Bauder Bio Solar Technical Report

Project: Land to the Rear of 159-163 Kings Cross Road

Project Reference: B172523

14 September 2017

Prepared for: MW Architects Ltd.

Prepared by: Bauder Ltd.

Technical Report

1. Project information

Project name	Land to the Rear of 159-163 Kings Cross Road
Client	MW Architects Ltd.
Contact	Mr Phil Chan
Bauder ATM	Mr Hayden Davies

2. Property information

Building/Areas	Roof Area RF1		
Address	Land to the Rear of 159-163 Kings Cross Road	*Postcode*:	WC1X 9BN

3. System configuration

Rated Power DC	1.89 kWp
Bauder System	BAUDER Bio Solar
Bauder Fixing Method	Ballasted*2
*Type of Module (power class)*1*	JA Solar (270Wp*3)
Module quantity	7 units
Bauder Mounts	7 units
Bauder Bio Solar Rails	15.4 lm (Number of mounts x 2.2m).
Type of Inverter	Fronius Galvo 1.5-1
Inverter amount	1 units
DC Cable length	Ca. m (Confirmed when design finalized)
Cable tray system	M (Confirmed when design finalized)
DC Isolator	1 units

4. Yield studies

Global radiation at Site Location	976.0 kWh/m²		
Module Tilt / Angle	15°	*Module Azimuth*	23° SE
Roof Pitch	1°		
*Yield Forecast Specific Annual Yield *4*	814 kWh/kWp/a		
MCS Yield Forecast Specific Annual Yield	914 kWh/kWp/a		
*Forecast for generated energy in the first year *4*	1.539 MWh		
*CO2 savings per year *5*	0.814 tonnes/a		

*1 *Module type or power class can differ – dependant on the order time and availability*

*2 *Using Bauder biodiverse green roof – See Bauder Q37 green roof specification for further information.*

*3 *In accordance to STC (Standard Test Conditions): 1.000 W/m², (25 ± 2)°C, AM 1,5 according to EN 60904-3*

*4 *Simulation model subject to detailed system specification including inverter concept, shading analysis, cable losses etc. MCS figure shown is based on the closest geographical location provided on MCS irradiance datasheets. Yield forecast is based on PVsyst computer generated site specific output.*

*5 *According to: CO_2-emmission factor 529 g/kWh for the electrical mix in United Kingdom in 2012.*

Technical Report

5. Result

This result is based on the basic information provided and is only meant to show a preliminary design.

Full AutoCAD roof drawings are required to undertake a precise engineering design.

The exact method of roof attachment should be decided under consultation with Bauder Limited.

For a more detailed layout, further information is necessary – please contact us for details.

Created	D.Mitchell	*Checked*	T.Raftery
Date	2017/09/14	*Date*	2017/09/14

Evaluation basis

Document	**Description**	**Input date**
Drawing	SK01 (6)	2017-09-14

Software used	AUTOCAD LT Version 2012, Weather Data Meteonorm Version 7.1.3, Program PVSYST Version 6.34,

6. Attachments

1. Layout	B172523PV - 20170914
2. Structural Analysis	Provided upon request.
3. Data Sheets	BAUDER Bio Solar
	Panel Datasheet
	Inverter Datasheet

This report was prepared by MW Photovoltaik Engineering GmbH on behalf of Bauder Limited.

