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COMBINED CYCLE POWER PLANT WITH INTEGRATED LOW TEMPERATURE HEAT (LOTHECO)

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OUTLINE OF PRESENTATION

- **INTRODUCTION**
- **DESCRIPTION OF THE LOTHECO CYCLE**
- **EXERGETIC ANALYSIS OF GAS TURBINE BASED POWER PLANTS**
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  - STIG Cycle with GT10C
  - HAT Cycle with GT10C
  - LOTHECO Cycle with GT10C
- **ECONOMIC ANALYSIS**
- **CONCLUSIONS**

INTRODUCTION

- Advantages and possibilities of the novel LOTHECO cycle, by comparison between: Simple Cycle Gas Turbine (SGT), Combined Cycle Gas turbine (CCGT), Steam Injection Gas Turbine (STIG), Humid Air turbine (HAT) and LOTHECO

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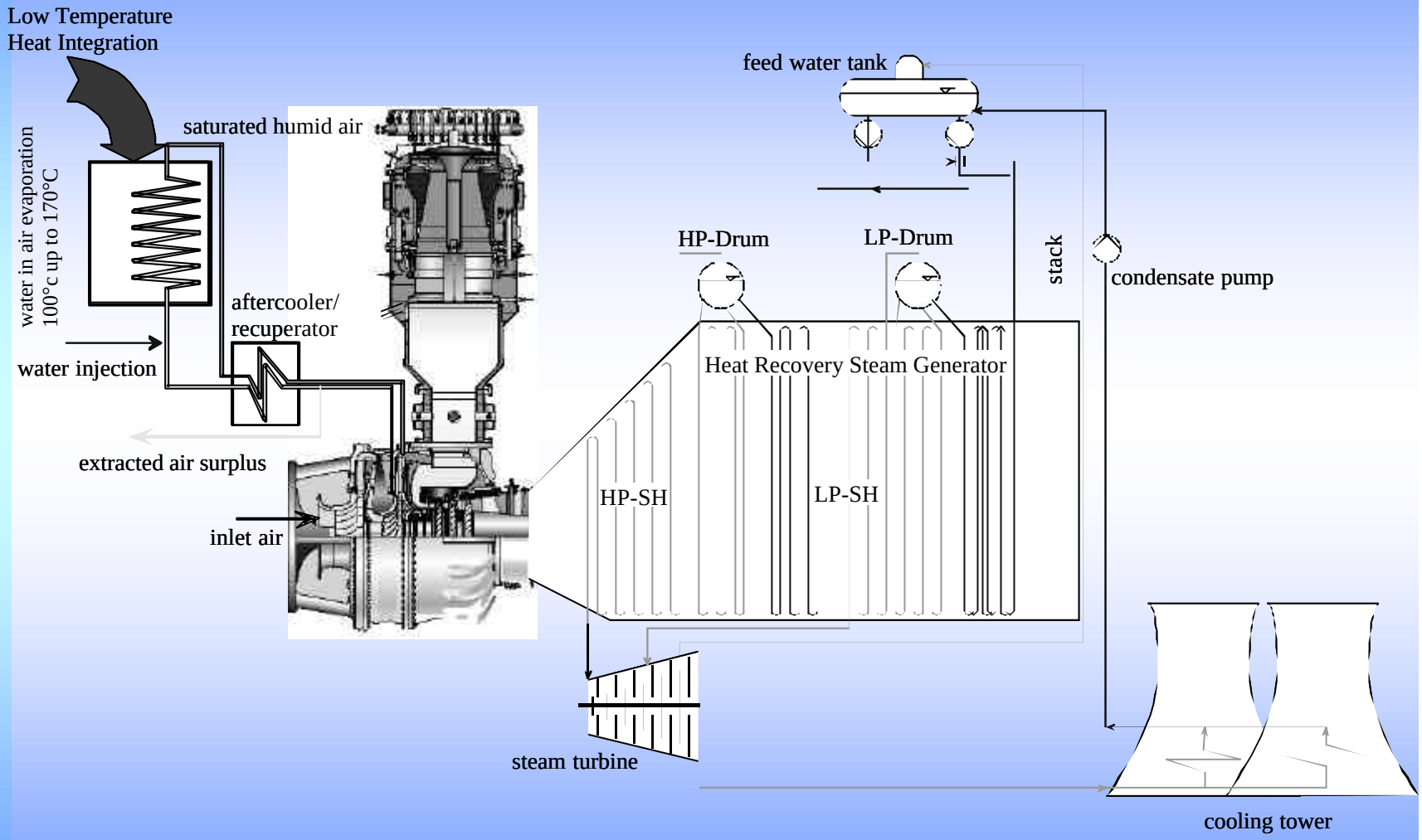
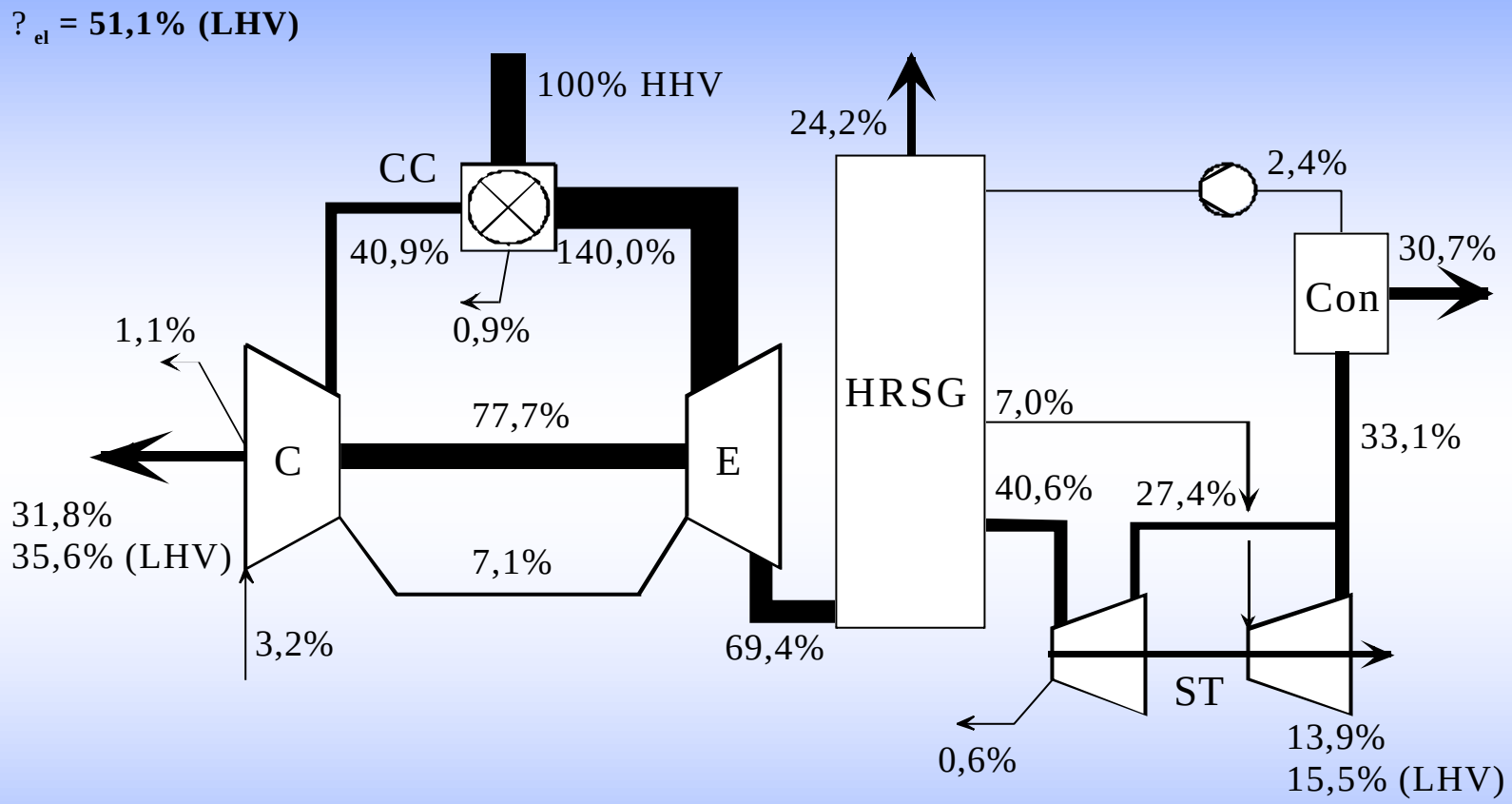
DESCRIPTION OF THE LOTHECO CYCLE (1)



DESCRIPTION OF THE LOTHECO CYCLE (2)

