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TECHNOLOGIES

Ground-Source Heat-Pumps

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Overview

- We begin with a technical overview.
- Then discuss the economics of GSHP.
- We end with an overview of opportunities that remain to be exploited

Energy Losses:
in conversion & delivery

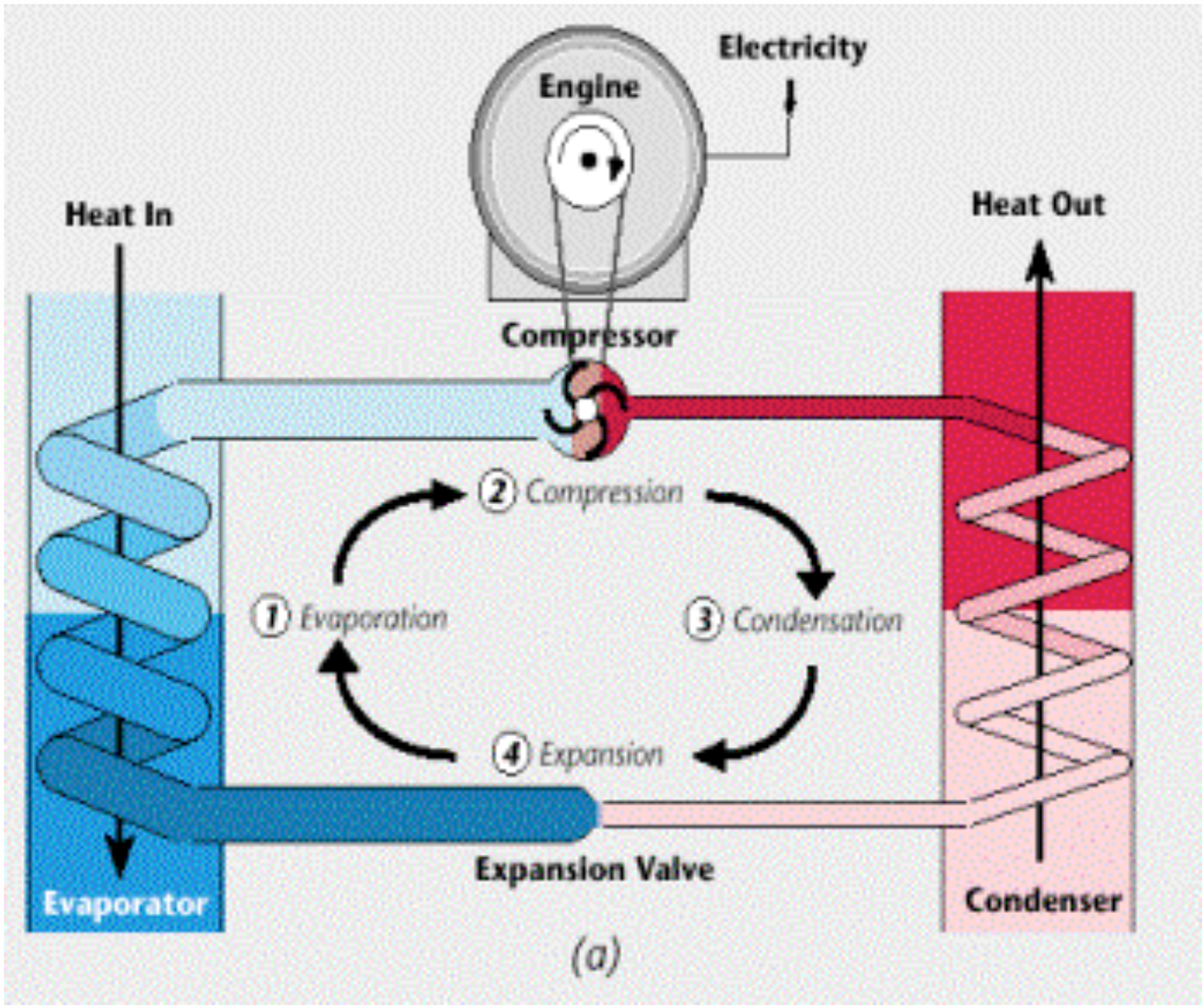
- The most efficient boilers using fossil fuels deliver 90% of the energy in the fuel as an energy service -- more typically we get 65-75%.
- Electric radiant heat can be 99% efficient, but 2/3 of the fossil energy is lost in producing and delivering the energy to the point of use.
- Heat pumps are a familiar product, we use them in refrigerators. They use as little as 1 unit of electricity in delivering 5 units of heat -- more typically 350% efficiency.
- Ground-source heat pumps are also 30 to 50% more efficient than conventional air conditioning.
- *Most consumers use both heat and air conditioning. Investing in GSHP allows greater efficiency in delivering both services, saving more than 50% in energy costs.*

Heat-pumps

A heat pump can move heat against the gradient of temperature -- e.g., cooling the inside of a refrigerator.

