



Northern Periphery and
Arctic Programme

2014-2020



EUROPEAN UNION

Investing in your future
European Regional Development Fund

H-CHP Electric Power grid options

9.9.2019

OAMK

Electric Power General

- › OAMK team
 - › Students: No students assigned
 - › Faculty: Esa Silomaa
- › Victron Grid inverter, LG Battery pack and Sinro Generator has been purchased and initial testing has been conducted
- › Electric cabinet designed and assembled by Anssi Saari and Lauri Timlin. The cabinet electrical design was review by Lecturer Ismo Pitkänen, our building electrical design specialist.
 - › Main switch is in backorder.

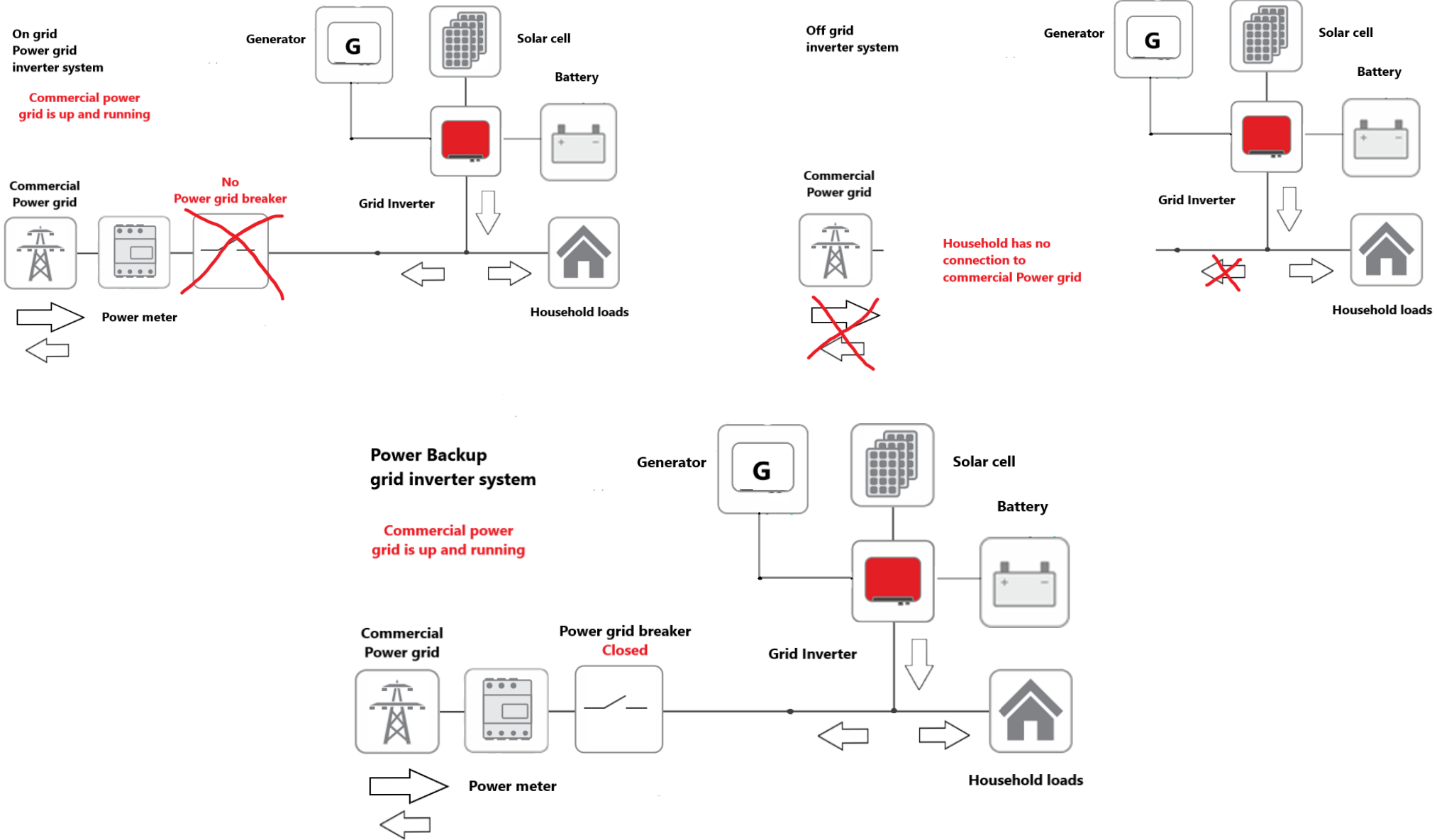
Table of contents

- › 4-5. Three Basic Power Grid options
- › 6. On grid operation mode details
- › 7. Off grid operation mode details
- › 8. Backup grid operation mode details
- › 9-10. Finnish Legislation requirements for HCHP build and installation
- › 12. Finnish Operator Oulun Energia requirements for equipment, installation and power grid agreement
- › 13. HCHP project basic 3-phase grid inverter configuration schematics
- › 14-15 UK Legislation and SSE Scotland network operator requirements for HCHP equipment and installation
- › 16-18 Detailed status of purchased Inverter, Battery back and Generator

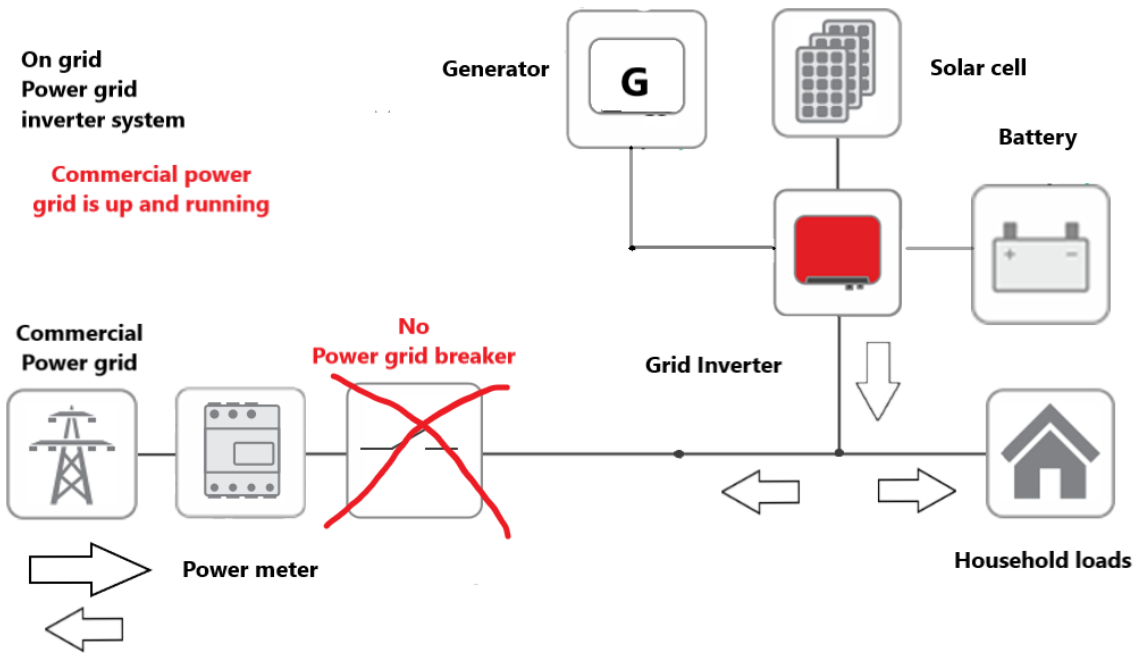
Three Basic Power Grid options

- › On Grid inverter power system is most common of these three Power Grid options
 - › Inverter power grid system is connected parallel with Commercial power grid. Equipment are cost effective and assembly procedure is fairly simple to carry out.
 - › Solar, Windmill, Generator and battery back can supply power to household power grid only when Commercial power network is connected and is up and running.
 - › When Commercial power network is down, the inverter based power grid system has to be shut down or disconnected from household power grid.
 - › Reasons are Electric safety regulations and possible damage for inverter based power systems.
- › Off Grid inverter power system is Stand alone system without Commercial network connection.
 - › Most On Grid inverters cannot create Stand alone power grid system. Grid inverter selection is less.
- › Backup Grid inverter power system is most expensive and complex of these three options.
 - › When Household grid has Connection to Commercial power grid and Commercial grid is up and running, the Backup Grid has to operate as On Grid system.
 - › At power outage the Inverter grid has to switch operation to the Stand alone Off Grid mode. The household power grid has to be disconnected from Commercial power grid.
 - › When Commercial power grid comes up and running again, the Inverter power grid has to disconnect itself from household power grid and synchronize with commercial power grid before reconnection.

