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	Project Reference Number
Jul 2024	NIA2_NGESO025

Project Progress

Project Title

3MD (Market Monitoring Model Development)

Project Reference Number

NIA2_NGESO025

Project Start Date	Project Duration
November 2022	1 year and 0 months

Nominated Project Contact(s)

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Scope

Whilst ML and hidden variable models are used across multiple innovation projects for different purposes and also in other industries and organisations outside of the ESO, they have not been applied in a utility for a similar purpose.

Learnings will be shared within the ESO where applicable, however this will be a non-default innovation project and, as such, detailed findings and models will not be shared externally.

Ultimately, knowledge of enhanced monitoring capabilities being used, may encourage market participants to better consider REMIT and Grid Code requirements as they develop new trading strategies and support the market monitoring team in working with trading parties to reduce instances of potential breaches. This may reduce costs to consumers through a reduction in incidents of prices that do not directly result from normal market supply and demand interactions. It will also enable detection of changes in pricing or positioning in response to the management of system conditions, reducing the risk for exploitation of dominant market positions where they arise because of geographic or technological monopolies.

Objectives

1. Develop methods for out-of-characteristic market prices, physical positions in response to system operability issues such as constraints by applying statistical techniques to identify potential market abuse.
2. Develop methods for detecting and characterising anomalies.
3. Enhance current manual investigative techniques by using multiple new data sources to generate alerts. This will enable detection of cross market events and ensure alerts better consider market externalities, reducing false positives compared with current monitoring systems.
4. Enable models of pricing and positioning to be developed that are individual to Balancing Mechanism Units (BMUs) which each have different economic drivers and therefore will behave differently given the same set of system and external conditions.

Success Criteria

The project will be successful if it improves potential REMIT breach detection and provides contextual information regarding pricing and positioning this will be tested through:

1. 90%+ effectiveness at detecting known anomalies within historic datasets
2. An input/output method that enables live system data to be assessed in this way
3. A low level on the number of false positive investigations to review

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

National Grid Electricity System Operator ("NGESO") has endeavoured to prepare the published report ("Report") in respect of 3MD (Market Monitoring Model Development), NIA2_NGESO025 ("Project") in a manner which is, as far as possible, objective, using information collected and compiled by NG and its Project partners ("Publishers"). Any intellectual property rights developed in the course of the Project and used in the Report shall be owned by the Publishers (as agreed between NG and the Project partners).

The aim of the project is to develop sophisticated statistical analysis-based tools for anomaly detection to increase the efficiency of the market monitoring team's activities and widen the scope of automated alerts received. These tools are scalable to new balancing services and increasing market participant numbers.

The project is exploring methods to identify types of possible market manipulation in the Balancing Mechanism. It seeks to apply core principles set out in the REMIT legislation and review balancing mechanism pricing, physical positioning, and any systematic patterns related to network constraints. These were split out into different work packages and ordered such that each one builds on the previous work package. Each of these packages will develop methods for detecting and characterising anomalies with datasets from ESO internal databases and external data sources, create ways of displaying the resulting information for the market monitoring team and produce a report and proof-of-concept code for finding the anomalies and displaying visualisations.

WP1 – Exploratory data analysis and error removal (07/02/2023 – 21/03/2023)

Due to the complexity and number of datasets provided as part of this project, exploratory analysis will naturally be a part of each work package where analysis is conducted with the different datasets to improve understanding of the data. However, WP1 was established to build the initial knowledge and understanding of the complex datasets to start preparing some of the data and conduct some initial analysis to explore whether it would be feasible to build an anomaly-based tool for at least WP2. As part of WP1, a data workshop was hosted with project partner Hartree to support and walkthrough relevant datasets and reaffirm the direction and outcomes the team would like to see. In addition, a data dictionary was produced by the market monitoring team detailing every dataset shared with descriptions for each column of data. The outcomes of the work pack were three commented Jupyter Notebook reports covering analysis of the datasets and the different filtering and error checking that was applied. This resulted in the market monitoring team streamlining what datasets to utilise for future development project requirements.

