2 Basics of energy and power

Fission is in Fashion

Useful energy

Heat

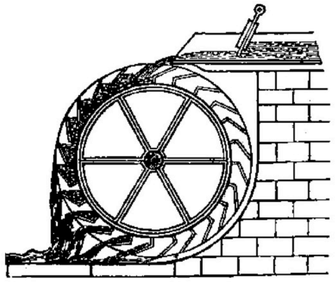
Work from heat

Power

Kinetic energy is a form of ***useful energy***.

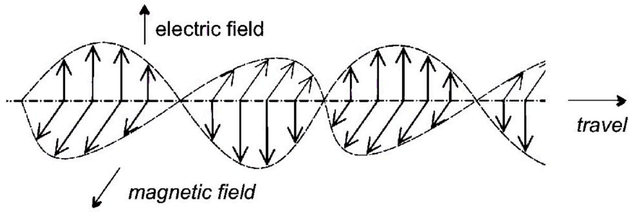
Kinetic energy: mass x velocity squared / 2

Gravitational energy: height x mass x g



Work: force (newtons) x distance (meters)

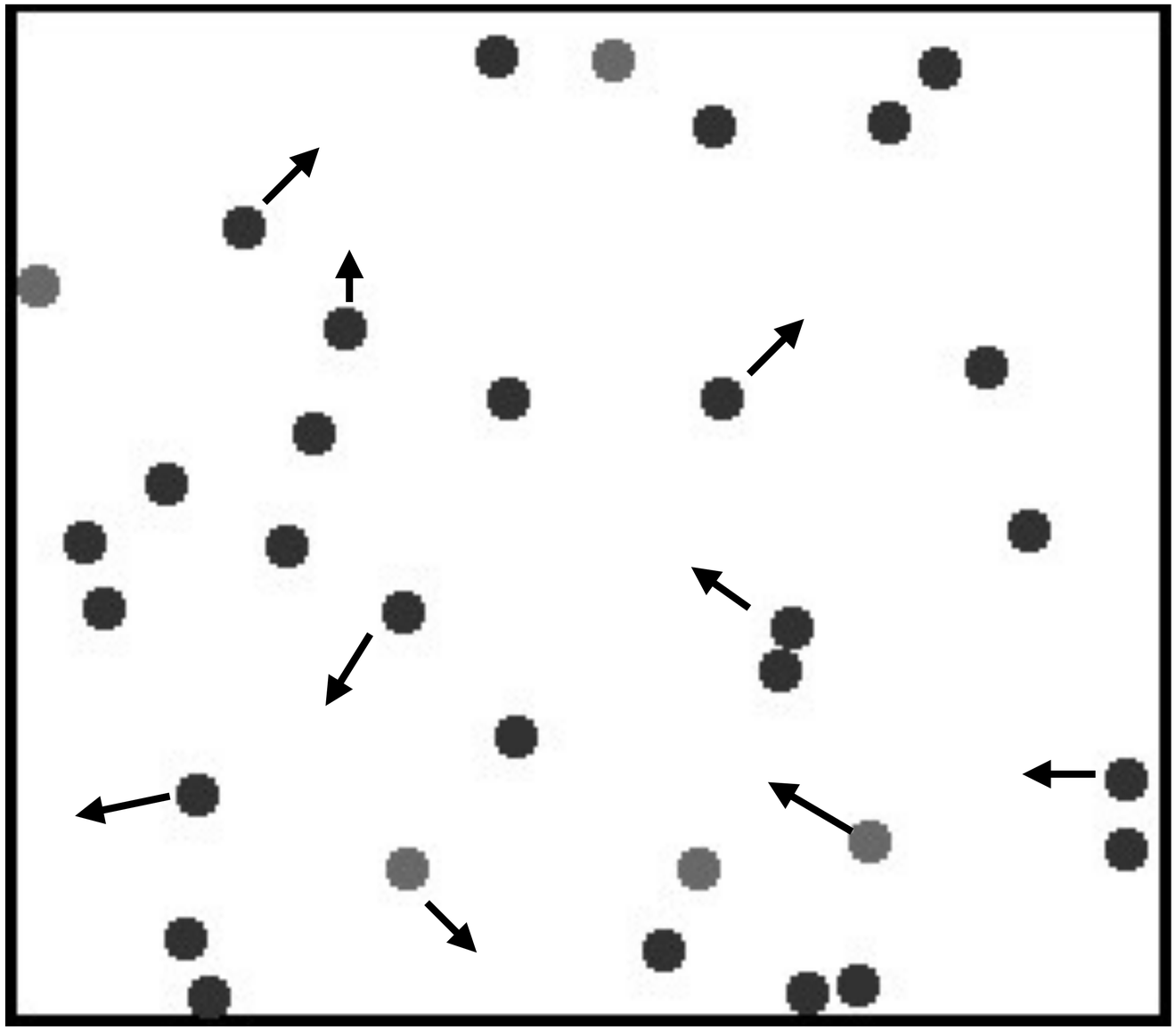
Electric energy: amps x volts x time



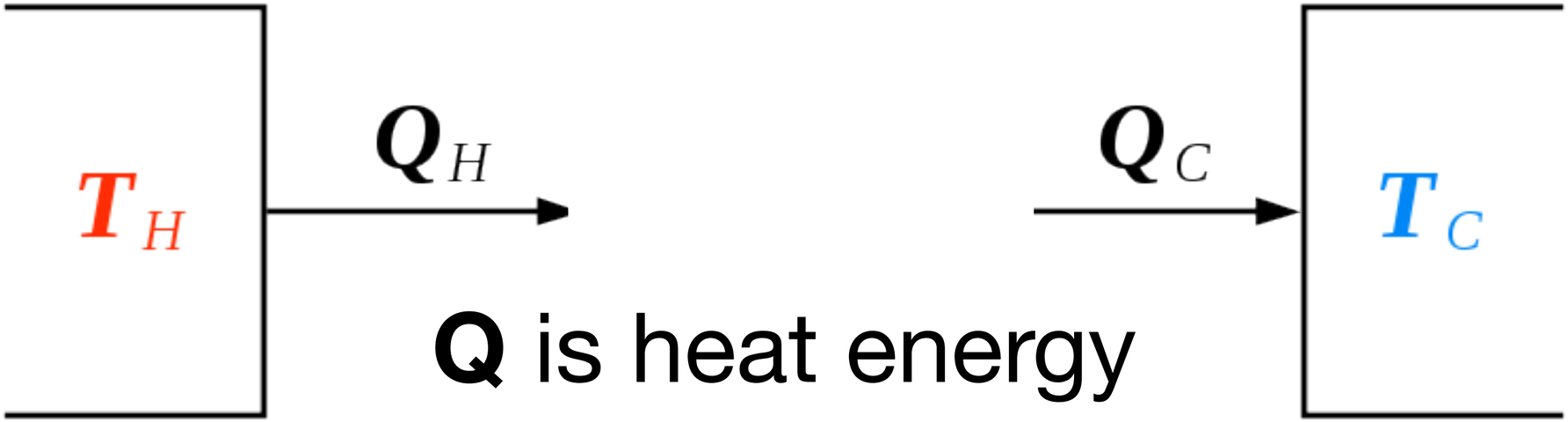
Joule = 1 amp x 1 volt x 1 sec

1000 x 60 x 60 *joules* = 1 kilo-watt hour, kWh

Heat **energy is the kinetic energy of many molecules.**



Heat flows from ***hot*** to cold.

