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0.01 Technical Data (at genset)

			100%	75%	50%
Power input	[2]	kW	886	682	479
Gas volume	*)	Nm ³ /h	161	124	87
Mechanical output	[1]	kW	374	280	187
Electrical output	[4]	kW el.	361	270	179
Heat to be dissipated (calculated with Glycol 3%)					
~ Intercooler (Low temperature circuit)	[9]	kW	70	37	14
~ Lube oil (Engine jacket water cooling circuit)		kW	50	43	31
~ Jacket water		kW	118	94	70
~ Surface heat	ca. [7]	kW	65	~	~
Spec. fuel consumption of engine electric	[2]	kWh/kWel.h	2,46	2,53	2,68
Spec. fuel consumption of engine	[2]	kWh/kWh	2,37	2,44	2,56
Lube oil consumption	ca. [3]	kg/h	0,11	~	~
Electrical efficiency			40,7%	39,6%	37,4%
Fuel gas LHV		kWh/Nm ³	5,5		

*) approximate value for pipework dimensioning
 □ Explanations: see 0.10 - Technical parameters

All heat data is based on standard conditions according to attachment 0.10. Deviations from the standard conditions can result in a change of values within the heat balance and must be taken into consideration in the layout of the cooling circuit/equipment (intercooler; emergency cooling; ...).

Main dimensions and weights (at genset)

Length	mm	~ 4.900
Width	mm	~ 1.700
Height	mm	~ 2.000
Weight empty	kg	~ 5.900
Weight filled	kg	~ 6.100

Connections

Jacket water inlet and outlet	DN/PN	50/16
Exhaust gas outlet [C]	DN/PN	150/10
Fuel Gas (at genset) [D]	DN/PN	80/16
Water drain ISO 228	G	½"
Condensate drain	mm	~
Safety valve - jacket water ISO 228 [G]	DN/PN	1½"/2,5
Lube oil replenishing (pipe) [I]	mm	28
Lube oil drain (pipe) [J]	mm	28
Jacket water - filling (flex pipe) [L]	mm	13
Intercooler water-Inlet/Outlet 1st stage	DN/PN	50/10
Intercooler water-Inlet/Outlet 2nd stage [M/N]	DN/PN	~

Output / fuel consumption

ISO standard fuel stop power ICFN	kW	374
Mean effe. press. at stand. power and nom. speed	bar	18,00
Fuel gas type		Biogas
Based on methane number Min. methane number	MZ	135 117 d)
Compression ratio	Epsilon	13
Min./Max. fuel gas pressure at inlet to gas train	mbar	80 - 200 c)
Max. rate of gas pressure fluctuation	mbar/sec	10
Maximum Intercooler 2nd stage inlet water temperature	°C	70
Spec. fuel consumption of engine	kWh/kWh	2,37
Specific lube oil consumption	g/kWh	0,30
Max. Oil temperature	°C	~ 93
Jacket-water temperature max.	°C	~ 95
Filling capacity lube oil (refill)	lit	~ 126

c) Lower gas pressures upon inquiry

d) based on methane number calculation software AVL 3.2

0.02 Technical data of engine

Manufacturer		JENBACHER
Engine type		J 208 GS-F525
Working principle		4-Stroke
Configuration		In - Line
No. of cylinders		8
Bore	mm	135
Stroke	mm	145
Piston displacement	lit	16,60
Nominal speed	rpm	1.500
Mean piston speed	m/s	7,25
Length	mm	1.890
Width	mm	1.020
Height	mm	1.630
Weight dry	kg	1.800
Weight filled	kg	2.000
Moment of inertia	kgm ²	3,51
Direction of rotation (from flywheel view)		left
Radio interference level to VDE 0875		N
Starter motor output	kW	6
Starter motor voltage	V	24

Thermal energy balance

Power input	kW	886
Intercooler	kW	70
Lube oil	kW	50
Jacket water	kW	118
exhaust when cooling down 180 °C	kW	140
exhaust when cooling down 100 °C	kW	186
Surface heat	kW	48

