The ENEA Thermodynamic Solar Laboratories (ST-ITES) includes the most part of the activities performed in ENEA concerning Concentrating Solar Energy. Its activity (as SOLTERM Project) has started in year 2000 and since that time it gained a specific experience in several fields of CST technologies particularly in Parabolic Trough system operating at high temperature with MS (Molten Salts) as HTF (Heat Transfer Fluid) and has recently expanded its research interests also in Dish systems. The ST-ITES is one of the largest public research centres in Europe. The centre extends over an area of around 90 hectares, with 188 buildings (offices, laboratories, facilities and service infrastructures). ST-ITES regularly hosts more than 1400 employees. Besides ENEA personnel, Casaccia hosts every day 300-400 people, Italians and foreigners, coming from universities, research organizations and industries.

- The **P.C.S.** (**P**rova **C**ollettori **S**olari, i.e. Test of Solar Collectors) facility operates with MS up to 550°C for field testing, in actual size, of PTCs and other components, including HEXs (Heat Exchangers) coupling MS with steam or air. The **PCS** facility is the main testing loop built by UTRINN-STD and it is unique in the world. It consists in two lines of PTCs operating at high temperature and uses, as HTF, a binary mixture of molten salt (60% $NaNO_3$ and 40% $KNO_3$) operating up to 10 bar, 550°C and 6.5 kg/s. It consists of a close loop totally instrumented (flow rate,pressures, temperatures, etc.) a molten salt storage (7 $m^3$ of useful volume). The PCS plant has been involved in several European projects (MATS, SFERA, SFERA-II, STAGE-STE, ORC-PLUS, RESLAG, InPOWER, ARCHETYPE) and other international collaboration with the compnies of the sector. Actually, the **PCS** facility is devoted to:

  - characterization of the receiver tubes in outdoor tests;
  - characterization of the molten salt circuit components in real operating environment;
  - training for management of CSP molten salt circuit;
  - characterization of different types of thermocline TES systems.

  From 2019 the PCS experimental loop will be integrated with two additional circuits:

  - RESLAG circuit that is a system dedicated at analysis of the performance of a TES system based on backed bed with MS as HTF and, this will be first facility in Europe at this scale (The first installation will be available for SFERA III project from September 2019).
  - ORC-PLUS circuit that is a system dedicated at analysis of the performance of a thermocline TES system that employs low melting molten salt as Heat Storage Material and oil as Heat Transfer fluid

- The **OMSoP** solar dish facility will be made available for the characterization of solar receivers to be coupled with the dish technology for the distributed electricity production. The peculiarity of this system is the integration of the dish technology with micro-gas turbines (MGTs) to produce electricity from solar source in a small scale capacity range (5-10 kWe). The introduction of a MGT in place of the more conventional Stirling engine, was aimed at increasing the system lifetime and improving its operability in relation to solar energy short time fluctuations.

- The **Thermophysical Characterization Laboratory** (TFC-LAB) consists of a proper set of equipment and devices able to obtain a complete experimental characterization of MS mixture and of each feasible HTF/HSM for CST applications; An experimental set-up to investigate the chemical stability was assessed during the last SFERA-II project and is present at the DTE/STT/ITES ENEA thermophysical characterization laboratory. The equipment allows the determination of the produced gases and the liquid chemical composition and permits to work in isothermal conditions and to control the reaction atmosphere. The TFC labs include instrumentations specifically dedicated to the characterization of thermal fluids. There is no other lab-scale facility in Europe like this one, uniquely designed and dedicated to thermal fluid chemical stability.

  The TFC-LAB has been involved in several European projects (MATS, SFERA-II, STAGE-STE, ORC-PLUS, RESLAG, Hycycles, Sol2Hy2) regarding the investigation of thermal fluids and the development of solar fuels.

