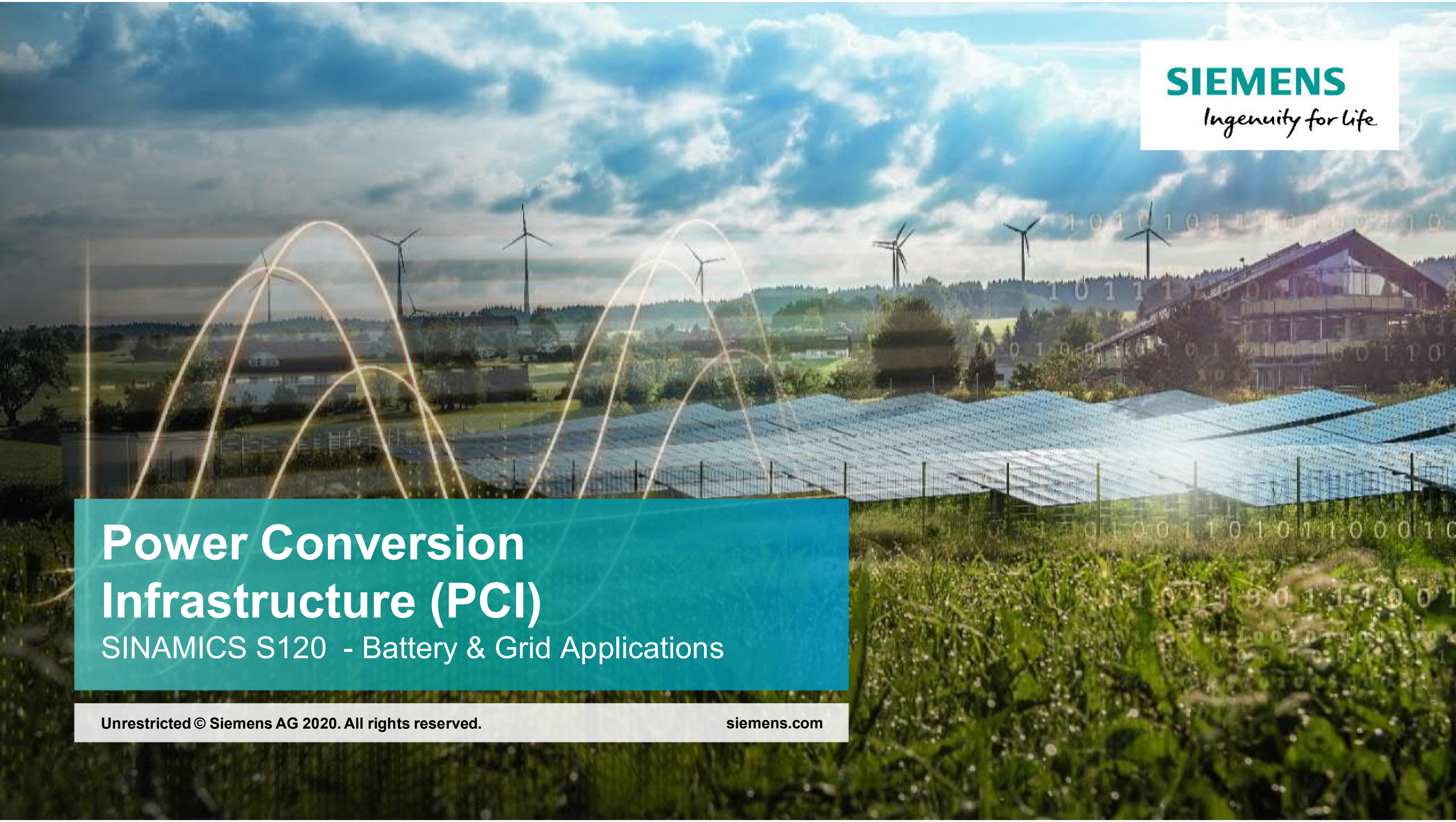

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Power Conversion Infrastructure (PCI)

SINAMICS S120 - Battery & Grid Applications

Agenda

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Market Drivers

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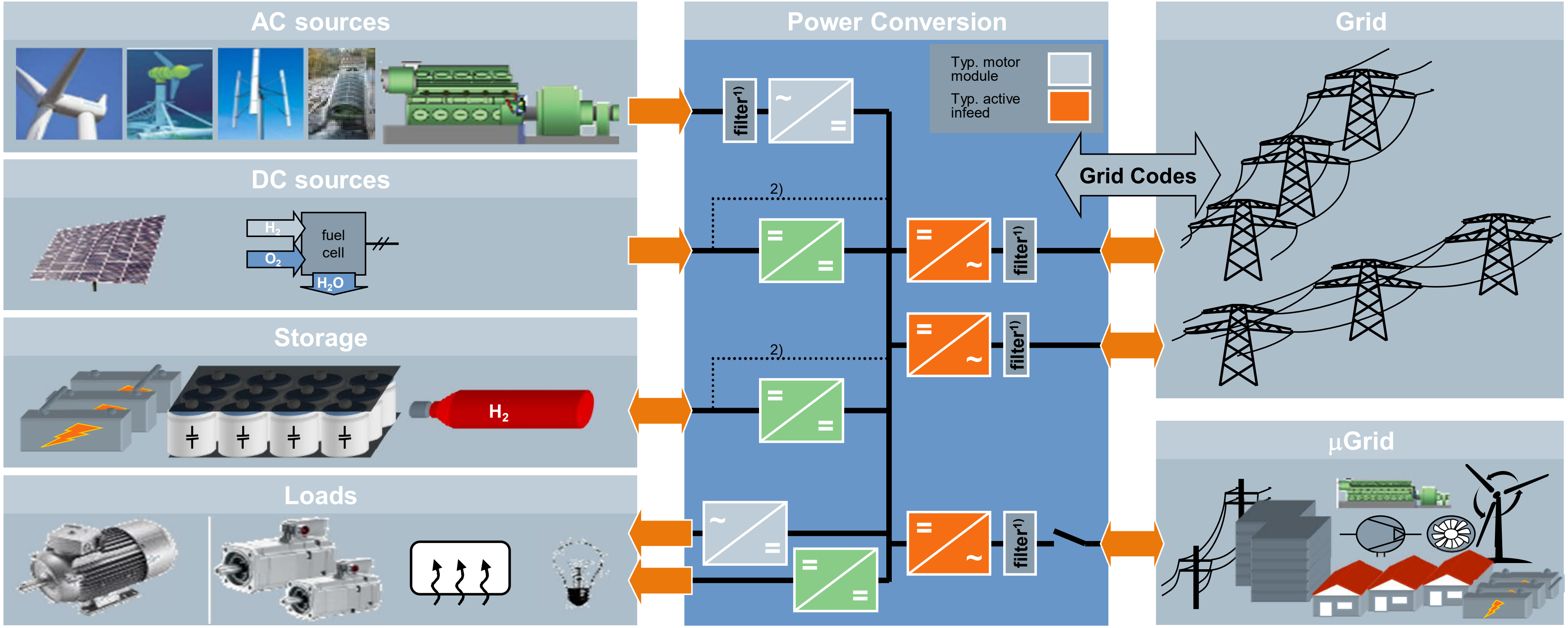
Drivers		Highlights
1	Cost & Performance improvements	Battery ↓ **80%** 2010-2017 PV ↓ **75%** 2005-2015
2	Grid Modernization	Centralized Traditional → Distributed Smart
3	Global movement towards Renewables	By2040 renewables overtake coal as the largest source of global power (>25%)
4	Participation in wholesale electricity market	Nearly every nation is revamping its wholesale market structure to allow batteries to provide service
5	Phase out of FIT or net Metering	Low or declining feed-in-tariffs (FITs) or net metering payments → businesses seek ways of greater returns
6	Desire for self-sufficient	Residential and C&I customers desires for energy self-sufficiency are fueling BTM markets
7	National Policy	Relative with Smart Grid, Environmental sustainability, efficient mobility, public transport etc.

