



# ANSALDO FUEL CELLS

“Operating experiences on MCFC full size power plant: the key to develop new opportunities in MCFC”

F. Federici

*State of progress, remaining bottlenecks, new opportunities for MCFC technology in Ansaldo Fuel Cells*

- Ansaldo Fuel Cells short profile
- MCFC technology development, field tests
- Bosco Marengo Test Facilities for industrial scale demonstrations
- TECNODEMO Plant: long lasting operation, field experience driving plants improvements
- New opportunity for MCFC: “active” CO<sub>2</sub> separation
- Using test facilities for full chain MCFC-CCS testing

# The Company

Ansaldo Fuel Cells (AFC) is active in the Molten Carbonate Fuel Cells sector for electricity generation since 25 years. After R&D phase, demonstration and field test program, AFC is presently involved into an ambitious development program aimed at meeting all the requirements for industrialization and commercialization of its products in the field of Carbon Capture and Sequestration (CCS) and Distributed Generation (DG).

**Local Unit - Bosco Marengo (AL)**  
Full scale field test units in operation. More than 35,000 hrs (12,000 with a single stack).

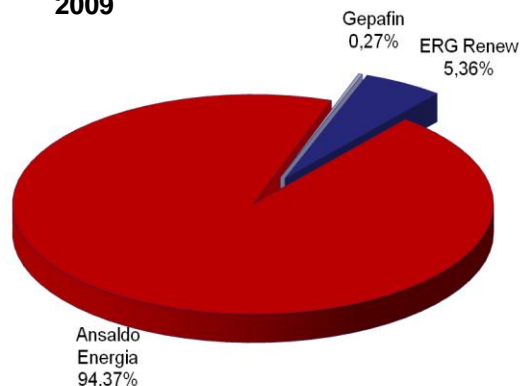


**Headquarters - Genova**  
Stack design  
Plant and Systems engineering  
Laboratories and all R&D activities



**Pilot Factory - Terni**  
Stack manufacturing  
Capacity 3 MW/y upgradeable to 10 MW/y  
Area: 11000m<sup>2</sup> (4500 m<sup>2</sup> indoor)

