Italian National Agency for New Technologies,
Energy and Sustainable Economic Development

Demonstration of Supercritical CO_2 Cycles Technology for Waste Heat Recovery Applications

ETN's 15TH Annual General Meeting & Workshop

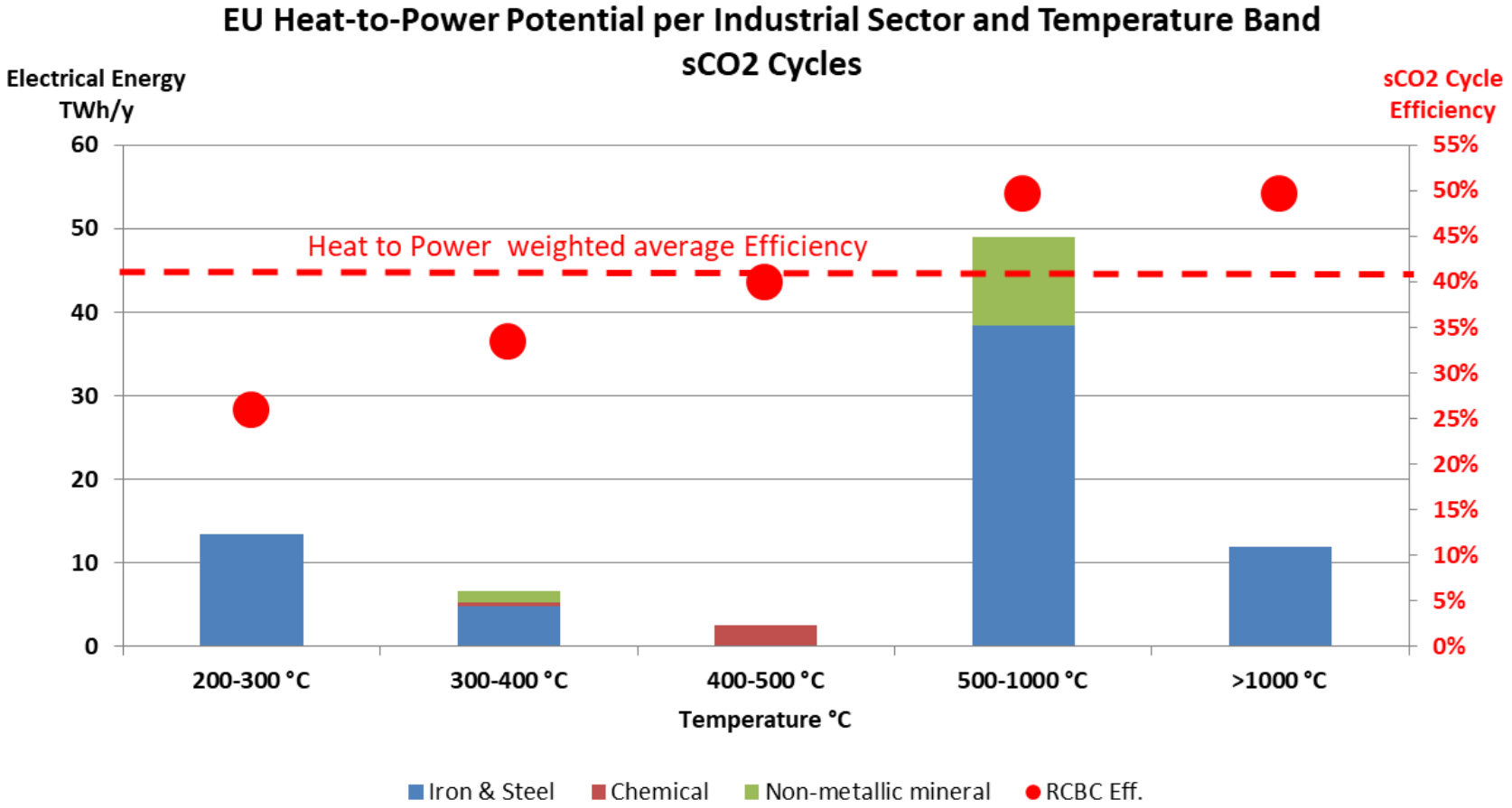
Pau, 27-28 March 2019

Giuseppe Messina and Eugenio Giacomazzi

Outline

- Heat-to-Power potential in EU
- ENEA Project Idea presented at the SET-Plan Workshop in June 2018
- ENEA facilities ready to involve in a H2020 demonstration project

