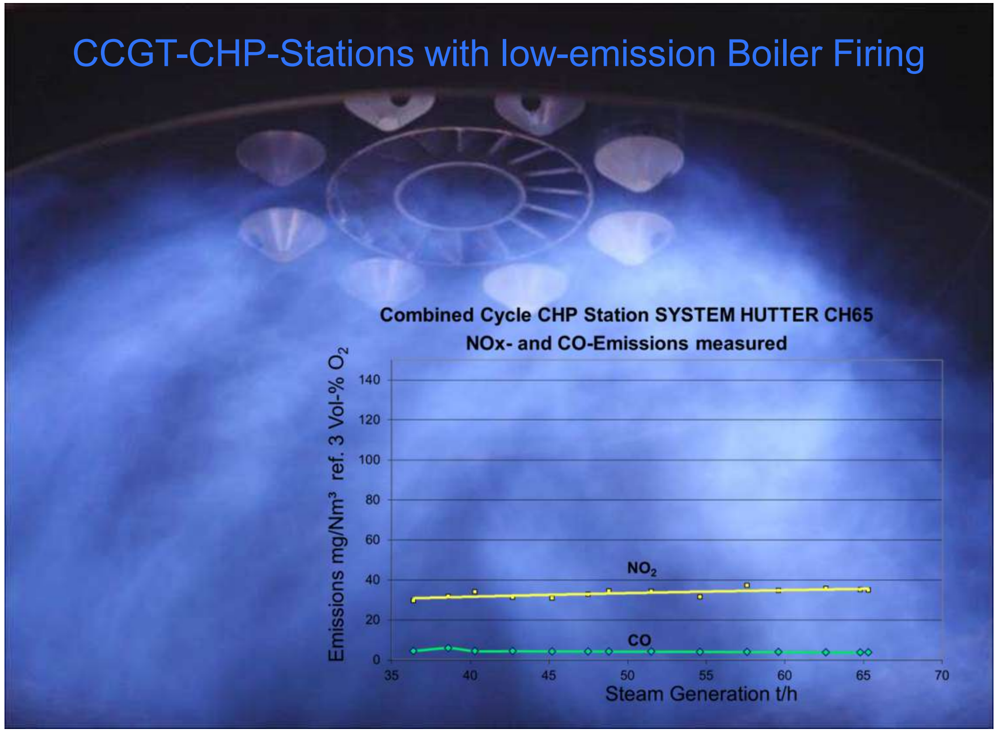
HUTTER FREI POWER GMBH



High-grade Recycling Rotary Kiln Plants,
such as Delacquering Plants

Company Presentation

Supplier, General Planner and Engineer of

CCGT-CHP-Stations, Turbine-based CHP Stations, Rotary Kiln Delacquering Plants, Thermal Power Stations, and Residue-to-Energy integrated in (CHP-)Power Stations

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History

HUTTER FREI POWER GMBH was formed from

the company **FRIEDRICH HUTTER GMBH** founded 1988 in Germany,
who developed, patented and successfully introduced
in 1989 the Combined Gas Turbine and Steam Turbine CHP Station SYSTEM HUTTER
(CCGT Combined Cycle Gas Turbine; CCPP Combined Cycle Power Plant; CHP = Combined Heat and Power)
as a Pioneer of industrial and gas turbine based CHP Stations into the market.

The multiple built **Combined Cycle CHP Station SYSTEM HUTTER** was developed specially
for highest fuel utilisation factors (total efficiencies) at higher electricity generation, for extended operating flexibility,
for low-emission and highly reliable energy supply and for CO_2-emission reduction.

HUTTER FREI POWER GMBH was founded in 2006

by M.Sc. Friedrich Hutter and M.Sc. Patrick Frei.
The Swiss company HUTTER FREI POWER GMBH has taken over the business activities of FRIEDRICH HUTTER GMBH
and the hand-over to the next generation was launched.

Overview of Activities

Our Company is **acting**:

- <u>on the one hand</u> as **Consulting-**, **Planning- & Executing Engineer (<u>Owner's Engineer, General Planner, EPCM</u>)**, and
- <u>on the other hand</u> in **Development**, **Design**, **Engineering, Procurement** and **Supply (<u>Component Supply, EPC/Turn-key</u>)**

of **Combined Heat, Cold & Power Stations**, **Power Stations**, **Rotary Kiln Recycling Plants, Therm. Residue-to-Energy Plants**

Our **Customers** are:

- Industries, Energy Supply Companies, (Public) Utilities, Waste Disposal Companies, Recycling Companies, University plants, Hospitals, Banks, State-owned Institutes, Investors, etc.

Our **Products**:

- **are based on innovative**, **high-grade** and **low emissioning** technologies, and
- form together with **competent** and **experienced** Employees the basis for successful solutions

Solutions: We offer **solutions**, which are **tailor-made** and **optimised** for the **individual** Customer needs

Know-how: By means of our **combined know-how** in Consulting, technical Planning and as Supplier:

- we have the **latest state of the art** at our disposal and consider and analyse **all available technological solutions**
- Consequently we are in a position to really **optimise** the **Customer benefit**

Our Guiding Principles in Customer Projects

- HUTTER FREI POWER provides **high-grade products and services** in the sector of Turbine-based Combined Heat, Cold and Power Stations, Thermal Power Stations, Thermal Recycling Plants and Residue-to-Energy Plants.
- We act as **Plant Engineer for the entire plant scope** in the role as Supplier, General Planner or Consultant.
- **The main focus of our strategy and actions** is the **goal** to place the **customer needs in the center** and to offer him products and services of the **highest quality** and **long-term value at fair costs**.
- We act as a **Partner for our Customers**, who analyses continuously the technical and economic developments in the (CHP-)Power Plant business and thermal recycling sector.

- Our **services** start with a careful and in-depth analysis of the customer needs and all relevant boundary conditions with the focus of mid- and long-term perspective, including a sensitivity analysis.
- Our way of proceeding takes place in a **structured manner**, considering all feasible options and concepts with **all applicable plant technologies**.
  The aim is to find the **tailor-made individually optimised solution** optimal for the Customer’s need.
- We **analyse** from the **Customer perspective**, defining **different scenarios** e.g. an expected, an optimistic and a pessimistic scenario, providing our Customer with the relevant decision making information.
- HUTTER FREI POWER **successfully lead complex projects** and **act in line with the overall project interest**.
- Challenges and problems are analysed and solved with a **specially developed methodology and proceeding**.
- We **act competently and experienced** and **keep at least the agreements**.

Our Customers

Our Customers are looking for a Partner for a high-grade solution,

- which provides with highest efficiency, extended operating flexibility, fast load change, highest reliability his energy need
  - for simultaneous useful heat, useful cold and electricity (**Combined Heat, Cold & Power Station**), or
  - for solely electricity (**Power Station**)
- which provides as **Recycling Rotary Kiln Plant** high conservation of energy and resources and low material loss
- which as **Thermal Residue-to-Energy integrated in Power Stations** saves fossil fuels and reduces waste disposal costs
- which turns out to be the <u>optimal</u> plant variant considering <u>all</u> applicable plant technologies
- which are <u>individually optimised</u> to his needs
- which uses high efficient and environmentally protecting technology
- and which offers the needed flexibilities in the type of operation and in the operating range

Our Customers are looking for a Partner,

- who analyses continuously technical and economic developments in the Power Plant & Thermal Recycling sector
- who acts competently and experienced
- who keeps at least the agreements
- who can successfully lead a complex Power Plant- and Thermal Recycling project
- and who acts in line with the overall project interest

Competent & experienced Employees for New- and Extension-Plants

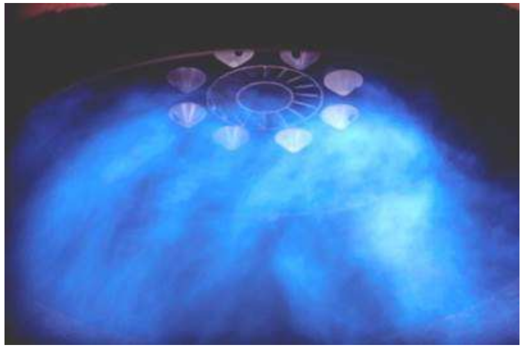
- Consulting and Studies
- Development of innovative plant technologies
- Development of projects
- Customer Support, e.g. with the preparation of permit application
- Expert Know-how of Plant Engineering and for Components of power plants, at latest state of the art
- Steam Generator detailed design with geometrical boiler construction, static and dynamic calculation
- Planning, Design, Engineering, Procurement, Supplier control, Erection control, Commissioning control
- Innovative open-loop- and closed-loop control concepts, e.g. for steam generator- and steam turbine plant
- Project management
- Site management, Overall Erection Management,
- Overall Commissioning Management
- Commissioning
- Acceptance tests measurement and/or its control

Patent Rights

Our Company is holder of Patent Rights:

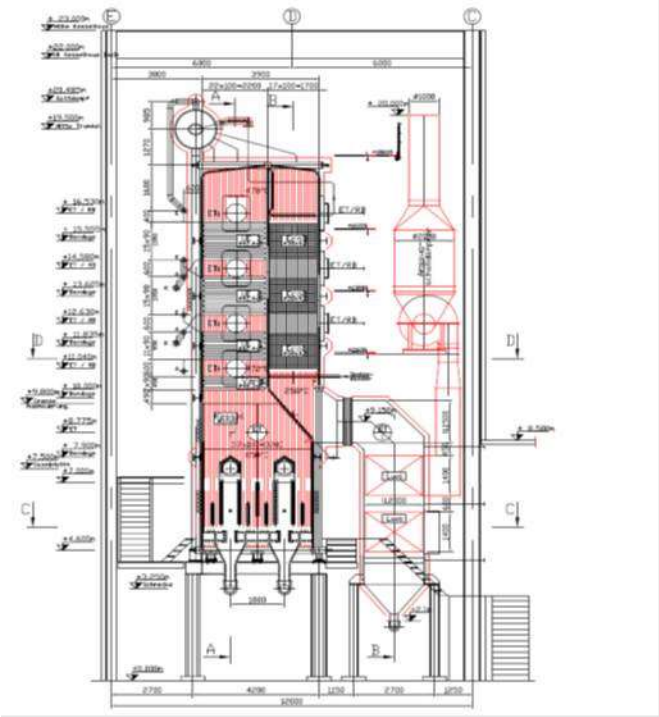
- on low emission technology of Steam Generator Firing, and on special thermal
  Steam Generator configuration of Radiation-type SYSTEM HUTTER Steam Generators downstream Gas Turbines to reach highest total efficiencies and consequently fuel savings and reductions of CO_2 emissions

- on CO reduction technologies on bubbling fluidized-bed Combustion Plants



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

Design of optimised Bubbling Fluidized-Bed Combustion for rejects from paper- and card-board- production with high-pressure Steam Generator



Product- and Services-Strategy

High-grade energy conversion plants and recycling plants
are the better answer
to the global challenge of climate change and preserving the CO_2 balance.

With our aim of
efficiency increase, **fuel savings**, **emission reductions, operating flexibilities** and **highest reliabilities**,
we **developed innovative technologies**, which are the basis of our services as Owner's Engineer and of our products.

Our services and products lead with their
primary energy savings (fuel savings), very low air pollutant emissions and conservation of resources to
environmentally-beneficial and highly economical solutions.

Our Combined Heat & Power Stations and Thermal Power Stations achieve **highest fuel utilisation factors** (SYSTEM HUTTER up to 94 %), **reliabilities** (SYSTEM HUTTER > 99,5 %) **and high operating flexibilities.**

Our Recycling Rotary Kiln Plants and Thermal Residue-to-Energy Plants result in **energy savings, conservation of resources and minimisation of material loss.**

Based on the **competence** and **experience** of our Engineers
HUTTER FREI POWER offers a **wide variety of high-grade engineering services and products in the power plant and thermal recycling sector**.