2009



**Finmeccanica, through Ansaldo Energia, controls the majority stake in Ansaldo Fuel Cells.**

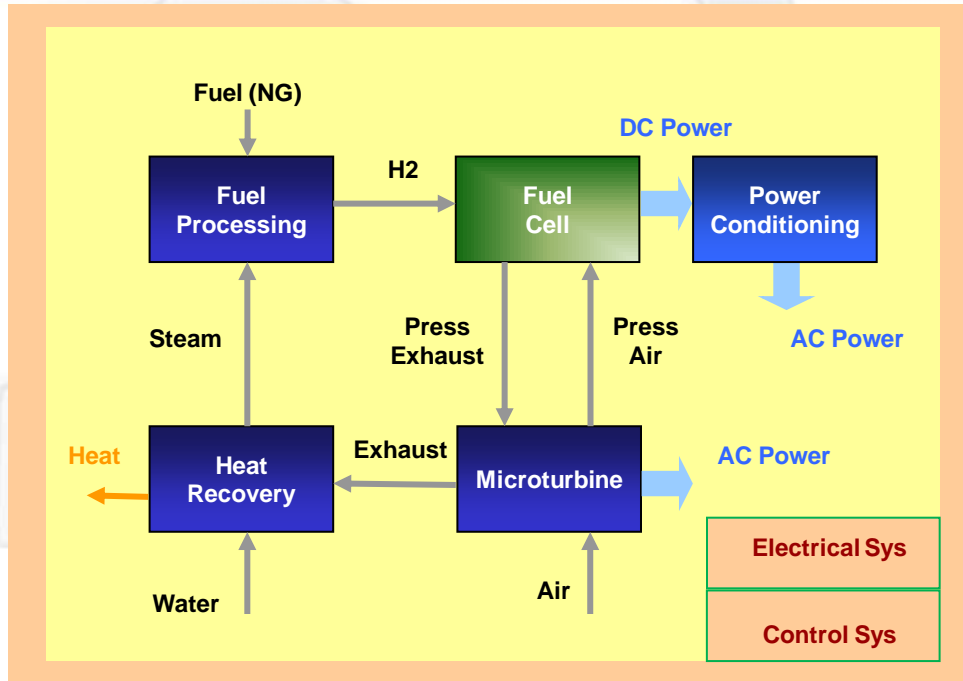
20 Patents in 15 Countries

900+ manYears experience on MCFC

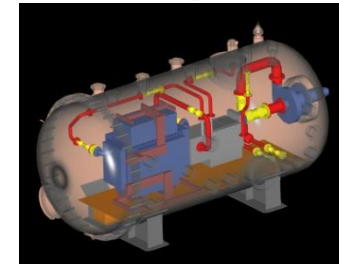
25 Projects presented to the "Company Innovation Award"

"2007 Frost & Sullivan European Award for Energy Technology Innovation of the Year"

# MCFC Plant Block Scheme



**STACK  
(MCFC)**



**Fuel Cell  
System**