In this diagram, heat is taken from a cooler source and dispersed into a warmer environment -- e.g., heating your home.

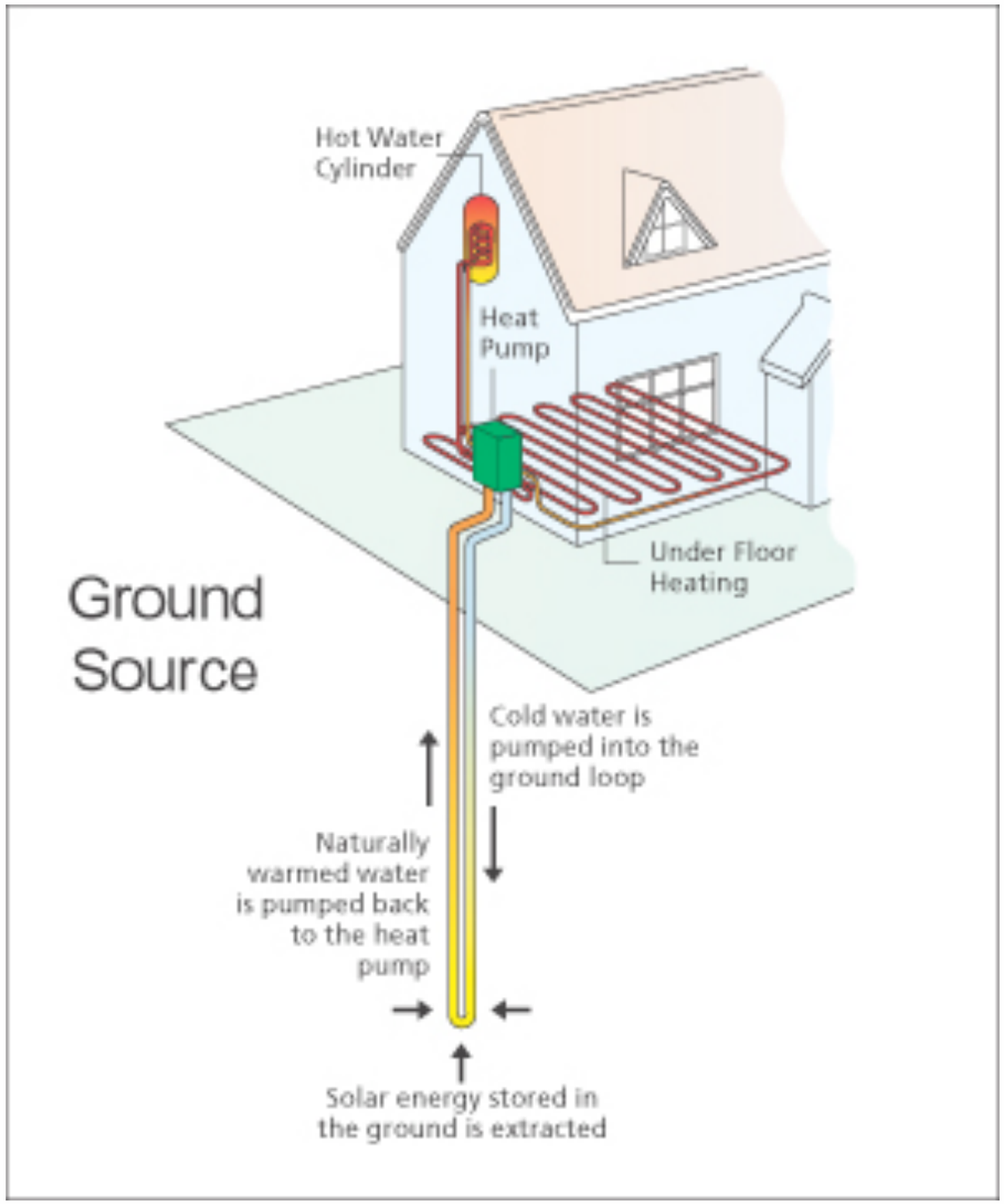
Some heat-pumps can be reversible, working to move energy in both directions



