JOINT INPUT TO ISSUE PAPER Nr 3 BY

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Our common commitment

The proposed targets by the European Commission in the *Issues Paper Nr. 3* are logically aligning on previous inputs provided by the European R+D centers and ESTELA on behalf the STE industry since 2008, namely all Lighthouse projects, the successive versions of the Solar European Industrial Initiatives with their respective Implementation Plans and comments to the Integrated Roadmap and related work programs.

In this context, it is noteworthy that the STE sector (ESTELA, EERA JP-CSP and EUTurbines) has decided to join forces in order to define joint research and innovation initiatives.

The whole sector is therefore willing to work with the European Commission and the Member States to achieve the defined targets and is confident that exploiting synergies and facilitating cross-sector fertilization will deliver important efficiency improvements and cost reductions of CSP/STE plants.

We believe that the STE European industry global leadership can be preserved based on <u>two main pillars</u>:

- **In the short term, a relaunched market development with associated learning and scaling effects;**
- **In the medium term, intensified R&D efforts to bring Technology Readiness Levels (TRL) of innovative concepts closer to markets.**

Both pillars will lead to a substantial cost decrease for STE.

Motivation and comments:

Taking into account the market development stop in Europe over the last 3 years, the whole sector considers the targets stated in the "Issues Paper" by 2020 ambitious and as such a strong challenge. Even though ambitious, these targets m**ay not ensure that the European STE industry becomes globally competitive if we continue to compare them with targets set at around** 5 c€/kWh e.g. in the USA - **not taking into consideration the additional costs for backup and storage to achieve a comparable availability of power on the grid as STE provides.**

An important part of the cost reduction will result from economies of scale, and in the short term this will not mainly depend on the improvement of the technology, but on the existence of framework conditions in the European Union and the Member States which foster the mass deployment of this technology – something which is missing at the moment.

As a comparison, at present there are about 400 GW of wind energy generation capacity and about 200 GW of PV installed worldwide, but only 4 GW of STE. The historical cost reductions in wind and PV have been mainly the result of increase in installed capacity, i.e. the result of scale.

- In the following section of this document a number of elements (obstacles, gaps and barriers) are reviewed that should be taken into consideration in order to achieve these targets.
- In the short term, a sustainable and predictable increase in capacity installed is needed, which in Europe requires a clear support towards the implementation of 1st-of-its-kind projects under either the framework of the cooperation mechanisms established in the RES directive or as new STE projects

supported by national deployment programs in specific member states. Such 1st-of-its-kind projects should also be designed and operated as part of a R&I strategy for STE allowing researchers and STE sector a) full access to operational experience and b) as much interaction as possible with technical parameters of the different subsystems of the plant. This would a) trigger incremental and disruptive innovations towards the final targets and b) provide replicable examples for further deployment of STE plans in Europe.

- In the medium and long term, a larger financial support at both national and EU level would be needed to support key technological research and demonstration projects and initiatives to successfully raise some current ideas from TRL 4/5 to 7/8. To this end, the joint use of national and EC funds to raise ambitious projects (in a much more straightforward and efficient way than current BERLIN and ERANET co-fund models) is considered essential. Defined financial schemes should allow for the launching of projects covering the range of 2-3 M€ (in the case of more focused technological initiatives) to 7-10 M€ (for broader projects requiring large consortiums). Limiting the long term target to supercritical cycles is too narrow.

- An extended intense cooperation between EU research centers and the industry is also needed to accelerate the incremental and disruptive innovations indicated below and bring them to markets (higher TRLs). It should be stressed that most of research lines established in ESTELA's Strategic Research Agenda (2012) are still fully compatible with all previous approaches and will also contribute to achieving the main goals of increasing efficiency and reducing costs.

- The above aspects and those mentioned in the Issues Paper as "framework conditions" to the R&I objectives of the *Issues Paper* need to be prioritized. The three elements (a) **economies of scale** due to market volume, (b) solid **risk finance** and (c) the use of existing legal tools to foster **international cooperation** around a 1st-of-its-kind STE project in Europe) **will be decisive to provide the targeted cost reduction in short term as well as marketable major technological innovations will do the same in the medium and long term**.

- **This means that one or more member states, supported by the EC services, should launch an attractive STE deployment program embedded (i.e. embedded in a reliable investment environment) with a view of either planning an own generation mix or making use of the cooperation mechanisms established in the RES Directive to extend to other countries without abundant resources of flexible generation the benefits of STE plants.**

Cost reduction: Facts and benefits

Fact 1: The already achieved cost reduction can be documented from the most recently awarded projects as follows:

- Morocco: Noor I to Noor II & III: around 15 % PPA cost reduction within 2 years
- South Africa: REIPPPP Round 3 to the current REIPPPP Expedited Bid Round: around 20 % cost reduction within 2 years
- Spain is showing clear improvements in the operation experience of the plants both in terms of increase of electricity generation and reduction of O&M costs.

- Market opportunities and scale factors for new large plants are being the main drivers for cost reduction and for bringing to markets incremental technological innovations based on lessons learned from previous plants.

Fact 2: LCOE is still used as a metric for CSP/STE targets. However LCOEs are essentially based on a cost approach (instead of a full value approach). Therefore, they cannot reflect the true value of STE for the electrical system. NREL & DLR reported incremental values of 3 – 5 c€ /kWh for dispatchable energy that is able to participate in the residual load management of a given system. It is therefore critical to be competitive considering the special electricity market where the CSP/STE is being sold.

