool depth/diameter (m)	26/10
Seismic design	0.3g
Distinguishing features	Coupling with desalination and radioisotope production
Design status	Basic design

ttps://aris.iaea.org/Publications/SMR-Book_2018.pdf

Co-generation uses rejected heat from steam turbine for district heating.



https://royalsociety.org/-/media/policy/projects/nuclear-cogeneration/2020-10-7-nuclear-cogeneration-policy-briefing.pdf

Do both! China is using two Westinghouse AP1000 power reactors for district heating.

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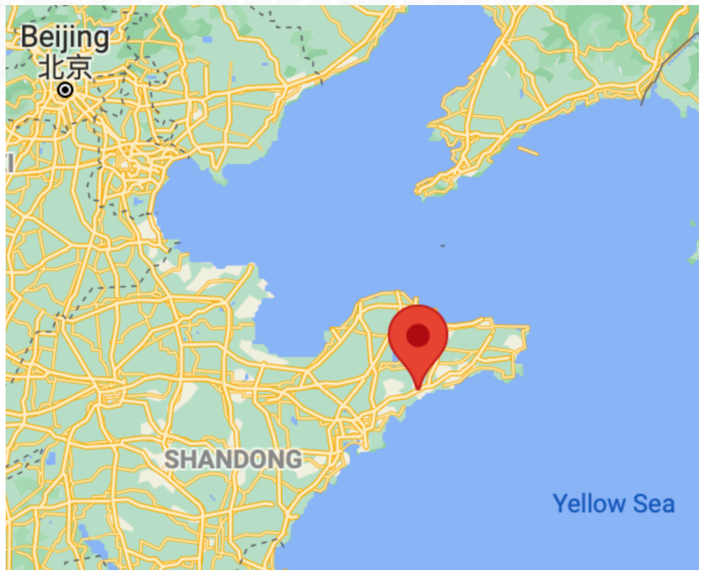
Second phase of China's Haiyang nuclear heating project begins operation

23 November 2021



Haiyang population 350,000

Haiyang 1&2 could heat 30 million square metres…

eventually provide heating to more than 200 million square metres of housing within 100 km

avoiding the use of about 6.62 million tonnes of coal.

Up to six CAP1000 units are planned for the Haiyang plant.

https://www.neimagazine.com/news/newssecond-phase-of-chinas-haiyang-nuclear-heating-project-begins-operation-9267335

Nuclear option to heat the campus

Valley News July 5, 2021

The University of Illinois is planning to heat its Urbana campus with a new, underground nuclear reactor with a fuel cartridge that lasts 20 years. The university is working with Seattle-based Ultra Safe Nuclear Corp. to partially replace a coal-fired plant, seeking Department of Energy funding and preparing a Nuclear Regulatory Commission license application.

Dartmouth College has already rebuilt its hot-water circulating district heating system in anticipation of plans for a wood chip burning plant, now dropped. Dartmouth continues to burn 3.5 million gallons of No. 6 fuel oil annually as it seeks a better energy source. The Ultra Safe Nuclear Corp. reactor generates 15 megawatts of heat, approximately the demand from the Dartmouth campus.

ROBERT HARGRAVES

https://www.vnews.com/Forum-July-5-41265620

Purdue and Duke Energy to explore potential for clean, nuclear power source for campus

April 27, 2022

https://www.purdue.edu/newsroom/releases/2022/Q2/purdue-and-duke-energy-to-explore-potential-for-clean,-nuclear-power-source-for-campus.html

12 Buildings

Cooling

Heating

Insulation

Co-generation

Fission is in Fashion