International Gas Union Research Conference
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Gas Innovations Inspiring Clean Energy

Combined cycle gas turbine efficiency enhancement using heat pumps for thermal power plants

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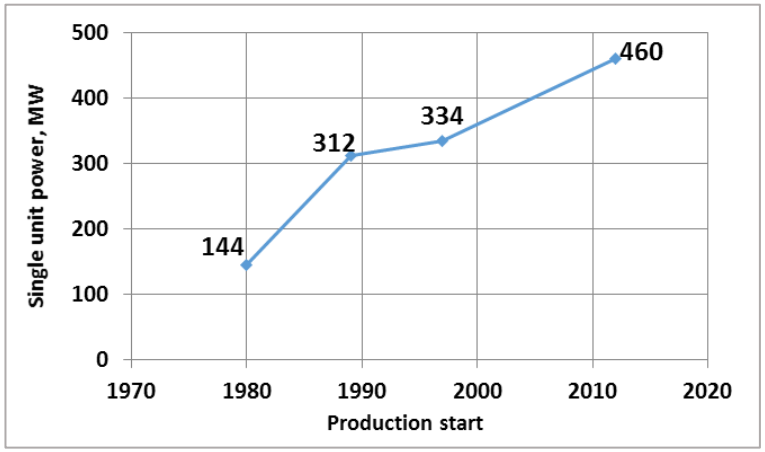
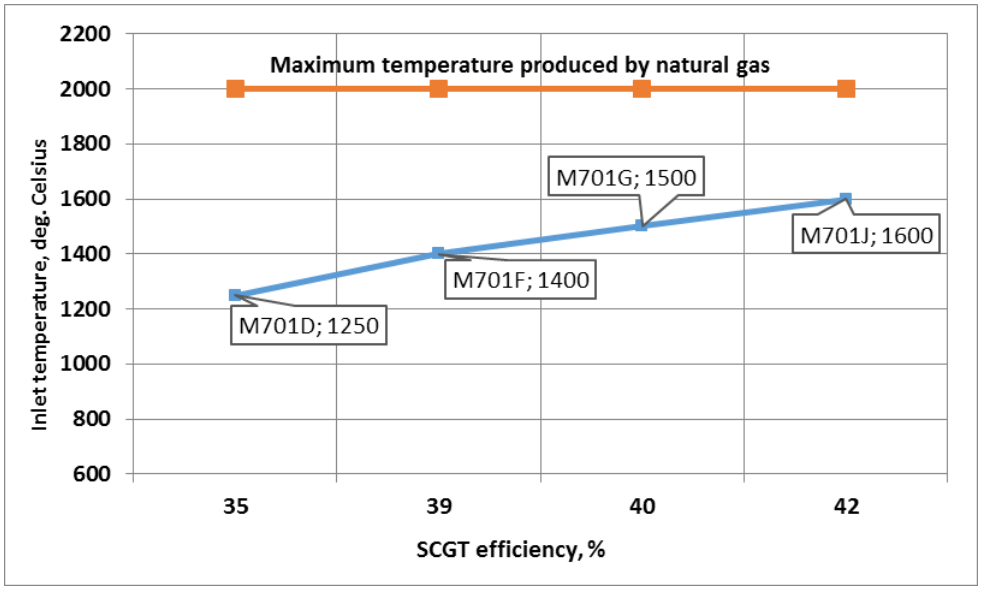
Efficient use of natural gas

- CCGTs are the most efficient way of generating power with natural gas as fuel
- Efficiency of new CCGTs goes over 60% when only power is generated and will rise in the near future
- Japan has a government policy of raising the efficiency up to 65%
- CCGTs by Siemens and Mitsubishi will soon be reaching this target
- This goal is being achieved mostly by raising the inlet temperature and in the long term there are some issues with it

