General information:

- Project developer (designer):
  - Gaz de France: site expertise
  - Midi-Pyrénées Region and ADEME regional delegation: technical support
  - CLIMAT Engineering Bureau: faisability study and designer

- Location : CNES (Centre National d'Etudes Spatiales) located in Toulouse, South West France
- Project starting date (year): 2000
- Project status: completed: 2002

Summary of project:

Founded in 1961, the French Space Agency (CNES) is the French government agency responsible for shaping and implementing France's space policy in Europe.

Mostly known for its three programs ARIANE, SPOT and HELIOS, the CNES is mainly located at the Toulouse Space Center (CST), the largest space center in Europe. Founded in 1968, the CST conceives and executes space programmes with its partners in the scientific community and industry.

Although energy production facilities at the CST were already up to environmental standards, the CNES wished to achieve the best possible match between energy needs and production. The trigeneration plant seemed to be the best solution to the CST case, and, in 2001, the CNES chose to develop the first European plant's trigeneration system.

Description of project:

The CST is a great energy consumer. Hot water was previously produced by 3 natural gas heating systems for a total of 15 MW, and cold water was previously produced by 5 centrifuge groups and 2 piston groups (using R 22) for a total of 17 MW.

To improve the existing system, the CNES, in partnership with Gaz de France, ordered studies to find the best way to:

- Optimize the plants while ensuring their durability and safety
- Improve the environmental and economical report of the existing plant

The study's outcomes demonstrated that a trigeneration plant could bring a better energy efficiency and profitability than "traditional" systems with a reasonable investment's cost overrun.

The project consisted in implementing this technology, which actually is a cogeneration system combined with an absorption chiller that uses some of the heat to produce cold water.
Therefore, trigeneration uses a combustible material (natural gas in the current case) to provide three useful energy products: electricity, hot water (or steam) and cold water.

In addition, the plant recycles almost 80% of the energy it consumes, against about 37% for most centralized generating facilities.

Technical description

- Climate condition

The CST is located in Toulouse, in the southwest France. In this area, the climate is quite particular as it is a mix between the Oceanic, Mediterranean and Continental climate.

- Technical requirements of the buildings

The CST occupies 57 hectares and gathers almost 2500 people in about 150 000 m² distributed in 60 buildings.

The CST's plant needs constant temperature and hygrometry which is possible by the simultaneous production of hot water (95°C) and cold water (6°C).

- Innovative building technologies

The CST example real originality is the concrete implementation of an innovative technology: the trigeneration.

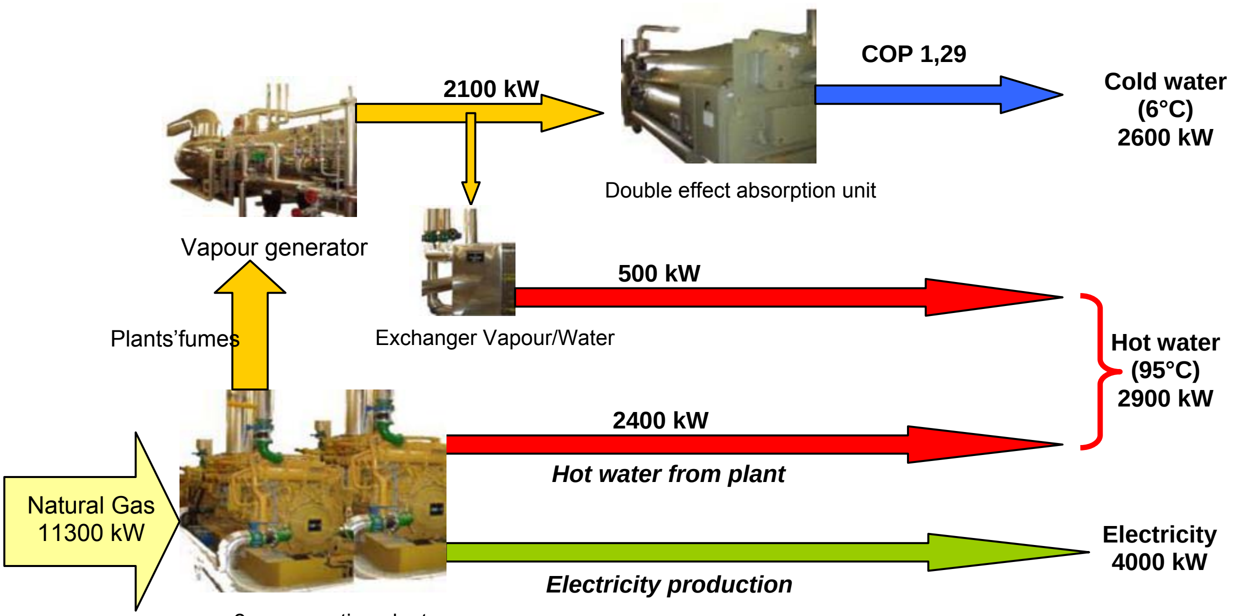
European Project "Eco-Building International Club for advanced European sustainable energy technology dissemination in Europe and China"