Exhaust gas data

Exhaust gas temperature at full load	[8]	°C	414
Exhaust gas temperature at bmep= 13,5 [bar]	[8]	°C	~ 451
Exhaust gas temperature at bmep= 9 [bar]	[8]	°C	~ 490
Exhaust gas mass flow rate, wet		kg/h	1.923
Exhaust gas mass flow rate, dry		kg/h	1.785
Exhaust gas volume, wet		Nm ³ /h	1.503
Exhaust gas volume, dry		Nm ³ /h	1.331
Max.admissible exhaust back pressure after engine		mbar	60

Combustion air data

Combustion air mass flow rate		kg/h	1.771
Combustion air volume		Nm ³ /h	1.370
Max. admissible pressure drop at air-intake filter		mbar	10

**basis for exhaust gas data: natural gas: 100% CH₄; biogas 65% CH₄, 35% CO₂
biogas with 50% CH₄ -> exhaust gas temperature increase by approx. 25 to 40°C**

Sound pressure level

Aggregate a)		dB(A) re 20 μ Pa	92
31,5	Hz	dB	80
63	Hz	dB	84
125	Hz	dB	89
250	Hz	dB	90
500	Hz	dB	88
1000	Hz	dB	87
2000	Hz	dB	83
4000	Hz	dB	81
8000	Hz	dB	86
Exhaust gas b)		dB(A) re 20 μ Pa	107
31,5	Hz	dB	99
63	Hz	dB	103
125	Hz	dB	111
250	Hz	dB	104
500	Hz	dB	105
1000	Hz	dB	103
2000	Hz	dB	99
4000	Hz	dB	88
8000	Hz	dB	67

Sound power level

Aggregate	dB(A) re 1pW	111
Measurement surface	m ²	83
Exhaust gas	dB(A) re 1pW	115
Measurement surface	m ²	6,28

a) average sound pressure level on measurement surface in a distance of 1m (converted to free field) according to DIN 45635 and ISO 3744, precision class 3.

b) average sound pressure level on measurement surface in a distance of 1m according to DIN 45635 and ISO 3744, precision class 2.

The spectra are valid for aggregates up to bmep=16,5 bar. (for higher bmep add safety margin of 1dB to all values per increase of 1 bar pressure).

Engine tolerance \pm 3 dB

0.03 Technical data of generator

Manufacturer		CGT e)
Type		S5L1S E42 e)
Type rating	kVA	476
Driving power	kW	374
Ratings at p.f. = 1,0	kW	361
Ratings at p.f. = 0,8	kW	357
Rated output at p.f. = 0,8	kVA	446
Rated reactive power at p.f. = 0,8	kVar	268
Rated current at p.f. = 0,8	A	621
Frequency	Hz	50
Voltage	V	415
Speed	rpm	1.500
Permissible overspeed	rpm	1.800
Power factor (lagging - leading) (UN)		0,8 - 0,9
Efficiency at p.f. = 1,0		96,5%
Efficiency at p.f. = 0,8		95,5%
Moment of inertia	kgm ²	8,70
Mass	kg	1.535
Radio interference level to EN 55011 Class A (EN 61000-6-4)		N
Cable outlet		left
Ik" Initial symmetrical short-circuit current	kA	8,25
Is Peak current	kA	21,01
Insulation class		H
Temperature (rise at driving power)		F
Maximum ambient temperature	°C	40