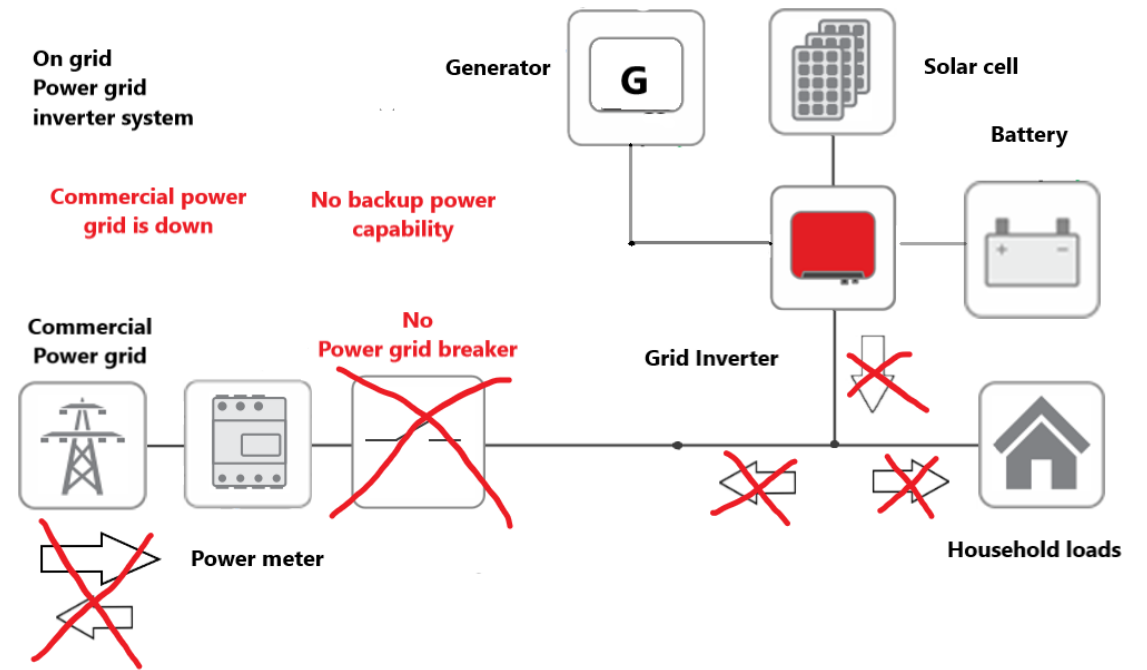
Three Basic Power Grid option Schematics



On Grid Inverter System



Grid inverter operates parallel with Commercial power grid. If Household power consumption is less compared to the power production, the excess electricity can be sold or stored to the battery pack.



When commercial power outage, the Grid inverter has to be disconnected from Household grid