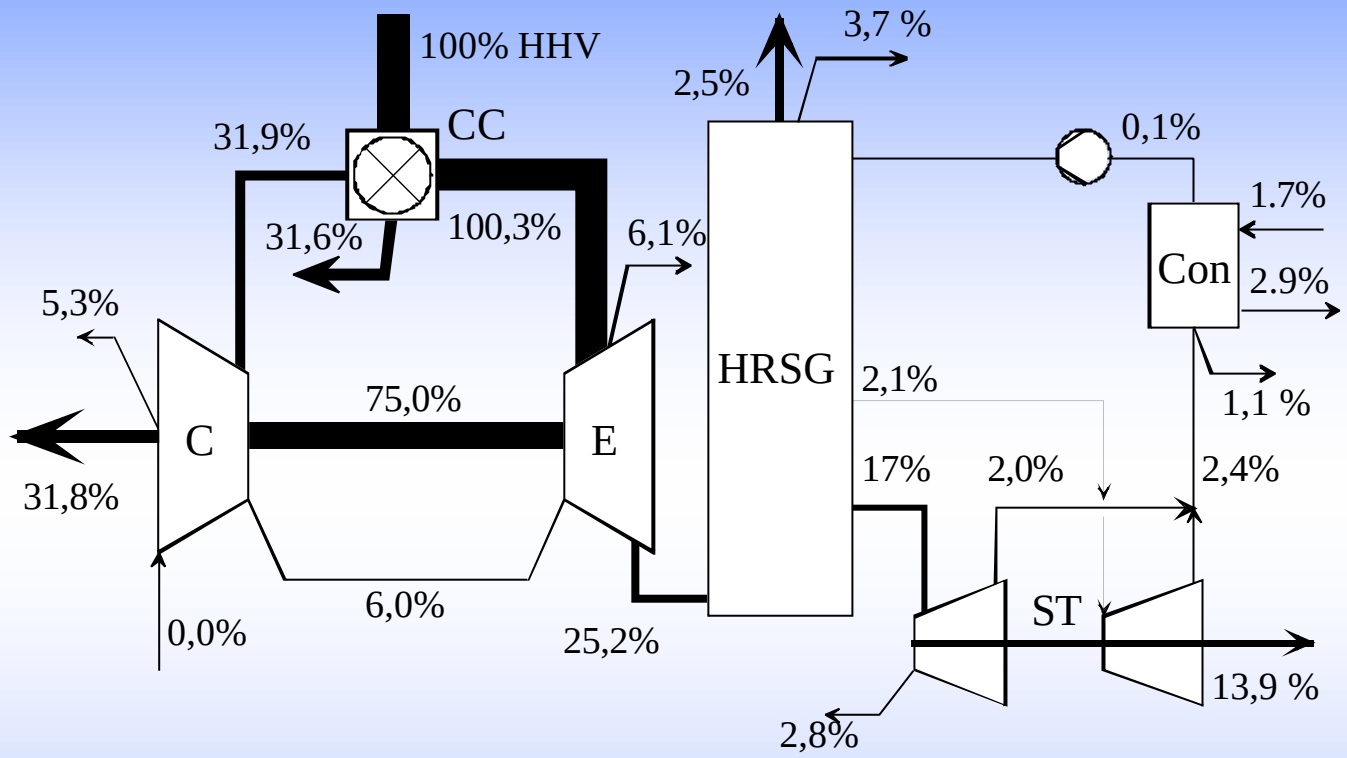
- Utilisation of low-temperature waste heat or solar heat to evaporate water injected into the compressed combustion air of the gas turbine.
- Water-in-air evaporation takes place at the vapour partial pressure and, therefore, at low temperatures (from below 100°C up to 170°C).
- High heat transfer rate in the evaporator, due to the higher heat transfer enhanced by water evaporation.
- Unlike other Wet Gas Turbines, the bottoming steam cycle remains unchanged.
- Compression of stoichiometric airflow, leading to reduced compressor's size and power consumption compared with conventional CC's.
- Very low NOx emissions, due to the high water vapour content in the combustion air and the low combustion temperatures.

