

GETTING THE MOST FROM A CHP DESIGN & ANALYSIS

## **ENGINEERS NEWSLETTER**

The efficient use of natural resources is an important contribution to reduce the environmental impact of human activities.

In the electricity generation field, the most part of the world electricity production comes from thermal plants powered by fossil fuels [1]. While renewable electricity production (mainly solar and wind) is rising its participation in the global scenario, some challenges associated to a high participation of intermittent electricity production in the electrical grid still need to be solved - including instability. Several technologies are being suggested and used as a contribution to stabilized electric grid; including

quick start of thermal plants, hydrogen, batteries, thermal plants operating at part load, hydropower plants, etc.

Hydropower plants allows dammed water use for electricity production at low renewable production hours and/or grid peak hours. Quick start thermal plants, usually engines and gas turbines are also used as a solution, but with low/medium thermal efficiency.

Renewable electricity production can lead to an excedent electricity generation that can be used for hydrogen production and/or pump water to hydropower dams. Hydrogen and dammed water later can be converted to electricity at low

renewable production hours and/or peak grid demand hours.

As the renewables make greater contributions to our energy mix, balancing the grid is more challenging than ever. Every country should plan and explore their possibilities looking forward to improving the renewable electricity production while maintaining the grid stability with reduced CO<sub>2</sub> emissions technologies. Better choices are a compromise among available options, natural resources, efficiency, emissions, country experience, strategic planning, electricity grid complexity and the distance between generation sites and the main cities, etc.

## **Where CHP fits into this broad perspective in terms of electricity generation with low environmental impact?**

CHP (cog/trig) is a well-tested technology, recognized worldwide as a feasible alternative to traditional centralized electricity production. It can bring a lot of benefits by providing cleaner electricity and useful thermal energy for different purposes, like (I) use of sanitary hot water, (II) space heating, (III) space cooling - using absorption chillers, (IV) steam and (V) process heating and/or cooling needs. Instead of purchasing electricity from the grid/utility, using electric cooling equipment and fuel at on-site steam generator, boiler or furnace, an industrial or medium to large commercial user can use an engine CHP (cog/trig) in order to provide their energy services with high energy efficiency.

A high efficiency fossil fuel use reduces CO<sub>2</sub> produced per generated electrical kWh and reduces countries' dependencies on fossil fuels

(sometimes imported). In countries where coal or other fossil fuels are intensively used, engine CHP (cog/trig) is an effective solution for high efficiency decentralized electricity production.

Previous experiences reveal that hotels, airports, hospitals, commercial and residential buildings, malls, data centers and industries are good candidates for an engine CHP system. COGMCI case studies reveal that engine CHP (cog/trig) systems can be the best natural gas use.

“Combined Heat and Power (CHP) systems can provide a range of benefits to users regards the efficiency, reliability, costs and environmental impact. Furthermore, increasing the amount of electricity generated by CHP systems in the United States has been identified as having a significant potential for impressive economic

and environmental outcomes on a national scale. Given the benefits from increasing the adoption of CHP technologies, there is value in improving our understanding of how desired increases in CHP adoption can be best achieved. These obstacles are currently understood to be from regulatory as well as economic and technological barriers.” [2].



## If it can bring several tangible benefits to the users, why it hasn't been employed in sites where such favorable conditions?

One of the biggest challenges when facing the CHP (cog/trig) business is a lack of favorable policies. In most of the countries, the feasibility is based on cost of fuels and electricity and not all the time this lead to an attractive return on the invested capital. In addition, even though they are present, sometimes they are not enough to support and encourage the investment. Still, in most countries the governmental policies are outdated and were formulated to an electricity generation industry based on a centralized system.

Another challenge is that the best energy savings engine CHP (cog/trig) possibilities are normally in an industry or building in which the decision makers sometimes are not comfortable to make a big investment outside their own "core business". An agreement with an

engineering company/investor is necessary.