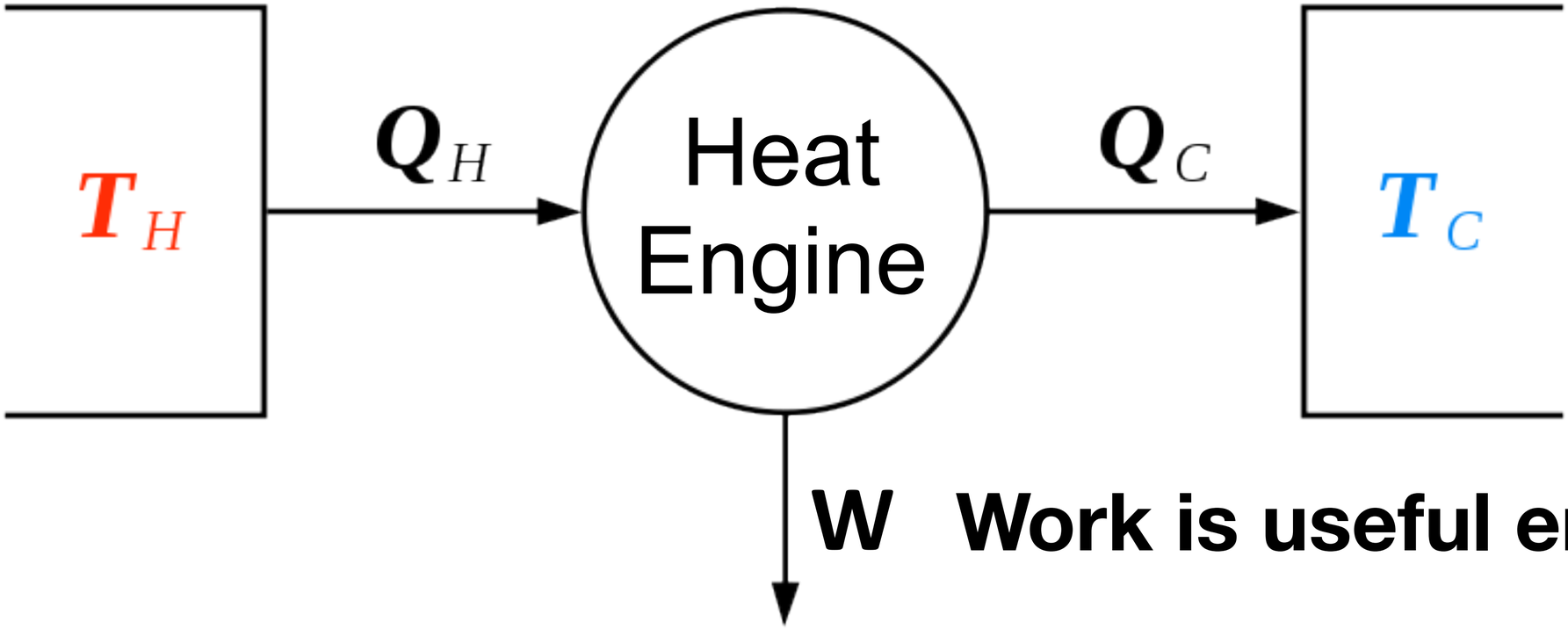


Q is heat energy

Hot heat source

Cold heat sink

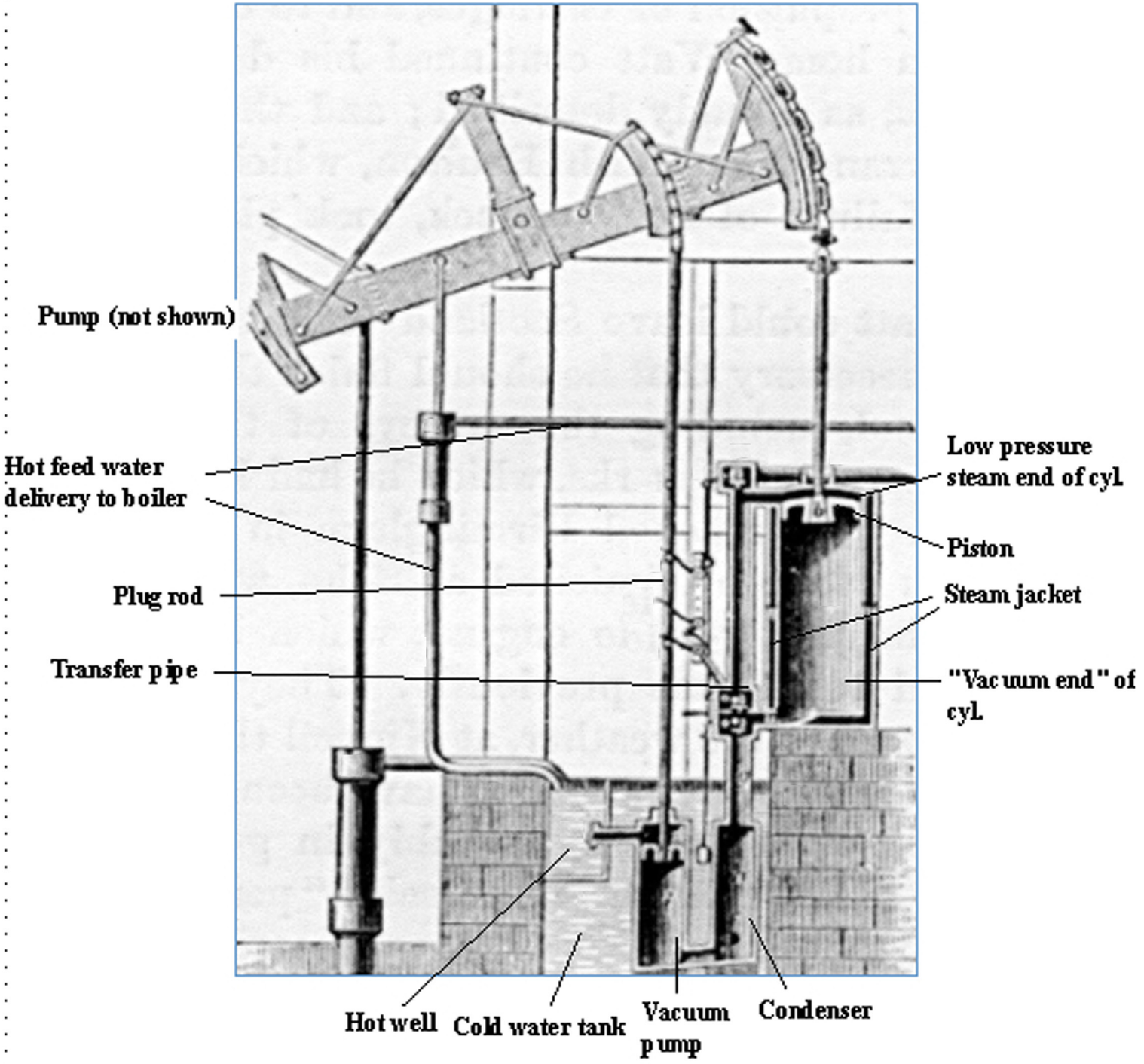
Work, **energy, can be extracted from the *flow* of *heat* from *hot* to cold.**



"**Exergy**" is a term for the useful energy extracted.

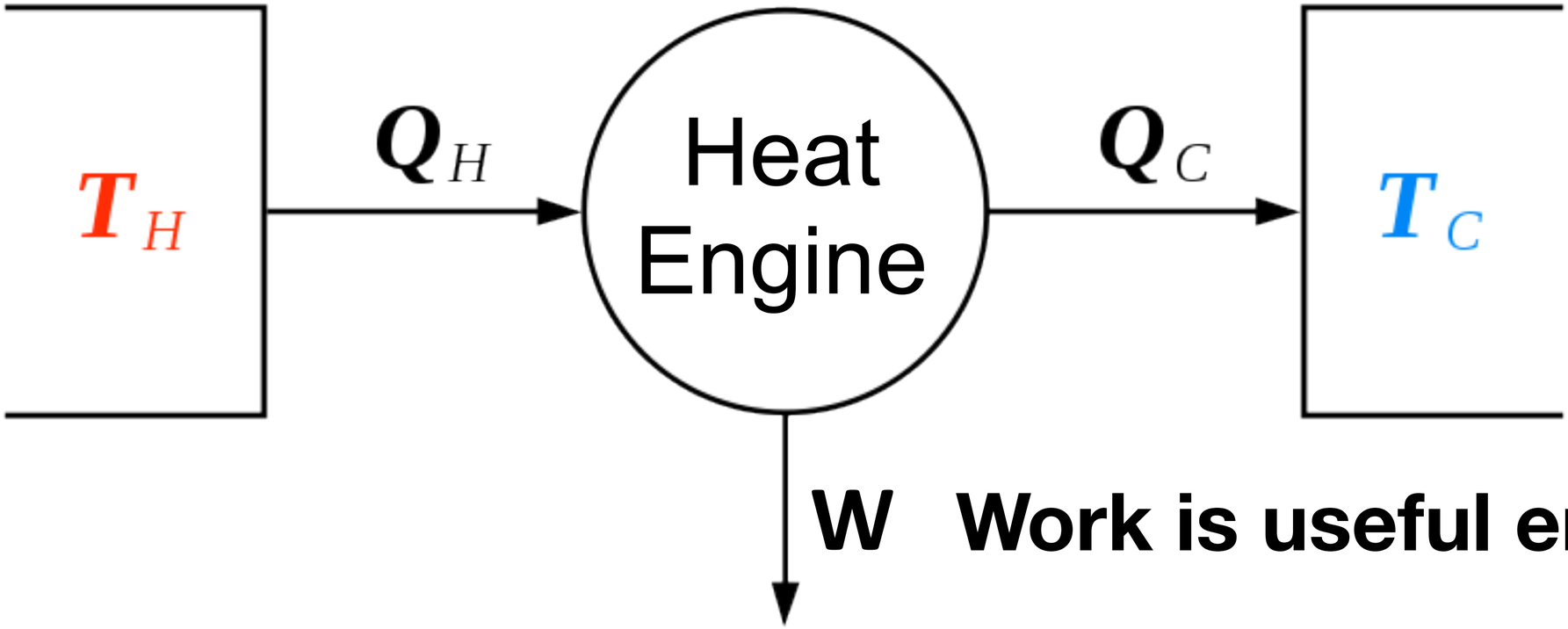
1763-1775 James Watt developed the steam engine.