**Generation Plant**

**Fuel Processing:** Fuel is processed and converted in a hydrogen rich gas through a strongly integrated system (typically steam reforming).

**Microturbine and Heat Recovery System:** It supplies the pressurized process air to the fuel cell system, expand the exhaust in turbine producing additional energy.

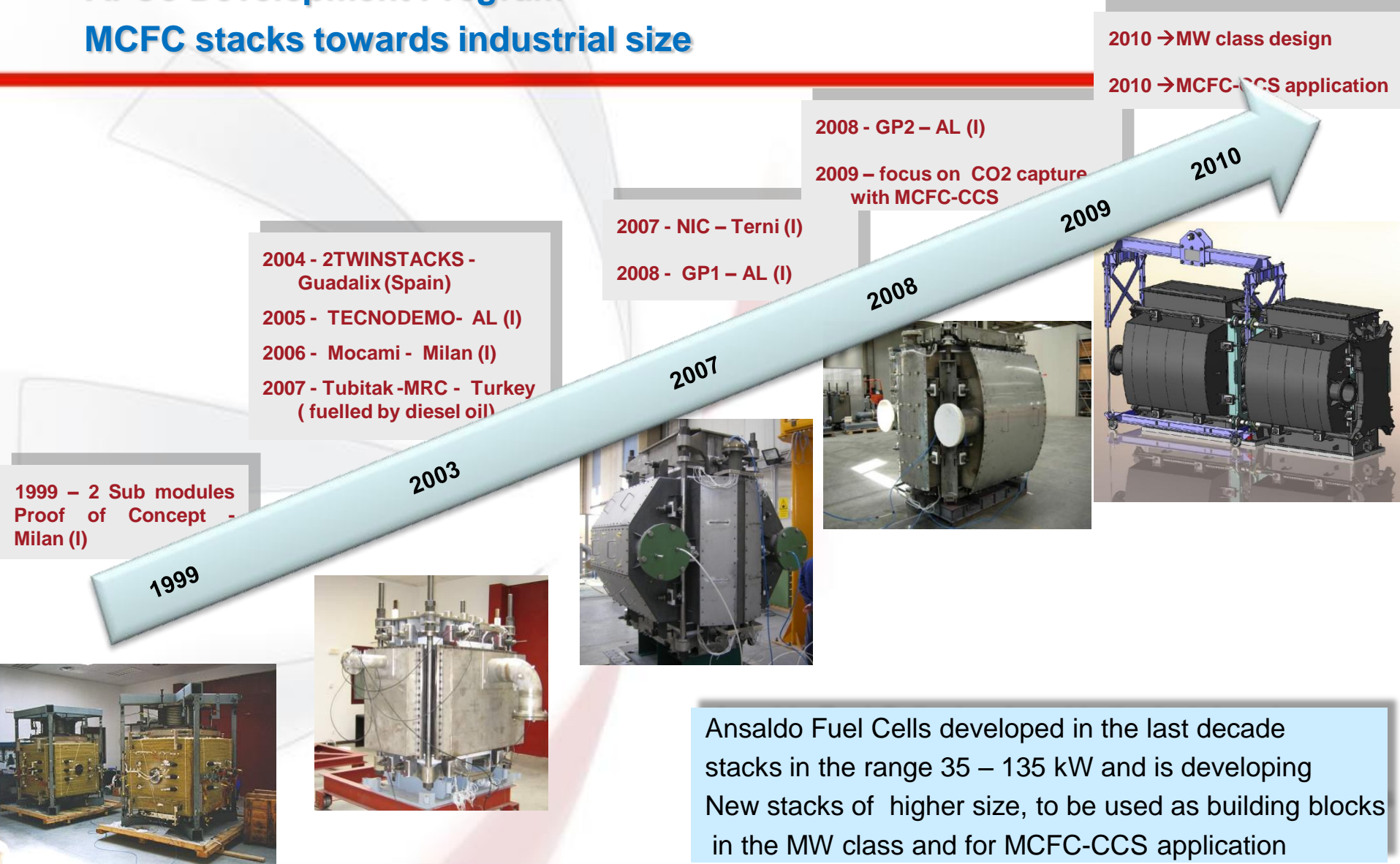
**Fuel Cell System:** Through cell reaction the chemical energy of hydrogen and air is converted in electrical energy and heat

