Bifalo
Bifacial PV modules for lowest levelized cost of energy

Project Duration: 10.2016 to 09.2019
Initital report submitted: 04.2017

Summary

After several years of dramatic reductions of PV module production cost and prices, module prices are now stabilizing and further reductions of LCOE (levelized cost of energy in €/kWh) will now be driven by reduction of the Balance Of System (BOS) cost. A main driver for reduction of the BOS cost is the enhancement of the energy yield (kWh/m2 of module area) of the PV modules. On the one hand, this can be achieved by increasing the energy conversion efficiency of the solar cells - with the risk of increased production cost for cells and modules (see e.g. back-contact module technology by Sunpower and hetero-junction technology by Sony/Panasonic). A more cost effective way for increasing the energy yield of PV modules is the implementation of bifacial cells and modules: under favorable installation conditions (e.g. high albedo of the ground at the installation site), the rear side contribution to the total energy production of a bifacial module can reach 30% or more, while 10-15 % gain can be easily achieved even with bifacial PV systems installed over grassland. Taking the example of a bifacial module with 19% front side efficiency, its total energy yield will be the same as the energy yield of a monofacial module with 24.7% (= 19.0% x 1.3) - accordingly, the bifacial module has an equivalent efficiency of 24.7%, outperforming any non-concentrating PV module based on c-Si and, first and foremost, in the same price and cost range as standard modules with less than 18% efficiency. In addition, contrary to e.g. back-contact technologies, bifacial cells are suitable to be processed in standard module manufacturing lines that are currently available for more than 40 GW/year capacities worldwide. Bifacial PV is becoming even more relevant due to the fact that many new advanced cell concepts (as e.g. n-type and p-type PERT) are inherently bifacial. Accordingly, very recently, bifacial PV is gaining more and more interest, both from manufacturers and from PV system operators. Most companies that are currently implementing high efficiency bifacial cells on industrial scale are working on n-type wafer based cell-technology. The same is valid for the research activities at the main R&D institutes worldwide.

From the technological point of view, working with n-type Si-wafers is more straightforward with respect to achieve high front side efficiencies and, in addition, bifaciality comes automatically with n-type cell production (P-diffused BSF instead of Al-alloyed BSF in p-type). However, current market prices for n-type Cz-Si wafers are around 20% higher compared to p-type Cz-Si. The reason for this is mainly the better economy of scale of the p-type wafer production that today represents around 80% of the overall monocrystalline production capacity for PV - accordingly, the situation is not expected to change in the short term. The latest achievements in fabrication technology of high efficiency p-Si based bifacial solar cells allow starting development of high efficiency bifacial modules using such cells. Cheaper starting Cz p-Si, readiness of the industry to produce material with high quality recombination parameters and existing cell fabrication technology able to retain the bulk lifetime are making this cell type very promising for production of

high efficiency bifacial modules enabling a low LCOE. The working conditions of a bifacial module are different compared to the conditions of a regular monofacial module: higher current density due to the both sides contribution to the current generation, time and weather dependence of the gain due to back side contribution, effect of the back shading on the power generation. These differences affect the test set-up, power classification, design and safety requirements. These topics were not investigated practically up to now. The achievements of the BiFaLo project in the field of cell and module design and manufacturing in terms of module efficiency and energy yield (kWh/kWp) and of manufacturing cost will contribute to the overall project goal: a reduction of the LCOE of 10% compared to the state of the art of bifacial modules at time of the project kick-off.

Project consortium

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Participating countries and financing:

Country	**Number of organisations involved**	**Project costs in EUR**	**Public funding in EUR**
Germany	3	919’729	735’775
France	1	96‘416	42‘358
Israel	2	348’000	148’000
Total	*6*	*1’364’145*	*926’133*

Funding agencies involved and contracts

Funding Agency	Contract N° and Title
Projektträger Jülich (PtJ)	"Verbundvorhaben: BiFaLo- Bifaziale PV Module für minimale Stromgestehungs-kosten; Teilvorhaben: Entwicklung einer bifazialen Solarzelle und Modul sowie Entwicklung eines Modells für die Ertragssimulation und Berechnung der Produktions- und Stromgestehungskosten" (Förderkennzeichen 0324088A)
PtJ	Föderkennzeichen: 0324088B Kassenzeichen: 810303466044 Verbundvorhaben: BiFaLo- Bifaziale PV Module für minimale Stromgestehungskosten; Teilvorhaben: Entwicklung von Herstellungsprozessen und Moduldesigns für Bifacialsolarzellmodule
PtJ	# 0324088C BiFaLo – Bifaziale PV Module für minimale Stromgestehungs-kosten
ADEME	1605C0018: “Projet BiFaLo”
Ministry of National Infrastructures, Energy and Water	215-11-039 Development of simulation tool for predicting energy generation and of methods for field testing, for new high efficiency bifacial modules