- Pumped water from coal mines.
- Powered industrial revolution.
- Patented, but not paid for.



https://en.wikipedia.org/wiki/James_Watt

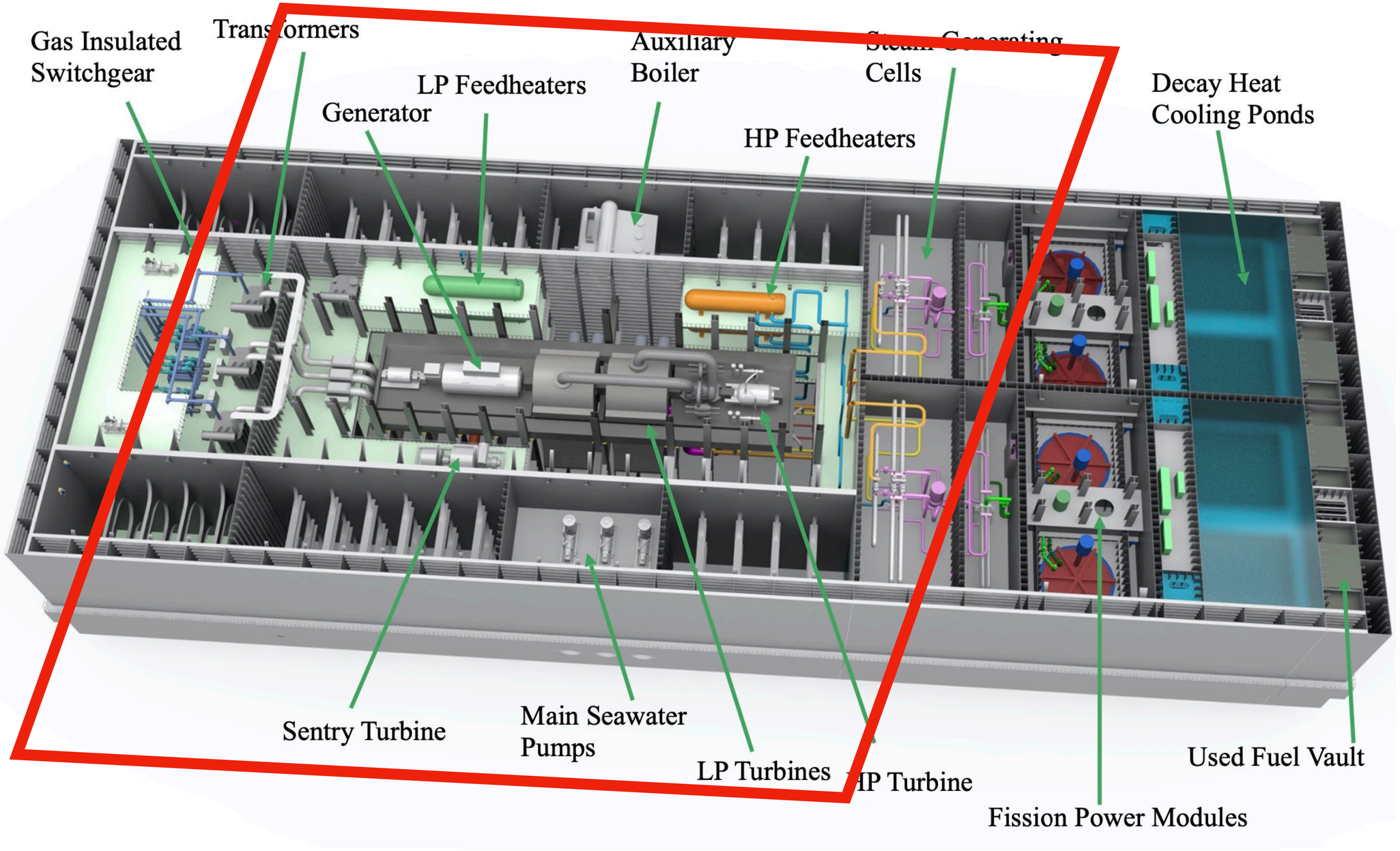
Work, energy, can be extracted from the _flow_ of _heat_ from _hot_ to cold.



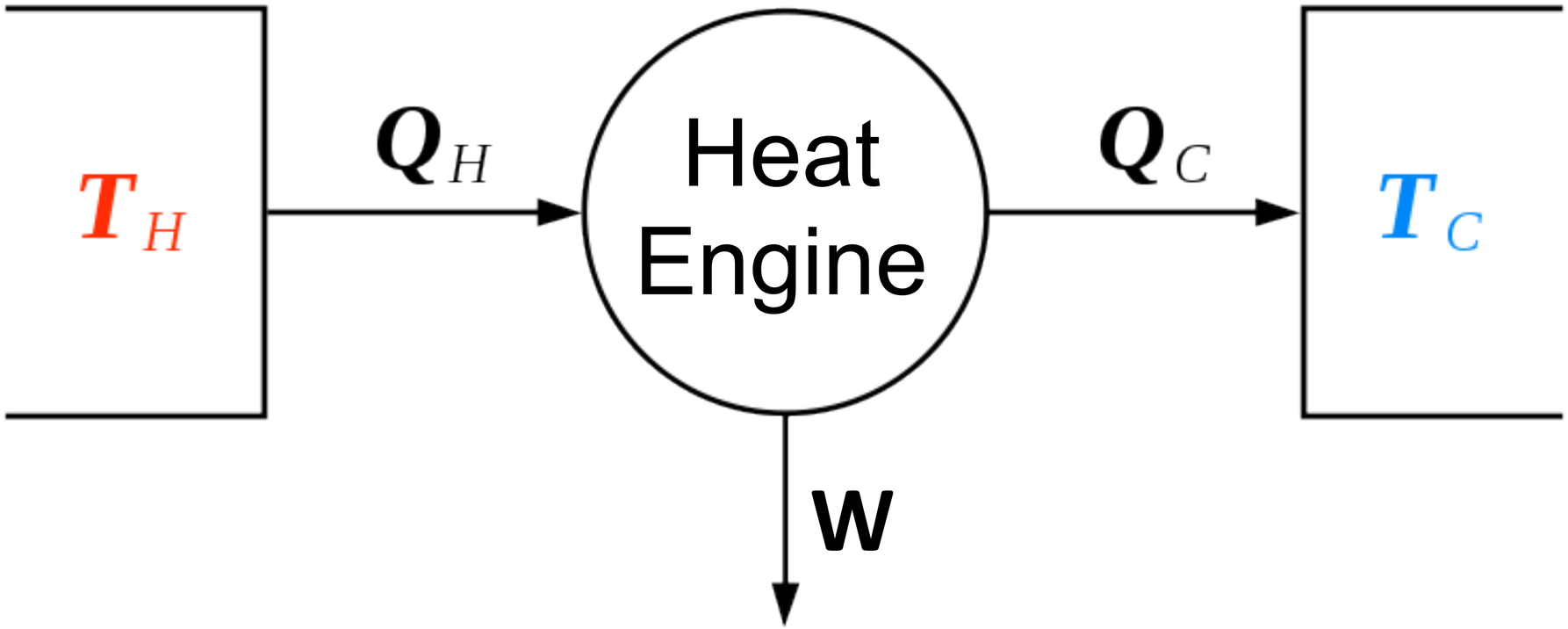
Efficiency max = (T_H - T_C) / T_H
(Carnot theorem)

eg: 100°C to 0°C
(373K - 273K) / 373K
= 100/373 = 27%

The *heat engine* is the biggest part of a power plant.

