HUTTER FREI POWER GMBH

High grade, high efficient and low emission Combined Heat and Power Stations and Combined Cycle Gas Turbine CHP Stations with high operating flexibility

Combined Cycle CHP Station = Combination of Gas Cycle & Water-Steam Cycle

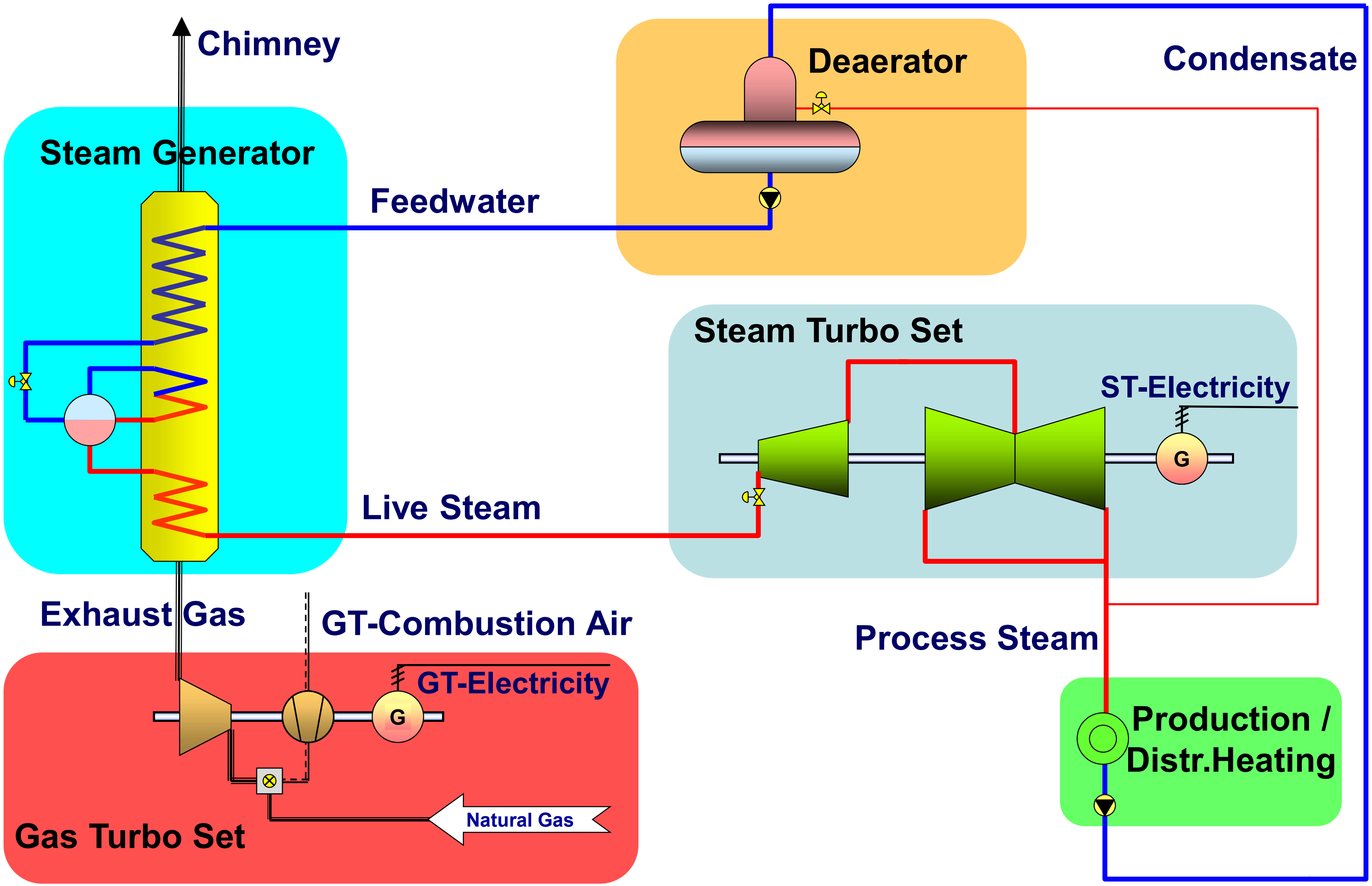
(Combined Cycle CHP Station without Process-Steam-Condensation outside the Useful-Heat-Consumer)

Gas Turbine generates Mechanical Energy, hot GT-Exhaust Gases and Rest-Oxygen in Exhaust Gas (for possible combustion in Boiler Firing)

GT Exhaust Gases are cooled-down in **Steam Generator** and generate Steam

Steam generates in **Steam Turbine** Mechanical Energy and supplies Useful Steam

Mechanical Energies of Turbines are transformed in GT- and ST-Generator in Electricity



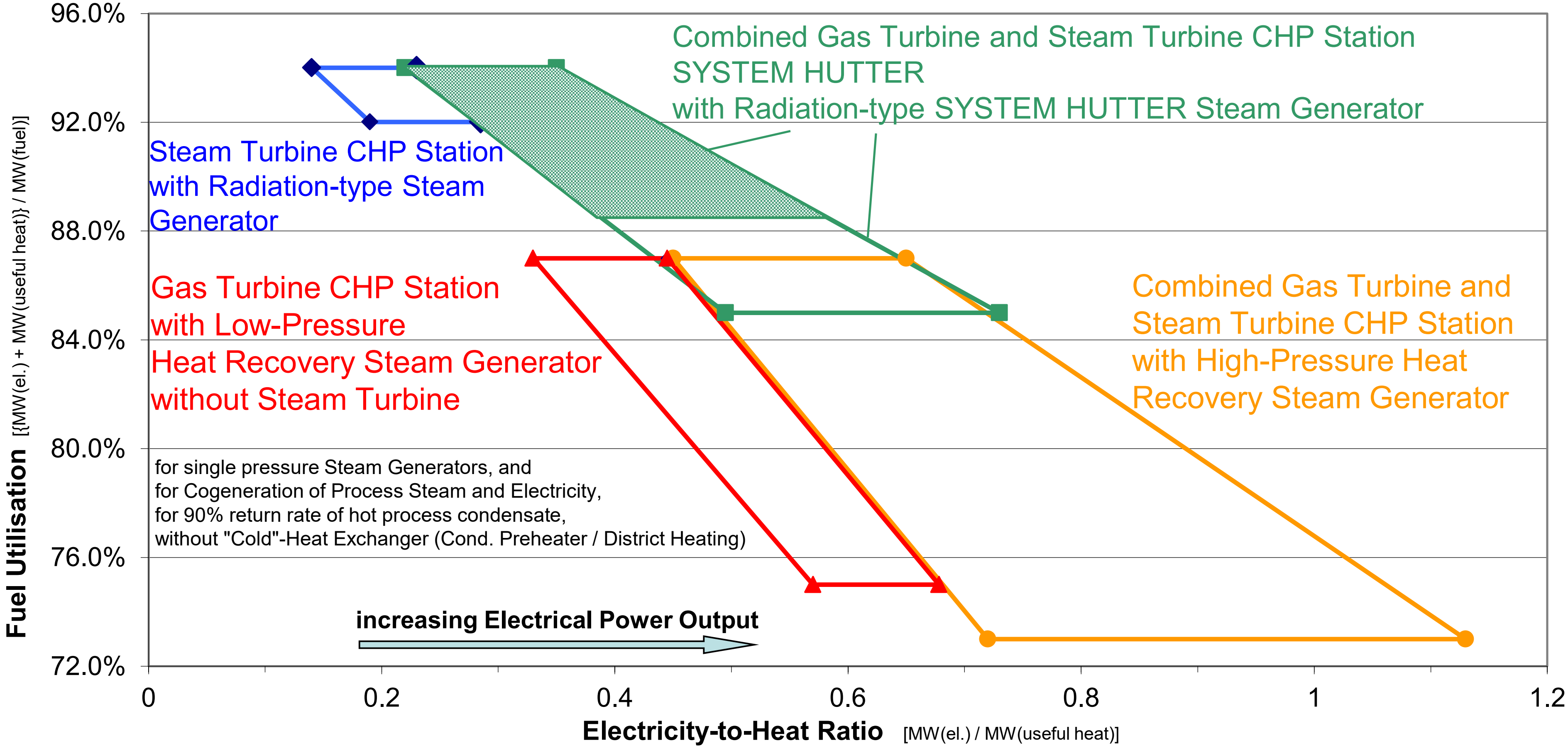
Turbine-based Cogeneration Plant Cycles

Heating Plant (Steam Generator only)	Low Pressure Steam Generator without electricity generation (purchasing of all electricity)
Steam Turbine CHP Station (CHP = Combined Heat and Power)	Radiation type High Pressure Steam Generator back-pressure, extraction and/or condensing Steam Turbine
Gas Turbine with Low Pressure HRSG (HRSG = Heat Recovery Steam Generator)	Gas Turbine with unfired or fired Low Pressure Heat Recovery Steam Generator (without Steam Turbine)
Gas Turbine with High Pressure HRSG & ST	Gas Turbine with unfired or fired High Pressure Heat Recovery Steam Generator back-pressure, extraction and/or condensing Steam Turbine
GT with Multiple-Pressure HRSG & ST (GT = Gas Turbine)	Gas Turbine with unfired or fired Multiple-Pressure Heat Recovery Steam Generator back-pressure, extraction and/or condensing Steam Turbine
Combined Cycle CHP SYSTEM HUTTER	Gas Turbine with Radiation-type SYSTEM HUTTER Steam Generator back-pressure, extraction and/or condensing Steam Turbine

Turbine-based Cogeneration Plant Cycles

Design Range of Gas Turbine and/or Steam Turbine based Combined Heat and Power Station Types

without Condensation Steam Turbine



Remark: This diagram does show the possible Range of 100% Load Points, but not the Operation Range of one particularly designed Plant

Turbine-based Cogeneration Plant Cycles

Steam Turbine CHP Station

- with classical Radiation-type Steam Generator
- highest Fuel Utilisation Factor (Total Efficiency)
- lowest Fuel Heat Input
- less sensitive against Fuel Price Escalation
- generate less Electricity than Combined Cycle CHP Station SYSTEM HUTTER

Gas Turbine with Heat Recovery Steam Generator (and Steam Turbine)

- significantly reduced Fuel Utilisation Factor
- significantly more Fuel Heat Input than Combined Cycle CHP Station SYSTEM HUTTER
- highly sensitive against Fuel Price Escalation
- restricted operation flexibility

SYSTEM HUTTER (Combined Gas Turbine & Steam Turbine CHP Station)

- with radiation-type SYSTEM HUTTER steam generator instead of heat recovery steam generator
- same highest Fuel Utilisation Factors than Steam Turbine CHP Stations
- less sensitive against Fuel Price Escalation
- generate significantly more Electricity than Steam Turbine CHP Stations
- extended operation flexibility and the ratio between electricity- & steam generation is adjustable
- most economical in a wide area of variable boundary conditions
  (e.g. typically at Price Ratio “Electricity / Fuel” between approx. 3.6 and 1.8)

Choice of Turbine-based Cogeneration Plant Cycle

Turbine-based Cogeneration Stations
can due to technical reasons **not have at the same time**
highest Electricity Generations and highest Fuel Utilisations

Turbine-based Cogeneration Stations for useful steam without Condensation Steam Turbine have at given Cogeneration-Cycle and at const. Live Steam Pressure and -Temperature with **increasing Electricity-to-Heat Ratio above approx. 0.4 decreasing Fuel Utilisation Factors**, resulting in:

- increasing Electricity Generation,
- excessively-increasing Fuel Consumption and Fuel Costs,
- increasing Sensitivity against Fuel Price Escalation,
- increasing Environmental Costs / CO_2-Costs.
- The Economics is dependent i.e. on Price Ratio “Electricity / Fuel”

Consequently there are two technical extreme directions for the Optimisation:

1. Turbine-based Cogeneration Power Stations with **highest Fuel Utilisation** (lower “Electricity-to-Heat” Ratio)
2. Turbine-based Cogeneration Power Stations with **highest Electricity Generation** (higher “Electricity-to-Heat” Ratio)

Radiation-type Steam Generator versus Heat Recovery Steam Generator

Heat Recovery Steam Generator after Gas Turbine:

Low Steam Generator Firing or unfired Steam Generator after Gas Turbine, therefore:

- Oxygen Content in Flue Gas after Steam Generator is high (15 – 8 Vol.-% O_2), and
- Flue Gas Temperature after Steam Generator Firing is low (normally limited at 800 °C), therefore:
  - Steam Generator Design is Heat Recovery Steam Generator without significant radiation type heat transfer
- **Steam Generator efficiency is low** due to high Flue Gas Massflow and high Flue Gas Temperature at stack
- Steam Generator needs more volume and more space

Radiation-type Steam Generator after Gas Turbine:

High Steam Generator Firing after Gas Turbine, therefore:

- Oxygen Content in Flue Gas after Steam Generator is low (2 – 8 Vol.-% O_2), and
- Flue Gas Temperature after Steam Generator Firing is higher (> 1000 °C), therefore:
  - Steam Generator Design is Radiation-type Steam Generator with significant radiation type heat transfer
- **Steam Generator efficiency is high** due to low Flue Gas Massflow and low Flue Gas Temperature at stack
- Steam Generator is a compact design and needs only a smaller space