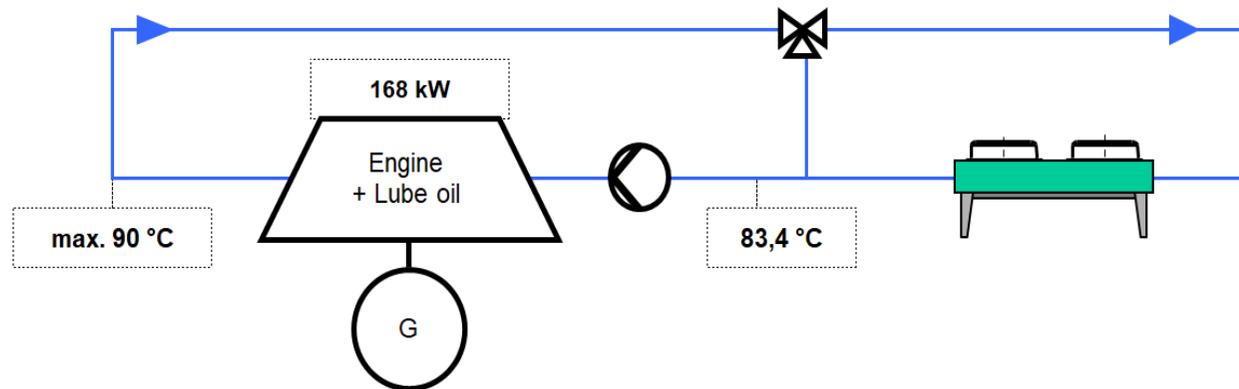
Reactance and time constants at rated output (saturated)

xd direct axis synchronous reactance	p.u.	1,956
xd' direct axis transient reactance	p.u.	0,104
xd'' direct axis sub transient reactance	p.u.	0,074
x2 negative sequence reactance	p.u.	0,112
Td'' sub transient reactance time constant	ms	12
Ta Time constant direct-current	ms	19
Tdo' open circuit field time constant	s	2,50

e) JENBACHER reserves the right to change the generator supplier and the generator type. The contractual data of the generator may thereby change slightly. The contractual produced electrical power will not change.

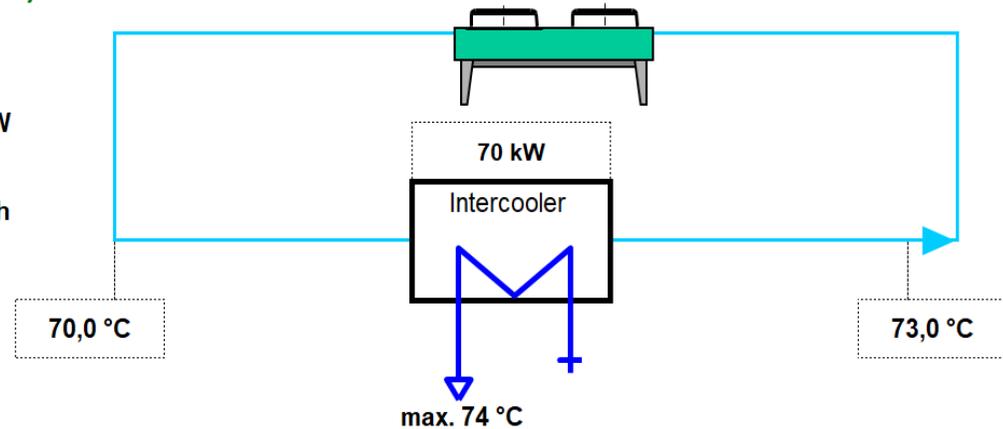
Engine jacket water cooling circuit (calculated with Glycol 3%)

Heat to be dissipated = 168 kW
 (+12/-8 % tolerance)
 Engine jacket water flow rate = 22,0 m³/h



Low temperature circuit (calculated with Glycol 3%)

Heat to be dissipated = 70 kW
 (+12/-8 % tolerance)
 Cooling water flow rate = 20,0 m³/h



0.05 Cooling water circuit

Oil - heat (Engine jacket water cooling circuit)

Nominal output	kW	50
Max. Oil temperature	°C	93
Loss of nominal pressure of cooling water	bar	0,20
Safety valve - max press. set point	bar	2,50

Engine jacket water - heat (Engine jacket water cooling circuit)

Nominal output	kW	118
Max. engine jacket water temperature (outlet engine)	°C	90
Engine jacket water flow rate	m³/h	22,0
Safety valve - max press. set point	bar	2,50

Intercooler - heat (Low temperature circuit)

Nominal output	kW	70
Max. inlet cooling water temp. (intercooler)	°C	70
Aftercooler water flow rate	m³/h	20,0
Nominal pressure of cooling water / (max. operating pressure)	PN	10
Intercooler water pressure drop	bar	0,20
Safety valve - max press. set point	bar	2,50

The final pressure drop will be given after final order clarification and must be taken from the P&ID order documentation.

