

Future power grid architectures - nanogrids to super grids

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Keywords:

Abstract

The paradigm for electrical energy delivery and usage has been the subject of much anticipation and speculation by various groups including academics, environmentalists, governments and technology companies. The various viewpoints notwithstanding the grid structures of the future are likely to undergo dramatic revision from those used today. This idea is especially compelling in terms of new distributed energy technologies, particularly for distribution network control while allowing much greater customer engagement. This talk gives a somewhat personal review of these developments with comments on how they might affect Hong Kong.

From an international perspective, the paradigm of electrical energy delivery usage is being revised quite dramatically in terms of new technologies and structures, which are largely based on new ways for consumer engagement. These include new ways to generate energy, e.g. efficient rooftop PV, process the energy, e.g. storage, deliver the energy, e.g. microgrids, and control the energy, e.g. demand-response, and use the energy, e.g. EVs. The concept of smart grids arose largely to bring ICT to enhanced methods of power distribution. Significantly, in all these developments, the role of the consumer moves from being a ‘passive’ random load to one who produces as well as consumes energy; hence the idea of a prosumer. These new entities on the grid can also play an active role in grid services. In this new era, consumers, or prosumers, can also choose to optimize their situation with much greater control including the extreme option of grid defection.

A striking feature of the discussion is the wide range of options being considered, all the way from self-contained households (nanogrids) to massive intercontinental supergrids. To some extent this can reflect diverse situations from large sparsely populated islands like Australia to small highly interconnected countries like Denmark (the latter being closer to the HK situation).

Several major studies have explored the future grid [1], [2]. The picture presented is of a vastly different looking grid in terms of similar issues. The author’s own research program at HKU and previously at The University of Sydney, deals directly with issues of future grids. The paper will build on this experience to introduce the issues one by one.

In this talk, the future will be defined in terms of distributed energy resources (DER), new issues, new architectures, and just briefly the new systems level research needed. Further, the emphasis is on structures and operational aspects. The planning of such systems will also require new ideas.

[1] Change and Choice: The Future Grid Forum’s Analysis of Australia’s Potential Electricity Pathways to 2050, CSIRO Report, December 2013.

[2] FUTURE GRID: Public Report on the Future Grid, PSERC Report for USA DOE, 2016.