**Power Conditioning System:** It convert the electrical DC current in AC power and supplies it to the grid.

**Control System:** It automatically controls and safely manage the normal and emergency plant operation.

# AFCo Development Program

## MCFC stacks towards industrial size



Ansaldo Fuel Cells developed in the last decade stacks in the range 35 – 135 kW and is developing New stacks of higher size, to be used as building blocks in the MW class and for MCFC-CCS application



# Demostration Program

## MCFC systems field tests

Tecnodemo 1 x FA150  
Bosco Marengo (I)  
Natural Gas



MCFC-NAV 4 x FA150  
Gebze (TK)  
Diesel Oil



Mocami 1 x FA150  
Milan (I)  
Natural Gas

GP1/GP2- 2 x FA200  
Bosco Marengo (I)  
Natural Gas

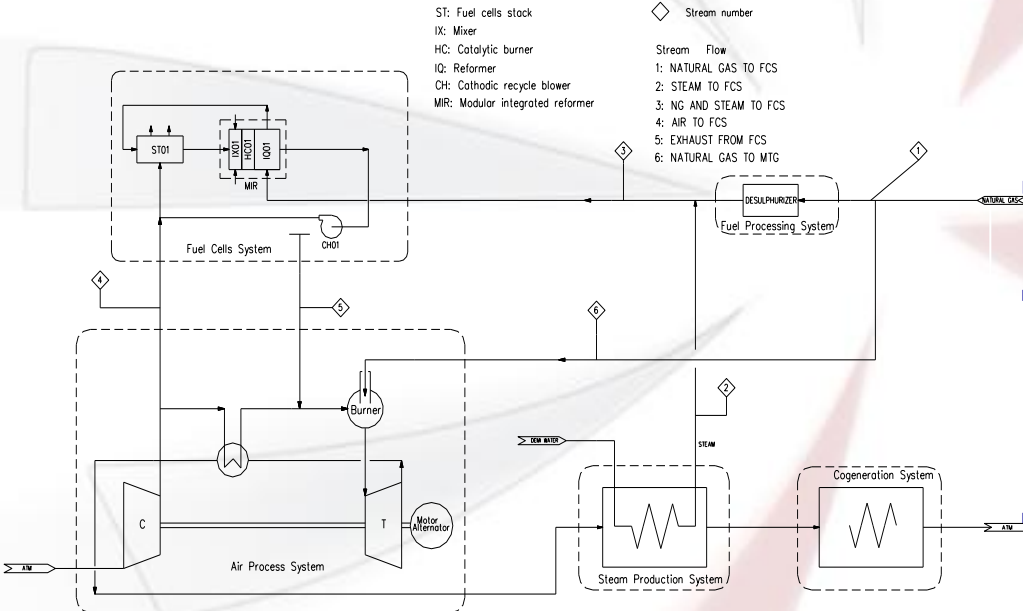


FOAK 4xFA150 - Guadalix (SP) – Natural Gas



# BOSCO MARENGO SITE - Full Scale Tests – TECNODEMO Plant

- Single stack
- MIR (Modular Integrated Reformer)
- Turbec T100 Microturbine



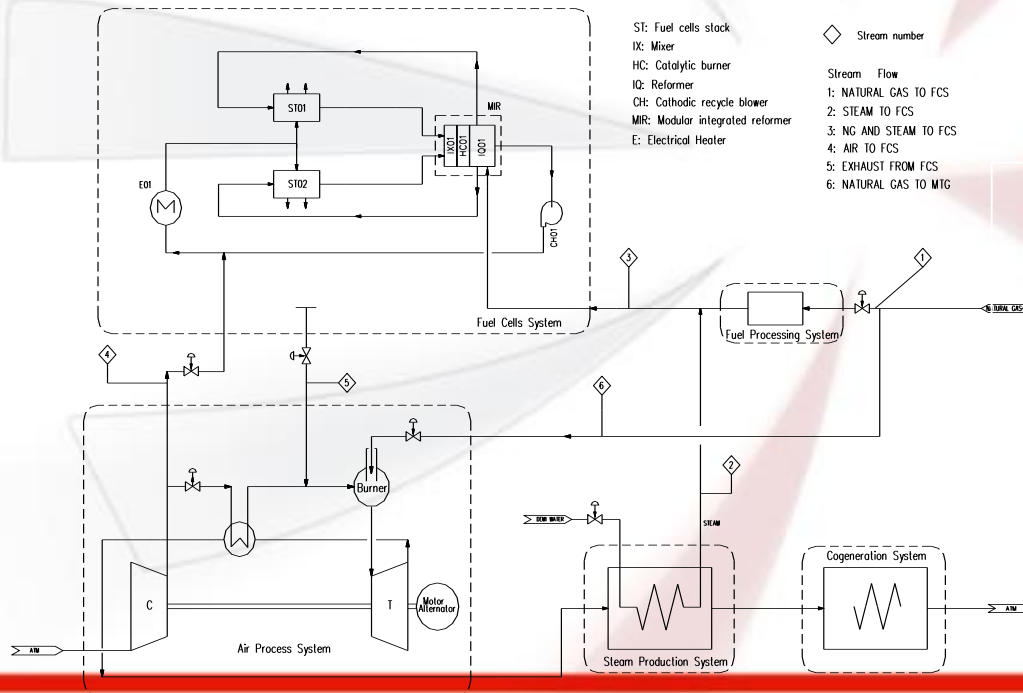
- Operating since **june 2005**
- **35000** hours of plant operation:  
BoP component and stack validation, control optimization finalized to unmanned operation, fault analysis and maintenance schedule
- **12000** hours on single stack during fuel cell system test

# BOSCO MARENGO SITE - Full Scale Tests – GP2 Plant

- 2 New Generation Stacks
- TWIN – STACK Technology
- MIR (Modular Integrated Reformer)
- Turbtec T100 Microturbine



- In operation since 2008
- Load test up 250 kW
- BoP component specific tests and optimization
- Automatic and unmanned operation



