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”Biomasse Polygeneration – die Zukunft ”

Swedish plants with integration of absorption cooling and flue gas condensation

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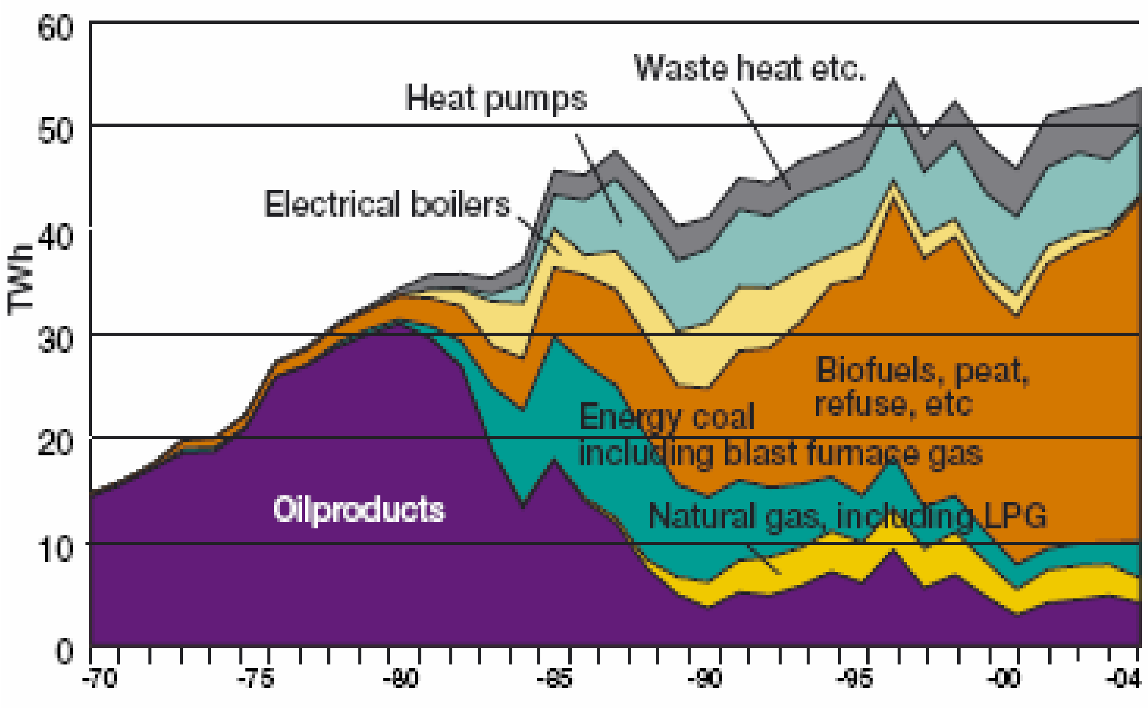
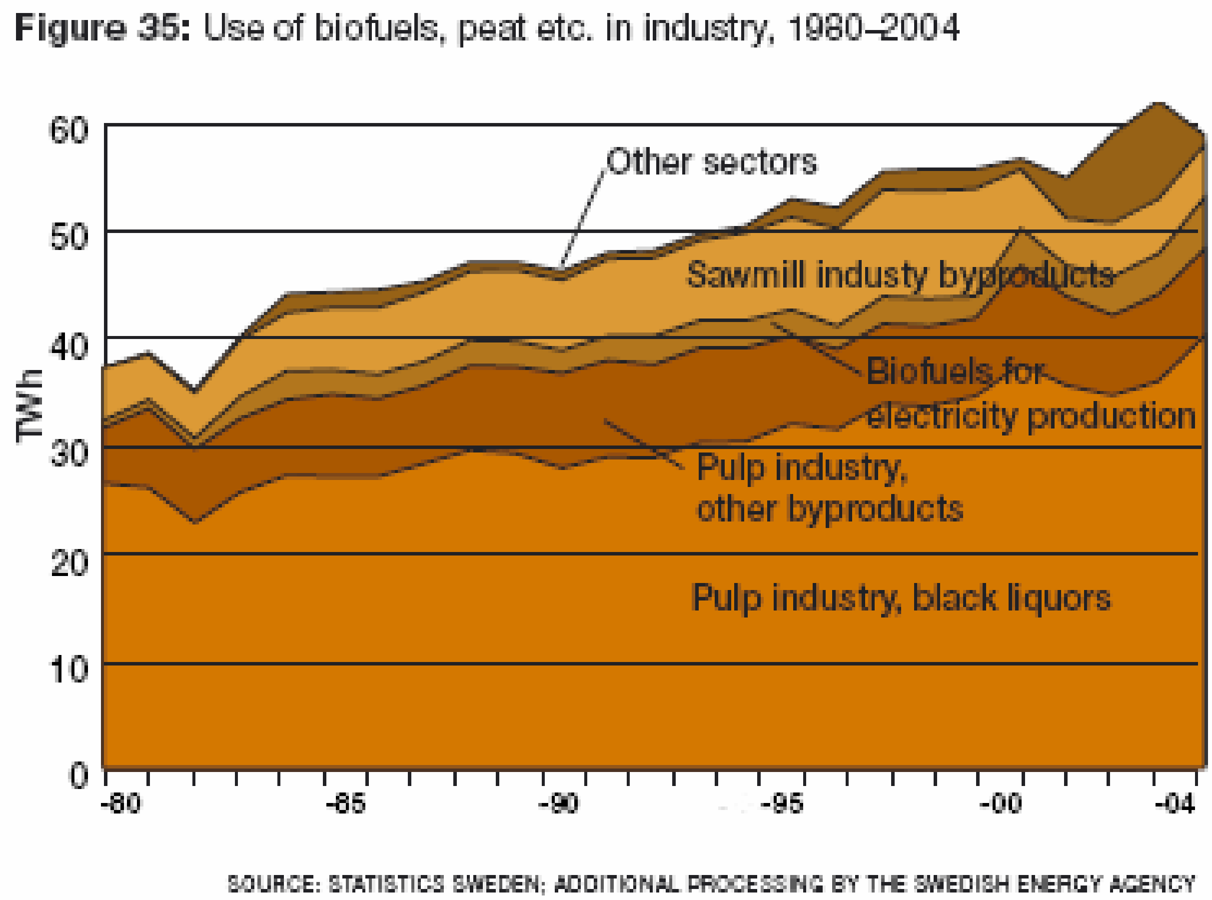
Background