Benefit 1: Preserving the current technological leadership for STE in Europe during the expected STE world market development (IEA STE roadmap 2014) represents an added value (business and export opportunities for the entire supply chain for STE in Europe with the corresponding job creation effect in Europe). This requires that STE in Europe needs to be globally competitive (US currently target an LCOE of 6 c$/kWh via the SunShot program for a DNI of 2600 kWh/m2/yr).

Benefit 2: The positive macroeconomic effects on the economy of countries having launched a consistent STE deployment program (local industry empowerment) are being increasingly perceived by policy makers as another reason to increase their domestic STE market – with corresponding effects on cost reduction.

Non-technological barriers to cost reductions

Barrier 1: Retroactive changes in legal / regulatory conditions in Spain and subsequent deterioration of the investment climate and budgetary commitments to R&D; ongoing legal cases;

Barrier 2: No implementation action taken by the 6 countries that had included STE in their National Renewable Energy Action Plans (Portugal, Spain, France, Italy, Greece, Cyprus). Although Spain implemented 3,2 GW in the period 2007-2013, there are yet no political signals that this deployment will continue;

Barrier 3: No implementation of all STE plants awarded in the NER 300 program due to the absence of necessary conditions in the host European countries;

Barrier 4: No use of Cooperation Mechanisms by EU Member States (→ ECOFYS Study)

Barrier 5: Still weak electrical interconnections among European Countries

Barrier 6: **All actors involved in a STE power plant need to work together to achieve the goals. Many companies that support the R&I efforts of the European Commission are multi-national and expect from the European Commission guidance on how to deal with local and global competition versus collaboration.**

Suggestions about technological elements likely to trigger cost reductions

To reach the targeted cost reductions for the short term target (2020) the achievement of successful developments within the following areas of R&D cooperation are also considered crucial:

- Advanced materials with increased durability, reliability and performance at high temperature solar receivers (achievement of higher working temperatures in central receiver systems).

- Improvement of materials and components in order to:
  - Increase lifetime durability (ageing) under harsh conditions (e.g., more resistant to the erosion caused by sand storms in desert areas)
  - Increase compatibility with Heat Transfer Fluids (HTF).
  - Improve the resistance to thermal and mechanical cycling.
- Downsizing supercritical steam turbines to 100-150 MW (that would perfectly fit into tower STE plants) and at the same time increase the working temperature for molten salts up to a bit more than 600 °C
- Materials development for cheap and efficient thermal storage with sensible and latent heat.
- Suitable thermal storage schemes and systems to cover larger working temperature ranges.
- Suitable HTFs working at higher temperatures for all STE technologies.
- Environmental footprint reduction at STE plants, especially with regard to water consumption.
- New cycles and/or power plant schemes: Innovative hybrid cycles using alternative working fluids such as supercritical CO2. This could include highly recuperated Brayton cycles to achieve significantly higher cycle efficiencies. This would require advanced supercritical CO2 turbomachinery (compressors and expanders) to execute the power system.
- Improvement of short-term meteorological prediction in STE plants.
- Increasing the flexibility of the CSP power plant through the use of fast reacting fossil fired boilers/gas turbines for frequency response (primary, secondary + tertiary reserve). Start-up/shut-down ability and load following capability to better respond to changes in availability of solar power and demand as well as minimum load to improve the overall efficiency of the turbine.
- Optimizing the integration of CSP systems with thermal power plants with Integrated Solar Combined Cycle Systems (ISCC) by reducing the efficiency loss in fossil fuel only mode (measures to mitigate overdesign) and increasing efficiency in ISCC mode (use of excess heat in Boiler).
- In many situations smaller scale CSP plants (used for electricity and/or process heat and/or desalination) may be competitive against other technologies (islands, off-grid, difficult topology). Therefore these SME-related activities should be considered as well.

Essential aspect for a 1st-of-its-kind proposal

The STE sector believes that there are **several commercial projects** developed among its members that could be realized without any additional obstacles (such as land use authorization procedures, access to the grid, social acceptance, regional support, etc.). In case such projects would benefit from a political support combined with the access to several financial support instruments e.g. NER 450 programs, Juncker's Plan, EU structural funds, InnovFin, they would result in a very competitive opportunity for countries that might not meet their national 2020 targets, in order for them to acquire dispatchable renewable energy at a premium price above market of 4-7 c€/kwh.

As the graph at the end of the document shows, in spite of a market price of around 5 c€/kWh, the high-quality dispatchable STE renewable power could be an interesting value proposition for off-takers in those countries likely to miss their national RES targets. The challenge would be for the gap of 4-7 c€/kWh, after the financing support (which in itself might reduce the cost of investment by about 3 c€/kWh.

The STE sector believes that part of that 4-7 c€/kWh gap can be reduced by technology improvements by 2020 (perhaps 1-2 c€/kWh). The remaining 2-6 c€/kWh gap can only come from increased deployment scale, from engineering replication and efficiency increases. For example, the cost of a second-of-a-kind plant is expected to be 10-15% lower than the 1st-of-a-kind (which would represent a 2-3 c€/kWh reduction only in the second plant built. To sum up, the 9 c€/kWh cost reduction from the current 18 c€/kWh to below 8-9 c€/kWh realistically could only come from R&I, scale and financing support (see pie chart below)