WP2 – Price based anomaly detection (22/03/2023 – 16/06/2023)

Work pack 2 focused on building an anomaly detection-based tool for evaluating offer prices in the balancing mechanism. Exploratory analysis was undertaken initially to start scoping ideas for models which could be utilised to fit the team's requirement and data. Weekly meetings between the market monitoring team and Hartree was the adopted approach throughout the project to allow analysis and feedback to be shared across teams. Two models were explored as part of this work pack: isolation forests and matrix profiling. Hartree provided annotated Jupyter Notebooks exploring both methods and how they could be applied for anomaly detection of offer pricing were produced including separate Jupyter Notebooks for the ability to run each tool. The market monitoring team tested and discussed the benefits and cons of each approach and decided to adopt the isolation forests model. The team were then able to configure the isolation forest model to connect directly to ESO's internal database with live up-to-date data to run as an ongoing tool to be utilised by the team. The team since the completion of this work pack have been utilising the model to evaluate anomalous based offer pricing.

WP3 – Position based anomaly detection (19/06/2023 – 08/09/2023)

This work pack built upon the previous one to evaluate anomalous physical notification submissions whilst incorporating changes to

offer pricing. The same structure of exploratory analysis of new additional datasets and tool development was conducted. Two models were explored as part of this analysis: isolation forests similar to work pack 2 and Kmeans clustering. Alongside these two models, bespoke analysis was also conducted utilising physical notification data to highlight significant changes to physical notifications in conjunction with changes to a unit's offer pricing. Following testing of the models, it was decided that the two models through the Isolation Forest and Kmeans clustering approaches would be useful to utilise and adopt in the work as part of WP4 with the addition of adding constraint data. However, during the timespan of work pack 3, the Inflexible Offer Licence Condition (IOLC), a new licence condition which would prohibit electricity generators from taking advantage of dynamic parameters in order to obtain excessive benefit in the balancing mechanism, was announced and within industry consultation. With the knowledge that the market monitoring team would be required to monitor against the licence ongoing, the bespoke PN analysis completed as part of work pack 3 was configured by the team to add the additional elements under IOLC. A process was then created to be able to produce alerts to monitor against the new licence condition on day 1 of the licence condition being active.

WP4 – Constraint based anomaly detection (11/09/2023 – 01/12/2023)

Work pack 4 continued to build upon the previous work packs to include constraint data comparing both physical notifications and pricing of units when constraints are active against periods without constraints. Two avenues of analysis were explored as part of this work pack: assessing offer pricing of units in and outside of constraints at differing timescales and assessing bid pricing in conjunction with physical notifications and changes to these. The outputs of these were two models, one utilising statistical analysis and advanced filtering and the other an isolation forests approach. These models have yet to be embedded to read data from ESO's live database, however, will be configured to do so by the team across FY25.

WP5 – Dynamic Parameters anomaly detection (04/12/2023 – 01/03/2024)

The final work pack was rescoped from an optional implementation work pack to a final anomaly detection focusing on dynamic parameters. This change was made due to the successful implementation of the previous work packs extracting data from ESO's live database as part of the project and thus there was no longer a requirement for implementing the models created. Therefore, to expand on the models that were being produced, work pack 5 was rescoped to focus on a new area of dynamic parameters submitted by units into the balancing mechanism. The outputs of this work were a retrospective bespoke analysis piece looking at all submissions and changes of dynamic parameters up to 10 years of data assessing different units and fuel types; whilst the other piece built a model for anomaly detection of the dynamic parameters to be able to run for future ongoing use utilising the isolation forests model.

Overall, the project has been a success with tools and models produced for each work pack which the team has already been utilising and embedded as part of core monitoring activities, including identified cases which have been escalated to Ofgem and has triggered more detailed investigations into market participant behaviours. These have delivered against the original aim of the project with each work pack fulfilling the required outcome. The work packs were scoped in a way that if a meaningful output could not be reached, then it would be evaluated whether the project would continue or explore a different area as a 'fail fast' approach. However, each work pack delivered sophisticated analysis and models that the team could utilise to assess anomalous transactions or have bespoke analysis which will be investigated in greater detail.

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

Before the project started, there was a delay of the commencement of the project with the original start date being 01/11/22 in comparison to the revised start date of 07/02/23. This was the result of ensuring all security requirements were met and agreed on both sides by the ESO and Hartree given the scale of data intended to be shared and the confidentiality. The revised and updated timescales of the project can be found in the section above.

There was also a change to the sources of data in the exploratory analysis as part of WP1. The original scope was to purely focus on data from within ESO's internal database. However, this was expanded to include a range of public platforms and datasets. These were included as not only did some datasets provide valuable information which would not have been covered by internal datasets alone, but it was valuable to determine whether public datasets would be sufficient to reduce the reliance on integration to secure internal databases.