The market for biomass as a fuel has expanded very rapidly in Sweden since the oil crisis. The dominating markets are :

- industry (mainly forest industry)
- district heating (used in center parts of most towns)
- houses (schools, hospitals etc as well as individual houses)



Expansion of biomass in the Swedish district heating market



Expansion of biomass in the Swedish industrial market

The main driving forces for the expansion have been :

•Good access of biomass due to wastes from the forest industry (but no access to natural gas and no domestic production of fossil fuels)

•Expansion of district heating nets, stimulating the expansion of boiler capacity for biomass and for solid wastes

•High taxes of fossil fuels (CO_2 tax) and no taxes on biomass

•The district heating companies are normally owned by the local communities. They are powerful actors since they also are important buyers of district heating and take a leading role in the planning process.

•Expansion of the market for wood pellet in individual houses, due to increasing prices of oil and electricity

Some typical examples of technologies:

Harvesting and transport of logging residules

The fresh residules are then stored at the main road for pre-drying

Next step is normally cutting to chips for futher transport to local boilers

Further drying and pelletizing is used before ship transportation from regions with surplus of wood-fuels to towns with biomass deficit

Example of a large district heating plant for biomass:
(Växjö plant for 110 MW wet biofuel $\rightarrow$ 33 MW power + 80 MW district heating

Typical example of retrofit installation of pellet silo (7,5 m3)
+ pellet boiler for individual house
http://www.mafa.se/

Advanced plants for heat & power production

The Swedish biomass plants are the most advanced in the world in terms of efficiency for heat production. Flue gas condensation is normally used to maximize the heat production from wet biofuels. Total efficiency is 85-90 % of LHV in conventional plants but is rased to 105-110% by flue gas condensation.