ALSTOM CCGT Plant with GT10C



Energy flow of the ALSTOM CCGT plant (based on HHV)

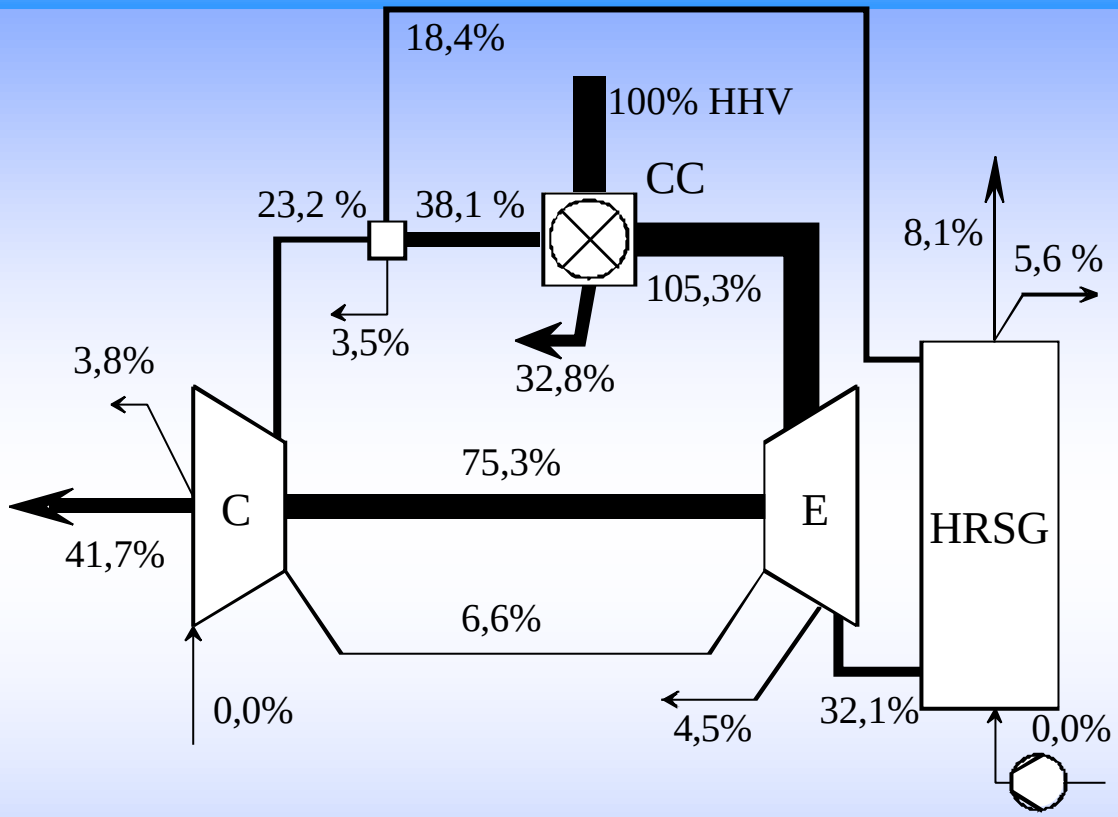
ALSTOM CCGT Plant with GT10C



Exergy flow diagram of the ALSTOM CCGT plant

- Largest source of exergy destruction is the combustion chamber

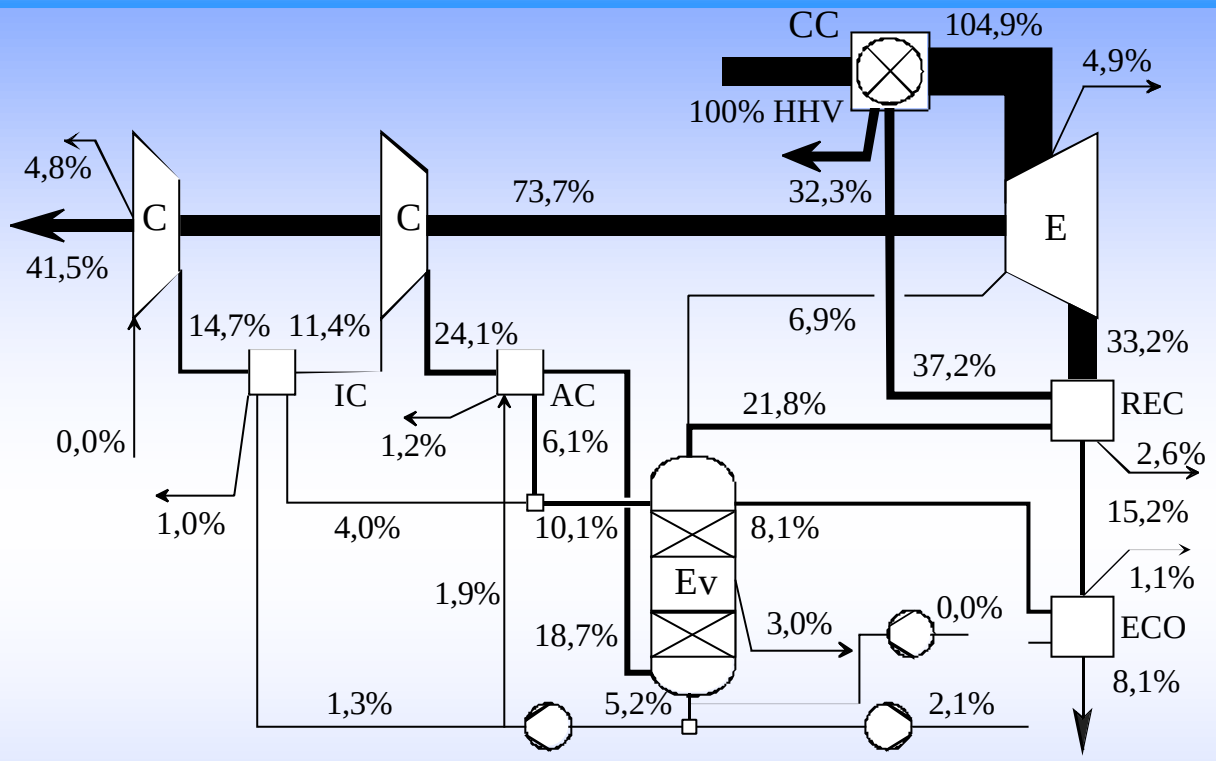
STIG Cycle with GT10C



Exergy flow diagram of the STIG cycle

- The single pressure HRSG results in higher exergy destruction than in the CCGT
- Increased flue gas exergy waste with respect to CCGT

