SOUND ENERGY
thermo acoustic technology

Technology and application of thermoacoustic ~~heat pumps~~ **heat transformers**

MVO/NAP-Workshop recente ontwikkelingen warmtepompen
op 2 oktober 2018 bij Tata Steel

Kees de Blok

Introduction Soundenergy

Technology

Generic applications

Power and temperature range

Development and product status

Practical experience

Economics

Input from the market

Search for pilot plants

Introduction Soundenergy B.V.

- Established March 2014
- VC funded (1M€)
- Team (per 01-10-2018)
  - Research (4 fte)
  - Product development (3 fte)
  - Commercial (3 fte)
- Workshop and R&D facilities
- Test facility for thermoacoustic heat transformers ($100kW_T$ - 220°C)
- Production contract with a local metal works company
- Product: **THEAC-25** (generic heat transformer)

Workshop with a heat transformer under construction

Part of the TA test bench

Technology

Energy conversion process based on "classic" thermodynamic cycles in which compression, displacement and expansion of the gas is controlled by an acoustic wave instead of by pistons and displacers

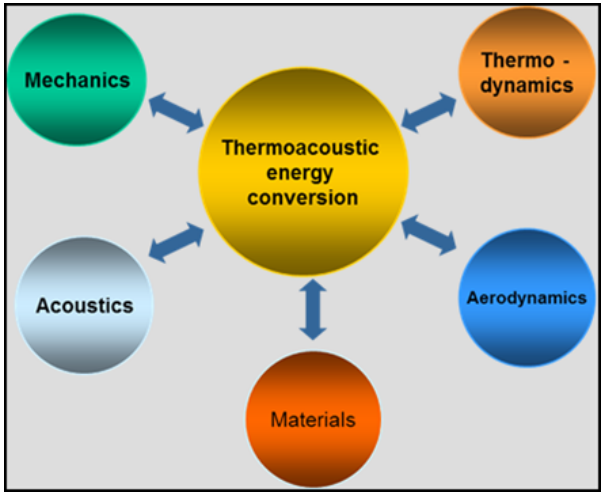
Characteristics

- No electricity
- No mechanical moving parts in the thermodynamic process
- Robust construction
- Maintenance free
- Large freedom of implementation
- Low noise
- High efficiency
- Large temperature range
- Scalable from Watt's to MWatt's
- Inert gas as working medium (F-gas regulation doesn't apply)

Operation modes

- **Heat engine – heat pump ⇒ heat transformer**

Involves multiple technology areas

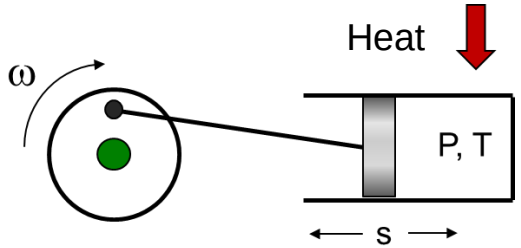


SOUND ENERGY
thermo acoustic technology

How does heat create acoustic waves?

The interaction between heat and sound is about cyclic compression and expansion with properly timed heat exchange.

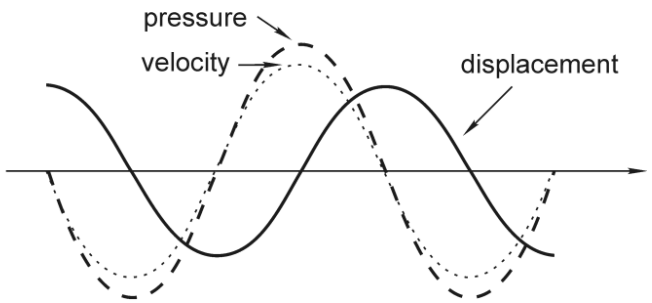
"Classic" by means of a crank + piston

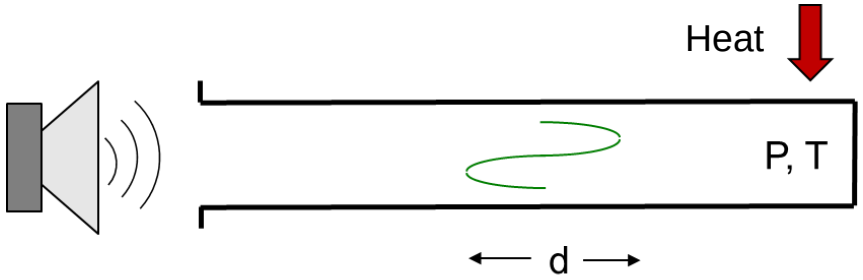


Heating the gas while compressed will raise pressure

- In the mechanical system this increases rotational output power
- In the acoustic system this increases acoustic output power