Reference: Challenge and Opportunities in global battery storage markets, Deloitte

Energy conversion in voltage and frequency will be the backbone of future supply and distribution concepts



[1)] Filter depending on inverter type
[2)] DC devices can in some cases also be directly connected to DC bus bar, depending on the overall concept

What is PCI ?

Power Conversion Infrastructure

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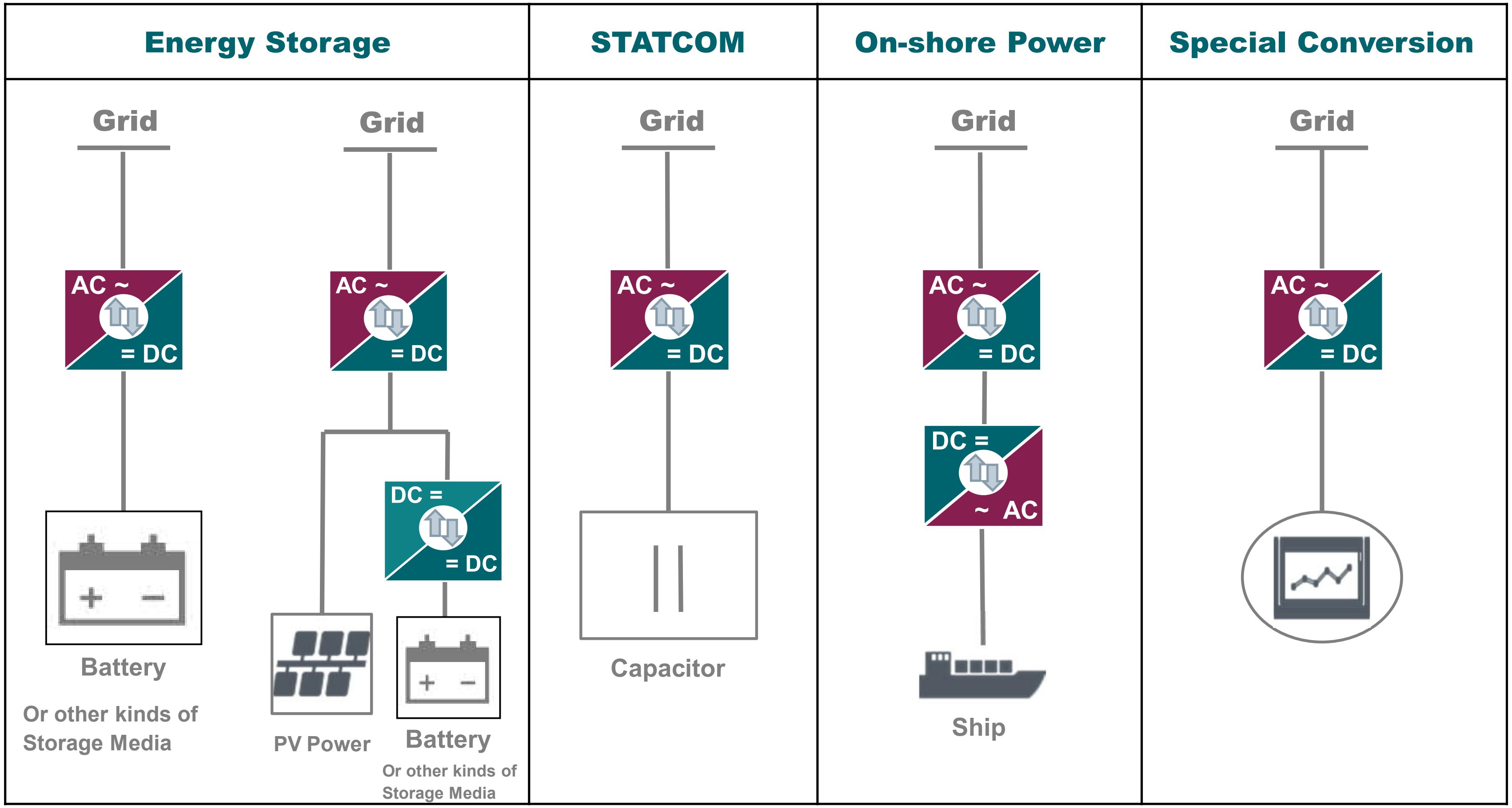
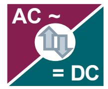
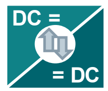




Sinamics S120

AC/DC power converter is now using Sinamics S120 chassis with certain optimization on firmware (no Grid Codes)



Sinamics S120 MoMo or Sinamics DCP

DC/DC power converter can now be addressed with Sinamics DCP and S120 Motor Modules

Where to use PCI?

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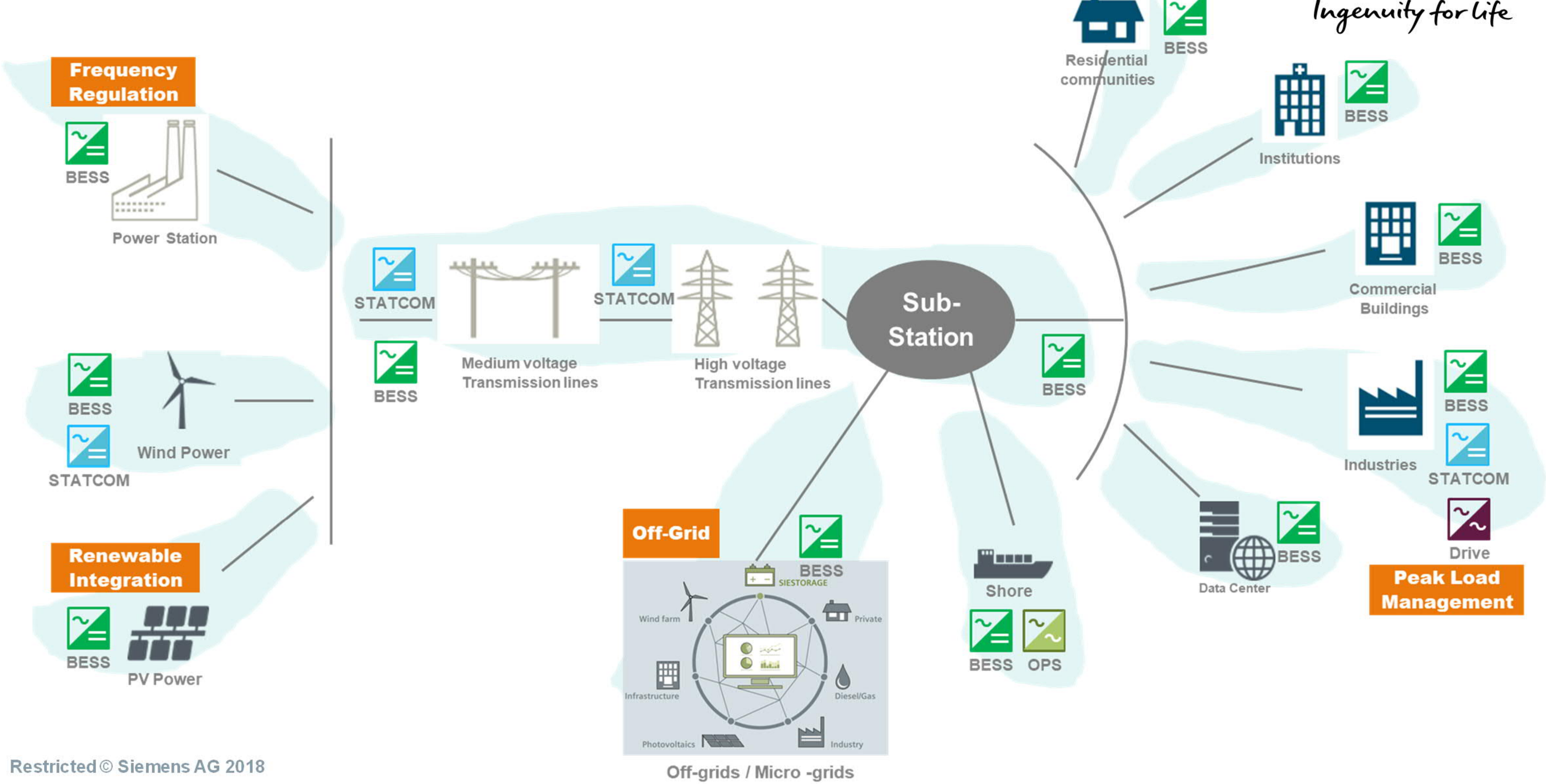