Another issue that seems to be adverse to decision makers, is an inadequate process to gather information regarding the energy demand profiles year round which leads to a poor planning and evaluation from the beginning. Oversizing or under sizing the system may lead to a project failure in terms of expected results.

In fact, engine CHP (cog/trig) systems must be faced by countries as a strategic planning to reduce CO2 emissions and rise the average thermal efficiency. Rising a country average thermal efficiency reduces the natural gas imports or allow more natural gas to be exported.

Engine CHP (cog/trig) systems is a

tested and effective available high efficiency energy option that can help countries enhance their energy efficiency, reduce greenhouse gas (GHG) emissions, promote economic growth, and maintain a resilient energy infrastructure

COGMCI case studies reveals that engine CHP (cog/trig) can be designed for base loads (all the produced electricity is used at the site) or can be oversized (electricity export to the grid - mainly outside building/process peak loads). Both solutions can contribute to rise a country average thermal efficiency. Oversized systems deal with the demand response strategy. COGMCI can help you evaluate your project, predict their performance and take the decision based on local regulations and on your project goals.

## How COGMCI can give confidence to the user while developing a demand profile perspective?

In order to provide a better and more reliable feasibility analysis, COGMCI enable the users to input several load profiles as a representative year - 24, 192, 576 and 8760 hours analysis are available. COGMCI allows design modifications to meet customers energy needs. This feature leads to a better design step as the customer energy demand is used to optimize the design.

"Regardless of the type of facility at which they were installed, many on-site cogeneration power plants built in the last 10 years have failed (or performed sub-optimally) due to poor project planning and evaluation from the beginning" [3].

## When is the time to best look at CHP (cog/trig) implementation?

Energy efficiency activities may be undertaken at any time as part of a permanent financial and environmental enhancing perspective.

Engine CHP (cog/trig) systems should always be considered when:

- Designing a new building.
- Installing or replacing a new boiler or water heating plant (steam and hot water).
- Replacing, updating or refurbishing an existing plant.
- Reviewing electricity supply in general and new public /private utilities contract.
- Reviewing standby electricity generation.
- Exploring options towards building regulation compliance (energy savings standards and regulations).
- Reducing CO<sub>2</sub> emissions and environmental impact.