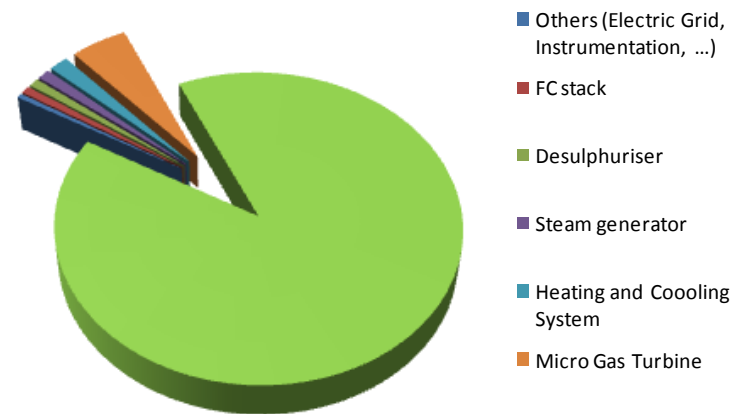
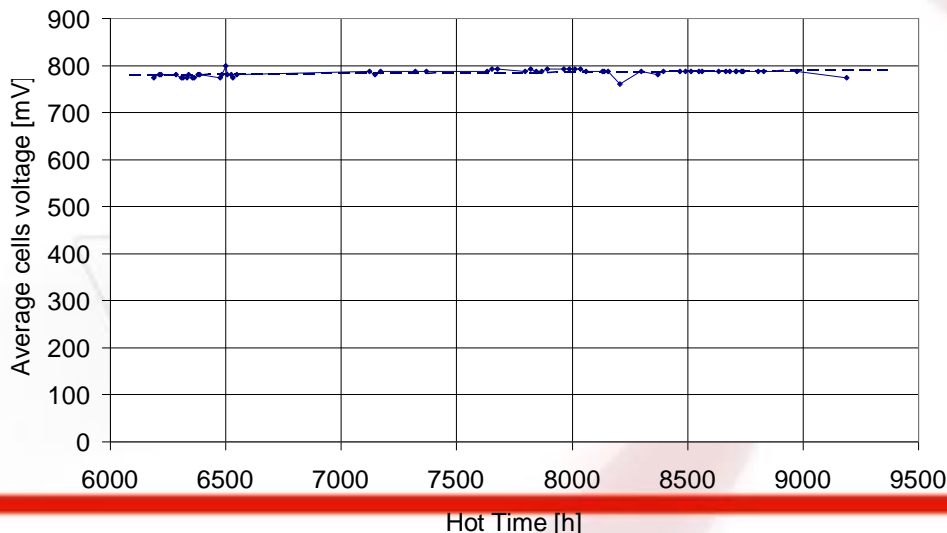


# TECNODEMO PLANT - LONG LASTING OPERATION

**90 % AVAILABILITY GOAL  
WAS SUCCESSFULLY  
REACHED**

- 12000 hours of stable operation
- NO Fuel Cell System Maintenance

- NO MCFC Stack maintenance
- NO Reformer maintenance
- NO Cathodic Blower maintenance



Minor Unavailability caused by:

1. Microturbine
  - MTG Electronic Power conversion (23000 hours old)
  - MTG Fuel Block Valve
2. Heating Up and Cooling Down Procedure
  - Normal Start up and Shut Down
  - MTG Emergency Stops
3. Steam Generator
  - Fouling – Cleaning Procedure
4. Desulphurization System
  - Activated Carbon Replacement
5. FC Stack
  - Specific Test
6. Others
  - Electric Grid Loss
  - Control System
  - Demi-water system

# BOSCO MARENGO PLANT IMPROVEMENTS – TECNODEMO 2 & GP2

operation experiences drives Bosco Marengo Plants improvements

## TECNODEMO

### Main Improvements:



## TECNODEMO 2



### Actual and Future Activities:

- Fuel Cell Stack specific tests for Carbon Capture
- CO<sub>2</sub> Separation system tests
- Endurance Tests

## GP2

### Main improvements:

- Unmanned Operation
- Integrated Electrical Heater
- Electrical Grid independent – Designed to be started up also without electrical grid .