Overview of Products

Development, Planning, Design, Engineering, Supply and Commissioning
of high-grade, high-efficient, environmentally-protecting, operation-flexible and low-emissioning
Combined Heat, Cold & Power Stations, **Heating Plants**, **Rotary Kiln Recycling Plants**, **Residue-to-Energy Plants**

and as Consultant, General Planner or EPCM-Contractor
of **Combined Heat, Cold & Power Stations, Thermal Power Stations,** entire **Waste Incineration Plants**

- Engineering Services (Consulting, Planning, Engineering, General Planning, Owner's Engineer, EPCM-Contractor)
- Thermal Recycling Rotary Kiln Plants, such as Delacquering of UBC- or aluminium sheet material
- Thermal Rotary Kiln Residue-to-Energy integrated in (Combined Heat &) Power Stations
- Thermal Waste-to-Energy Plants and Waste CHP Stations
- Combined Cycle CHP Stations SYSTEM HUTTER with own-developed SYSTEM HUTTER Radiation-type Steam Generator
- Combined Gas- and Steam Turbine CHP Stations (CCGT or CCPP) with Heat Recovery Steam Generator
- Steam Turbine CHP Stations
- Heating Stations with Steam Generators and/or District Heating Grids
- Thermal Power Stations, such as Combined Cycle Gas Turbine Power Stations, Steam Turbine Power Stations
- Process Automation & Distributed Control Systems

Products

Engineering Services (Consulting, Engineering, General Planner, Owner's Engineer, EPCM-Contractor)

Electrification & Master Plans; Project Development, Pre-, Parameter-, Feasibility Studies, Pre-Engineering;
Design, Engineering, Project Management, Specification, Supplier Supervision, Site-, Erection- & Commissioning Mgmt.;
Requirements for Process Automation as Process Function Plans, Step Sequence- & Logic Diagrams, Control Schematics, etc.

As Consultant, Planning- / Executing Engineer, as Owner's Engineer, as General Planner or as EPCM-Contractor

- we can act at our Supply Products, if the Customer does not want a General Contractor / EPC-Supplier
- we act at Products for the Construction of Power Stations, which are not in our Hardware Supply Program, as e.g. Large Power Stations (large CCGT, large Steam Power Stations) or Overall Waste Incineration Plants

Thermal Recycling-Rotary Kiln Plants

Supply of Recycling-Rotary Kiln Plants; e.g. aluminium recycling with delacquering of used beverage cans (UBC) or aluminium sheets with high delacquering quality and with further developed process & control; for high reliability

Thermal Rotary Kiln Residue-to-Energy integrated in (Combined Heat &) Power Stations

Supply of Rotary Kiln Residue-to-Energy Plants; for the safe and environmentally friendly disposal of a wide range of residues (e.g. production residues, agriculture, agricultural waste, biomass); innovatively integrated in a (CHP-)Power Station for generation of electricity and useful heat/-cooling and substitution of fossil steam generation fuels with efficiencies up to approx. 90 %.

Thermal Waste-to-Energy Plants & Waste CHP Stations

At waste incineration plants we act as Planning and Executing Engineer and supply the water-steam cycle with the electricity and useful heat generation. For the thermal waste-to-energy and flue gas cleaning we act as ENGINEER.

Products

Combined Cycle CHP Stations SYSTEM HUTTER (Combined Cycle Gas Turbine CHP)

Supply of Combined Gas- and Steam Turbine CHP Stations with SYSTEM HUTTER Radiation-type Steam Generator for the simultaneous generation of useful steam & electricity, efficiencies up to 94%, extended operating range and flexible fuel use. As fuel in the Steam Generator Firing, bio fuels and in combination with Rotary Kiln residues as well can be used.

Gas Turbine CHP Stations with Heat Recovery Steam Generator (and Steam Turbine ⇒ CCGT)

Supply of Gas Turbines with further developed Heat Recovery Steam Generator (and Steam Turbine) for the simultaneous generation of hot water and electricity, or at price ratios electricity to natural gas greater than 3.6, for fuels natural gas & temporarily diesel.

Steam Turbine CHP Stations

Supply of Steam Turbines with Radiation-type Steam Generator with a wide range of fuels: gas, oil, biomass, bio fuels or in combination with Rotary Kiln residues. If Gas Turbine CHP Stations are not economically optimal or if Gas Turbines can not be realised.

Heating Plants with Steam Generator and/or District Heating Grids

Supply of Steam Generator Plants for SYSTEM HUTTER-, Gas Turbine- and Steam Turbine CHP Stations. The Steam Generator can be equipped with different fuel systems. Supply of district heating grids.

Thermal Power Stations (as Supplier for Power Stations up to medium industrial plant size)

Supply of Thermal Power Stations up to medium size, with all Turbine-based technologies, with fuels gas, oil, biomass or bio fuels, for the generation of electricity. Electricity subsequently can be used for cooling as well.

We supply as well the **Distributed Control System** with innovative process control based on mathematic algorithms and specially designed open- & closed loop controls; for fast load changes and stable closed-loop controls, easy operability and high automation degree.

Overview of Services

Consulting Engineer (Owner‘s Engineer)

Planning- and Executing Engineer

General Planer / EPCM-Contractor

Component-Supplier

Turn-key Supplier (EPC-Contractor)

HUTTER FREI POWER offers all Services in all project phases of our Products:

Analysis and Design (Project-Development Phase and Project-Pre-Planning-Phase)

- General Planning for Electrifications, Master Plans, Integrated Infrastructure Concepts, Site Investigations, Project Developments, Pre-Studies, Parameter Studies, Feasibility Studies, Environmental Impact Assessments, economic-technical Analysis, Plant Concept Designs, Preliminary Planning

Planning and Procurement (Project-Planning-Phase with Pre-Engineering)

- Overall Planning, Conceptual Planning, Permitting Studies, Execution Planning, Plant specification, Inquiry Specifications (ITT), Bid Evaluations, Contract Award Negotiations and -Recommendation, Contract Preparation, Pre-Engineering

Execution / Project Realisation from Order to Hand-over (Project-Execution-Phase)

- Project Management, Execution Planning, Interface Management, Supplier- & -Document Control, Factory Acceptance Test, Site Management, Overall Erection Management, Overall Civil Management, Commissioning Management, Environmental Health & Safety Coordination, Training, Acceptance Tests, Trial Run, Documentation, Warranty Support

Operation-Phase

- Operation- & Maintenance Supports, Plant Assessments, Modernisations, Environment-, Performance- and Efficiency Increases

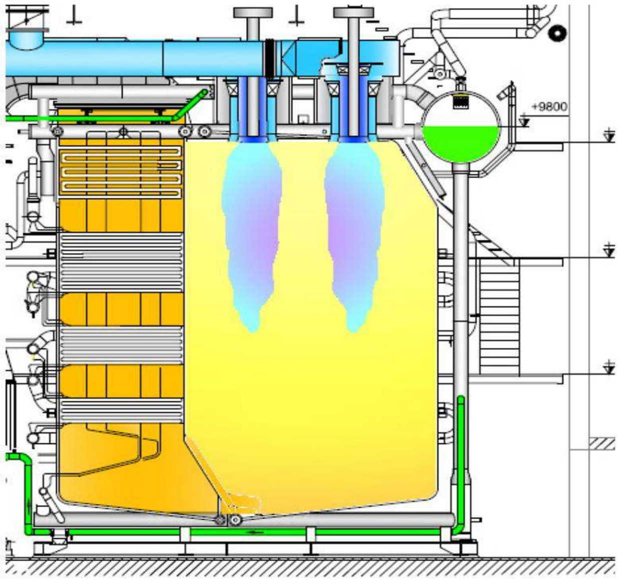
General Consulting

- Market Analysis, Project Developments, Project Financing, Lender's Engineer, Due Diligence, Portfolio Management for Energy Purchasing, Studies

Overview of Services

Detailed Component Design & Commissioning:

Steam Generators



- Detailed Design with preparation of Steam Generator Model
- Calculation with special Steam Generator calculation program
- Determination of heat exchanger configuration, geometry, material and heat exchanger type for all heat exchangers (incl. number of tubes, wall thicknesses, distances, etc.)
- Calculation of Thermal Calculations, Water Calculations
- Preparation of open-loop and closed-loop controls for Steam Generators
- Hot Commissioning of Steam Generators
- Performance Measurement of Steam Generators

Exhaust Gas System

- Detailed Design of GT Exhaust Gas Duct System with Special Dampers, Exhaust Gas Ducts, Exhaust Gas Impact Plate Diffusor, Expansion Joints

Rotary Kiln

- Detail design of Rotary Kiln with fittings, drive, bearings, inlet- and discharge casings

Overall Distributed Control System (DCS)

- Detailed Input for DCS application program with step sequence diagrams, logic diagrams, control schematics, system descriptions, failure reactions
- Commissioning of DCS application program

Each Plant is tailor-made and individually optimised for the Customer's Needs

Sequence for Design, Engineering and Purchasing

1. Step: Prepare overall cycle concept and overall heat balances

2. Step: Develop the optimal variant of the overall cycle according to the Customer needs (and with Gas Turbine CHP Stations select the most optimal suiting Gas Turbine)

3. Step: Prepare overall operation and control concept of the overall plant

4. Step: Prepare of Component-Specifications, inquire Supplier proposals and adjust them

5. Step: Supplier proposals with the technically necessary quality, competence and delivery schedule are evaluated according to economy, technology, competence, delivery schedule and opportunities / risks; The orders will be placed according to the comprehensive assessment of all criteria.

- the only in-depth standardisation is with the Gas Turbine; all other components are individually designed and purchased
- the competence and experience of the ENGINEER is the key for each individual project

Plant References of HUTTER FREI POWER

Summary of Plant References from HUTTER FREI POWER

Plant Type	No. of References		Smallest Plant		Largest Plant
CCGT CHP Stations	34	from	7.2 $MW_{el.}$; 26 t/h live steam; 25 t/h process steam	to	154 $MW_{el.}$; 400 t/h live steam; 388 t/h process steam
Gas Turbine CHP Stations	3	from	3 $MW_{el.}$; 10 t/h live steam; 12 t/h process steam	to	4 $MW_{el.}$; 12 t/h live steam; 12 t/h process steam
Steam Turbine CHP Stations	5	from	3 $MW_{el.}$; 10 t/h live steam; 12 t/h process steam	to	7 $MW_{el.}$; 70 t/h live steam; 68 t/h process steam
CCGT Power Stations	8	from	170 $MW_{el.}$; 190 t/h HP live steam; 42 t/h LP live steam	to	870 $MW_{el.}$; 540 t/h HP live steam; 640 t/h reheat steam; 95 t/h LP live steam
Steam Power Stations	3	from	3 $MW_{el.}$; 11 t/h live steam; 10 t/h reheat steam	to	700 $MW_{el.}$; 2000 t/h live steam; 1800 t/h reheat steam
Waste-to-Energy Plants	7	from	97'000 t/a waste; 46 t/h live steam; 10 $MW_{el.}$; 14 t/h steam extraction for external heat supply	to	360’000 t/a waste; 160 t/h live steam; 22 $MW_{el.}$; 80 t/h steam to CCGT; 60 t/h district heating steam
Waste Incineration Plants	8	from	80'000 t/a waste; 37 t/h live steam	to	360'000 t/a waste; 160 t/h live steam
Residue-to-Energy Plants	6	from	25'000 t/a Residues (Rejects); 2 Mio m^3/a Sewer Gas; 14 t/h live steam; 14 t/h process steam	to	120'000 t/a Residues; 9 $MW_{el.}$; 32 t/h live steam; 29 t/h reheat steam
District Heating Stations	11	from	20 t/h district heating steam	to	95 t/h district heating steam
Rotary Kiln Delacquering Plants	1	from	7.1 t/h UBC feedstock capacity	to	7.1 t/h UBC feedstock capacity

Plant References

- In addition to the plant references of HUTTER FREI POWER, our Employees have worked, as part of their previous Employers, in numerous further plant references in the sector of thermal power stations, turbine-based combined heat & power stations and steam generator plants, such as:
  - ABB POWER GENERATION, Switzerland
  - ALSTOM POWER, Switzerland
  - SIEMENS ENERGY, Germany
  - ABB Enertech, Switzerland
  - ABB Boiler Plants, Switzerland
  - SULZER THERMTEC, Switzerland
  - STONE & WEBSTER ENGINEERING Corp., USA
  - ESCHER WYSS, Switzerland
  - FICHTNER CONSULTING ENGINEERS, Germany
  - Pöyry AF Colenco, Switzerland

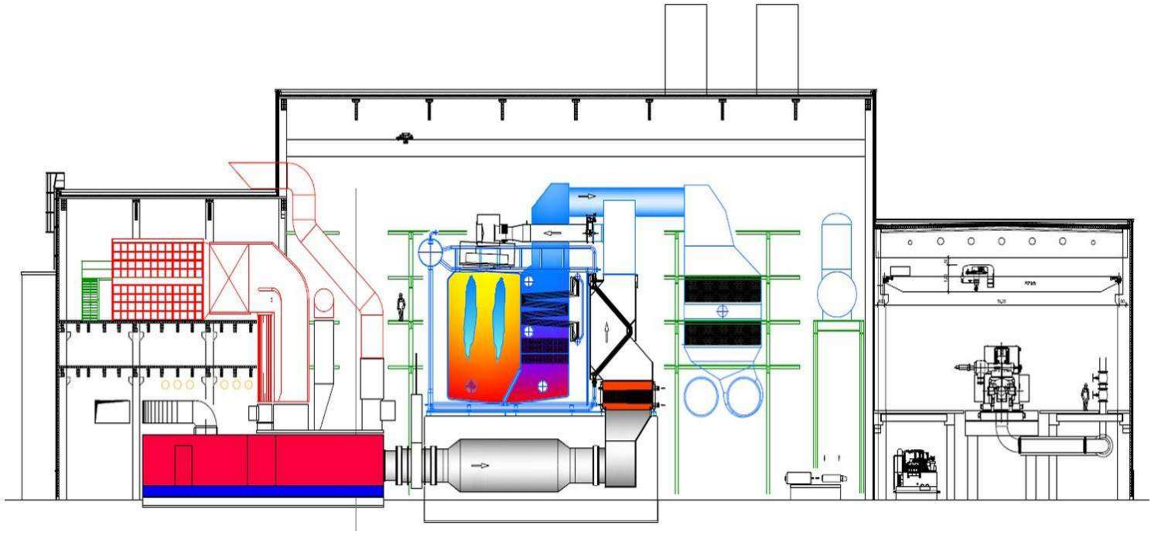
Product Descriptions

- In the following slides the Product Descriptions and Engineering-Services of HUTTER FREI POWER, its advantages, its Customers & Operators and selected references are included.
- At the Thermal CHP Stations at first slides with regard to the selection of the CHP technology follow, which describe the important technical and economic interrelationships. In the following the slides about the description of the CHP Station Products and at the end of the Thermal Power Station Products follow.

