Low Demand- Operability Challenges from COVID-19 (spring and summer 2020)

A System Operability Framework document

January 2021

nationalgridESO

Executive Summary

The COVID-19 pandemic led to partial or total lockdowns in Great Britain in the spring of 2020, which in turn caused a reduction in electricity demand. This low demand, combined with large renewable output at times, resulted in a high penetration of non-synchronous machines on the system. This combination led to challenges with demand forecasting and maintaining flexibility for system integrity, voltage profiles and system stability. This paper provides a brief on the challenges in 2020 which National Grid ESO faced, the measures applied to tackle the challenges and the work we will look to carry out to improve the system operability in the future. More information regarding these challenges and what we are doing about them can be found in our Operability Strategy report.

Background

The UK was put into lockdown on the 23rd of March in an unprecedented step to limit the spread of coronavirus. People were not allowed to leave their homes except for essential activities, and industrial activity was reduced.

The demand for electricity was suppressed during the pandemic. With low demand, various challenges became significant for system operation, including:

- We needed to ensure sufficient negative reserve and high frequency response was available to balance generation and demand. Under these record demand levels additional flexibility was required. National Grid ESO used a new commercial tool, Optional Downward Flexibility Management (ODFM), to reduce generation output and therefore provide extra downward magin.
- There were fewer options to control system voltage due to fewer generators being connecting to the system, along with lightly loaded circuits leading to a higher voltage profile. Additional analysis was carried out to identify potential issues and to work out mitigating solutions with collaboration from all stakeholders, including Transmission Owners (TOs) and generators.
- As a significant proportion of demand in GB has been met at times from renewables, low levels of inertia driven by high penetrations of non-synchronous renewable generation resulted in action been taken to ensure there were no frequency stability issues. The ESO identified a series of additional tools to address stability related challenges.

Demand Forecast

In order to assess the influence of the lockdown on electricity demand, high level impacts were estimated for the three most significant demand types as follows:

Domestic – Increased

- Working from home and travel restrictions meant that people spent more time at home
- Closure of schools/ nurseries/ universities/leisure places led to an increased usage of electronic devices

Commercial– Decreased but not dramatic

- Demand for lighting and heating of commercial properties decreased
- Computer usage shifted into domestic group
- Warehousing/ storage/ food refrigeration assumed to remain constant

Industrial– Fell sharply, but with uncertainty on the evolution of the pandemic

- Many businesses in pause
- Pressure from childcare and schools

Three alternative demand scenarios were developed for operation during the restrictions , including low impact, medium impact and high impact scenarios as expressed in Table 1 as a proportion of BAU demand. The forecasted reductions of the demand due to Covid -19 against business as usual was in a range from 4% in a low impact scenario to 20% in a high impact scenario [1].

Table 1: Scenarios for GB demand

	Overnight			
Scenarios	Domestic	Commercial	Industrial	Total
BAU	20%	40%	40%	100%
Low	20%	39%	39%	98%
Medium	20%	38%	34%	93%
High	20%	37%	30%	87%
	Daytime			
Scenarios	Domestic	Commercial	Industrial	Total
BAU	33%	33%	33%	100%
Low	33%	31%	31%	96%
Medium	33%	26%	27%	87%
High	33%	23%	24%	80%

The variations (%) of national demand outturn before and during the lockdown are also represented in Figure 1. The reduction of the in-day demand due to the Covid -19 restrictions was in the range of 5%-20%. The reduction of the overnight demand was between 2%-15% (Bank Holidays are excluded) during April and May. The black vertical lines on the graph indicate when the lockdowns were introduced in the UK. The chart shows the outturn demand falls within the reductions in the ESO demand forecast model which was specially developed for Covid-19 pandemic (Table 1).