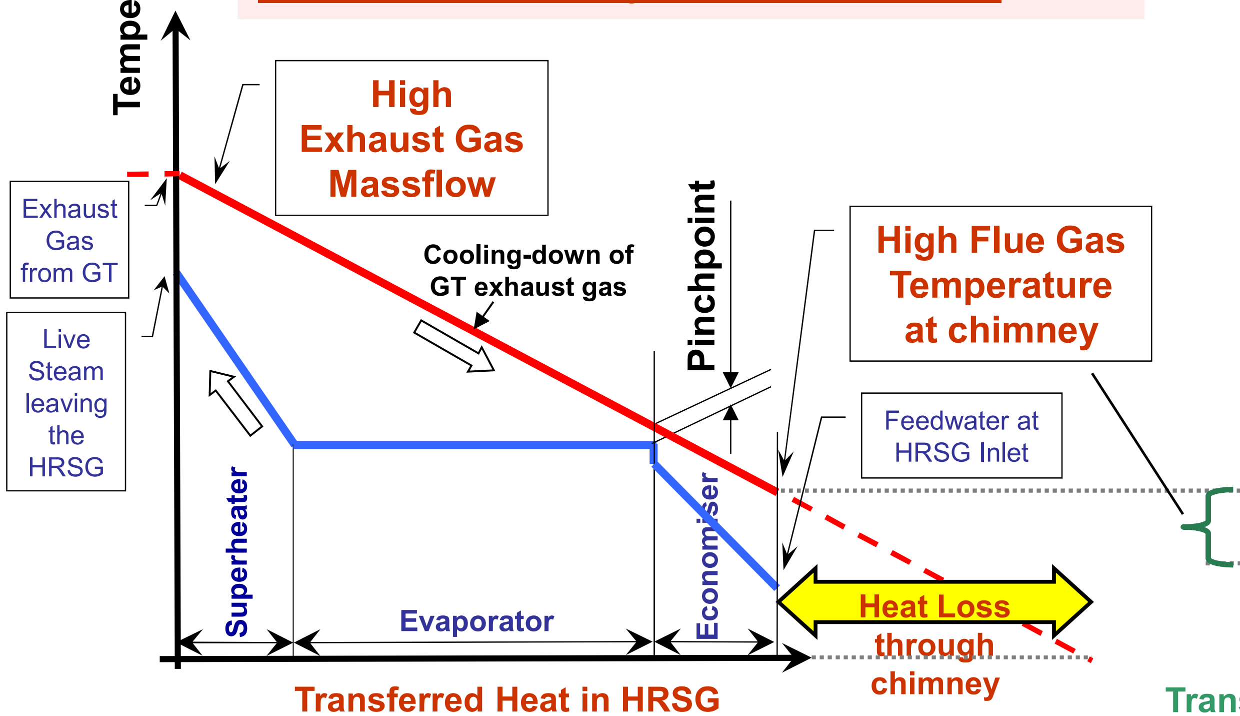
Choice of Turbine-based Cogeneration Plant Cycle

GT with Heat Recovery Steam Generator HRSG

Flue Gas Mass Flow up to 5 times higher

Flue Gas Temperature at chimney up to 40% higher

Heat Loss through chimney up to 7 times higher than with Radiation-type Steam Generator

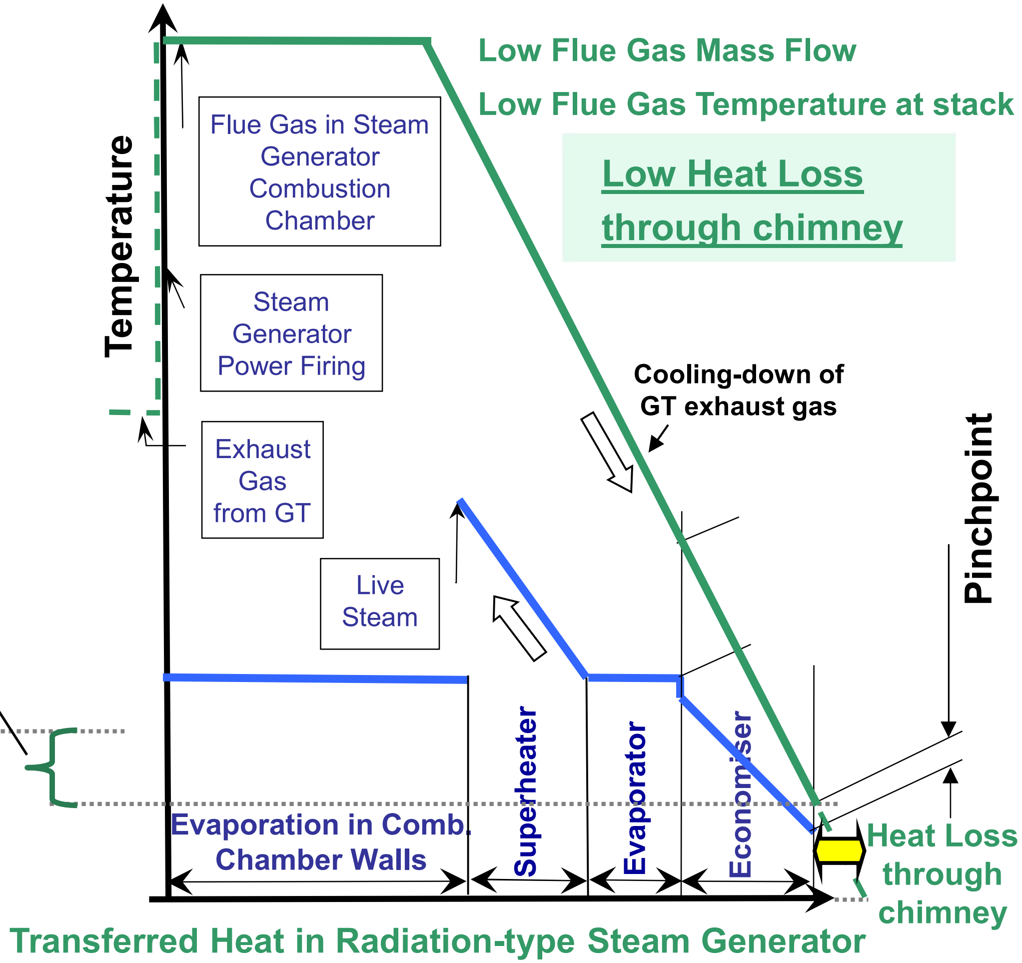


GT with Radiation-type Steam Generator

Low Flue Gas Mass Flow

Low Flue Gas Temperature at stack

Low Heat Loss through chimney



Heat Loss through chimney ~ Flue Gas Mass Flow x Flue Gas Temperature

Choice of Turbine-based Cogeneration Plant Cycle

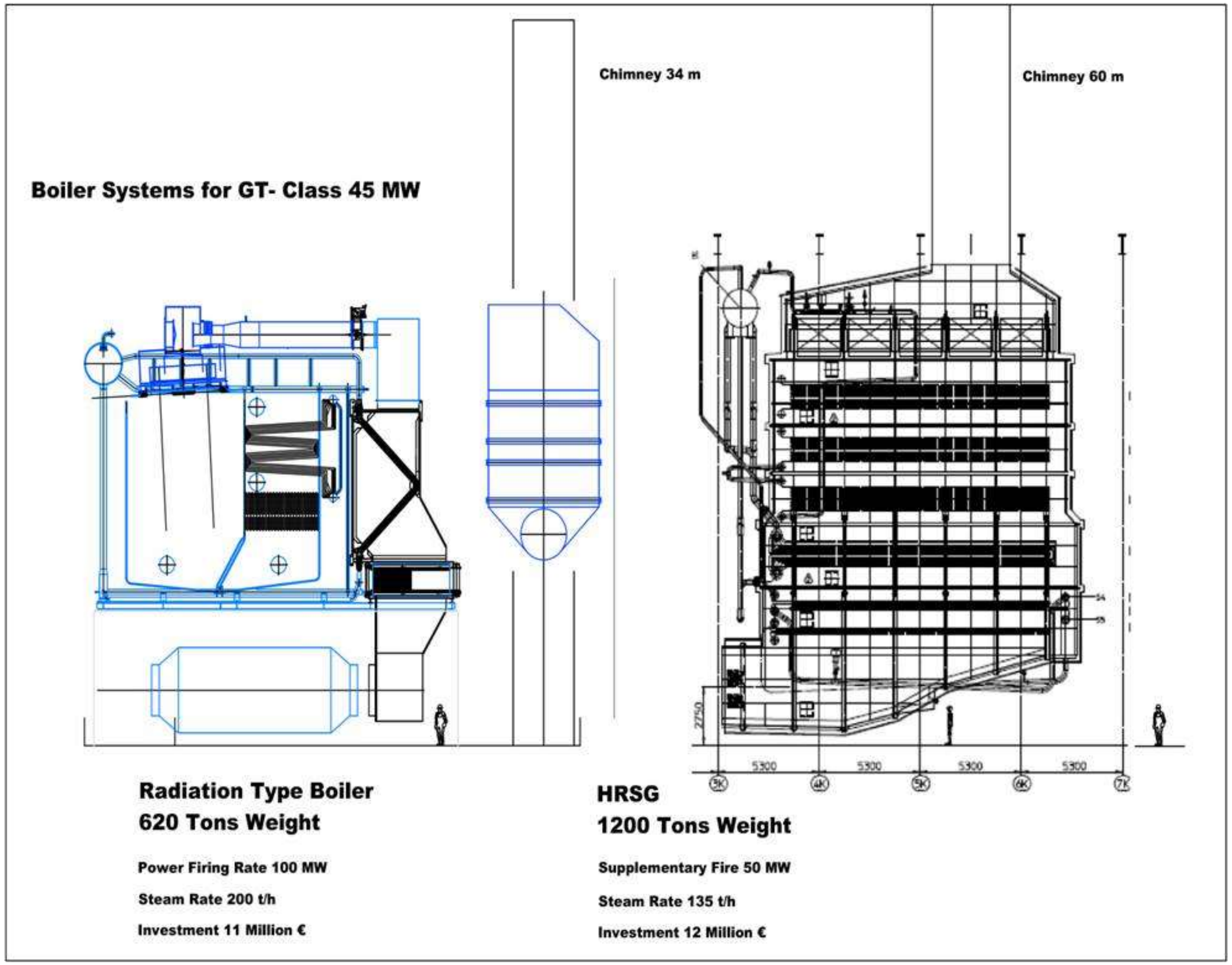
For the same Gas Turbine: **Heat Recover Steam Generators have up to double weight and 35% lower nominal live steam mass flow than Radiation-type Steam Generators**

Radiation-type Steam Generator:

The **combustion chamber** is cooled by Evaporator walls (**membrane walls**), to take the radiation heat from the Steam Generator firing.

The **heat transfer by radiation** in the combustion chamber is **by factors more effective** than in the convection heat exchangers.

The Radiation-type Steam Generator needs less heat exchanger surfaces and steel.



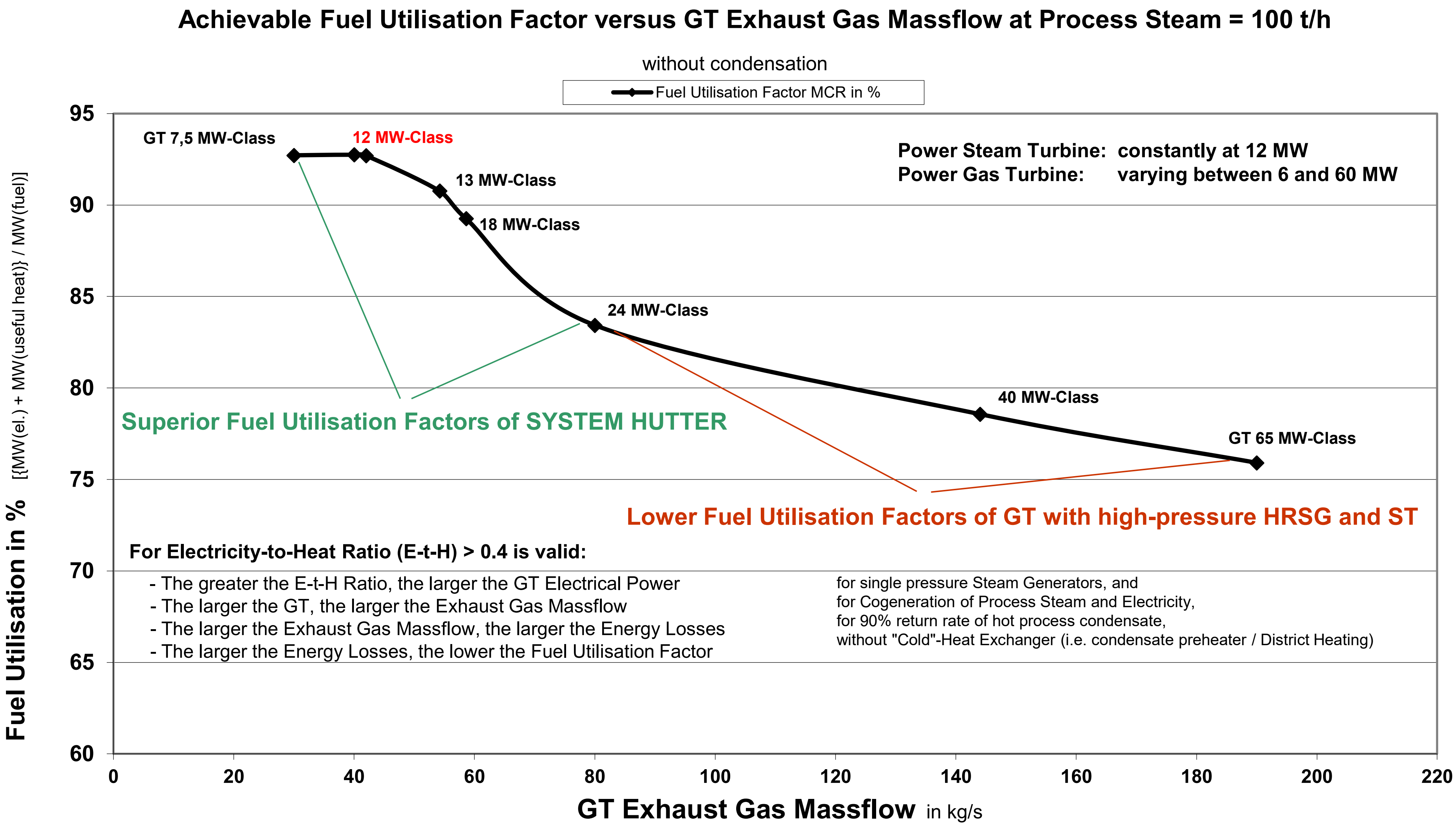
Heat Recovery Steam Generator:

If fired, the supplementary firing is located either in the exhaust gas duct or in a **combustion chamber**, which consists of refractory setting walls (**un-cooled walls**).

