SOLAR TRES: Proposal of a solar-only 24-hour-operation Solar Tower Plant for Southern Spain

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The main objective of the SOLAR TRES project is to demonstrate the technical and economic viability of solar thermal central receiver system–molten salt technologies to deliver clean, cost-competitive bulk electricity. Within the frame of the project, participants will design, construct and evaluate a 10-MWe "solar-only" power plant to be built in southern Spain. The central receiver system (CRS)-type plant uses molten salt as the heat transfer medium for both solar to thermal energy conversion at the central receiver and energy storage, and steems from the US experience in Solar Two project. To demonstrate its economic viability under the present Spanish special legal framework for electricity production from renewable sources, the plant will be a model commercial operation from the start.

Key aspects of the plant are the very large size of the molten salt thermal storage, which is large enough to allow for 24-hour operation of the "solar only" plant, and the use of a new type of reduced-dimension, low cost heliostat. The table reflects the main differences compared to the previous Solar Two project.

	Solar Two	**Solar Tres**
Steam Turbine Net Power (MW)	**10**	**10**
DNI (MWh/m^2)	**2.7**	**2.0**
Field Layout	**Surround**	**North**
Solar Multiple	**1.1**	**2.6**
Field Size (m^2)	**82,000**	**150,566**
Receiver size (MW_t)	**40**	**96**
Receiver configuration	**Cylindrical**	**Billboard**
Storage (hrs)	**3**	**12**
Mature annual capacity factor	**20%**	**52%**
Mature annual efficiency	**8%**	**14%**
Mature year O&M cost ($/kWh)	**0.140**	**0.011**
Levelized Energy Cost ($/kWh)	**----**	**0.13**

The SOLAR TRES heliostat field has a total reflective area of 150,566 m^2 composed of 7,842 heliostats of 19.2 m^2 of reflective area each. Under nominal conditions (noon at summer solstice, assuming direct irradiance of 900 W/m^2) the plant delivers a net power of 10 MWe to the grid and sends 52.7 MWt of thermal energy to the storage. The annual net power output estimated with SOLERGY is 44.2 GWh.

Solergy printout for SOLAR TRES 12-hour Storage Molten-Salt Plant

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  PLANT SUMMARY - DAYS 1 TO 365 YEAR 1996

EFFICIENCY        (MWHRS)           ENERGY LOSSES
        I-------------------------I   (MWHRS)
        I     TOTAL INSOLATION    I
        I        309683.10        I
        I-------------------------I
                     V
        I-------------------------I FIELD LOSSES (INCLUDES OUTAGE LOSSES)
  1.000 I    REDIRECTED ENERGY    I
   .645 I        199718.00        I  109965.10 COSINE, SHADOWING, BLOCKING,
        I-------------------------I            SPILLAGE, TRANSMISION )
                     V
        I-------------------------I STORAGE FULL OR CHARGING HX IN STARTUP
  1.000 I  RCVR INCIDENT ENERGY   I  0.00 DEFOCUS HELIOSTATS (YSUPTR)
        I        199718.00        I
        I-------------------------I
                     V
        I-------------------------I RECEIVER LOSSES
        I        RECEIVER         I    5816.30 RCVR MIN FLOW      (YPLRMF)
        I     ABSORBED ENERGY     I       6.42 SURPLUS ENERGY TO RCVR
   .835 I                         I        .00 ABSORPTANCE
        I        166717.80        I   14513.30 THERMAL LOSS (RAD. AND CONVECTION)
        I-------------------------I   12664.15 RCVR STARTUP (YRSTRT)
                     V
        I-------------------------I PIPING LOSSES
  1.000 I    ENERGY TO STORAGE    I      79.61
        I        166638.20        I
        I-------------------------I
                     V
        I-------------------------I STORAGE LOSSES
        I                         I        .00 CHARGING HX START (YCSTRT)
        I        ENERGY TO        I        .00 LOSS FROM CHARGING HX (YTPLDC)
   .974 I         TURBINE*        I    3504.01 TANK LOSS (YTNKLOS)
        I        162355.60        I        .00 STEAM GENERATOR STARTUP (YESTRT)
        I-------------------------I     778.69 LOSS FROM STEAM GENERATOR (YTPLDD)
                     V               *    -.06 MWHRS IN STORAGE AT END OF DAY 365
                     V
        I-------------------------I EPGS LOSSES
   .326 I      GROSS ENERGY       I    1914.17 TURBINE SYNC LOSS (YTSTRT)
        I         52889.48        I  107551.90 RANKINE LOSS (APPROX)
        I-------------------------I
                     V
        I-------------------------I AUXILIARY ENERGY
        I       NET ENERGY        I        .00 BALANCE OF PLANT (YBOPPAR)
   .835 I         OUTPUT          I    3710.72 TURBINE PLANT (YTPPAR)
        I                         I    3729.38 SOLAR PLANT (YSPPAR)
        I         44175.95 MWHe   I    1273.42 OVERNIGHT (YPMPAR)
        I-------------------------I        .00 SHUTDOWN (YSDPAR)
   .143                           (   8713.53 TOTAL AUX ENERGY (YPARN))

   .143 OVERALL PLANT EFFICIENCY (TOTAL NET ELECTRICITY/ TOTAL DNI ON FIELD)
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The project involves the US Solar Two consortium partners Bechtel, Boeing and Sandia, and Spanish companies and research centers like GHERSA and CIEMAT. After the execution of this project, the partners expect to promote new commercial solar thermal power plants in Southern Spain and elsewhere.