Two different condensation technologies are used:

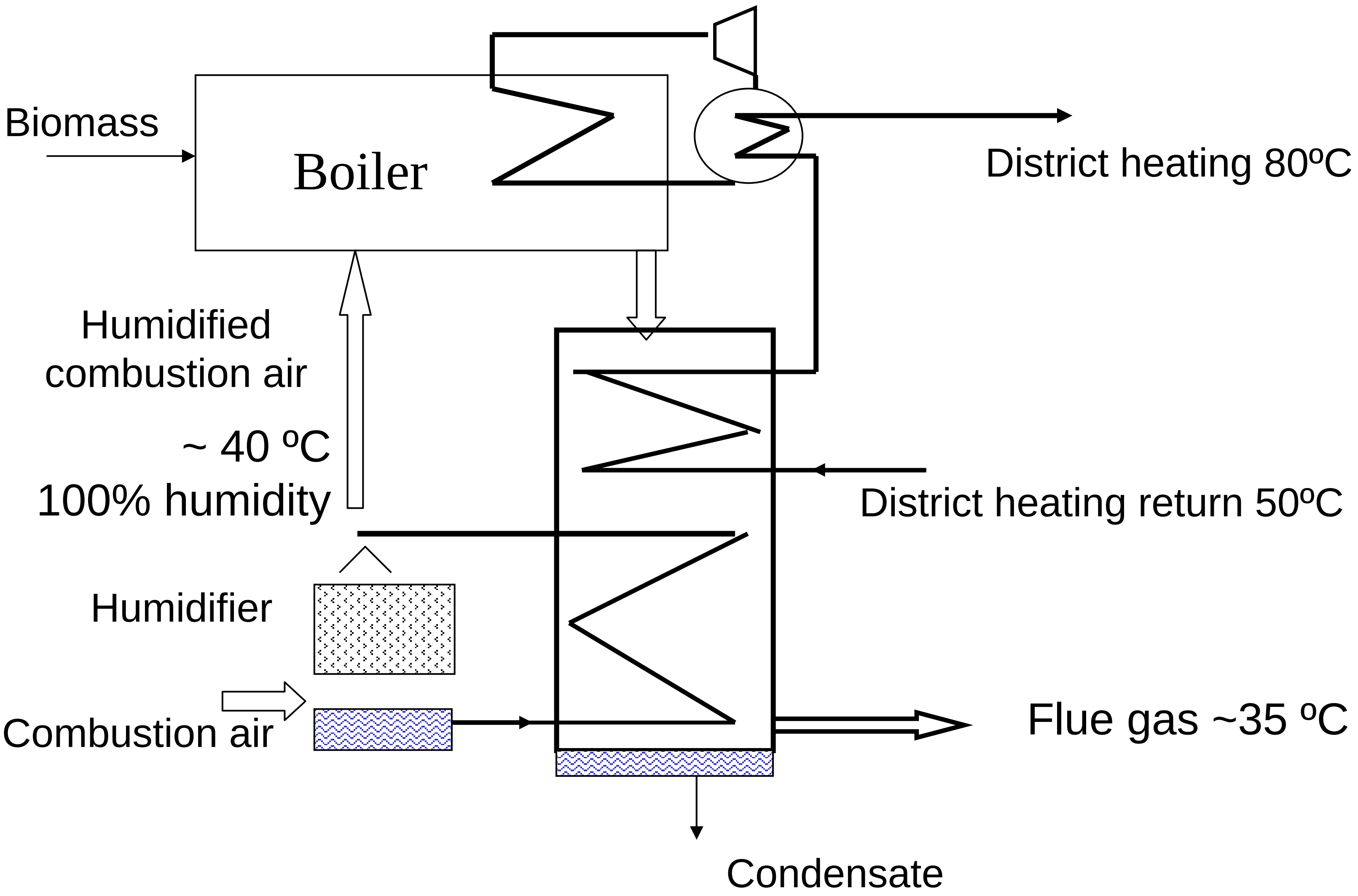
•~ 600 MW of flue gas condensing capacity is installed as inlet humidification

