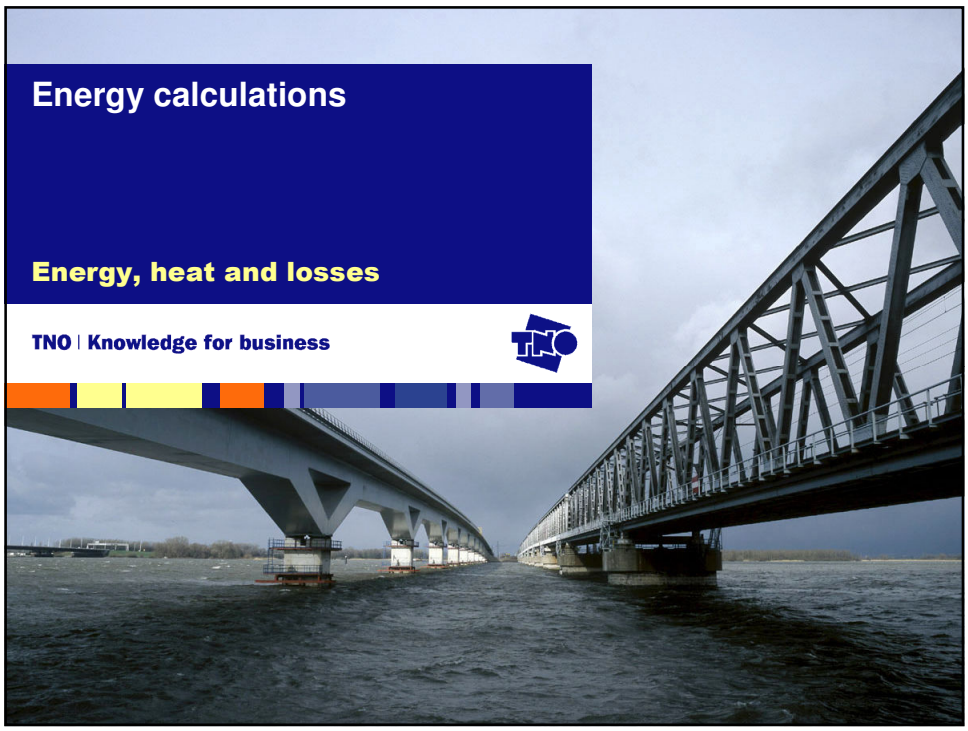
Energy calculations

Energy, heat and losses

TNO | Knowledge for business



Heat

- Heat
- Temperature
- Mass
- Volume
- Combustion
- Evaporation

Energy can not be lost

- Only conversion from one type into another
- Work is the amount of energy transferred by a force
- Ability to work decreases in a conversion

- Energy balance (what goes in, what goes out, losses)
- Mass balance (fuel, air, flue gas, ash)

- Losses: radiation, conduction, heat content flue gas

3

Heat content

- S.I. unit: Joule (other units: meter, second, ℃)
- BTU = 1054–1060 Joule (1055)

- **Heat: $m.C_p.\Delta T$**

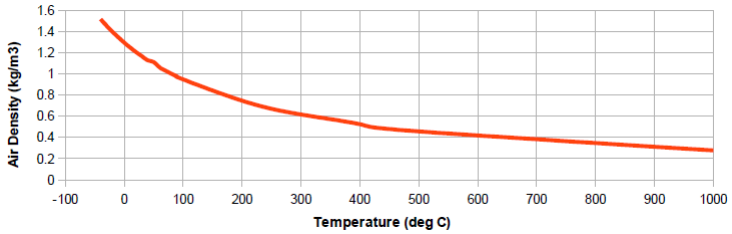
  (m: mass, C_p :Specific heat, ΔT: temperature difference)

- The specific heat is the amount of heat per unit mass required to raise the temperature by one degree Celsius.

4

Specific heat (mass-specific heat capacity)

- water : 4.2 J/g (so to raise 1 litre from 20 to 90℃ needs 294 kJ)
- air: 1 J/g
- wood: 1.2 – 2.3 J/g
- steam: 2 J/g (at 100℃)
- 1 m^3 air equals 1 kg



5

Fuel

Type	Unit	Cost $/Unit	Cost $/MJoule	Uses
Electricity	1Kwh = 3.6 MJ	0.20	0.055	appliances, motors
Gasoline	1 litre	2.00	0.0625	transportation
Natural Gas	m^3 = 31.56 MJ	0.35	0.011	heating
AA battery	1 battery = 1200 mAh, 1,2V = 5184 Joule	1	193	portable electronics
Milky Way candy bar	1 bar = 1 MJ	0.60	0.60	food

6

Energy content

Type	Unit	Energy (MJ)
Wood	kg	18
Natural gas	m^3	31.65
Oil	litre	38.5
Oil	kg	42.4
Electricity	kWh	3.6
Coal	kg	35
Steam	kg	2.7
Boiling water	litre	0.34

7

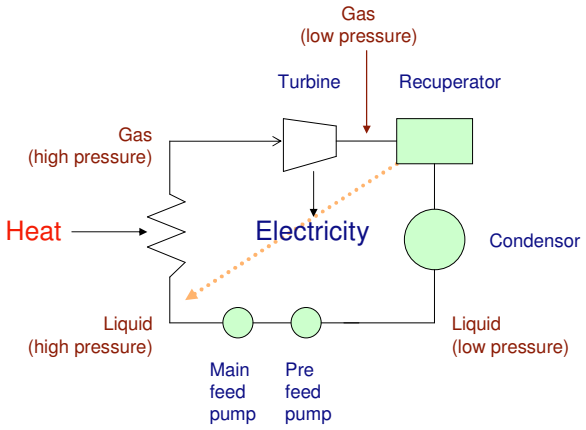
Flue gas

- 1 m^3 natural gas needs about 10 m^3 air (Stoichiometric Combustion)
- So for every m^3 natural gas we produce 11 m^3 flue gas
- Heat loss: (ΔT: 180-30): 11.1.150 = 1650 kJ

- More air, more loss

8

Tri-o-gen



Tri-o-gen

System specifications:

- Working fluid: Toluene
- Heat source inlet temperature: > 350 ℃
- Heat source: 450 – 900 kW_{th}
- Cooling: Water 350-700 kW_{th}
- Power range: 60 – 165 kW_e
- Cooling temperatures 35 → 55 ℃

Questions

- What is the boiling point of toluene?
- How much water do we need to cool?