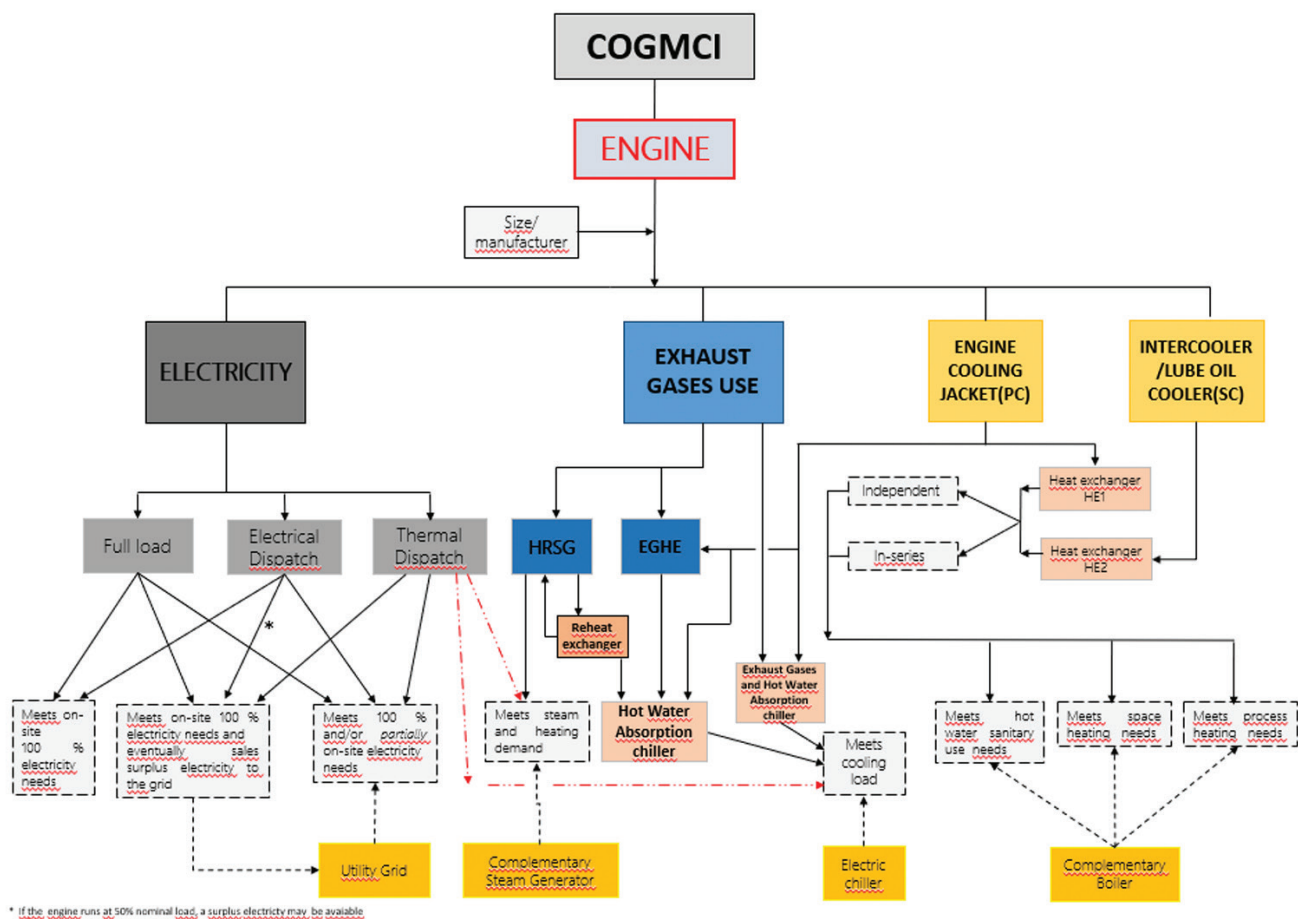
## COGMCI at a glance

While running an engine CHP (cog/trig) project analysis, the user needs to look for a variety of options to define which one is the most suitable configuration to his needs. The way COGMCI were designed, bring out a lot of flexibility when dealing with how to use the waste thermal energy provided by the internal combustion engine.

COGMCI flexible paths can help the user to try several possible settings, engines sizes and operational strategies to deal with the variables that affects an engine CHP (cog/Trig) system project. COGMCI possibilities offer the most from a data collection and overall inputs the users have in their hands.

# COGMCI

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COGMCI software helps the users meet their goals: (I) payback, (II) electrical grid independence (III) efficiency - environmental impact, (IV) energy supply security, etc. COGMCI helps you develop complex analysis when designing your engine CHP (cog/trig) project.

Spreadsheet result files allow the user to evaluate the analysis main results and select the most attractive solution. A good engine CHP (cog/trig) solution should be able to operate with high efficiency for the whole year.

## Defining size and paths to recover waste energy is critical in getting to a good project

Good engine CHP (cog/trig) design depends on the project main goals. At a low-cost fuel scenario, oversized systems can lead to good payback periods even giving up on high efficiency. Low cost fuel scenarios aren't expected to last for a long time.

At a severe environmental rule scenario

and medium fuel cost, engine CHP (cog/trig) system should be able to operate at high efficiency in an annual basis to be an achievable project. Different engine CHP configuration, operational modes and engine sizes produce different forms of usable energy (electricity, hot water, steam and chilled water) at different amounts.

Comparing the engine CHP (cog/trig) system energy with the building/process energy demands requires a detailed and complex analysis.