As referenced in the section above, the Inflexible Offer Licence Condition (IOLC, was announced during the timespan of work pack 3. As a result of this change, the bespoke PN analysis completed as part of work pack 3 was configured by the team to add the additional elements under IOLC. A process was then created to be able to produce alerts to monitor against the new licence condition on day 1 of the licence condition being active.

The biggest change throughout the course of the project was the rescoping of the original WP5 which was aimed to be an optional

integration and implementation work pack to support the configuration of the outputs to extract data directly from ESO's live database. However, the team had the capability to start configuring these work packs independently and start embedding them into ESO's environment and team's processes. Therefore, it was decided that given the successful outcomes of the work packs that had already completed, it would be worthwhile to rescope the optional work pack to be an expansion of the other work packs to continue and build additional anomaly-based detection models. This change went through the internal innovation budget allocation and rescoping process and was successfully approved. The led to a total increase of £26,326 from the original scope.

Lessons Learnt for Future Projects

The conclusion to WP1 determined that some internal datasets would enhance the capability of the tools for monitoring the types of manipulation and there were fundamental differences in naming conventions between the ESO and public datasets selected. It was considered not beneficial to continue conducting analysis on all these datasets given the volume of data provided in WP1 and especially where the data provides a similar level of information. Therefore, it was concluded to focus on a subset of data from the ESO database with some public datasets for the development of the models in the future work packages.

Despite having WP1 as a dedicated exploratory analysis phase, one of the main lessons learnt was to ensure that there was sufficient time across the first half of each work pack to enable Hartree Innovation Centre to understand the additional new datasets they would be analysing and to understand our requirement. Given the complexities and scales of both the datasets and asks of the project, it would require time for Hartree to be able to digest and understand the data before being able to start conducting analysis and consequently build the anomaly-based models. This was an integral part of the process and thus we maintained our weekly catchups across the whole lifespan of the project to allow consistent feedback and questions to be asked.

The other key lesson learnt was being prepared for the following work packs especially in relation to the data extraction. The team would discuss ideas and determine what outcome from the next work pack would be an ideal and successful outcome as well as prepare materials for Hartee Innovation Centre to provide background information required for the delivery of the upcoming work pack. However, the duration of time it would take for the required data extraction was not always considered and thus work packs would be initiated without all data having been provided to Hartree Innovation Centre. This resulted in some small delays in the initial start of the work packs. Earlier consideration for the time intensity of data extraction and planning would have resolved this.

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 successful outcome of the project will be a new suite of tools which would allow for anomalies to be identified and investigated by the market monitoring team against the different REMIT principles. The tools are integrated into market monitoring processes and are understood and utilised within the team. At the end of WP2-WP4, a report describing the methods for finding and characterising anomalies for the type of manipulation alongside a proof-of-concept code for extracting the anomalies with visualisations will be produced. In the instance where the behaviour can't be detected with the required confidence, the difficulties and the possible routes to improve the data will be identified.

Working with Hartree Innovation Centre we have created anomaly-based detection models for each of the focused possible types of market manipulation identified as part of the project scope. Throughout the progress of the project these models have been embedded into market monitoring processes incrementally as each piece of work has completed to generate more sophisticated alerts to review. This includes monitoring price levels of balancing mechanism units and creating a new process to assess cases against the new Inflexible Offer Licence Condition (IOLC).

Each work pack produced commented Jupyter Notebook scripts showing the methodology and steps for processing the data into the anomaly-based models as well as example outcomes of the model which were tested and feedback to Hartree Innovation Centre throughout the project. These scripts are fully configurable and with the comments throughout the scripts allows for easier future proofing if additions need to be made in the future following changes to the data or market.

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

Given the nature of the project being the development of market monitoring tools which is considered a ring-fenced area and analysis being completed on confidential ESO data, the reports produced from this project will not be shared externally This project was approved by Ofgem as a non-default NIA project in August 2022 allowing deviation from the default NIA rules.. However, where possible, outputs of the project and the methods used will be shared.

Planned Implementation

Throughout the course of the project, the outputs from work packs 2 and 3 have been embedded to extract data from ESO's live database and implemented into market monitoring processes. These tools are producing alerts for the team to review.

The outputs from WP4 and WP5 have been tested using the same manual datasets provided to Hartree and work successfully. These work packs have yet to be embedded into the ESO's live systems and the team's processes but is planned to be completed during the course of FY25.

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.

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