NIA Project Close Down Report Document

Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total.

Network Licensees must publish the required Project Progress information on the Smarter Networks Portal by 31st July 2014 and each year thereafter. The Network Licensee(s) must publish Project Progress information for each NIA Project that has developed new learning in the preceding relevant year.

Date of Submission

Jul 2024

Project Reference Number

NIA2_NGESO055

Project Progress

Project Title

QWID FLEXER

Project Reference Number

NIA2_NGESO055

Project Start Date

September 2023

Project Duration

0 years and 6 months

Nominated Project Contact(s)

Alex Hart

Scope

The scope of the project is:

- Flexibility for balancing inflexible demand and inflexible generation across the whole of the electricity system (transmission and distribution)
- Flexibility for energy balancing only, excluding any locational component and therefore any network management component
- Flexibility for energy balancing only between 0.5 and 24 hours (energy balancing within 0.5 is considered frequency management and energy balancing over more than 24 house is considered adequacy)
- The need for flexibility only (not how much flexibility will be provided, how it will be provided, the benefits, the barriers, the business models etc.)

Objectives

The project is expected to:

1. Provide a clearly defined method for calculating the need for WDF
2. Provide an explanation of why this is the best method to use
3. Use the selected method to calculate the system need for WDF. Provide and discuss the results
4. Provide all of the tools required to repeat the calculation using the chosen method
5. Propose possible future work to build on this project

Success Criteria

The project will be successful if:

1. A rigorous method is developed to calculate the need for WDF and explore how drivers change it
2. The ESO can provide industry with a clear explanation of how the method works and why it was selected, allowing industry to challenge and build upon it

Performance Compared to the Original Project Aims, Objectives and Success Criteria

Project Overview

The decarbonisation of the GB electricity network is happening at pace, introducing many changes to the way the system operates. There is a huge amount of work going on across industry to enable flexibility in the energy system and ensure the grid continues to serve its core function of reliably delivering electricity to customers in the face of changing patterns, increased variability and changing levels of dispatchability in both generation and demand. One obstacle in achieving a net zero-carbon network is the need to replace within day flexibility (WDF) from fossil fuels with a system where zero-carbon resources can deliver WDF.

Determining how much total WDF is required is an essential step in moving forward with this transition and understanding how this might evolve under different scenarios. Within-day flexibility is used to match demand and generation across daily peaks and troughs, usually lasting for a few hours. A deficit in generation would be resolved either increasing the amount of energy available to the network or decreasing energy demand, and vice-versa for a deficit in demand. As the contribution to flexibility from traditional dispatchable generation decreases, it is also envisaged that demand-side solutions will increasingly be employed for flexibility, as well as other sources of generation and storage.

Project Activities

Work Package 1: Data Gathering and Pre-Processing

This work package involved collecting historical data on the variability of inflexible demand and generation, as well as weather data from average and extreme years. The data sources included Elexon for historic demand and BMU generation data, Sheffield Solar for live and historic solar PV output, and the European Centre for Medium-Range Weather Forecasts for long-term weather data. Data from these sources were pre-processed to standardise and cleanse any bad or missing data, involving steps like resampling, adjusting structures, and converting units. This process ensured that the data used for analysis was robust and reliable, providing a solid foundation for developing WDF metrics.

Work Package 2: Method Development and Literature Review

In this phase, a comprehensive literature review was conducted to identify existing methods and best practices related to WDF. The team developed a new, transparent method for quantifying the need for WDF, incorporating relevant data sources and statistical modelling techniques. The method was designed to be repeatable and adjustable, ensuring its applicability under various future scenarios. Visual diagnostics and appropriate metrics were used to evaluate the statistical models, ensuring the method's robustness. The interim results and tools developed were reviewed and refined through a series of workshops, ensuring stakeholder engagement and feedback.

Work Package 3: Analysis and Sensitivity Testing

This work package focused on applying the developed method to the data gathered in Work Package 1. The resulting time-series were combined with future-looking data from Future Energy Scenarios (FES) and summarised with metrics that are able to characterize the future need for WDF from different angles. Sensitivity analyses were conducted to understand the impact of different assumptions and uncertainties on the WDF need. The analysis highlighted the variability and uncertainty in future projections, providing insights into how WDF requirements might evolve under different scenarios. The results were discussed with stakeholders to ensure the method's transparency and credibility.

Work Package 4: Tool Development and Final Reporting

The final phase involved developing tools in Python to automate the WDF quantification process. These tools were designed to be user-friendly, allowing stakeholders to repeat the calculations and explore different scenarios. The final report documented the method, tools, and results, providing a clear explanation of how the method works and why it was selected. The report also included proposals for future work, addressing potential improvements and further applications of the method. The project's outputs were handed over to stakeholders, ensuring they could build upon the work and adapt the tools for their needs.

Project Outputs and Conclusion

The project successfully developed a robust, transparent method for quantifying the need for WDF, providing a critical tool for planning and operating a zero-carbon energy system. The method and tools created during the project will enable the ESO and wider network licensees to estimate future system requirements with greater confidence and precision. This will help reduce the extra capacity required to manage uncertainties, ultimately lowering the cost of ensuring system security. The project's findings and tools have been shared with industry stakeholders, promoting further development and application of the method. By addressing the need for a rigorous WDF quantification method, the project has made a significant contribution to the ongoing transition to a zero-carbon energy system.