"Innovative" by means of gas motion in an acoustic wave





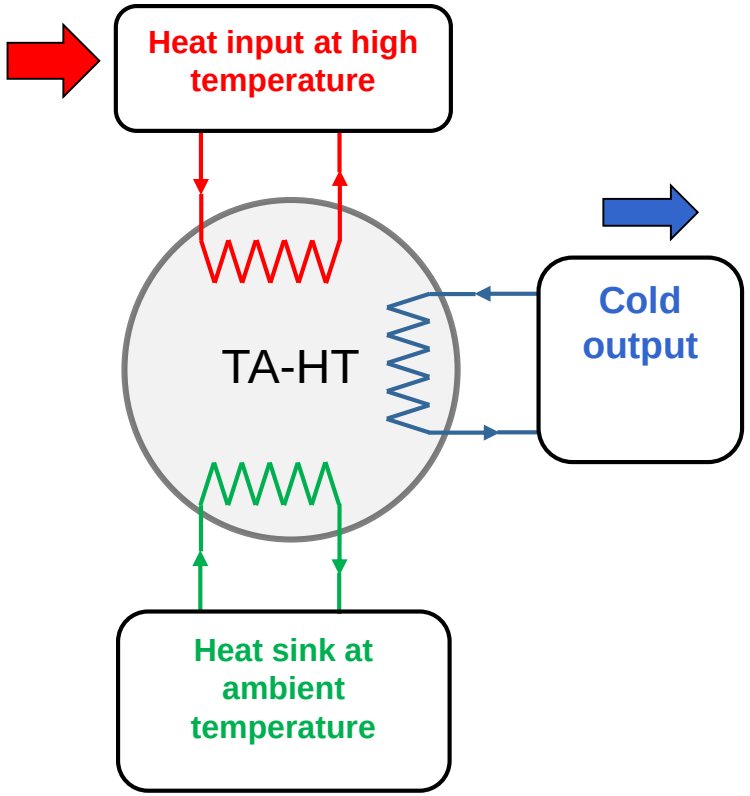
Gas displacement (d) in acoustic waves is similar to piston stroke (s) in mechanical compressors

Generic applications

SOUND ENERGY
thermo acoustic technology

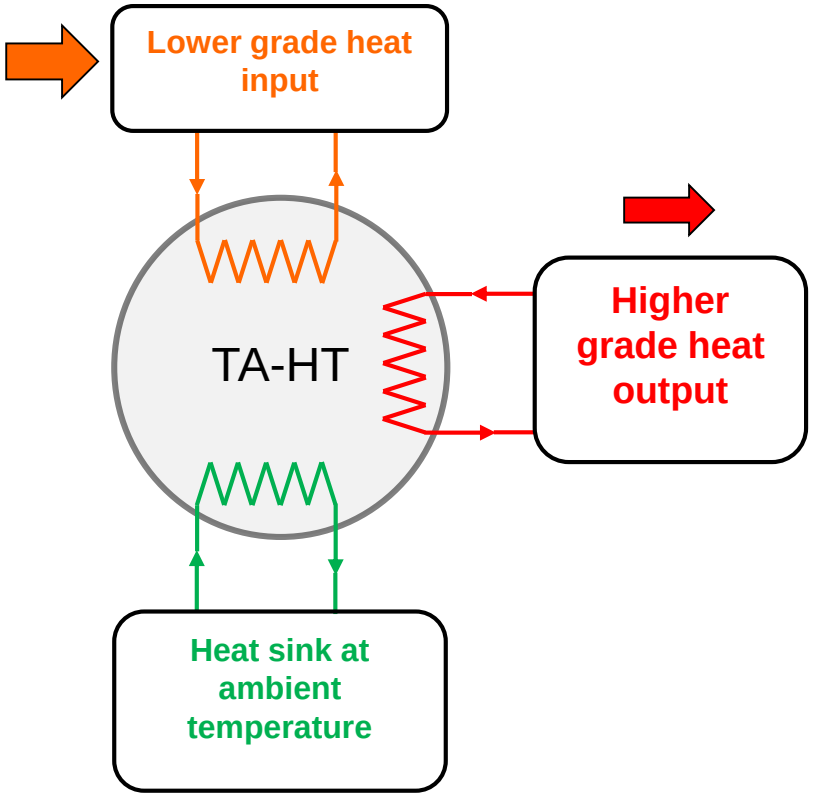
Heat transformer (1)