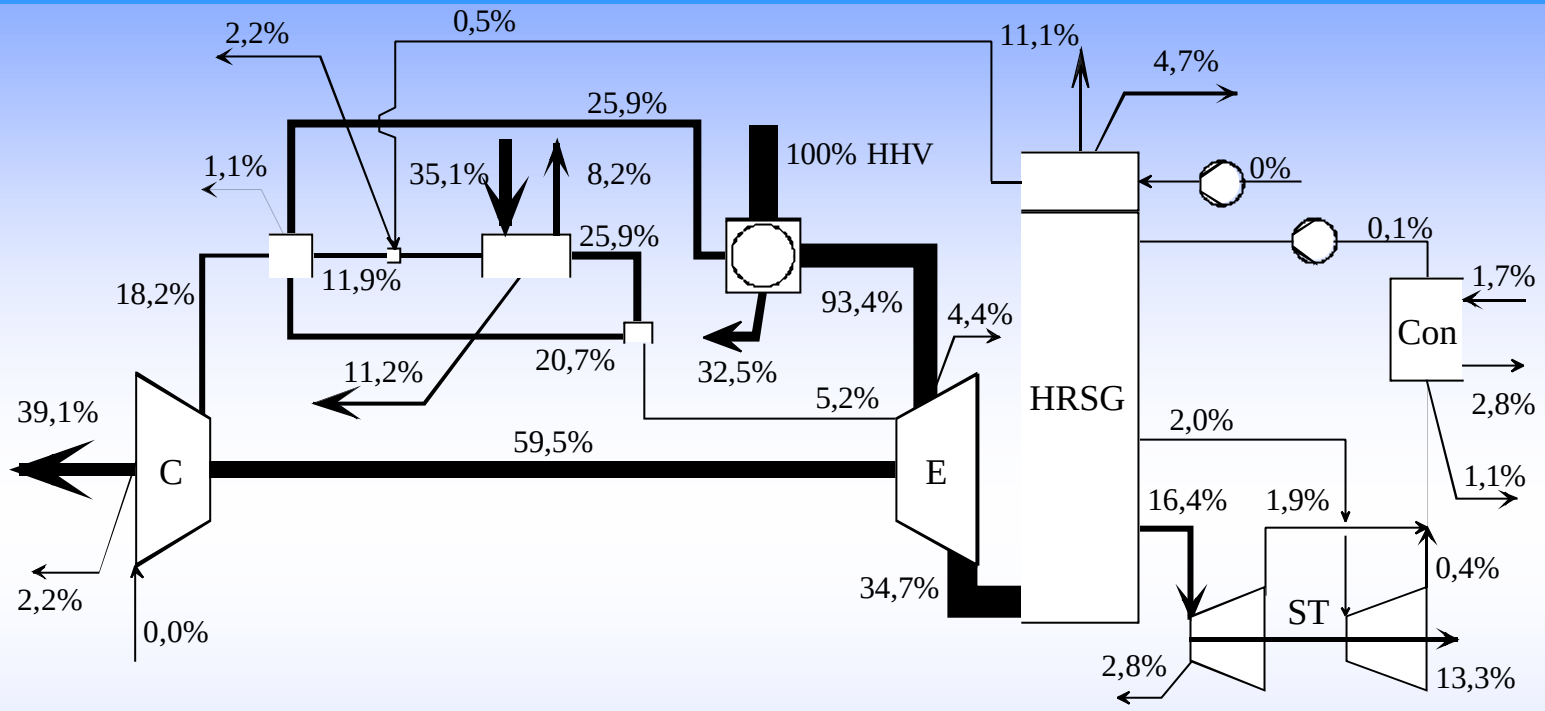
HAT Cycle with GT10C



Exergy flow diagram of the HAT cycle

- Flue gas recovery is more efficient than in the STIG cycle
- Irreversibilities within the STIG and HAT process result in higher exergy destruction than CCGT
- STIG and HAT have lower exergy destruction during compression and expansion than in the CCGT

LOTHECO Cycle with GT10C