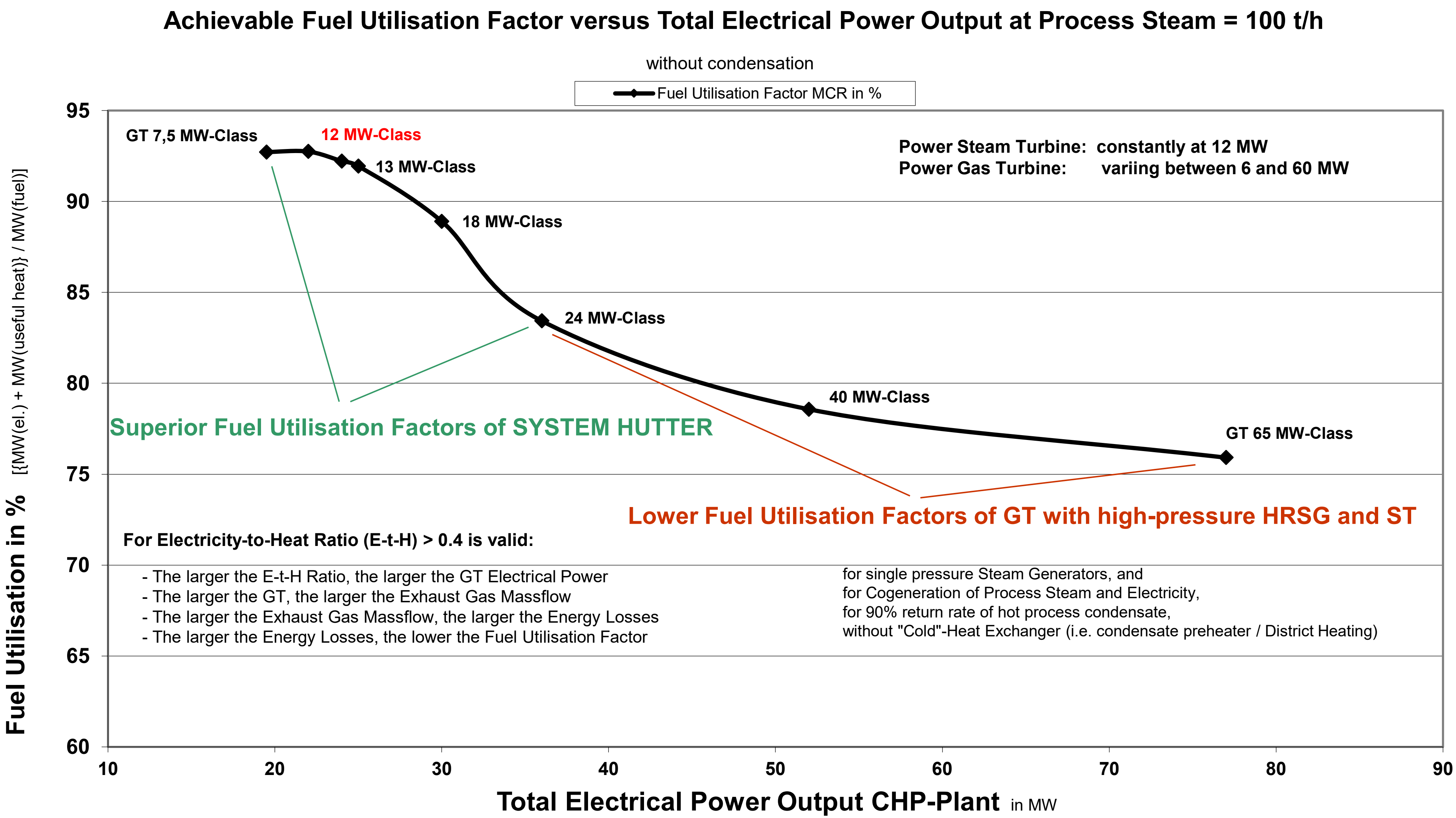
Consists **only of convection heat exchangers**. Only small content of heat transfer occurs as radiation, biggest part as convection, therefore **less effective heat transfer**.

The Heat Recovery Steam Generator needs more heat exchanger surfaces and more steel.

Fuel Utilisation decreases with larger GTs due to higher Exhaust Gas Massflow



Fuel Utilisation decreases for Power-to-Heat ratio >0,4 with increasing El. Power



Superior Economy of Plants with high Fuel Utilisation Factors

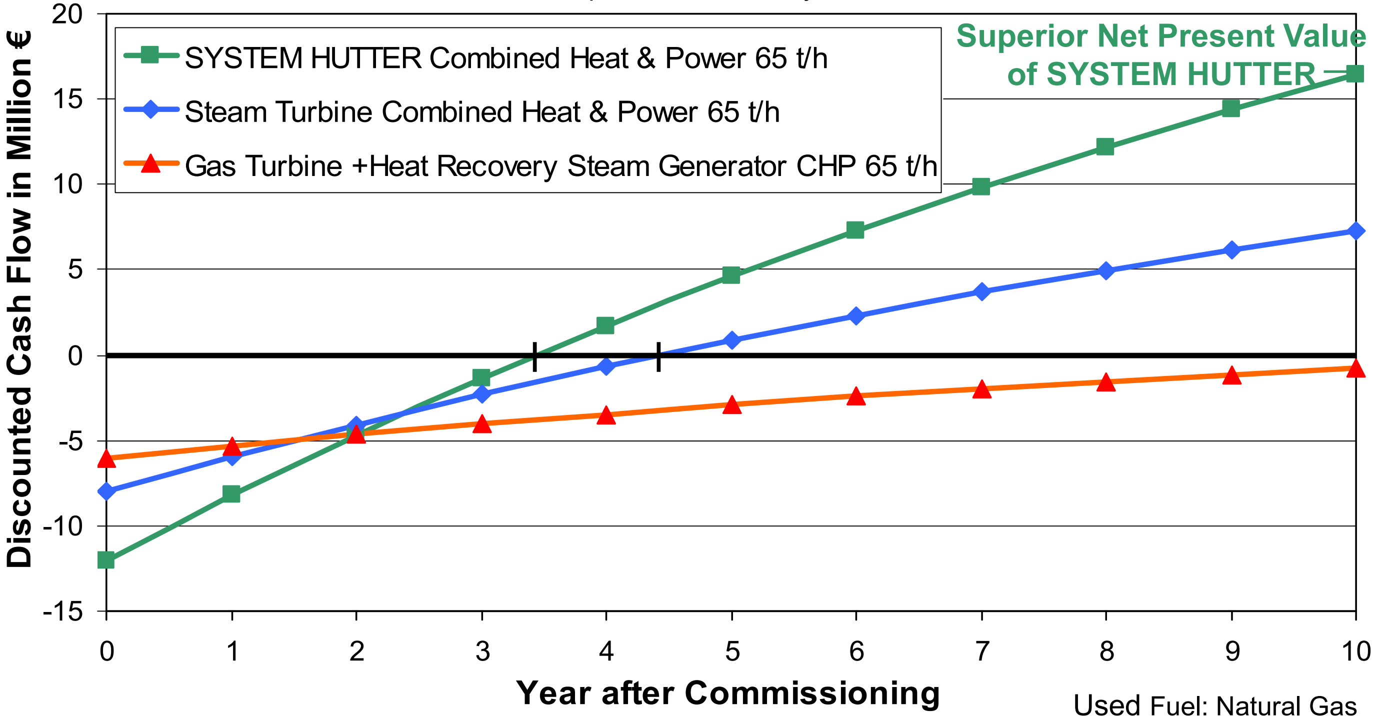
Economical Comparison:

Base is Steam Generator Plant and
Purchasing of all Electricity

- SYSTEM HUTTER CHP Station
- Classical Steam Turbine CHP Station
- Gas Turbine with Heat Recovery Steam Generator (HRSG) CHP Station

Discounted Cash-Flow DCF & Net Present Value

Price Ratio "Electricity / Fuel Gas" = 2.6
Rate of Interest = 7%
Depreciation = 10% / year



Used Fuel: Natural Gas

for single pressure Steam Generators, and
for Cogeneration of Process Steam and Electricity and for 90% return rate of hot process condensate,
without Condensation,
without "Cold"-Heat Exchanger (i.e. condensate preheater / District Heating)

Break Even Time:

- SYSTEM HUTTER CHP 3.4 Years
- Steam Turbine CHP 4.5 Years
- Gas Turbine with HRSG CHP > 10.0 Years

Net Present Value:

- SYSTEM HUTTER CHP 17.0 M €
- Steam Turbine CHP 7.5 M €
- Gas Turbine with HRSG CHP -1.0 M €

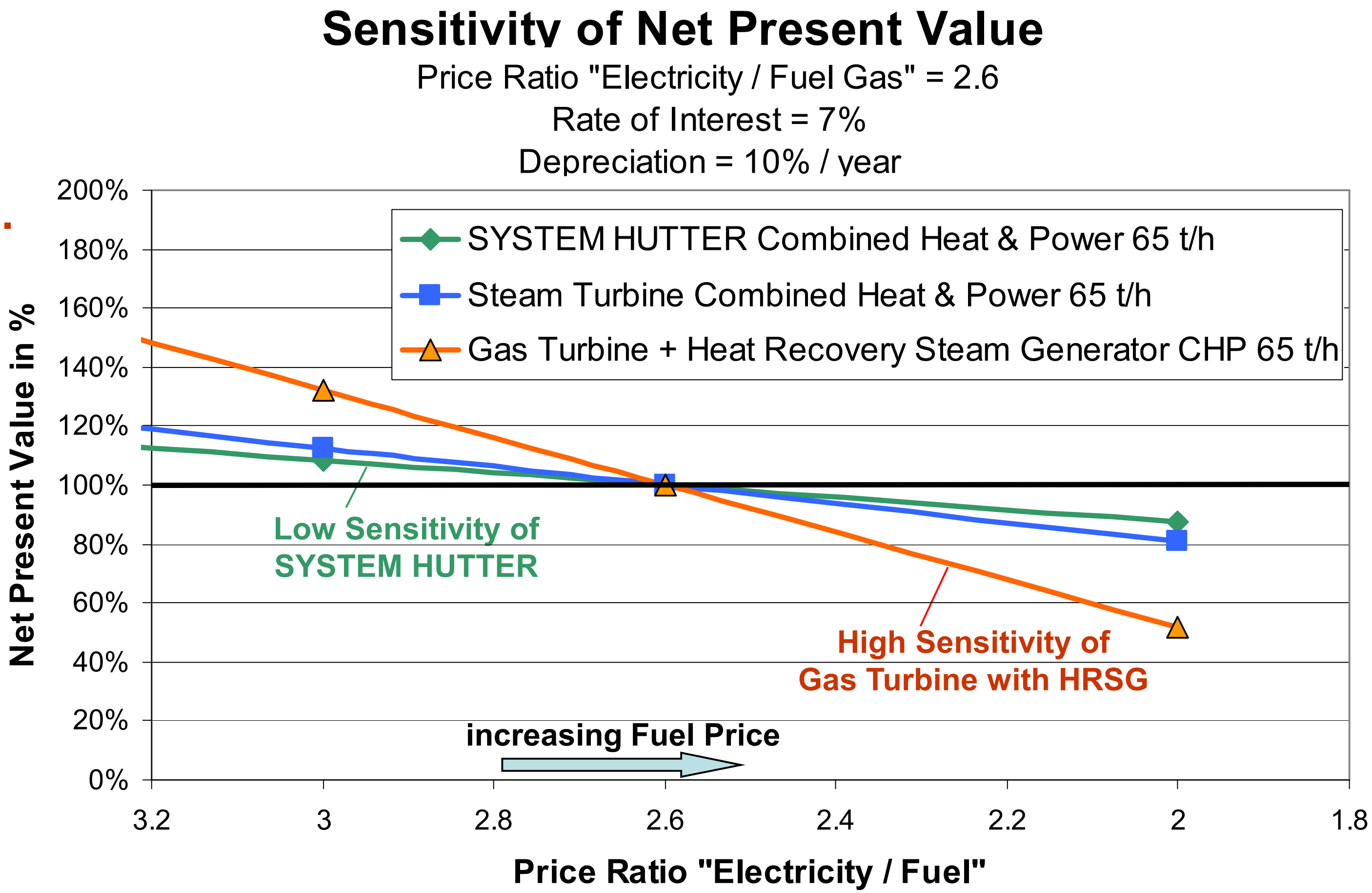
High Fuel Utilisation - Low Sensitivity against Fuel Price Escalation

GT with Heat Recovery Steam Gen.

