University of Perugia
ITALY
Department of Industrial Engineering
Energy Systems Group

Main activities in University of Perugia about Technologies for Greenhouse Gases Mitigation

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Scientific Activities in Cycle Efficiency and Low CO2 Emissions

- **Since 1988: Kalina cycles and Ammonia-water mixtures cycles**
- **Since 1993: HAT cycles, combined gas-steam cycles and gas turbines based innnovative cycles**
- **Since 1997: CO2 capture and sequestration (CCS)**
  - **simulation activities with Aspen Plus of several configurations of post and pre decarbonization, integrated with different types of plants.**
  - **development of in-house models integrated with Aspen Plus for specific modelization of components**
- **Since 1998: High temperature fuel cells and hybrids**
  - **experimental activities: our laboratory is the only Academic laboratory in Italy where MCFC and SOFC testing facilities are available.**
  - **numerical activities in fuel cell and hybrids simulation with particular interest in the utilization of fuels derived from renewable energy sources (biomass)**
- **Since 2000: Biomass slow pyrolysis with gas turbines and reciprocating engines**
  - **simulation activities of small size pyrolysis gas fired gas turbines**
  - **pilot plant with a biomass pyrolyzer and a microturbine installed at the University of Perugia.**

Activities on CO_2 Mitigation

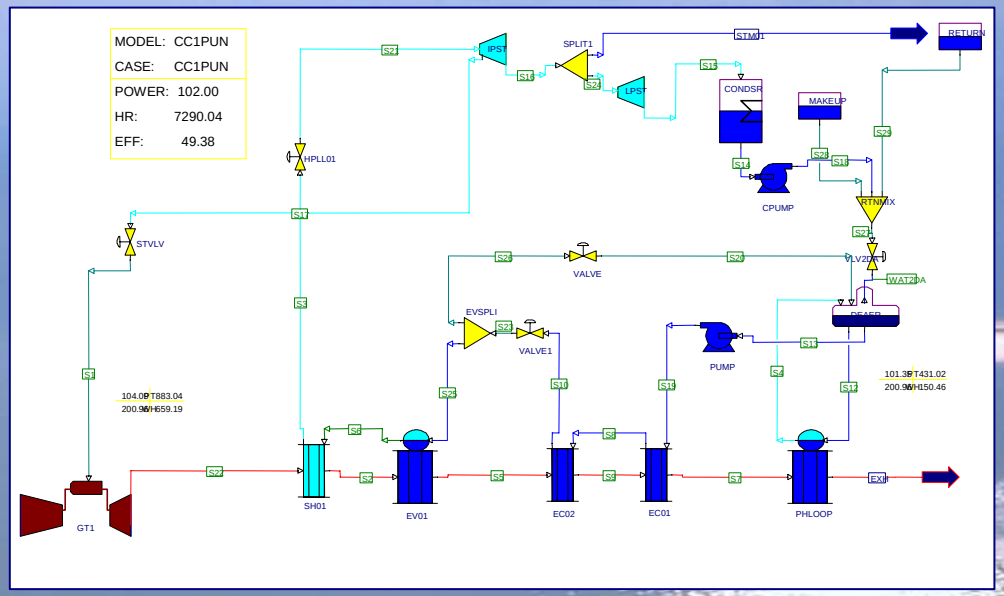
- Numerical simulations of CO_2 capture systems with commercial softwares (Aspen Plus®)
- Devolopment of in-house built codes for modelling innovative capture systems
- Techno-economic analysis of power plants (GateCycle®) with integrated CO_2 capture systems
- Studies for the installation of capture systems in existing power plants
- Development of models and simulation of power plants with pre- or post-combustion decarbonization
- Technical and economic analysis of CO2 mitigation technologies
- Biomass utilization in advanced power plants
- Fuel cells and hybrids using renewable energy sources

Activities on Post-Combustion CO_2 Capture

Analysis of Gas-Steam Combined Cycle with amine absorption system for CO_2 capture

Related Article: Desideri, U., Proietti, S., *CO_2 Capture and Removal System for a Gas-Steam Combined Cycle,* Presented at: International Mechanical Engineering Congress and Exposition, November 17-22, 2002, New Orleans, LA.

- Power Plant: Single pressure Combined Cycle. Gate Cycle® simulation.
- CO_2 capture system: MEA 30%. CO_2 liquefied at 140 bar. Aspen Plus® simulation.