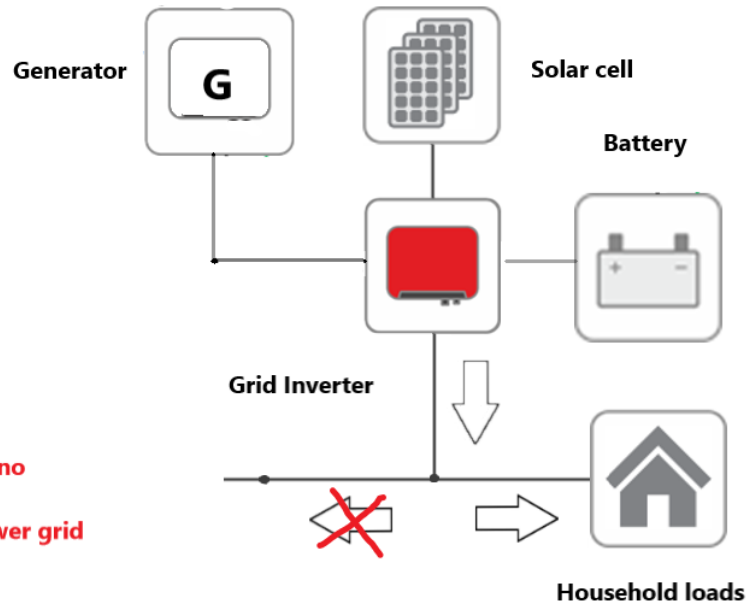
Off Grid Inverter System

Off grid inverter system

Commercial Power grid

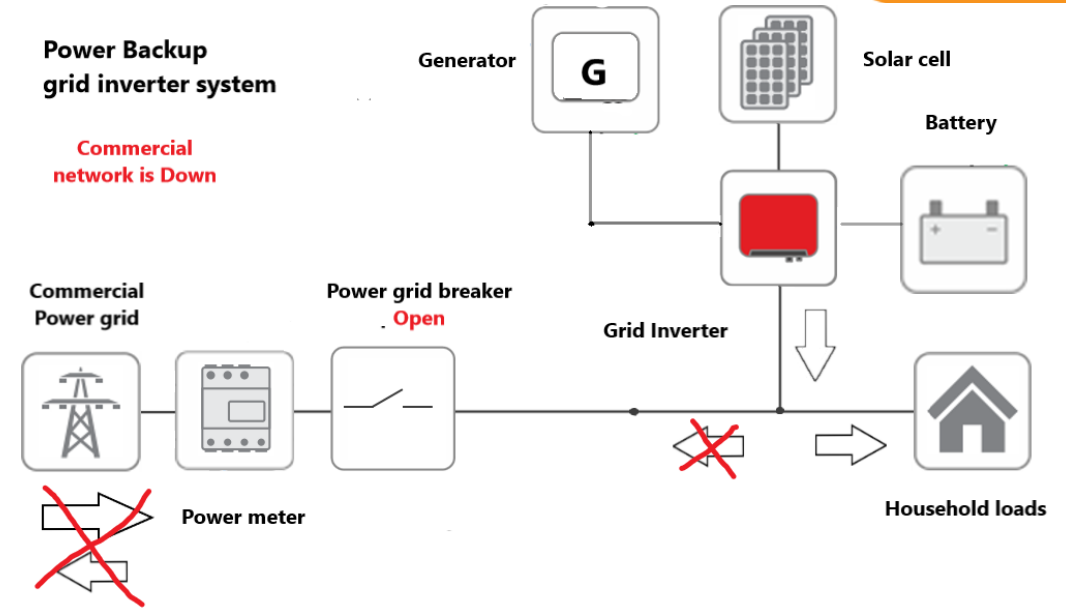
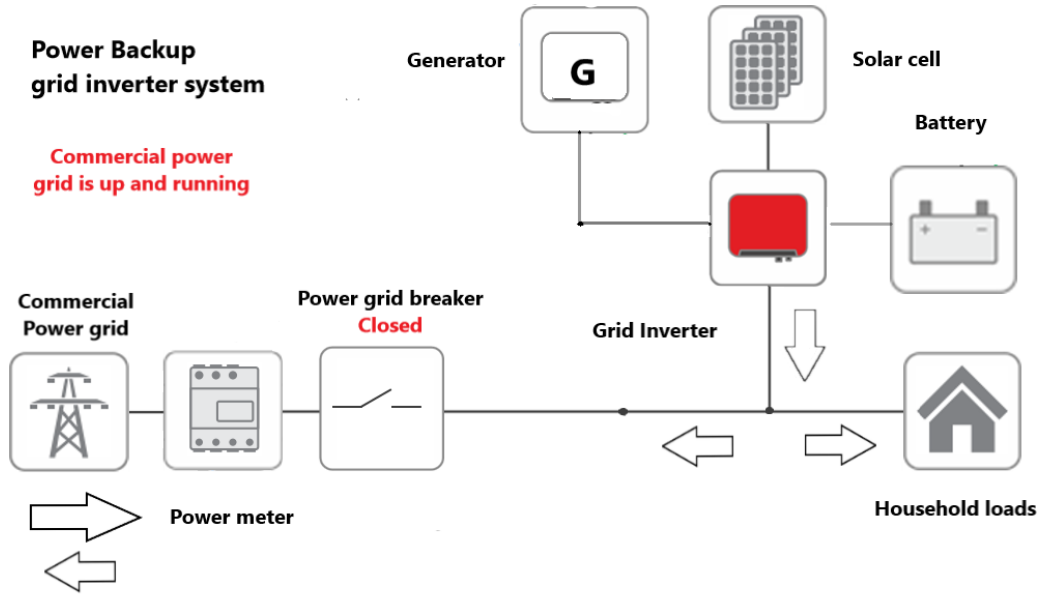