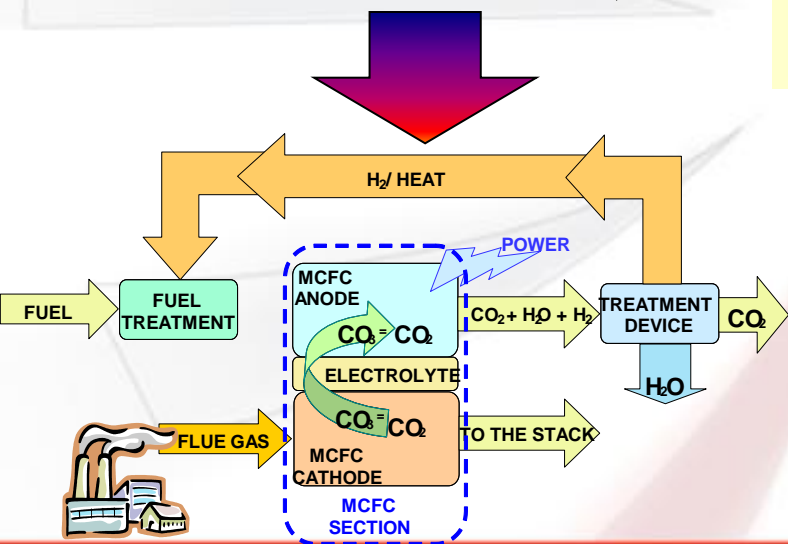
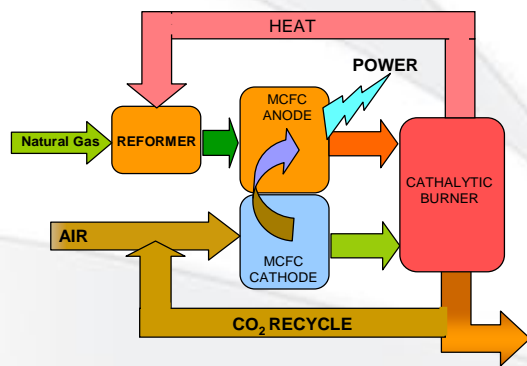
### Actual and Future Activities:

- Specific Component Tests:
  - Microturbine Test – MTG
  - Combustion Chamber suitable for oxygen poor comburent gas
- BoP component and auxiliaries Optimization Tests



# New opportunities for Molten Carbonate Fuel Cells: “active” CO<sub>2</sub> separation

Molten Carbonate FUEL CELLS (MCFC) use CO<sub>2</sub> to **produce** electrical energy with H<sub>2</sub>/O<sub>2</sub>.



## MCFC-CCS

- CO<sub>2</sub> separation with no energy penalty; additional power produced
- Separation > 70% of CO<sub>2</sub> contained into the flue gas, considering additional power produced
- Modular solution, allows a step by step implementation of a CCS, without large cost at the early steps
- MCFC can use **renewable fuels**, if available

## MCFC-CCS configurations

### Post combustion

MCFC integration down stream of the main power plant (e.g. natural gas combined cycles)

### Pre combustion

MCFC/IGCC integration for coal fired plant allows high CO<sub>2</sub> capture using reliable standard gas turbine operating with low H<sub>2</sub> content.

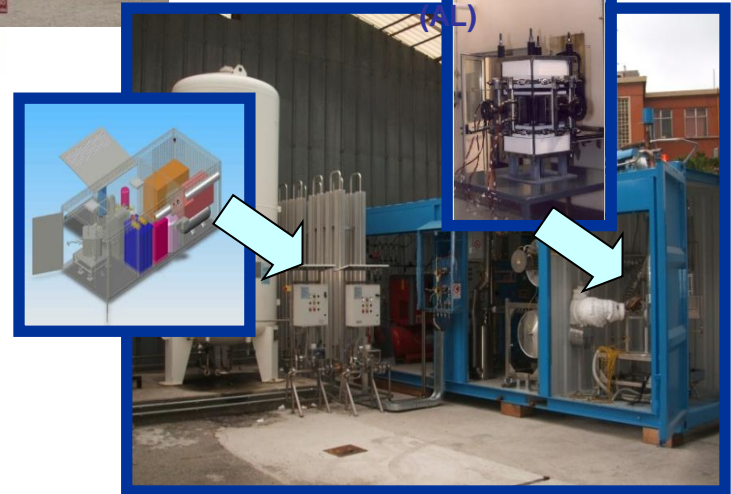
Feeding cathodes with the flue gas from a combustion process, MCFC produces a CO<sub>2</sub> **concentrated** stream at the anode exit where it can be easily separated for sequestration. The “active” separation process **produces additional electrical power**, resulting in a positive energy balance for the main power plant.