- will go out of economic operation with increasing Fuel Price

SYSTEM HUTTER

- **is economically superior at Price Ratio "Electricity / Fuel" between approx. 3.6 and 1.8**



Used Fuel: Natural Gas

Base is Steam Generator Plant and
Purchasing of all Electricity

Superior Economy of Plants with high Fuel Utilisation Factors

Economical Comparison:

Base is Steam Generator Plant and
Purchasing of all Electricity

Fuel: Natural Gas

Discounted Cash-Flow DCF & Net Present Value

Price Ratio "Electricity / Fuel Gas" = 2.6
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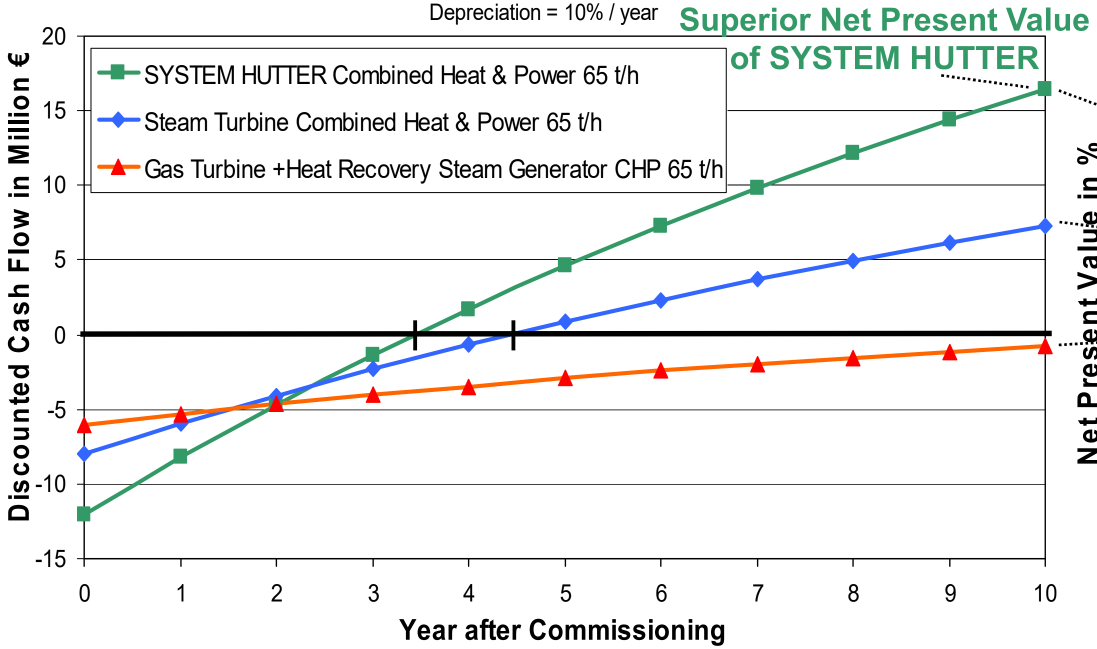
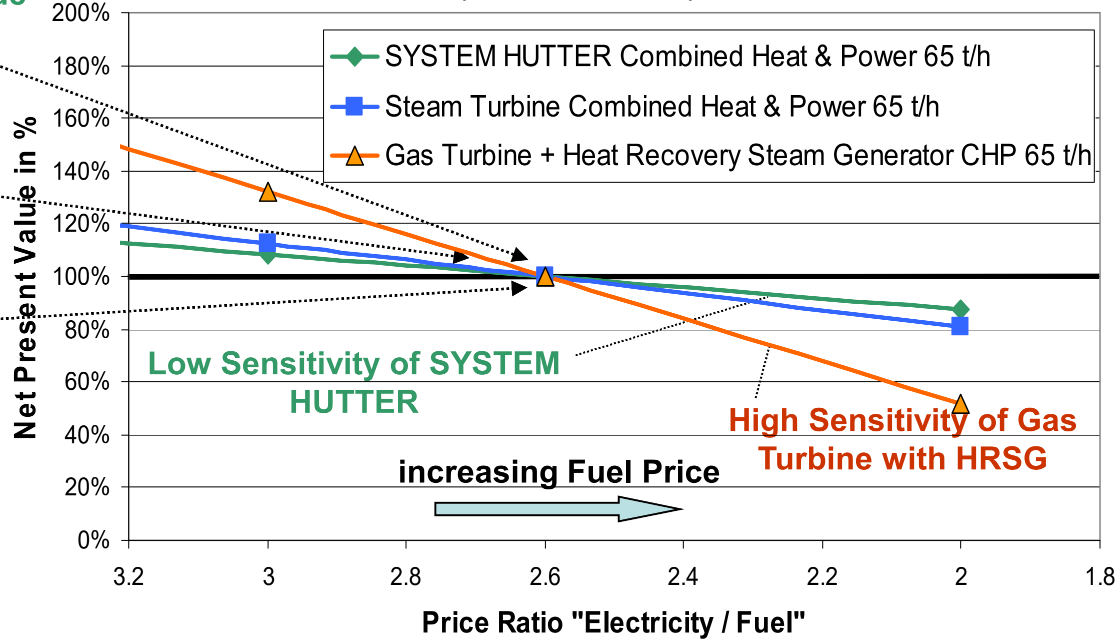


Sensitivity of Net Present Value

Price Ratio "Electricity / Fuel Gas" = 2.6
Rate of Interest = 7%
Depreciation = 10% / year



for single pressure Steam Generators, and
for Cogeneration of Process Steam and Electricity and 90% return rate of hot process condensate,
without Condensation
without "Cold"-Heat Exchanger (i.e. condensate preheater / District Heating)

Choice of Turbine-based Combined Heat & Power Station Cycles

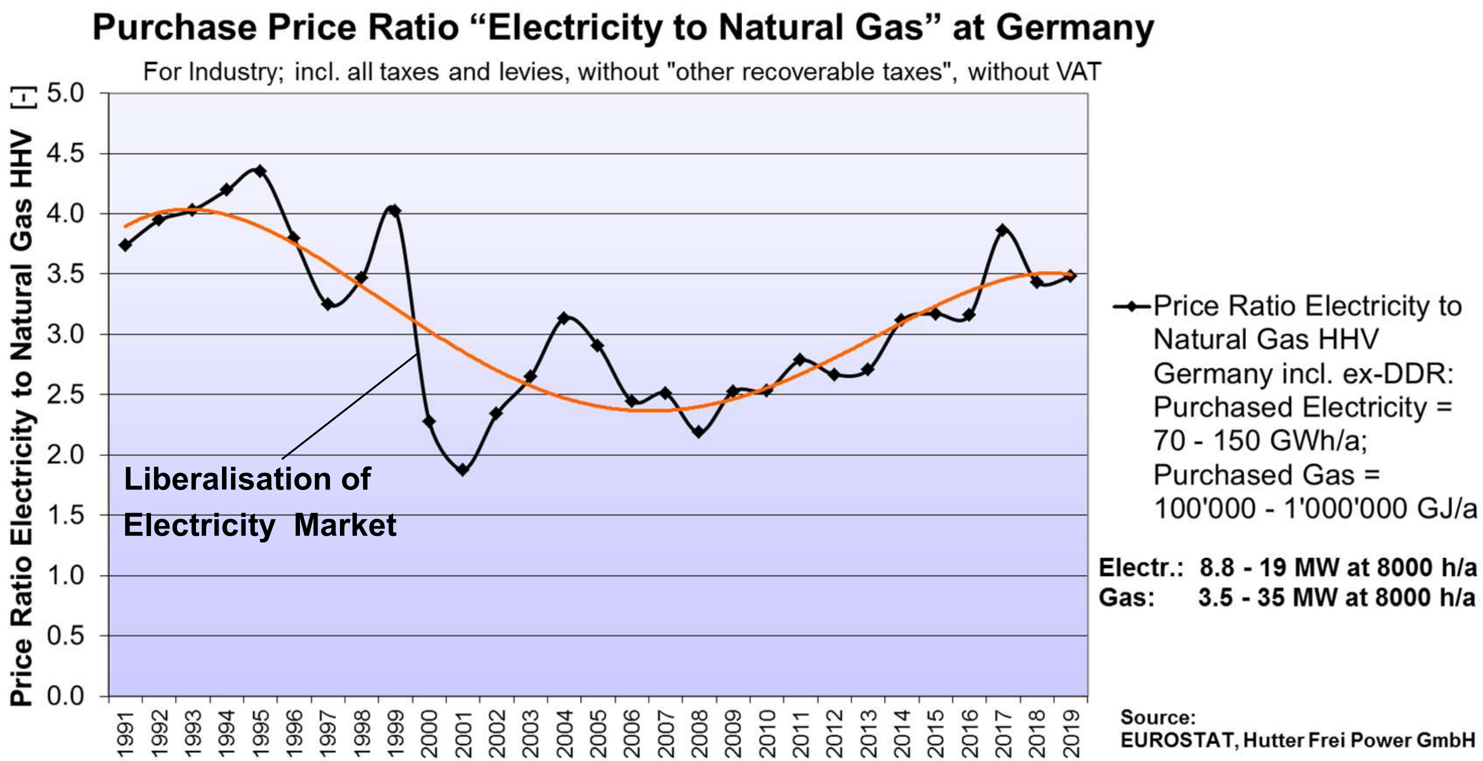
Price Ratio Electricity / Natural Gas in Europe is without big crises expected to stay between ~ 1.8 and 3.5 in the medium term

Natural Gas:

Natural Gas price still is correlated to Fuel Oil price. In the future this will change. Higher demand is covered by new pipelines. There is no supply bottle-neck in the mid term. Prices are especially influenced by crises situations or latest to a certain extent by speculation.

Electricity:

Price and demand correlates with economic growth rates. Price is heavily dependant on political / legal boundary conditions for the different Electricity Generation Technologies. There is no significant dependence between Natural Gas and Electricity price level



Choice of Turbine-based Cogeneration Plant Cycle with fossil fuels

Typical economically optimal Range

of Turbine-based Cogeneration (Combined Heat & Power) Stations
with fossil fuels for useful steam,
expressed with Price Ratio Electricity / Fuel;
without subsidies,

	Economic Optimum at Price Ratio Electricity / Fuel	Achievable Fuel Utilisation Factor	Achievable Ratio Electricity-to-Process Heat
Radiation-type Steam Generator with Steam Turbine (Steam Turbine CHP Station)	less than 1.8	> 90 %	0.1 – 0.3
Gas Turbine with Radiation Type SYSTEM HUTTER Steam Generator and Steam Turbine (Combined Cycle CHP Station SYSTEM HUTTER)	1.8 to 3.6	88 - 94 %	0.2 – 0.8
Gas Turbine with Heat Recovery Steam Generator (HRSG) and Steam Turbine (Combined Cycle CHP Station with HRSG)	more than 3.6	70 – 87 %	0.3 – 1.2

for 1-pressure Steam Generators,
without Condensation,
without „cold"-heat exchangers (Condensate Preheater / District Heating)

Choice of Turbine-based Cogeneration Plant Cycle with fossil fuels

Cogenerations for useful steam (Price Ratio Electricity / Fuel < 1.8):

The optimisation typically leads to
forced-draught fan operated **Radiation-type Steam Generator**
with subcritical live steam conditions, and
(extraction-) back-pressure steam turbine (**Steam Turbine CHP Station**)

Gas-fired Cogenerations for useful steam (Price Ratio Electricity / Fuel 1.8 - 3.6):

The optimisation typically leads to
Gas Turbine with exhaust gas operated **Radiation-type Steam Generator** with maximum possible Steam Generator power firing, using all remaining oxygen from gas turbine exhaust gas,
with subcritical live steam conditions, and
(extraction-) back-pressure **Steam Turbine** (**SYSTEM HUTTER CHP Station**)

Gas-fired Cogenerations for useful warm water or high electricity-to-heat ratio demands:

The optimisation typically leads to
Gas Turbine with single or multiple-pressure cycle **Heat Recovery Steam Generator** (HRSG) with additional Steam Generator firing, with subcritical live steam conditions, and
(extraction-) back-pressure or condensing **Steam Turbine** (**Gas Turbine CHP Station with HRSG**)

Example of the Economy of Turbine-based CHP Stations for useful steam

- 15 percent point differences of the total efficiency η determine a Return of Investment between an IRR (Internal Rate of Return) of Zero (η = 75%) to 35 % (η = 90%)

- The emphasis of the design is placed on a maximisation of the Steam Turbine Power in the Steam Turbine back-pressure process

- The Investment-Security increases (Sensitivity decreases) with an increasing Fuel Utilisation Factor

Combined GT & ST CHP Station SYSTEM HUTTER

is a high-grade Combined Gas Turbine- and Steam Turbine-CHP Station,
own developed and based on **own patents**,
achieving highest fuel utilisation factors and
superior economy,
saving CO_2-emissions and reducing CO_2-Costs,
using a Radiation-type SYSTEM HUTTER Steam Generator
instead of a Heat Recovery Steam Generator (HRSG)

SYSTEM HUTTER

is designed for Cogeneration / Combined Heat & Power (CHP) Applications
in Industries and District Heating Systems,
for the simultaneous generation of
Electricity and Process Steam or District Heating Steam

Background of Development of Combined Cycle CHP Station SYSTEM HUTTER

Steam Turbine (ST) CHP Station

- is the Classical Turbine-based Cogeneration Cycle
- contains a Radiation type Steam Generator, therefore
- achieve highest Fuel Utilisation Factors
- economical for the price ratio “Electricity / Fuel” < 1.8
- low Sensitivity against Fuel Price Escalation