Examples of our Products:

Aluminium-Recycling for 8 & 11 t/h feedstock flow with the new Generation of Rotary Kiln Delacquering Plants:

Combined Cycle CHP Station SYSTEM HUTTER in the example with a nominal live steam mass flow of 200 t/h with 45 MW Gas Turbine:



Consulting / Engineering / General Planning / Owner's Eng. / EPCM-Contractor

Description:

- HUTTER FREI POWER offers for all plants according to the page «Overview of Products» (Combined Heat & Power Stations, Thermal Power Stations, Thermal Recycling Plants and Thermal Residue-to-Energy Plants) as well pure high-grade Engineering Services through all project phases according to the page «Overview of Services».
- The scope of services and responsibilities can either be agreed as EPCM-Contractor, as Owner's Engineer, as General Planner or as Planning- / Consulting Engineer. We act independently from Component- / Plant-Suppliers.

Advantages:

- Our Customers receive no standard solutions but a tailor-made and individually optimised solution. Our Customers also receive no solution, which seems to be the better variant based on short-term boundary conditions, but our Customers receive a solution, which is the optimal one in the longer-/long term also based on sensitivity analysis.
- By the combined knowledge as Plant Engineer and Planning / Consulting Engineer, we have the latest state of the art at our disposal about all reasonably possible plant solutions and Planner- / Consultant Solutions. Therefore we optimise the Customer benefit.
- This knowledge allows to consider in the evaluation all tailor-made and up-to-date solutions for the Customer already in the consulting- / planning phase, and allows, that the evaluated solutions can also be implemented / executed in such way by the Plant Supplier.
- Long-term experience and expert know-how / -know-why about plant technologies and leadership of complex projects
- Long-term experience in consulting, development, planning, design, engineering, order execution until hand-over to Customer
- Our technical approach, methodology and work planning generates strongest contribution to the success of the Customer project.
- Our specially developed methodology and proceeding for the analysis and solution of complex challenges.

Consulting / Planning / Engineering / General Planning / EPCM-Contractor

Application Areas:

- For the project phases for all plants according to the page «Overview of Products» (CHP Stations, Thermal Power Stations, Thermal Recycling Plants and Thermal Residue Waste-to-Energy Plants).
  We provide Services for Owners, Operators, Financers, General Planner, Consultant, Project Developer, Plant Supplier

References:

- The majority of the projects realised by us have been executed as General Planner or EPCM-Contractor.
- **Summary of Engineering Services References from HUTTER FREI POWER**
  - Numerous Project References with the following Services
    Project developments, Pre-Concepts, Concepts, Feasibility Studies, Power Sector Development Plans, Pre-Engineering, Owner's Engineer and EPCM-Contractor
  - for various plant types as e.g.
    CCGT CHP Stations, Gas Turbine CHP Stations, Steam Turbine CHP Stations, CCGT Power Stations, Steam Power Stations, Waste-to-Energy Plants, Residue-to-Energy Plants, Rotary Kiln Delacquering Plants and District Heating Systems.
  - Our references for Power Plants vary between small distributed CHP Stations to large central Thermal Power Stations.
  - Our references for Waste-to-Energy Plants are municipal plants, mostly with process steam supply and/or district heating supply, and concepts with additional interconnections with Power Stations.
  - Our references for Residue-to-Energy Plants contain plants with residues from paper and cardboard mill production, from wood, from biomass and with sewage gas.
  - Our references for Rotary Kiln Delacquering Plants contain a plant for delacquering of aluminium used beverage cans (UBC) for thermal recycling.

Consulting / Planning / Engineering / General Planning / EPCM-Contractor

Excerpt from our Customers for Engineering Services References:

(further references see separate presentation about references)

- Egyptian Electricity Authority, Cairo, Egypt
- Swiss Federal Office for Energy, Bern, Switzerland
- Swiss Federal Office for the Environment, Bern, Switzerland
- Government of The Socialist Republic of the Union of Burma
- Paper- and Board Mill VAREL, Varel, Germany
- Board Mill BUCHMANN, Rinnthal, Germany
- Board Mill SMURFIT KAPPA; Obertsrot, Germany
- Paper Mill SMURFIT KAPPA EUROPA CARTON; Hoya, Germany
- Sirnac- Silopi Power Plant, Turkey
- Saline Water Conversion Corporation, Riyadh, Saudi Arabia
- Energy Supply Schwaben AG (EnBW), Stuttgart, Germany
- Isar Amper Werke AG, Munich, Germany
- Municipal Company Mainz-Wiesbaden AG, Mainz, Germany
- Bangladesh Power & Water Development Board, Dacca, Bangladesh
- Medina Electric Company, Jeddah, Saudi Arabia
- Makkah Taif Power Station, Taif, Saudi Arabia
- Korea Electric Company, Seoul, Korea
- Societé Nigerienne d'Electricité Niamey, Niger
- Electricity Corporation Riyadh, Saudi Arabia
- Municipal Company Ludwigsburg AG, Ludwigsburg, Germany
- Nederlandse Energie Ontwikkelings Maatschapij BV, Sittard, Niederlande
- Veba Oil AG, Gelsenkirchen-Buer, Germany
- Municipal Company Kassel AG, Germany
- Public Corp. for Electric Power, Aden, People's Democratic Republic of Yemen
- Government of Malaysia, Economic Planning Unit, Kuala Lumpur, Malaysia
- UPM Kymmene Oyi, Helsinki, Finland
- UPM Nordland Papier GmbH, Dörpen, Germany
- UPM Schongau GmbH, Schongau, Germany
- United Westphalian Electricity Company VEW, Dortmund, Germany
- Ministère du Plan, Cotonou, Benin, Africa
- Government of Morocco
- Elektroandina CCPP Tocopilla, Tocopilla, Chile
- Entsorgungsgesellschaft Mainz mbH, Waste-to-Energy Plant, Mainz, Germany
- EDELMAG S.A. Grupo CGE, Punta Arenas, Chile
- Meyr-Melnhof Gernsbach AG, Gernsbach, Germany
- Energy Service Westfalen Weser AG – Melitta, Minden, Germany

Rotary Kiln Delacquering Plants

- Intended purpose of the delacquering plant is the delacquering as well as the removal of organic compounds and of contaminants from used beverage cans (UBC) or other materials as e.g. from aluminium.
  The delacquered parts are fed without any further treatment into the melting furnace for recycling.
  The shredded feedstock material can come from production, can cycle, waste stream or deposits.
- The delacquering includes organic compounds such as lacquers, stickers, etc.
  The removal of contaminants includes contents residues, adhering parts such as dust, etc.
- The delivered material is pre-treated depending on its condition in an upstream shredder and sorting plant which sorts-out foreign matter as well. Subsequently the feedstock material is transported to the delacquering plant (cold material).
- In the delacquering plant, the feedstock material enters the rotary tube which is heated by hot flue gas. Due to the innovative process control different reaction zones within the rotary tube develop, by which the material is discharged from the rotary tube free of lacquer und other stickers to the largest content and in blank condition (warm material).
- The delacquered material is transported to the melting furnace by means of the product conveyor system.
  In the melting furnace the delacquered material is melted down for liquid Aluminium.
- The process gas leaving the rotary tube is oxidised with process gas burners in the thermal post-combustion chamber. The thermal post-combustion chamber is equipped with a natural burner as well, which operates as pilot burner making sure that the flue gas temperature in the combustion chamber is kept at constant temperature.
- A partial heat recovery occurs in the air preheater and by using the flue gas as necessary for heating the rotary tube.
- The remaining part of the flue gas enters the downstream arranged flue gas cleaning system.

Rotary Kiln Delacquering Plants for Aluminium Recycling – Advantages

- Continuous process with max. annual operating hours resp. min. standstill hours.
- Use of used aluminium parts from waste, deposit and recycling with low quality is possible, not only from production residues.
- Natural resources are being conserved by the thermal recycling process in delacquering plants.
- The metal loss with the use of used aluminium parts is considerably lower with this innovative process compared with other recycling processes as two chamber melting furnace or rotary drum. This is achieved by
    - optimised delacquering because of optimised material flow control and parameter selection
    - low oxide formation in rotary tube
    - low fine grain fraction with fine grain separation; therefore low dross generation in furnace
- With this innovative process the conversation of resources is with the use of used aluminium parts even higher than with other recycling processes as two chamber melting furnace or rotary drum.
- Approx. 95 % of the energy used for the primary production of aluminium is saved by thermal recycling.
- With this innovative process the energy savings are even higher. Reasons are: metal loss is lower; flue gas heat is recovered partially in the plant; delacquered parts with approx. 350 °C enters the melting furnace.
- With aluminium recycling air pollution emissions and solid residues are lower by a power of 10.
- With this delacquering plant air pollution emissions are minimised (measured: NO_x 43,8 mg/Nm^3; CO < 5 mg/Nm^3)
- Recycling aluminium ("green aluminium", "low carbon aluminium") achieves higher aluminium prices (CEO Norsk Hydro) and is for many clients a precondition as qualified supplier (environmental protection, resource efficiency, circular economy).
- In all operating conditions safe explosion protection by defined low air inlet, continuous optimal mixing and spacially separate process gas generation, process gas combustion and melting process.

Delacquering Plant HYDRO Aluminium Neuss – Main Data

Innovative Rotary Kiln Delacquering Plant at HYDRO Aluminium Neuss for delacquering of Used Beverage Cans UBC from the can stream or from the waste stream.

Within the context of a restructuring, the company VSH has contracted HUTTER FREI POWER for the further project execution with project management, process- & mechanical engineering, commissioning management and commissioning. Until the first operation HUTTER FREI POWER identified and executed various modifications and improvements.

Delacquering Plant, HYDRO ALUMINIUM, Neuss, Germany

Feedstock material:	
Capacity:	7.1 t/h
Max. moisture:	5 weight-%
Max. organic:	6 weight-%
Max. dust:	0,5 weight-%
Combustion chamber:	850 °C / 2 s
Plant annual operating time:	~ 8200 h/a
Reliability w/o cleaning outages:	> 97 %
Air pollution emissions upstream FG Cleaning:	
CO:	< 5 mg/Nm^3
NO_x as NO_2:	43,8 mg/Nm^3
Energy savings by recycling process:	~ 95 %
Reuse of feedstock material:	~ 85 %

Delacquering Plant HYDRO Aluminium Neuss – Research & further Development

- In Commissioning of the Rotary Kiln Delacquering Plant for the end-customer HYDRO ALUMINIUM in Neuss, HUTTER FREI POWER has carried out basic research and executed numerous trials in different subject areas.
- For this purpose, we as well have performed analytic measurements in the process gas and flue gas system. In a first phase by a University Institute, in the second phase by a specialised Measurement Institute.
- The trial programs and the measurement scope have been specified by us. The attention was not only in normal operation but in operational disruptions as well, which are crucial for the explosion protection concept and the risk analysis.
- HUTTER FREI POWER analysed together with other involved parties the measurement results and gained important findings about the processes and interrelationships in the Delacquering Plant.
- We have equipped the Delacquering Plant with additional sensor systems and at critical sensor conditions, new measurement technologies have been tested and finally installed after the evaluations.
- The operating characteristics of approx. 2 years have been analysed systematically and on-site by us while being in intensive exchange with the plant operation. The many developed interrelationships were integrated in the plant operation.
- The explosion protection concept was mainly further developed by us in collaboration with the explosion protection appraiser.
- With the operating experience and above mentioned findings and knowledge from the research and trials, HUTTER FREI POWER has further developed and optimised the Delacquering Plant at HYDRO Aluminium Neuss.
- The operating range was extended down to 20 % of the nominal feedstock throughput and fast load changes are possible.
- Based on the described findings and knowledge, HUTTER FREI POWER has developed a plant simulation model with taylor-made adapted components, which is applied at the project development, design and engineering of a project.