# The biggest test facilities in Europe for MCFC and Hybrid Cycles real testing at ANSALDO FUEL CELLS sites

Full Scale Stack test facility - Terni



2 Field tests – Bosco Marengo (AL)



Subscale stack test rig – Genova

## MCFC-CCS activities

Pre-normative standardisation of MCFC test procedures (*FC TESQA / EC Project*)

Ongoing tests from LAB level to sub-scale MCFC stack level (*MCFC- Contex / EC project; GERICC-Ispa / Funds for Italian Electric System Development*)

Test Facilities available at Bosco Marengo (Italy) for full scale stack testing and the complete chain from flue gas-MCFC-CCS-final CO<sub>2</sub> separation (*proposal submitted for partial EU funding*)

Sub MW CCS pilot plants using real flue gases in the next three years (*submitted proposals on national research programme for co-funding*)

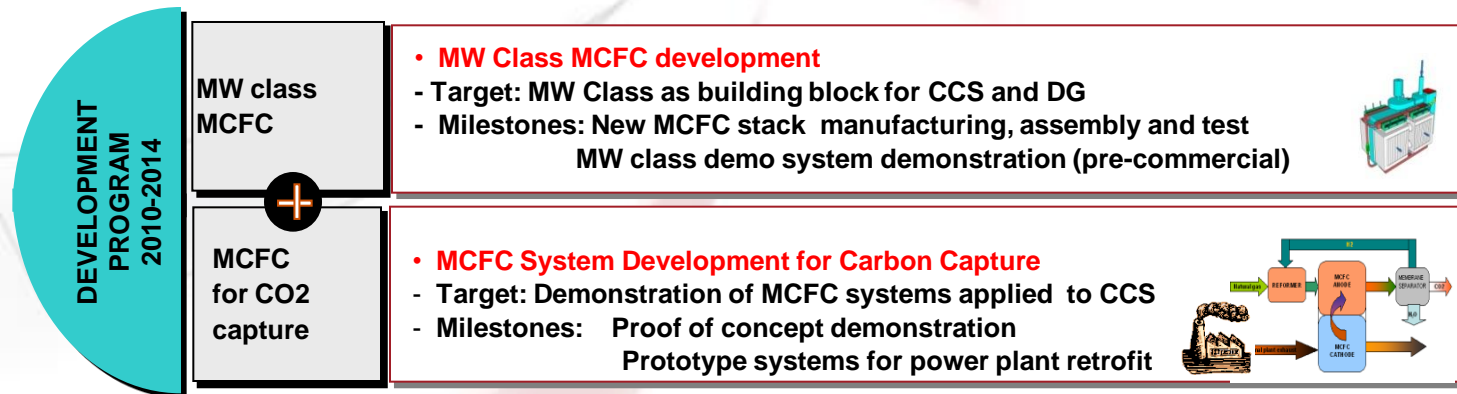


# CONCLUSIONS

Operation performed on real plants demonstrates the Ansaldo Fuel Cells MCFC technology at industrial level

- Plant availability
- Hybrid configuration long lasting test
- BoP component and MCFC stack validation
- Control optimization directed towards unmanned operation
- Fault analysis and maintenance schedule

It allows to face the challenge of “active” CO<sub>2</sub> separation and its bigger plant sizes as the new goals for the next years



**Thank you for the attention**