Apparatus and control method of self organized operation of grid segments through a Frequency Decoupling Smart Transformer without new physical communication infrastructure

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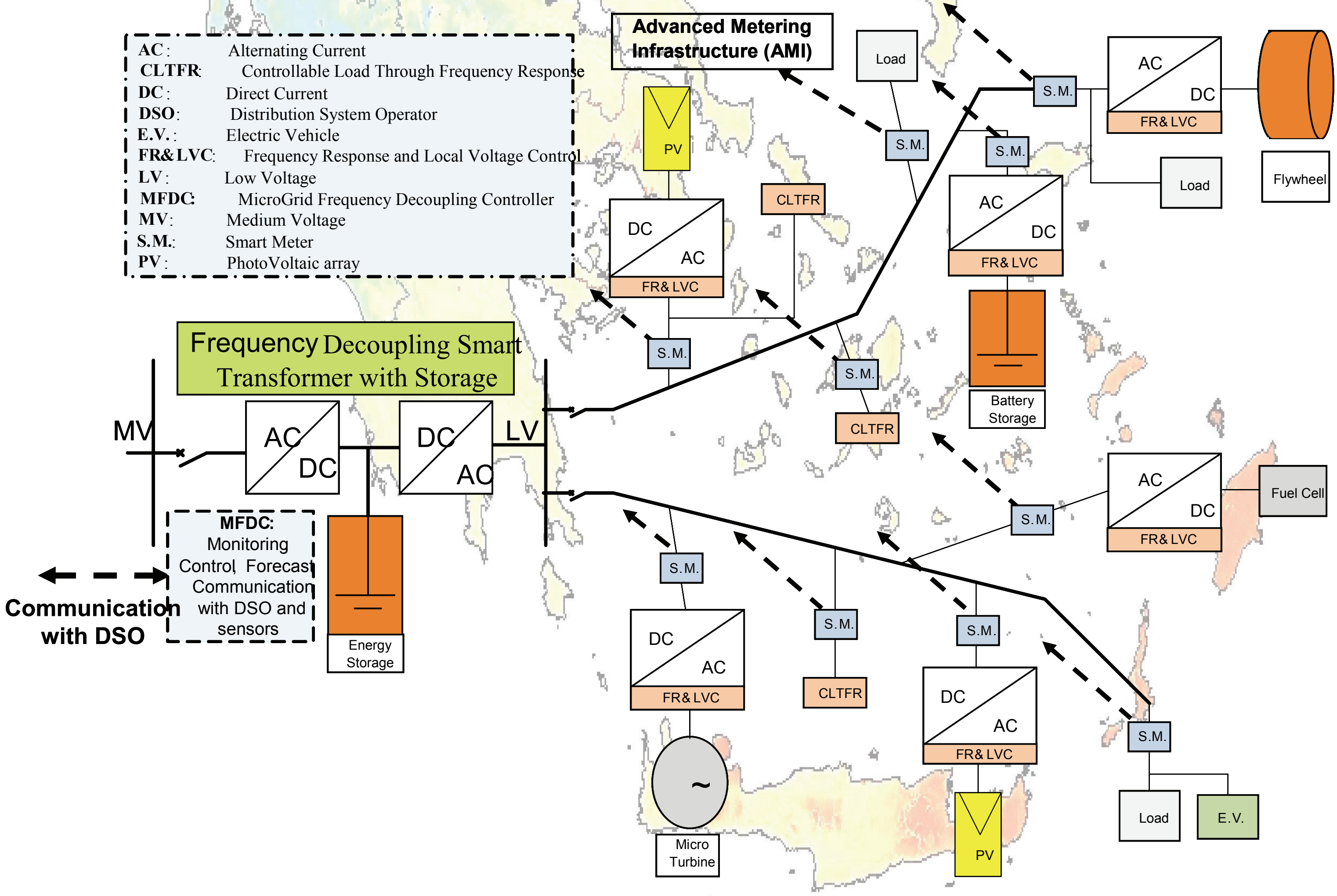
The large integration of renewable energy sources (RES), active distributed energy resources (storage) and controllable loads in the electricity networks is imposing key operational, technical and economic challenges and barriers. These are voltage regulation issues, especially in rural areas but increasingly in urban grids, requiring coordinated operation of a very large number of variable generation and controllable devices connected to the grids. Traditional grid reinforcement is the preferred solution to increase the hosting capacity for RES in the distribution grids, while recently On-Load Tap Changing (OLTC) transformers have also been used in the LV grids. In the future control and management of controllable devices is designed to be effected through point to point communication mainly through internet communication solutions.

The aim of this concept (Patent application PCT/IB2016/054496 pending) is to increase RES generator accepting capacity and enhance load management at the distribution networks, without new physical communication infrastructure, enhancing the associated environmental, economic and operational benefits, while contributing to the transformation of the networks to self organized active smart grids with minimized curtailment of RES generator production through storage management and power sharing between adjacent grid segments within a "Microgrid" or even in coordinated exchange of power flows through the upstream distribution and transmission system.

The integration of Distributed Energy Resources (DER), such as RES generators, storage and controllable loads in the grids will increase dramatically in the near future, leading consequently to the extraordinary increase of communication flows and data processing volumes, while data security issues will immerge. Therefore, it is proposed at the level of the Distribution System Operator (DSO) to avoid investing in new infrastructure of OLTC transformers and for direct communication systems, in data processors and links for control and energy management in distribution grid segments (in Microgrids). The key issue is to avoid new communication infrastructure with the associated latency and vulnerability in distribution grid segments by controlling in a coordinated manner a very large number of grid connected controllable devices through the grid frequency variation. To allow grid frequency variation in distribution grid segments, the downstream operating frequency should be decoupled from the frequency of the medium voltage upstream grid, or other adjacent grid segments within the same "Microgrid". Each grid segment within a "Microgrid" could have a separate Frequency Decoupling Smart Transformer (FDST) with the features presented in the Drawing below. By allowing frequency variation, we are able to realize control and energy management of generators, controllable loads and battery storage capacity. In this way, plug and play functionality, within certain predefined technical limits, can be applied for new DER units and controllable loads, within a defined grid segment. This will allow uniform application of a solution within a grid segment per point of user connection without the need for individual assessment. In practice, the local controllers of all the grid-connected units, such as energy generators, storage and active loads in the "Microgrid" will have to be able to monitor and respond accordingly to local voltage variation, (already most recent Photovoltaic system inverters have this feature integrated), standardized local droop frequency logic for power control, energy management, black start, etc., allowing for self organized "Microgrid" operation. The distributed active DER units in the "Microgrid" will provide balancing and ancillary services such as voltage, frequency support as well as energy buffering depending on their local voltage situation, the grid frequency and their own operation state/limitations within a self-organized grid segmen0t according to the proposed concept.



The FDST will be monitoring in real time: power flow, Voltage, Current and the data available from the smart meters along the length of the grid segment will be provided by the DSO through the smart metering data communication infrastructure. The smart meter information will be providing a snap shot of the state of the grid segment to the FDST. This grid segment snap shot allows decisions for new control measures and it is a reiterated validation of the already implemented operational control by the FDST.