Project partners: ENEA (IT), ISNOVA (IT), FINCO (IT), ADEME (FR), AIMCC (FR), DTI (DK), DI (DK), CRES (GR), EBHE(GR), GPREC (GR), SEC(B), ZERI (CN), CBEEA (CN)

SIXTH FRAMEWORK PROGRAMME

If the cogeneration aims at producing heat and electricity, the trigeneration proves its supremacy by producing at the same time cold water. As premises cooling is required all year round in the CST, this system is economically effective.

The following functional diagram tries to synthesise the way the system works:



- 2 cogeneration engines, working with natural gas, drive an alternator and feed electricity into the public network (4 000 kW). 35.5% of the gas's energy consumed is converted into electricity.

A heat recovery system, located on the cooling circuit of the engines, feeds the heating network with a 2,400 kW calorific power through hot water production (95°C).

- A vapour generator, located on the exhaust gas evacuation, collects fumes and produces a 2,100 kW calorific power in the form of saturated vapour at 180°C. This vapour feeds the double effect absorption machine, which supplies to the cooling network a 2,600 kW frigorific power through cold water production (6°C). The absorber Energy Efficiency Rating (EER) is consequently 1.24.

In addition, 7 frigorific groups, functioning with HCFC 22 Freon Gas, are added to the trigeneration system in order to furnish a supplementary 17,000 kW frigorific power.

- A vapour/water exchanger, connected to the vapour generator, feeds the heating network with an additional 500 kW calorific power through hot water production (95°C).

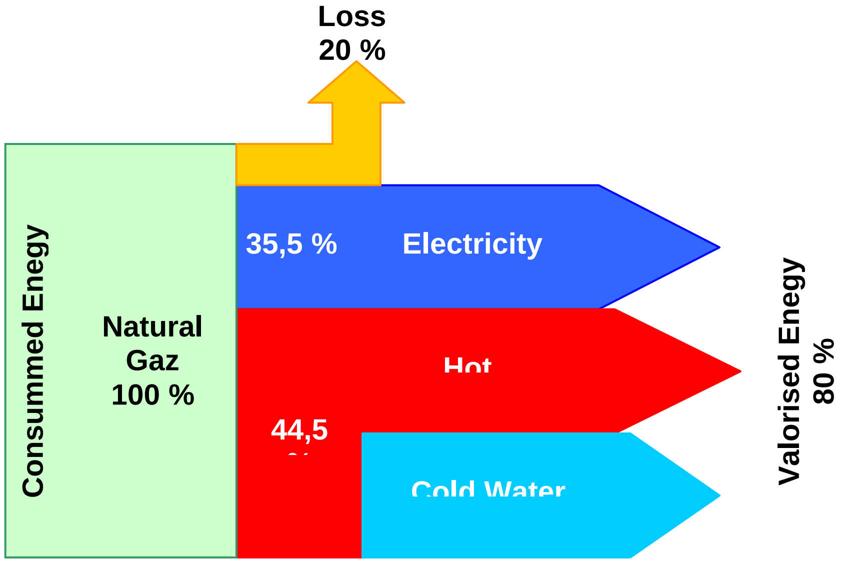
Added, to the 2,400 kW calorific power previously mentioned, the trigeneration plant permits to produce a total calorific power of 2,900 kW.

Moreover, 3 natural gas heating systems fill out the trigeneration heating production in adding a 15,000 kW calorific power.

