Infrastructure Factsheet

Description of the infrastructure	
Name(s) of the infrastructure(s)*:	**ZECOMIX (Zero Emission of Carbon with Mixed technologies)**
Location (town, country):	Rome
Website:	www.enea.it
Legal name of organisation operating the infrastructure:	ENEA
Location of organisation (town, country):	
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****Infrastructure (s)**: means a facility, a resource (or a coherent set of them) together with the related services that are used by the scientific community to conduct research.*
*****Installation:** is a part of an infrastructure that could be used independently from the rest.*

Description of the facilities

Give a brief general description of the infrastructure to which access is offered. Illustrate, in particular, its state-of-the-art equipment and services offered to users that make it rare or unique in Europe. Outline the areas of research normally supported by the infrastructure, as well as new areas opening to users, if any. If the infrastructure is composed of several installations**, describe these including their specific features. If parts of the infrastructure are still under construction, specify the starting date of construction and indicate the date when access can realistically be made available.

FACILITY NAME **Delete and replace with name**

Purpose and brief technical description, including figures as appropriate

The purpose of the ZECOMIX (Zero Emission of Carbon with Mixed technologies) pilot plant is twofold. One is the production of hydrogen from conventional fuels (e.g methane and coal) by means of the Calcium Looping (CaL) process which is an high temperature gas solid reaction. The Ca based material used in ZECOMIX is low cost (<10 €/t) and has no impact to the environment and the human being. The other objective of the ZECOMIX is the study of the CaL process as thermochemical storage of heat. The main aim of the project is to demonstrate, through a series of modelling and experimental activities, the feasibility of an this innovative process for storage not only the solar energy but also the waste heat produce in high energy demand industries (e.g. steel making process and cement production).

Figure 1 ZECOMIX pilot plant

The plant which has a TRL 6/7 (see figure1) was presented in international research frameworks (e.g. CSLF, ZEP and EERA) as one of the advanced technological initiatives of the European and worldwide scientific community. One of the key advantages of this option which makes it a valuable route for gas decarbonisation or the heat storage is the low cost and wide availability of the feed material (a naturally occurring sorbent such as limestone or dolomite) and its high reactivity with CO_2. In the CaL process, CaO is converted into $CaCO_3$ by reacting with gaseous CO_2, then the spent solid sorbent is regenerated in a calcination step (heat storage) at a temperature range

from 800 to 850 °C leading to the release of the captured CO_2 in a pure stream that can be sent to final storage. The heat is released during the successive reaction between CO2 and CaO (carbonation step) at 650 °C.

ZECOMIX is also composed of a 500 kW_{th} steam/oxygen blown bubbling fluidised bed coal gasifier. The coal feed system was designed for a nominal load of 1.4 t/d of coal. The system includes a 2 m^3 unit for coal storage, which allows the stationary operation of the gasifier for up to 36 hours, and two screws driven by an engine connected to an inverter. Finally, the clean syngas generated by the coal gasifier will fed a 100 kW micro turbine.

State of the Art, uniqueness (if applicable), and any specific advantages (e.g. technical, economic etc)
The novelty of ZECOMIX is the combination of well-known industrial processes (e.g. calcination for the clinker production, gasification and reforming of conventional fuels) for the production of H_2 as energy carrier and the storage of solar power and industrial heat waste. The Ca based material used in ZECOMIX is low cost (<10 €/t) and has no impact to the environment and the human being.

Scientific environment (related and potentially available scientific and technical services at RI's location e.g. analysis, material preparation etc.)

Synthesis of high regenerable material for O_2 carrying capacity and/or CO_2 capture.
Alternatively to modifying naturally occurring minerals to improve their properties there is also the option to develop completely new synthetic sorbents with tailored properties. ENEA is investigating the use of synthetic long life sorbent $CaO/Ca_{12}Al_{14}O_{33}$ synthesised our laboratories which has been used for 1000 CO_2 uptake / regeneration cycles under industrially relevant conditions. This material could be used as a support of O2 carrying phase (e.g. CuO);
Process intensification: integration of CaL technology with cement production process
In the field of process intensification a potential common area of interest is the integration of cement production process with a fluidised bed of CO2 acceptor to decarbonise flue gases leaving a rotary kiln. In the facility of ENEA is currently investigating the effect of CO2 presence during the calcination of limestone;
Developing of particle models for the study of simultaneous diffusion and reaction process in gas solid reaction – ENEA is active in developing a grain model which can be integrated in commercially relevant software tool for the simulation of CO2 capture systems (e.g. bubbling fluidised bed reactors).

