EPSRC-NSFC Workshop in Sustainable Power Supply

3 & 4 June 2019

Report on the Workshop Outputs

Aims

This work will build on the excellent collaborative work carried out through a number of joint research activities by EPSRC and NSFC over the past few years. This workshop, held on 03 and 04 June 2019 scoped out the significant research challenges in the area of sustainable power supply, with the intent of steering the direction of this research call. The two wide areas of focus were *intelligent and resilient control for smart urban energy* and *grid scale storage*, at the city scale. In particular, the workshop served to address the following aims:

- To explore the current research landscape in UK and China (to create a research roadmap).
- To network UK and Chinese research communities in the area of control and grid scale storage.
- To identify priority themes/challenges for collaborative research in these areas.
- Scope the remit for a joint EPSRC and NSFC call in sustainable power supply, to be funded in January 2020
- Understand where future EPSRC focussed research can best add value to the landscape

Format of the workshop

The workshop began with a series of presentations:

- Welcome and workshop aims by Ruhina Miller, EPSRC
- Introduction to EPSRC and UKRI by Jim Fleming, EPSRC
- Introduction and NSFC and UKRI China by Xu Jin, NSFC Bureau of International Cooperation and Chan Wang, UKRI China
- UK Overview of intelligent and resilient control for smart urban energy systems by Peter Crossley, University of Manchester
- China overview: intelligent and resilient control for smart urban energy systems by Tianshu Bi, North China Electric Power University

The group proceeded to address the following questions each day on the two subject areas highlighted above:

- Barriers towards creating intelligent and resilient control for smart urban energy systems/grid scale storage
- Solutions towards creating intelligent and resilient control for smart urban energy systems/grod scale storage
- Research in the area by the UK, China, and how the two countries can work together to meet any gaps and needs
- Discussion and prioritisation of the research challenges for each area

Highlighted areas for intelligent and resilient control for smart urban energy systems

The key challenges identified by the group to creating intelligent and resilient control for smart urban energy systems are described below. The categories below serve as a loose structure, as there is overlap between them.

i) Interconversion, flexible power conversion and control systems: the conversion of different energy vectors at the urban scale are critical, which needs to have flexibility, rapid response, available when needed and be well controlled. This was primarily considered a power systems and electronics issue, with the following points highlighted:

- Utilisation of different energy sources
- Tools for operating these systems
- Demand side management to enable flexibility in the load source
- Design and control of power electronic systems
- Future city energy networks (integration of electrical and thermal)

ii) Methods of handling and processing high volumes of energy data: Systems at the urban scale often generate large sets of data, which can result in numerous complications including: difficulties in processing it and extracting the relevant data rapidly, result in time delays in the system, or the rate at which it is collected might be constrained by hardware. It was highlighted that improvements around this would be beneficial, with the following points highlighted:

- Handling of data at the storage level
- High volumes of performance data
- Data mining for improving system, operations, control and reliability operations
- Multi-factor analysis, modelling and optimisation
- Common platform(s) for sharing and interpretation
- Distribution and co-ordinated control
- (Privacy of data, Internet of Things (IoT) – ICT)
- (Lag at the millisecond timescale – ICT)

iii) Integration of energy systems, impact of locally decentralised systems and legacy systems: integration of systems at this level can often be problematic, especially with centralised and decentralised systems, and communications with legacy systems. It was highlighted that methods to enable the successful integration of different types of system, both new and legacy, in addition to different vectors would be of benefit, with the following points highlighted:

- Integration and optimisation under dynamic conditions with multi-energy vectors
- Alleviation of bottlenecks
- Overcoming limitations and restrictions of infrastructure
- Ensuring that new technologies are compatible with existing infrastructure and future-proofing them
- Integration across different regions

iv) Smart system protection and fault restoration: security of supply, especially during periods of high demand is a key factor for any system. It is therefore important that faults are detected or alterted to early and that the system has adequate back-ups in place in these events. Furthermore, it is important that the system is protected from physical as well as virtual damage, for safety and reliability reasons respectively, with the following points highlighted:

- Protection that allows for rapid response
- Protection and control of hybrid grids
- Resilient and fault tolerant networks
- Stability issues of power electronics based storage equipment and grid
- Operation and maintenance

v) Policy, markets and awareness: social and economic issues are key research drivers to ensure that technology is taken up, to understand consumer behaviour, whether there is enough knowledge in the system and so forth, with the following points highlighted:

- Lack of regulation – customer expectation of continued, infinite supply, insufficient incentives
- Lack of trained engineers
- Lack of policy to drive the research
- Uncertainty of consumer behaviour
- Seasonal demand

vi) Other disruptive technology: smart urban energy systems are not in isolation, with a magnitude of different systems running in parallel. Consideration of a whole systems approach is therefore crucial as opposed to looking at each in isolation, with the following points highlighted:

- Inability to deal with loads during peak hours
- Tunnel visioning needs, e.g. companies don't account for wider issues or the entire supply chain
- Sensors, sensor networks and new technology, e.g. robotics, Big Data

