Introduction

In these notes is a comparison between a system (e.g. 1MWp) consisting of numerous small unit power converters (e.g. 15kW) with respect to the solution consisting of a limited number of higher power conversion units (e.g. 120kW).

The first column lists the considerations relevant to the system consisting of many small power inverter (String inverters), and the second column shows the considerations relevant to the system made with high power inverter unit (Central Inverter).

1) Number of converters

Solution 15kW	Solution 120kW
Total number: 67	Total number: 8

2) Cables

Solution 15kW	Solution 120kW
The connection between the converter and the transformer 15kW LV/ MV is made with a three-phase AC. The line voltage is equal to 3F 400Vac (230Vac Starry 3F). The number of cables used in each section is equal to 4 + protective earth conductor (R, S, T, N, GND). The current in each of the three phase cables (in case it leads to maximum power) is: 1450A. (Related to Copper Cable 4350A) The fourth neutral wire can be sized only for the unbalanced current.	The link between individual sub fields of 40kW inverter is made via a direct current. The operating voltage at the point of maximum power is approximately 550Vdc. The number of cables used in each section is equal to 2 (+, -). The current in each of the two wires of the DC (in the case leads to maximum power) is:1820A. (Related to Copper Cable 3640A)
Lower cost of power wiring for the centralized solution than that formed by string inverters.	

3) Yield

Solution 15kW	Solution 120kW
The yield related only to the electronic conversion is lower than the yield of the corresponding high-power solution. It is not expected the isolation transformer between the solar field and the grid. Overall performance of the solution with solar power converters without transformer has a yield slightly higher than the solution with high power converters.	The yield related only to the electronic conversion is higher than the yield of the corresponding low power solution. It is expected the isolation transformer between the solar field and the grid with related losses. Overall performance of the central solution with high power solar converters with transformer (Central inverters), has a slightly lower yield than the solution with low power converters.

The slight advantage related to the yield, as described in paragraph 4 below, is frustrated by the inability to operate with very low irradiation.

4) Operation at low radiation

Solution 15kW	Solution 120kW
The three single-phase converters, which are the 5kW of the 15kW inverters, must start working all at once (to prevent the placing on the unbalanced line currents). If you consider that each 5kW converter starts to operate with a radiated power of about 80W, meaning that 1MWp plant will start to produce energy to input into the grid with an power equal to 16KW (80x3x67). A 5kW converter reaches 90% yield with an output of about 250W, which means that the converters connected to a solar field of 1MWp achieve an efficiency of 90% for an incident power of approximately 50kW (250x3x67).	The three-phase converters of 40kW which compose the inverter of 120kW start to run one at a time in order to take advantage also in case of lower radiation situations. The first 40kW three-phase converter starts to operate with a power of about 600W, which means that a field of 1 MW (consisting of 8 converters) will begin to produce an incident power of 4.8 kW (600x8). So a plant thus deployed, will generate during all hours of the day and all the days of bad weather in which the solution consists of many small power inverter does not produce anything. This results in a net production of the plant definitely higher than that of the fractional solution (strings inverters). The first converter of 40kW with a yield up to 90% for an incident power of 3 kW, which means that the connected inverters to a solar field of 1MWp achieve an efficiency of 90% for an incident power of approximately 24kW (8x3)

All of this allows a much higher average daily production in case of centralized modular converters with higher power.

5) Frequency of failure (MTBF)

Solution 15kW	Solution 120kW
Consider that the average time between failures of a single-phase converters, which is the three-phase inverter is equal to 20 years (175,200 hours). Since the system is made up of 67 three-phase inverter, internally consisting of 3 single-phase inverter, it means that failures in the system will happen on average every 870 hours (175200 / (67 * 3)): 36.5 days.	Since the system consists of 8 power inverters, each consisting of 3-phase inverter, it means that failures in the system will happen on average every 7291 hours (175200 / (8 * 3)): 304 days. Note that this calculation is very conservative since, in this case, the converters all work only at full irradiation, while for most of the time at least one of the converter is blocked and then the average time between failures is significantly longer. In addition, the higher power converters, by their nature are more robust and, being housed within a fixed structure (cabin inverter), are subjected to environmental conditions far less stressful than those who undergo converters installed outdoors at the panels solar (this increases the reliability of the system).
A system consisting of central inverters has a failure rate about 10 times lower than that of a power plant consisting of string inverters.	