Exergy flow diagram of the LOTHECO cycle

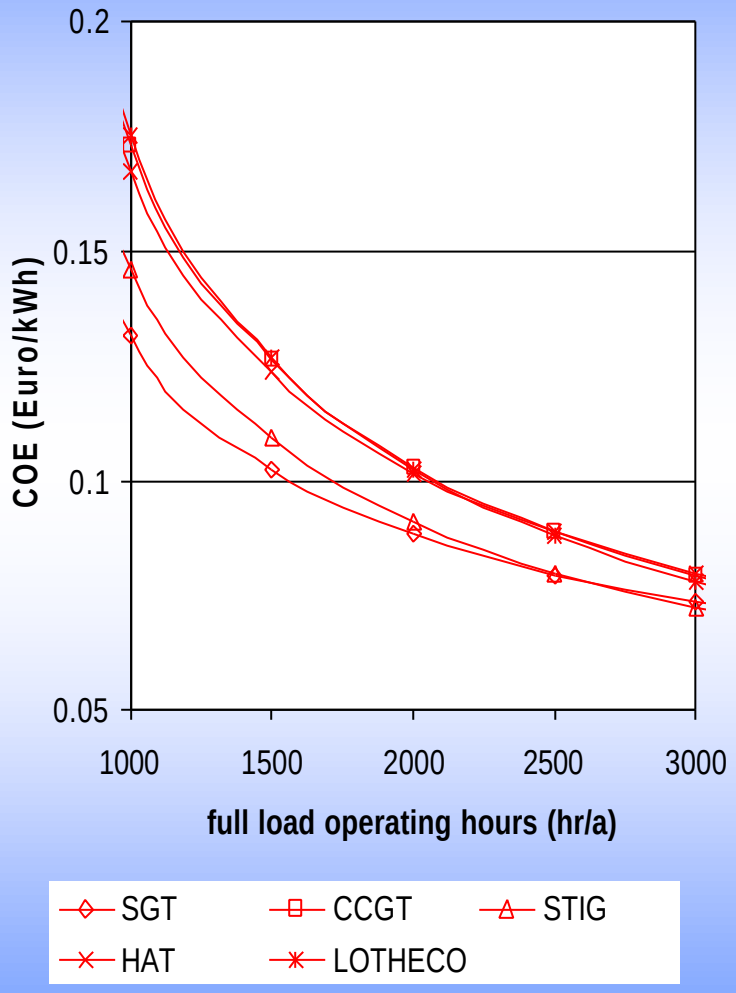
- Flue gas utilisation in HRSG results in low exergy destruction
- Integration of low-temperature heat source introduces high exergy losses
- Exergy destruction at the evaporator can be minimised by decreasing waste heat temperature, affecting its size and the cost of the plant