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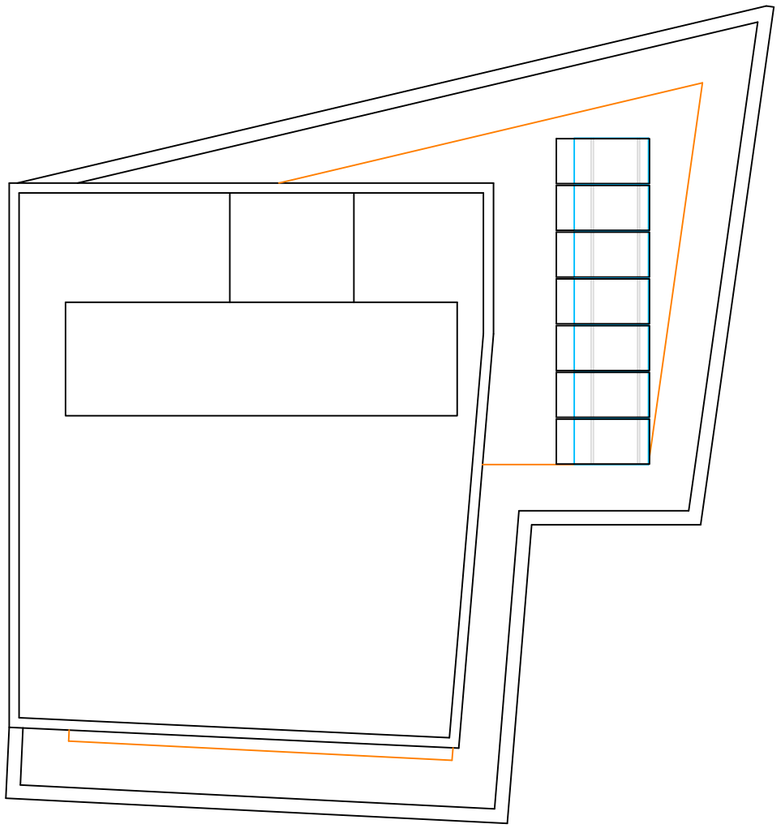
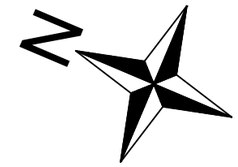
MW Photovoltaik Engineering GmbH





Wind suction areas (Structural analysis)

- Corner area F
- Edge area G
- Inner area H

General Information	
Total power DC	1.89 kWp
BAUDER System type	Bauder Bio Solar
Module type	JA Solar (270wp)
Module amount	7 Units
Azimuth	23 Degrees SE

This Layout is based on the given information. For a more detailed engineering, more information about the roof and nearby objects are necessary.

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	Date	Name
Drawn	14.09.17	Darren Mitchell
Changed		
Checked		

Drawing No.: B172523PV - 20170914

File Name: B172523PV - 20170914.dwg

Scale:

Client: MW Architects Ltd.

Project: Land to the Rear of 159-163 Kings Cross Road London

Drawing Title: PV Layout Plan
PV Design Layout

Planning Period:

Format: A

Sheet

BAUDER

BIOSOLAR

BAUDER BioSOLAR
Integrated Photovoltaic Green Roof

The construction and development of buildings in today's market is calling for rooftop solutions that include a duality of technologies for environmental advantage; a biodiverse green roof coupled with ecological and SUDS enhancement and a solar photovoltaic array. Bauder embraces this cohesive stance with our BioSOLAR solution designed to meet planning and BREEAM requirements.

Bauder BioSOLAR is an integrated mounting solution for photovoltaic renewable energy with a green roof where the substrate and vegetation provide the ballasted installation mechanism which removes the need for penetrating the waterproofing to secure the mounting units to the roof.

A key element of the BioSOLAR system is that the front edge of the PV panel is set at around 300mm above the level of the substrate which allows liberal growing room for the extensive vegetation without blocking light to the polycrystalline solar cells which would otherwise reduce the output and efficiency of the panels. This height setting also enables light and moisture to reach beneath the panel to support the plants below.

Improved Solar Panel Efficiency

A combined green roof with PV delivers advantages to the building as the cooling effect of the vegetation and water held within the green roof system preserves the ambient temperature around the photovoltaic array. Studies in Germany have shown that PVs work most efficiently with an ambient temperature of around 24°C and that when an array is combined with a green roof, the panels are expected to achieve around a 6% higher output.

Varied Habitats for Flora and Fauna

The mixture of sunny, shaded and sheltered areas together with a variable depth of FLL compliant extensive substrate gives a matrix of different habitats which allow a broader range of plant species to thrive, and small invertebrates to seek refuge from strong wind and rain. The broad mix of flowering vegetation provides a rich foraging environment for bees and insects.