ZECOMIX is supported by a set of analytical apparata composed of:

Micromeritics ASAP 2020N – Automatic physiosorption analyser for the evaluation of specific surface area and distribution of the pore in porous solid material
Micromeritics Autochem HP micro-reactor is an automated high-pressure catalyst and sorbent characterization system that is capable of preparing and analyzing samples at elevated pressures up to 68 atm and at temperatures up to 1100 °C. The instrument can perform a variety of experiments including pulse chemisorption, temperature-programmed reduction (TPR), desorption (TPD), oxidation (TPO). This micro-reactor, combined with a FTIR or gas chromatograph GC, can also be used to determine product yields and catalytic and sorbent activity under industrial conditions;
Mettler Toledo GC-200 thermo-gravimetric analyser, differential scanning calorimetry TGA-DSC – TGA-DSC records the change in weight of a solid sample when it is heated, cooled or dwelled at constant programmed temperature. Heat exchanged with the environment is also recorded during the analysis. The apparatus can be connected online to a FTIR spectrometer or gas chromatograph GC. Analysis of the decomposition products yields additional information about the investigated solid sample;
Varian 640-IR Fourier Transfer Infrared (FTIR) Analyzer – FTIR spectroscopy provides quantitative determination of a wide range of species. This enables us to interpret measurement curves collected from micro-reactor and TGA-DSC with greater accuracy;
Agilent 6850 Gas Chromatograph (GC) – Agilent GC is available for H_2, N_2, CH_4, CO, CO_2, H_2S and equipped with an Electron Capture Detector (ECD).

QUALITY CONTROL / QUALITY ASSURANCE (QA):

Activities / tests / data are:

☐ accredited to Standard _____

☐ while not specifically accredited, data quality is controlled in accordance with institute's accreditation to Standard _____

If none, please specify associated risks:

Data collection and analysis methods are chosen to match the particular evaluation in terms of its key evaluation questions and the resources available. Probability sampling allows for 'statistical generalization' in which a certain margin of error risk is set (typically, 5 to 10 per cent) that defines the level of acceptable risk.

Link to your institution QA webpages if available:

www.enea.it

CCS PROJECTS:

EU-funded CCS projects:

1) Project full title: ***Advanced Solids Cycles with Efficient Novel Technologies*** (ASCENT), Work Programme topic addressed:ENERGY.2013.5.1.2: New generation high-efficiency capture processes.
2) Project full title: ***UNIQUE gasifier for hydrogen Production*** (UNIfHY), Work Programme topic addressed:SP1-JTI-FCH.*2011*.2.3: Biomass-to-hydrogen (BTH) thermal conversion process.

Other CCS projects:

3) National Program on Electric System Research funded by the Italian Ministry of Economic Development

Main/major non-CCS projects: -

Patents :-

Selected publications:

- Stefano Stendardo, Pier Ugo Foscolo, Mirko Nobili, Silvera Scaccia: High quality syngas production via steam-oxygen blown bubbling fluidised bed gasifier. Energy 03/2016; 103, DOI: 10.1016/j.energy.2016.03.011
- M. Della Pietra, M. Santarelli, S. Stendardo, S. McPhail, Juan Pedro Perez-Trujillo, Francisco Elizalde-Blancas: *Integration of a calcium looping process (CaL) to molten carbonate fuel cells (MCFCs), as carbon concentration system: First findings*. Journal of CO2 Utilization 05/2018; 25:14-21., DOI:10.1016/j.jcou.2018.03.002
- Carlos Herce, Cristóbal Cortés, Stefano Stendardo: Computationally efficient CFD model for scale-up of bubbling fluidized bed reactors applied to sorption-enhanced steam methane reforming. Fuel Processing Technology 12/2017; 167:747-761., DOI:10.1016/j.fuproc.2017.07.003
- Milena Morone, Giulia Costa, Stefano Stendardo, Renato Baciocchi: Characterization and density separation of coal gasification residues generated from the ZECOMIX research infrastructure. Fuel Processing Technology 09/2015; 139:204-215., DOI:10.1016/j.fuproc.2015.07.011
- Antonio Calabro, Paolo Deiana, Paolo Fiorini, Giuseppe Girardi, Stefano Stendardo: Possible optimal configurations for the ZECOMIX high efficiency zero emission hydrogen and power plant. Energy 06/2008; 33(6)., DOI:10.1016/j.energy.2008.01.004
- Carlos Herce, Antonio Calabrò, Stefano Stendardo: Numerical simulation of a high temperature CO2 capture fluidized bed
- Silvera Scaccia, Stefano Stendardo, Giuseppina Vanga, Leandro Pagliari, Stefano Cassani, Mirko Nobili, Giuseppe Messina, Andrea Assettati, Giuliano Guidarelli, Salvatore Attanasi, Caterino Stringola, Andrea Grasso, Ivano Cassani, Antonio Calab O, Pier Ugo Foscolo: Steam-O 2 Coal Gasification in the Italian ZECOMIX Bubbling Fluidized Bed Gasifier Unit: Spent Bed Material Characterization.
- Milena Morone, Giulia Costa, Evangelos Georgakopoulos, Vasilije Manovic, Stefano Stendardo, Renato Baciocchi: Granulation–Carbonation Treatment of Alkali Activated Steel Slag for Secondary Aggregates Production. 11/2016;, DOI:10.1007/s12649-016-9781-0

FACILITY AVAILABILITY:

Unit of access:-

Availability per year:

10 months per year

Expected duration of single experiment:

2 days

OPERATIONAL OR OTHER CONSTRAINTS:

Specific risks: Potential risks are associated with a forklift or material elevators including hazards relating to its mobility, its electrical, hydraulic and mechanical power sources, its moving parts, its load-carrying capacity and operator protection.

Legal issues: A code of practice is a guide to achieving the standards of health, safety and welfare required under the Italian Work Health and Safety Act.