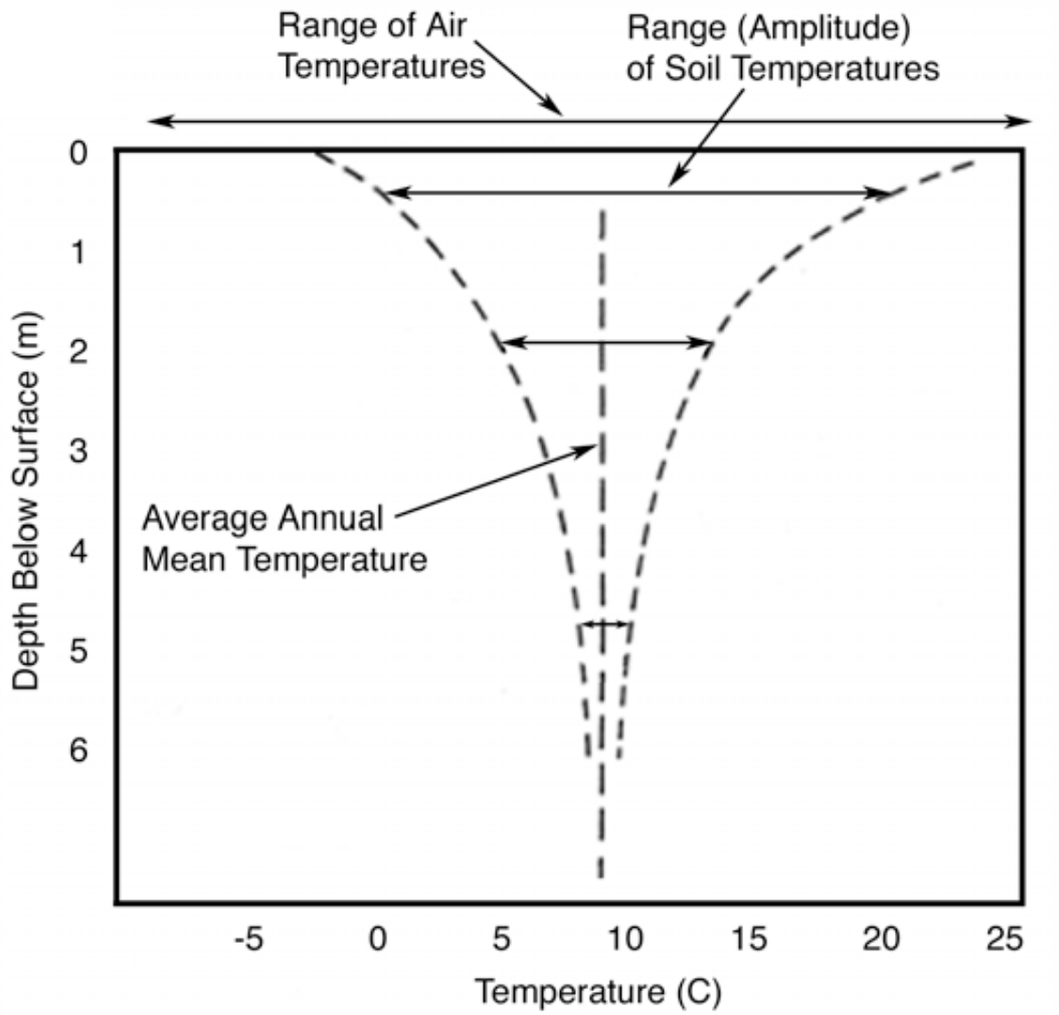
http://www.esru.strath.ac.uk/EandE/Web_sites/01-02/heat_pump/hpexplain.gif