0.10 Technical parameters

All data in the technical specification are based on engine full load (unless stated otherwise) at specified temperatures and the methane number and subject to technical development and modifications.

All pressure indications are to be measured and read with pressure gauges (psi.g.).

[1] At nominal speed and standard reference conditions ICFN according to ISO 3046-1, respectively

[2] According to ISO 3046-1, respectively, with a tolerance of **+5 %**.

Efficiency performance is based on a new unit (immediately upon commissioning). Effects of degradation during normal operation can be mitigated through regular service and maintenance work.

reference value --> 65%CH4 / 35%CO2

[3] Average value between oil change intervals according to maintenance schedule, without oil change amount

[4] At p. f. = 1.0 according to IEC 60034-1:2017 with relative tolerances, all direct driven pumps are included

[5] Total output with a tolerance of +12/-8 %

[6] According to above parameters [1] through [5]

[7] As a guiding value at p.f. 0.8 and only valid for (engine, generator, TCM). Other peripheral equipment is not considered.

[8] Exhaust temperature with a tolerance of ± 8 %

Note: an optimised operating mode to minimise methane slip can result in changed exhaust gas data (exhaust gas temperature, NOx emissions, etc.) and must be taken into account in the design of the exhaust gas aftertreatment

[9] Mixture temperature at:

If the engine is designed for intake air temperatures of $> 30^{\circ}\text{C}$, then the stated mixture heat of the 1st stage is to be increased from 25°C in 2°C increments. The additional temperature must be added to the resulting full load point.

Radio interference level

The ignition system of the gas engines complies the radio interference levels of CISPR 12 and EN 55011 class B, (30-75 MHz, 75-400 MHz, 400-1000 MHz) and (30-230 MHz, 230-1000 MHz), respectively.

Definition of output

- ISO-ICFN continuous rated power:

Net break power that the engine manufacturer declares an engine is capable of delivering continuously, at stated speed, between the normal maintenance intervals and overhauls as required by the manufacturer. Power determined under the operating conditions of the manufacturer's test bench and adjusted to the standard reference conditions.

-

Standard reference conditions:

Barometric pressure: 1000 mbar (14.5 psi) or 100 m (328 ft) above sea level
Air temperature: 25°C (77°F) or 298 K
Relative humidity: 30 %

- Volume values at standard conditions (fuel gas, combustion air, exhaust gas)
Pressure: 1013 mbar (14.7 psi)
Temperature: 0°C (32°F) or 273 K

Loss of engine performance

a) Performance reduction due to gas quality

If the reference methane number is not reached and the knock control responds, the ignition timing at full performance is adjusted in conjunction with the engine management system; only then is performance reduced.

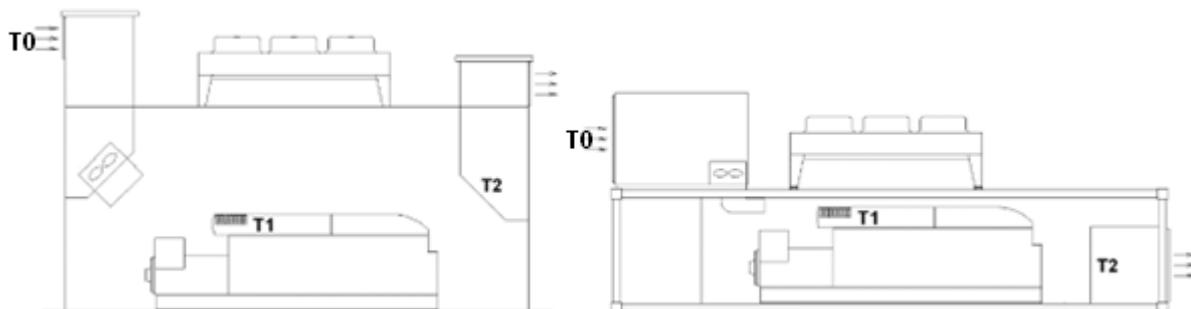
b) Performance reduction due to voltage and frequency limits

If the voltage and frequency limits for generators specified in IEC 60034-1 Zone A are exceeded, performance is reduced.

c) Performance reduction due to environmental conditions

Standard rating of the engines is for an installation at an altitude $\leq 500\text{m}$ and combustion air temperature $\leq 30^\circ\text{C}$ (T1)

Engine room outlet temperature: 50°C (T2) -> engine stop



The minimum recommended air change ratio (C) must be observed to maintain according to TA 2300-0030.