Household has no connection to commercial Power grid



Inverter Household grid and Commercial power grid are separate power grids without any co-operation.

Backup Grid Inverter System



Grid inverter operates parallel with Commercial power grid. If Household power consumption is less compared with the power production the excess electricity can be sold or stored to the battery pack.

When commercial power outage, the Household power grid has to be disconnected from Commercial power grid with Power Grid Breaker. The inverter grid operates as Standalone Off grid system.

When Commercial power grid comes up and running again, the Inverter power grid has to disconnect itself from household power grid and synchronize with commercial power grid before reconnection.

FINNISH legislation requirements for building electrical equipment for HCHP system.

- › Manufacture of permanent unclassified electrical equipment need following documentation, Commission checks and electrical safety authority notifications.
 - › The electrical safety authority has to be notified before manufacturing activity and electrical work commences.
 - › Manufactures has to provide Device identifiers, Electrical drawings, Installation documentation and Commissioning checks in accordance with the general requirements for electrical equipment. Section 6 of the Electrical Safety Act December 16, 2016/1135
 - › Section 6 general requirements for electrical equipment and installations
 - › Electrical equipment and installations shall be so designed, constructed and maintained as to be fit for their intended purpose:
 - › 1) they do not endanger the life, health or property of anyone
 - › 2) they shall not cause undue interference, electronically or electromagnetically
 - › 3) they are not easily interfered with electrically or electromagnetically
 - › If the electrical equipment or apparatus does not meet the conditions laid down in paragraph 1, it may not be placed on the market, assigned to another person or put into use.

