The European sCO2 Research & Development Alliance

The European sCO2 Research & Development Alliance aims at providing a platform for exchanging knowledge on supercritical carbon dioxide (sCO2) technologies in the energy sector for academia and industry, as well as promoting this topic in society.

Supercritical Carbon Dioxide (sCO2) technology is an innovative concept in power generation, which employs CO2 in supercritical state as working fluid in closed-loop Joule-Brayton cycles. Unlike conventional power generation, sCO2 power systems would ensure security and flexibility of electricity supply at lower capital and operational costs with a reduced carbon footprint.

All over the world, extensive research is being carried out on sCO2 power cycles, which resulted in the development of several experimental facilities. In the United States, Sandia National Laboratory is operating a 1 MWe test loop, while a 10 MWe sCO2 system is being developed at the South West Research Institute in San Antonio, New Mexico. India is operating a small-scale test loop at IISc Bangalore, and several projects to develop sCO2-test loops are also ongoing. The Korean Institute of Energy Research (KIER) is operating a test loop in the kWe range and constructing a hundreds of kWe loop. In Japan, the Tokyo Institute of Technology and the Institute of Applied Energy have demonstrated a 10-kWe sCO2 turbine generator.

In this respect, Europe seriously lags behind, in particular in the high power, large-scale range. Component test loops are currently available in Czech Republic and Germany. As concerns EU-funded initiatives, a small-scale prototype in the kW-power range has been built within the sCO2-HeRo project. In the I-ThERM project, a 50kWe sCO2 loop is being developed for high-grade heat to power conversion from industrial waste exhausts. The sCO2-flex project is designing a 25MWe power cycle for coal applications (TRL-5). The sCO2-4-NPP project is designing a heat removal system (TRL-5) based on a sCO2 cycle. Even though the Helmholtz-Zentrum Dresden-Rossendorf and TU Dresden have agreed to set-up a test loop with electric heating in the 2MW range, as of today, Europe does not benefit of an infrastructure to carry out research activities on sCO2 components and full power systems on a large scale, namely in the order of megawatts. Furthermore, no operational data are available for validation of numerical models. There is no information of start-up, shut-off and part-load conditions, which are crucial to assess the capabilities of this innovative technology.

For this reason, the European sCO2 Research Alliance brings academic and industrial stakeholders together in order to bridge the knowledge and technological gaps that Europe has experienced in the last decades and in order to develop and retain expertise that will enable the promotion of the deployment of large scale sCO2-based power plants by 2030 (“sCO2-demo”).

Objective

The objective of the European sCO2 Research Alliance is to break ground in the design, construction and operation of a European sCO2 research cycle on MW scale. The alliance joins European key actors on sCO2 technology interested to operate a power cycle in Europe by 2030.

Governance Structure

The key actors are biannual meetings for exchanging current knowledge and state of the art developments. The alliance consists of members and a governing board which organises the biannual meetings.

Fact sheet: Why applying sCO2 in power cycles?

Thermal energy technologies are playing a key role in power generation with a global share of more than three quarters. In addition, they also dominate the large heat market. Primary and secondary heat sources are utilised for covering a wide range of temperature.

Stable and predictable energy supply, a low ecological footprint and affordability of energy require a mix of energy technologies with thermal energy included. In this context, sCO2 power cycles promise a large development step. These are closed cycles with sCO2 as alternative working fluid to today's fluids like steam, organic fluids and gases. CO2 is supercritical at pressure > 73.8 bar and temperature > 31°C.

Here are some benefits of sCO2 encouraging the European sCO2 Research and Development Alliance to push the subject ahead:

- The supercritical fluid features favourable properties of a liquid like high density, specific heat capacity and thermal conductivity. High energy density results in compact design of components.
- Supercritical CO2 allows for utilization of heat in a wide range of temperatures (from geothermal up to CSP). It covers the range of ORC, steam and gas cycles with the same fluid.
- The fluid is non-hazardous, available everywhere and relatively cheap compared to ORC fluids.
- Higher efficiency compared to water/steam results in a lower ecological footprint (less heat release to the atmosphere, higher utilization of the primary and secondary heat sources).
- Higher efficiency, less complex cycle architecture and compact component design result in lower LCOE compared to current technologies.
- Less complex cycle architecture and compact design are also advantageous for load flexibility and application in distributed power generation.
- Supercritical CO2 cycles allow for less water consumption in power generation.

Despite of the advantages given above, the following scientific and technological challenges have to be addressed:

- To bring the sCO2-power cycle technology from TRL-5 (technology validated in relevant environment) to TRl-9 (technology ready for industrial application). It requires a large-scale demonstration facility, which differs from MW-scale component test facilities. The purpose of a demonstration facility is to produce power and gain operation experience, as opposed to providing a dedicated mass flux at dedicated temperature and pressure for a component test.
- The effectivity of turbines and compressors are higher and heat losses per unit volume in all heat exchangers are lower if a large-scale infrastructure is build. Therefore, a "sCO2-demo" is necessary.
- Design points of the components are determined numerically, but the operation of the cycle also requires off-design conditions. It is necessary to learn from the operation of the loop with all data available for analysis.
- Auxiliary systems must be adjusted to the operation of the cycle. Actually, it is unknown whether e.g. a sCO2-purification system is required. Only long-term measurements of sCO2 purity in a sCO2 demo plant can answer this question.
- Suitable materials must be tested and selected for long-term operation without severe corrosion and erosion. Manufacturing has to be taken into account simultaneously.
- Licensing aspects are important to be addressed in parallel to technology development.

We are looking forward to your feedback and comments!

The European sCO2 Conference Committee Members