Delacquering Plant HYDRO Aluminium Neuss – Delacquering UBC to blank Condition

Cold-UBC material quality upstream rotary kiln

The last black C-layers in warm-UBC material as per picture...

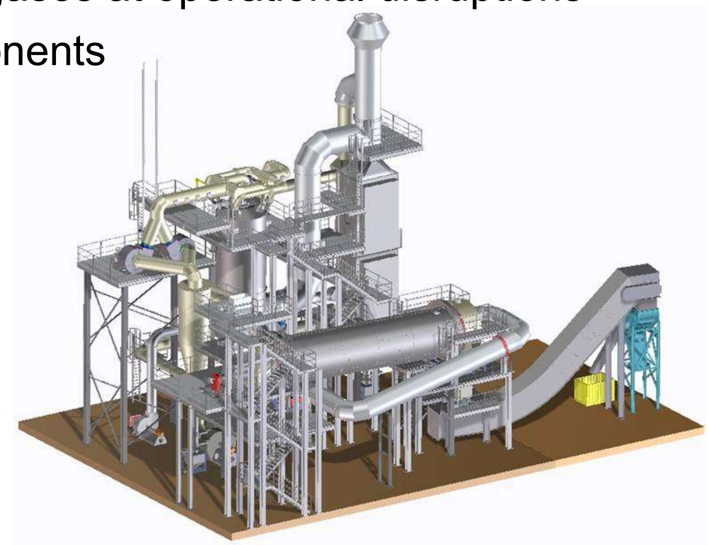
... are removed to the largest content by the optimised process

Next Generation of Rotary Kiln Delacquering Plants – Advantages & Improvements

We developed a plant simulation model with taylor-made adapted components, which we apply at the project development, design and engineering of a project. The model results are consistent with the operating experience.

The **new generation of delacquering plants** is available in different sizes (currently 8 & 11 t/h feedstock) and keep the proven advantages of the rotary kiln delacquering plant for HYDRO ALUMINIUM Neuss, but **offers the following enhancements**:

- Extension of the operating time between off-line cleaning outages to 6 months by
  - design changes at air preheater, combustion chamber, rotary tube, rotary tube inlet
  - online high performance dust precipitations with specially developed design & extension of online dust discharge systems
- Extension of the operating application range and the useable feedstock material qualities by
  - design changes at rotary tube, natural gas burner, control flaps, fan construction
  - changes at conveyor construction type
- Extended process gas configuration for controlled behaviour of unburned gases at operational disruptions
- Shortening of cleaning outages by online-dust discharge at multiple components
- High-grade standard with high availability
- Reduced metal loss in melting furnace by
  - optimised delacquering because of optim. material flow control & parameter selection
  - low oxide formation in rotary tube
  - low fine grain fraction with upstream fine grain separation
- Low emissions NO_x, CO and unburned gases
- New concept for arrangement
  - optimised accessibility as well with lift trucks & optimised small footprint requirement



Recycling Rotary Kiln Plants – Customers and Operators

Companies, who delacquer and recycle feedstock in sufficient quantity, as e.g.:

HYDRO ALUMINIUM, Rheinwerk, Neuss, Germany

- Foundry
- Automobile
- Cement
- Chemistry
- Aluminium
- Mines
- Thermal Recycling
- Waste Disposal

Thermal Rotary Kiln Residue-to-Energy integrated in (CHP-)Stations – Description

Thermal Rotary Kiln Residue-to-Energy for generation of electricity and useful heat / cooling:

If the Customer has available residues, agricultural waste, other biomass and needs electricity (and useful heat/cooling) or can sell it, the optimal solution is the Residue-to-Energy with Rotary Kiln, innovatively integrated in a (CHP-) Power Station

Description of Thermal Rotary Kiln Residue-to-Energy integrated in (CHP-) Power Station:

- Residues are thermally decomposed in the rotary tube; burnable gases are produced, which are used as fuel.
- The rotary tube is heated with flue gas; the input volume of the residues are significantly reduced in the rotary tube.
- The concept developed by us integrates the rotary kiln plant with innovative efficient process technology in the (CHP-) Power Station.
- With this plant the energy bound in the residues are used for the generation of electricity- and useful heat / cooling; and simultaneously the plant ensures a safe, environmentally friendly and economic residue (waste) disposal.
- The amount of energy entering with the burnable gases in the (CHP-) Power Station replaces fossil fuel energy.
- With integration in a power station the thermal efficiency of the Residue-to-Energy achieves between approx. 35 % and approx. 55 % depending on residue composition and depending on power station technology; with integration in a CHP Station SYSTEM HUTTER (Co- or Trigeneration) the fuel utilisation factor totally increases to up to over 90 %.
- A wide range of residues can be used, such as e.g.
    - Residues from the production (e.g. rejects from paper- / cardboard production)
    - Agricultural waste such as biomass from plant/crop production, crop remainders and crop residues, grass, animal feed
    - Car tyres or polluted, contaminated and intermixed waste

Thermal Rotary Kiln Residue-to-Energy integrated in (CHP-)Stations – Advantages

Thermal Rotary Kiln Residue-to-Energy Plants for generation of electricity and useful heat / cooling:

If the Customer has available residues, agricultural waste, other biomass and needs electricity (and useful heat/cooling) or can sell it, the optimal solution is the Residue-to-Energy with Rotary Kiln, innovatively integrated in a (CHP-) Power Station

Advantages:

- safe and environmentally friendly disposal of waste/residues and therefore savings on disposal costs
- Reduction of the volume of residues up to over 90 %
- Residue treatment such that the discharged remainder residues / slag can be disposed without danger
- a recovery of the valuable substances in the residues is possible depending on the composition
- with residues electricity and useful heat / cooling is generated from the energy bound in the residues
- with integration in a (CHP-)Power Station fossil fuel of the Steam Generator is replaced;
  therefore more environmentally friendly; reduction of fuel costs and reduction of CO_2 emission or rather CO_2 costs
- superior economy (e.g. Net Present Value, IRR), as well by innovative integration of the plant in a (CHP-)Power Station
- a wide range of residues can be used (e.g. production residues, agricultural waste, crop remainders and crop residues, biomass, tyres)
- suitable for Customers with electricity demand and possibly useful heat / cooling as well as with availability of residues
- high time-availability; by robust design, choice of integration of residue disposal in (CHP-)Power Stations,
  by supplier choice, quality management and -control

Thermal Rotary Kiln Residue-to-Energy integrated in (CHP-)Stations – Customers

Companies, who have available suitable residues in sufficient quantity such as:
Residues from the production (e.g. rejects from paper- / cardboard production), Agricultural waste such as biomass from plant/crop production, crop remainders, crop residues, grass, animal feed, Car tyres or polluted, contaminated and intermixed waste
and need electricity (and useful heat/cooling) or can sell it, as e.g.:

- Paper- and Cardboard Mills
- Production with suitable Residues
- Thermal Recycling
- Waste Incineration Plants
- Agricultural Waste Recycling
- Biomass Recycling
- Animal Feed Recycling
- Car Tyres Recycling
- Recycling of polluted, contaminated and intermixed waste

Thermal Waste-to-Energy Plants & Waste CHP Stations – Description

Thermal Waste-to-Energy Plants & Waste CHP Stations for generation of electricity and useful heat / cooling:

If the Customer has available waste and needs electricity (and useful heat / cooling) or can sell it, the optimal solution is the Thermal Waste-to-Energy Plant with Waste CHP Station

Description and Advantages of Thermal Waste-to-Energy Plant with Waste CHP Station:

- Waste can be thermally disposed with different technologies depending on the boundary conditions. Apart from the classical waste incineration with grate firing, there are e.g. the fluidised bed technology, the rotary kiln technology, et al.
- Normally waste has a considerable heating value, whereby waste is considered as most efficiently-to-use fuel.
- In addition to the efficient use (energetic efficiency), the electricity generation shall significantly increased, whereby the energetic efficiency will remain as high as possible.
- An effective measured method to that is the **combination** of a Thermal Waste-to-Energy with a (CHP-)Station.
- In the case of a waste incineration, there are different types of combination. We have analysed those in a study for the Swiss Federal Office of Energy. The advantage lies in the significantly higher electricity generation.
- In the case of a waste gasification in a rotary kiln, the combination is similar to the Thermal Residue Waste-to-Energy with a Rotary Kiln. The advantage lies in the highest fuel utilisation (total efficiency) at simultaneously higher electricity generation.
- With the Thermal Waste-to-Energy, the energy bound in the waste is used for electricity- and useful heat / cooling generation; and simultaneously, the plant ensures a safe, environmentally friendly and economic disposal of waste.

Thermal Waste-to-Energy – Waste CHP Station combined with CCGT & District Heating

- The Waste Incineration Plant Mainz has been extended with a third line. The three waste incineration lines together generate 155 t/h steam.
- Part of the steam is supplied to the Steam Generator of the 400 MW CCGT Power Station, where this steam finally is transformed to electricity, district heating as well as process steam in a high efficient manner.
- Another part of the steam is supplied to the new 90 t/h and 20 MW extraction-condensing steam turbo set, where electricity is generated, where the controlled extraction supplies steam to the waste incineration plant for own consumption and where steam is extracted for district heating. This enables a further efficient use of the steam, generated in the waste incineration plant.
- These interconnected processes were for the first time implemented in Germany and are a bench-mark solution regarding energetic & exergetic use of waste for electricity-, own consumption steam-, process steam- & district heating supply.

Waste CHP Station combined with CCGT Power Station & District Heating, Mainz, Germany

Plant annual operating time	8600	h
Electrical nominal power output new Steam Turbo Set	20.7	MW
Live steam nominal mass flow to new Steam Turbo Set	90	t/h
Live steam nominal condition	40 / 415	bar / °C
Condensate preheating	5.1	MW
Exhaust steam direct cooled; max. cooling water mass flow	5200	m3/h
Planned with 2-stage district heating extraction	25	MW
Time reliability	> 99	%

Thermal Waste-to-Energy – Customers and Operators

Companies, who have available sufficient waste, and need electricity (and useful heat / cooling) or can sell it, as e.g.:

Waste CHP Station Mainz, Mainz, Germany

- Waste Incineration Plants
- Waste CHP Stations

Products – Technologies of Thermal Combined Heat and Power Stations

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

Choice of Turbine-based Combined Heat & Power Station Cycles

Steam Turbine CHP Station

- with classical Radiation-type Steam Generator
- generates less electricity than Combined Cycle CHP Station SYSTEM HUTTER
- highest Fuel Utilisation Factor (Total Efficiency) and lowest Fuel Heat Input
- wide range of fuels useable
- economy of the investment reacts less sensitive against Fuel Price Escalation
- most economical at a Price Ratio “Electricity / Fuel” lower than approx. 1.8

Combined Gas- & Steam Turbine CHP Station SYSTEM HUTTER

- with classical Radiation-type Steam Generator, extended for SYSTEM HUTTER, instead of Heat Recovery Steam Generator
- generates significantly more electricity than the Steam Turbine CHP Station, but less than with HRSG
- same highest Fuel Utilisation Factor than with the Steam Turbine CHP Station
- extended operating flexibility; ratio electricity- / steam generation is adjustable; wide range of fuels useable
- economy of the investment reacts less sensitive against Fuel Price Escalation
- most economical at a Price Ratio “Electricity / Fuel” between approx. 3.6 and 1.8)

Gas Turbine with (HRSG) Heat Recovery Steam Generator (and Steam Turbine ⇒ CCGT)