•~ 100 MW of flue gas condensing capacity is installed as absorption heat pumps

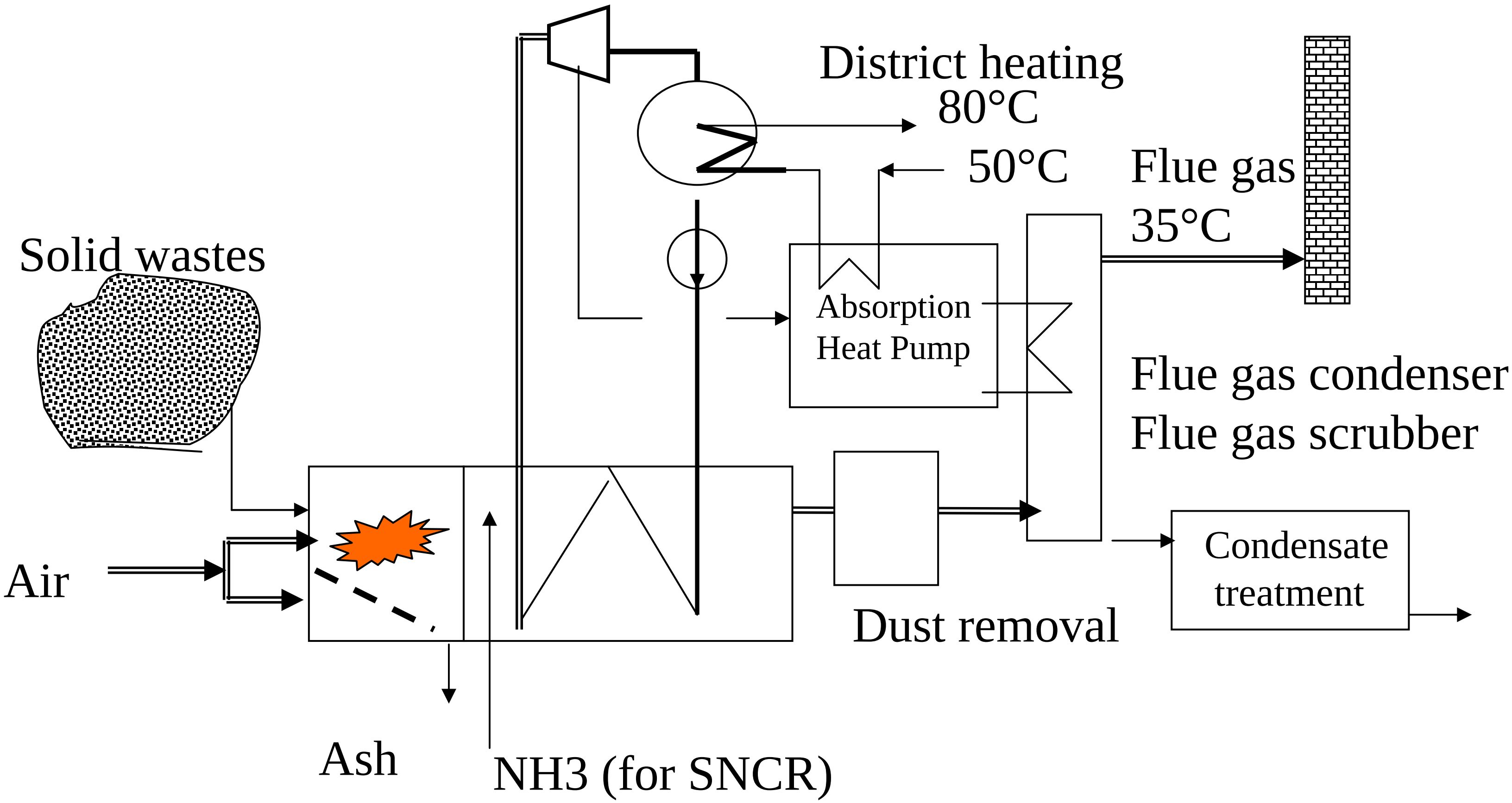
Boilers for solid wastes prefer absorption heat pumps since humidification would decrease the combustion temperature and decrease combustion efficiency.

The environmental data are also excellent: fluidized beds are used for the combustion to reduce nitrogen oxide formation. Electrostatic precipitators for dust removal. NOx reduction (SNCR or SCR) is normally used in large plants.