Semi-passive 3-terminal device converting solar heat or industrial waste heat directly into cold



Heat transformer (2)

Semi-passive 3-terminal device for upgrading industrial waste heat above the pinch



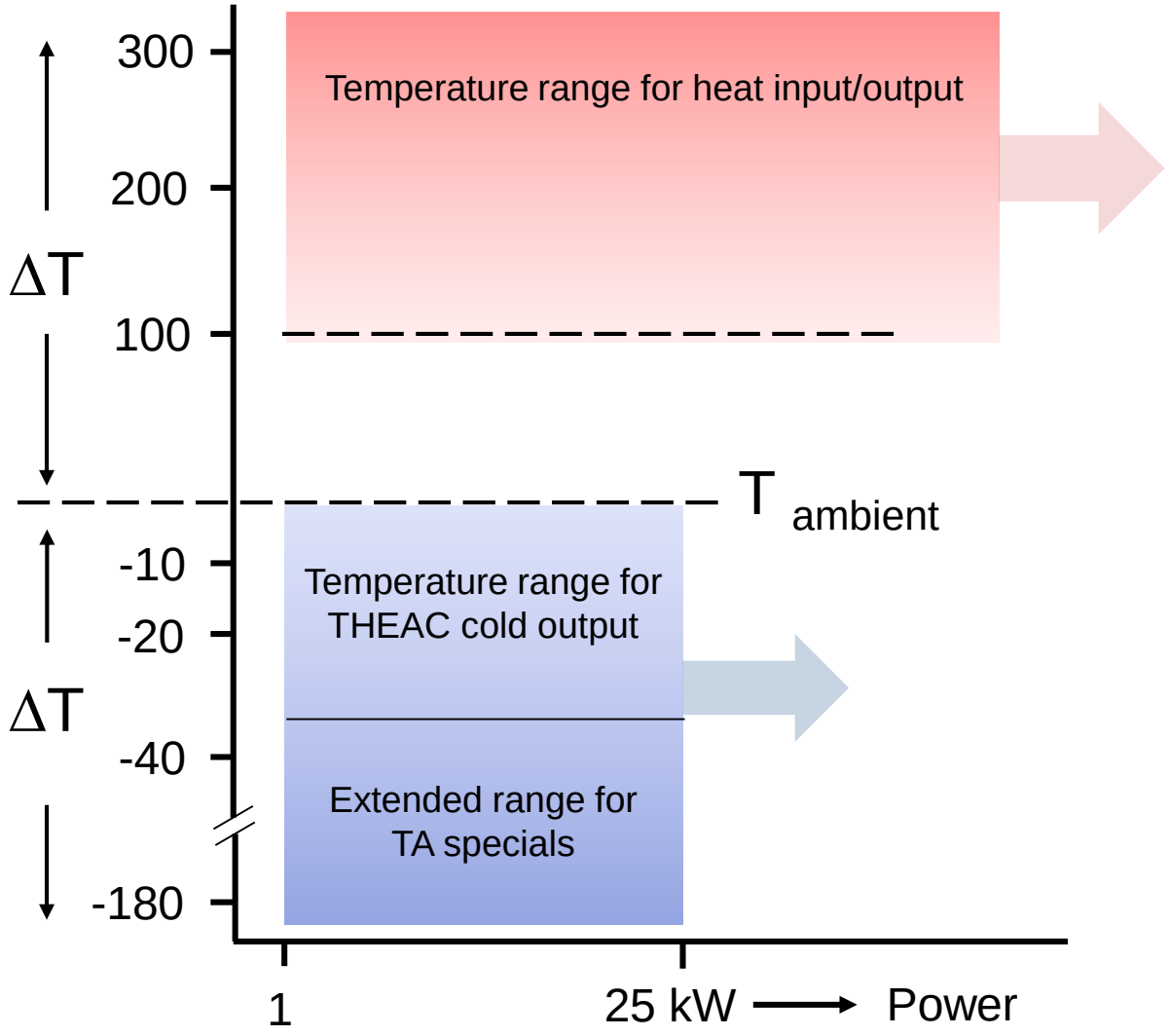
Power and temperature range

Actual performance is direct related to:

- Heat input temperature(T_H)
- Heat sink (e.g. ambient) temperature (T_A)
- Cold output temperature (T_C)

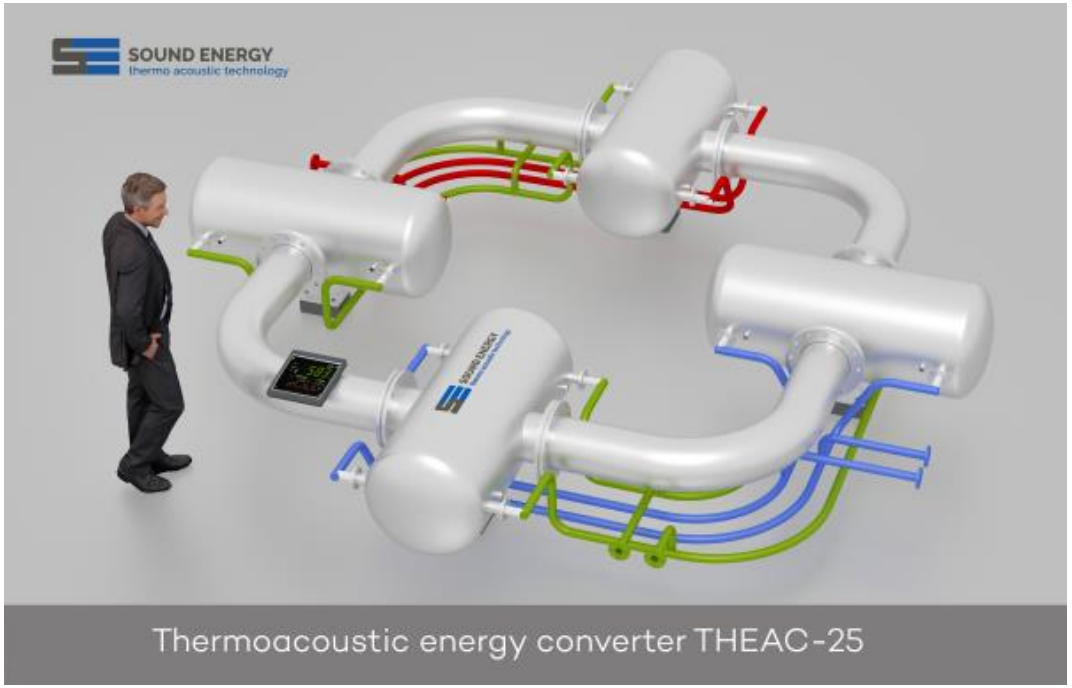
Featured applications strongly depend on:

- **Local (process) conditions**
- **Geographic location**
- **Outdoor conditions**

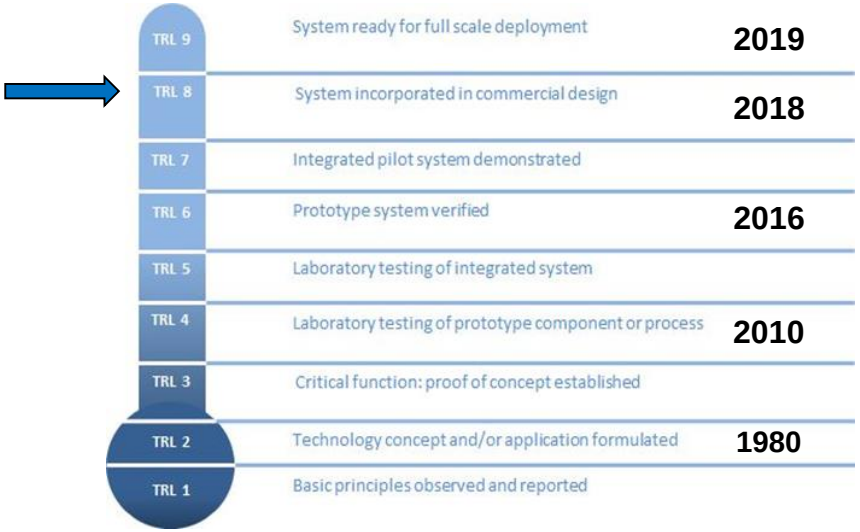


Development and product status THEAC-25

Typically a thermoacoustic heat transformer is comprised of four thermoacoustic energy converters (TAEC's) located inside vessels, of which two of them are configured as **HEAT ENGINE** and two as **HEAT PUMP** mutually connected by resonance and feedback tubes.