Required Modifications to the Planned Approach During the Course of the Project

Change to approach

- The final report doesn’t include a section showing an initial literature review, to compare any previous approaches to the proposed method, because a limited number of relevant resources have been found, mainly focused on the solution to the need, rather than on its quantification. For this reason, there is not a justification of why this is the best method compared to others, as the literature review didn’t reveal any suitable method.
- A conservative approach was used to model demand, in particular EV and HP demand, which have a flexible and an inflexible component. However, due to the lack of data and the high uncertainty around future contribution to flexibility from end-users, all demand was assumed as inflexible.

Change to cost

A 10% increase of the total cost was necessary to reduce the code run time from several hours to few minutes.

Lessons Learnt for Future Projects

When the model was fully developed and run internally by ESO colleagues, the code run time was on the order of several hours. A code optimization has been requested, which caused a 10% cost uplift, but allowed us to have a code 40 times faster. Unfortunately, delivering an optimized code wasn’t among the initial requirements for this project.

Over the course of the project and once the interim report was issued, the project team realized that the challenge of dividing the flexible component from the inflexible component of certain type of demand (in particular electric vehicle and heat pump demand) was underestimated. Currently, the method uses a conservative approach, assuming all EV and HP demand as inflexible, due to the lack of large public datasets able to show profiles of engaged and not engaged consumers, as well as predictions on how consumers will behave in the future.

Note: The following sections are only required for those projects which have been completed since 1st April 2013, or since the previous Project Progress information was reported.

The Outcomes of the Project

The project addressed the challenge of replacing fossil fuel-based flexibility with sustainable alternatives by establishing a robust methodology to calculate within-day flexibility (WDF) needs. This methodology, based on probabilistic modelling and detailed time series analysis, enabled a comprehensive understanding of both typical and extreme values of WDF requirements under various future scenarios, ensuring the grid's reliability amidst increasing renewable integration and shifting demand patterns.

The project's rigorous approach to defining and measuring WDF needs incorporates unmodified generation and demand behaviours, distinguishing between inflexible and flexible resources. By excluding controllable behaviours from the WDF calculation, the methodology accurately captures the true flexibility requirements of the grid. The inclusion of extensive historical data and sensitivity analyses further strengthens the model's reliability, allowing it to accommodate future uncertainties in technology uptake and behaviour changes. This detailed analysis highlights wind generation as a primary driver of WDF needs.

Overall, the project equips the ESO and network licensees with a sophisticated tool for assessing and planning for within-day flexibility needs, which is critical for maintaining grid stability in a decarbonized energy system. The use of Python ensures the methodology's scalability and adaptability, providing a foundation for ongoing improvements as input data evolves. Importantly, this outcome represents a significant advancement over previous methods by focusing exclusively on understanding WDF need without conflating it with flexibility solutions. This approach maintains the methodology's integrity and ensures its applicability to future energy scenarios.

Data Access

Details on how network or consumption data arising in the course of NIA funded projects can be requested by interested parties, and the terms on which such data will be made available by National Grid can be found in our publicly available “Data sharing policy related to NIC/NIA projects” and www.nationalgrideso.com/innovation.

National Grid Electricity System Operator already publishes much of the data arising from our NIC/NIA projects at www.smarternetworks.org. You may wish to check this website before making an application under this policy, in case the data which you are seeking has already been published.

Foreground IPR

TO BE FILLED.

Planned Implementation

During this project, several avenues for future work have been identified, including but not limited to:

- Modelling spatially disaggregated need. This would increase the computational complexity as a separate set of rescaled time series would have to be fitted per area.
- Data on offshore wind connection points and other locational information necessary may not be publicly available.
- This work is based on historic weather data, albeit rescaled to represent current demand and generation levels and patterns. This could be extended to consider future climate projects data, although this would mainly benefit results looking further into the future than 2035, and the results of this could depend heavily on the emissions pathways considered.
- Similarly, there is ongoing research looking at correcting historic extreme events to reflect the current or future climate. This work is not mature enough to incorporate yet but may be of future interest.
- Refinement and further investigation of the behavior of individual component models, in particular heat and transport demands. As more complete datasets before unavailable for new technologies, these component models may be updated, either by replacing the input profiles or by introducing more complex modelling if the data allows.
- Consideration of the most meaningful and intuitive extreme value statistics, and the distribution through time of these extremes. For example, for a 1-in-10-year threshold, does it matter whether all 4 events are clustered in the same year in a 40-year period?
- The answer to this question determines whether one tail model should be fitted to all data at once, or to individual years separately: the current implementation allows both approaches, but only the overall extreme quantiles have been given in the report. Fitting separate models to each year might require different approaches for partially pooling data (such as random effects models or Bayesian hierarchical models) to overcome the small sample size when looking at daily metrics (where there are only 18 days beyond the 95th quantile).
- Similarity and clustering of days of similar WDFN. This work has treated all days as completely independent from each other, but it is likely there are relationships between adjacent days (correlations) that could affect the ability of flexibility sources to deliver consistently.
- Persistence of levels of WDF. By defining a fixed cutoff for each day, some persistently high or low periods of WDFN that run from the end of one day into the next could be missed. This is natural consequence of calculating the energy imbalance of each day independently, but its effect should be considered.

Other Comments

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