Some plants have steam cycles for combined heat and power production



Typical biomass boiler with flue gas condensation and humidification of combustion air
Total efficiency 105-110% of LHV for wet wood fuels



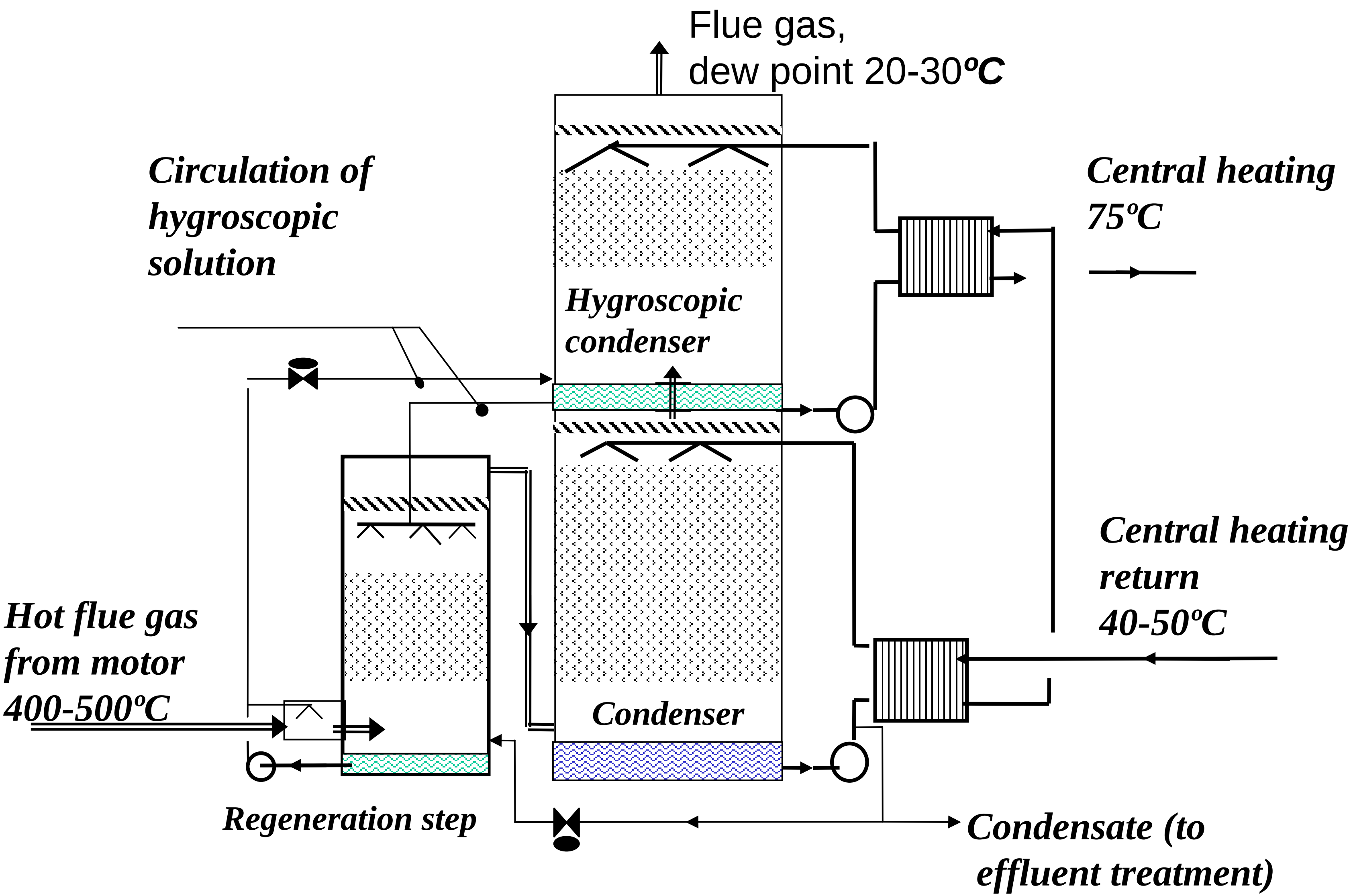
Typical boiler for solid wastes. Absorption heat pump is used for upgrading of waste heat from flue gas condensation. Total efficiency: 100-105% of LHV for wet fuel.

Technical development of open-cycle absorber

The conventional absorption heat pumps are rather expensive and have limited temperature capacity (using LiBr as absorbent). Therefor, we are engaged in developing a open-cycle absorption heat pump. It uses flue gases or wet air as waste heat source.

The direct contact between absorbent and gas provide counter-current contact. A demonstration plant is now under construction and will be recovering waste heat from flue gases from a gas motor. The heat for regeneration is provided by the hot flue gas.

Patented open-cycle heat pump for gas motors etc (regeneration by hot flue gas)



Integration of absorption cooling with boilers for solid wastes

The absorption heat pumps are used for upgrading of waste heat from flue gas condensers during the heating season. However, the same machine can be used for absorption cooling during the summer season!