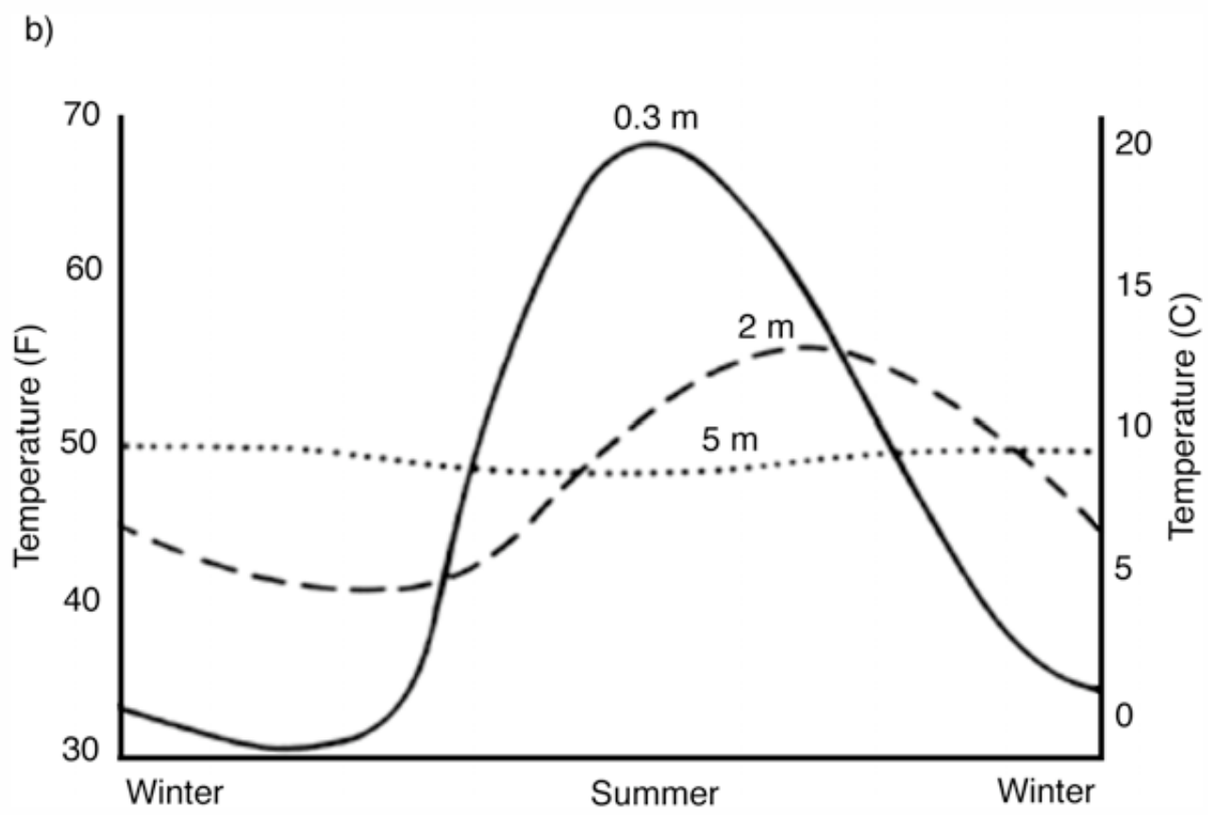
Ground-source heat-pumps

Ground-source heat-pumps use the ground as the source or sink for heat.