	Base NGCC power plant	NGCC power plant with CO_2 recovery
Net power output [MW]	102	85
Efficiency [%]	49.4	41.1
% CO_2 recovered	--	90
Steam extraction for the reboilers [kg/s]	--	24.66
% avoided CO_2	--	87.5

Activities on Post-Combustion CO_2 Capture

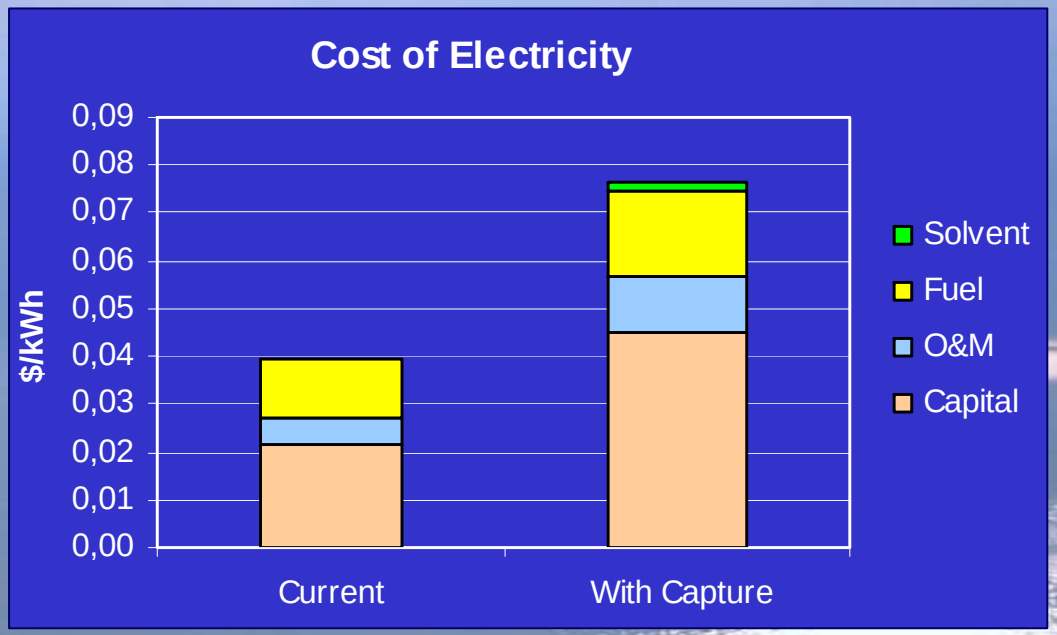
Techno-Economic analysis of an amine absorption system for an existing coal power plant (2x75 MWe)