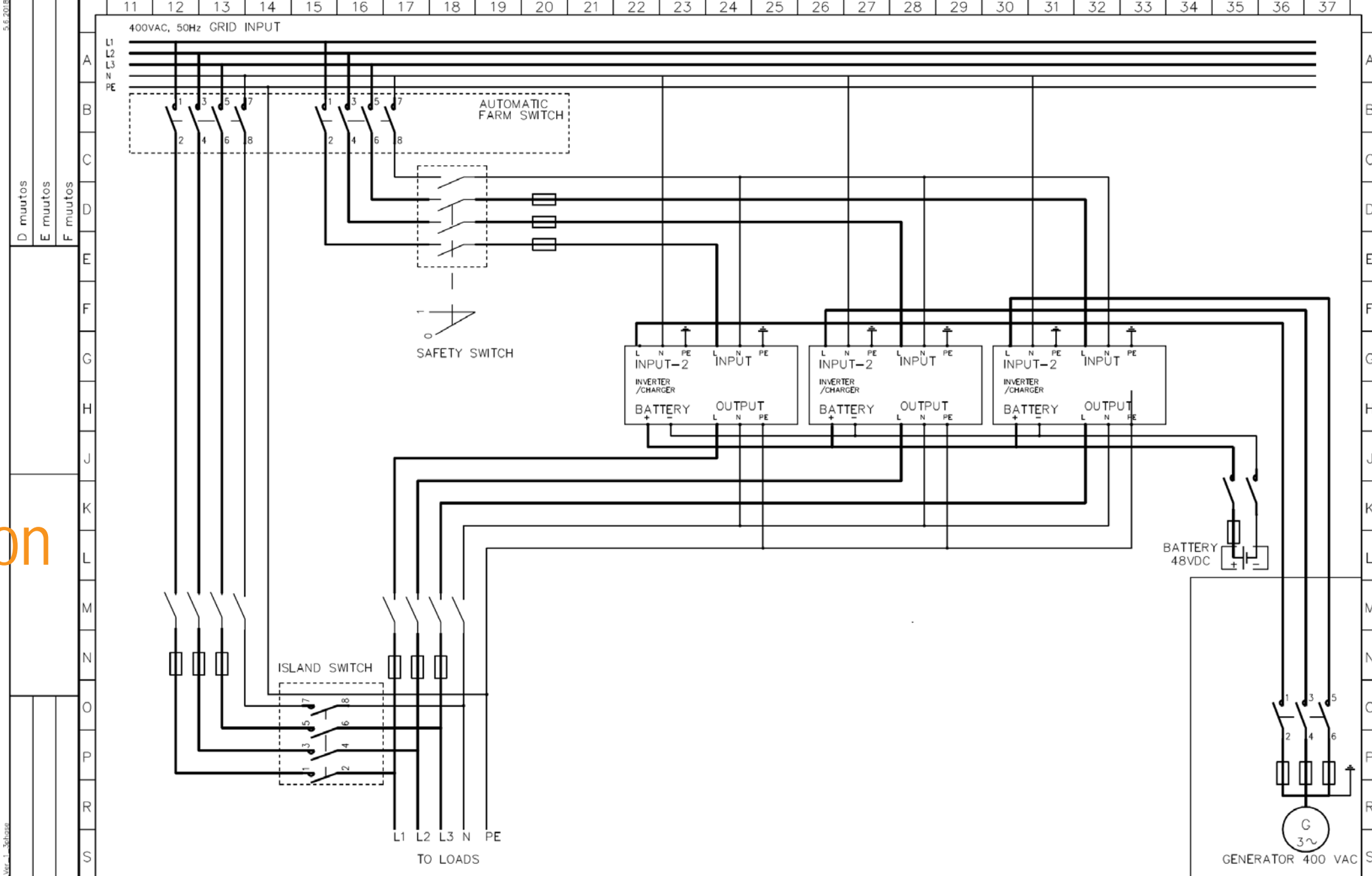
FINNISH legislation requirements for HCHP electrical system end user installation

- › Section 55 of the Electrical Safety Act December 16, 2016/1135
 - › The operator may carry out electrical work under the following conditions:
 - › 1) a person with sufficient qualifications (manager of electrical work) has been appointed to manage the work
 - › 2) the person performing and supervising the work independently has sufficient qualifications or otherwise sufficient professional skills
 - › 3) the operator has at his disposal the equipment necessary for the performance of the work and provisions relating to electrical safety
 - › 4) the activity has been notified to the electrical safety authority before the work on electrical work commences
 - › The notification referred to in paragraph 1 (4) shall state that the requirements of paragraph 1 and Article 58 are met. The notice shall indicate the consent of the electrical work manager to his position. The notice shall also indicate the information referred to in Article 86 (2) (1) to (3) for entry in the Register. Changes to the information contained in the register shall be notified in writing to the ESA within one month. Notification can also be done electronically.

Oulun Energia Network operator in Oulu Finland

- › Ensure that small-scale production equipment is compatible with Oulun Energia Transmission and Distribution Ltd's network before purchasing the equipment. The production equipment and installation shall meet the following requirements:
 - › The production equipment complies with the recommendations of the Energy Industry, German Standard VDE-AR-N 4105: 2011 or Micro-Production Standard EN50438
 - › The production can be separated from the distribution network by means of a lockable isolating switch, which is freely accessible to the network operator, Oulun Energia Transmission and Distribution Oy
 - › The main control panel and the production equipment have a warning sign for rear feed danger and instructions for disconnecting production
 - › The installation is done by a professional contractor
 - › Bidirectional measurement may require you to replace your existing electricity meter
 - › Before purchasing equipment, find out the need for a building and operating permit from the municipal building authority. Requirements vary by municipality. In Oulu, you need a building permit to operate.
- › You need to make power grid agreement with Oulun Energia Transmission and Distribution Oy
 - › The power grid agreement entitles you to feed the electricity you produce into a distribution network and to sell your surplus electricity to the electricity supplier of your choice