Thermoacoustic energy converter THEAC-25

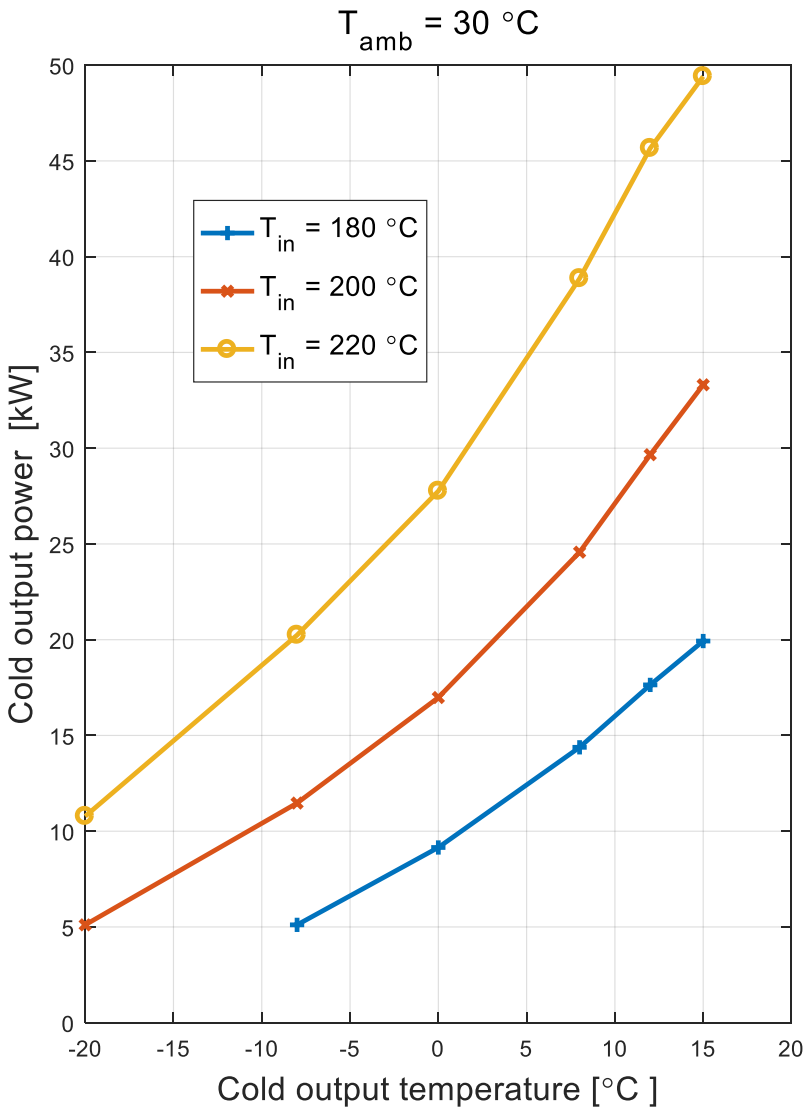


Development product status THEAC-25

THEAC-25 β currently in production

One THEAC-25 β sold to Dubai (UAE)