Basis for economic analysis

Coal cost = 1.24 $/GJ

Capital cost = 1150 $/kW$_E$ vs. 2090 $/kW$_E$

Cost of avoided CO_2 = 47 $/ton ~ 37 €/ton

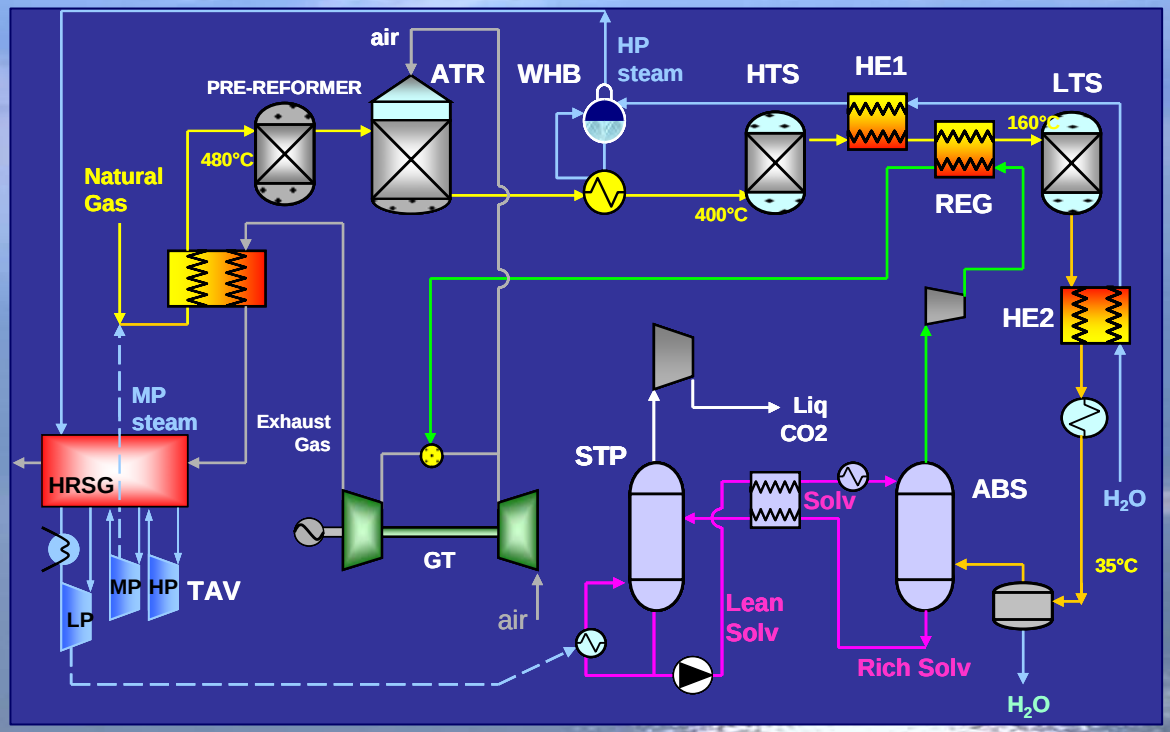


$$CAC = \frac{(\$/kWh)_{capture} - (\$/kWh)_{curr}}{(t/kWh)_{curr} - (t/kWh)_{capture}}$$

Activities on Pre-Combustion CO_2 Capture

Aspen Plus® simulation of Combined Cycle plants based on natural gas Auto-Thermal Reforming (ATR)

Related Article: Corradetti, A., Desideri, U., *Analysis of Gas-Steam combined cycle with Natural Gas refoming and CO_2 capture*. ASME Journal of Engineering for Gas Turbines and Power – 2005, 127, 545-552

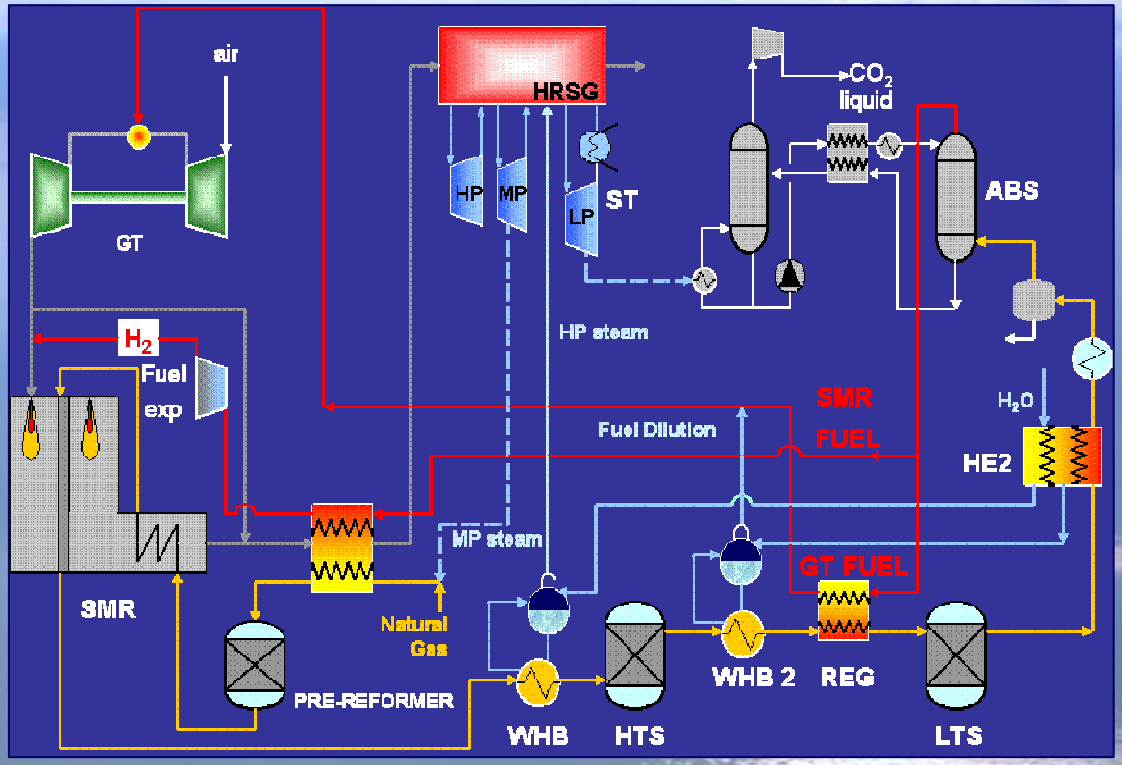


- ATR used for syngas production
- Syngas shift and cooling
- CO_2 capture by amine absorption
- CO_2 compression and liqefaction
- Power Production: Combined Cycle ~ 400 MW (GT: SIEMENS V94.3A)
- Different Configurations investigated, including Post-Combustion and Gas-Gas High Temperature Heat Eschanger before ATR