Key Features

- Maximises solar output and allows entire roof to qualify as biodiverse green roof.
- No roof penetrations as the green roof substrate acts as ballast, ensuring that the waterproofing guarantee remains uncompromised.
- Quick and simple installation process.
- Cost competitive compared with a mechanically fixed alternative.
- Raised modules allow light and moisture under the panels so reduces the unproductive area.
- System can be retrofitted on many roofs without structural modification to the building.
- Single point responsibility for the waterproofing, green roof and PV installation.
- Increased module space between substrate and panels reduced risk of panel damage during green roof maintenance.

PHOTOVOLTAIC GREEN ROOF CONSTRUCTION

Mounted photovoltaic panel prior to the installation of the ballasting green roof and vegetation.

Service

Bauder is renowned for its green roofs and our BioSOLAR system is an extension to this provision and as such you receive the service that accompanies all our project commitment, delivery and management.

We will work with you through the entire process from consultation and initial site survey, design the PV array and green roof construction with appropriate Bauder waterproofing, suitable substrate depths and vegetation, create a specification package for every element of the roof including detail design and wind uplift calculations, monitor the installation and handover to the client with full guarantee.

Quality of Installation

Our approved contractors, engineers and installers are the only people fully trained and certified to install our rooftop solutions as excellent workmanship is crucial to the guarantee that accompanies all works on the Bauder roof.

BAUDER

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JA SOLAR

JAP6(K)

-60/255-275/4BB
F 35-35
MULTICRYSTALLINE SILICON MODULE

JA Solar Holdings Co., Ltd.

JA Solar Holdings Co., Ltd. is a world-leading manufacturer of high-performance photovoltaic products that convert sunlight into electricity for residential, commercial, and utility-scale power generation. The company was founded on May 18, 2005, and was publicly listed on NASDAQ on February 7, 2007. JA Solar is one of the world's largest producers of solar cells and modules. Its standard and high-efficiency product offerings are among the most powerful and cost-effective in the industry.

A d d : Building No.8, Nuode Center, Automobile Museum East Road, Fengtai District, Beijing
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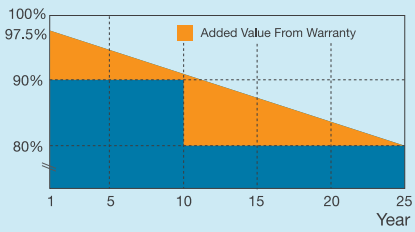
Superior Warranty

- 12-year product warranty
- 25-year linear power output warranty



Key Features

- JA 4BB design module reduce cell series resistance and stress between cell interconnectors improves module reliability and module conversion efficiency
- High output, 16.51% highest conversion efficiency
- IEC 1000V — Designed for DC IEC 1000V applications
- Anti-reflective and anti-soiling surface reduces power loss from dirt and dust
- Outstanding performance in low-light irradiance environments
- 5400 Pa — Excellent mechanical load resistance: Certified to withstand high wind loads (2400Pa) and snow loads (5400Pa)
- TÜV — High salt and ammonia resistance certified by TÜV NORD

Reliable Quality

- Positive power tolerance: 0~+5W
- 100% EL double-inspection ensures modules are defects free
- Modules binned by current to improve system performance
- Potential Induced Degradation (PID) Resistant

Comprehensive Certificates

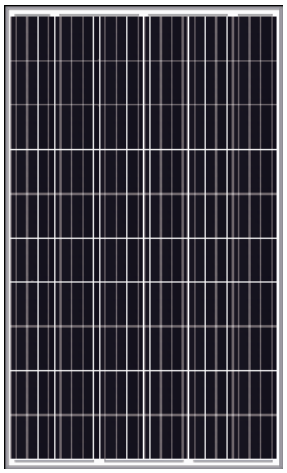
- IEC 61215, IEC 61730, UL1703, CEC Listed, MCS and CE
- ISO 9001: 2008: Quality management systems
- ISO 14001: 2004: Environmental management systems
- BS OHSAS 18001: 2007: Occupational health and safety management systems
- Environmental policy: The first solar company in China to complete Intertek's carbon footprint evaluation program and receive green leaf mark verification for our products

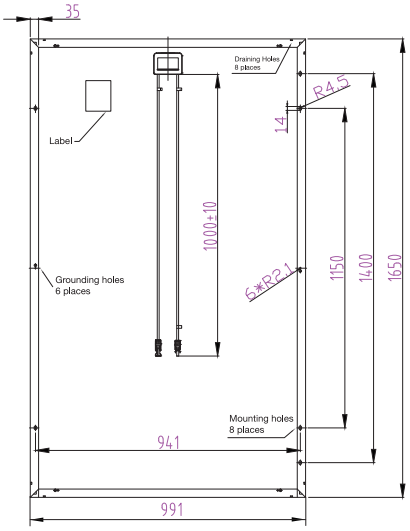
Specifications subject to technical changes and tests. JA Solar reserves the right of final interpretation.

