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.

NIA Project Close Down Report Document

Date of Submission

Jul 2023

Project Reference Number

NIA2_NGESO019

Project Progress

Project Title

Peak Demand Forecasting

Project Reference Number

NIA2_NGESO019

Project Start Date

August 2022

Project Duration

0 years and 6 months

Nominated Project Contact(s)

Robbie Mulvany (NGESO)

Scope

The analysis and knowledge generated in this project will provide:

- Improved understanding of peak demand forecasting in demand modelling.
- Enable improved accuracy and risk analysis of forecasted demand.
- Better capture of the forecasting uncertainty that feeds into the capacity markets, supporting BEIS' ambition to interpret forecasts based on appetite for risk.
- Recommendations of further steps for follow on work.

Objectives

This project will follow a staged approach, based on an initial exploration stage followed by a more in-depth analysis stage. This will provide the opportunity to identify data that could improve or validate assumptions derived in the preliminary stages of the analysis.

The objectives are as follows:

- Create a written report highlighting key uncertainties in forecasting methodologies and potential risk areas requiring further analysis.
- Carry out quantitative analysis of the listed contributing factors, focusing on how changes in economic activity, weather and incentives/restrictions on electricity use have impacted demand patterns to be presented in a written report and accompanying workbook.

Success Criteria

The following will be considered when assessing whether the project is successful:

- Findings from the project can be used to explain peak demand in its current state and the assumptions made from its future state to our stakeholders
- The project will improve understanding of uncertainty in NGESO forecasting methods and how to improve by targeting high return areas of improvement

- Evidence provided can support an industry discussion about risk appetite – e.g., how can stakeholders benefit from quantified uncertainty in future peak forecasts
- The project will help identify how societal behaviours that affect peak demand may change and under what conditions

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

Consumer demand for electricity varies seasonally, with peak demand usually coming in the winter when people spend more time indoors and the need for lighting, space heating and hot water is higher. Being able to forecast in advance how high that winter peak is going to be ensures we have enough generation on the system to meet consumer demand.

The Peak Demand Forecasting model we use to calculate this figure is more than a decade old, and when it was created there was much less data available. Consumer demand has also changed a lot during this time, so peak demand is now affected by different factors such as the electrification of domestic heating, the uplift in electric vehicle charging, the improved efficiency of appliances and people changing the way they consume energy. There's also more weather dependent technologies on the electricity system which impact the forecast's accuracy.
This project was setup to review the Peak Demand Forecasting model with the aim to aid rebuilding it from the bottom up using the latest research and available data on consumer energy use to improve the accuracy of the peak forecast.

Work Package 1 consisted of a literature review of historical demand drivers, future demand drivers and electricity demand forecasting methodologies. Key conclusions drawn from the literature are summarised below. Further analysis of historical data is required to ascertain the full validity of these conclusions.

The main drivers of changes to historical electricity demand are:

- Weather has been found to correlate with electricity demand, with specific considerations such as temperature, hot and cold days and extreme weather events linked with peak demand periods
- Socioeconomic factors (e.g. population demographics, income and industrial activity) are believed to be key drivers of long-term, multi-year total electricity demand trends, even more so than typical weather variations which were found to have a greater impact on monthly or annual demand profiles
- Social behaviour has also been found to influence electricity demand patterns over time, with evolving human habits (e.g. working patterns) and the adoption of various new technologies (e.g. electronic media) significantly changing the need for and timing of electricity demand, including peak electricity demand of residential consumers

Based on this review of historical trends, it is expected that future demand drivers will affect electricity demand in Great Britain as follows:

- Socioeconomic factors will continue to drive future electricity demand in the long term – the correlations between these drivers and demand are expected to evolve over time, requiring further study to form a more accurate view on future trends
- The adoption of new technologies such as smart heat pumps, smart electric vehicles (EVs), hydrogen electrolysers, and demand-side management are expected to increase the time shifting of demand away from demand peaks, whilst contributing to an overall increase in demand due to fuel switching, therefore potentially affecting the annual average to peak demand ratio
- Many studies point to the increasing impact of climate change on electricity demand – extreme temperatures in the warm and cold months are expected to increase demand for heating and cooling, while more frequent extreme weather events may also significantly affect electricity demand (greater transmission & distribution system losses are also expected as they become less efficient at high temperatures)
- Increases in embedded generation are also expected to impact transmission peaks while overall energy efficiency improvements are expected to have a minimizing effect on demand, the magnitude of which needs to be studied in further detail

