1500-SiC
Develop a new photovoltaic inverter with SiC for full power operation at 1500V

Project duration: from 03.2018 to 06.2020
Report submitted: 07.2020

Publishable Summary

Photovoltaic (PV) energy is experiencing significant cost reduction over the last years. Lately, the bias voltage of photovoltaic panels has risen from 1000 V to 1500 V, leading to a significant reduction of the Balance of Plant cost. In order to improve the Levelized Cost of Energy (LCoE), manufacturers are increasing the installed DC (Direct Current) power of PV panels for a given nominal AC (Alternating Current) power of the inverter (so-called capacity factor) from 1.2-1.3 to higher values. This results in a larger voltage at the maximum power point of the PV panel. As a consequence, conventional power electronics solutions rated at 1700 V maximum voltage are not suitable. This is because they are typically designed to deliver nominal power below approximately 1300 V, but increasing the capacity factor leads to higher maximum power point voltage. Therefore, new solutions are required in order to deliver rated power near 1500 V.

The aim of 1500-SIC is to develop enabling power electronics solutions capable of delivering nominal power at 1500 V with very high efficiency and high volumetric power density at competitive cost. The consortium includes Gamesa Electric from Spain, worldwide supplier of PV inverters; Infineon Technologies Austria, worldwide supplier of semiconductors for power electronics; and ETH Zurich Advanced Power Semiconductor Laboratory from Switzerland, a world-class research centre focused on semiconductor devices and power modules. Specifically, the consortium has worked together to develop a novel Silicon-Carbide diode and a MW-class inverter optimized to deliver nominal power at voltage levels up to 1500 V. The developed technologies have been built and tested at full scale through a comprehensive testing campaign.

The consortium includes key industrial actors in the supply chain of power electronics for PV solutions and a research centre. This maximizes the impact of the R&D outcomes of this program into the European Renewable Energy Industry.

Main outcomes of the project

<u>New installation assets</u>

It has been developed two different test rigs to validate the core new designs. These test rigs are:

- Double-pulse test rig. Valid to measure the semiconductor losses during on and switching states. It has been compared standard silicon solutions with novel SiC solutions.

Figure 1: Double pulse test bench

- 5 MW full power test rig. This new test rig has capabilities to test the new PV central inverter at real operating conditions:
  - electrical tests with virtual grid capacity to enable changes in voltage and frequency, including LVRT (Low Voltage Ride Through) and HVRT (High Voltage Ride Through)
  - thermal test, using a climatic chamber that enables measuring the inverter efficiency at different ambient temperature conditions.