PCI Core Product Portfolio

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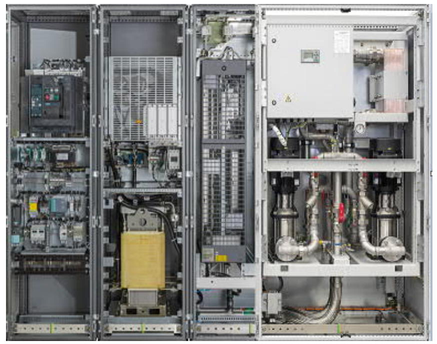
	PCI – Power Conversion Infrastructure				
Int. Product	**SINAMICS S120**				
					
Power Range	30 kW	100 / 200 kW	300 / 600 / 900 kW - 3MW (Parallel)	950 / 1200 kW- 4.5 MW (Parallel)	1200 /1400 kW- 5.3 MW (Parallel)
Sinamics S120	30 kW	110 / 250 kW	300 / 630 / 900 kW	1100 / 1400 kW	1400 / 1700 kW
AC Voltage	3 AC 320 -10 % ... 3 AC 480 +10 %			3 AC 500 -10 % ... 3 AC 690 +10 %	3 AC 500 -10 % ... 3 AC 690 +10 %
DC Voltage	520~780V (Max. 800V) 520~780V (Max. 800V) 520~780V (Max. 800V)			750~1100V (Max. 1380V)	750~1100V (Max. 1380V)
Topology	AC/DC	AC/DC	AC/DC	AC/DC	AC/DC
IP Class	IP20	IP 20	IP20 - IP54		
Cooling	Air-cooling	Air-cooling	Air-cooling	Air-cooling	Liquid-cooling

SINAMICS DCP

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	30 kW DCP	120 kW DCP
Input/output voltage	30 V – 800 V DC	30 V – 800 V DC
Max. input voltage	1,000 V DC (I_{max} = 5 A for 30 s, every 5 min)	920 V DC (with derating)
Current / voltage / power	I_{max} = 50 A @ U_e = U_a = 600 V, P = 30 kW	I_{max} = 200 A @ U_e = U_a = 600 V, P = 120 kW
Power supply	24 V DC (18 V – 30 V), I = 5 A	24 V DC (18 V – 30 V), I = 20 A
Current ripple	< 3 %	
Scalability	4x parallel at both sides (input/output)	
Efficiency 30 kW / 120 kW	> 98 %	
Temperature range	0 °C – 40 °C, up to 55 °C with derating	
Installation altitude	Up to 2,000 m without derating, up to 5,000 m with current / voltage derating	
Communication	PROFIBUS, PROFINET, DriveCLiQ with OALINK connection to CU320-2	
Closed-loop control type	Closed-loop current-controlled: Setpoint can be entered for the input or output.	
Control module	Own Control Unit	
Electrical isolation	No	
Weight	Approx. 38 kg	Approx. 118 kg
Dimensions	600 mm x 155 mm x 545 mm (incl. mounting)	900 mm x 205 mm x 500 mm
Degree of protection	IP20	IP00
Certifications/approvals	CE, cURus, EAC	
Standards	IEC 62109-1, IEC 61800-5-1, IEC 61800-3, UL 61800-5-1	

Australian Grid Compliance

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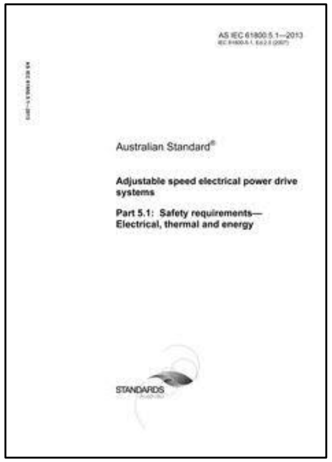
- SINAMICS S120 inverters and SINAMICS DCP are compliant for connection onto the low voltage network as per Australian/New Zealand Standards

- SINAMICS S120 book size components (120kW) have been certified compliant to AS4777.2:2015 and AS 61800.5.1:2013

- SINAMICS DCP is a Clean Energy Council compliant inverter suitable for installation under the Small-scale Renewable Energy Scheme (SRES)



SAA APPROVALS®

Certificate of Suitability

Certificate No.: SAA180620

Certificate Holder: Siemens Ltd.
885 Mountain Hwy
Bayswater VIC 3153
Australia

Class Description: Non-Declared
Product Description: Generic Grid-interactive Inverter (Built-in)
Brand Name: SINAMICS S120 ACTIVE LINE MODULE
Model No.: 6SL3130-7TE31-2AA3
Markings: Input: 600Vdc, 200A Max
Output: 380-480V~ 50/60Hz 120kVA
IP54
Standard: AS IEC 61800.5.1:2013
AS/NZS 4777.2:2015
Conditions: All models approved under this Certificate must comply with the Standard requirements of the end product when installed.

Certification Mark: SAA180620 or RCM

Date First Registered: 15 June 2018
Date of Expiry: 15 June 2023

For and on Behalf of
SAA Approvals Pty Ltd

SAA Approvals Pty Ltd as accredited by JAS-ANZ under ISO/IEC 17065 certifies in accordance with the SAA Approvals Electrical Product Safety Certification Scheme that the product nominated in this certificate complies with standard/s listed.

When using the RCM the requirements of all relevant parts of AS/NZS 4417 applicable to the article must be fulfilled.

For SAA Contact Details and to verify this Certificate go to:
www.saaapprovals.com.au

JAS-ANZ
www.jas-anz.org/register

SAA Approvals CERTIFIED

Issued: 15-06-18 180620/1

BUREAU VERITAS 1828

Certificate of compliance

Applicant: Siemens AG
Frauenauracher Str. 80
D-91056 Erlangen
Germany

Product: Grid-tied power inverter

Model: 6SL3130-7TE31-2AA3

Use in accordance with regulations:

Automatic disconnection device with three-phase mains surveillance in accordance with AS/NZS 4777.2:2015 for systems with a three-phase parallel coupling via an inverter in the public mains supply. The automatic disconnection device is an integral part of the aforementioned inverter.

Applied rules and standards:

AS/NZS 4777.2:2015 Grid connection of energy systems via inverters, Part 2: Inverter requirements

At the time of issue of this certificate the safety concept of an aforementioned representative product corresponds to the valid safety specifications for the specified use in accordance with regulations.