Key conclusions from reviewing literature relating to long-term peak demand modelling methodology were also drawn from the reviewed literature along with NGESO's long-term demand modelling methodology:

- Bottom-up modelling, as is NGESO's current model, is well-suited for future trends forecasting where historical data is not available – a hybrid approach can be considered as more data on emerging electricity demand drivers (e.g. EV uptake and demand-side management programmes) becomes available
- For situations with historical data, multiple linear regression analysis has been found to be well suited to long-term, multi-year peak and annual demand forecasting, with potential for considering additional methods such as autoregression and artificial neural networks if more detailed forecasting methodologies are desired
- Limitations to the ACS and 1-in-20 methodologies are raised, with further analysis needed to quantify these limitations on forecasting demand moving forward, given expected changes in weather patterns, social behaviors and technology and the impact this will have on future peak electricity demand
- Current NGESO methodology and assumptions to model the relationship between demand drivers and demand are questioned
  - Changing demand profiles with the adoption of new technologies and smart technologies due to the demand/time-shifting ability of these technologies, operation constraints and changing consumer behaviors need to be incorporated into the methodology
- The current assumption of peak demand timing – in the winter months at 5-6pm, which increasingly needs to be considered alongside summer peak demand which is expected to grow in future years from a combination of increased air-conditioning uptake and increased occurrences of heat waves

The expected magnitude of change of future demand trends based on the key drivers identified is required to determine how the existing NGESO methodology can be improved upon. This highlighted further areas which were explored in Work Package 2 :

- Annual peak demand is made up of a combination of consumer behaviour & synchronisation, weather factors, socio-economic factors and policy
- Over the 5-, 10- and 30-year horizon, the factors driving changes in peak demand are likely to include behavioral change, technological advancement and uptake, fuel switching in heat and transport, policy and embedded generation buildout
- Peak demand is expected to be a combination of individual consumption components that align with the predominant synchronous factors

Work Package 2 aimed to present findings from a statistical analysis of the main drivers of peak electricity demand in Great Britain. Key conclusions drawn from the analysis are summarised below.

The literature reviewed in WP1 suggested that multiple linear regression analysis is well suited to long term, multi-year peak demand forecasting, therefore we chose to focus on this approach during WP2.

Within the project timeframe, a partial least squares (PLS) linear regression model for peak electricity demand was developed, incorporating various demand drivers including weather, socioeconomic, economic, technology and behavioral factors.

The results of this analysis suggest that peak demand from historical drivers can be modelled to an acceptable degree of accuracy using the PLS linear regression model.

The model was able to predict historical peak demand with a degree of accuracy comparable to other methodologies reviewed in the WP1 literature review, obtaining a mean average percentage error (MAPE) of 5.4% compared with a MAPE of 1.4% to 7.9% seen in the literature

Further refinements to the regression model through the consideration of additional demand driver datasets and or the use of a different combination of demand drivers could yield further improvements in accuracy.

Key takeaways
Overall, the regression analysis of historical demand drivers showed that:

- Temperature was the most significant driver of peak demand out of all the demand drivers captured in the regression model
- The next most significant drivers of demand were day of week and seasons, suggesting a strong behavioral contribution to peak demand historically

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

After continued discussions with Aurora the team continued to refine the outputs and the scope was expanded to incorporate more datasets that weren't initially outlined.

Additionally, working arrangements and the timing of the project coincided with summer annual leave which meant that there was limited opportunity for in person workshops during the project, and it was difficult to gather all interested parties. However, many of these workshops were successfully conducted virtually with good attendance.

Lessons Learnt for Future Projects

Working arrangements

The project was undertaken during the latter stages of the pandemic and as such the meetings were carried out remotely. On the whole this worked well, but the project would have benefitted from some in person workshops, to collaborate on some spontaneous idea generation and discussion.