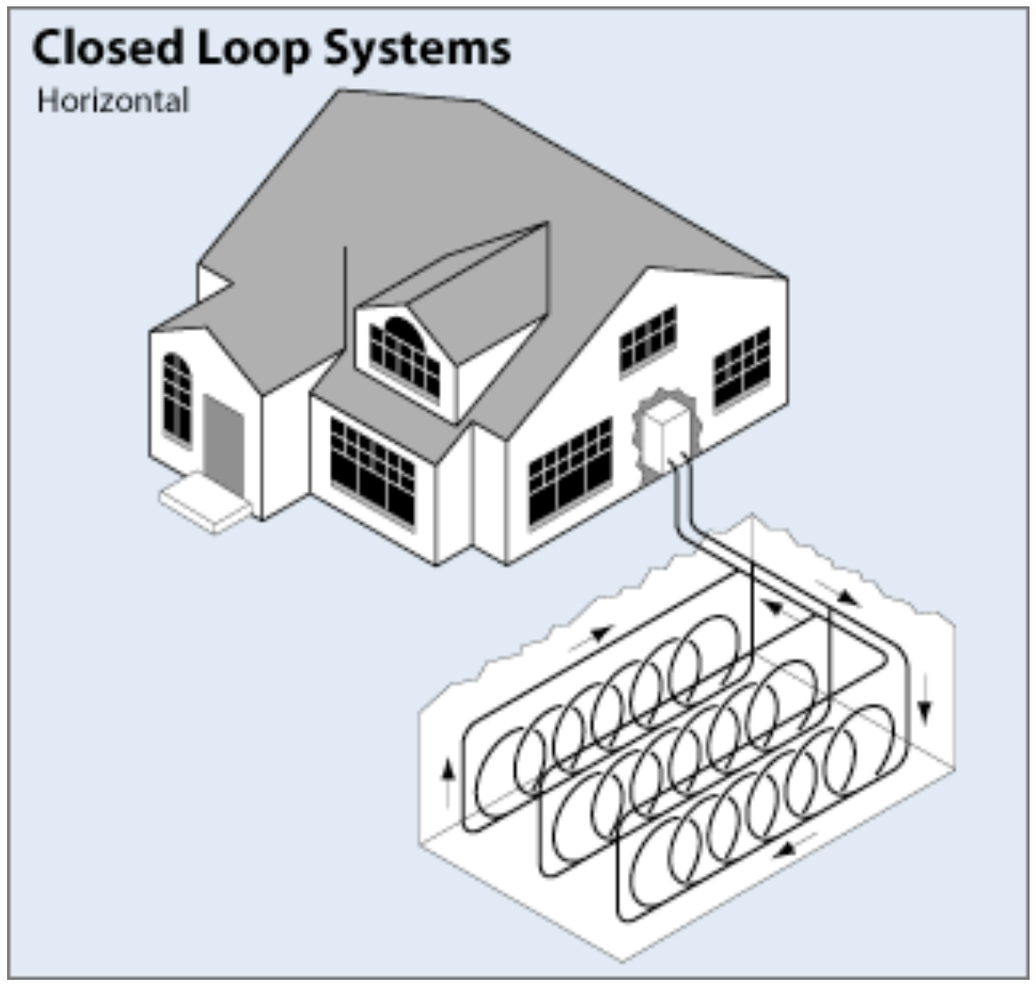
Average Air and Ground Temperature



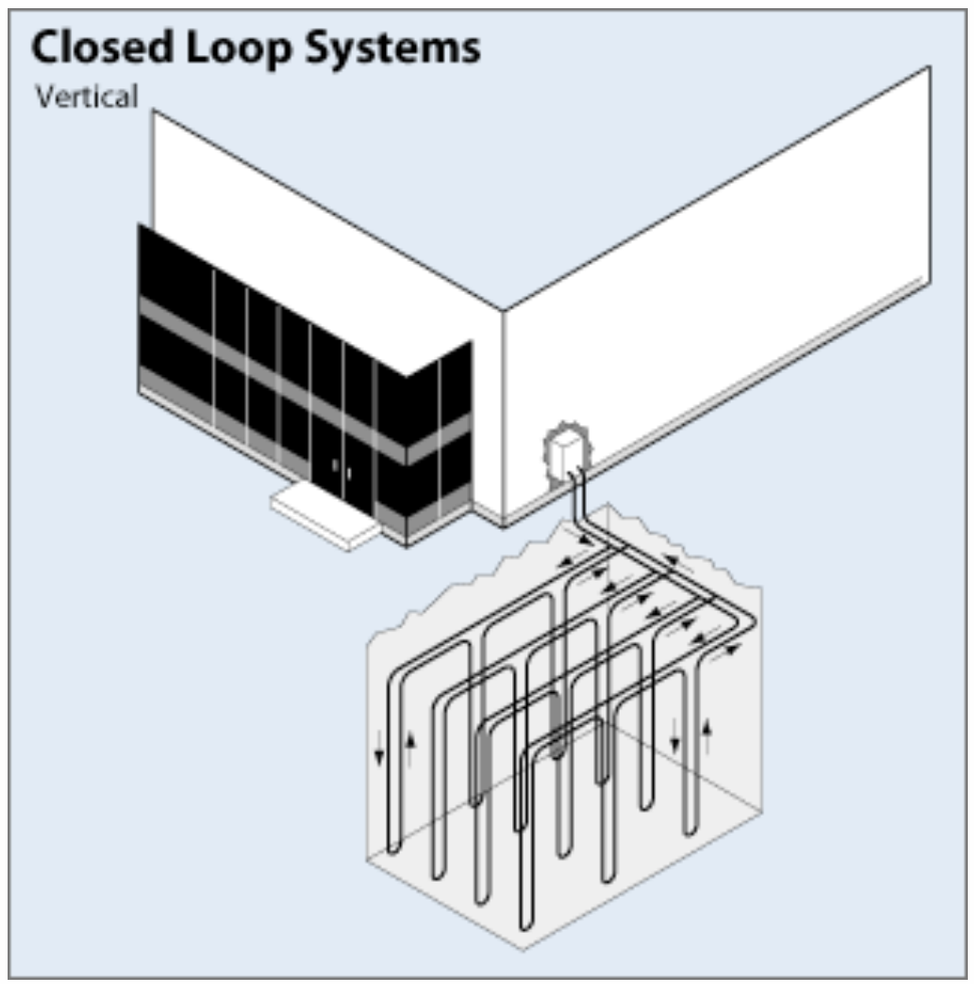


The ground averages out the air temperature of a region. At 5 meters depth, the ground temperature is at the average annual temperature. Heat exchange coils at that depth can draw