Report number: 13TH0487-AS/NZS4777

Certificate number: U18-0126

Date of issue: 2018-03-23 **Valid until:** 2022-03-22

Certification body
Holger Schaffer

DAkkS Deutsche Akkreditierungsstelle D-ZE-12024-01-00

Certification body of Bureau Veritas Consumer Products Services Germany GmbH
Accredited according to DIN EN ISO/IEC 17065

BUREAU VERITAS Consumer Products Services Germany GmbH · Thurn-und-Taxis-Straße 18, 90411 Nürnberg, Germany · Phone: +49 40 74041-0 · cps-nuernberg@de.bureauveritas.com · www.bureauveritas.de/cps

1 **Siemens Ltd**

Power Conversion Equipment

CLEAN ENERGY COUNCIL

MODEL NUMBER	CERTIFICATE NUMBER	SERIES TYPE	APPROVAL DATE	EXPIRY DATE
6RP0000-0AA25-0AA0	SAA170361	SINAMICS DCP	25/05/2017	12/03/2022

SINAMIC S120 - Grid Infeed Applications

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Features of the Grid Infeed Applications available for the SINAMICS S120:

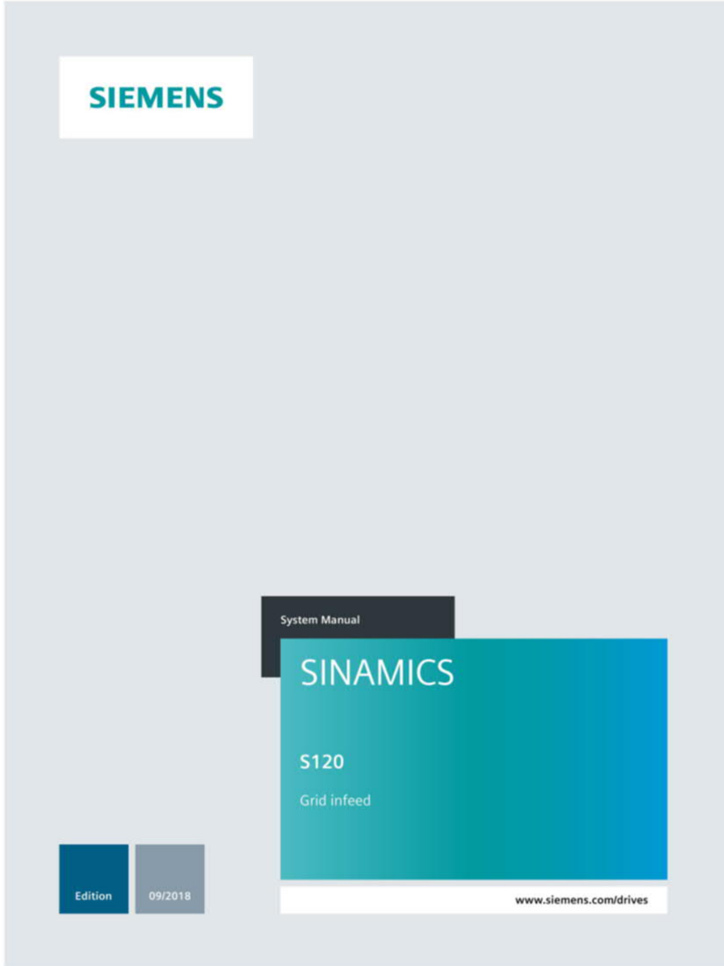
- Grid Infeed applications provide SINAMICS units with the functionality to feed into a power grid or to an island grid from various energy and generation sources.

- Grid Infeed is offered as an add on software module for the CU320-2 through SD memory card.

- Integrated Drive Control Charts (DCC) allowing the SINAMICS units to operate as hybrid inverters, islanded generators, STATCOM function and power factor correction.

- The Grid Infeed manuals provides detailed descriptions of the function modules, commissioning examples and relevant hardware data sheets and is available on Siemens Industry Support.

- Details of the relevant DCC charts and inverter parameters are provided in the SINAMICS S120 List Manual.



Grid Types – Power Grids

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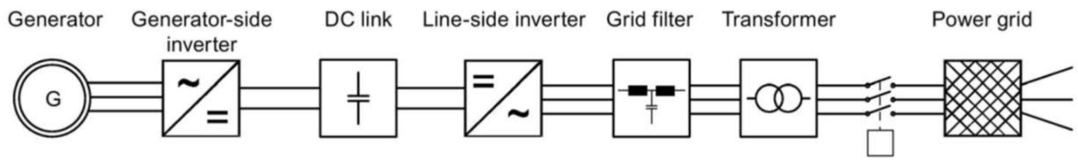
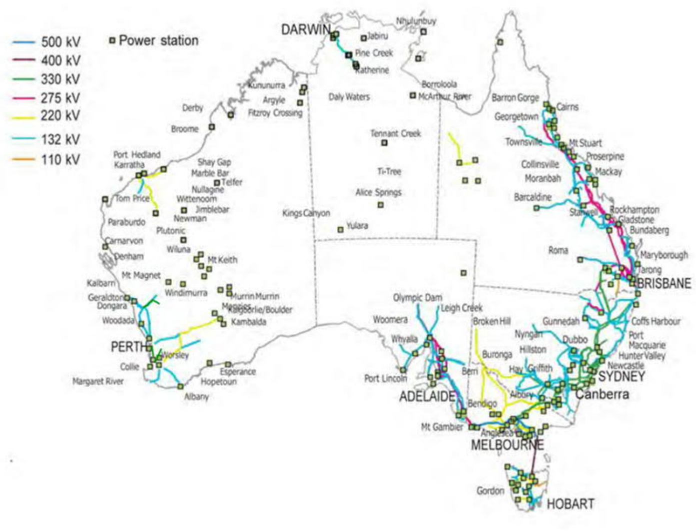
What is a power grid?

A power grid covers a wide area network, comprises large power generating units (regarding the electric power) with each unit required to be synchronised to the grid frequency and voltage

operated by a power supply utility, which is responsible for the grid, and therefore also grid codes.



Schematic diagram of a power generating system connected to a power grid



Requirements of an inverter system in a power grid:

- Compliance with utility grid codes for connection of inverter systems (e.g. AS4777.2)
- Fault ride through capability including for voltage dips and short circuits between two or three phases.
- Provision of a steady-state reactive power for compensation if necessary
- Dynamic grid support - During voltage dips or short-circuits, a reactive current must be impressed into the grid, which counteracts/corrects the voltage deviation.
- Maintaining the limits of the voltage quality

Grid Types – Island Grid

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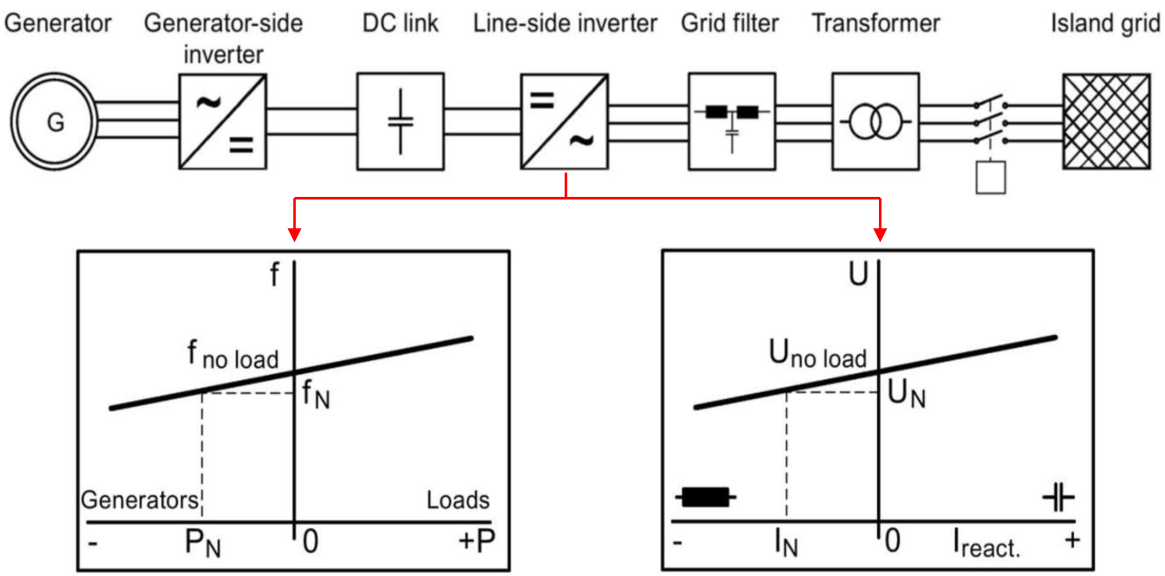
What is an island grid?