- high electricity generation (CCGT) at significantly reduced Fuel Utilisation Factor
- significantly more Fuel Heat Input than with CCGT CHP Station SYSTEM HUTTER; increased emissions at part load
- restricted operating flexibility; restricted part load capability; fuels natural gas and diesel useable
- economy of the investment reacts highly sensitive against Fuel Price Escalations
- most economical at a Price Ratio “Electricity / Fuel” greater than approx. 3.6

Choice of Turbine-based Combined Heat & Power Station Cycles

Radiation-type Steam Generator after Gasturbine:

High Steam Generator Firing after Gas Turbine, therefore:

- Oxygen Content in Flue Gas after Steam Generator is low; 2 Vol.-% O_2 (max. fired) – 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
- **Less heat from Gas Turbine exhaust is necessary, which is why the Gas Turbine gets smaller**
- **Steam Generator efficiency is high** due to low Flue Gas Massflow and lower Flue Gas Temperature before stack
- Steam Generator is a compact design and needs only a smaller space

Heat Recovery Steam Generator after Gasturbine:

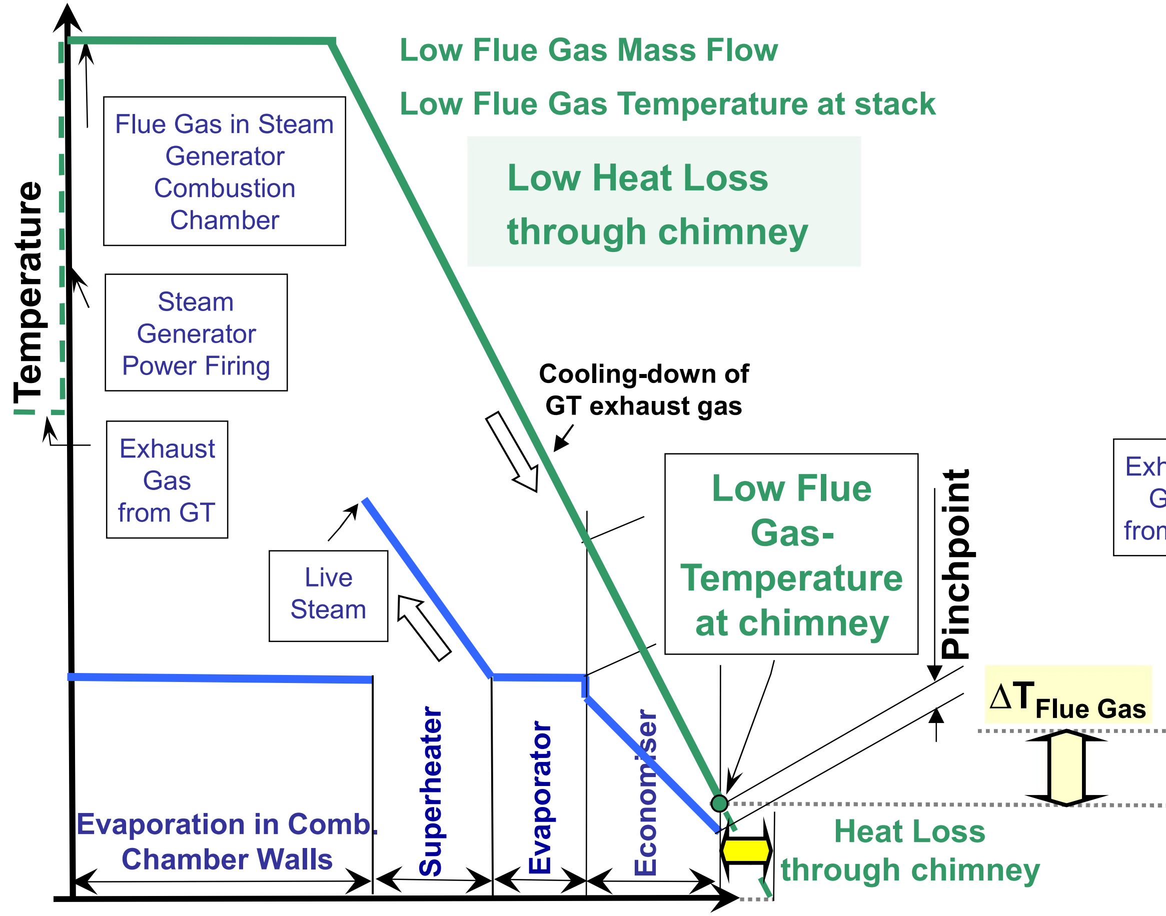
Low Steam Generator Firing or unfired Steam Generator after Gas Turbine, therefore:

- Oxygen Content in Flue Gas after Steam Generator is high; 15 Vol.-% O_2 (unfired) – 8 Vol.-% O_2 (additional firing),
- and Flue Gas Temperature after Steam Generator Firing is relatively low (normally limited at 800 °C), therefore:
  - Steam Generator Design is Heat Recovery Steam Generator without significant radiation type heat transfer
- **More heat from Gas Turbine exhaust is necessary, which is why the Gas Turbine gets relatively large**
- **Steam Generator efficiency is low** due to high Flue Gas Massflow and high Flue Gas Temperature before stack
- Steam Generator needs more volume and more space

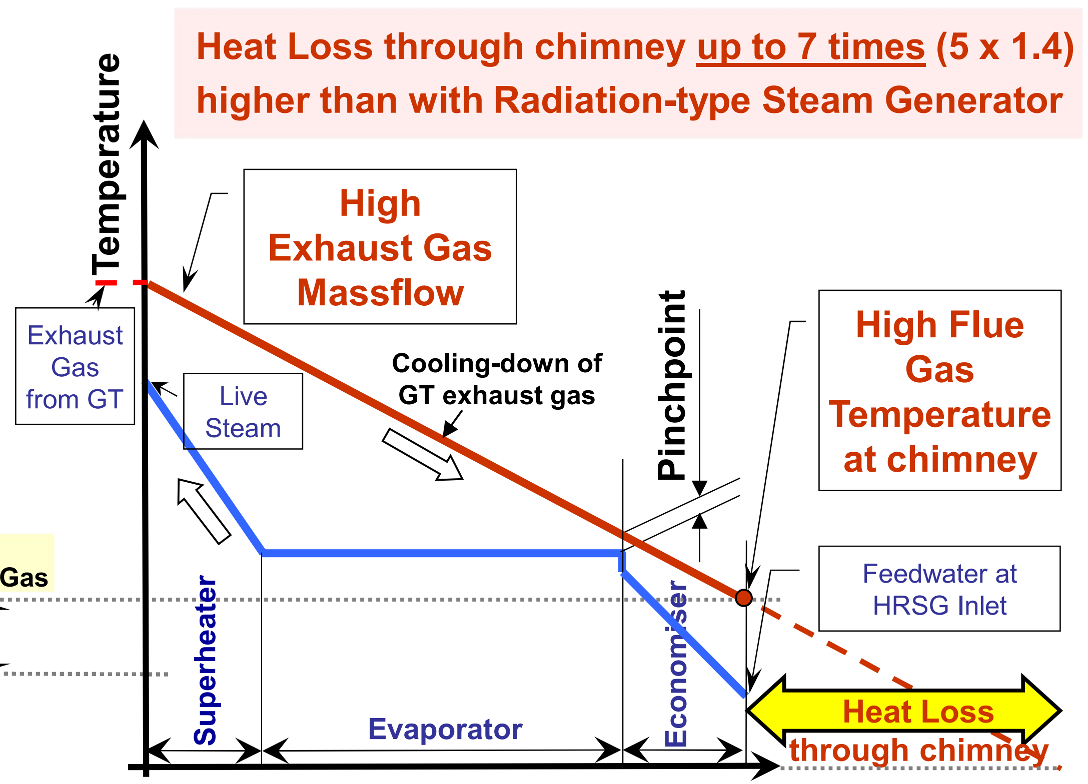
Choice of Turbine-based Combined Heat & Power Station Cycles

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

GT with Radiation-type Steam Generator



GT with Heat Recovery Steam Generator HRSG



Choice of Turbine-based Combined Heat & Power Station Cycles

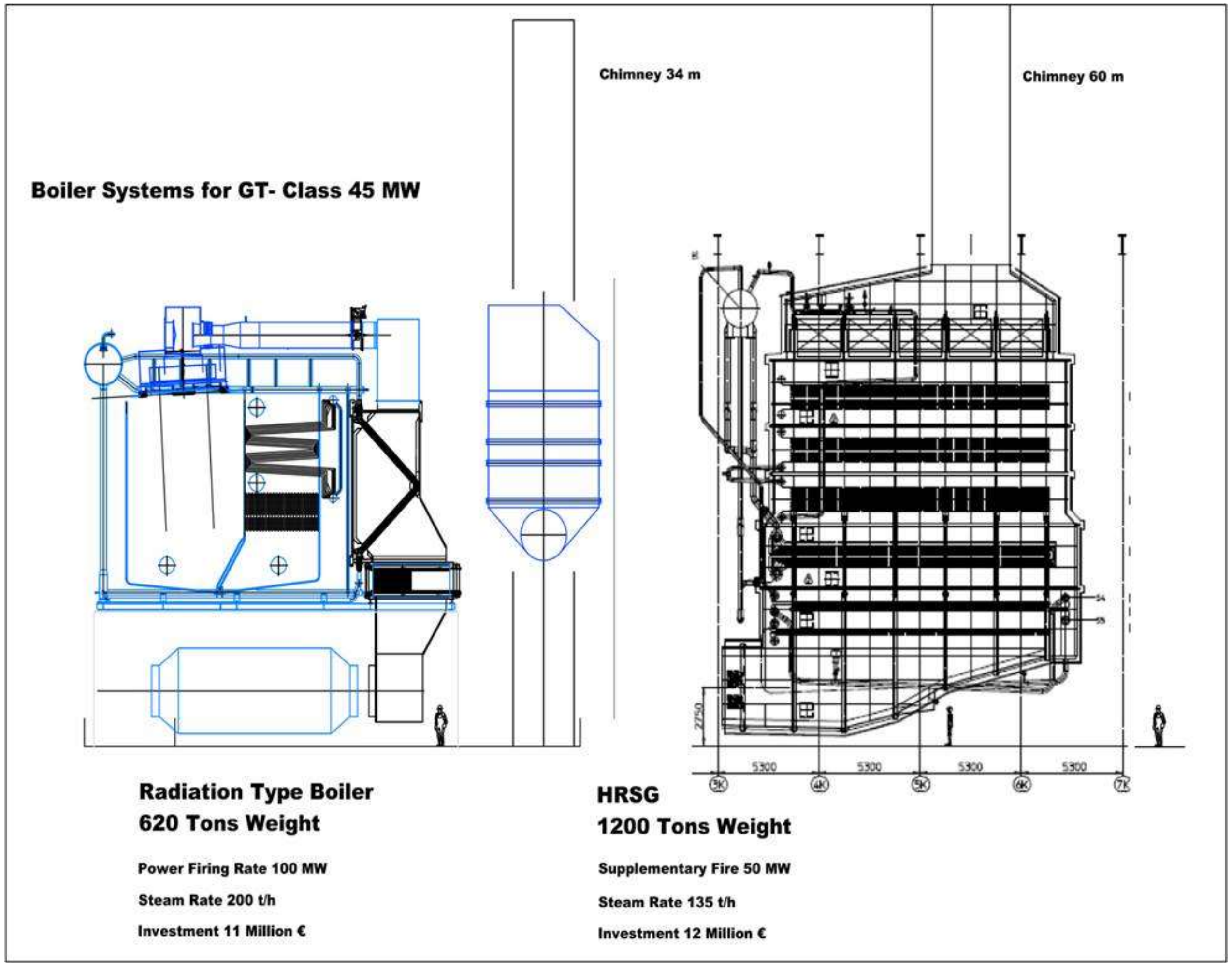
For the same Gas Turbine applies: **Heat Recover Steam Generators have up to double weight and 35% lower nominal live steam mass flow than Radiation-type Steam Generators**

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 com-bustion chamber is **by factors more effective** than in the convection heat exchangers.