Heat-to-Power Potential in EU …some numbers



The waste heat recovery potential in EU amount to about 200 TWh/y in the temperature band between 200 °C and > 1000°C. The correspondent conversion potential using sCO2 power cycles amount to about 83 TWh/y of electrical energy. Iron & Steel industry have the greater heat-to-power conversion potential.

Data elaborated by ENEA from M. Papapetrou, et. Al., "Industrial waste heat: Estimation of the technically available resource in the EU per industrial sector, temperature level and country", Applied Thermal Engineering, Volume 138, 25 June 2018, Pages 207-216. sCO2 RCBC efficiency data from G. Subbaramann et Al. "GTI step forward on sCO2 Power", IGTC18

Heat-to-Power Potential in EU
…some numbers

The power installed in compression stations to move natural gas in the European pipeline network amounts to 12500 MW as declared by ENTSOG (European Network of Transmission System Operator for Gas). In most cases, compressors are driven by Open Cycle Gas Turbines (OCGT) with an average efficiency of about 35%. Consequently, 65% of primary energy used by OCGT is lost as high temperature waste heat. Coupling the compressor stations gas turbine with supercritical CO_2 bottoming cycles could result in about 37% primary energy saving, assuming a conservative value of 20% efficiency for the supercritical CO_2 cycle. As a noteworthy consequence NOx and CO_2 emissions could be lowered proportionally to the obtained primary energy saving.

SET Plan Workshop 27-28 June 2018
Project Idea Description

Priority	Activity	Idea Nb
3–Heat & Cold	3.3 – Heat-to-Power	36

Project Idea Title

Demonstration of Supercritical CO_2 Cycles Technology for Waste Heat Recovery Applications

Project Idea sponsor(s)

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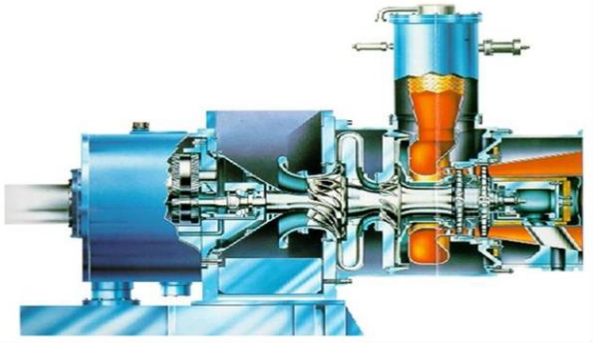
SET Plan Workshop
Brussels, 27-28 June 2018