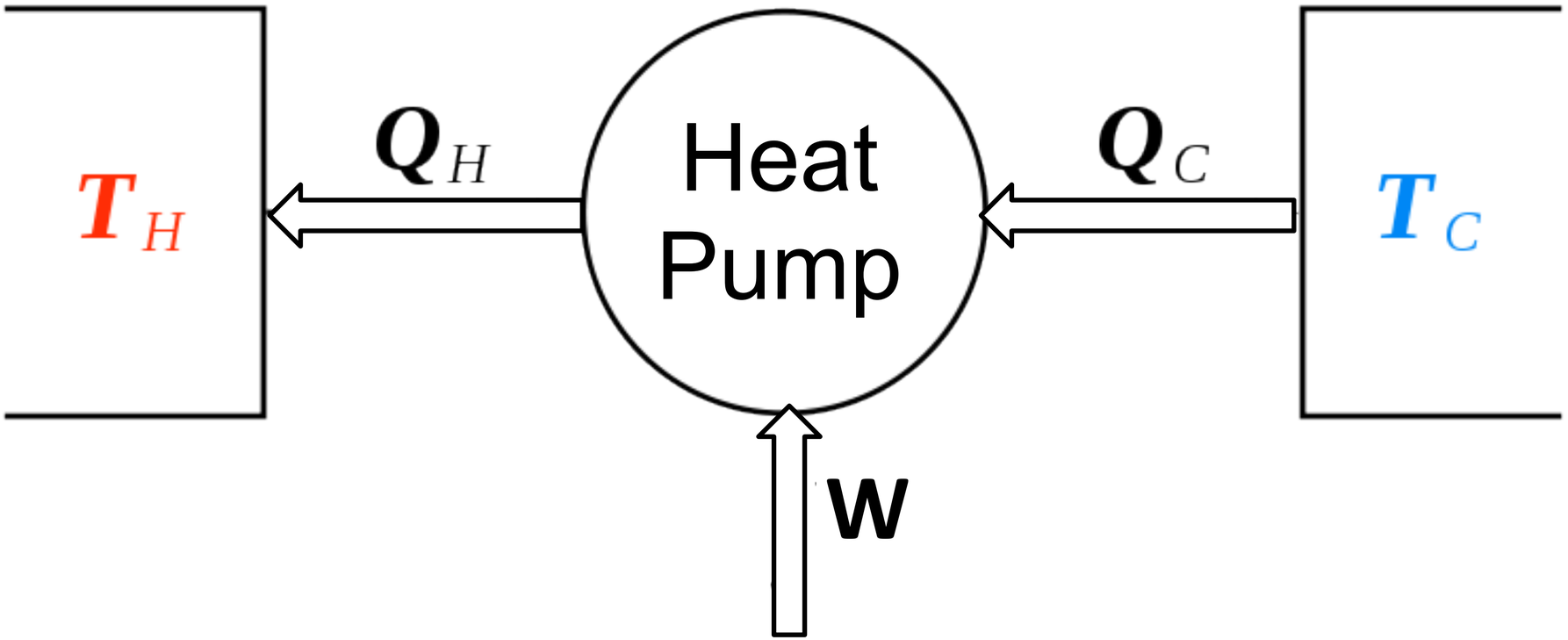


In a power plant, Qc is termed rejected heat, sometimes called waste heat.



Cogeneration
Rejected heat can be transferred in hot water to heat buildings.

Using ***work*** energy, *heat* can flow from cold to *hot*.