on thermal reservoirs that are much cooler than the air in the summer and much warmer in the winter.

Ground heat exchange loops



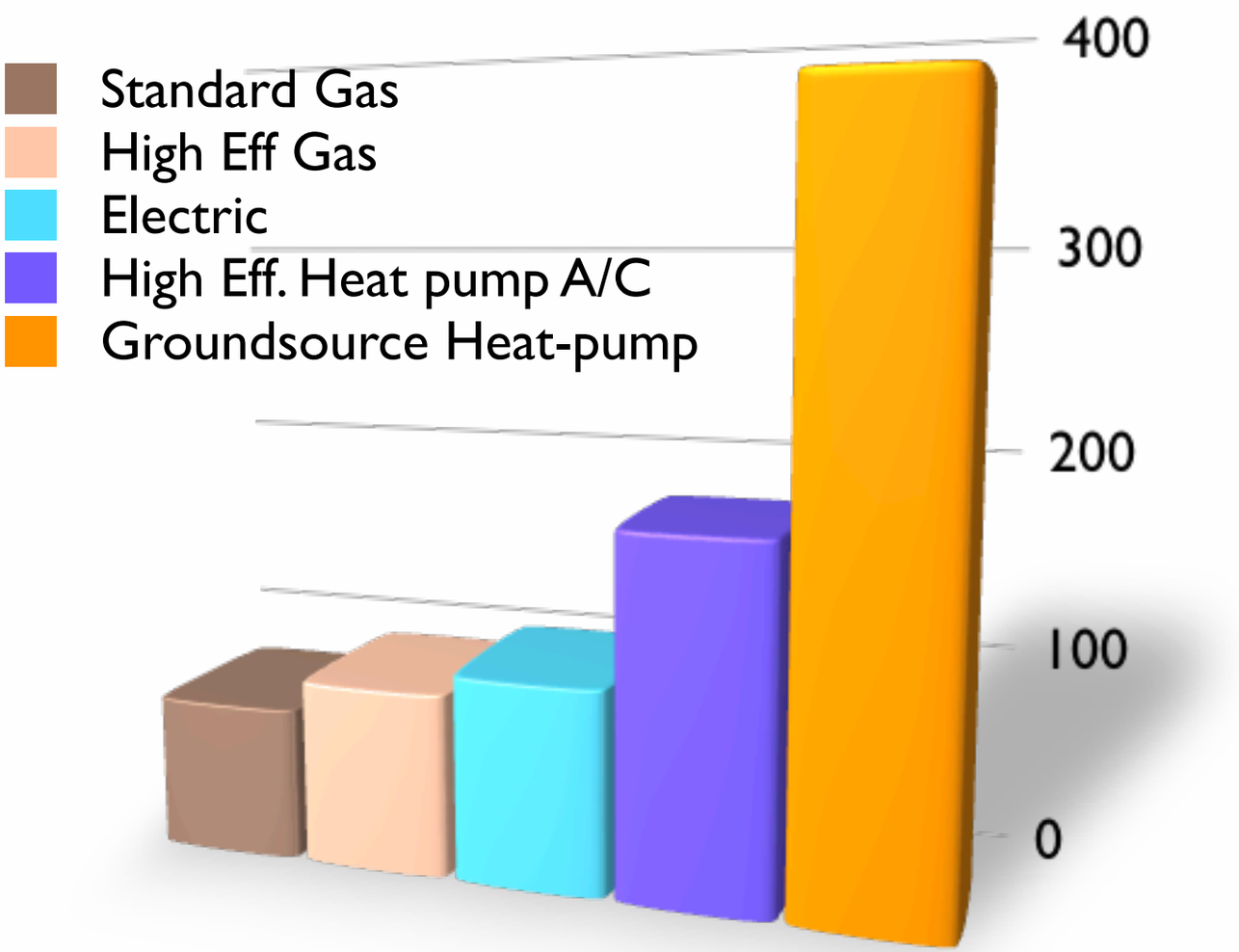
Where there is access to sufficient land, horizontal loops can be employed. These cut the cost of installation significantly