The project aims at promoting and widespread disseminating EU innovative Research and Technology Development and Demonstration results, as well as eco-sustainability criteria in building sector, which include:

- energy efficient building materials, components and systems not yet introduced into the building market or in their first market phase;
- innovative applications of heating/cooling and power supply technologies, combined with the use of renewable energy sources, in building sector;
- best EU demonstration eco-building projects.

Trigeneration Energy Conversion Diagram



Considering the above data, the full trigeneration plant has been designed to provide a 9 000 kW power (electricity plus simultaneous heating and cooling) from a 11 300 kW lower heating value (LHV) gas consumption.
In other words, the plant is able to convert 80 % of the consumed primary energy, which represents a very high ratio compared to the conventional electrical plants (37 %).

Picture of the building hosting the power plants

Here-above is the picture of the building that was retrofitted in order to host the various machines of the complete power production system. On the roof, we can notice external parts of each machine:

- On the left, the heat exchanger of the conventional cooling machines (total cooling power: 17 000kW)
- In the middle, the high chimney is used to extract the fumes of the 15 000kW gas boiler
- Under the chimney, the heat exchanger of the absorption machine
- On the right, the 3 chimneys of the co-generation gas engine, one for each engine

Performances:

The system performances have been studied, in terms of energy data, economical data and environmental data (CO_2 production). A monitoring has been realised over 2 seasons of normal use, and data have been compared to the previous energy production. The results are the following ones:

Gas Trigeneration Plant using Asborbtion Double Effect Cold Production Unit

Project's Costs	Investment : 3,85 M€ (25% of additional cost respect to a conventional plant), of which: - Electricity production 1 830 000 € - Heat production 330 000 € - Cold Production 920 000 € - Civil Engineering 430 000 € - Network connexions 190 000 € - Construction assistance 150 000 €
Financial Support	ADEME: 457 000 € Regional Council: 152 000 €

Economical Balance (in €, tax exempted)	**Annual Cash Flows**	**Old Plant (2001)**	**Provisional**	**2002-2003 Season**	**2003-2204 Season**
	Electricity for Cold production purchasing	127 000			
	Gas for Heat production purchasing	298 000			
	Gas for Trigeneration purchasing		764 000	732 226	768 811
	Trigeneration maintenance		249 000	250 353	257 436
	EDF contract			0	1752
	Annual expenditures	**425 000**	**1 013 000**	**982 579**	**1 027 999**
	Electricity sold to the grid		1 232 000	1 290 352	1 313 470
	Subsidy for high efficiency		98 000		
	Avoided expenses of Cold production		108 000	83 304	88 302
	Avoided expenses of Heat production		243 000	169 499	172 637
	Others			3 000	10 930
	Annual Revenues	**0**	**1 681 000**	**1 546 155**	**1 585 339**
	Estimated Annual Savings		**668 000**	**563 576**	**557 340**
Energy Balance (in MWh/year)	Annual consumptions and productions	**Values 2001**	**Provisional**	**2002-2003 Season**	**2003-2204 Season**
	Grid electricity	40 000	N.D.	25 873	30 324
	Cogeneration electricity		-14 131	-14 225	-14 627
	Total Electricity	40 000	N.D.	11 648	15 697
	Gas for boilers	29 000	29 000	19 091	17 560
	Gas for trigeneration		40 004	43 972	45 770
	Total Gas	**29 000**	**69 004**	**63 063**	**63 330**
	Total Primary Energy	**129 300**	**N.D.**	**123 509**	**135 233**
CO2 Balance	CO2 emissions due to consumption (in ton / year)	**Values 2001**	**Provisional**	**2002-2003 Season**	**2003-2204 Season**
	Electricity*	16 000	N.D.	4 659	6 279
	Gas	5 346	12 720	11 625	11 674
	Total émissions	**21 346**	**N.D.**	**16 284**	**17 953**
	* taking into account the average European CO2 content of each KWH produced: 400g/kWh				

Further information:

Name of project owner	CNES : Centre National d'Etudes Spatiales
Address	18 av Edouard Belin
Postcode	Cedex 31401
City	Toulouse
Country	France
Telephone	05 61 27 31 31 (swichboard)
Fax	05 61 27 31 79
Web-site	http://www.cnes.fr/

Brochure prepared by ADEME, Dec. 2008

Source: ADEME Midi Pyrénées Regional Delegation, ADEME Buildings and Urbanism Department