JAP6(K)-60/255-275/4BB
F 35-35

JA SOLAR

Engineering Drawings





MECHANICAL PARAMETERS

Cell (mm)	Poly 156.75x156.75
Weight (kg)	18 (approx)
Dimensions (L×W×H) (mm)	1650×991×35
Cable Cross Section Size (mm^2)	4
No. of Cells and Connections	60 (6×10)
Junction Box	IP67, 3 diodes
Connector	MC4 Compatible
Packaging Configuration	30 Per Pallet

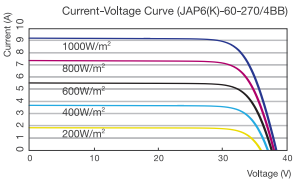
WORKING CONDITIONS

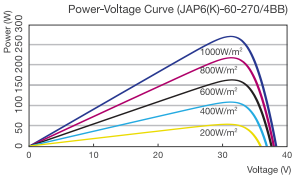
Maximum System Voltage	DC 1000V (IEC)
Operating Temperature	-40℃~+85℃
Maximum Series Fuse	15A
Maximum Static Load, Front (e.g., snow and wind) Maximum Static Load, Back (e.g., wind)	5400Pa (112 lb/ft^2) 2400Pa (50 lb/ft^2)
NOCT	45±2℃
Application Class	Class A

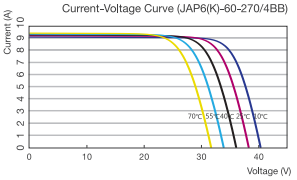
ELECTRICAL PARAMETERS

TYPE	JAP6(K)-60-255/4BB	JAP6(K)-60-260/4BB	JAP6(K)-60-265/4BB	JAP6(K)-60-270/4BB	JAP6(K)-60-275/4BB
Rated Maximum Power at STC (W)	255	260	265	270	275
Open Circuit Voltage (Voc/V)	37.51	37.74	37.95	38.17	38.38
Maximum Power Voltage (Vmp/V)	30.49	30.71	30.92	31.13	31.34
Short Circuit Current (Isc/A)	8.93	9.04	9.11	9.18	9.29
Maximum Power Current (Imp/A)	8.36	8.47	8.57	8.67	8.77
Module Efficiency [%]	15.59	15.90	16.21	16.51	16.82
Power Tolerance (W)	-0~+5W				
Temperature Coefficient of Isc (αIsc)	+0.058%/℃				
Temperature Coefficient of Voc (βVoc)	-0.330%/℃				
Temperature Coefficient of Pmax (γPmp)	-0.410%/℃				
STC	Irradiance 1000W/m^2, Cell Temperature 25℃, Air Mass 1.5				

I-V CURVE







NOCT

TYPE	JAP6(K)-60-255/4BB	JAP6(K)-60-260/4BB	JAP6(K)-60-265/4BB	JAP6(K)-60-270/4BB	JAP6(K)-60-275/4BB
Max Power (Pmax) [W]	185.13	188.76	192.39	196.02	199.65
Open Circuit Voltage (Voc) [V]	34.44	34.60	34.84	35.15	35.46
Max Power Voltage (Vmp) [V]	27.85	28.07	28.29	28.49	28.68
Short Circuit Current (Isc) [A]	7.06	7.10	7.13	7.17	7.23
Max Power Current (Imp) [A]	6.65	6.72	6.80	6.88	6.96
Condition	Under Normal Operating Cell Temperature, Irradiance of 800 W/m^2, spectrum AM 1.5, ambient temperature 20℃, wind speed 1 m/s				