SYSTEM HUTTER CHP Station

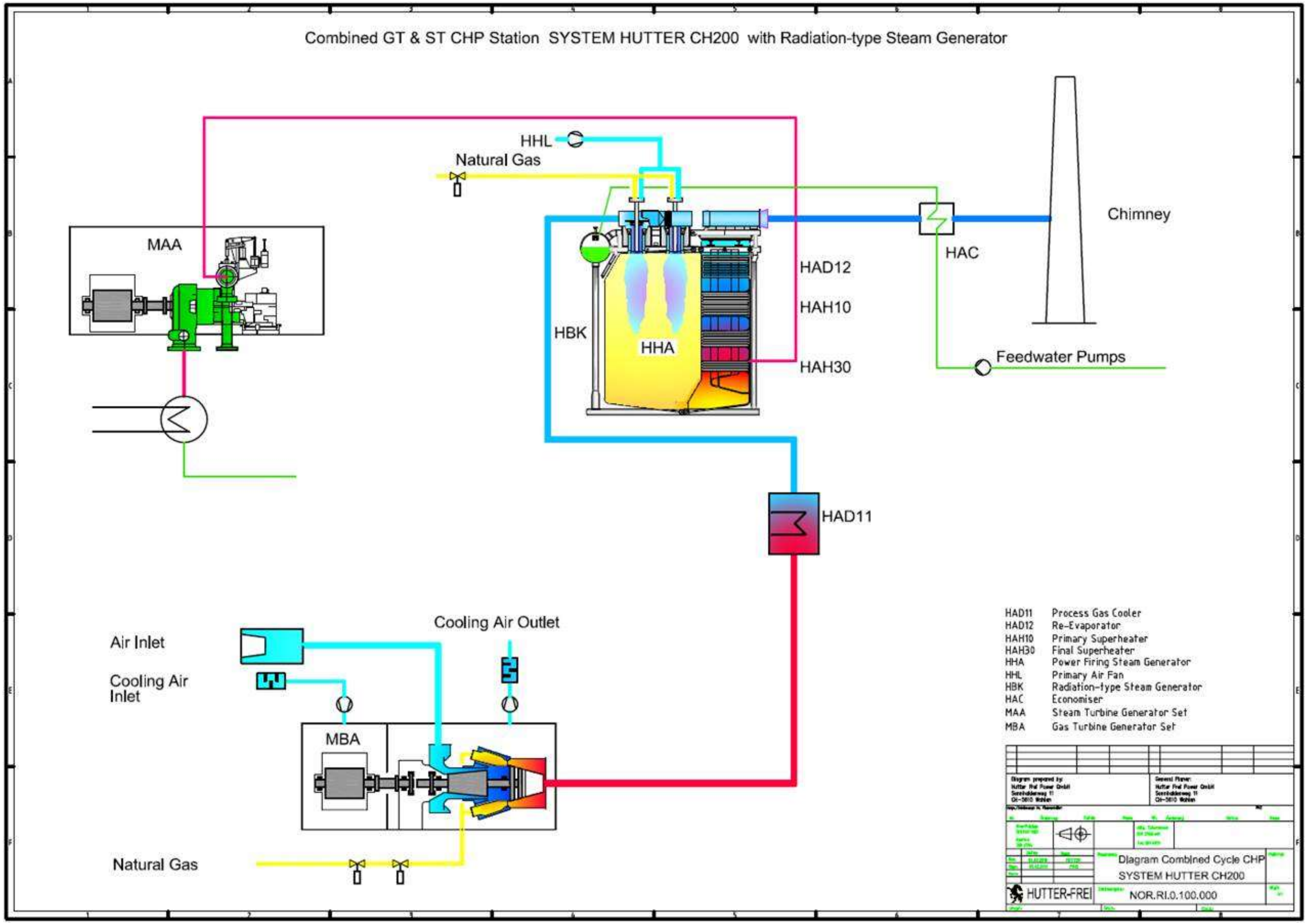
- is based on the Steam Turbine CHP Station, but
- added with Gas Turbine (GT) upstream the Radiation-type SYSTEM HUTTER Steam Generator, therefore
- generate higher Electrical Power Output, by
- keeping the same highest Fuel Utilisation Factors than with Steam Turbine CHP Stations, and
- keeping the low Fuel Consumption and low CO_2-Emissions
- extended operation flexibility and the ratio between electricity- & steam generation is adjustable
- low Sensitivity against Fuel Price Escalation
- resulting in a **superior Economy** for the price ratio “Electricity / Fuel” between 1.8 & 3.6

Main Components of Combined Cycle CHP Station SYSTEM HUTTER

- Gas Turbine Package with GT Air Filter House & Acoustics
- GT Exhaust Gas Silencer
- GT Exhaust Gas and Flue Gas Duct System
- GT Exhaust Gas Flaps
- Special Heat Exchangers, external to Steam-Generator-Casing
- Radiation-type Steam Generator SYSTEM HUTTER
- Power Firing for Steam Generator
- Electrical Systems and Components
- Distributed Control Systems and Equipment
- Instrumentation
- Piping & Valves
- Optional depending on available existing Equipment:
  - Steam Turbine Package
  - Water / Steam Cycle Components and Systems
  - Balance of Plant Components
  - Electrical & Control Components
  - Buildings, HVAC

Flow Scheme of Combined Cycle CHP Station SYSTEM HUTTER

Combined Cycle CHP Station
SYSTEM HUTTER
with
Gas Turbine on down-stream-arranged Radiation-type High Pressure SYSTEM HUTTER Steam Generator and
Steam Turbine

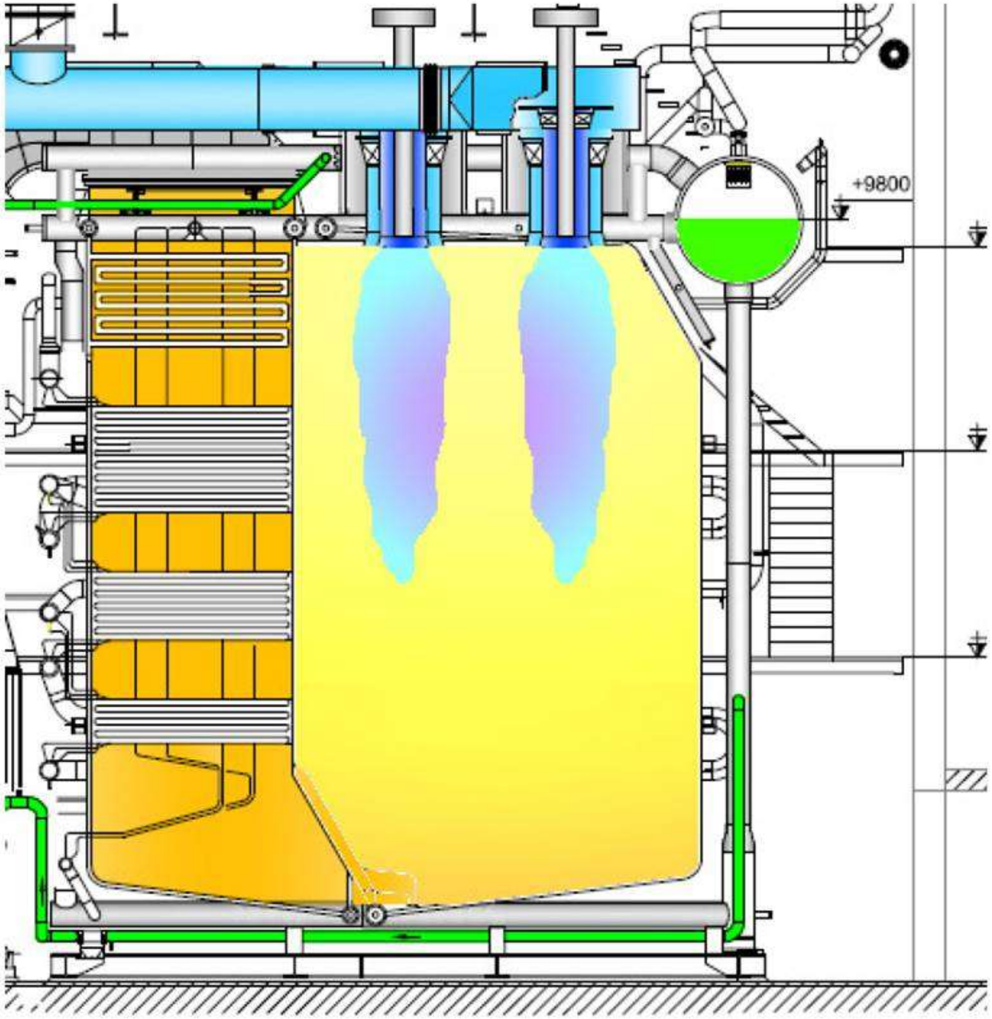


Radiation-type Steam Generator SYSTEM HUTTER

Live Steam Generation	30 t/h
Live Steam Pressure	45 bar
Live Steam Temperature	450 °C

Radiation-type Steam Generator SYSTEM HUTTER

Live Steam Generation	90 t/h
Live Steam Pressure	90 bar
Live Steam Temperature	480 °C



Combined Gas Turbine & Steam Turbine CHP Stations SYSTEM HUTTER

SYSTEM HUTTER are the **solution** of investigations **concerning optimisation** of

- thermal plant cycle concepts
- economic plant parameters
- macro-economic scenarios

Advantages:

- Superior Economy (i.e. Net Present Value, Internal Rate of Return)
- Lower Sensitivity against Fuel Price Escalation
- Highest Fuel Utilisation Factors (Total Efficiencies) up to 94 % – Reduced Fuel Costs
- Reduced CO_2-Emissions – Reduced CO_2-Costs
- Extended Operating Range down to 20 - 30 % of nominal steam generation
- Operation Field (ratio between electricity- & steam generation adjustable) without Condensing Steam Turbine
- High Operation Flexibility with fast process steam load changes
- Highest Time-Reliability
- Environmental Protection by low Air Pollutant Emissions – No Secondary Emission Reduction Costs
- Repowering of existing Steam Turbine CHP Stations or GT with Heat Recovery Steam Generators possible

SYSTEM HUTTER achieve Highest Fuel Utilisation

Fuel Utilisation Factors at full load: (for process steam applications with back-pressure steam turbines)

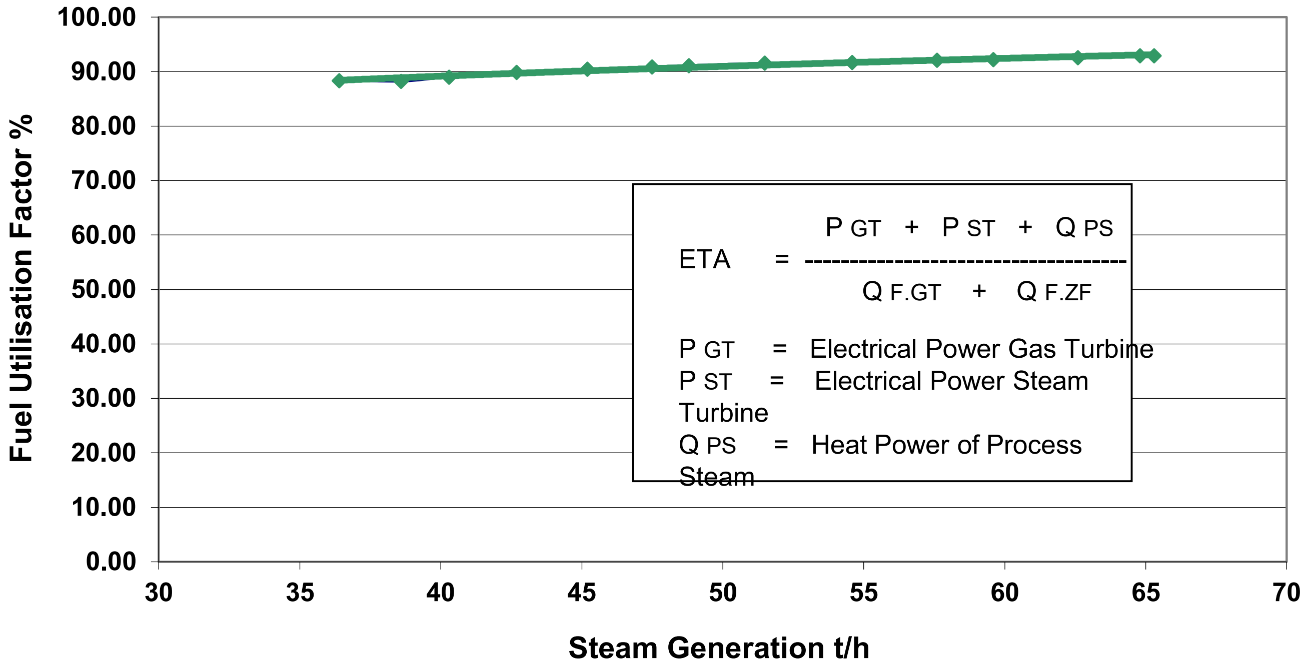
- SYSTEM HUTTER 88 - 94 %
- Gas Turbine with HRSG 74 - 75 %
- GT with High Pressure HRSG and ST
  - fired HRSG 72 – 87 %
  - unfired HRSG 70 – 72 %

for single pressure Steam Generators, and
for Cogeneration of Process Steam and Electricity,
for 90% return rate of hot process condensate,
without "Cold"-Heat Exchanger (i.e. condensate preheater / District Heating)