- **Efficiency ~ 47–48 %**
- **CO_2 emissions ~ 42 g/kWh (reduction of 88%)**

Activities on Pre-Combustion CO_2 Capture

Aspen Plus® simulation of Combined Cycle plants based on natural gas Steam Methane Reforming (SMR)



- SMR used for syngas production
- Syngas shift and cooling
- CO_2 capture by amine absorption
- CO_2 compression and liqefaction
- Power Production: Combined Cycle ~ 400 MW (GT: SIEMENS V94.3A)
- Gas Turbine exhaust gas used as oxidizer of SMR furnace

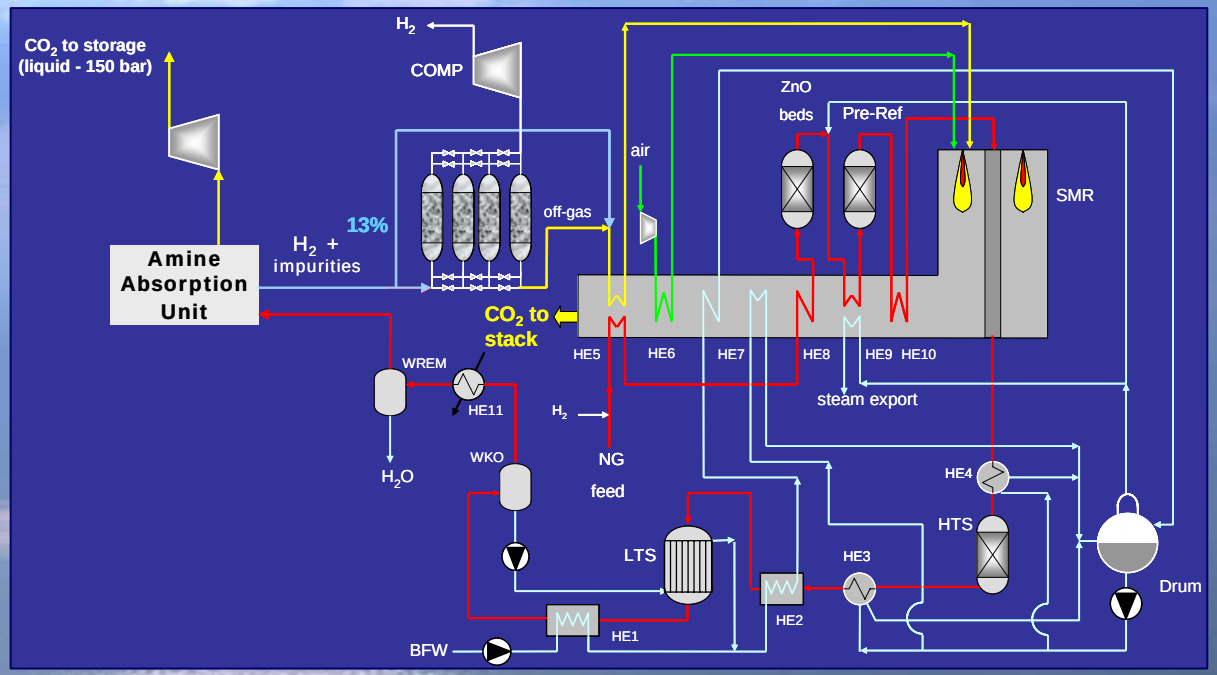
- **Efficiency ~ 45 %**
- **CO_2 emissions ~ 42 g/kWh (reduction of 88%)**

Activities on Pre-Combustion CO_2 Capture

Aspen Plus® simulation of hydrogen plant based on natural gas reforming with CO_2 capture and power cogeneration

Related Article: Corradetti, A., Desideri, U., *A Techno-Economic Analysis of Different Options for Cogenerating Power in Hydrogen Plants Based on Natural Gas Reforming,* Presented at ASME Turbo Expo 2006, May 8-11, Barcelona. Paper accepted for publication on Journal of Engineering for Gas Turbines and Power.

A conventional H_2 plant based on SMR, followed by Shift, CO_2 capture and PSA unit has been investigated in various configurations for power production, to determine performance, H_2 cost and the cost of carbon capture.