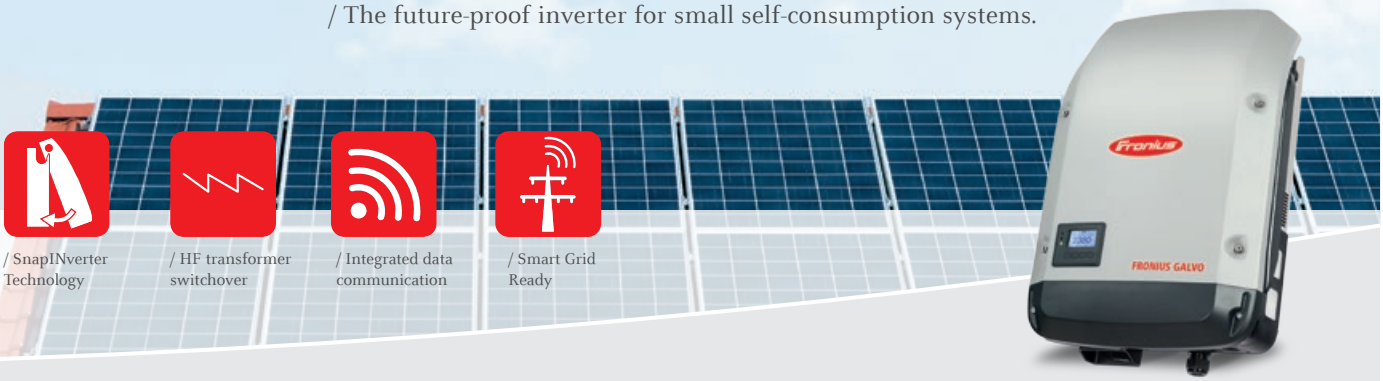
Electrical data in this catalog do not refer to a single module and they are not part of the offer. They only serve for comparison among different module types.

/ Perfect Welding / Solar Energy / Perfect Charging

SHIFTING THE LIMITS

FRONIUS GALVO

/ The future-proof inverter for small self-consumption systems.



/ SnapINverter Technology

/ HF transformer switchover

/ Integrated data communication

/ Smart Grid Ready

/ With power categories ranging from 1.5 to 3.1 kW, the Fronius Galvo is perfect for households – and is especially suitable for self-consumption systems. The integrated energy management relay allows the self-consumption component to be maximised. A host of other smart features make the Fronius Galvo one of the most future-proof inverters in its class: for example, the integrated datalogging, the simple connection to the internet by WLAN, or the plug-in card technology for retrofitting additional functions.

TECHNICAL DATA FRONIUS GALVO

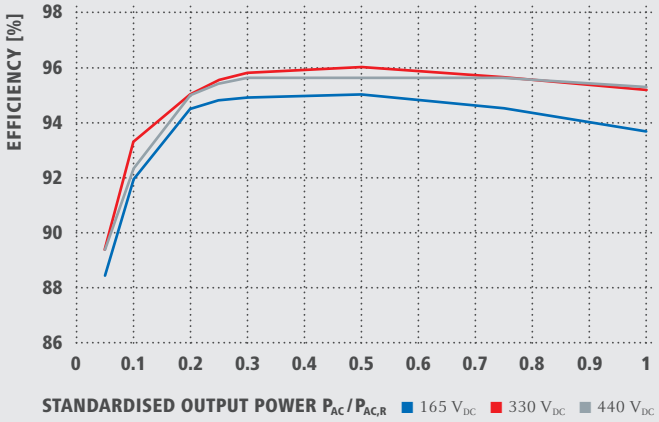
INPUT DATA	GALVO 1.5-1	GALVO 2.0-1	GALVO 2.5-1	GALVO 3.0-1[1)]	GALVO 3.1-1
Max. input current ($I_{dc\ max}$)	13.3 A	17.8 A	16.6 A	19.8 A	20.7 A
Max. array short circuit current	20.0 A	26.8 A	24.8 A	29.6 A	31.0 A
Min. input voltage ($U_{dc\ min}$)	120 V		165 V		
Feed-in start voltage ($U_{dc\ start}$)	140 V		185 V		
Nominal input voltage ($U_{dc,r}$)	260 V		330 V		
Max. input voltage ($U_{dc\ max}$)	420 V		550 V		
MPP voltage range ($U_{mpp\ min}$ – $U_{mpp\ max}$)	120 - 335 V		165 - 440 V		
Number of MPP trackers	1				
Number of DC connections	3				