An island grid supplies a limited area and has no connection to the public grid or to other grids. Island grid utility must balance the between power generation and load to maintain grid stability.



Schematic representation of an island grid

Requirements of Battery Energy Storage Systems in islanded power systems:

- Black start of the island grid - This function involves establishing an island grid voltage starting from zero with the disconnector open to the external grid
- Controlling the grid voltage and frequency, and quickly adapting the generated power to the varying load conditions
- Provision of the entire short-circuit current in the event of a short-circuit
- Provision of reactive power for grid support
- Re-establishing the voltage and maintaining the frequency after the short-circuit has been cleared

Grid Types – Microgrid

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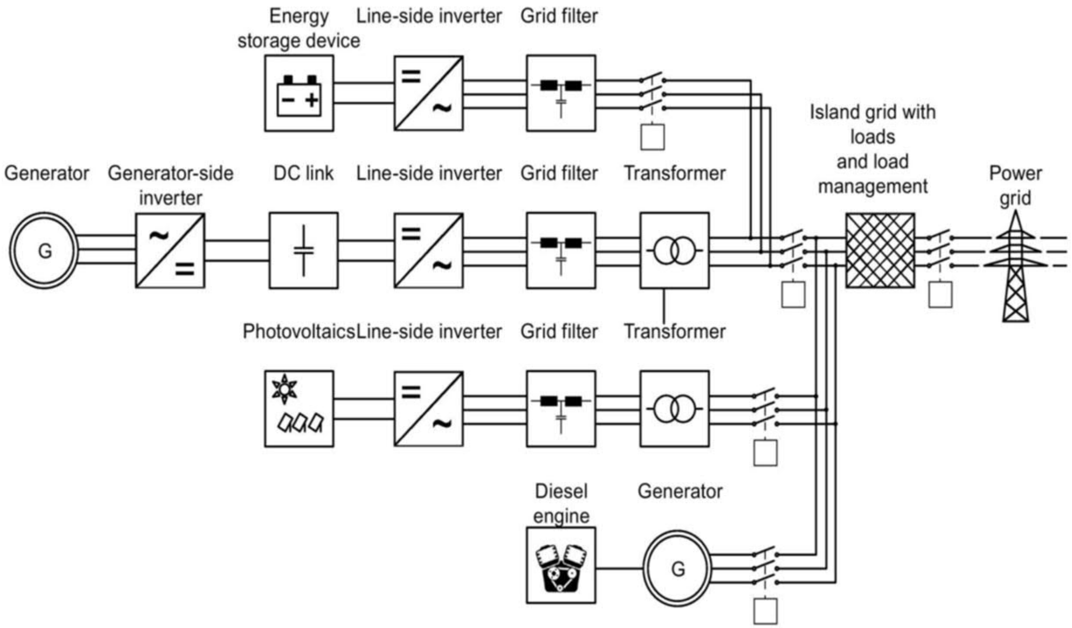
What is a microgrid?

A micro grid represents a locally constrained electrical system with several power generating units, loads and possibly energy storage systems. This can be connected to a large power grid – or can also be independently operated (i.e. an island grid with one or several power generating units).



Schematic representation of an microgrid

Requirements of an inverter system in a microgrid power system are aligned with an islanded grid but also include:

- Transition between grid connected and islanded modes must be able to be reliably handled.
- Load sharing with other individual power generating systems to achieve reliable supply to connected loads

Grid Infeed Function Modules

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Grid Transformer

- Used to magnetize, synchronize and to connect a grid transformer to a power or island grid eliminating any inrush current from the power grid.

Grid Droop Control (S02)

- This function involves establishing an island grid voltage starting from zero with the disconnector open to the external grid
- The inverter for feeding into the grid has the task of controlling the frequency and the voltage in the grid, and assumes an "grid former function".

Dynamic Grid Support (S01)

- Allows grid faults to be ridden through and allows grid-supporting reactive currents to be injected to clear faults.
- Includes anti-islanding functionality.
- STATCOM functionality including power factor correction and voltage management.

Grid Transformer Function Module

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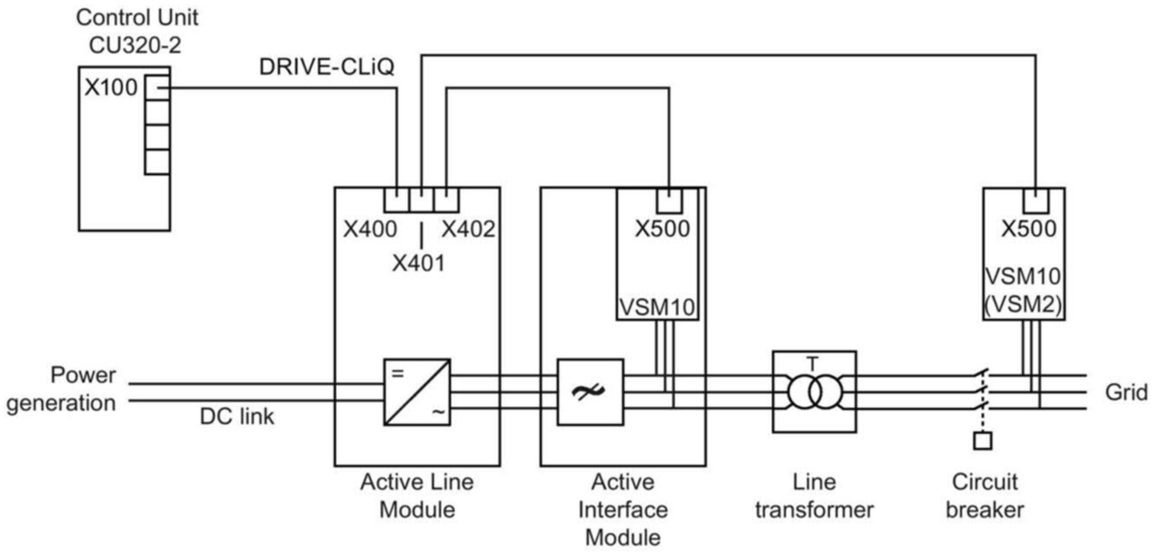