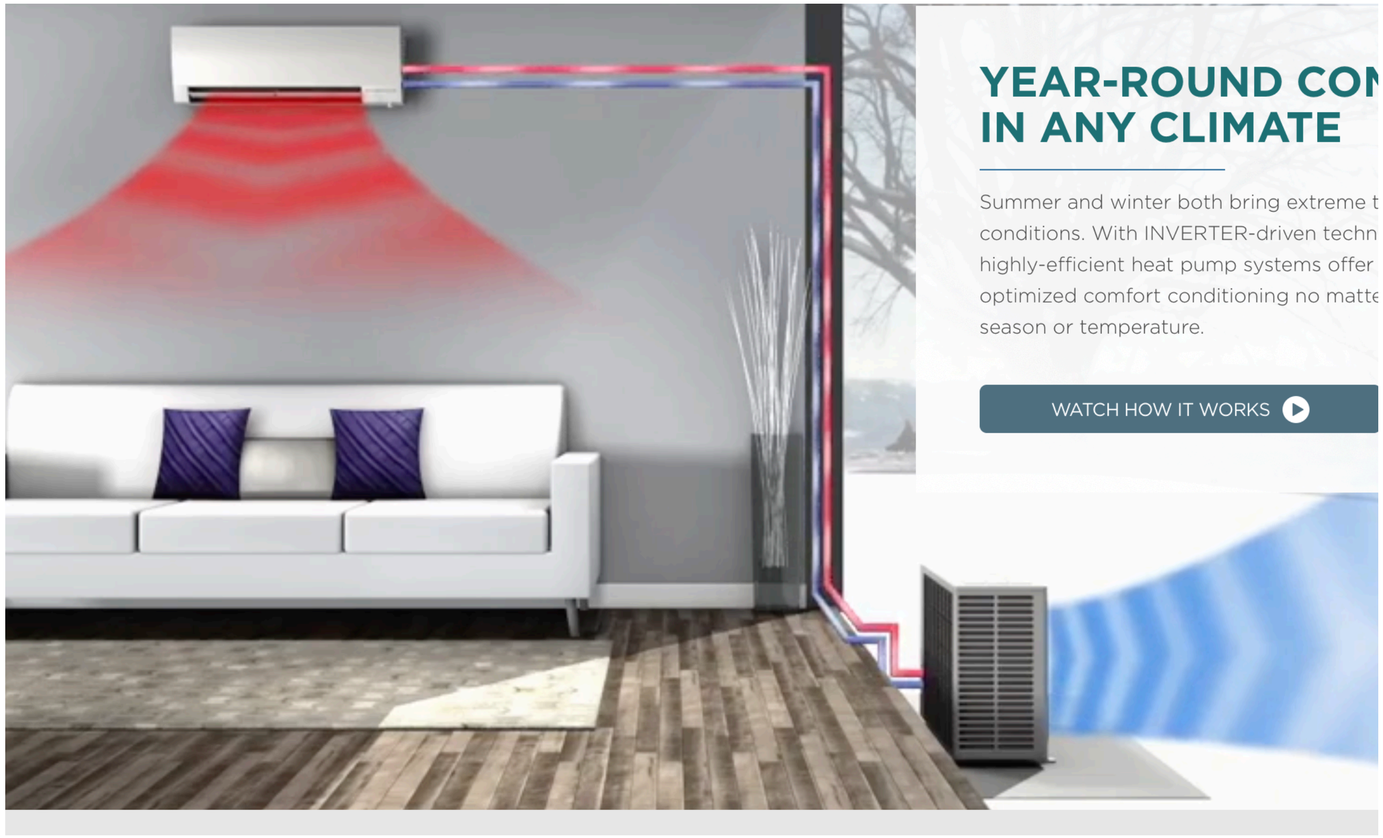


Heat pump examples:

LG air conditioner

For cooling

Mitsubishi air source heat pump



For heating and cooling

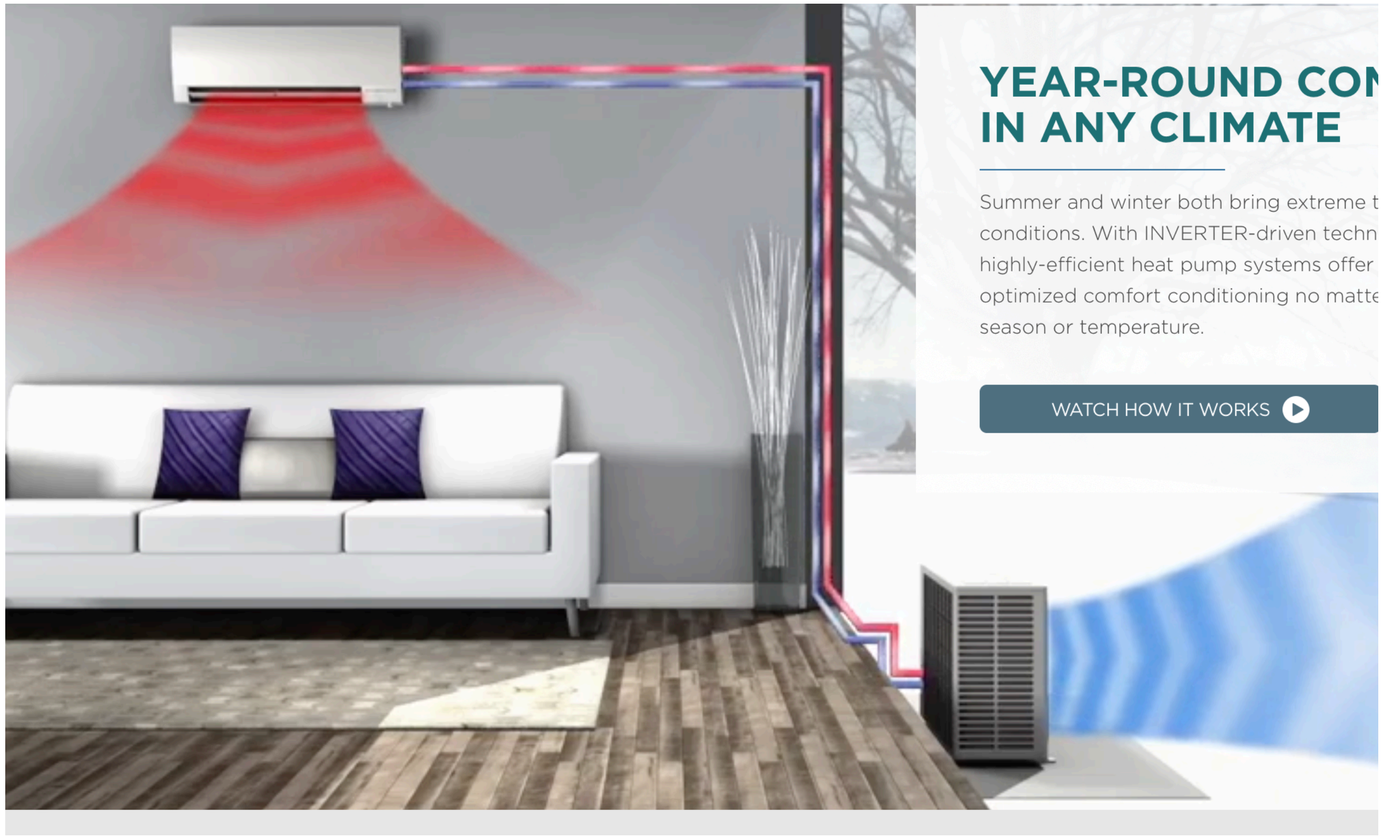
Heat pump

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

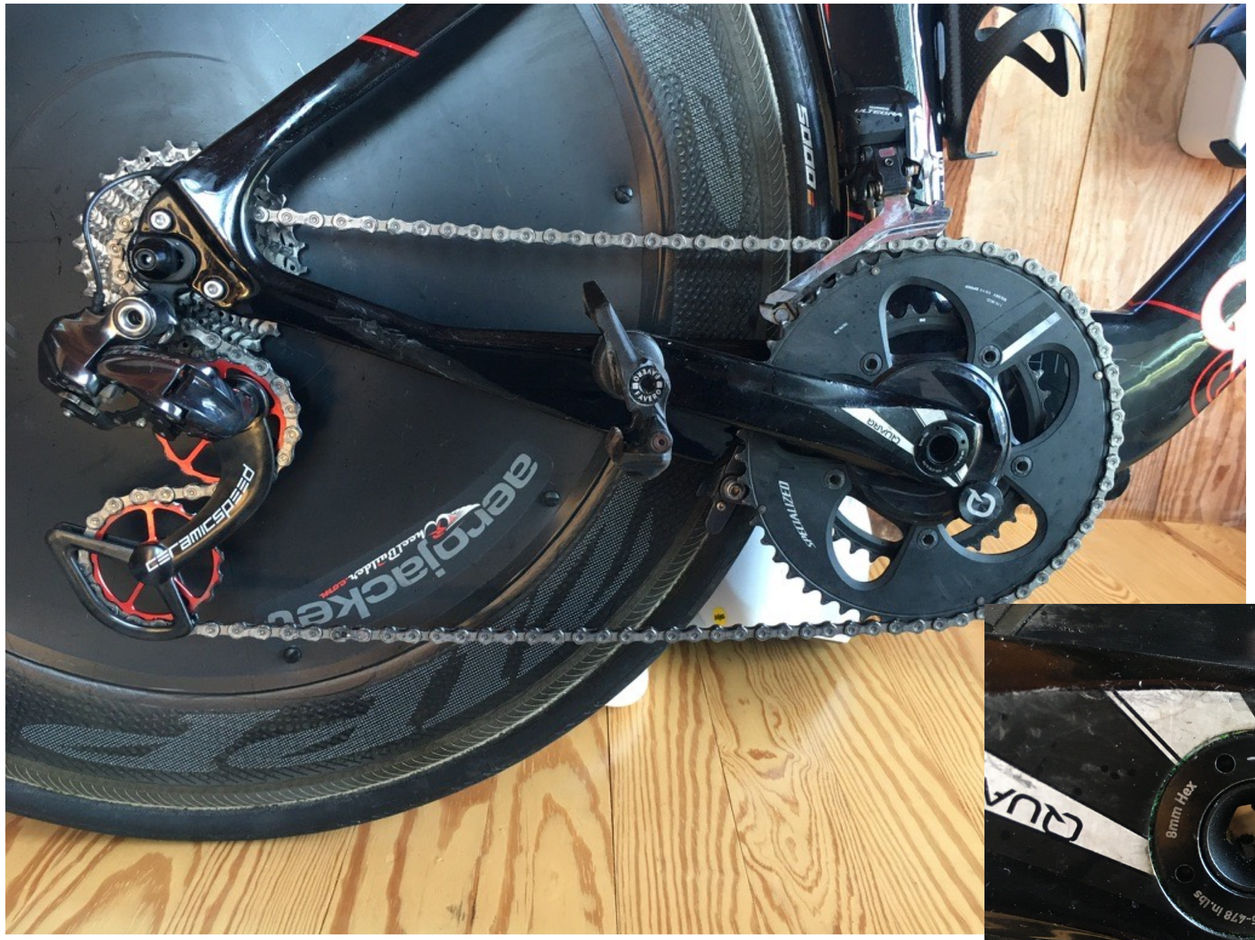
COP
~ 3.8 to 2.9

As air temperature drops
from 55°F to 5°F
heat output may drop
from 7 kW(t) to 3 kW(t).

Mitsubishi air source heat pump



Power = energy ***flow,***
measured in joules/sec = watts



NH Electric Coop buys/sells *energy* @ 6.6 cents/kWh.
It provides me *power* service up to 96 kilowatts.

Account Number	Cycle	Service Locatio
0303139512	1	4 STONE WAY

Meter Information — CANAAN

Rate	Meter #	Reading Dates Prev	Reading Dates Pres	Meter Re Prev
B	824271	07/01/2020	08/03/2020	4871

NHEC ELECTRIC CHARGES			AMOUNT
MEMBER SERVICE CHARGE			29.32
DELIVERY CHARGE	632 kWh x	0.040310	25.48
SYSTEM BENEFIT CHARGE	632 kWh x	0.006780	4.29
REGIONAL ACCESS CHARGE	632 kWh x	0.027060	17.10
CO-OP POWER	632 kWh x	0.066150	41.81
CURRENT NHEC ELECTRIC CHARGES			118.00

incl Power service -->
Transmission -->
Grant programs-->
Transmission -->
Energy -->

Power = energy *flow,* measured in joules/sec = watts

Dumb answers to real questions:

Q: How far away is Burlington?
A: 65 miles per hour

Q: How much energy is stored in world batteries?
A: 180 megawatts

Next: California's grid operator and largest newspaper print such nonsense.

California ISO

Renewables Grid Initiative

"As of September 2019, global tracked energy storage totalled nearly 188 GW"

https://www.caiso.com/Documents/EnergyStorage-PerspectivesFromCalifornia-Europe.pdf

BUSINESS

Giant batteries, key to solar and wind power plans, start to get bank backing

"The U.S. has about 1,400 megawatts of battery storage — equivalent to the output of two natural-gas-fired power plants"

https://www.latimes.com/business/story/2020-03-04/solar-batteries-banks

Notation assistance: (t) (e)

Heat flow and power both measured in watts (joules/sec)

kW(t) = kilowatts thermal (3600 x 1000 joules/sec)

kW(e) = kilowatts electrical (3600 x 1000 joules/sec)

Notation assistance: heat(t) electricity(e)