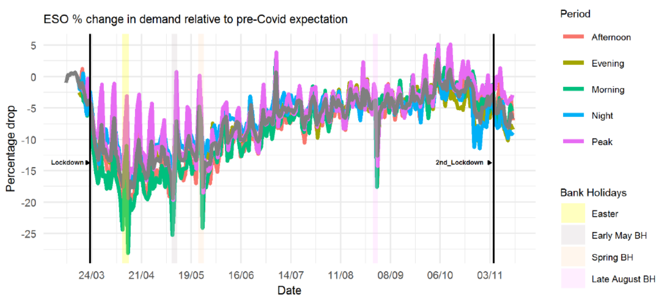

Figure 1: variations (%) of national demand outturn before and during the lockdown

Whilst the reduction in transmission system demand was most significant during daytime, our lowest ever observed national demand occurred during the lockdown during night-time: 13.4GW, overnight on Sunday June 28th 2020.

Another new development which helped ESO manage the electricity system while demands were low was to develop and use more granular demand forecasts. Forecasts were provided for each Grid Supply Point (GSP), the key nodes of the network, with a Half-Hourly (HH) resolution. Demand forecasts are normally only required on a system wide level for different cardinal points, which are the points which can normally be used to characterise the electricity demand curve during the day (the evening peak for example). With a newly developed deep-learning AI algorithm, an energy forecast (including demand, wind and PV forecast) was performed for each GSP in the network. This was derived from historical data from the past few years and the weather forecast from the Met Office. The HH resolution enabled more accurate analysis for any periods of the day, and for better coverage of any areas of interest during the period where restrictions meant that our cardinal points could not represent the demand curve as effectively as normal.

The new GSP level demand forecast was fed into the ESOs Offline Transmission Analysis application (OLTA), allowing a better assessment. The learning from this work will feed into the development of the ESO's facilities for demand forecasting known as the Platform for Energy Forecast (PEF).

Downward Flexibility

The Grid system needs downward flexibility to ensure generation can be brought down to meet the demand level and manage any uncertainties in doing so. For significant periods during the COVID-19 restrictions, there was a risk that the available generation and supply mix did not allow for the reserve to manage the frequency second by second. Optional Downward Flexibility Management (ODFM) was a new commercial tool developed to provide necessary flexibility. As all our normal routes to accessing negative reserve such as the balancing mechanism, interconnector and bilateral trades were expected to be fully utilised, ODFM was created to give our control room an additional tool to operate the system safely and reliably, by reducing the amount of electricity supplied at the local distribution network level.

Many embedded generators and demand consumers participated in ODFM as service providers which had not previously participated in any flexibility mechanism . They provided service information on a weekly basis including bid prices, volumes and availability window. Volumes needed were assessed at Day-ahead and dispatch instructions issued based on cost order and other operational considerations. Figure 3 shows the weekly process.

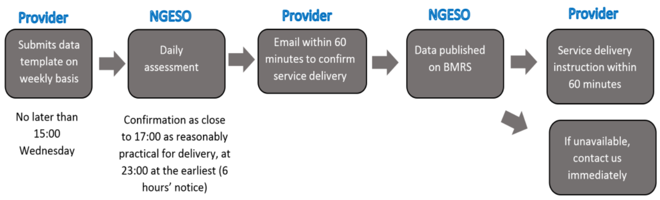

Figure 3: Weekly process of ODFM

The ODFM service is a simple mechanism which instructs either embedded generators to reduce output to 0MW or demand assets to sustain a consistent increase in demand for the specified time. The total volume required varied from 0-3GW and in total 4.77GW of generation signed up to be available. This was made up of predominantly embedded wind (1.2 GW) and solar generation (2.7 GW), but it also included a number of demand turn-up assets. The requirement for ODFM usually applied for weekends (23:00-17:00) but could be enacted on weekdays (23:00-7:00), in the case of a low demand with high wind or PV output.

ESO assessed the need for ODFM for critical low demand periods, usually for each weekend, and included the effect of network conditions which could affect the dispatch of ODFM service. Relevant information from the assessment was shared with Distribution Network Owners (DNOs) to allow any potential restrictions on the distribution network regarding the ODFM service to be fed back to the ESO.

The OFDM service was used 5 times during 2020, with a total cost of the actions of approximately £7m. Table 2 shows the occasions on which ODFM was instructed.