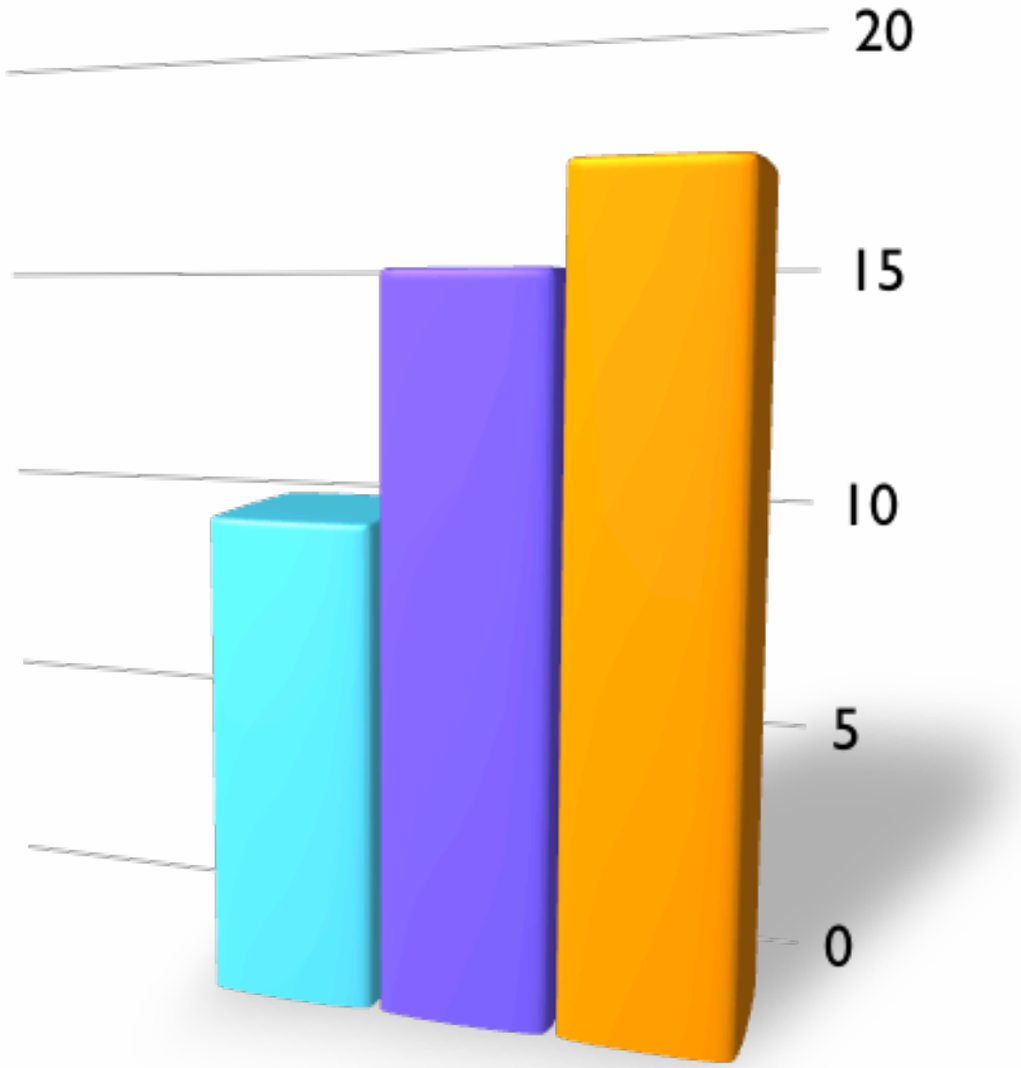
Where there is less land, deep bore-holes are needed to achieve the same exchange volume. Bore-holes typically account for 50% of installation costs.