CCGTs / GTs efficiency overview





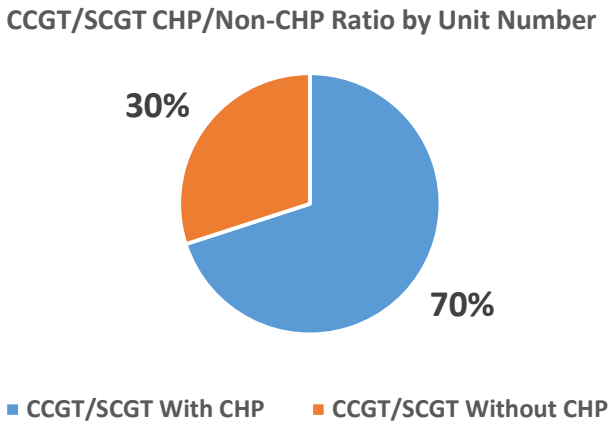
- There are only 400 degrees left before the limit is reached
- Since the losses, the limit is even lower than 2000 degrees Celsius
- The materials for the GTs are becoming more and more complex and expensive as we raise the temperature

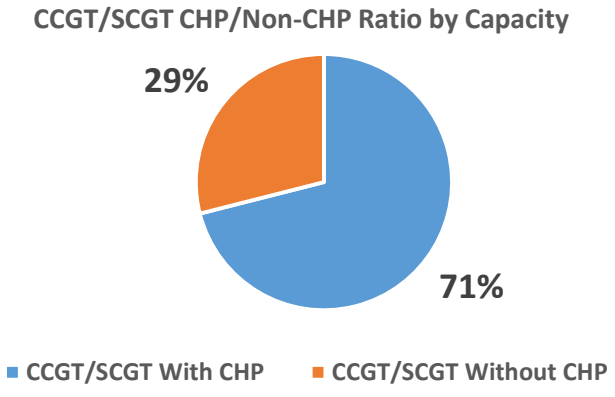
Aspects of efficiency

- Siemens and Mitsubishi way – raising the inlet temperature
- GE Energy Aero way – raising the compression ratio
- Other ways – steam injection, recirculation, etc.
- All these measures are aimed at raising the efficiency of power generation, the combined heat and power generation is overlooked
- Steam extraction for heating purposes decreases the electric efficiency of the CCGT
- What is the solution for regions with developed district heating networks?

The stats on Russia – power generation

- Russia historically has developed district heating networks
- Heat is produced either by CHPs or by district heating boilers
- In 2010 a Government subsidy plan was approved for new power generation units
- 30% of units were meant only for power generation
- 70% of units were meant for cogeneration of power and heat
- CHP generation is still the best option for Russia