That's what COGMCI can help you to do: Design a good solution for your energy

## COGMCI methodology

COGMCI software has been developed by joining many FORTRAN engineering codes and a Delphi interface. Graphical results are generated by a spreadsheet (Excel) that imports data from result files. The Fortran programs is composed of four main algorithm and more than 30 subroutines dealing with (I) different engines, (II) water and steam properties, (III) exhaust gas properties, (IV) hot water absorption chiller selection and simulation, (V) exhaust gas and hot water absorption chiller, (VI) heat recovery steam generator (HRSG) design and simulation, (VII) HRSG economizer design and simulation, (VIII) exhaust gas heat exchanger (EGHE) design and simulation, (IX) cooling tower design

and simulation, (X) air cooler design and simulation, among others [4-5].

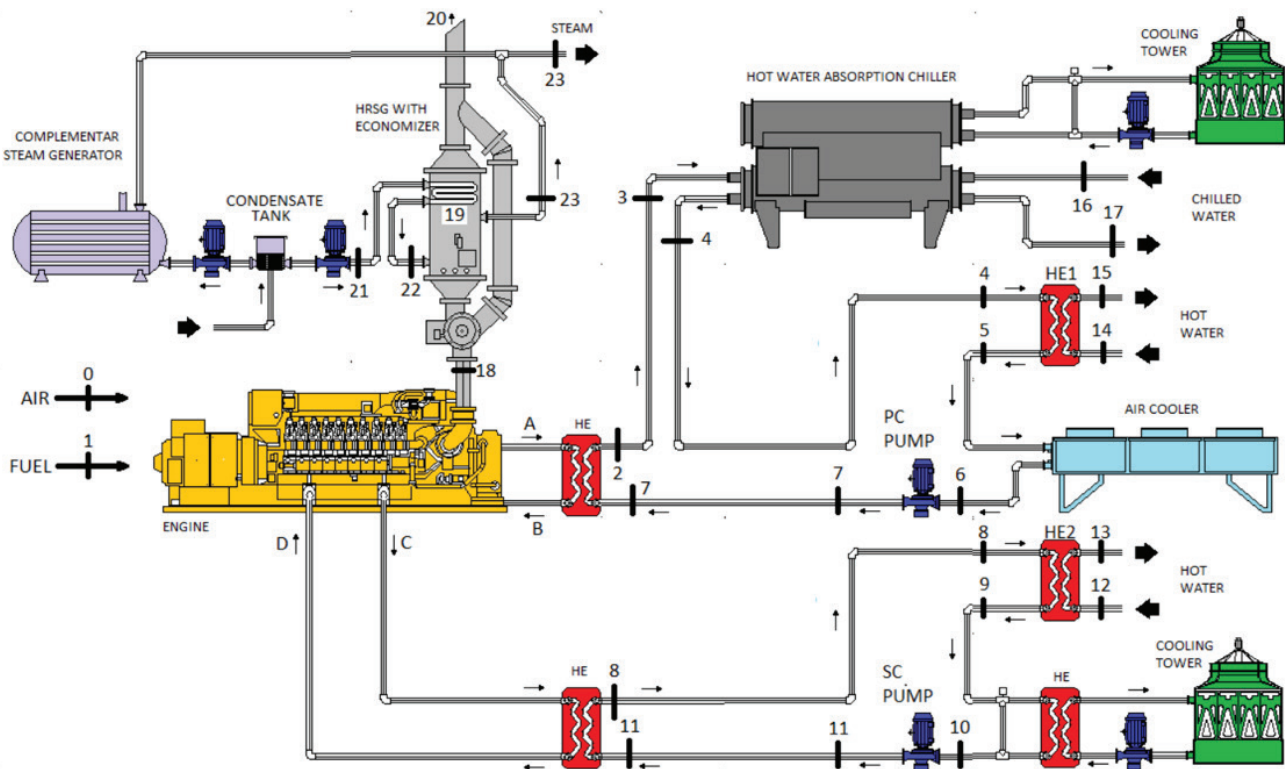
The main program controls data input, output and all calculations. Calculation procedures use polynomial curve fitting (engine and absorption chiller performance); deterministic modeling or mathematical representations of physical phenomena (heat transfer and pressure drops) and physical properties (water and exhaust gases). Four computational algorithm involving several iterative procedures were developed, simulating the system as an integrated thermal system, i.e., considering all pieces of equipment as operating as a single system. It produces