OUTPUT DATA	GALVO 1.5-1	GALVO 2.0-1	GALVO 2.5-1	GALVO 3.0-1[1)]	GALVO 3.1-1
AC nominal output ($P_{ac,r}$)	1,500 W	2,000 W	2,500 W	3,000 W	3,100 W
Max. output power	1,500 VA	2,000 VA	2,500 VA	3,000 VA	3,100 VA
AC output current ($I_{ac\ nom}$)	6.5 A	8.7 A	10.9 A	13.0 A	13.5 A
Grid connection (voltage range)	1-NPE 230 V (+17 % / -20 %)				
Frequency (frequency range)	50 Hz / 60 Hz (45 - 65 Hz)				
Total harmonic distortion	< 4 %				
Power factor (cos $\varphi_{ac,r}$)	0.85 - 1 ind. / cap.				

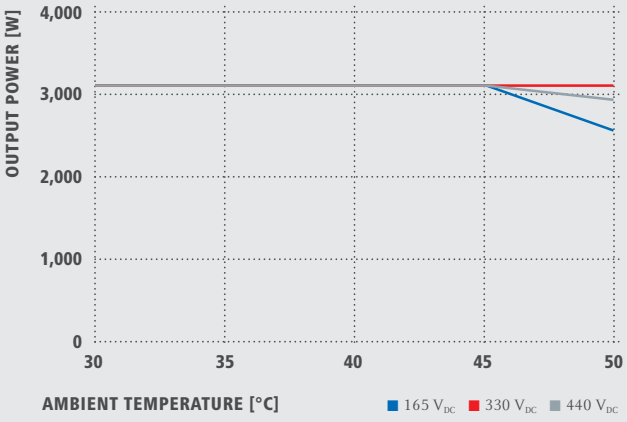
GENERAL DATA	GALVO 1.5-1	GALVO 2.0-1	GALVO 2.5-1	GALVO 3.0-1[1)]	GALVO 3.1-1
Dimensions (height x width x depth)	645 x 431 x 204 mm				
Weight	16.4 kg		16.8 kg		
Degree of protection	IP 65				
Protection class	1				
Overvoltage category (DC / AC) [2)]	2 / 3				
Night-time consumption	< 1 W				
Inverter concept	HF transformer				
Cooling	Regulated air cooling				
Installation	Indoor and outdoor installation				
Ambient temperature range	-25 - +50 °C				
Permitted humidity	0 to 100 %				
Max. altitude	2,000 m / 3,500 m (unrestricted / restricted voltage range)				
DC connection technology	Screw terminal connection 2.5 mm² - 16 mm²				
AC connection technology	Screw terminal connection 2.5 mm² - 16 mm²				
Certificates and compliance with standards	ÖVE / ÖNORM E 8001-4-712, AS 4777-2, AS 4777-3, AS3100, DIN V VDE 0126-1-1/A1, VDE AR N 4105, IEC 62109-1-2, IEC 62116, IEC 61727, CER 06-190, CEI 0-21, EN 50438, G83, G59, NRS 097				

[1)] Available for countries where 3 kW restrictions apply. [2)] Testing to IEC 62109-1.
Further information regarding the availability of the inverters in your country can be found at **www.fronius.com.**

