CEA DURASOL infrastructure is located at French National Institut for Solar Energy (INES) and consists of: On one side, equipment for indoor ageing tests reproduce the environmental conditions for accelerated testing, such as climatic chambers, UV weather-ometer, mechanical test bench, potential induced degradation chambers... On the other side, outdoor experimental benches monitor the aging of solar technologies under real operating conditions with continuous monitoring. Finally, there is also a number of characterisation equipment to analyse the degradation of materials and to adapt the processes for solar systems development versus durability issues.

The **DURASOL** infrastructure comprises three installations located in the same centre:

- **Optical Characterisation of Materials (Opti-Lab)**: Absorbance & emittance at ambiance temperature and high temperature. Spectral emittance in temperature up to 1000°C. Emittance at 80°C. Optical microscopy observation. Hemispherical reflectance, specular reflectance, directional reflectance. Colorimetry of paints. FTIR spectra. Optical microscopy observation.
- **Optical Characterisation of Systems, (Shape)**: Reflector qualification: Optical performance evaluation, flux mapping, tracking accuracy evaluation. Absorber qualification: Thermal performance evaluation. Accelerated ageing: Flux up to 60 suns
- **Accelerated Ageing Under Controlled Conditions (Indoor)**: A unique ensemble of equipment: Mechanical Load Test bench for PV Modules, Damp Heat Chamber, Dark and Illuminated Lock-In Thermography, Dynamic Mechanical and Thermal Analyser (DMTA), Hazemeter, High Accelerated Stress Test (HAST) Chamber, Industrial Manufacturing Line for PV Module Prototyping, Insulation Resistance Tester, Module-scale Impact and Vibration Test bench, Multi-angle Colorimeter, Portable Digital Microscope, Potential Induced Degradation Test Bench, Real-time and in-situ thermal measurement system, Small-scale climatic chambers for parameter screening, Solar Simulator for PV Modules, Spectrophotometre IR Emissivite Haute Temperature, Spectrophotometre UV Visible ARTA, Suntest XXL +, Surge Voltage Tester, Thermal and Optical test chamber for large PV modules, Weatherometer LMPV-WOM.

The areas of research normally supported by the infrastructure are related to PV/ST/CST systems:

- Opti-Lab: optical characterisation of materials,
- Shape: optical characterisation of systems,
- Indoor: accelerated ageing under controlled conditions.

The infrastructure could also be open to any area of research interested in shape measurement and accelerated ageing of material subjected to solar flux.

<u>Services currently offered by the infrastructure:</u>

The services offered by the infrastructure within the framework of the SFERA-III project are:

- Advanced lab equipment for accelerated ageing under controlled conditions,
- optical characterisation from materials to systems,
- absorbance, emittance at ambiance temperature and high temperature,
- spectral emittance in temperature.

The DURASOL fully anticipates today's world-wide interests (US, Asia, EU) on the reliability and durability of solar systems as some other similar ongoing initiatives like DURAMAT (NREL, SANDIA and Lawrence Berkeley National Labs) or INFINITY (Austrian Institute of Technology and research center Carinthian Tech Research).

DURASOL is aligned with these initiatives through technical / scientific exchanges during conferences / seminars and visits (as from SANDIA to INES) as well as by participation in the PVQAT (PV Quality Assurance Taskforce) and SolarPACES Task III. The large variety of climate stresses available for outdoor testing and the large variety of lab equipment to test solar systems under stress conditions in an accelerated way makes the DURASOL a unique R&D platform. DURASOL hosted 46 international users in 2015, including 21 non-academic; and 85 international users in 2016, including 39 non-academic.

Below is a selection of scientific papers based on experimental works realized with DURASOL facility for different scientific fields:

- 'Critical constraints responsible to solar glass mirror degradation', R. Girard, O. Raccurt, C. Delord, A. Disdier, Energy Procedia, Vol. 69, 2015, p 1519-1528.