Parameters for the operation of JENBACHER gas engines

The genset fulfils the limits for mechanical vibrations according to ISO 8528-9.

The following forms an integral part of a contract and must be strictly observed: **TA 1000-0004, TA 1100 0110, TA 1100-0111, TA 1100-0112, and TA 2300-0030.**

Transport by rail should be avoided. See **TA 1000-0046** for further details

Failure to adhere to the requirements of the above-mentioned TA documents can lead to engine damage and may result in loss of warranty coverage.

The engine is tested on the test stand with a specific natural gas. The natural gas as used by the Seller on the test stand may differ from the gas as ultimately used by the Customer. For this reason, performance and efficiency levels, exhaust-gas temperatures, gas consumption, etc. may deviate from the parameters specified in the contract.

Ready for H2 means a possible adaptation up to 100vol% H2 operation. Performance data, timeline and costs can be determined on a project-specific basis.

Parameters for the operation of control unit and the electrical equipment

Relative humidity 50% by maximum temperature of 40°C .

Altitude up to 2000m above the sea level.

Parameters for using a gas compressor

The gas quantity indicated under the technical data refers to standard conditions with the given calorific value. The actual volume flow (under operating conditions) has to be considered for dimensioning the gas compressor and each gas feeding component – it will be affected by:

- Actual gas temperature (limiting temperature according to **TA 1000-0300**)
- Gas humidity (limiting value according to **TA 1000-0300**)
- Gas Pressure
- Calorific value variations (can be equated with methane (CH₄) variations in the case of biogas)
- The gas compressor is designed for a max. relative under pressure of 15 mbar(g) (0.22 psi) and a inlet temperature of 40°C (104°F) , if within scope of supply JENBACHER.

0.20 Mode of Operation

Grid Parallel Mode

The genset is running in parallel to the utility. The unit load can be adjusted via its power control set point or designated option.

Procedure in the event of mains failure:

When the mains monitor relay (protective relay ANSI No. 27, 59, 81, 78- provided either by JENBACHER or the customer) is activated due to a mains failure, the engine is isolated from the mains by opening the generator breaker. The module is shut down without any cool-down run.

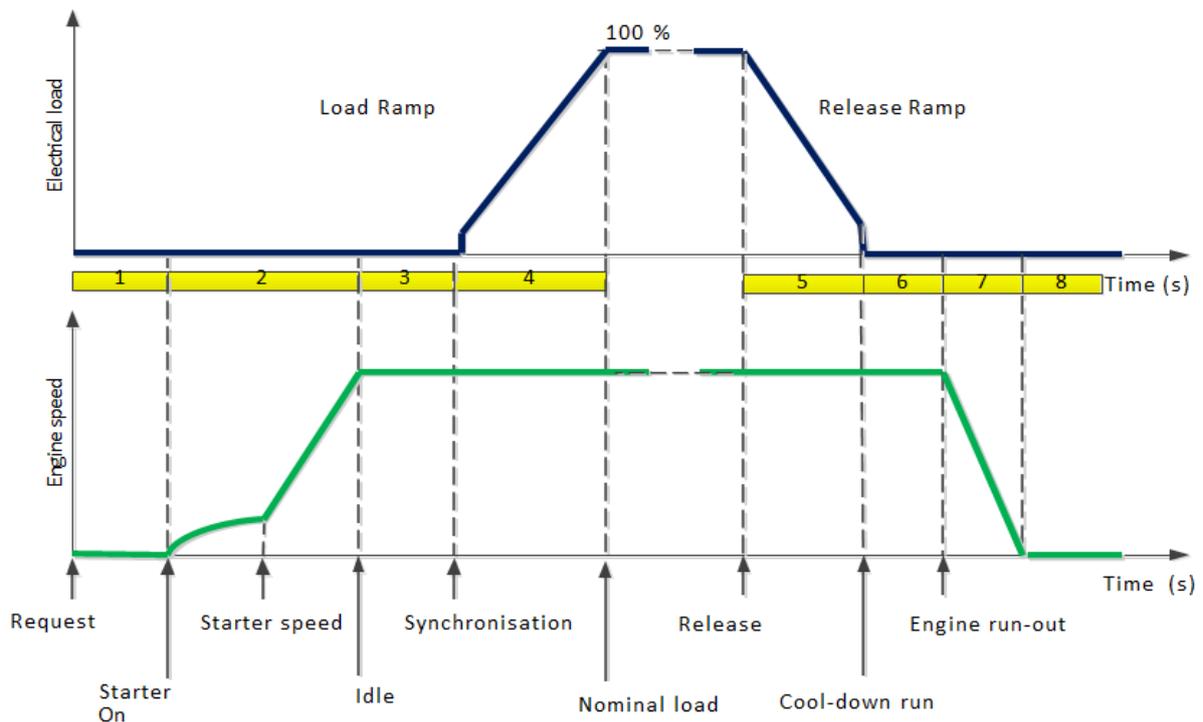
Island operation is not available in this case!