- The **ENEA Solar Collector Optics laboratory** (ESOL) is deeply involved in the international effort to outline guidelines for CST components. ESOL is devoted to the optical characterization of materials, components, and systems for CST applications. At this purpose several innovative instruments have been proposed along the last years. The most relevant are:
  - Solar Mirror Qualification set-up: it is an innovative instrument specifically conceived for measuring solar near-specular reflectance versus incidence and acceptance angle.
  - VISprofileLF: shape measuring of reflective panels (facets) for linear Fresnel CST plants. Differently to the other instruments, VISprofileLF is based on an original digital version of deflectometry, which ensures better reliability and accuracy.
  - VISprofilePT: idem, but for parabolic trough panels and by means VIS approach.
  - VISfield: in-field direct measurement of the intercept factor of parabolic trough modules by means of the
  - An upgraded version of VISprofilePT of ESOL which will be made available in January 2019. ENEA patented VIS methodology (shape evaluation and ray tracing are not needed!). Optical coating characterization: spectrophotometric measurements, modelling and features evaluations.

Services currently offered by the infrastructure:

- The **PCS** plant is equipped to auxiliary experimental loop to test *Components and Systems for molten salt solar plant* as : Molten Salt Thermal Energy Storage, Coil Steam Generators , New generation of Receiver Tubes and Linear Solar PTC, System Engineering and Management specialized to Heat Transfer Fluid as molten salt, Numerical Analysis/Simulation Codes, measure of thermal loss for molten salt pipe heated with electric cable heater or with joule direct system with or without molten salt circulation. The tests are performed by operators according to the tests matrix, and they control the plant process by means of a Digital Control System (DCS). The DCS system plant allows to look in real time all the data related to the tests, and to store it in a proper file. Its main purpose is the testing, in actual operating conditions, of all the components (and operating procedures) of a molten salt solar field and namely: parabolic solar collector (including supporting structure, mirrors, tracking and driving systems and heat collecting elements), components of molten salt loop (circulating pumps, sensors, valves, preheating systems) and operation and maintenance procedures (control loops, draining and filling procedures, etc.). More recently a full steam loop has been added: which can operate up to 70 bar, 550°C and 0.15 kg/s. So, it is now possible to test HEXs that couple MS-Steam, e.g. SG, (Steam Generator), MS-Air or Steam-Air. Moreover, the MS storage tank has been improved as TES (Thermal Energy Storage) with integrated SG (submerged in the MS) acting as stratifying system. In the new experimental mock up devoted at packed bed + MS will be possible to perform test of thermocline system during the charge and discharge operation of the TES System. The PCS is also equipped with an additional Fresnel loop using oil as the heat transfer fluid. This second experimental loop is used as a test bench.
- The **OMSoP** solar dish facility is a unique installation, recently completed (July 2017), to validate advanced technical solutions for coupling the solar dish technology with the MGTs, enabling the production of small scale, reliable and easy to maintain units for either on or off-grid applications. The replacement of the Stirling engine, which is the most common technology coupled with the solar dish systems, with a micro-gas turbine is the distinctive feature of the project. The use of MGT with the concentrated solar source for distributed electricity production in remote areas is a new perspective. This technology provides highly efficient and reliable components, capable of standing high temperature levels (800-900°C) and unstable operative conditions and provides an integrated solution for the MGT and the solar dish maximizing the overall plant efficiency, depending on the meteorological conditions.
- The **TFC-LAB** has in general a key role in the national and European project where ENEA is involved and that are concerned with the innovation and characterization of thermal fluids. Several reports, posters and peer reviewed publications have been produced by the DTE/STT/ITES laboratory ENEA staff, also in collaboration with other Italian and European researchers. As a rule, the laboratory provides information about the thermophysical features of thermal fluids (both for heat storage (HTF) and transfer (HSM)), especially molten salts, their compatibility with fillers and

CST components, and their chemical stability. In particular, the latter topic is currently of considerable interest, given the necessity to determine the upper temperature limit of thermal fluids before their use in real conditions for CST plants. Actually, the degradation reactions can be very slow and lead to the production of gases, besides the changes in the melt composition. To date few data are agreed upon regarding the chemical stability of molten salts, and there is a clear interest from the concerned scientific community and the materials manufacturers to obtain information about this feature.

- The **ESOL** is endowed of several on the top original instruments making it a unique place to conduct advanced experiments. Guests will be assisted by the ENEA stuff for the best usage of instruments and methods of the laboratory, many of which are greatly influencing the drafting of the international guidelines in the optical sector.