- ‘Accelerated aging tests of solar reflectors according to new AENOR standard – Results of a Round Robin Test ‘, Fernández-García, A.; Martínez-Arcos, L.; Sutter, F.; Wette, J.; Sallaberry, F.; Erice, R.; Diamantino, T.; Raccurt, O.; Pescheux, A.-C. & Iparraguirre, I. (2017), in 'Solar PACES 2017'.
- An outdoor platform for PV ageing study: electrical parameter extraction from I-V curves, Faggianelli G.A., Haurant P., Rodler A., Poggi P., ISES – Solar World Congress, 8 – 12 November 2015, Daegu, Corée du Sud. tiffness and fracture analysis of photovoltaic grade silicon plates
- Zhao, L., Maynadier, A., Nelias, D. (2016) International Journal of Solids and Structures, 97_98, pp. 355-369

Name of the infrastructure: **ESTHER** (Stone, Lhassa)
Location (town, country) of the infrastructure: Grenoble, France
Web site address: www.liten.cea.fr
The **ESTHER** infrastructure belongs to the experimental platform of CEA’s Grenoble center dedicated to thermal applications. It comprises thermal storage and heat exchangers testing facilities, a PCM corrosion test bench, and storage media characterisation devices (Thermal-diffusivity, conductivity, calorimetry, ovens). Two main facilities located in the same building will be included in SFERA-III Trans-national Access programme:

- **Dual media thermocline facility (STONE)**: This sensible thermocline heat storage involves a tank filled with solid materials (rock and sand) that are gradually heated or cooled by an oil loop. This prototype-scale (3 m^3) thermocline tank has been built and successfully operated at CEA Grenoble since 2010, demonstrating highly controllable and predictable operation at different oil velocities and fine understanding of the hydraulic and thermal behaviours of the storage tank.
- **Latent Heat Storage with PCM (LHASSA)**: The LHASSA facility is a high pressure water-steam closed loop designed to test latent storage modules under operating conditions similar to those of commercial DSG STE plants (145 bar, 350 °C) with a flow rate of 35 g/s. Electric heaters simulate the STE solar field while a condenser and an air cooler condense and subcool the fluid flow at the storage outlet. A pressurizer is used to maintain the required pressure level in the loop and acts as an expansion vessel. Two PCM storage modules (3 m^3 and 1 m^3) have been installed on this loop and tested successfully. These modules contain sodium nitrate as PCM, compatible with water’s evaporation temperature of 300°C.

The area of research normally supported by the infrastructure is thermal energy storage for CST applications. The infrastructure could also be opened to research on thermal energy storage for other applications for industry or other thermal power production systems. Participation in SFERA will increase the visibility of these unique facilities initially dedicated to private partners and undoubtedly increase the opportunities for international cooperation.

Services currently offered by the infrastructure:
The services offered by the infrastructure within the framework of the SFERA-III project are:

- Validation of the thermo-hydraulic behaviour of storage systems under operating conditions similar to commercial STE plants,
- Performance and durability assessment of thermal storages,
- Optimization of the operating procedures,
- Validation of numerical model of thermal storage systems.

The STONE facility already showed highly controllable and predictable operations, allowing fine understanding of the hydraulic and thermal behaviours of the thermocline tank in controlled operating conditions. Results from numerical models were already successfully compared with the experimental data, proving that they can be used for performance predictions and for the definition of operating strategies of commercial STE plants. In 2016, STONE hosted academics from CIEMAT’s Thermal Storage Group for 3 weeks. One outcome has been a paper presented during SolarPACES 2017. You will find below a selection of scientific papers based on experimental work on this facility:

- Bruch, A., Fourmigue, J.F., Couturier, R., Experimental and numerical investigation of a pilot-scale thermal oil packed bed thermal storage system for CST power plant, Solar Energy 105 (2014) 116–125.

- Esence, T., Bayón, R., Bruch, A., Rojas, E., Study of thermocline development inside a dual-media storage tank at the beginning of dynamic processes, AIP Conference Proceedings, 1850, 080009 (2017).
- Bruch, A., Molina, S., Esence, T., Fourmigué, J.F., Couturier, R., Experimental investigation of cycling behaviour of pilot-scale thermal oil packed-bed thermal storage system. Renewable Energy 103, 277-285 (2017).

The LHASSA facility was already used to validate the thermo-hydraulic behavior of PCM storage tanks under operating conditions similar to commercial DSG STE plants, with measured storage performances meeting the specifications, optimized operating procedures, and obtaining good agreement with simulation results given by dynamic models developed at CEA. You will find below a selection of scientific papers based on experimental work on this facility:

- Garcia, P., Rougé, S., Nivelon, P. (2016). Second test campaign of a pilot scale latent heat thermal energy storage – Durability and operational strategies. SolarPACES 2015, AIP Conf. Proc. 1734, 050016-1–050016-7.
- Garcia, P., Olcese, M., Rougé, S. (2015). Experimental and numerical investigation of a pilot scale latent heat thermal energy storage for CST power plant, Energy Procedia 69, 842 – 849.