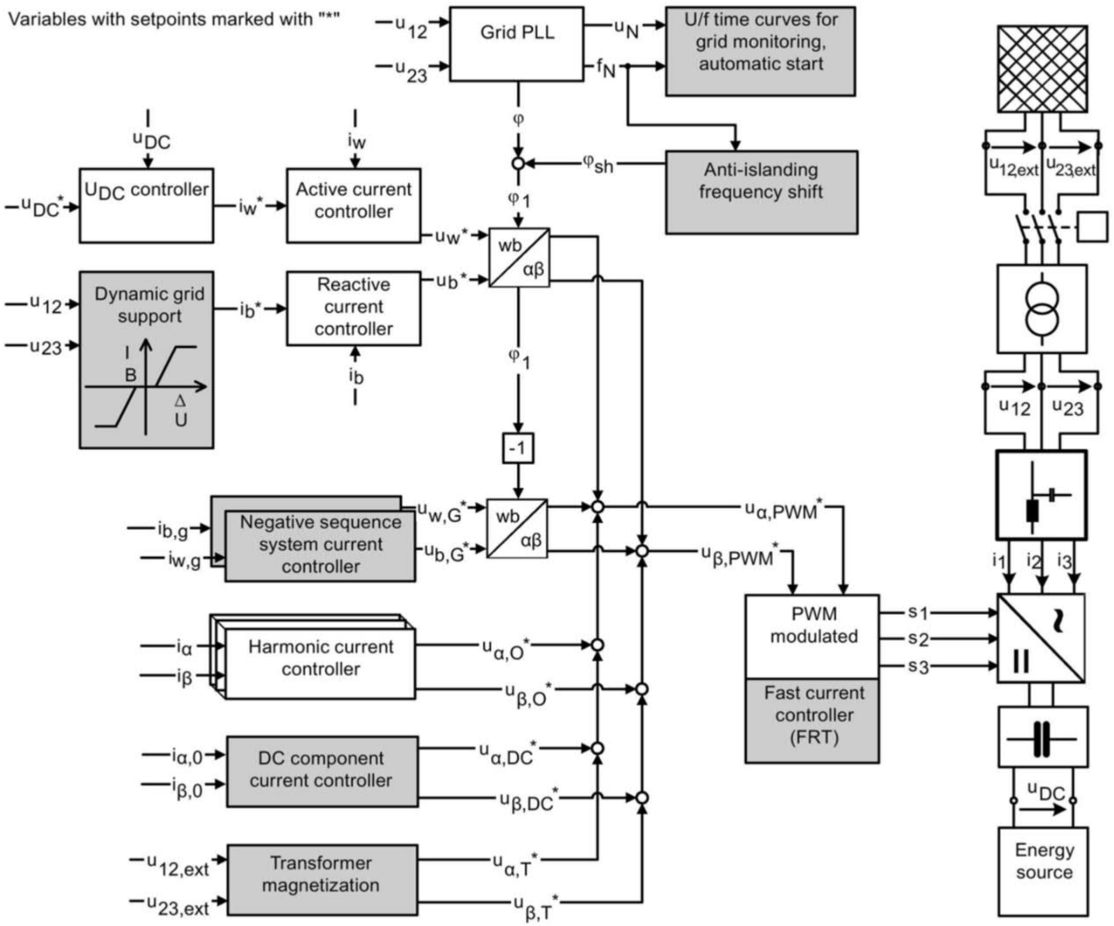
Example configuration of the grid transformer energisation function

The "Grid transformer" function module does not require an additional license

The Grid Transformer function module includes the following subfunctions:

- Grid-friendly transformer magnetization
- Identification of the transformer data
- Transformer model to take into account the transformer for the grid control and dynamic grid support
- Negative sequence system current control to compensate for grid dissymmetry.
- DC component control to avoid DC components in the AC current, therefore avoiding transformer saturation

Dynamic Grid Support Function Module (License S01)



Dynamic Grid Support (S01) is the S120 grid following control which includes:

- Dynamic grid support functionality providing reactive power in response to voltage deviations based on programmed slope setting and measured system voltage.
- Fault ride through controller providing reactive current support during fault conditions.
- Harmonic current controller for harmonic suppression between the 5th and 13th harmonic.
- DC component controller for compensation of the DC component of phase currents.
- Negative sequence controller for correcting unbalanced loads and unsymmetrical faults.
- Closed Loop Power Factory Control
- Closed Loop Voltage Control

Grid Droop Control Function Module (License S02)

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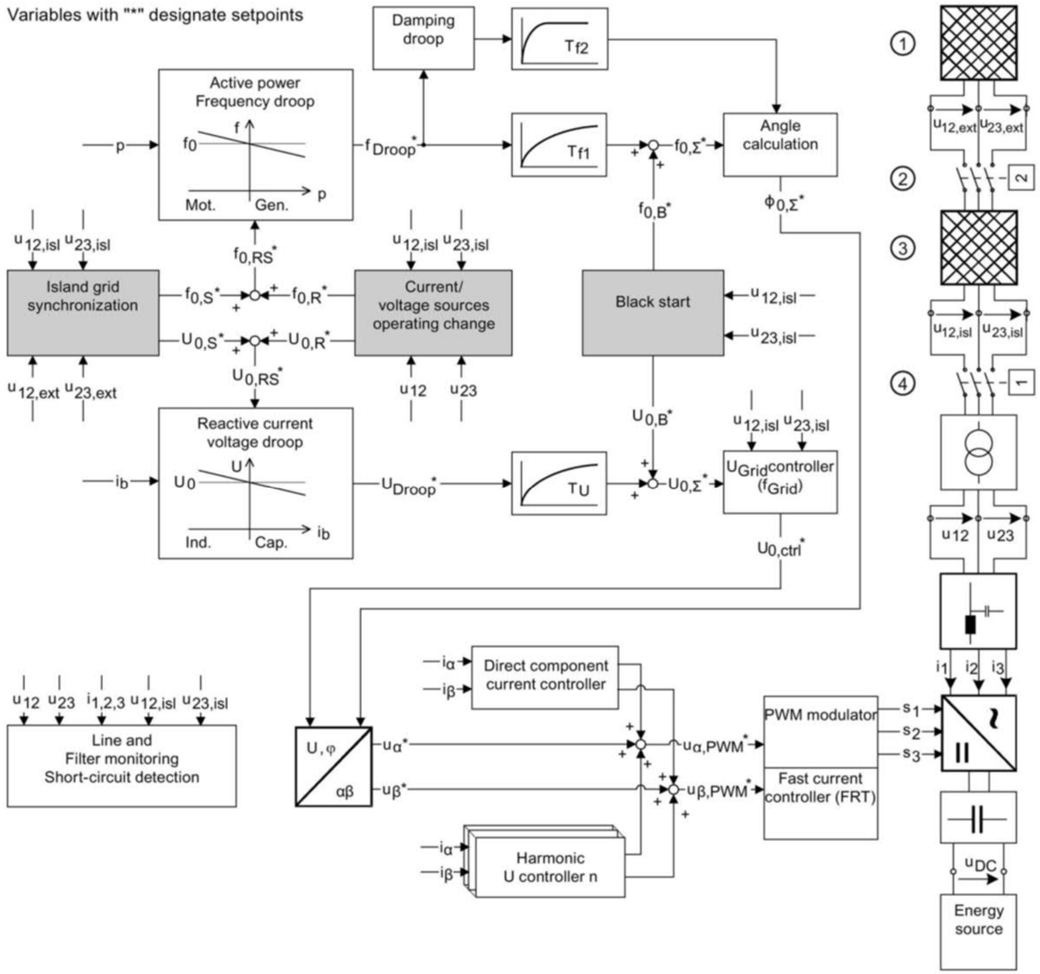

Grid Droop Control (S02) is the S120 grid forming control which includes:

- Active and reactive power droop functions (V & F control).
- Virtual generator ("Artificial Inertia").
- Black Start
- Islanding Re-synchronising
- Fault ride through controller providing fault current support during fault conditions.
- Harmonic current controller for harmonic suppression between the 5th and 13th harmonic.
- DC component controller for compensation of the DC component of phase currents.
- Negative sequence controller for correcting unbalanced loads and unsymmetrical faults.