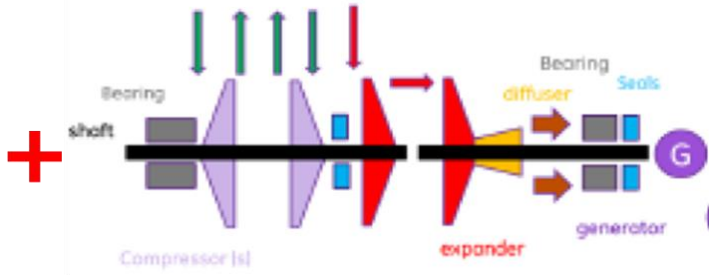
European Commission

SET Plan Workshop 27-28 June 2018
Project Idea Description

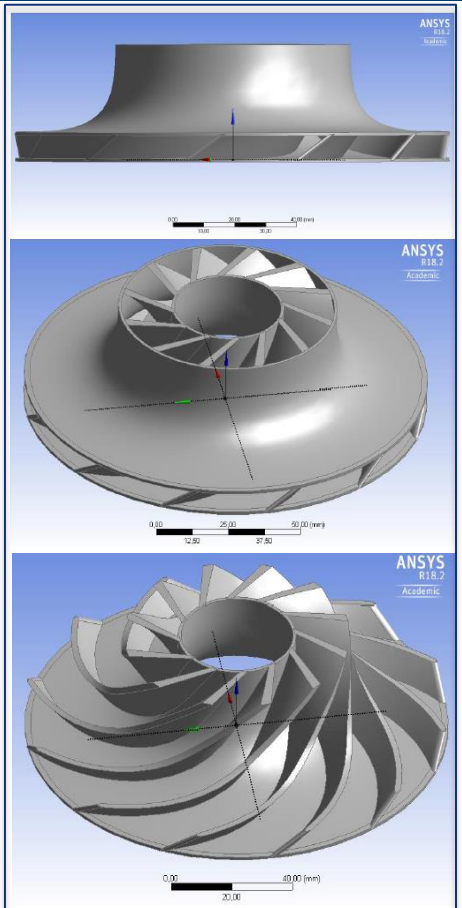
sCO_2 power cycles technology can be fruitfully developed for WHR applications. It can be used in industrial heat recovery as well as nuclear and Concentrated Solar Power or it can replace the steam section of present designs of Combined Cycle Gas Turbine plants to improve their load-flexibility. In particular, sCO_2 cycles are exploitable in maritime transport. This is interesting since the GHG emissions of international maritime transport is increasing and accounts for about 4% of global man-made CO_2 emissions. Special attention and development are required for specific devices, such as turbomachinery, sealings, bearings and heat exchangers, the identification of materials able to resist at high pressure and temperature and the development of quick plant start up strategies. The present project aims to design, build and operate a technology demonstrator. The basic idea is to design and build a "staminal" prototype (TRL 7) not specialized for a specific WHR application. The prototype will be managed as a test bench reaching the starting point for the full technology development in different WHR applications after overcoming the common technology barriers. In the past 3-Years plan ENEA invested over 200K€ in R&D on a ≈3MWel sCO_2 power cycle prototype coupled with a 2MWel / 7MWth gas turbine owned in the Casaccia RC. Most of efforts to now was focused on turbomachinery design and cycle configurations. In the next 3-Years plan ENEA will increase over 2-3X the current funds.



Nuovo Pignone PGT2 Gas Turbine



S-CO_2 Power Cycle



sCO_2 Turbomachinery design by Prof. Ambra Giovannelli – Roma Tre University as ENEA partner in sCO_2 power cycles technology development.