Combined Cycle SYSTEM HUTTER

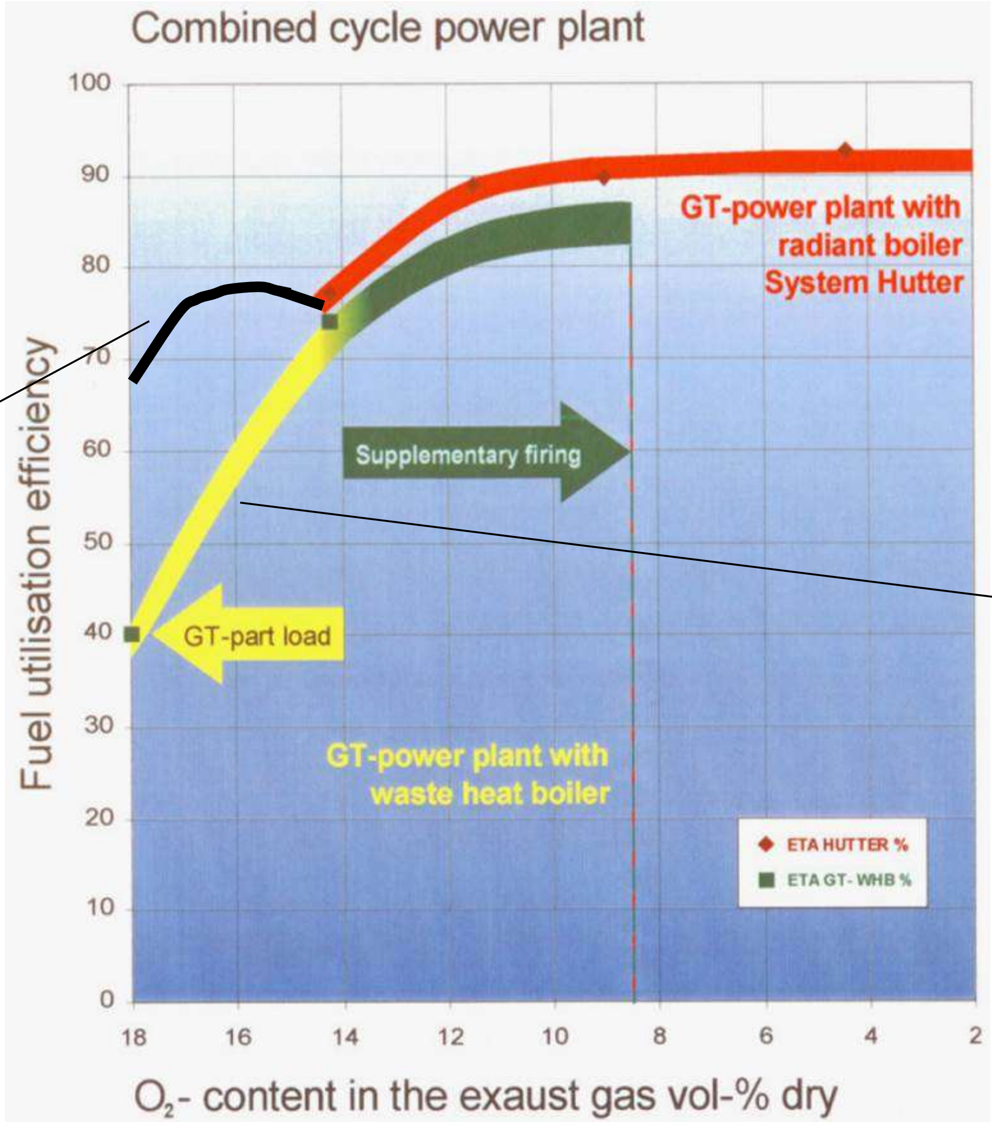
achieve superior Fuel Utilisation Factors at full load and at Part Load

SYSTEM HUTTER CH65
Fuel Utilisation Factors measured



Gas Turbine CHP Stations – Fuel Utilisation vs. Flue Gas Oxygen-Content

for Gas Turbines with decreasing combustion air mass flow at GT part load



for Gas Turbines with constant combustion air mass flow at GT part load

Environmental Costs Reduction by maximum CO_2 Conservation

High-efficient Energy Conversion Systems
are the better answer to
the global challenge of preserving the CO_2 balance.

High-efficient Combined Heat and Power Stations
reduces global CO_2 Emissions by
substituting electricity generation in Thermal Power Stations with
lower Fuel Utilisation Factors.

SYSTEM HUTTER

(compared with Gas Turbine with HRSG)

- **reduces CO_2 costs** due to **reduced CO_2 freight**
- **CO_2 freight is reduced**
  by highest Fuel Utilisation Factors and therefore
  lowest Fuel Heat Input.

SYSTEM HUTTER - Highest Time-Reliability

Time-Reliability of Combined Cycle CHP Stations SYSTEM HUTTER References > 99 % achieved by:

- Integrated System Design with consideration of specific Customer requirements
- Operation Flexibility and fast load changes
- High Quality Components with proven Design
- Robust Design
- Selected Redundancies
- Strong Focus on Quality Assurance from Project Start until Hand-over

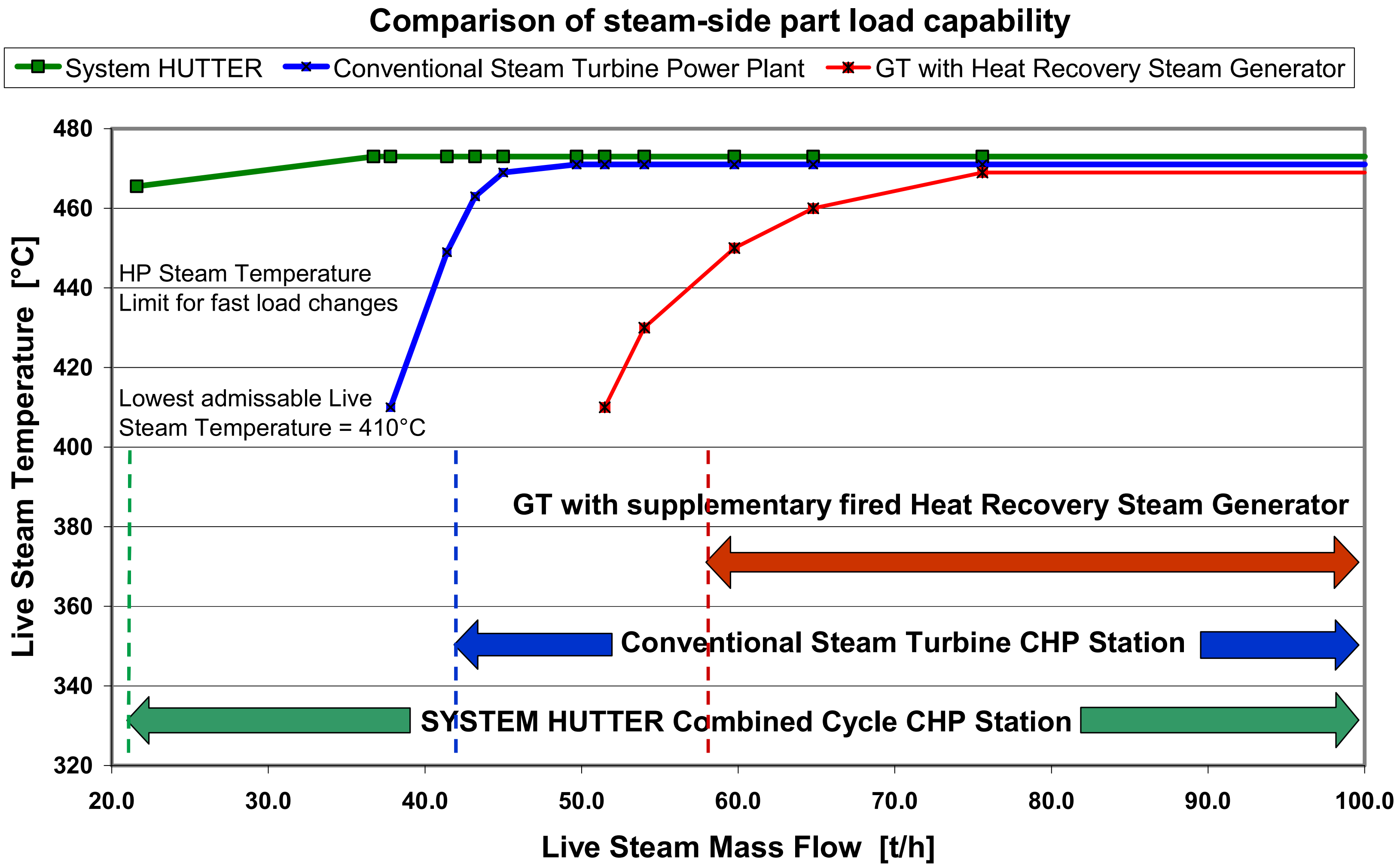
SYSTEM HUTTER – Extended Operation Flexibility

SYSTEM HUTTER Steam Generator Design:

- burning at lowest excess oxygen (2 – 6 Vol.-% O_2 in flue gas at stack), leading to the classical Radiation-type Steam Generator technology (known from ST Power Stations) with highest Steam Generator Efficiency and highest Fuel Utilisation Factor
- optimum burning conditions at Steam Generator Power Firing through the entire load range, no emission escalations at lower load
- stable flame with optimum reliability
- fast firing load changes are possible in order to follow fast changing steam demand
- steam generation can be de-loaded to a low minimum part load of approx. 20 - 30 % of the nominal steam generation
- no fixed ratio between electricity generation and useful heat generation necessary SYSTEM HUTTER CHP Stations can be operated with different adjustable ratios of electricity- and useful steam generation, **without** condensing the steam in a Steam Turbine Condensation Process.
- compact design, smaller footprint and smaller space

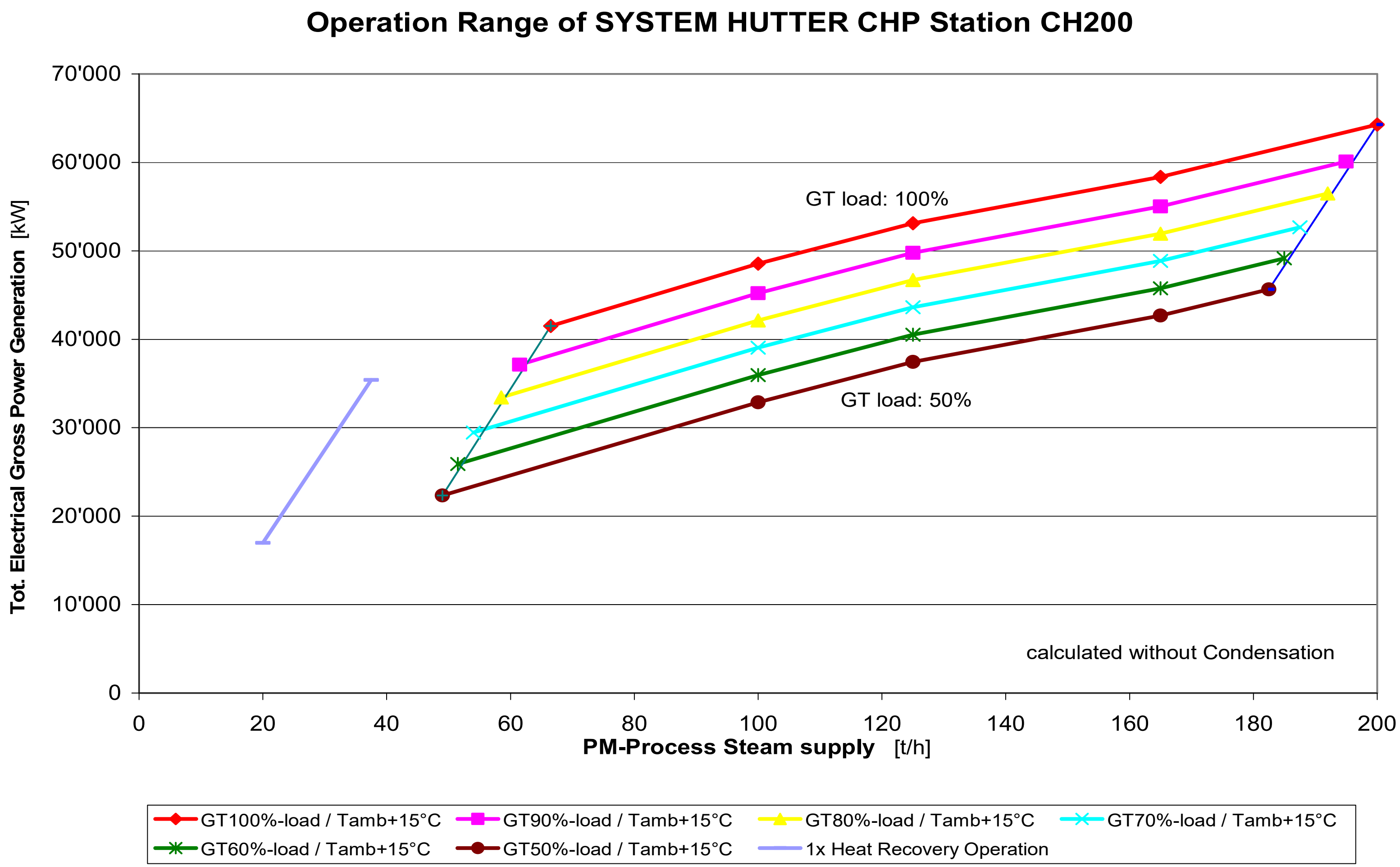
Extended Operating Range down to 20 - 30 % of nominal steam generation

SYSTEM HUTTER – Steam Generation can be de-loaded to a minimum part load of approx. **20 - 30 %** of the nominal steam generation



SYSTEM HUTTER – Extended Operation Flexibility

For SYSTEM HUTTER there is no fixed ratio between electricity generation and useful heat generation. SYSTEM HUTTER CHP Stations can be operated with different ratios of electricity- and useful steam generation, **without** condensing the steam in a Steam Turbine Condensation Process.