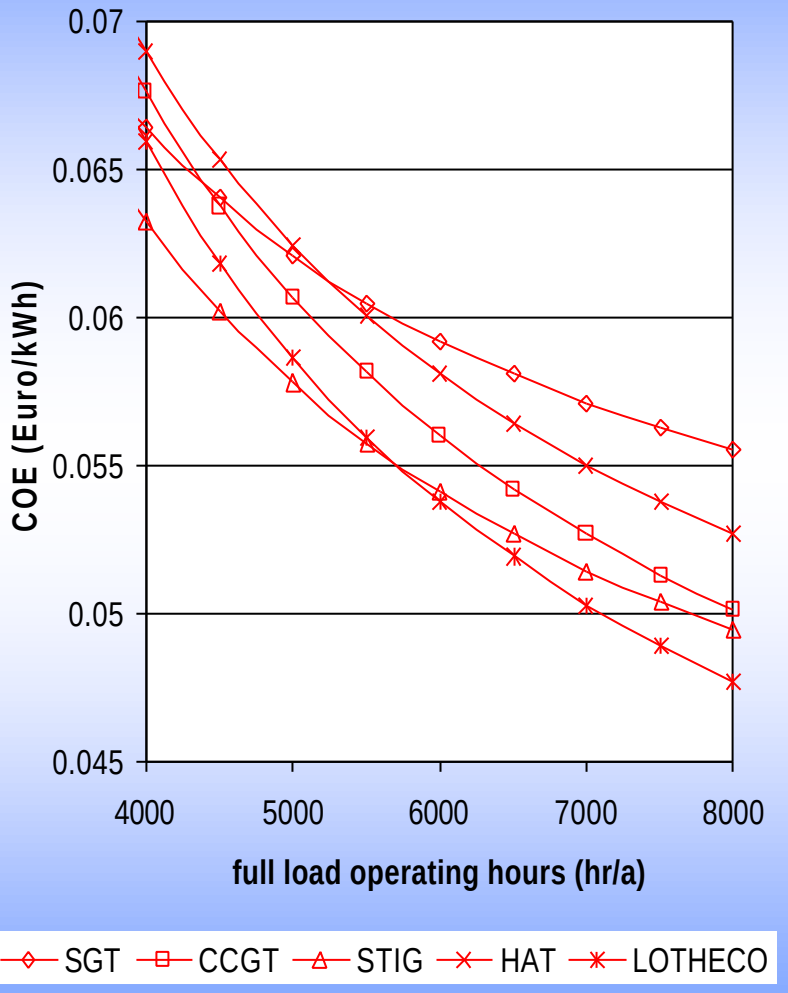
ECONOMIC ANALYSIS (1)

	SGT	CCGT	HAT	STIG	LOTHECO
P_{el} (MW)	29,13	41,30	36,55	37,25	46,6
n_{el} (%)	36,0	51,1	45,2	46,0	57,6%
k_{inv} (M€)	11,6	30,97	25,85	20,90	36,82
k_F(€/GJ)	3	3	3	3	3
k_{Mai}	0,2	0,3	0,25	0,25	0,35
k_{Op}	1,8	2,0	1,9	1,9	2,1
$K_{t\&i}$	0,02	0,02	0,02	0,02	0,02
Personnel	18	30	24	24	34

Basic assumptions made for the economic analysis
(operating period of 20 years)

ECONOMIC ANALYSIS (2)





ECONOMIC ANALYSIS (3)

- For less than 4000 full load operating hours, the COE of the SGT and STIG units are lower than the equivalent cost of the Combined Cycle plant.
- The CCGT unit operates more cost efficiently for intermediate base load applications.
- The COE of the HAT cycle is always higher than the COE of the STIG and CCGT cycles. Only for more than 4500 full load operating hours, the HAT unit generates electricity at lower costs than the SGT cycle.
- The economic evaluation of the LOTHECO concept reveals that the integration of low quality (waste) heat source results in such an increase in fuel efficiency, that the additional investment cost for the waste heat utilisation can be recovered.

CONCLUSIONS

- The advantages of the LOTHECO natural gas-fired Combined Cycle concept have been demonstrated by comparison with four gas turbine based power generation systems for small and large-scale applications (SGT, CCGT, STIG and HAT).
- The results from the exergy analysis have provided information on the source of exergy losses of each process.
- The economic analysis showed that for smaller scale power plants and for intermediate operation, where the CGGT power plants are relatively expensive to operate, other innovative designs, such as the STIG or the LOTHECO cycle, could be used to generated electricity at significantly lower costs.