Systems efficiencies compared

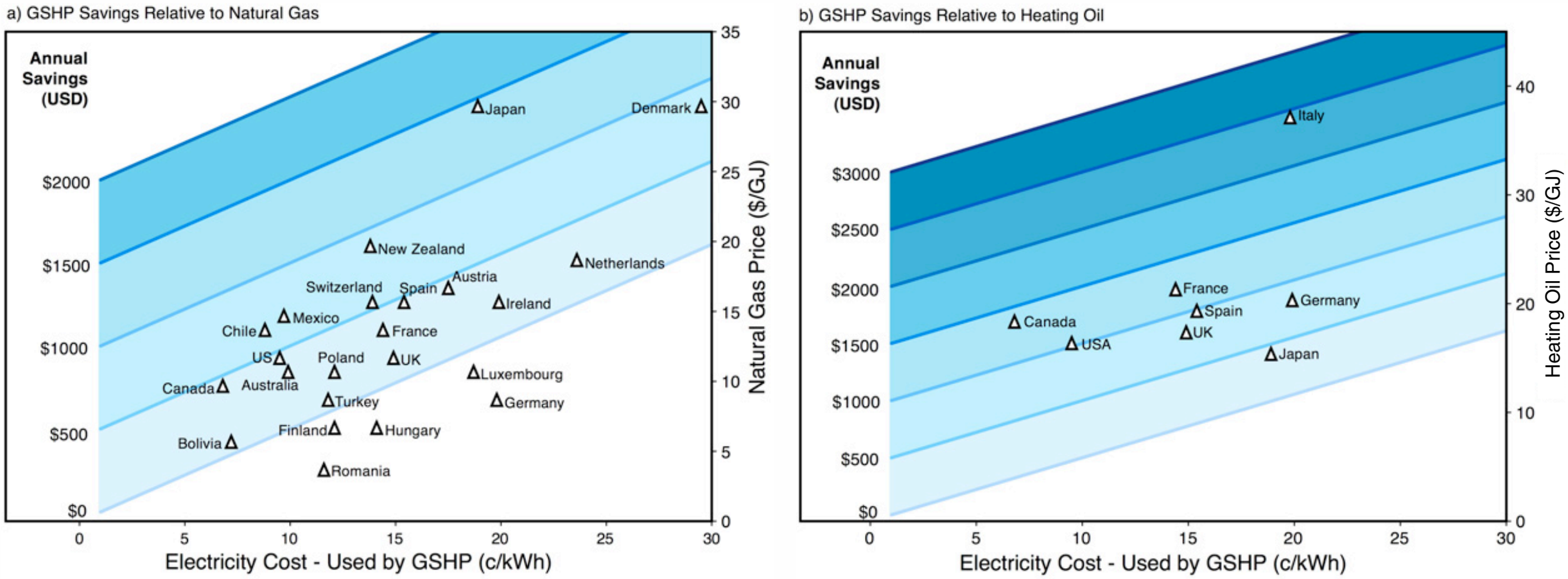
Heating Efficiency (COP)



Cooling Efficiency (EER)



Economics



The economics of GSHP depends on the cost and choice of heating fuels vs. electricity. The incremental system costs is usually 8 to 12 thousand dollars. Compared to gas heating (panel a) savings in Japan would lead to a pay-back period of 4 years. The system pays for itself in even less time when compared to heating-oil. Finally, if air conditioning is included, the incremental cost of the system is more in the 6-8 thousand dollar range with even shorter pay-back periods.

Synergistic systems

- The full value of GSHP is realised when we couple such systems to the vast supply of low-grade heat available in most urban environments. For example:
  - Sewer pipelines
  - Cooling towers
  - Refrigeration units ...
- *When coupled to waste heat sources, GSHP can deliver usable heat at 400% efficiency, with far lower installation costs because the need for bore-holes can be dramatically reduced.*

Conclusions

- Ground-source heat-pumps can reduce energy use for space conditioning and hot water provision by more than 50%.
- The higher capital costs of such systems is easily paid off -- *pay-back periods of less than 10 years.*
- In a setting where electricity is used for heating and cooling, the cost of GSHP is far than the cost of electric power system expansion -- *a net savings in both cost and energy.*

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