Methodology

Electricity demand is currently going through a period of change, with the movement towards net zero. Aurora have suggested a base regression model for demand forecasting. This has been constructed using traditional drivers based on their literature review: Temperature, day factors (weekend, weekday, bank holidays…). The model performed well during their tests, particularly in the near term. However, incorporating new demand behaviours such as: electrification of heating and transportation, requires alternative modelling methods and this will become increasingly important as the forecast covers deeper into the future. In the second phase of their work Aurora have considered these factors and proposed a hybrid model, utilising the original regression, along with individual demand elements that were derived from small datasets. From the methodology, the key learning point is that there is much more to do, the project has identified that many of the items highlighted in the list below are almost mini projects in there own right. Key areas within the method requiring additional understanding based on learning from the project:

- Further development of the regression model and its drivers.
- Analysis of the relationships between the individual drivers.
- Individual studies on new areas of demand and their effect on the peak forecast:
  - Electrified heat;
  - Electrified transportation;
  - Hydrogen production;
  - Behavioural changes (residential, industrial, commercial);
  - Timing of peak for different demand groups.
- Develop an optimal hybrid technique for compiling the individual demand methods.
- Consider a bottom up modelling technique.
- Investigate the effect of alternative peak periods, not just winter.
- Incorporate global climate models.
- Introduce price forecasting elements.
- Carry out inflection point analysis.

Data

One of the key challenges faced by the team was the acquisition / availability of high-quality high-resolution data. This was particularly noticeable within new peak demand drivers, as little, or no data was currently available. The learning suggested that creating relationships with third party providers, such as academic institutions, or research institutes, could provide major benefits to further studies.

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 produced an initial model along with accompanying documents outlining the research findings, build method, model performance and suggested areas for future development.

The two reports listed below are published on the Smarter Networks Portal and learnings have been incorporated into FES 2023:

- Peak demand forecasting methodology
- Historical analysis of peak electricity

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/SIF projects on the Smarter Networks Portal (www.smarternetworks.org) and National Grid ESO Data Portal (data.nationalgrideso.com). You may wish to check these websites before making an application under this policy, in case the data which you are seeking has already been published.

Foreground IPR

The following Foreground IPR will be generated from the project:

- WP1 Report with key uncertainties in forecasting methodologies, challenge areas where there is a risk to assumptions being made and suggested areas to be studied in more depth.
- WP2 report outlining the project, assessment of hypothesis with recommendations for further work plus accompanying workbooks.

Planned Implementation

The High-Resolution Residential Demand project has already incorporated some of the outputs and findings from the Aurora work. The sector modelling of Transport, Heat, Industrial and Commercial, are continuing to develop their capabilities including the level and timing of peak demand. Also underway is a project looking at data requirements for the future system operator, this has captured the additional data deficiencies outlined by Aurora.

The project has delivered learnings that will draw benefits to wider network licensees through improved modelling accuracy of peak demand included in the Future Energy Scenarios. The ability to forecast peak demand more accurately with new data and methodologies is also helping ESO maintain a stable and reliable electricity supply, as the GB energy landscape continues to change. Our better understanding of the rationale behind peak consumer demand is also helping to de-risk operations and set the groundwork for other legacy models used by the control room the demand team to be updated in the future.

The outcomes of this project have also sparked further discussions on how we can continue to improve our modelling capabilities and discussions are ongoing around potential follow-on projects around sector modelling of Transport, Heat, and Industrial and Commercial.

Other Comments

The Project outcomes and results contain confidential information and intellectual property rights that cannot be disclosed in this Report due to their proprietary nature. Should the viewer of this Report (“Viewer”) require further details this may be provided on a case by case basis following consultation of all Publishers. In the event such further information is provided each and any Publisher that owns such confidential information or intellectual property rights shall be entitled to request the Viewer enter into terms that govern the sharing of such confidential information and/ or intellectual property rights including where appropriate formal licence terms or confidentiality provisions. Dependent upon the nature of such request the Publishers may be entitled to request a fee from the Viewer in respect of such confidential information or intellectual property rights.

Standards Documents

No new standards have been developed or implemented through this project.