SYSTEM HUTTER – Fuel-Flexibility

SYSTEM HUTTER allows the use of different fuels:

Fuel for Gas Turbine

- Natural gas
- Bio gas, e.g. from waste water treatment plant
- Purified gases from technical manufacturing plants
- Purified gases from wastes or residues
- or a mixture of above fuels
- Fuel oil extra light or Diesel (depending on Gas Turbine model only as substitute fuel)

Fuel for Steam Generator-Power Firing

- Natural gas
- Bio gas, e.g. from waste water treatment plant
- Purified gases
- Fuel oil extra light or Diesel
- Fuel oil heavy
- Hard coal (black coal)
- Brown coal (bituminous coal)

SYSTEM HUTTER Operation Flexibility – Installation of either 1 GT or 2 GTs on 1 Steam Generator possible

SYSTEM HUTTER allows the following configurations:

- 1 Gas Turbine on 1 Steam Generator
- 2 Gas Turbines on 1 Steam Generator
- Multiple Lines (Gas Turbine with Steam Generators) on 1 or multiple Steam Turbines

Advantages of 2 GTs on 1 Steam Generator:

- Redundancy of GT Electricity Generation;
- Full Redundancy at GT Exhaust System in case of Maintenance- or Repair Works;
- Plant Load can be reduced to lower minimum part load, therefore
- Minimum steam generation is lower than with 1 GT on 1 Steam Generator.

Operation Flexibility – on line switch-over between GT- and FD Fan operation

SYSTEM HUTTER Steam Generator Design:

- On line switch-over
  between GT operation and Forced-Draught Fan operation
  is possible and was demonstrated

- SYSTEM HUTTER, when equipped with FD Fan system,
  don't impact the Steam Generation
  in case of a GT shut-down

- SYSTEM HUTTER don't need to get oversized for FD Fan Operation, because in Forced Draught Fan Operation, the SYSTEM HUTTER Steam Generator achieves the same max. steam generator as in GT-operation

Extended Part Load Capability & Adjustable Ratio of Electricity to Useful Heat

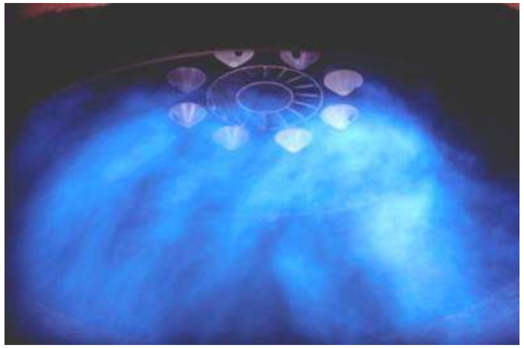
- The SYSTEM HUTTER can control as well **fast** Useful Heat Demand Changes (e.g. paper break), **without the need** of a Condensation Steam Turbine, an Auxiliary Condenser or a Steam Accumulator.
- The SYSTEM HUTTER can then follow the Useful Steam Supply down to a **low part load** of approx. 20 - 30 %, which considerably extends the operation flexibility and the part load capability.
- With the SYSTEM HUTTER the ratio of Electricity- to Useful Steam Generation is not fixed, but can be adjusted within a range, **without the need to condensate** the steam in a Condensation Steam Turbine or Auxiliary Condenser, or without the need of a steam accumulator.

Consequently the SYSTEM HUTTER can adapt the operation mode to changes of the Energy Cost (Electricity- and Fuel Prices) and to the future changes of legal boundary conditions, without restricting the Useful Heat Supply.

- ➢ At very low ratio of Electricity- to Natural Gas Price or even at negative Electricity Prices and with installation of a forced-draught fan for the boiler firing, the Combined Heat & Power Station can be operated as a Heating Plant without Electricity Generation.
- ➢ At low ratio of Electricity- to Natural Gas Price, the Gas Turbine can be de-loaded to part load.
- ➢ At very high ratio of Electricity- to Natural Gas Price and with installation of a condensation process, the Combined Heat & Power Station can generate peak-load Electricity.
- ➢ At request or at the wish of the Electrical Grid Operator, the electrical power output can be reduced.

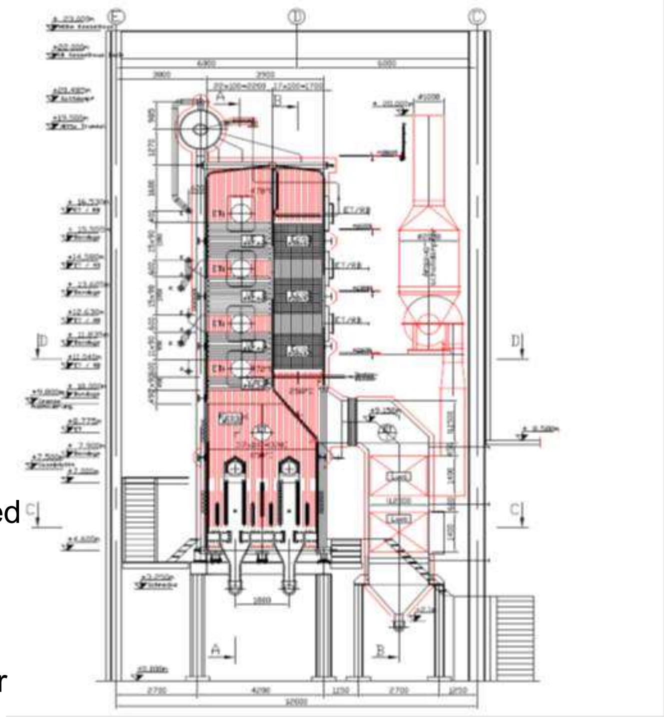
Patent Rights

Our Company is holder of Patent Rights:



- on low emission technology of Steam Generator Firing, and on special thermal
  Steam Generator configuration of Radiation-type SYSTEM HUTTER Steam Generators downstream Gas Turbines to reach highest total efficiencies and consequently fuel savings and reductions of CO_2 emissions
- on CO reduction technologies at fluidised bed incineration plants

Cut-away Gas Turbine ROLLS ROYCE KB5
in the Zellcheming Fair in Wiesbaden, Germany



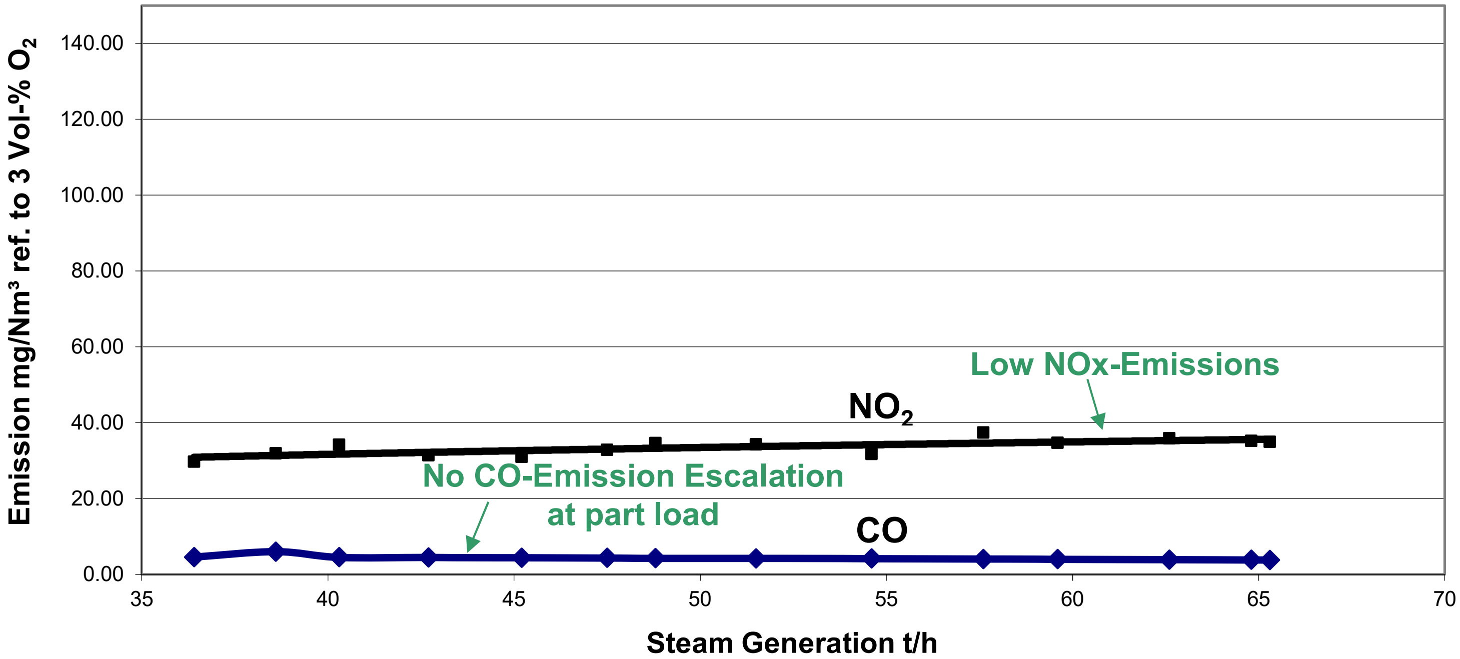
Design of an optimised fluidised bed incineration for the residues from a paper- / cardboard mill production with high-pressure steam generator

SYSTEM HUTTER Environmental Protection – No Secondary Emission Reduction Costs

SYSTEM HUTTER Steam Generator Design:

- optimum burning conditions at the Steam Generator Power Firing through the entire load range
- Low NO_x – Emissions
- Negligible CO – Emissions
- No CO – Emission-Escalation at low part load
- No Secondary Emission-Reduction Measures
- No Restrictions on min. allowable part load due to Emission Escalation

SYSTEM HUTTER CH65
NOx- and CO Emissions measured



Repowering from existing Steam Turbine CHP Stations to SYSTEM HUTTER

- existing Steam Turbine CHP-Stations can be extended to a Combined Cycle CHP Station SYSTEM HUTTER (Repowering)
- existing Steam Generator can be reused; the Steam Generator Firing need to be replaced
- Heavy Oil- or coal-fired Steam Generator can be modified to Natural Gas-fired Steam Generator
- only a few conditions at the existing Steam Generator need to be fulfilled for modifying it into a SYSTEM HUTTER Steam Generator
- the existing Steam Turbine and Water-Steam Cycle can be re-used
- It is **neither necessary** to install a **new Steam Turbine** nor a complete **new Steam Generator** or **Heat Recovery Steam Generator**

Repowering from Steam Turbine-CHP-Station to SYSTEM HUTTER leads to:

- Increase of the Electricity Generation
- Maintaining the high Fuel Utilisation Factor of the Steam Turbine CHP Station
- Reduction of the Investment Cost by re-use of large components
- Improvement of the Profitability of the CHP Station

Modification of existing “GT with HRSG” CHP Stations to SYSTEM HUTTER

- With SYSTEM HUTTER, the existing Gas Turbine can be reused
- Installation of a new SYSTEM HUTTER Steam Generator
- Installation of a Steam Turbine and High Pressure Water-Steam Cycle
- The installation of a new Gas Turbine and a completely new High Pressure Steam Generator would not be necessary in this case

Modification from GT with HRSG-CHP-Station to SYSTEM HUTTER leads to:

- Increase of the Steam Generation with the existing Gas Turbine
- Increase of the Fuel Utilisation Factor and the Electricity Generation
- Improvement of the Profitability of the CHP Station

Modification of existing "GT with HRSG & ST" CHP Station to SYSTEM HUTTER

- With SYSTEM HUTTER, the existing Gas Turbine can be reused.
- SYSTEM HUTTER can use major parts of the High Pressure HRSG
- The re-use of the existing Steam Turbine and Water-Steam Cycle need to be checked due to higher Live Steam Generation
- The installation of a new Gas Turbine and a completely new Steam Generator would not be necessary in this case.

Modification from GT with HRSG & ST-CHP-Station to SYSTEM HUTTER leads to:

- Increase of the Steam Generation with the existing Gas Turbine
- Increase of the Fuel Utilisation Factor and the Electricity Generation
- Improvement of the Profitability of the CHP Station

Combined Gas Turbine & Steam Turbine CHP Stations SYSTEM HUTTER

SYSTEM HUTTER Modules for single-line configuration

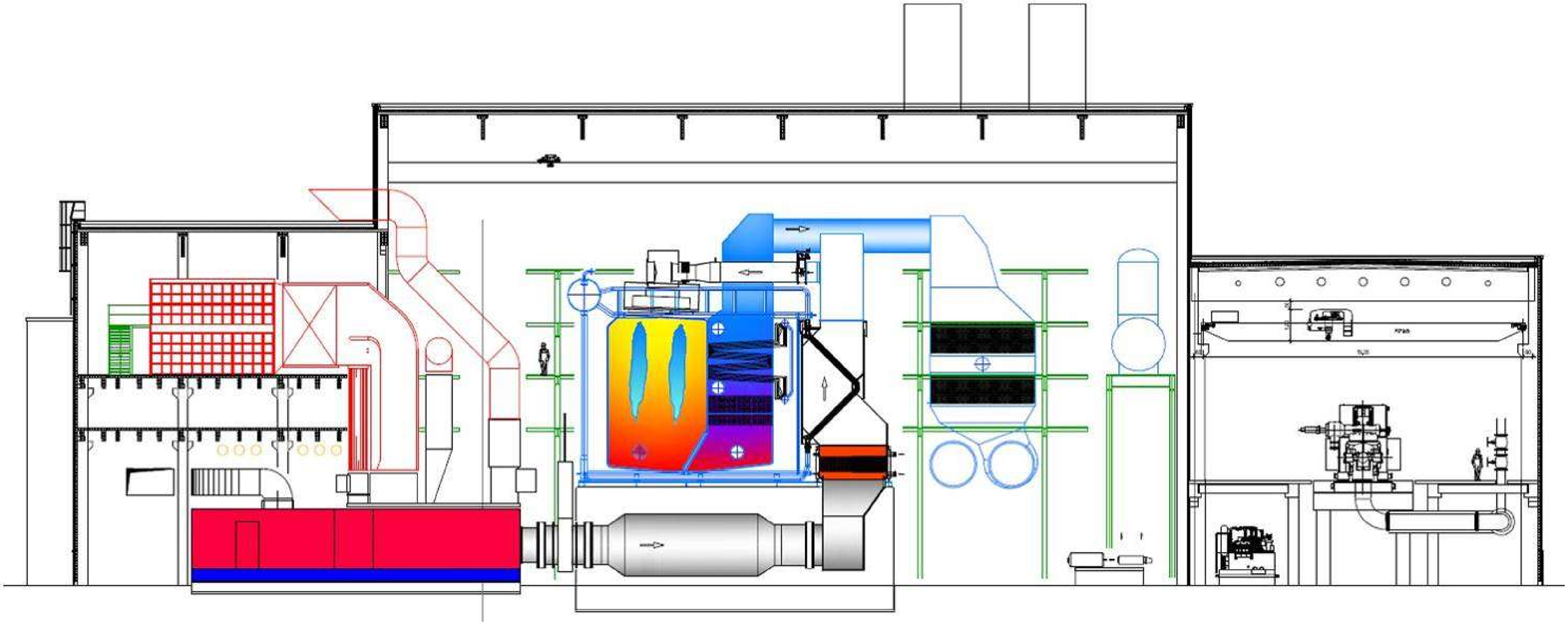
- Electrical Power from 2 MW to 78 MW
- Steam Generation from 12 t/h to 200 t/h