Uppsala is now using 2 absorption machines in this way.
The cooling capacity is 2*5MW= 10 MW which is used for district cooling
Additional investment cost is low for the cooling option (cooling towers for summer operation + some additional piping).

During summer the surplus of heat from the solid waste boiler is enough for driving of the absorption chiller!

Integration of absorption cooling with CHP boilers

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District heating nets with”low temperature driven” absorption cooling

Traditionally, most absorption heat pumps are driven by steam at 110-120°C However, it may be good economy to enlarge the heat exchange surfaces in order to use driving heat of 70-80 °C. Such low-temperature driven units are now available on the market.

In Västerås a 7 MW low temperature driven cooling plant is driven by heat from a district heating plant with steam cycle. The heat is available as surplus heat from the steam cycle (heat that has no alternative use during summer).

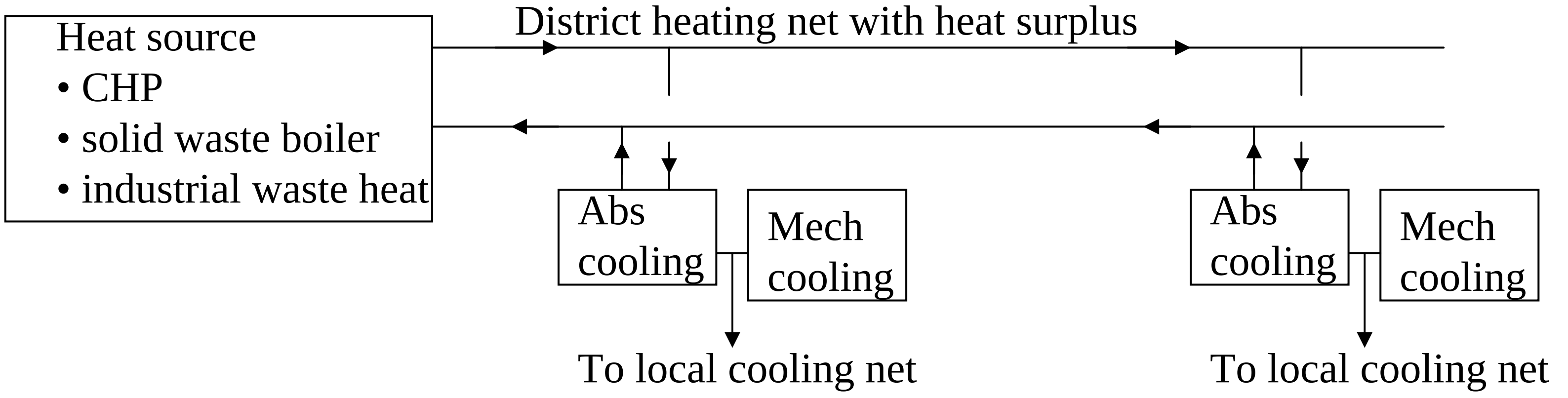
In Gothenbourg a 1 MW demonstration plant with falling film heat exchangers is using industrial waste heat (which has no alternative use during summer).

Low temperature driven absorption chiller with falling film heat exchangers
Demonstration plant with 1 MW cooling capacity in Gothenbourg

Distributed absorption chillers

A number of local absorption chillers can be connected to a district heating net. This is a good strategy for nets with surplus heat during summer (e.g. due to steam cycles, solid waste boilers or industrial waste heat).

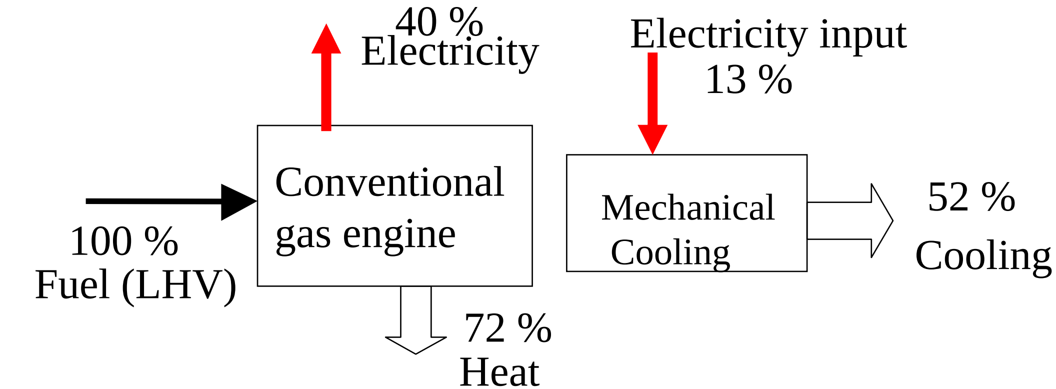
In one of our projects the town of Växjö is now planning 3 separate absorption chillers of about 2 MW each. Each chiller is used for a local cooling net. The best economy is obtained by parallell operation of absorption cooling (base load) and mechanical cooling (peak load). The heat is provided as surplus heat from the bio-fuelled steam plants showed before