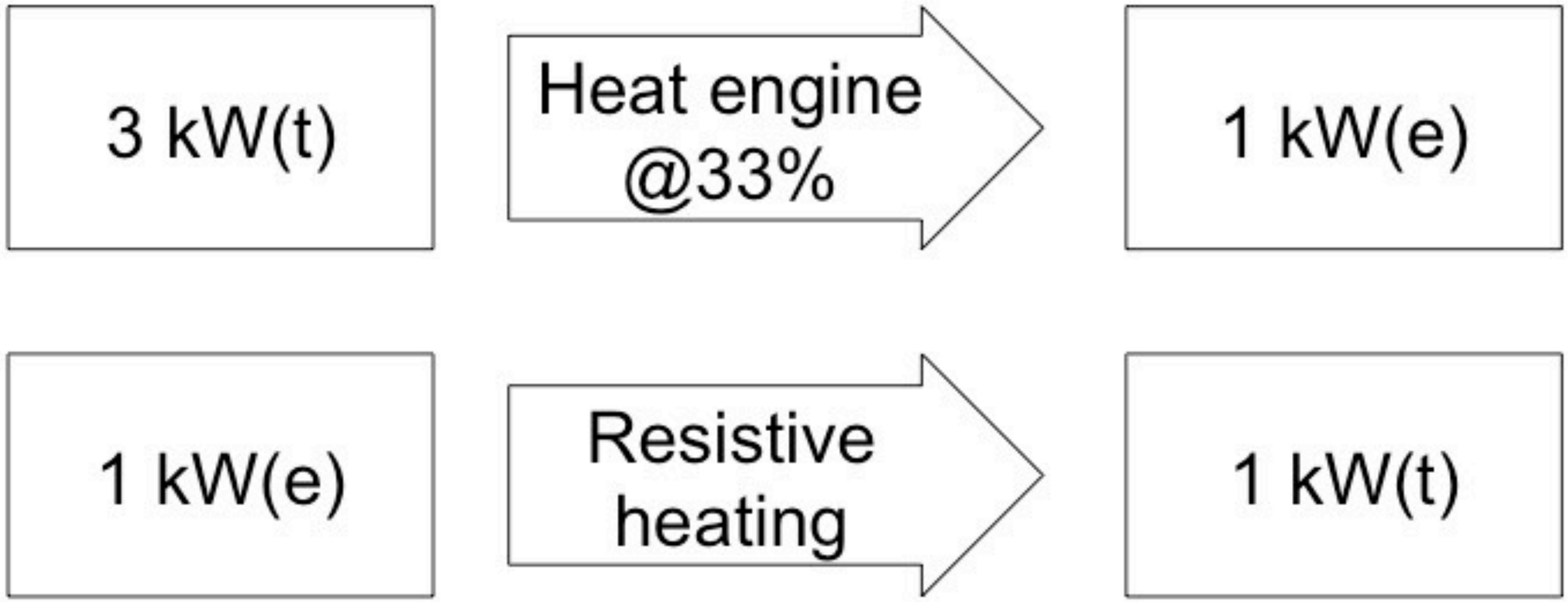
Heat flow and power both measured in watts (joules/sec)

kW(t) = kilowatts thermal (3600 x 1000 joules/sec)
kW(e) = kilowatts electrical (3600 x 1000 joules/sec)

Heat and useful energy both measured in joules (watt-seconds)

kWh(t) = kilowatt hours thermal (3600 x 1000 joules)
kWh(e) = kilowatt hours electrical (3600 x 1000 joules)

Typical efficiency.

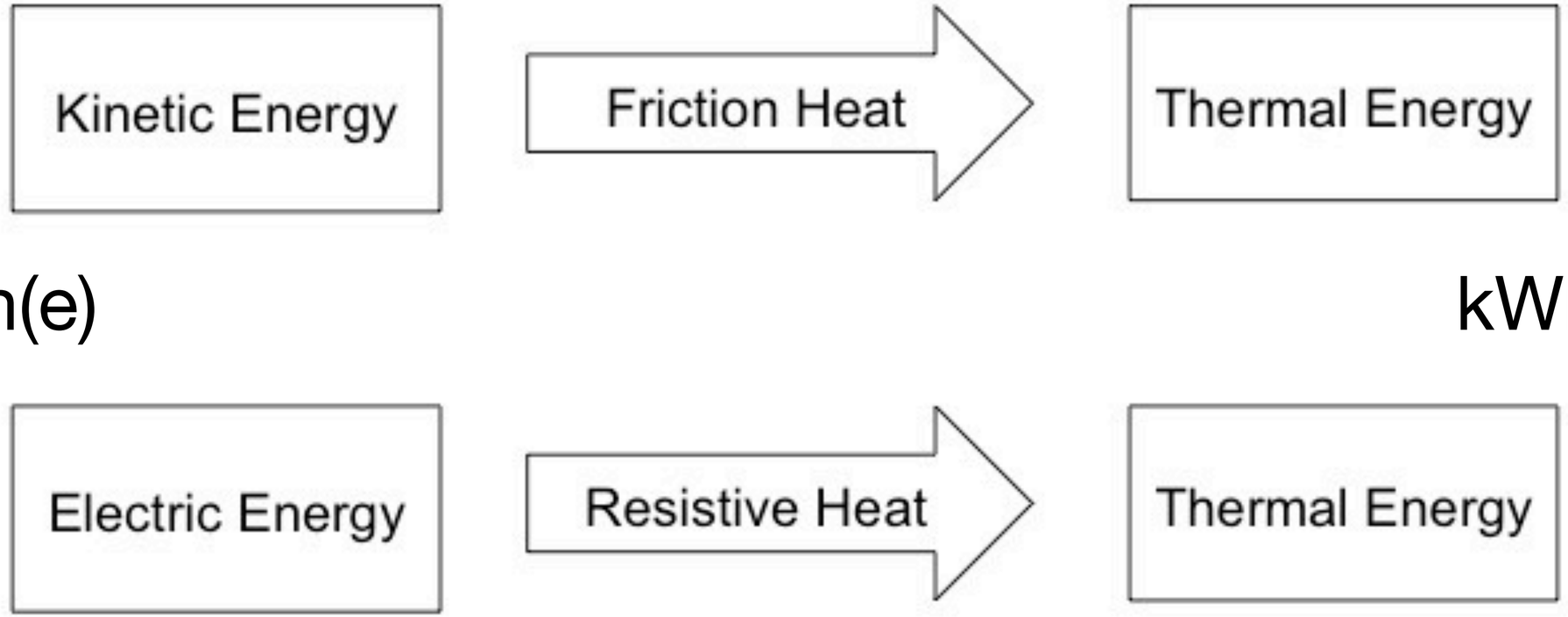


Useful energy decays to heat. [2nd Law]

kWh(e)

kWh(t) heat

Useful energy decays to heat. [2nd Law]

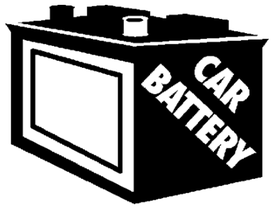


Never add Wh(t) and Wh(e) and call it "total energy".

It’s like adding Miles + Kilometers, calling it Distance!

Examples: energy, flowing (power) to energy

Lithium ion battery



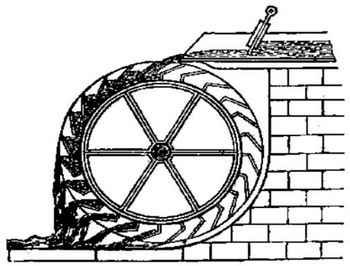
Chemical potential energy

200 kW
electric power

Electric car

Kinetic energy

Hydro power plant



Gravitational potential energy

1000 W
electric power

Toaster

Thermal energy

2 Basics of energy and power

Fission is in Fashion

Useful energy

Heat

Work from heat

Power