Application Example – Battery Storage

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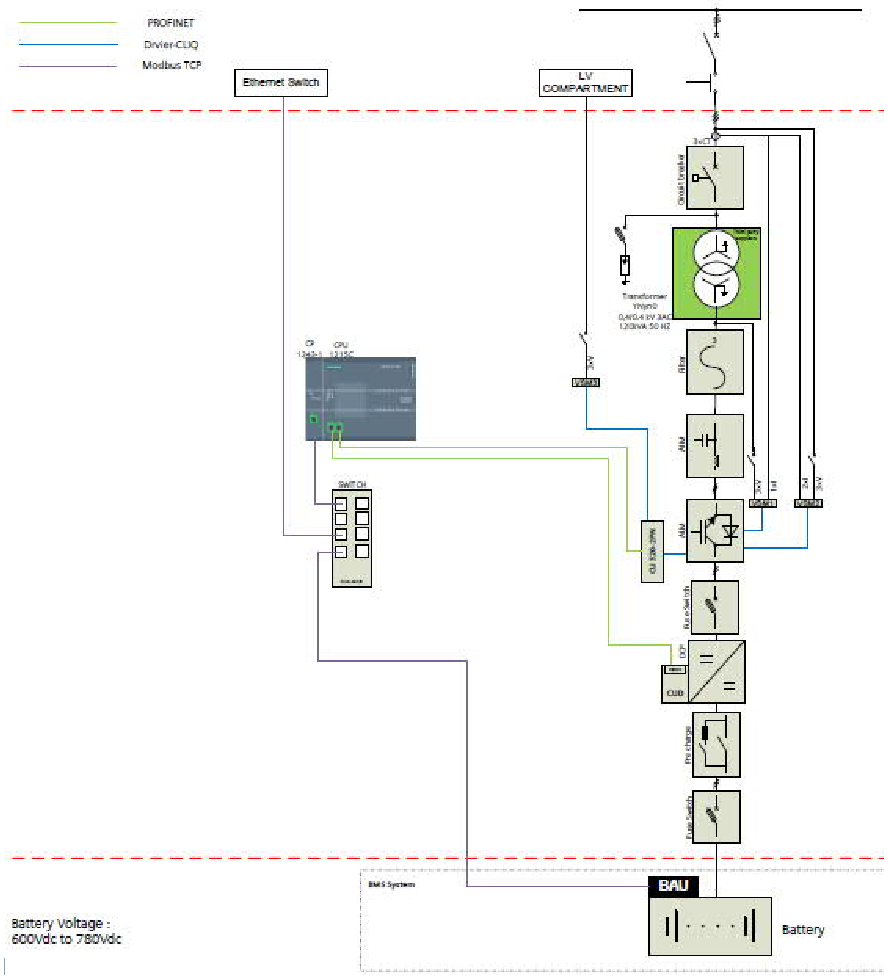

Step 1 – Calculating Inverter LV Output Voltage (V_{AC})

$$V_{AC} = \frac{Battery\ String\ Minimum\ Useable\ Voltage}{1.5}$$

$$V_{AC} = \frac{600Vdc}{1.5} = 400\text{Vac}$$

Step 2 – Calculating Inverter Current Deratings (as per engineering manual)

- Deratings apply for operating the inverter at power factors <1 up to 25% for operating at power factor of 0.
- Deratings also apply for operating the inverter at operating temperatures >40˚C

$$I_{Derated} = I_{rated} \times I_{PF\ Derating} \times I_{Temp\ Derating}$$

Assuming the system operates at a power factory of 0.8 and ambient temperature of 35˚C

$$I_{Derated} = 182\text{A x } 0.90 = 163.8\text{A}$$

Step 3 – Calculating Inverter Apparent Power

$$S = \sqrt{3} \times I_{Derated} \times V_{AC}$$

$$S = \sqrt{3}\text{ x } 163.8\text{A x } 400 = 113\text{kVA}$$

Application Example – STATCOM

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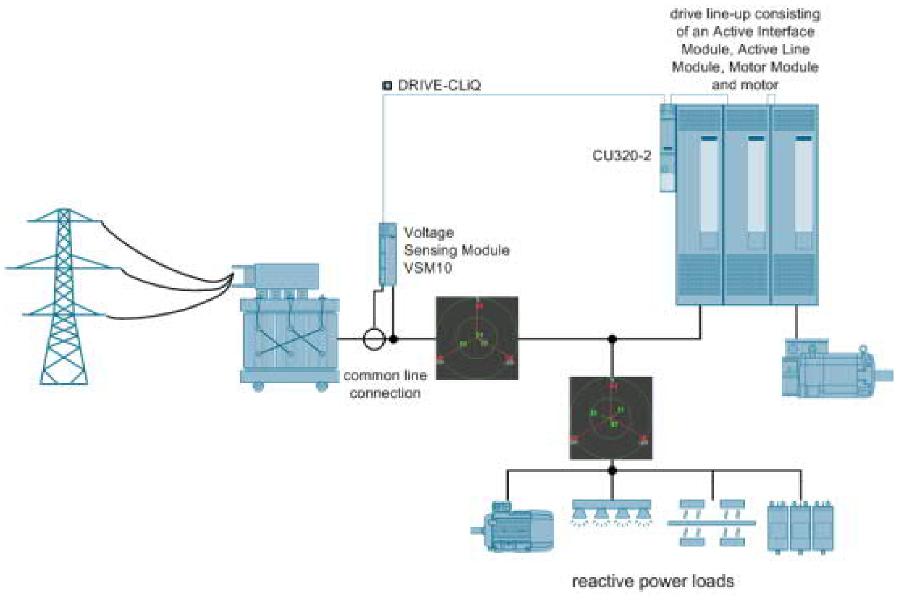


For this application, the operating point with the highest power is at 1300 rpm at a power of 600 kW. The motor has an efficiency of 96.4 %, the SINAMICS S150 has power losses of 30.25 kW (see catalog). The Motor Module only transfers active power to the Active Line Module via the DC link. So first it has to be determined how much power the motor draws. Furthermore the power loss of the SINAMICS S150 is taken from catalog.

$$P_{motor} = \frac{P_{shaft}}{\eta} = \frac{600\ kW}{0.964} = 620\ kW$$

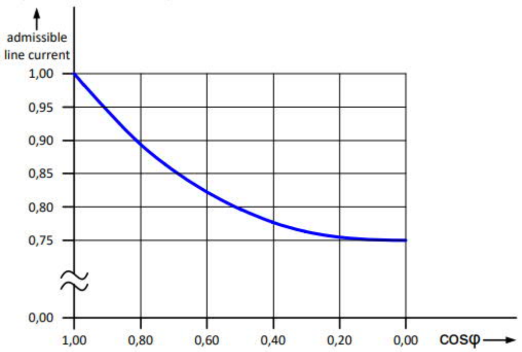
$$P_{line} = P_{motor} + P_{losses\ S150} = 620\ kW + 30.25\ kW = 650.25\ kW$$

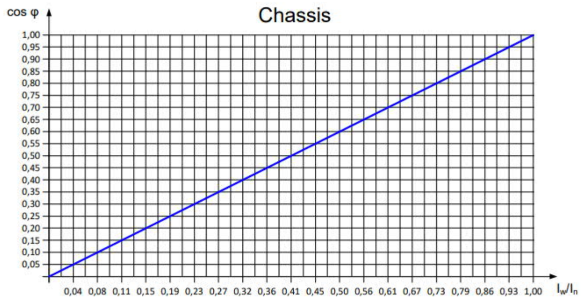
Determining the active current I_W:

$$I_W = \frac{P_{line}}{\sqrt{3} * U_{line}} = \frac{650.25\ kW}{\sqrt{3} * 690\ V} = 544\ A$$

SINAMICS S150 with 710kW has a rated current of I_N = 735A.

$$\frac{I_W}{I_N} = \frac{544\ A}{735\ A} = 0.74$$





From the characteristic, for I_W/I_N = 0.74, a cos φ of 0.82 can be determined. This is the lowest possible value for cos φ, when drawing active power.