Basic 3-phase Grid inverter Configuration options



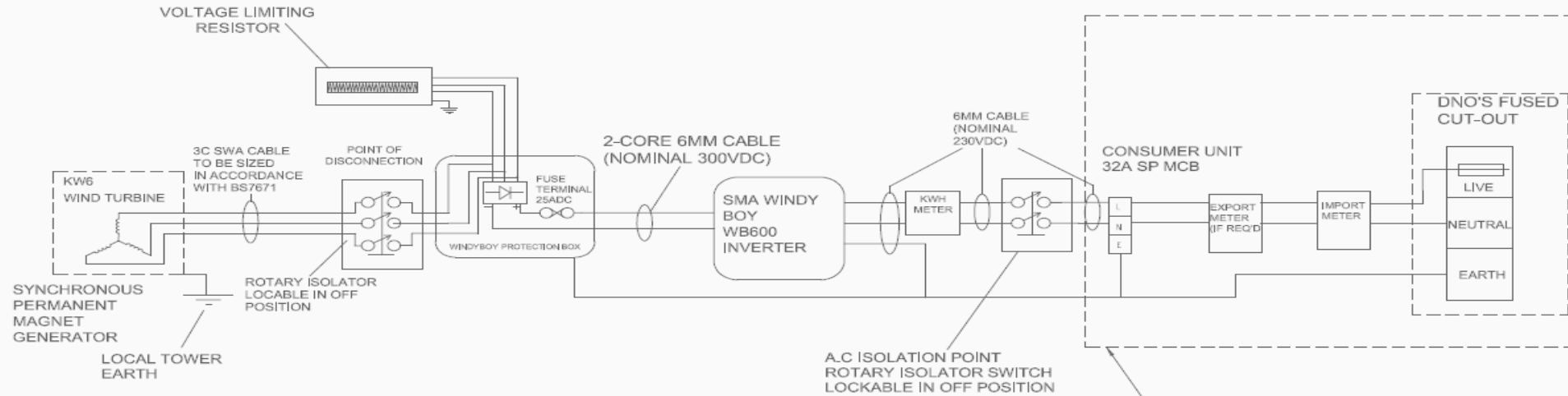
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UK legislation and Power operator requirements for HCHP system. SSE Scotland network operator.

- › SSE Microgenerations step by step guide, and according to this guide:
 - › Small scale microgeneration (G83/2 Stage 1). For installations less than 3.68kW (kilowatts) per phase at a single premises.
 - › You do not need to apply to us prior to installing your generator.
 - › You are legally obliged to notify us within 28 days of your generation equipment being installed with details of the project. Your installer will do this for you.
 - › Your installer is required to send the information on your behalf
- › According to the SSE guidelines it is recommendable to use local installer to do Power grid connection for our HCHP unit.
- › It would be helpful if we could get local support to ensure that procedure above is valid and find local company to do power grid installations for our test sites.

SSE basics for power grid installation



NOTES

1) WIND TURBINE OUTPUT IS NOMINAL 250VAC 3PH UNDER NORMAL OPERATING CONDITIONS 20HZ BUT VOLTAGE, CURRENT AND FREQUENCY PROPORTIONAL TO RPM/WIND SPEED. OPEN CIRCUIT VOLTAGE APPROX 2 X NORMAL OPERATION. MAX OUTPUT 6kW AT APPROX 200RPM.

2) SMA WINDY BOY WB6000 INVERTER IS EA APPROVED FOR CONNECTION TO UK GRID.

IT INCLUDES

- A) OVER/UNDER VOLTAGE PROTECTION
- B) OVER/UNDER FREQUENCY PROTECTION
- C) LOSS OF MAINS PROTECTION (BY MEANS OF FREQUENCY DRIFT)
- D) 180s DELAY FROM RETURN OF MAINS AFTER FAULT TO START OF SELF INITIALISE PROCEDURE.