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



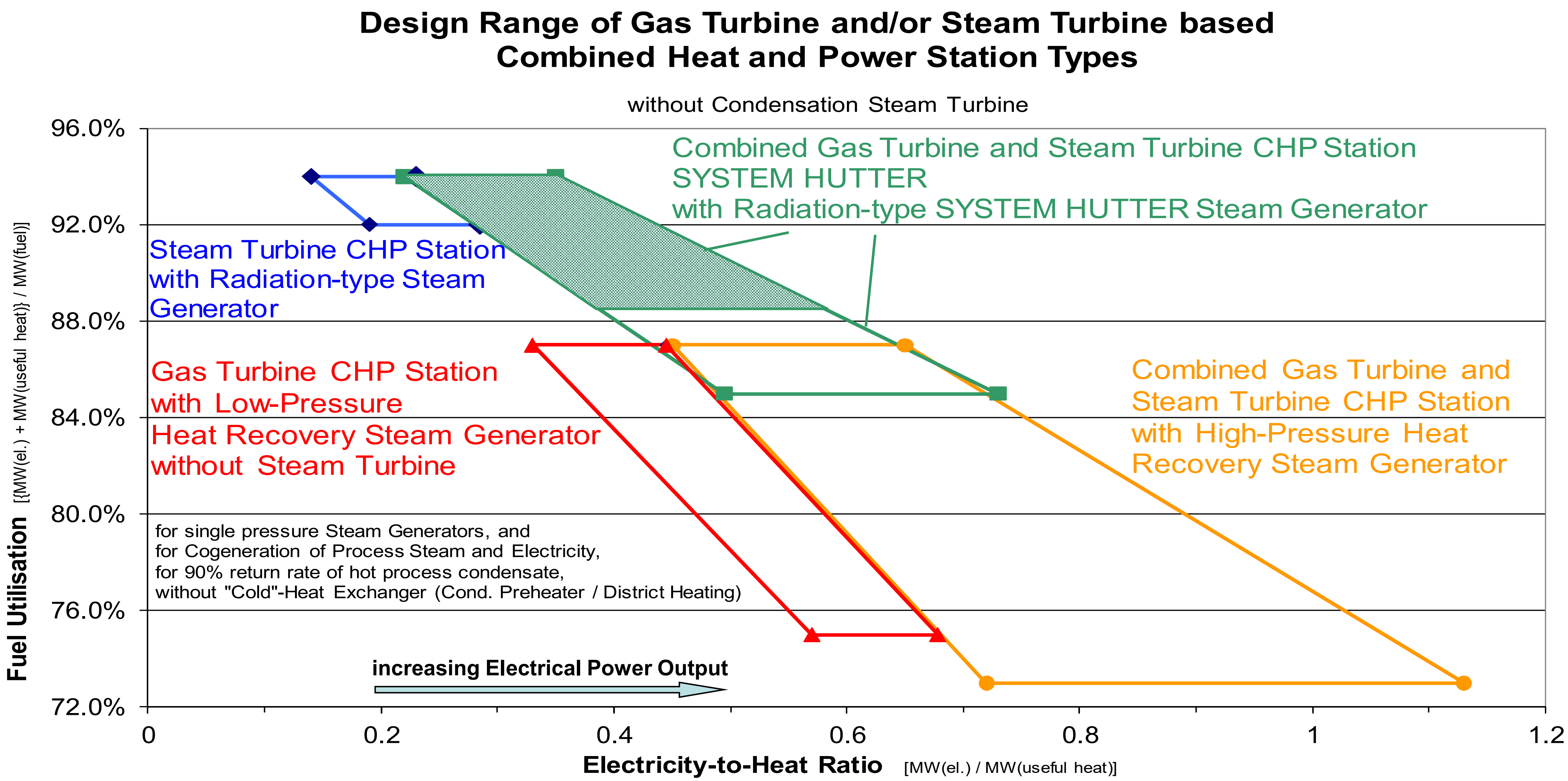
Heat Recovery Steam Generator:

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.

Choice of Turbine-based Combined Heat & Power Station Cycles



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

Choice of Turbine-based Combined Heat & Power Station Cycles

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

Choice of Turbine-based Combined Heat & Power Station Cycles

Typical economically optimal Range of Application

of Turbine-based 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)	lower than 1.8	> 90 %	0.1 – 0.3
Gas Turbine with SYSTEM HUTTER Radiation Type Steam Generator and Steam Turbine (Combined Cycle CHP Station SYSTEM HUTTER)	between 1.8 and 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)	greater 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 Combined Heat & Power Station Cycles

Combined Heat & Power Stations 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**)

Combined Heat & Power Stations 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** (**Combined Cycle CHP Station SYSTEM HUTTER**)

CHP Stations for useful steam (price ratio Electricity / Fuel > 1.8 or 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** (**Combined Cycle CHP Station with HRSG**)

Choice of Turbine-based Combined Heat & Power Station Cycles

Superior Economy for Combined Heat & Power Stations with high total efficiencies:

Basis of Comparison is the Steam Generator Plant only
and purchasing of all Electricity

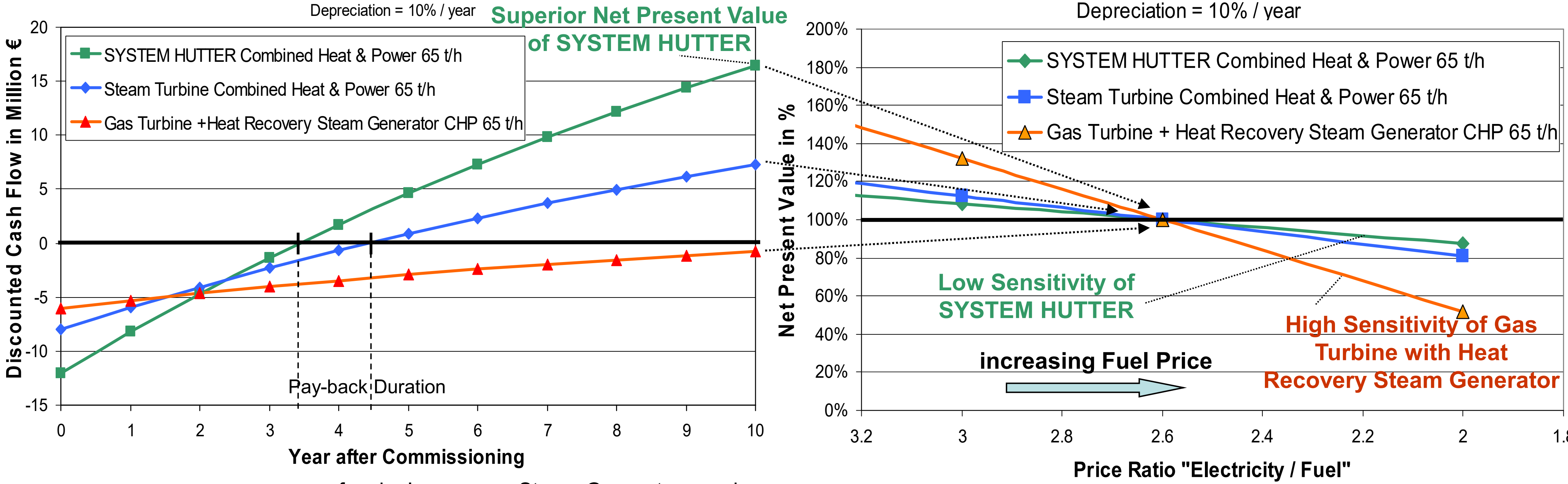
Fuel: Natural Gas

Discounted Cash-Flow DCF & Net Present Value

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

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)

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 Total Efficiency (Fuel Utilisation Factor)

Choice of Turbine-based Combined Heat & Power Station Cycles

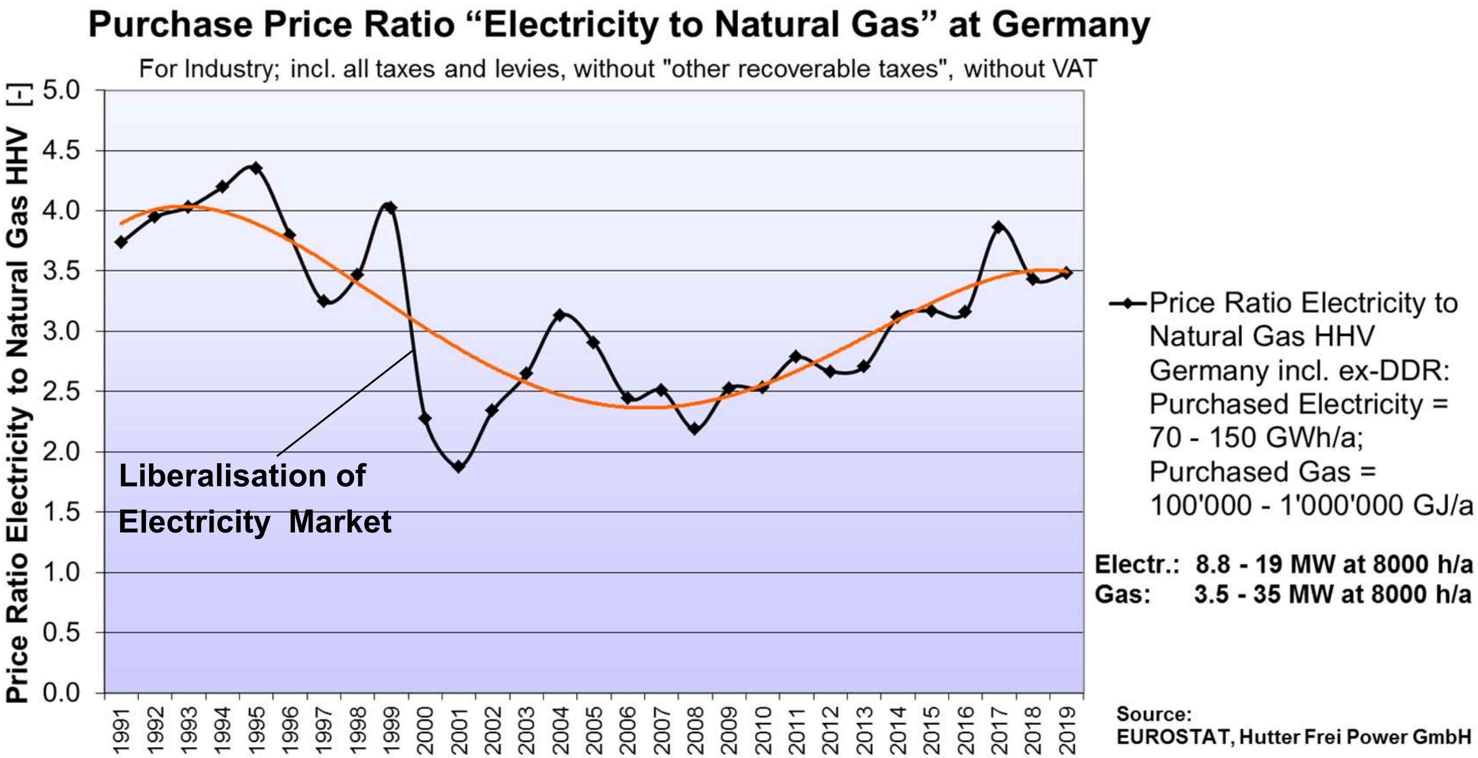
Price Ratio Electricity / Natural Gas in Europe
is without big crises expected to stay between ~ 1.8 and 3.5 in the medium term