International Master in Technologies for Greenhouse Gases Mitigation

is the one and only master in the world concerning this topic !

The Master is organized by the University of Perugia, in cooperation with the Université de Liège (Belgium) and Mälardalens Högskola (Sweden).

Objectives

Governments, authorities, industry, consultants, need competent advisors who have a multidisciplinary formation ranging from physics of the atmosphere, economics of energy sources, engineering of power plants and energy systems, chemical engineering of capture and removal systems. This kind of education cannot be achieved with degrees in mechanical or energy or chemical engineering, but can be achieved in the framework of the International Master in Technologies for Greenhouse Gases Mitigation.

The Master includes also professional teaching modules that allow the student to achieve a specialization for the auditing of GHG emission certification as foreseen in the EU directive 87/2003/CE (Emission trading).

International Master in Technologies for Greenhouse Gases Mitigation

The Master lessons, followed by a training in industrial or academic laboratories and the preparation of a Master's thesis, will last one year and will provide 60 ECTS.

Classes will be held at the School of Engineering of the University of Perugia by professors from the cooperating universities and from other important academic institutions and industry.

Structure of the course

The course is divided into 360 hours of lessons, and 500 hours for stage and Master's thesis preparation. The teaching modules are the following:

The Earth and its climate, The Greenhouse effect, Political and legislative aspects of climate changes, Economic aspects of energy systems and greenhouse gases, Energy sources, High efficiency energy systems, Renewable energy systems, Energy saving, Certification of GHG emissions, Flexible mechanism of the Kyoto Protocol, Emission Trading, Post combustion CO2 capture, Pre-combustion CO2 capture, Non CO2 emissions mitigation, CO2 transport and storage, Non fossil fuels and hydrogen, Fuel cells

International Master in Technologies for Greenhouse Gases Mitigation

The master can be attended by graduates in all specialization of Engineering, Architecture, Science, Mathematics, Physics, Chemistry and Environmental Sciences. All the lessons are held in English and enrolment of students from all over the world is encouraged.

The Master is open to all the interested students.

The location

Perugia is a small town with a population of 150,000 inhabitants located in central Italy, 150 km SE of Florence and 170 km NE of Rome in the Region which is called Umbria and is considered as the Green Heart of Italy. The University of Perugia was founded in 1308 and will celebrate its 700th anniversary in 2008. The town of Perugia is a lively town with a students population exceeding 30,000 people, making it one of the most attractive University towns in Italy. It can be reached by plane (PEG airport code), train and car. Nearby airports (Florence, Rome and Ancona) can be reached from all over the world with normal and low cost airlines.

International Master in Technologies for Greenhouse Gases Mitigation

The University of Perugia has launched the third Course of the International Master in Technologies for Greenhouse Gases Mitigation that will be offered in 2007.

Contacts

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Spin-off of Perugia University

Based on research experiences and technical know how, the Energy Systems people coordinated by Prof. Umberto Desideri founded 2 academic spin-off

TREE srl - Technologies for Greenhouse Gases Reduction

and

BIONET srl – BIOmass and New Tecnologies

Spin-off main target is to offer the synergy on research results and practical engineering experience to an increasing number of customers (industries, governmental and private institution involved in GHG mitigation or trading)

Spin-off of Perugia University

TREE srl - Technologies for Greenhouse Gases Reduction

TREE

EMISSION TRADING SYSTEM

- Audit of GHG emission certification
- Monitoring of GHG emission
- Advisory ab. EU directive 87/2003/CE
- Trading of emission certificates

CDM and JI PROJECT

GHG REDUCTION SYSTEMS and CCS

- Feasibility and project

ENERGY EFFICIENCY SYSTEMS

- Feasibility and project
- Trading of white certificates

ENERGY AND ENVIRONMENTAL AUDITS

Spin-off of Perugia University

BIONET srl – BIOmass and New Tecnologies

bio net
biomass & new technologies

Biomass slow pyrolysis with gas turbines and reciprocating engines:

- simulation activities of small size pyrolysis gas fired gas turbines
- pilot plant with a biomass pyrolyzer and a microturbine (80 kW Elliot) installed at the University of Perugia. ON RUN !

Focused on:

- Biomass utilization in advanced power plants
- Feasibility study and project of energy systems based on biomass
- Renewable energy plants: feasibility and project
- Biomass slow pyrolysis with gas turbines
- Trading of green certificates

Thank you for your attention!

FOR FURTHER INFORMATION

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