Table 2 Instructed ODFM occasions

Delivery date	Delivery period	MW capacity of ODFM	Fuel type
10th May 2020	04:00 – 07:00	411	Wind and demand turn up
23rd May 2020	23:00 – 19:00	2633	Combined Heat and Power (CHP), demand turn up, load bank, solar and wind.
24th May 2020	23:00 – 10:00	1610	CHP, demand turn up, solar and wind
25th May 2020	09:00- 18:00	1578	CHP, demand turn up, solar and wind
5th July 2020	00:00 – 20:00	3177	wind, solar, load banks, energy from waste, biomass, CHP and demand turn up

These instructions were used both during daytime (due to high solar output) and night time periods (as demand is lowest during night). It is noted that three of these five OFDM instructions occurred on the bank holiday weekend in May (22nd to 25th of May). Electricity demand is traditionally lowest in GB during bank holidays and weekends. More information and market data about ODFM service can be found in NGESO website [3].

Voltage

The challenges of voltage management due to Covid-19 include:

- As fewer generators were self dispatched due to low demand, the number of generators which can be used to support voltage: either absorbing reactive power for steady state or recovering voltage when a fault occurs was reduced.
- Less power flow across the network increased reactive gain from lightly loaded circuits.
- Less reactive power is consumed thus need more reactive capability to absorb excess reactive power .
- Whilst safe working practices were being developed, less resources were available for reactive equipment maintenance, e.g. bringing shunt reactors back to service if in planned outage or fault condition.

Additional actions were applied to manage voltage securely and effectively across the network covering planning and real-time operation stages, including:

- Additional offline studies were carried out to identify any potential issues within the network and to work out mitigating solutions with collaboration from all stakeholders. The analysis covered different time scales (e.g. 14 week ahead to week ahead), and different scenarios (e.g. overnight and daytime scenario). Additional effort was put into the analysis for voltage management during Bank holiday weekends. The voltage operational strategy was derived from the analysing results for Electricity Network Control Centre (ENCC) and TOs.
- Additional Super Stable Export Limit (SEL) contracts. The service has the benefit of securing reduced active power output but maintaining a certain level of MVAr capability to support voltage management. This created extra headroom to allow more generators connected to the network. Thus the voltage requirements could be met under the extremely low demand level [4].
- We also explored the possibility of switching off additional lightly-loaded circuits to reduce reactive power gain from these circuits. Some

circuits which would inject a large amount of reactive power into the network when lightly-loaded can be switched off if power flows can still be managed securely. These transmission circuits are called Voltage Control Circuits (VCC) and a number are used as a matter of routine. In order to manage voltage issues during the very low demand situation, we worked with Transmission Owners (TOs) and identified several new VCCs which were used during the Easter and May bank holiday weekends. This significantly improved system capability of voltage management in an economic way.

- ESO also explored the possibility of operating the Western HVDC link in a reverse flow direction (south to north) to assess the benefits for voltage management against any other costs/risk. Operating this way increases network flows and hence reduces voltages. It has the disadvantage of increasing system losses and can only be used to the extent that increased flows do not cause other issues. Although not used, having this option available provided flexibility in considering some of the more severe low demand scenarios which were plausible at the time.

Stability

Low demand, combined with large renewable output at times resulted in high penetration of non-synchronous machines in the system. This introduced challenges to maintain system stability.

The ESO identified a series of tools which were key to addressing stability related issues.

- The Rate of Change of Frequency (RoCoF) and Vector Shift monitor tools

ESO enhanced and recalibrated these operational tools to monitor system inertia and the trigger level of RoCoF and Vector Shift events and so we could run the system at low forecast trigger levels for RoCoF. These tools are regularly reviewed and updated to improve the accuracy and usability.

