CLEAN ENERGY BY SWEDEN

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Performance validation data from Azelio TES.POD 1.0 test rig in Sweden

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The TES.POD 1.0 unit has been in operation in Sweden with the objective to gather operational performance data, such as reliability, up-time, nominal power, round-trip efficiency, and dynamic behaviours to validate the design requirements.

The TES.POD 1.0 performs in all aspects according to the technical performance specifications. In this paper, some data is presented to provide evidence of the performance and key characteristics of the product.

INTRODUCTION

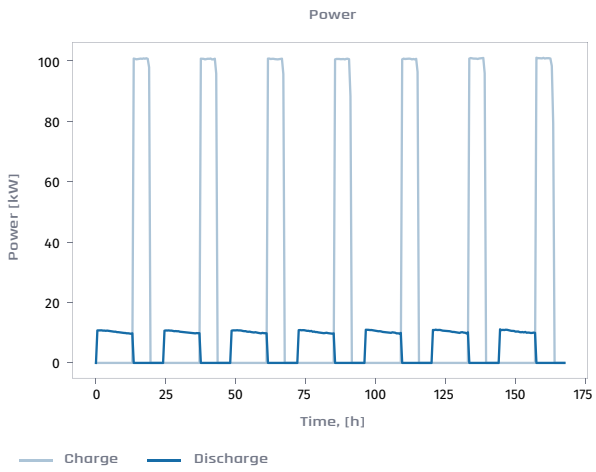
The TES.POD 1.0 in standard configuration consists of a Stirling engine as power conversion unit and a thermal energy storage filled with 4,4 tons of PCM AlSi. The nominal power at generator and at state of charge 100% is 13 kW_e in ISO conditions. The PCM is designed to provide the engine with heat for 13 hours, hence around 165 kWh_e of energy produced during a full discharge cycle. The PCM is charged with electricity that is converted to around 600 kWh of heat.

The test system in Sweden has been gathering an extensive amount of data over a long time.

CHARGE AND DISCHARGE PERFORMANCE

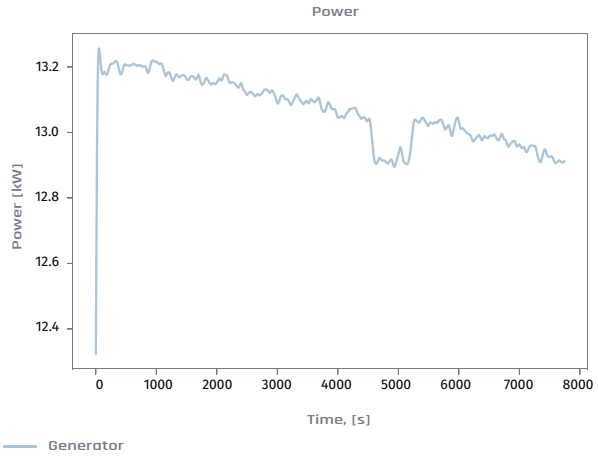
The TES.POD 1.0 has been operated in continuous operational mode during the test period and data from 7 consecutive days is shown in Figure 1. The engine was operated in continuous power setting for 13 hours and directly thereafter charged with 100 kW_e for around 6 hours to state of charge 100%. The small tapering in output power is a result of lower temperature from the PCM over time when SoC is decreased.

Figure 1 Charge and discharge power test data from 7 consecutive days.



A nominal power test was performed for a duration of 2 hrs as shown in Figure 2. The nominal power at ISO condition was measured to 13.2 kW_e at generator.

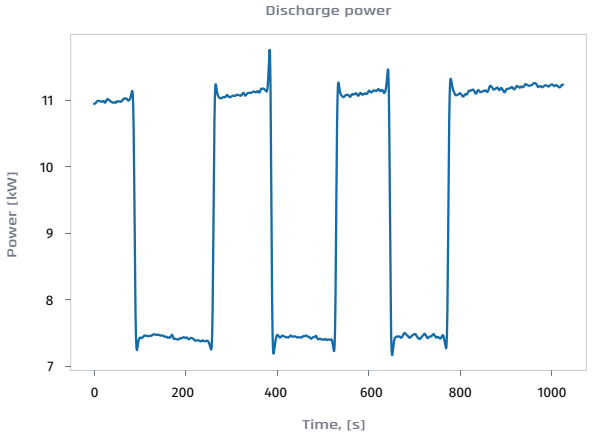
Figure 2 Nominal power during a 2 h test period.