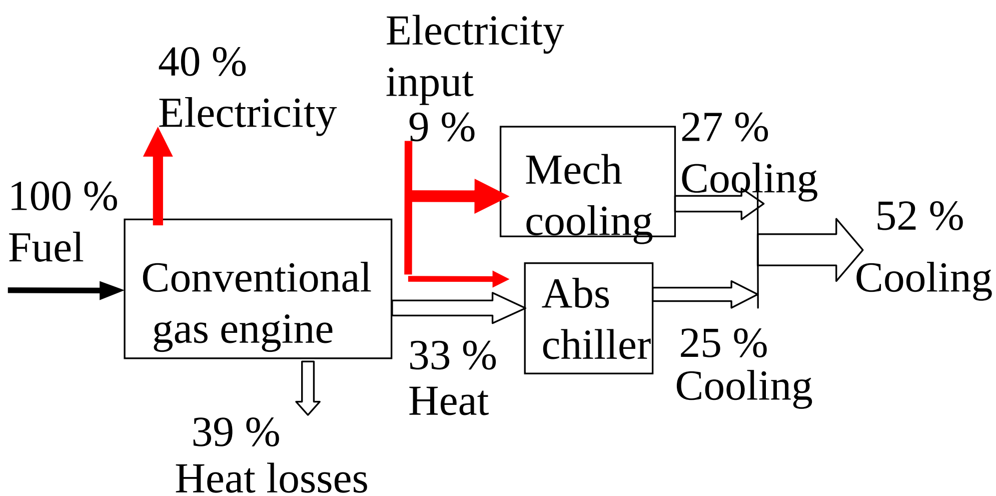
Integration of gas motors and absorption chillers

For power plants in warm climate it is a good idea to integrate production of cooling
The co-production of power and cooling is commercially used for gas motors. The waste heat from gas motors is used in several plants for driving of absorption chillers.
The waste heat from jacket cooling and flue gas boiler amounts to 23-39 % of LHV in fuel
The production of cooling from waste heat corresponds to an extra power efficiency of 4%

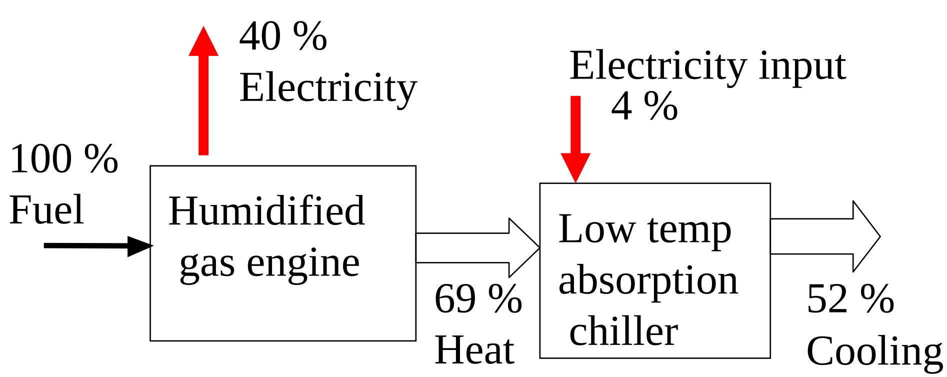
Humidification of inlet air and pressurized flue gas condensers in the gas motors may be useful to obtain more heat for the driving of absorption coolers.
The waste heat from such an ”advanced trigeneration plant” amounts to 69 % of LHV in fuel.
The production of cooling from waste heat corresponds to an extra power efficiency of 9 %
The process has been simulated but not yet demonstrated in practical operation



