# Toward the development of SLES Flexibility Metrics

## SmartHubs SLES Technical Note

Robin Wardle, Chris Mullen, and Neal Wade

February 2021

## Acknowledgements and Disclaimer

This work was carried out as part of the Innovate UK-funded project “SmartHubs SLES”, Project Reference: 104980, <https://gtr.ukri.org/projects?ref=104980>. These are the collected notes of a work-in-progress on SLES flexibility metrics. They do not represent a complete development of the subject due to the curtailment of the project in February 2021.

## Overview

In [1] and [2] the modelling and design of Smart Local Energy Systems is considered, wherein the idea of modes of operation of a SLES are considered. For example, it might be necessary to compare the operation of a SLES’s assets as part of a coordinated control philosophy with the operation of individual assets meeting their own objective, to answer the question of whether a co-ordinated SLES system is better than the sum of its parts. Comparing different modes of operation within a SLES or indeed two or more SLESs in their entirety requires the development of one or more flexibility metrics.

What is meant by ‘flexibility’, and how can a flexibility metric be defined? The question can be broken into two parts. Firstly, the parameters of the system that influence the idea of ‘flexibility must be enumerated, being quantities such as:

* Magnitude of power change +ve/-ve
* Duration of power change
* Time of day
* Rebound effect

Such parameters as these can be provided by the asset installers / operators; a method for collecting these is described in [2]. Other system parameters of interest are not known and would need to be discovered through field trials on the SLES, such as:

* Magnitude of asset interventions (control actions)
* Duration of asset interventions
* The above, both for individual assets, and fleet-aggregated
* Dependence on time of day, season, weekday / weekend split, and temperature

The sensitivity of an asset to these parameters can be studied through modelling and / field trials, enabling a picture of the best and worst cases for flexibility of the SLES system to be built up. This can also help identify assets that could be added to make the system flexibility less sensitive to these factors, and / or how to modify the size of particular assets to enable a more consistent flexibility in the face of these changing parameters. This approach is validated by axiomatic design’s second axiom, which instructs the designer to reduce the information content of the design. By reducing the variability of the design parameters, the sensitivity of the design to its inputs is reduced and the quality and robustness of the design is improved.

Secondly, the purpose of the flexibility needs to be considered, i.e.:

* Avoided cost for power system infrastructure
* Environmental ‘load’ (e.g. CO2 emissions)
* Bill cost reduction
* Energy efficiency – might be better expressed as CO2 emissions, as energy efficiency per se might not be a good indicator of ‘benefits’
* The ability to cope with variability and uncertainty in generation and demand

Alternatively, it might be that flexibility is inherent in the power system (magnitude of power change, duration etc.) but that it is valued differently depending on its intended purpose. Then the result or value of flexibility is a separate thing, and a given intervention on a value basis may hit more than one purpose. This form of flexibility – as a value proposition with multiple benefits – may be similar in structure to the renewable energy guarantee of origin scheme (REGO), and tackling the question of recording and attributing the provision of the flexibility that has delivered multiple benefits is an open question in the SLES domain.

## Literature

A 2020 power system flexibility survey by Heggarty *et al.* [3] forms a good starting point for the study of SLES flexibility metrics. In this paper the authors identify four flexibility metric groups: a) “How much flexibility does my system need?”, b) “How flexible is my flexibility solution?”, c) “How flexible is my power system?”, d) Who is providing flexibility in my power system?”. They review the literature for the four categories described, and they create a mechanism called a Flexibility Solution Modulation Stack which fits into category d) in this paper, for which they identify a gap. While very much centred on electrical power systems, this framework can be used to create an initial structure for SLES flexibility metric development. Other literature of note on the subject of flexibility metrics include work by Abrantes and Gross [4], Lannoye *et al.* [5, 6] and EPRI [7].

In the literature reviewed, the main definition of flexibility in power systems is “the ability [of a system] to cope with variability and uncertainty in generation and demand”, and the main dimensions of flexibility can generally be seen to be, coupled with the parameters listed above, ramp rate (response time), duration and output power. One possibility might be that assets can be categorised using these dimensions to create a flexibility “stack”. In any case the objectives of the SLES project extended beyond balancing supply and demand within the system and extended to a raft of objectives including for example local employment and equitable distribution of value. These additional objectives, centering around the idea of the coordinated operation of assets being of greater value than the sum of each asset being operated individually, will need to be included in any SLES metric.

[1] C. Mullen, R. Wardle, and N. S. Wade. An approach to modelling a Smart Local Energy System demonstrator project. In 12th International Renewable Engineering Conference, April 2021.

[2] R. Wardle, N. S. Wade, C. Mullen, and M. Royapoor. Axiomatic design of smart local energy systems. In 12th International Renewable Engineering Conference, April 2021.

[3] T. Heggarty, J-Y. Bourmaud, R. Giraud, and G. Kariniotakis. Quantifying power system flexibility provision. Applied Energy 279 (2020) 115852.

[4] A. L. Abrantes and G. Gross. Towards the development of a class of grid operational flexibility metrics. Electric Power Systems Research, 190 (2021) 106674.

[5] E. Lannoye, D. Flynn, and M. O’Malley. Evaluation of power system flexibility. IEEE Transactions on Power Systems 27 (2), 2012, 922-931.

[6] E. Lannoye, D. Flynn, and M. O’Malley. Transmission, variable generation and power system flexibility. IEEE Transactions on Power Systems, 30 (1), 2015, 57-66.

[7] Electric Power Research Institute. Metrics for quantifying flexibility in power system planning. EPRI Technical Paper Series, July 2014.