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Project Idea Description

Potential cooperation partners and tasks

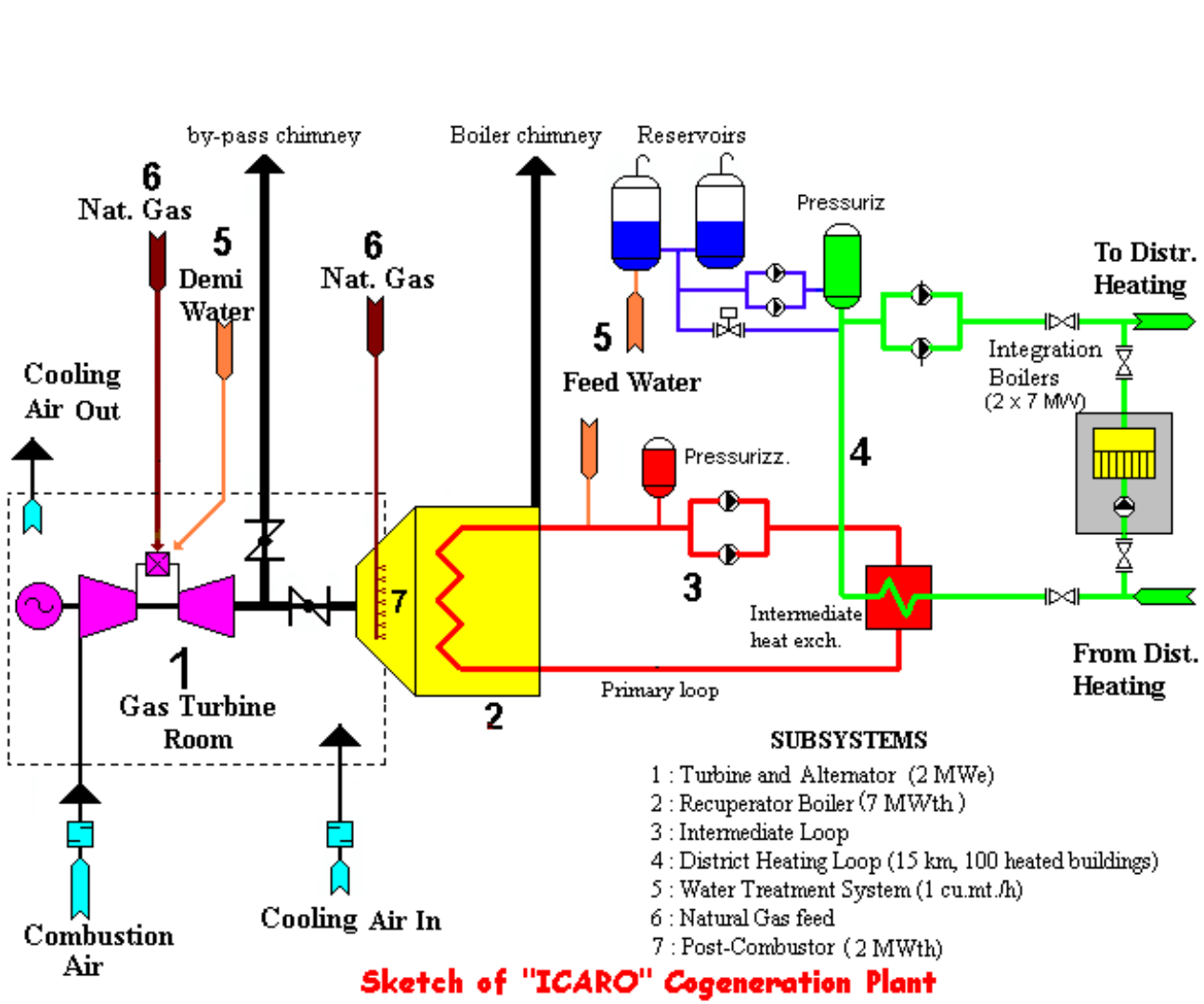
Baker Hughes (BHGE), Siemens, Ansaldo Energia, European Turbine Network (ETN), Genoa University, Roma TRE University, University of Stavanger, City University of London, Cranfield University, ELEO^2 Engineering, Heatric, Softinway Inc.

- Project management
- Experimental matrix design
- Identification of a multi-operational cycle configuration R&D oriented
- Turbomachinery development
- Power unit heat exchangers identification and sizing
- High temperature/pressure materials identification
- Heat recovery unit
- Shaft design including bearings and sealings
- Power unit design
- Power plant ancillary services design
- Start-up and control strategies
- Power plant working plan
- Power plant construction
- Tests activities