6) Consequences of failure of a converter

Solution 15kW	Solution 120kW
In case of failure of an inverter (with a failure frequency as described at point 5) you have to stop production of a whole section equal to 15kW. The repair is done by replacing (simply) the inverter in the field. This operation, easy in case of optimal environmental conditions, may become far less pleasant in the event of inclement environmental conditions, in addition to the foregoing, the repair must be done quickly to avoid a shortfall in production.	In case of failure of a converter (with the frequency set out in paragraph 5) we don't experience a total stop of the production, but only a limitation of the nominal power to be input in the grid (approximately 70% of total power). Note that this situation occurs only in the rare cases in the presence of a maximum radiation (only a few days a year and only for a few hours), otherwise the arrest of a power module has no impact on production. Consequently, it is possible to intervene with service assistance with a lot less urgency degree. The repair is the replacing of one power module of the inverter. This operation always takes place in a sheltered environment and with all the necessary equipment at hand, in addition, as noted above, the repair can be done in a more relaxed time as any shortfall in production is statistically unlikely.

With a Central inverter solution, unlike the plant consisting of string inverters, the arrest of a power module in an inverter does not decrease the production of energy in the grid.

7) Issues relating to electromagnetic compatibility

Solution 15kW	Solution 120kW
The positive and negative potential of the solar panels are not fixed with respect to ground potential and the large size of many solar modules in the system, is the armature of an electrical condenser, whose other armor is the ground. The fluctuations in potential of the solar panels electrical conductors flow an “important” current towards ground: this current can cause serious problems to the solar panels, to the structures and to the protections of the plant. The large surface of several panels which form a system with high power, consist in an “antenna” which is able to significantly disturb the plants diagnostic, video surveillance or remote monitoring in the immediate vicinity.	The positive and negative potential of the solar panels are fixed with respect to ground potential due to the presence of isolation transformers toward the plant. As a result there is virtually no current flows to ground. Since the potential of the panels do not float, there aren’t problems of electromagnetic interference with electronic equipment that may be present on site; this is especially true since the distance between the elements that generate high-frequency harmonics (inverter) and the antennas (panels) is significant and then the panels are subjected to currents and voltages perfectly continuous and leveled.

The plant with central inverters, with respect to the system composed by string inverters, presents not considerable problems of electromagnetic compatibility and circulation of ground currents.

8) Issues of remote diagnostics

Solution 15kW	Solution 120kW
The large number of converters determines the need for a much more complex and extensive wiring, compared to that needed for a system consisting of central inverters. At the same frequency interrogation of the devices, the data update time is much longer.	The low number of converters and their grouping into a single room requires a much more simple and economical wiring, compared to that needed for a plant consisting of string inverters. At the same interrogation frequency of the equipment, the data update time is much shorter.
The plant with central inverters, with respect to the system composed with string inverters, has a more powerful, reliable and economical remote diagnostic system.	

9) Customization

Solution 15kW	Solution 120kW
The low-power computing (microprocessor) on board installed on the converters does not allow high customization.	The considerable computing power (multi-microprocessor structure for high performance) installed on board of the central converters (with more power), allows an high customization potential and its easy upgrading (8 machines concentrated in a room, compared to 67 machines distributed in the field)
The plant with central inverters, with respect to the system composed by string inverters, has much greater possibilities of customization and evolution over time.	

10) Safety

Solution 15kW	Solution 120kW
The devices are outdoors installed and are therefore more prone to accidental damages, vandalism or incorrect maneuvers.	The devices are housed in a protected and locked environment; it is much more unlikely to occur in problems associated with accidental damage, vandalism or incorrect maneuvers.
The plant with central inverters, with respect to the system composed by string inverters, presents a greater security against accidental damages, vandalism or incorrect maneuvers.	