- Accelerated Loss of Mains Change Programme

The Accelerated Loss of Mains Change Programme (ALoMCP) is a programme designed to encourage embedded generation to change their RoCoF and Vector Shift relay settings to reduce the risk of unnecessary MW loss caused by faults on the transmission network. This helps ESO to manage the network and reduce system balancing issues. These changes have to be made by September 2022 to meet new requirement in the Distribution Code regardless of whether generators apply to the programme or not. To improve the resilience of the electricity network at the earliest opportunity, a 'fast track scheme' was introduced in June 2020. This pays eligible generators that meet certain criteria and have a capacity of between 500kW and 5MW an additional £5,000 if they can complete the work within four weeks of applying for funding. The detail of the programme can be found on ESO website [5].

Conclusion and Future Work

The GB power system encountered unprecedented low demands due to the impact of Covid-19 restrictions in 2020. The low electricity demand leads to several operability challenges. National Grid ESO successfully applied the following measures to tackle the issues which we have to face during pandemic.

Forecasting

COVID-19 restrictions led to a significant reduction in electricity demand and required National Grid ESO to develop new ways of dealing with electricity demand across different consumer sectors. The recorded outturn demand aligned well with the forecast.

ESO has also established a deep-learning AI algorithm to enable energy forecast for each GSP in the network with a Half-Hourly resolution. A method which was developed to use forecasts at a local level to assess network voltage performance.

ODFM

Due to Covid-19 additional downward flexibility was required to reduce generation. ODFM gave ESO an additional tool to operate the system safely and reliably, by reducing the amount of electricity supplied at the local distribution network level. 4.77GW of generation signed up for this service, predominantly embedded wind (1.2 GW) and solar (2.7 GW), but also a number of demand turn-up assets. This service was instructed 5 times during the COVID related restrictions of 2020.

Voltage

Reduced support for voltage, and lightly-loaded circuits resulted in a higher voltage profile during the pandemic. Additional generation services were used to control voltage as were additional operational measures such as the use of Voltage Control Circuits and wider network reconfigurations. ESO worked closely with TOs' maintenance teams to facilitate good levels of reactive equipment availability.

Stability

Fewer synchronous generators connected to the system due to low demand caused by Covid-19 resulted in risks for stability and lower system inertia. Operational tools were developed to monitor system inertia and the trigger level of RoCoF and Vector Shift events. ESO also progressed the Accelerated Loss of Mains Change Programme (ALoMCP) to incentivise embedded generation to change its frequency relay settings to reduce the risk of unnecessary MW loss caused by inadvertent tripping event in transmission network.

As experienced during the pandemic, the electricity system will continue to experience lower inertia in future. The number of significant losses, and their absolute size, will also increase as we welcome new interconnection and offshore wind onto our system. Therefore, system frequency is moving away from 50Hz more rapidly as a consequence of imbalances and lower inertia. Managing low inertia is a key element of our 2025 zero carbon ambition.

Our stability pathfinder work is creating opportunities to provide inertia and short circuit infeed. We have worked with stakeholders in exploring and developing our understanding of the requirements and examining the technologies available to support stability. Much of this work has been world leading, with further innovation required to progress the deployment of solutions.

Over the next few years, the ESO aims to deliver a new suite of faster-acting frequency response services to support our operations as the electricity system is decarbonised and to ensure that these new services enable a level playing field for all technologies. Dynamic Containment (DC) is the first of our new end-state services that is designed to act rapidly when triggered by a fault on the system – for example the loss of a generator – to catch and 'contain' the resulting deviation in frequency. It has significantly boosted our ability to respond rapidly to disturbances in the flow of electricity around the grid. We have created a new market, based on daily auctions, so that suppliers can offer this new service in a way that ensures value for GB consumers. The speed and flexibility of batteries make them particularly well-suited to the task, but any technology type can take part and we anticipate a wider range of providers participating in the future.

Reference

[1] "Electricity summer outlook report," https://www.nationalgrideso.com/document/167541/download

[2] "Energy Forecasting Strategic Project Roadmap," https://www.nationalgrideso.com/document/145941/download

[3] https://data.nationalgrideso.com/ancillary-services/optional-downward-flexibility-management-odfm1

[4] https://www.nationalgrideso.com/industry-information/balancing-services/reserve-services/super-sel

[5] https://www.nationalgrideso.com/industry-information/accelerated-loss-mains-change-programme-alomcp/key-documents

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