FRONIUS GALVO 3.1-1 EFFICIENCY CURVE



FRONIUS GALVO 3.1-1 TEMPERATURE DERATING



TECHNICAL DATA FRONIUS GALVO

EFFICIENCY	GALVO 1.5-1	GALVO 2.0-1	GALVO 2.5-1	GALVO 3.0-1[1]	GALVO 3.1-1
Max. efficiency	95.9 %	96.0 %	96.1 %		
European efficiency (ηEU)	94.5 %	94.9 %	95.2 %	95.4 %	95.4 %
η at 5 % $P_{ac,r}$ [2]	84.5 / 86.0 / 86.0 %	84.2 / 86.1 / 85.9 %	88.6 / 89.6 / 89.4 %	88.2 / 89.2 / 89.1 %	88.4 / 89.4 / 89.4 %
η at 10 % $P_{ac,r}$ [2]	87.5 / 89.7 / 89.6 %	89.6 / 91.4 / 91.3 %	91.2 / 92.3 / 91.4 %	91.8 / 93.1 / 92.1 %	91.9 / 93.3 / 92.3 %
η at 20 % $P_{ac,r}$ [2]	91.3 / 93.3 / 93.1 %	92.6 / 94.3 / 93.9 %	94.0 / 94.8 / 94.5 %	94.4 / 95.0 / 94.9 %	94.5 / 95.0 / 95.0 %
η at 25 % $P_{ac,r}$ [2]	92.4 / 94.1 / 93.9 %	93.3 / 94.9 / 94.5 %	94.5 / 95.1 / 95.0 %	94.8 / 95.5 / 95.3 %	94.8 / 95.5 / 95.4 %
η at 30 % $P_{ac,r}$ [2]	93.0 / 94.6 / 94.3 %	93.6 / 95.2 / 94.9 %	94.8 / 95.5 / 95.3 %	94.8 / 95.7 / 95.6 %	94.9 / 95.8 / 95.6 %
η at 50 % $P_{ac,r}$ [2]	93.9 / 95.5 / 95.2 %	94.3 / 95.8 / 95.2 %	95.0 / 95.7 / 95.2 %	95.0 / 96.0 / 95.5 %	95.0 / 96.1 / 95.6 %
η at 75 % $P_{ac,r}$ [2]	94.2 / 95.6 / 95.4 %	94.0 / 95.9 / 95.6 %	94.8 / 95.9 / 95.6 %	94.6 / 95.8 / 95.6 %	94.5 / 95.6 / 95.6 %
η at 100 % $P_{ac,r}$ [2]	94.0 / 95.9 / 95.6 %	93.5 / 95.6 / 95.5 %	94.4 / 95.7 / 95.5 %	93.9 / 95.4 / 95.3 %	93.7 / 95.2 / 95.3 %
MPP adaptation efficiency	> 99.9 %				

PROTECTION DEVICES	GALVO 1.5-1	GALVO 2.0-1	GALVO 2.5-1	GALVO 3.0-1[1]	GALVO 3.1-1
DC insulation measurement	Warning/shutdown (depending on country setup) at R_{ISO} < 600 kOhm				
Overload behavior	Operating point shift, power limitation				
DC disconnector	Included				

INTERFACES	GALVO 1.5-1	GALVO 2.0-1	GALVO 2.5-1	GALVO 3.0-1[1]	GALVO 3.1-1
WLAN / Ethernet LAN	Fronius Solar.web, Modbus TCP SunSpec, Fronius Solar API (JSON)				
6 inputs and 4 digital inputs/outputs	Interface to ripple control receiver				
USB (A socket) [3]	Datalogging, inverter update via USB flash drive				
2x RS422 (RJ45 socket) [3]	Fronius Solar Net				
Signalling output [3]	Energy management (floating relay output)				
Datalogger and Webserver	Included				
External input [3]	S0-Meter Interface / Input for overvoltage protection				
RS485	Modbus RTU SunSpec or meter connection				

[1] Available for countries where 3 kW restrictions apply. [2] And at $U_{mpp\ min}$ / $U_{dc,r}$ / $U_{mpp\ max}$. [3] Also available in the light version.
Further information regarding the availability of the inverters in your country can be found at **www.fronius.com.**

/ Perfect Welding / Solar Energy / Perfect Charging

WE HAVE THREE DIVISIONS AND ONE PASSION: SHIFTING THE LIMITS OF POSSIBILITY.

/ Whether welding technology, photovoltaics or battery charging technology – our goal is clearly defined: to be the innovation leader. With around 3,000 employees worldwide, we shift the limits of what's possible - our record of over 1,000 granted patents is testimony to this. While others progress step by step, we innovate in leaps and bounds. Just as we've always done. The responsible use of our resources forms the basis of our corporate policy.

Further information about all Fronius products and our global sales partners and representatives can be found at **www.fronius.com**

v04 Nov 2014 EN

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M,06,0091,EN v09 May 2015 as17