Expectations from this session's discussion

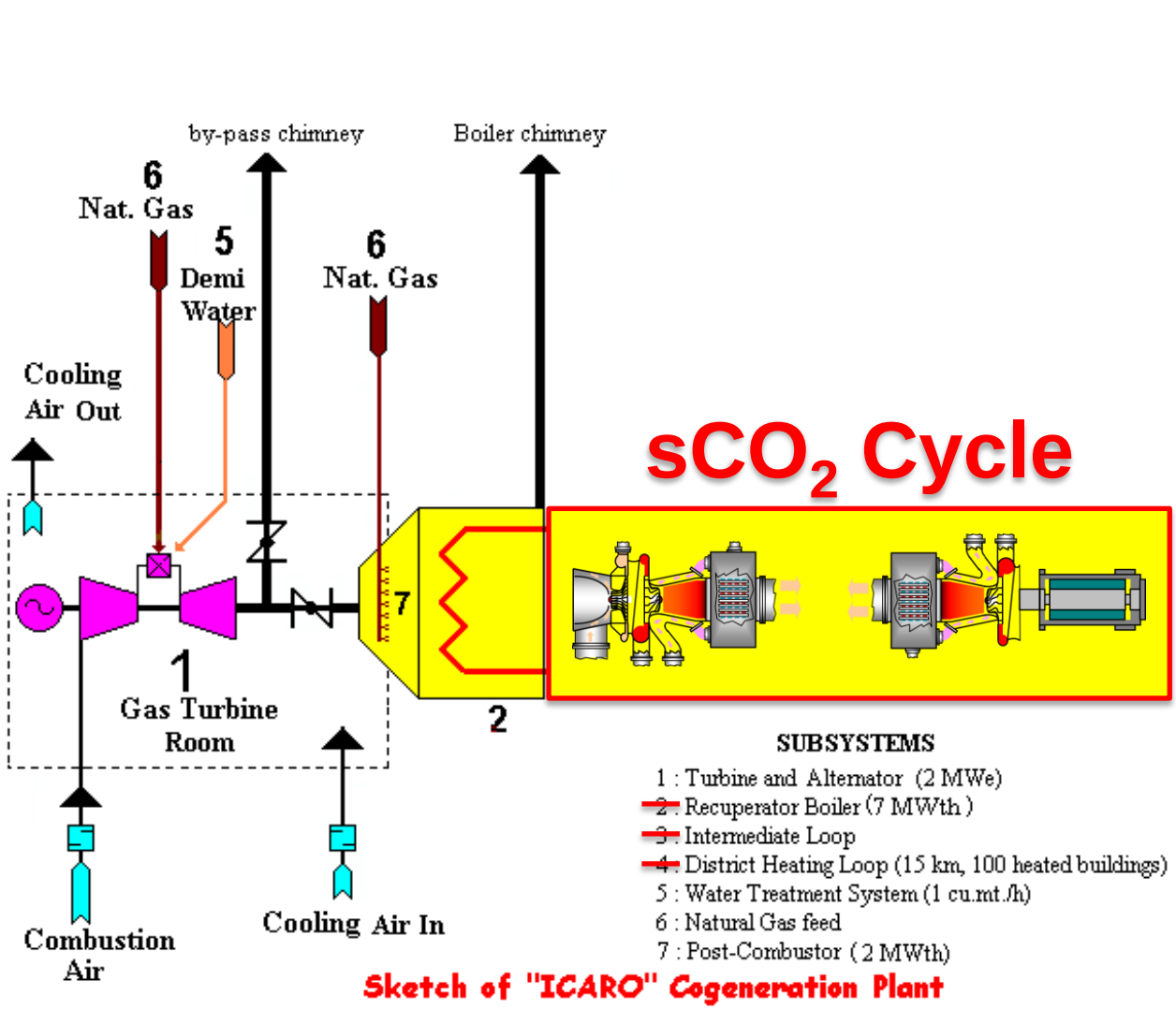
ENEA is open to share their knowledge and infrastructures, first of all the PGT2 gas turbine as a WHR "generator", to form a consortium aimed at the design, the implementation and the management of the sCO_2 power cycle prototype. Cooperation with any other potential partner not mentioned before is welcome.
Likewise, ENEA is open to discuss the merging with other complementary ideas and build a common path to reach a shared goal. Ideas and suggestion about the financial issues and/or funding mechanisms are very welcome as well as any other suggestion/criticism.

ENEA facilities ready to involve in a H2020 demonstration project



Sketch of "ICARO" Cogeneration Plant

ENEA facilities ready to involve in a H2020 demonstration project



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Thanks for your attention!

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