Determining the available reactive current I_Q:

$$I_Q = I_W * \tan(arccos\varphi) = 544\ A * \tan(arccos 0.82) = 380\ A$$

Determining the reactive power Q available:

$$Q = \sqrt{3} * U_{line} * I_Q = \sqrt{3} * 690\ V * 380\ A = 454\ kvar$$

Determining the absolute current:

$$I_{total} = \sqrt{(I_W^2 + I_Q^2)} = \sqrt{544\ A^2 + 380\ A^2} = 663.6\ A$$

Application Resources

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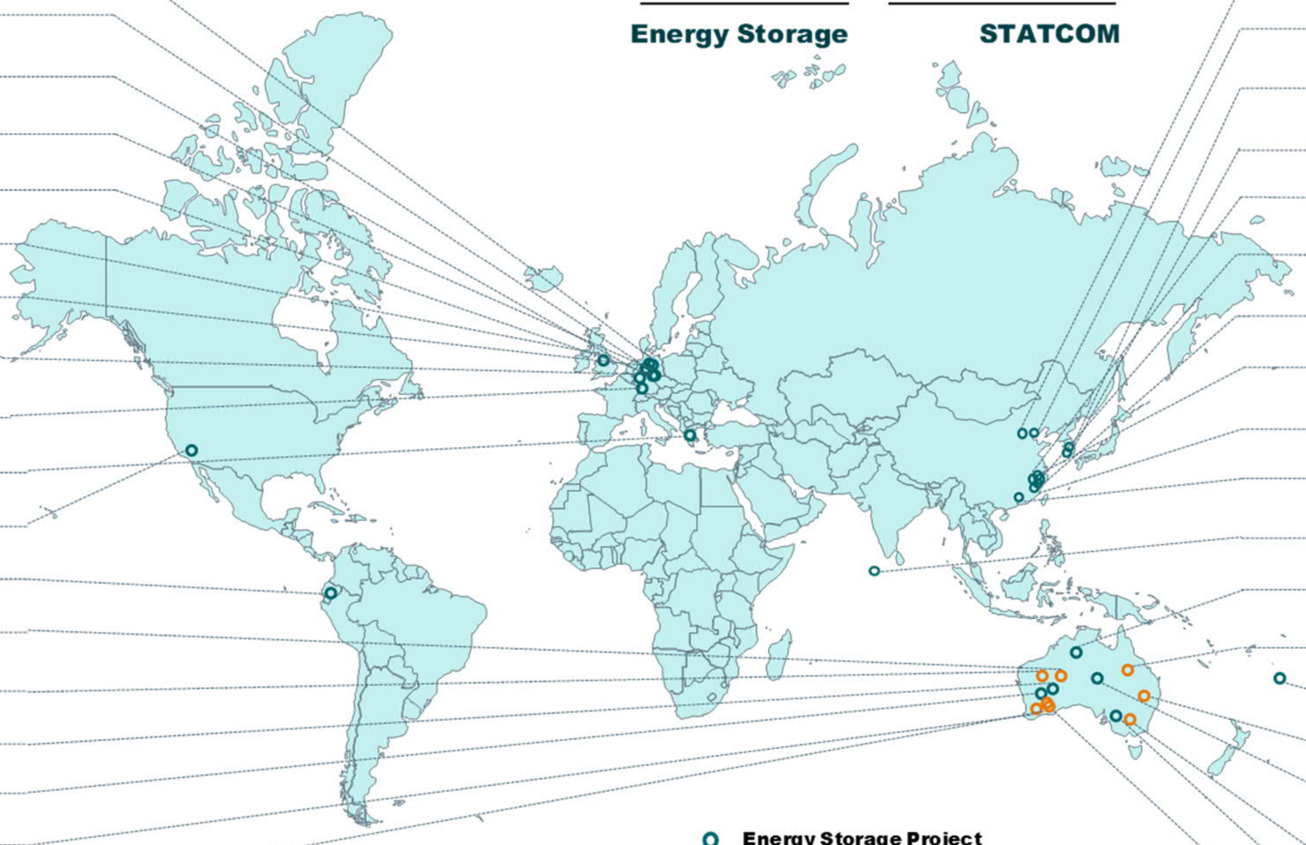


References

Documentation available on Siemens Industry Support:

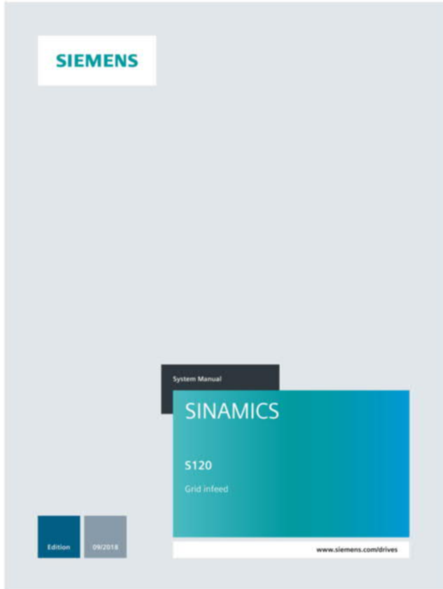
- **SINAMICS S120 System Manual Grid Infeed**
https://support.industry.siemens.com/cs/document/109760371/sinamics-s120-system-manual-grid-infeed?dti=0&lc=en-AU

- **SINAMICS S120 Book Size Power Units**
https://support.industry.siemens.com/cs/document/109754297/sinamics-s120-booksize-power-units?dti=0&lc=en-AU

- **Catalog D 21.3: SINAMICS DRIVES, SINAMICS S120, SINAMICS S150**
https://support.industry.siemens.com/cs/document/109749470/catalog-d-21-3%3A-sinamics-drives-sinamics-s120-sinamics-s150?dti=0&lc=en-AU

- **SINAMICS S120/S150 List Manual**
https://support.industry.siemens.com/cs/document/109763271/sinamics-s120-s150?dti=0&lc=en-AU

- **Engineering Manual SINAMICS G130, G150, S120 Chassis, S120 Cabinet Modules,S150**
https://support.industry.siemens.com/cs/document/83180185/engineering-manual-sinamics-g130-g150-s120-chassis-s120-cabinet-modules-s150?dti=0&lc=en-AU



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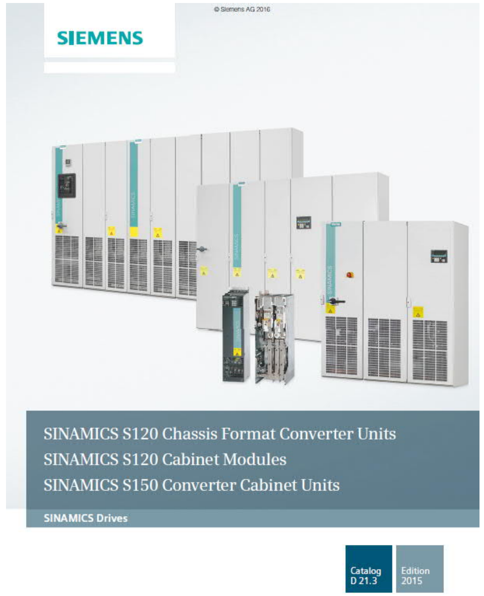

Thanks

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Questions?

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