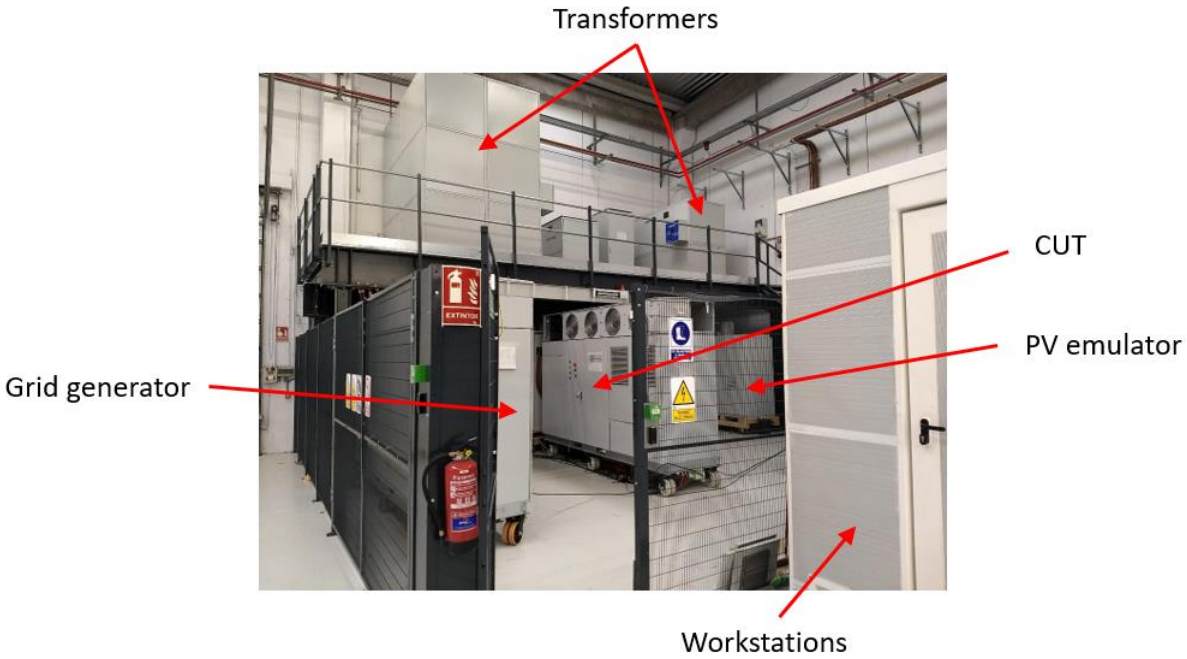

Figure 2: Picture of the full power test bench

New product achievements

- Validation of a new SiC module for 1500 V PV applications

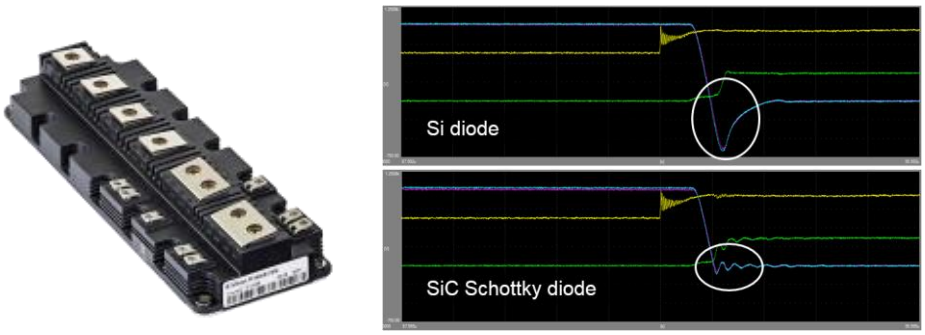

Figure 3: New power module validated and switch off event comparison

Test results show a 30% less losses with the new SiC module compared to an equivalent Si module. This achievement enables increasing the inverter power density.

- The new Gamesa Electric PV central inverter generation

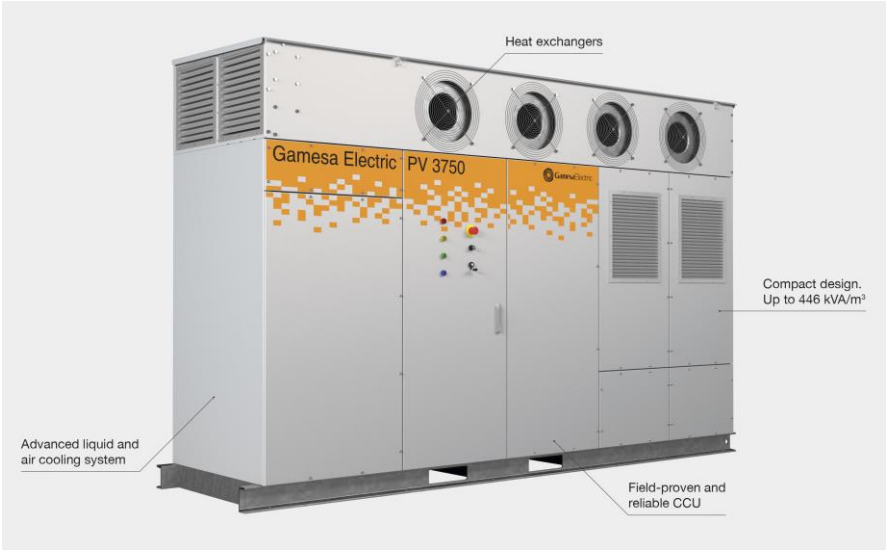

Figure 4: New 3.75 MW Central PV Inverter equipped with the technology developed with funding support from SOLAR-ERA.NET

Main characteristics improved (compare to existing PV Central Inverter):

- +8% power density with Outdoor characteristics.
- +0.5% CEC (California Energy Commission) effiency increase. The certified CEC efficiency boosts from 98.8% to 99.3%, achieving a world record thanks to the improved semiconductor performance.
- Cosmic ray certified by ETH Zurich, showing the same performance as the Si modules

Further activities and collaboration

Currently, there is development undergoing in a European funded project (TALENT – GA 864459) to incorporate the new 2.0 kV IGBT generation in the PV inverter so the new product is ready for:

- Increase of PV Pdc/Pac (Power DC/Power AC) ratio. Thanks to the continuous reduction of the PV panel cost, it is very convenient to increase the Pdc/Pac ration to sature the inverter capacity. This will imply operation at DC voltages higher than current 1300 VDC.
- Operate batteries at 1500 Vdc. To reduce the LCOE of energy storage assests, battery manufacturers are increasing the maximum voltage of the battery from 1100-1300 Vdc to 1500 Vdc. This voltage change will imply changing the power stack technology and Gamesa Electric is developing a new power stack within TALENT project.

Project consortium

Coordinator and all contact details:

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Participating countries and financing:

Country	**Number of organisations involved**	**Project costs in EUR**	**Public funding in EUR**
Spain	1	527'764	211'106
Austria	1	531'508	276'070
Switzerland	1	595'603	241'875
Total	*3*	*1'654'875*	*729'051*

Funding agencies involved and contracts

Funding Agency	**Contract N° and Title**
CDTI	SERA-20181001, 1500-SIC
FFG	Project no. 863519, 1500-SIC
Bundesamt für Energie BFE	Photovoltaik-Inverter mit SiC zum Betrieb bei 1500V-Teilprojekt CH – SOLAR-ERA.NET / SI/501702-01

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