SYSTEM HUTTER Plant Types	Nominal Electrical Power Gas Turbine MW	Nominal Steam Generation t/h	Total Nominal Electrical Power Output MCR (max. contin. rating) MW	Nominal Live Steam Parameter of Steam Generator (values will be optimised depending on the commercial value for efficiency) bar a / °C
CMK3	1.2	12 - 18	2.0 – 3.8	45 / 450
CH30	3.5 - 4	36	8.5 - 9	64 / 450
CH45-EUROPA	5.0	45	10.6	64 / 450
CH65	6.0 - 7.8	65 - 80	15 - 17	70 / 480
CH100	2x6 - 18	100	26 - 32	90 / 480
CH200	25 - 45	200	58 - 78	92 / 505

Total Nominal Electrical Power Output are valid for Plants without condensation and depending on process steam parameter

Arrangement of Combined Cycle CHP Station SYSTEM HUTTER

Combined Cycle CHP Station SYSTEM HUTTER with Nominal Live Steam Massflow of 200 t/h with 45 MW Gas Turbine



Combined Cycle CHP Station SYSTEM HUTTER – Field of Application

- Combined Gas Turbine and Steam Turbine CHP Station
- with highest Fuel Utilisation Factors up to 94%
  (Competition is between 72% and 87%)
  for Cogen for Useful Steam and without "Cold"-Heat Exchanger and with 90% hot process condensate return
- for simultaneous demand of Electricity and Useful Steam or Useful Hot Water
- for a yearly operation time of at least 5000 hours / year
  (due to project economics)
- for an operational Electricity-to-Heat Ratio
  (Electricity demand in MW / Useful Heat Demand in MW)
  between 0.2 and 0.6 (- 0.8)
- Fuel Gas or Diesel Oil is available in sufficient quantity
- without considering subsidies, for Cogen for useful steam,
  under above boundary conditions, then
  SYSTEM HUTTER is economically superior for a
  price ratio of Electricity to Fuel Gas between 1.8 und 3.6

Operation Experience of Combined Cycle CHP Stations SYSTEM HUTTER

7 CHP Stations SYSTEM HUTTER in Operation

Cumulative Operating Experience:

- 155 Years
- 1'330'000 Operating Hours

Longest Operating Experience:

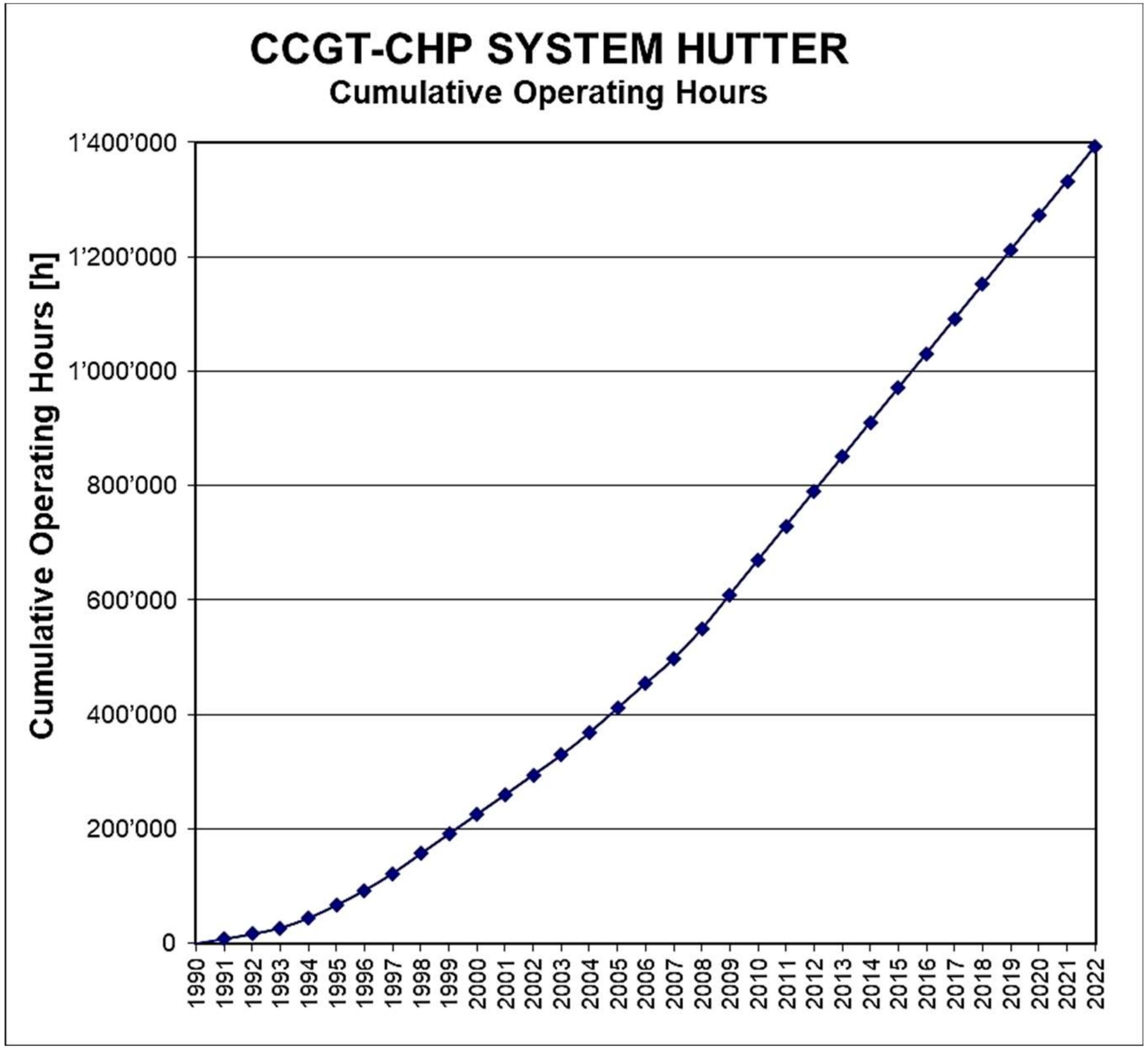
- 30 Years
- 266'000 Operating Hours

Time-Reliability:

- > 99.5 % for entire Power Station
- ø 99.98 % for Steam Generator Plant

Plant Reference sizes per block:

- from 7.2 $MW_{el.}$ / 32 t/h live steam
- to 25.6 $MW_{el.}$ / 95 t/h live steam



References of delivered SYSTEM HUTTER and further CHP Stations

- **SYSTEM HUTTER Varel 1**
  for Board Mill VAREL; Varel, Germany
- **Repowering to SYSTEM HUTTER Buchmann 1**
  for Board Mill BUCHMANN; Annweiler-Sarnstall, Germany
- **SYSTEM HUTTER Smurfit Kappa Badische Karton & Pappenfabrik (BKPO) 1**
  for Board Mill SMURFIT KAPPA BADISCHE KARTON & PAPPEN; Obertsrot, Germany
- **SYSTEM HUTTER Smurfit Kappa Europa Carton Hoya 1**
  for Paper Mill SMURFIT KAPPA EUROPA CARTON; Hoya, Germany
- **SYSTEM HUTTER Varel 2**
  for Board Mill VAREL; Varel, Germany
- **SYSTEM HUTTER Varel 3**
  for Board Mill VAREL; Varel, Germany
- **SYSTEM HUTTER Buchmann 2**
  for Board Mill BUCHMANN; Annweiler-Sarnstall, Germany
- **Extension of Heating Plant with Steam Turbine Plant - Refurbishment and Modernisation of a used Steam Turbine**
  for Paper Mill STORA ENSO UETERSEN, Uetersen, Germany
- **Waste Incineration Plant Mainz Line 3** – Overall Concept, Integration, Engineering and Delivery of Energy part around Steam Turbine
  KRAFTWERKE MAINZ-WIESBADEN – Entsorgungsgesellschaft Mainz mbH, Mainz, Germany
- **SYSTEM HUTTER UPM Nordland Papier 1** (Design, Pre-Engineering, Permitting)
  for UPM NORDLAND PAPIER; Dörpen, Germany

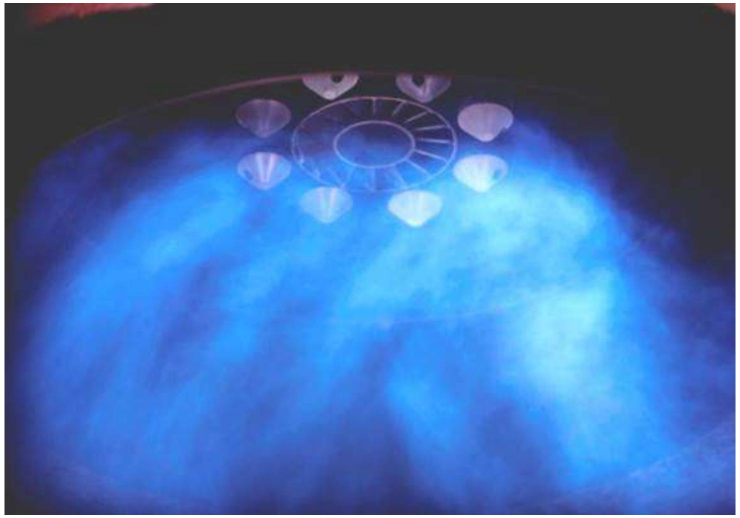
Three Combined Cycle CHP Stations SYSTEM HUTTER Varel 1, 2, 3

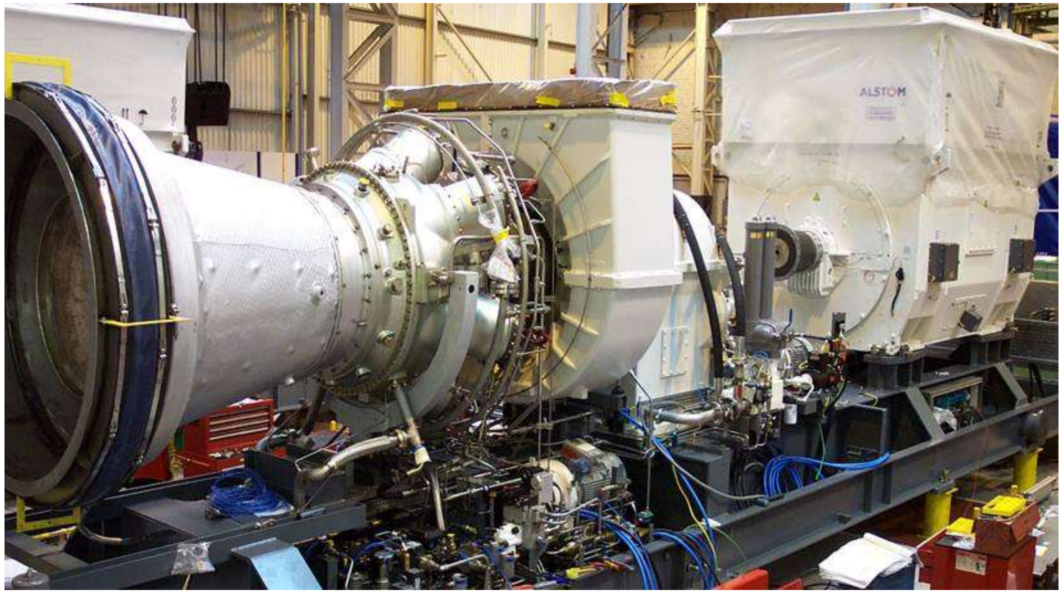
Three Combined Cycle CHP Stations SYSTEM HUTTER at the Paper and Board Mill Varel, Germany,

Varel 1; 1990; 266‘000 OH

Varel 2; 2003; 151‘000 OH

Varel 3; 2008; 115‘000 OH





Contact

Hutter Frei Power GmbH

Sonnhaldenweg 11
CH-5610 Wohlen (Schweiz / Switzerland)

Tel./Phone: +41 56 470 90 50
Telefax: +41 56 470 90 51
E-mail: office@hutter-frei.com
Homepage: www.hutter-frei.com

Patrick Frei, M.Sc.

Sonnhaldenweg 11
CH-5610 Wohlen (Schweiz / Switzerland)

Tel./Phone: +41 (0)56 470 90 53
Telefax: +41 (0)56 470 90 51
E-mail: patrick.frei@hutter-frei.ch

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