Thrust 5

Need for Essential Services

Increasing penetration of variable renewable energy resources leads to a set of increasingly difficult challenges: they are weather dependent, inherently more distributed, and are accompanied by more energy storage and a much more actively varied demand. At the heart of these research challenges are "essential services" that need to evolve with the changing characteristics of the power system and are fundamental to its socio-technical objective of "reliably maintaining supply-demand balance, at all points in time, at all locations, at least cost, equitably, and with minimum impact on the environment".

These essential services determine: the operation and planning of the electricity grid across all time scales; the required characteristics of the technologies connected to the power system; and, through commercial mechanisms, the incentives to innovate and invest and to do so equitably. Current state-of-the-art (e.g., capacity adequacy, ancillary services etc.) falls far short of future essential service requirements, and we are in danger of developing electricity grids that are costly, unreliable, inequitable and not resilient and will therefore not deliver the step-change needed for the energy transition. What is missing is a unifying framework for procuring essential services through which the right combination of solutions is found, recognising that system characteristics, technical and societal, vary by location. These services need to both adapt to the changing needs of the grid, society, and the changing capabilities of new technologies that are connected to the grid (e.g., increased digitalisation) to obtain an optimal technology mix on both the supply and demand side.

The Grant

The project is funded by a £4M grant from the Leverhulme Trust that will support a team of 14 over a five-year period and is hosted by the Department of Electrical and Electronic Engineering at Imperial College London. For further details please contact Mark O'Malley, Leverhulme Professor of Power Systems, Imperial College London.

The Research

Our Leverhulme Global Power System Transformation team, hosted by the Department of Electrical and Electronic Engineering at Imperial College London, is set on developing a set of new essential services based on electrical engineering, economics, and social factors to guide the transition towards higher penetrations of variable renewables in electricity grids. The research is done as an integral part of the Global Power System Transformation (G-PST) Consortium. The research will address part of the G-PST Research Agenda and attention is drawn to a recent report on the evolution of needs and services with increasing penetration of Inverter Based Resources (IBRs).

These services aim to:

1. define physical characteristics of services across the entire range of time scales from milliseconds to seasons;
2. ensure that these services cover the whole space parsimoniously, avoiding negative interactions and redundancy;
3. be robust and economic under all possible systems;
4. be forward looking with respect to an electricity grid that has increasing levels of variable renewables; and
5. be non-discriminatory towards various potential technical routes and hence both stimulate and be open to radical innovation.

To enable the energy transition by developing new essential services, the research programme has three distinct but inter-related strands:

Fundamental Analysis of Electricity Grids	**Analytical Underpinning of Digitisation**	**Testing and Validation**
Fundamental analysis of electricity grids with high penetrations of variable renewables to extract the core characteristics across all time scales and physical attributes that deliver on the socio-technical objectives described above.	The "smart grid" concept is maturing into fundamental research into how to harness "digitisation", i.e. machine-learning, internet-of-things and edge technologies, to characterise and access millions of distributed resources (renewables, storage and active demand) that can provide essential services in a secure and efficient manner.	This will require development of best in class models and case studies of future grids to validate the essential services and the digital algorithms for different renewable mixes, gird size, social, economic and climate conditions.