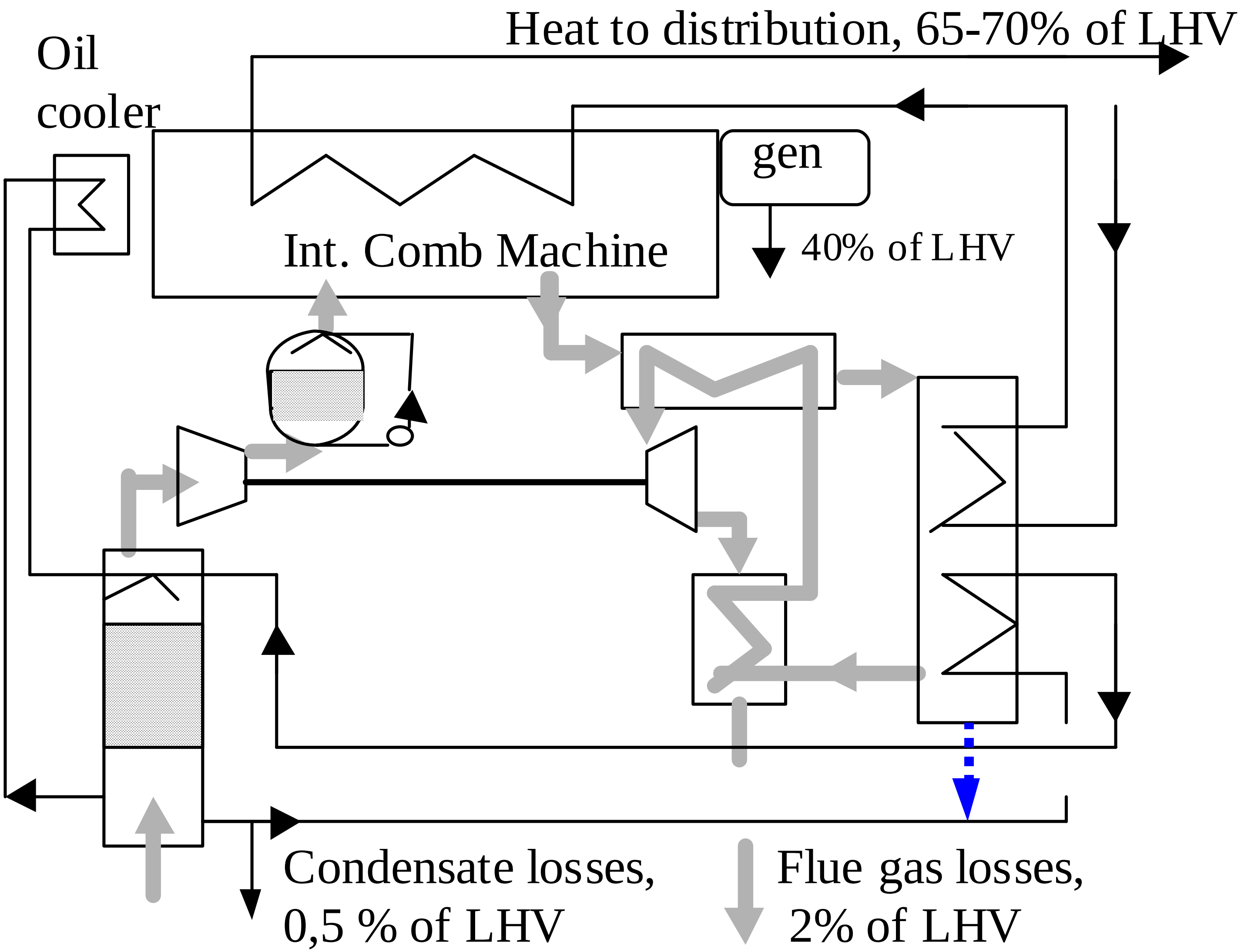
Reference case



Conventional trigeneration



Advanced trigeneration with humidi-fication and pressurized flue gas condensation



Flow scheme for advanced trigeneration plant with inlet air humidification and pressurized flue gas condenser .

Reference: Lindmark S.,Westermark M., Martin V., Dirodi N. Proceedings of ECOS 2003. Copenhagen, Denmark june 30- July 2, 2003, 233-240