results as a function of demands, energy supplied by engine, design parameters, equipment performance, and simplified assumptions. The hourly profile analysis simulation approximates the dynamic nature of energy consumption in buildings and the dynamics of thermal equipment performance in an integrated system by a series of quasi-steady-state operating conditions with one-hour time-step.

The COGMCI software is being developed since 1998. It was previously utilized to develop others case studies [6-23].

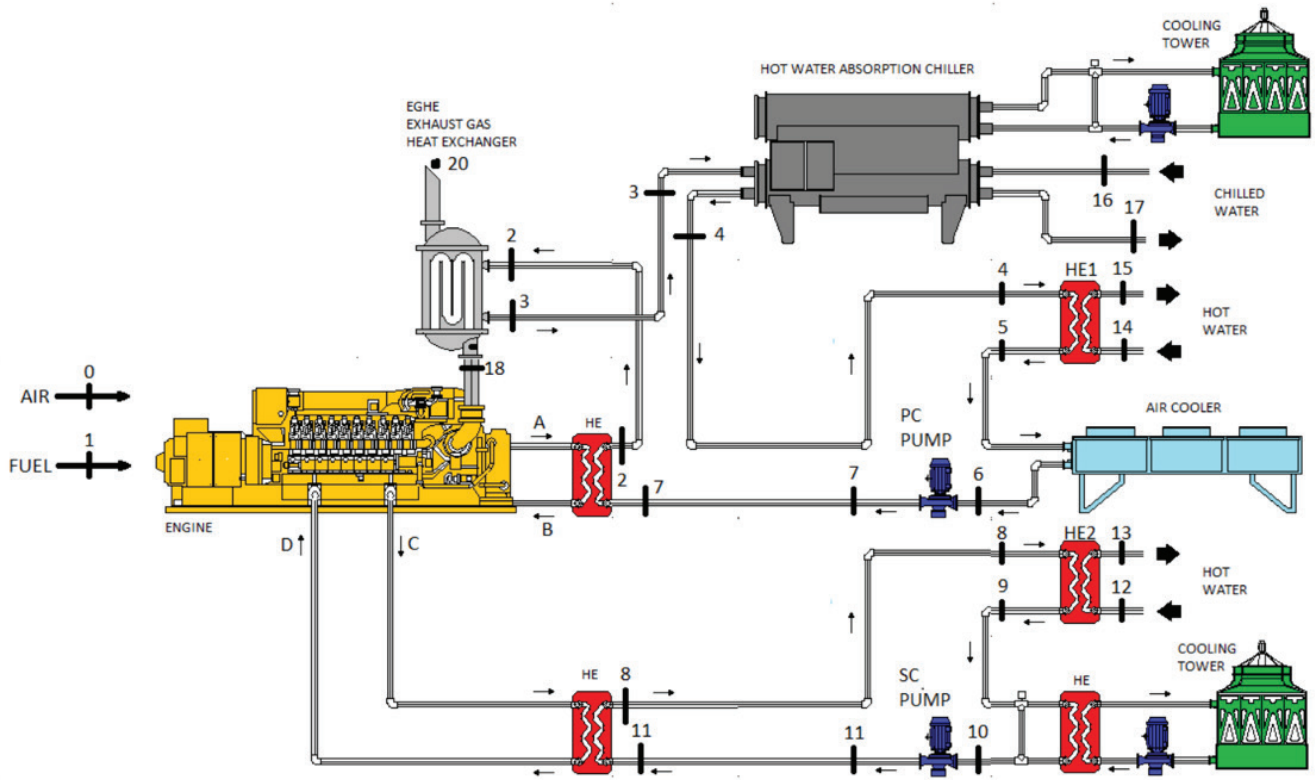
## COGMCI main solutions

Although several configurations are available, some of them should lead to higher efficiencies:

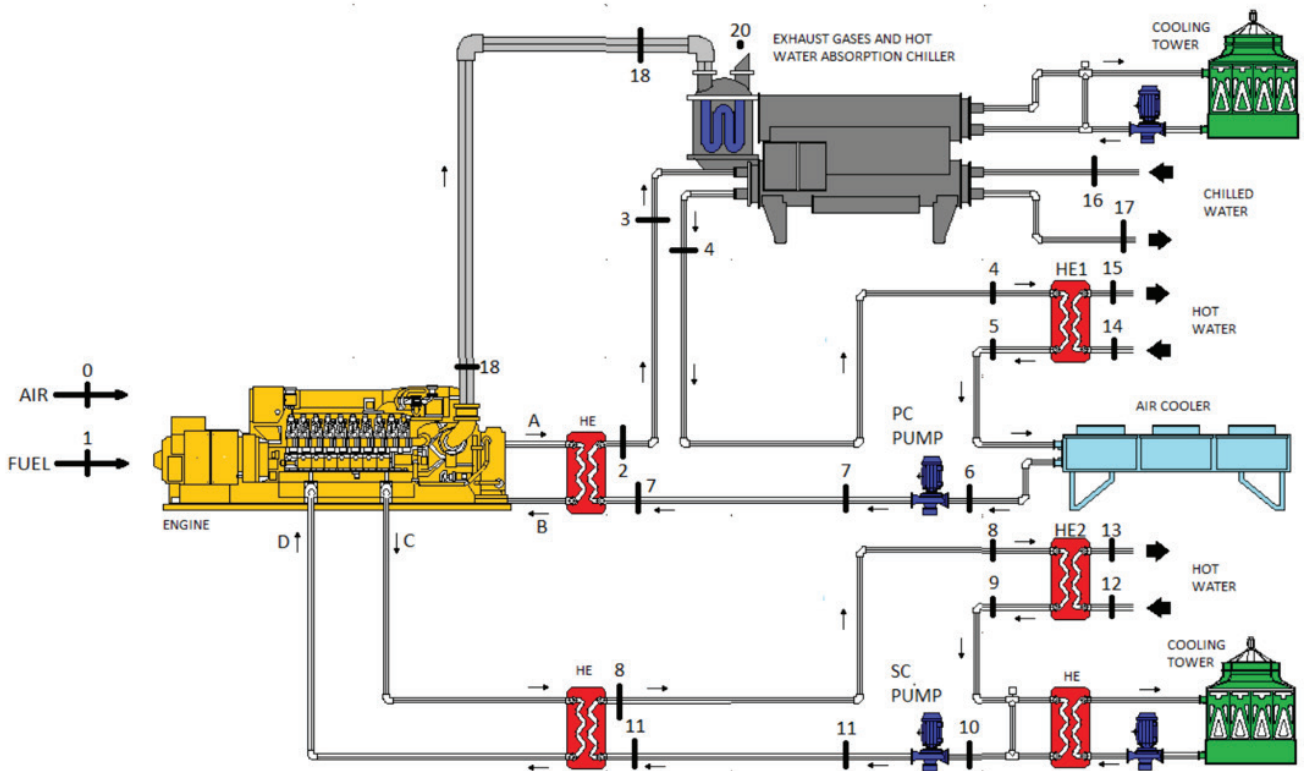


Engine + HRSG with an economizer + hot water absorption chiller + heat exchangers





Engine + EGHE (exhaust gas heat exchanger) + hot water absorption chiller + heat exchangers



Engine + exhaust gas and hot water absorption chiller + heat exchangers

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