- Solar heat powered water production
- Solar heat powered air-conditioning



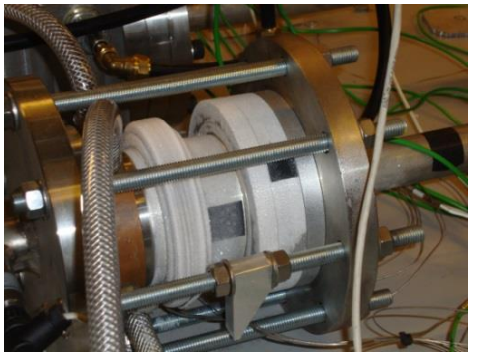
Practice

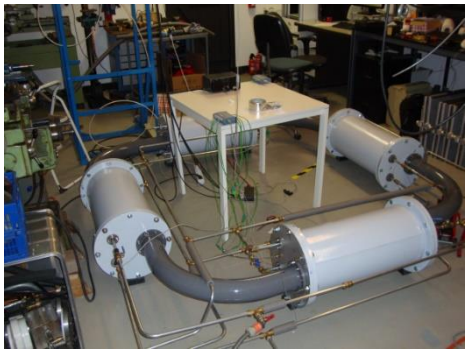
SOUND ENERGY
thermo acoustic technology

Long term track record on thermoacoustics :

- Theory and design
- Modelling and Simulation
- Design and built of small and large scale prototypes
- Transport
- Installation
- Process integration





Economics

SOUND ENERGY
thermo acoustic technology

OPEX $\Rightarrow$ 0

- Zero down time
- Fail save
- No mechanical moving parts
- Expected live span $\geq$ 30 years
- No maintenance
- No F-refrigerant
  - (GWP=zero, F-gas regulation doesn't apply)

TCO

- Cost of THEAC-25 heat transformer + cost for subsystems and process integration

Annual yield

- In general avoided cost of primary fuel and proportional CO_2 reduction
  - Cooling example: 25 (40kW) cold $\approx$ 10 (16)kW_e - 8000h - €0.05/kWh $\Rightarrow$ € 4000 (6200) + CO_2 tax
- Half year inspection, maintenance and refrigerant refill cost
  - Avoided cost €1000,-
- Zero down time
  - Avoided cost € ..?

Input from the market

Were to apply TA heat transformers?

In general, companies having a demand for cold and a surplus of (waste) heat at the same plant
More specific,

- Food industry
  - Cooking - cooling and cold storage
- Bakery's
  - Stove flue gas (200-300°C) for air condition workspace and packing area
- Process industry
- Buildings, mall's (preferably with large flat roofs)
  - Use solar heat to generate directly cold for air conditioning or storage

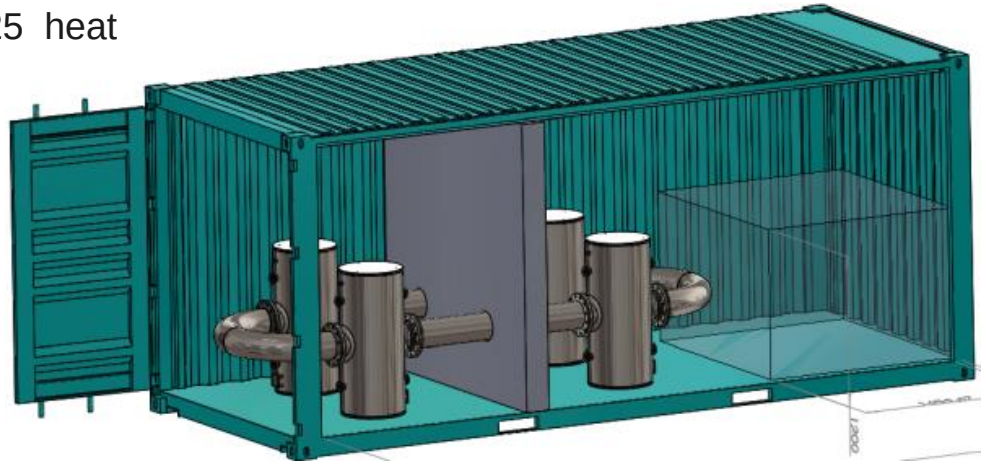
Bottlenecks?

In general, the low "compactness" could be an issue (e.g. automotive)

Search for customers and pilot plants

For introducing this heat transformer concept we are looking for customers having a need for energy /CO_2 reduction plus a demand for cold.

Starting November 2018 we are planning a tour with a mobile heat transformer to prove and demonstrate the THEAC-25 heat transformer at an industrial environment



For that event, we are looking for customers or plants,

- with a demand for cold (food, process, climate control etc.)
- were (waste) heat is available or could be harvested easily and made (temporarily) available for our demonstrator.
- accessible for a 20ft container

Connection diagram THEAC-25