3) VOLTAGE LIMITING RESISTOR IS RATED 3kW, 10OHM AND SHOULD BE MOUNTED IN A SAFE WELL VENTILATED AREA.

4) A 230VAC SUPPLY IS REQUIRED FOR THE AUXILLARY CONTACT ON THE WIND TURBINE ISOLATOR IN THE CONTROLLER TO OPERATE THE OVER VOLTAGE PROTECTION CIRCUIT.

5) IT IS ADVISABLE THE CONTROLLER, WINDYBOY INVERTER, kWh METER AND LOCKABLE ISOLATOR BE INSTALLED IN CLOSE PROXIMITY TO THE D.N.O CUT-OUT.

NOTE: Where the consumer unit, meters and fused cut-outs are housed in a separate enclosure an additional point of isolation should be installed.

	TITLE: KW6 Installation Drawing	REV: 01	SHEET: 1 of 1		NAME	DATE	STANDARDS: WELD SYMBOLS: BS499 PRT 2C WELDING: BS EN 1011, BS EN ISO 3834 & 9892 GALVANISING: BS EN ISO 1481	DIMENSIONAL TOLERANCES 0. ±0.5mm 0.0 ±0.25mm 0.00 ±0.1mm ANGULAR ±1°	
	DESCRIPTION: KW6 TN-S Single Phase	DWG NO:	DIMENSIONS IN MM U.O.S		DRAWN BY:				
	MATERIAL: N/A	FINISH: N/A	WEIGHT: N/A		DEBUR ALL SHARP EDGES	APPD BY:			

Grid Inverter Victron Quattro

- › Grid Inverter is Victron Quattro 48/8000/110. The unit is currently in Oulu.
 - › DC battery voltage is 48V, Power throughput is 8kVA.
- › Test plan. Inverter configuration and settings for different use cases.
- › Current status:
 - › **Off grid** Power production is doable with Victron Quattro Factory setup
 - › **On grid** Power connection with Quattro needs inverter input and out reconfiguration. For this reconfiguration Victron Color control or Venus unit is needed. Color control unit is preferred because of the faster communication response time with Grid inverter.
 - › Lithium battery back management with Quattro also needs Victron Color control or Venus unit. Also Battery control unit is needed ensure safe Lithium battery unit operation.
 - › **Victron Quattro specific configuration help and experience is crucial.** Currently best option looks to be Hollolan Sähköautomaatiikka Oy. They have experience with Victron Quattro and Lithium back combination.

Lithium Battery pack LG Resu 3.3

- › Battery pack is LG Resu 3,3. 63Ah, 3,3kWh, 48VDC. The unit is currently in Oulu.
- › Test plan: Battery unit charge and discharge scenarios
- › Current status:
 - › LG Resu 3.3 battery pack Charge and Discharge currents are limited to 18A DC.
 - › This means that the battery pack maximum power output is 850W.
 - › The LG Resu 3.3 is able to start up Grid invert Victron Quattro. Grid inverter Quattro start up power consumption is divided to three phases: 1. Power up Quattro internal control electronics. 2. Start up 48V DC/AC 230V inverter. 3. Connect AC supply input to Power output if AC input is available.
 - › Grid inverter Quattro battery pack power consumption varies during start up from 300W to 850W with LG Resu 3.3 Lithium battery pack.
 - › The Victron Color control or Venus unit as well Battery control units are needed to get LG resu Lithium battery pack to work with Grid inverter Victron Quattro

Generator Sincro 1-phase 6kVA

- › 1-Phase AC generator is Sincro SC.EK.6.B3/B14. Generator output power is from 6kVA, 230V AC, 50Hz, 3000 rpm to 7kVA, 230V AC, 50Hz, 3600 rpm. The unit is currently in Oulu.
- › Test plan: Operational voltage and power according the generator rpm
- › Current status:
 - › The unit has two 16A electrical outlets. 6kVA 230V equals to 26A current output. The recommendation is that each electrical outlet is not loaded over 16A current. The electrical outputs can be connected to parallel operation. According to our testing the total output current, during parallel connection, does not divide evenly between the two electrical outputs.



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