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

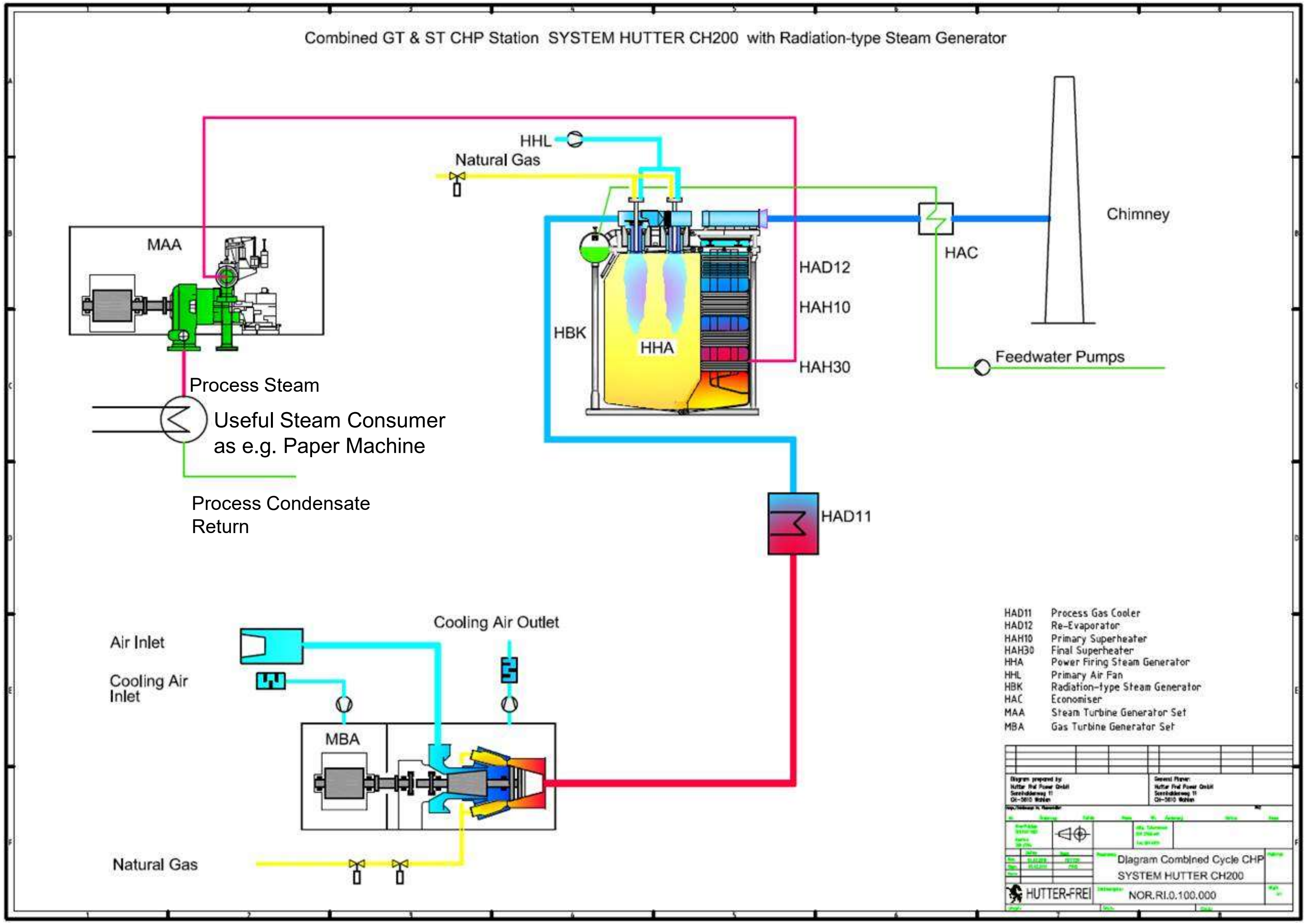


Combined Cycle (CCGT) CHP Stations SYSTEM HUTTER – Description

- The Combined Cycle CHP Station SYSTEM HUTTER is a high-grade environmentally protecting Combined Gas Turbine and Steam Turbine CHP Station (CCGT CHP) for Trigeneration with simultaneous generation of Useful Heat and Electricity.
- Instead of a Heat Recovery a Radiation-type Steam Generator SYSTEM HUTTER is used, which we have developed and patented.
- Radiation-type Steam Generators consist of power firings, which at full load optimally burn out the oxygen in the GT exhaust gas.
- SYSTEM HUTTER Steam Generators are based on the classical Steam Power Station process, which operates as well with Radiation-type Steam Generators, is proven for decades and achieves process related highest efficiencies (low flue gas losses).
  - We have changed the thermodynamic concept based on the concept with the upstream Gas Turbine.
  - The heat exchanger configuration has been extended and the water-steam- and exhaust gas - flue gas system specially developed.
  - The power firing with upstream systems have been developed for Gas Turbine exhaust gas- and forced draught fan operation. The firing operates at all loads with combustion-technically optimal conditions, therefore low NO_x / CO emissions at all loads.
  - Achieves highest fuel utilisation factors such as the Steam CHP Station (up to 94%); but generates significantly more electricity.
- SYSTEM HUTTER allows different fuels for the Steam Generator (SG) Firing, which amounts up to max. 64% of the tot. fuel consumption of the CHP Station; in combination with a rotary tube SG fuels are replaced by residues and others.
- We developed special closed-loop and open-loop controls for the overall plant and the steam generator. Those allow extensive operation automation, smooth conditions and fast load changes (e.g. paper break).
- A switch-over between Gas Turbine operation and Forced Draught Fan operation and vice versa is possible.
- SYSTEM HUTTER offers compact steam generator design with smaller steam generator footprint and -weight.
- SYSTEM HUTTER Steam Generators are construction independent; for new plants we preferably chose corner tube boiler construction. Advantages: short waterways with min. thermal stresses & lively water circulation, fast load changes, robust against unbalance load.

Combined Cycle (CCGT) CHP Stations SYSTEM HUTTER – Description

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



Combined Cycle (CCGT) CHP Stations SYSTEM HUTTER – Advantages

Combined Heat and Power (CHP) Stations for generation of useful steam and electricity:

At a price ratio electricity to fuel of low to high (approx. 1.8 up to approx.. 3.6) the optimisation typically leads to Gas Turbine with Radiation-type Steam Generator and (Extraction-) Back-pressure Steam Turbine (**CCGT CHP SYSTEM HUTTER**)

Advantages of the Combined Cycle CHP Stations SYSTEM HUTTER:

- Superior Economy (e.g. Net Present Value, Internal Rate of Return) in a wide range of boundary conditions
- Lower Sensitivity against Fuel Price Escalation; the investment security increases with increasing fuel utilisation factor
- Highest Fuel Utilisation Factors (Total Efficiencies) up to 94 %; consequently reduced fuel costs
- Different fuels for the Steam Generator (SG) Firing are useable, which amounts up to max. 64% of the tot. fuel consumption of the CHP Station; in combination with a rotary tube SG fuels are replaced by residues and others
- Extended Operating Range down to 20 - 30 % of nominal steam generation
- Operation Field: The ratio between electricity- & steam generation is within the operation field adjustable without inefficient Condensing Steam Turbine. Operation can be adjusted according to changing conditions (electricity- & fuel prices, laws)
- High Operating Flexibility with fast process steam load changes
- Highest Time-Reliability (for entire fleet > 99,5 %); by robust design, supplier choice, QC, redundancies
- Environmental Protection by low CO_2-Emissions (CO_2-Costs) and low Air Pollutant Emissions
- Repowering of existing Steam Turbine CHP Stations or GT with Heat Recovery Steam Generators is possible

Repowering of Steam Turbine Power Plants 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

Reduction of CO_2-Emissions and environmentally-friendly Repowering due to fuel change and efficiency increase

Combined Cycle (CCGT) CHP Stations SYSTEM HUTTER – Module Sizes

Combined Cycle CHP Station SYSTEM HUTTER Modules:

for single-line configuration (1 Gas Turbine on 1 Steam Generator on 1 Steam Turbine)

- Electrical Power from 2 MW to 82 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 – 4.5	36	8 – 9	45 / 450
CH45	5 – 7.5	45	10.4 – 12.9	64 / 450
CH65	8	65	17.2	90 / 505
CH100	2x6 – 18	100	27 – 33	100 / 505
CH130	18 – 30	130	43 – 55	120 / 540
CH200	30 – 45	200	63 – 82	120 - 140 / 540

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

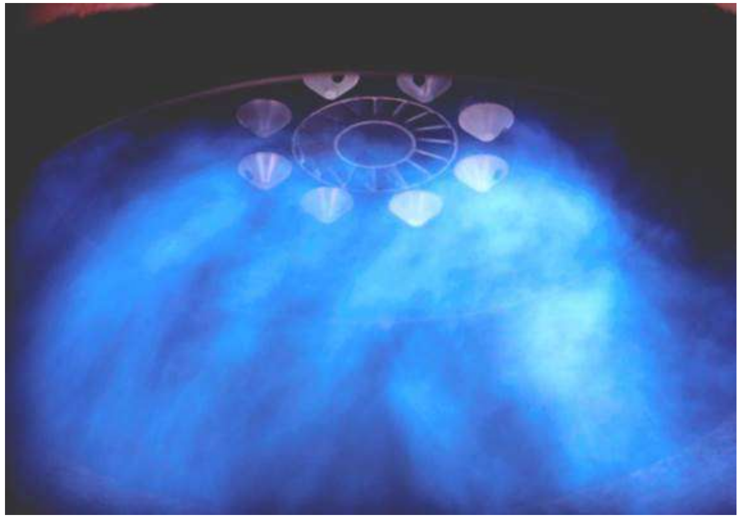
Three Combined Cycle CHP Stations SYSTEM HUTTER Varel 1, 2, 3

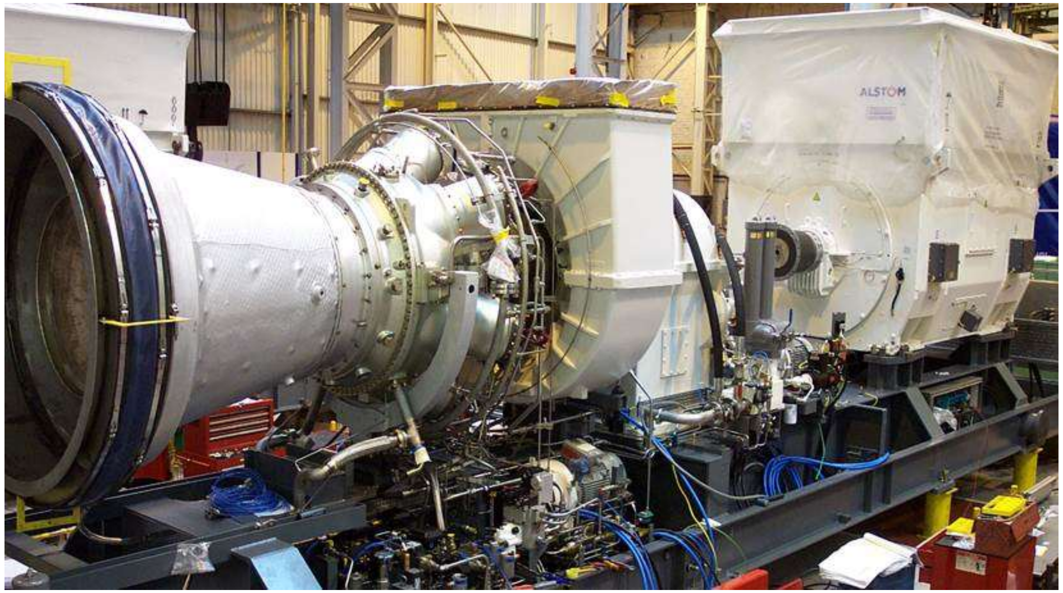
Three Combined Cycle CHP Stations SYSTEM HUTTER at the Paper and Board Mill Varel, Germany,

Varel 1; 1990; 266‘000 OH

Varel 2; 2003; 151‘000 OH

Varel 3; 2008; 115‘000 OH





Combined Cycle CHP Stations SYSTEM HUTTER – Operating Experience

7 CHP Stations SYSTEM HUTTER in Operation

Cumulative Operating Experience:

- 155 Years
- 1'370'000 Operating Hours

Longest Operating Experience:

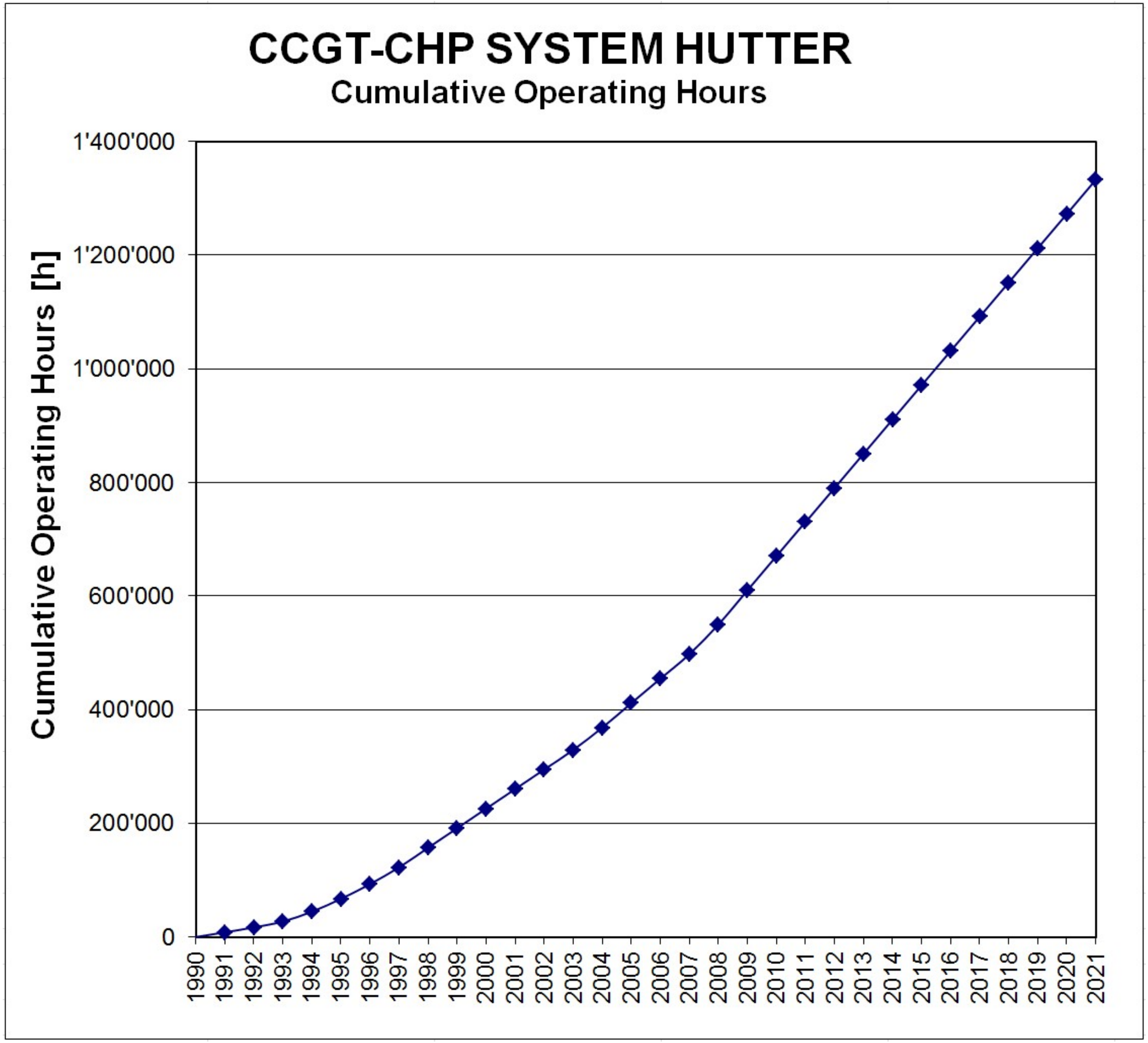
- 31 Years
- 270'000 Operating Hours

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



CCGT CHP Stations with Heat Recovery Steam Generator – Description & Advantages

Combined Heat and Power (CHP) Stations for generation of useful steam / warm water and electricity:

At a very low price ratio electricity to fuel (greater than approx. 3.6) the optimisation typically leads to Gas Turbine with Heat Recovery Steam Generator (HRSG) and Extraction-Condensing Steam Turbine **(CCGT CHP with HRSG)**

Description of Combined Cycle CHP Stations with Heat Recovery Steam Generator:

- Heat Recovery Steam Generator has a supplementary firing with much smaller rate than Radiation-type Steam Generator
- Therefore a much larger Gas Turbine is necessary with higher exhaust gas heat & -flow; ⇒ higher flue gas temperature
- Therefore the fuel utilisation factor is much lower, but more electricity is generated than with Radiation-type Steam Generator
- We have a specially developed firing with exhaust gas – flue gas system for low emissioning firing even at part loads

Advantages:

- superior economy (e.g. Net Present Value, Internal Rate of Return) at very high price ratio electricity to fuel
- high sensitivity against Electricity Price Escalation; the investment security decreases with decreasing fuel utilisation factor
- suitable for Customers with high electricity demand in relation to the useful heat demand
- suitable for Customers with warm water demand
- suitable for Customers with a relatively smooth demand of useful heat and electricity
- high time-availability; by robust design, supplier choice, quality management and -control

Steam CHP Stations – Description and Advantages

Combined Heat and Power (CHP) Stations for generation of useful steam / warm water and electricity:

At a very low price ratio electricity to fuel (lower than approx. 1.8) the optimisation typically leads to classical Steam CHP Station (Radiation-type Steam Generator with Extraction-Back-pressure / Condensing Steam Turbine)

Description of Steam CHP Stations:

- The Radiation-type Steam Generator consists of a power firing, which at full load optimally burn out the oxygen.
- Therefore the flue gas mass flow is minimised and the flue gas temperature is low
- Therefore highest fuel utilisation factors (Total Efficiencies) up to 94 %; therefore reduced fuel costs
- Much less electricity is generated than with the CHP SYSTEM HUTTER or the CCGT CHP with Heat Recovery Steam Generator

Advantages:

- superior economy (e.g. Net Present Value, Internal Rate of Return) at very low price ratio electricity to fuel
- low sensitivity against Fuel Price Escalation; the investment security increases with increasing fuel utilisation factor
- different fuels for the Steam Generator (SG) Firing are useable
- Environmental Protection by reduced CO_2-Emissions (CO_2-Costs)
- suitable for Customers with low electricity demand in relation to the useful heat demand
- high time-availability; by robust design, supplier choice, quality management and -control

CHP Stations – Customers and Operators

Companies, who continuously and simultaneously need
useful heat (steam or warm water), useful cooling as well as electricity, as e.g.:

UPM NORDLAND PAPER Mill, Dörpen, Germany

- Paper- and Cardboard
- Textile
- Automobile
- Steelwork
- Cement
- Chemistry
- Aluminium
- Mines
- Oil refinery and Oil production
- Sugar
- Food
- District Heating, Airports, Industrial Parks
- Process Industry
- Residue-Waste-to-Energy / Waste Incineration Plants

Delivered SYSTEM HUTTER and further CHP Stations – References

- **Combined Cycle CHP Station SYSTEM HUTTER Varel 1**
  for Paper- and Board Mill VAREL; Varel, Germany
- **Combined Cycle CHP Station Repowering to SYSTEM HUTTER Buchmann 1**
  for Board Mill BUCHMANN; Annweiler-Sarnstall, Germany
- **Combined Cycle CHP Station SYSTEM HUTTER Smurfit Kappa Badische Karton & Pappenfabrik (BKPO) 1**
  for Board Mill SMURFIT KAPPA BADISCHE KARTON & PAPPEN; Obertsrot, Germany
- **Combined Cycle CHP Station SYSTEM HUTTER Smurfit Kappa Europa Carton Hoya 1**
  for Paper Mill SMURFIT KAPPA EUROPA CARTON; Hoya, Germany
- **Combined Cycle CHP Station SYSTEM HUTTER Varel 2**
  for Paper- and Board Mill VAREL; Varel, Germany
- **Combined Cycle CHP Station SYSTEM HUTTER Varel 3**
  for Paper- and Board Mill VAREL; Varel, Germany
- **Combined Cycle CHP Station 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**
  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
- **Combined Cycle CHP Station SYSTEM HUTTER UPM Nordland Papier 1** (Design, Pre-Engineering, Authority Permitting)
  UPM NORDLAND PAPIER; Dörpen, Germany

Thermal Power Stations – Description and Advantages

Thermal Power Stations for generation of electricity:

If the demand is almost solely electricity, depending on the amount of the electricity demand, depending on fuels, cooling, electricity transmission requirements and depending on economic boundary conditions the optimisation can lead to Thermal Power Stations; depending on the boundary conditions to particular power station technologies

Description of Thermal Power Stations (Turbine-based):

- Thermal Power Stations are mainly Steam Power Stations, Gas Turbine Power Stations or Combined Cycle Power Stations (CCGT)
  - Main heat losses are necessary steam condensation and flue gas losses; relatively high heat losses
- Steam Power Stations are Radiation-type Steam Generator plus (Extraction-)Condensing Steam Turbine; Many Fuels are useable.
  - with power firing, which optimally burn out the oxygen; therefore low flue gas mass flow and -temperature
  - supercritical live steam conditions; overall efficiencies depending on fuel up to approx. 50 %
- Gas Turbine Power Stations are Gas Turbine without steam process; Fuel Gas or temporarily Diesel
- CCGT Power Stations are Gas Turbine plus Heat Recovery Steam Generator plus (Extraction-)Condensing-Steam Turbine; Fuel Gas/Diesel
  - therefore high flue gas mass flow and therefore high heat loss; Alternative processes w/ or w/o supplementary firing;
  - Multi pressure Steam Generators; therefore low FG-Temp.; subcritical live steam condition; efficiency up to approx. 60 %

Advantages:

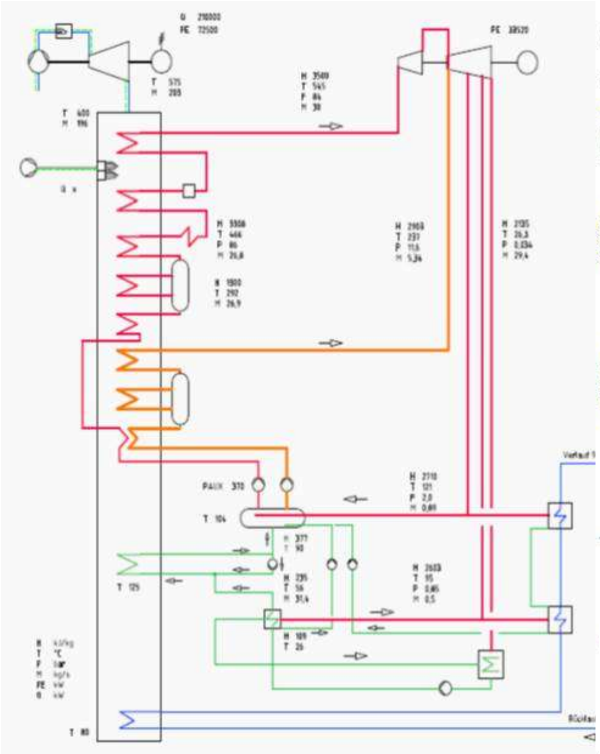
- superior economy depending on boundary conditions; low electricity generation costs; high electricity supply security
- high generation capacity per block; suitable for Customers, who sell respectively transport electricity

Thermal Power Stations – Description and Advantages

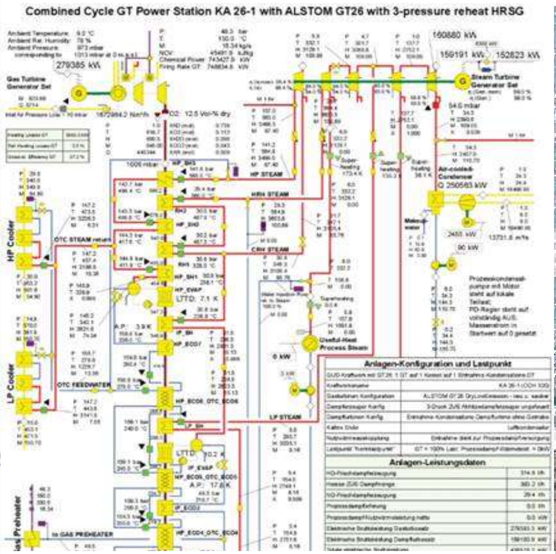
Optimisation for gas-fired Power Station Cycles for pure electricity generation leads to:

Gas Turbine with **unfired or low fired Multiple-Pressure Heat Recovery Steam Generator** with subcritical live steam conditions, and **Extraction-Condensing Steam Turbine**

CCGT CHP Station
($P_{el.}$ 106 MW; $Q_{District\ Heat.}$ 90 MW)



CCGT Power Station
(El. Power Output $P_{el.}$ 439 MW)



Realised Combined Cycle Gas Turbine Power Station
(El. Power Output $P_{el.}$ 400 MW)

Thermal Power Stations – Customers and Operators

Companies, who either
need pure electricity or
continuously and simultaneously need electricity and a relatively small portion of useful heat, or
continuously and simultaneously need electricity and useful cooling, as e.g.:

EDELMAG, Punta Arenas, Chile

- Power Utility Companies
- Municipal Utilities
- Municipal Service Providers
- Independent Power Producers
- Industries
- EPC-Suppliers
- Data Centres

Thermal Power Stations – References

- We have provided Engineering-Services for many projects about Project Development, Study, Engineering and Construction of Thermal Power Stations.
  Thereby our Scope of Services applied to the entire Plant.

- Our numerous references are listed under the Product "Engineering Services (Consulting / Planning / Engineering / General Planning / EPCM-Contractor)"

- The spectrum or our references comprises as follows:
  - **Gas- and Steam Turbine Power Stations (CCGT / CCPP)**

    from 16 $MW_{el.}$ per block with HP live steam conditions 65 bar / 470 °C
    to 875 $MW_{el.}$ per block with HP live steam conditions 140 bar / 565 °C

  - **Steam Power Stations**

    from 65 $MW_{el.}$ per block with HP live steam conditions 85 bar / 525 °C
    to 700 $MW_{el.}$ per block with HP live steam conditions 195 bar / 565 °C
    in pre-concept studies up to 1100 $MW_{el.}$ with 295 bar / 600 °C

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