The module can be restarted following the restoration of mains power after a 5-minute mains stabilization period.

0.20.01 Guide values for genset - start/stop times and el. load ramps

Basic boundary conditions for engine start:

Engine conditions	Oil temperature (°C / °F)	Cooling-water temperature (°C / °F)
Fast start release	> 27 / 80.6	> 55 / 131
Start enable automatic start		> 37 / 98.6
synchronization release		> 55 / 131



The following time data of the individual start sections up to the nominal load are **guideline values** for a fully automatic start under preheated conditions for mains parallel operation. Only the total start time is observed under the various engine conditions. The individual time periods specified in the table therefore do not necessarily add up to the specification of the total start time in mains parallel operation.

Deviations are possible for special designs.

	J208	Type 3	Type 4	Type 612 – 620	J624
(1) Start preparation [1] *)	0	0	20	70	90
(2) Engage starter until reaching nominal speed [s] *)	20	20	25	40	40
(3) Synchronisation [s] *) **)	1-50	1 – 50	1 – 50	1 – 50	1 – 50
(4) Load application up to nominal load [s] *) **)	180	180	180	160	160
Total start-up time from request to nominal load [s]	<300	<300	<300	<300	<330

*) The times for start-up preparation and synchronisation can vary greatly and depend on project specifications.

****) Fast start function and faster load ramps are available on request.**

The following **times for unloading the engine** are guide values for engine/generator combination inertia constant $H < 1$ kW/kVA (with LS, CGT, TDPS generators) and the hot operating condition.

	J208	Type 3	Type 4	Type 612 – 620	J624
(5) Load reduction ramp [s]	160	160	160	160	120
(6) Cool-down run [s]	60	60	60	10	10
(7) Run-down [s]	60	60	60	60	60
Total time from nominal load to run-down time [s]	280	280	280	220	180
(8A) gas tightness control [s]	<100	<100	<100	<100	<100
(8B) Flushing time exhaust tract after shutdown [s]***)				100	100
(8C) Flushing time exhaust tract after shutdown with SD and WT [s]***)				180	300
(8D) Flushing time exhaust tract after shutdown with SD, WT, SCR and greenhouse [s]***)				225	400
(8E) Blocking time for restart [s]	30	30	30	30	30

***) The exhaust gas purging times apply when the exhaust gas purging fan is installed

The table shows the waiting time between stopping the engine and starting it again, with the gas tightness check (8A), exhaust gas scavenging (8B-D) and blocking time (8E) being carried out in parallel. The flushing times can be extended project-specifically depending on the exhaust system. It should also be noted that the exhaust gas purge must be performed after each unsuccessful start attempt once the gas valve has been opened. (SD = silencer, WT = heat exchanger)

0.30 General information for connection to the public mains

Technical Instruction TA 1530-0188 describes the - possibly optional - functions and parameters for complying with the boundary conditions defined in the country-specific "Grid Codes".