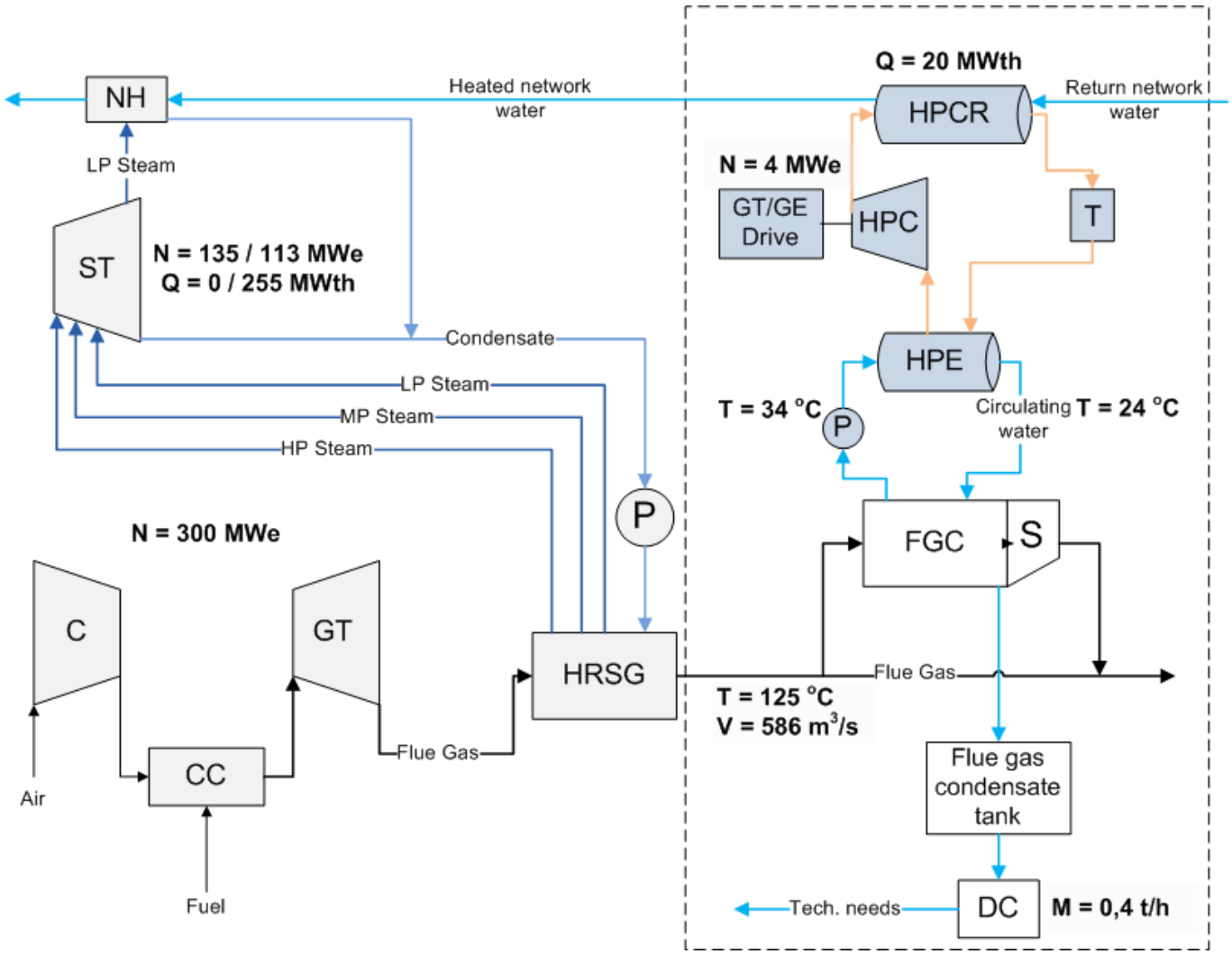
The stats on Russia – heat supply

- The cross-subsidy of electricity by heat makes heat from CHP less competitive against district heating from local boiler facilities
- Only inefficient boiler facilities are constructed in new areas
- No connection in new areas to district heating networks, where CHP heat is available
- The investments in large-scale heat pumps are too high
- Heat tariffs are regulated very strictly
- No investor interest to district heat pumps
- The Government plans to introduce a heat market to promote co-generation

The heat pumps

- The most effective way of heat generation
- Available in large and small-scale composition
- Numerous options for low-potential heat sources
- Electricity or natural gas is still required
- Lots of possibilities to use heat pumps at fossil fuel power plants since there are lots of sources with stable temperature over the year
- Could be used with renewable / waste energy sources such as incineration plants

The solution



C – GT compressor

CC – GT combustion chamber

GT – Gas turbine

HRSG – Heat recovery steam gen.

ST – Steam turbine

FGC – Flue gas cooler

S – Separator

P – Condensate/water pump

HPE – Heat pump evaporator

HPC – Heat pump compressor

T – Throttle

GT/GE Drive – Gas turbine/engine drive

HPCR – Heat pump condenser

DC – Decarb unit

NH – Network heater

The solution

The combination of two best available technologies – CCGTs and high temperature heat pumps:

- Almost no loss of power generation efficiency since no steam extraction is required
- Deep cooling of flue gas could potentially bring some amount of condensate water, which may substitute a part of feed water
- Electricity for the heat pump drive is not required, the heat pump could be gas-driven with highly efficient small-scale GTs or combustion engines
- The total efficiency rise of the combined unit could be over 2%

The problems

- The scheme is very sophisticated
- The possibility of water condensation from flue gas of the GT requires experimental confirmation, since the air-fuel ratio for the unit is very high
- There still has to be supplementary steam extraction since the heat pump has issues with load control
- Deep flue gas cooling requires extended surface which makes the aerodynamics of the system worse

Conclusion

- Efficient use of natural gas has its limit, which will be reached in the near future
- Efficiency of power generation of CCGTs grows fast, but efficiency of cogeneration is overlooked
- Regions with developed district heating networks need combined heat and power generation for efficient gas use
- Combining two most efficient power and heat generating technologies – CCGTs and HPs – could be the future option

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Thank you for your attention!

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