Current research in resilient control for smart urban energy systems

The group identified the separate research strengths of UK and China, then explored how the two countries can work together to meet any gaps and needs going forward.

i) UK

- Renewable energy
- Managing and adapting existing infrastructure; asset life extension
- Power electronics
- Local energy system reseach
- Market design, operation and deregulation
- Transitioning research to higher TRLs

ii) China

- Multi-scale, multi-site demonstrators
- City planning
- More and better access to data
- New distribution technologies e.g. DC-DC, AC-DC
- More and larger national R&D programmes
- Dedicated resources for large challenges

iii) Both

- Multi-energy coupling, transmission and distribution
- Resilliance and recovery
- Electrification of transport
- Power electronics – design and control
- Data analysis; data driven resilient operation, control, fault protection
- Energy network infrastructure
- Integration of systems
- Market design to support resident energy systems

Highlighted areas in grid scale storage

The key challenges identified by the group to towards grid scale storage are described below. The categories below serve as a loose structure, as there is overlap between them.

i) Multivector distributed storage: integration of systems at this level can often be problematic, especially with centralised and decentralised systems, and communications with legacy systems. It was highlighted that methods to enable the successful integration of different types of system, both new and legacy, in addition to different vectors would be of benefit, with the following points highlighted:

- Integration (into the whole system) and control
- Interface between the storage device and power grid
- Flexibility to convert between different forms
- Optimisation strategies for city scale – scalability and modulatity
- Islands sourced from batteries
- Legacy systems

ii) Performance: this aspect of storage is another key component and encompasses a variety of fields. Ultimately device designs need to develop to reduce inherent losses, improve their reliability, make them more environmentally friendly and safe, safe to the users and their surroundings, and so forth, with the following points highlighted:

- Efficiency, energy density
- Dynamic response of devices
- Lifetime/lifecycle, including environmental
- Hazards/safety
- Reliability
- Fault tolerance at high capacity

iii) Energy storage cloud (excluding software): the hardware which manages energy storage data has to be robust, be able to keep up with processing requirements and so forth. With the rate at which technology is developing, considerations in this space keep increasing, with the following points highlighted:

- Integration and optimisation under dynamic conditions with multi-energy vectors
- Alleviation of bottlenecks
- Overcoming limitations and restrictions of infrastructure
- Ensuring that new technologies are compatible with existing infrastructure and future-proofing them

- Integration across different regions

iv) Policy, markets and awareness: social and economic issues are key research drivers to ensure that technology is taken up, to understand consumer behaviour, whether there is enough knowledge in the system and so forth, with the following points highlighted:

- Lack of regulation – customer expectation of continued, infinite supply, insufficient incentives
- Lack of risk management
- Lack of an energy trading scheme
- Return on investments
- Seasonal demand supplied by high carbon solutions, as opposed to low/zero carbon options
- Current solutions are expensive
- Location, space and asthetics of current solutions
- Market value and inefficiency of the market
- Management of long-term commitments

Current research in grid scale storage

The group identified the separate research strengths of UK and China, then explored how the two countries can work together to meet any gaps and needs going forward.

i) UK

- Higher renewable uptake
- Thermal storage materials, manufacture and analysis
- Small scale demonstration batteries, e.g. 10MW batteries
- Chemical and mechanical storage
- Integration of storage into the market

ii) China

- Thermal storage
- Safety technologies
- Environmentally friendly and resource efficient storage technologies, e.g. recycling, reconditioning and regeneration of storage materials and devices
- Large scale demonstration batteries, e.g. 100MW, 4GW thermal
- Manufacturing, operation and implementation
- EV charging
- Air-pumped compressed storage
- Fly-wheel storage
- Policy support

iii) Both

- Integration of technologies
- Integration of heat storage into (electro)chemical storage
- Managing system interfaces between storage systems and energy networks
- High power, high energy density storage and ancillary devices
- Safety, cost and sustainability
- Responsiveness and flexibility for long-term storage

- Power-to-X devices and utilisation within grid

Conclusion

The area of achieving a sustainable power supply is currently generating a lot public interest. The call for participants of this workshop generated almost 100 applications for just 25 places, in addition to 15 Chinese delegates flying over for this, therefore it is clear the interest in this area from the research community. Thank you again to all those who contributed to the workshop and we look forward to working with you again.

Following on from the workshop, the outputs were discussed by EPSRC and NSFC to highlight seven priority research challenges i to vii:

a) Intelligent and resilient control for smart urban energy

i) Interconversion, flexible power conversion and control systems

ii) Methods of handling and processing high volumes of energy data

iii) Integration of energy systems, integration with legacy systems, and impact of locally decentralised systems

iv) Smart system protection and fault restoration

b) Grid scale storage

v) Multivector distributed storage

vi) Performance, e.g. efficiency, lifetime, reliability, fault tolerance

vii) Energy storage “cloud” hardware (not software)