Network operator-dependent requirements must always be coordinated with JENBACHER.

0.30.10 Generator operating range in mains parallel operation

Frequency:

Normal operation $f_n \pm 2\%$ - without power output reduction

Extended operation: $f_n \pm 4\text{--}6\%$ - with power output reduction between 2 – 10%/Hz

Frequency-measurement resolution: $\leq 10\text{mHz}$ (resolution)

Generator - voltage range: $\pm 10\%$ of generator U_n

Generator power factor $\cos \phi$ at the generator terminals: as specified in "0.03 Generator technical data"

FRT (Fault Ride Through) – capability: at mains connection point
Profile 1: 150ms/30%Un (applies to natural gas and biogas)
Profile 2 (150ms/5%Un) and Profile 3 (250ms/5%Un) upon request.

Requirement:

- mains short-circuit power must be at least 5 x SrE or 50MVA
- FRT capability of the onsite auxiliaries

Extended project requirements and country-specific design are optionally possible after consultation and approval with JENBACHER.

0.30.20 Possible mains operator requests

To protect the generating unit in mains parallel operation, appropriate mains protection monitoring functions are necessary to disconnect the generator from the mains in case of a mains fault.

The mains operator-dependent specifications such as e.g.: voltage and frequency range, active power limitation, load ramps, reactive power limitation and control, protection concept, necessary certification or declarations, process data and interfaces are to be specified in project enquiries and must be agreed with JENBACHER before conclusion of the contract.

- Selectivity assessment, protection tests and recurring tests: on-site by the system operator
- Control power provision via pool operator: on request e.g., primary, secondary, tertiary
- Black start capability and countering in own use: on request
- Power generation system (EZA) controller or central control: on-site or possible on request
- Process data scope / remote control:
 - System data must be provided by the connectee for the mains operator.
 - Remote control interface to the mains operator: on-site
 - Interface specification!

Billing measurements - installation, operation, maintenance and remote data transmission: on-site.

Models of genset and generator: simplified models executed as effective value models for mains parallel operation optionally available.

Model formats: Powerfactory, or PSS/E (as of PP23)

Validated genset models in Powerfactory according to FGW TR3, TR4 and TR8 by a body accredited for this purpose according to DIN EN ISO/IEC 17065

Functional scope of the models in mains parallel operation:

- static voltage stability
- dynamic mains support
- Provision of reactive power
- Behaviour at active power setpoint
- Active power adjustment in the event of overfrequency and underfrequency (LFSSM-O, LFSSM-U)
- Protective devices and settings

0.30.20.01 Active power adjustment in the event of overfrequency and underfrequency

The following functions are available:

- LFSM-U: Limited Frequency Sensitive Mode - Underfrequency
- LFSM-O: Limited Frequency Sensitive Mode - Overfrequency
- FSM

Reduced power output at overfrequency: (LFSM-O function)

The frequency threshold is freely adjustable from $f_n + (200 - 500\text{mHz})$ and the static from 2% to 12%.

Unless the relevant mains operator specifies otherwise for the LFSM-O mode, a threshold of $f_n + 200\text{mHz}$ and a static of 5% is set.

Power increase in the event of underfrequency (LFSM-U function) – (OPTIONAL as of XT4.5)

activated according to the mains operator's specifications

The frequency-sensitive active power feed-in has the effect that the generating plant also moves permanently up and down on the frequency characteristic curve ("driving on the characteristic curve") in the frequency range between $f_n - 200\text{mHz}$ (unless otherwise specified by the mains) and $f_n - 2.5\text{Hz}$ with regard to its maximum possible active power feed-in.

The prerequisite for this is a corresponding power setpoint.

Reduced power output at underfrequency:

below 98% of f_n , reduction by standard 10% of maximum capacity per Hz. Reduction up to maximum $f_n - 6\%$.

Lower reduction ramps of 2 - 10%/Hz on request

The FSM function is available as an option

The power generation system is capable of continuing to operate at this minimum power when the minimum power for controllable operation is reached.