LOAD FOLLOWING CHARACTERISTICS

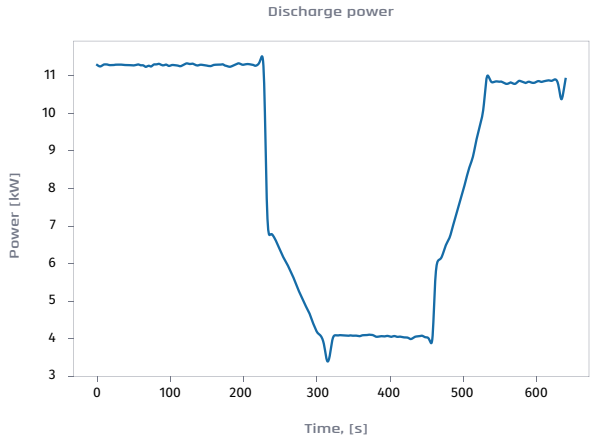
The output power from the TES.POD 1.0 can be controlled by varying the engine speed and the engine operating pressure. Speed control is very rapid as shown in Figure 3. The engine speed is varied between 1250 and 2000 rpm, and this enables a power output decrease of 35%. To achieve larger variation in power, engine pressure also must be adjusted.

Figure 3 Fast response power change with inverter speed control of engine from 1250 to 2000 rpm.



In Figure 4, the power output was decreased by 65% by lowering the engine speed from 2000 to 1250 rpm and the engine pressure from 125 to 75 bar. The effect of speed is instant whereas engine pressure is somewhat slower and completes the load change in 90 s.

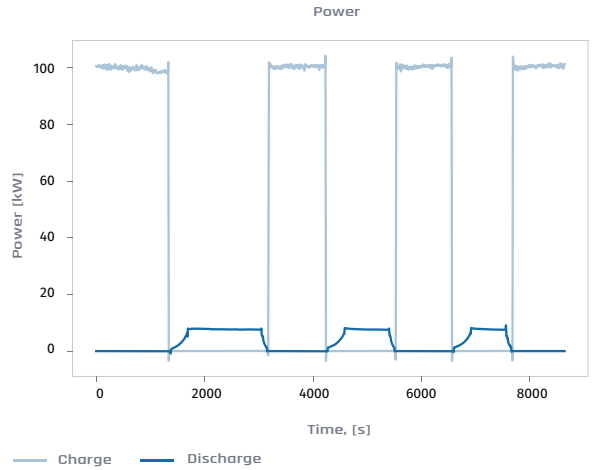
Figure 4 Load variation with both engine speed (1250 to 2000 rpm) and operating pressure (75 to 125 bar).



BACK-TO-BACK CHARGING AND DISCHARGING

The results from TES.POD 1.0 being charged with 100 kW_e and engine at idle and switching to no charging and engine producing nominal power are shown in Figure 5. This transition takes around 5 min and 30s. The transition back to full charge from operating the engine at nominal power takes around 2 min. The time between the 2 states could be minimised by starting the engine earlier should that be required.

Figure 5 System behaviour from full chargepower to continuous discharge power and vice versa.



TEST FACILITY IN SWEDEN

The TES.POD 1.0 unit is shown in Figure 6. The engine and generator are positioned to the left above the cooling fan and radiator. In the middle there are 2 HTF pumps, one for charging circuit and one for the discharging circuit. The PCM tank is fitted to the right in the square box insulated with perlite.

Figure 6 TES.POD 1.0 test unit in Sweden.

SUMMARY

The TES.POD 1.0 test system has logged a significant amount of validation data during the test campaign and all data is according to technical performance specifications set out in Tab 1. Key metrics such as nominal charge and discharge power, stored energy and produced energy and round-trip efficiency have been validated. The up-time has been good with only some minor interruptions due to communication errors between the SCADA system and the test unit.

Table 1 TES.POD 1.0 technical performance specification.

Feature	Value
Nominal Power – Output electricity[1]	13.0 kW_e
Rated Energy Capacity, electricity	165 kWh_e
Rated Energy Capacity	600 kWh
Output duration[2]	13h to 40h
Maximum Charging Power	100 kW_e
Charging duration	6h

[1] Parameters are specified at ambient temp of 25 °C and pressure of 1 atm

[2] When energy is withdrawn from the system