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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

Jun 2022

Project Reference

NIA_NGSO0028

Project Progress

Project Title

Study of Advanced Modelling for Network Planning Under Uncertainty

Project Reference

NIA_NGSO0028

Funding Licensee(s)

NG ESO - National Grid ESO

Project Start Date

October 2019

Project Duration

0 years and 11 months

Nominated Project Contact(s)

Thomas Petty

Scope

The overall aim of this project is to identify potential alternatives and opportunities for new planning methodologies that evaluate both technical and economic aspects in a more integrated manner and introduce flexibility and risk awareness in dealing with large-scale planning uncertainty. Differently from other projects that may look at testing specific solutions, this project will investigate more fundamental and wider aspects of how the current planning process could be improved to deal with an evolving energy system, new technologies and potential operational solutions, and addressing long-term uncertainties in a more systematic way. Clear recommendations will be produced for how new techniques could be adopted to enhance the overall planning process in light of all the relevant emerging issues and opportunities.

Objectives

The project will undertake the following objectives:

- Review/identify issues with the current deterministic planning processes and standards
- Review the state-of-the-art methodologies for energy system planning under uncertainty
- Review/identify issues with the current (i.e., one snapshot-based) technical modelling used in planning
- Outline a general decision-making framework for planning under uncertainty, e.g., to inform/extend the current NOA process
- Define the key and most desirable elements and methodological options for such a framework, for example based on stochastic optimization, decision theory techniques, and risk analysis.

Success Criteria

The project will be considered successful if at the end we will be able to:

- Clearly evaluate the pros and cons of using a LWR approach, whilst identifying and proposing alternative decision making approaches that could improve the recommendations output in the NOA
- Better understand potential issues in using a deterministic approach to planning while there are increasing uncertainties in the longer time scales
- Better understand potential issues in using a single-snapshot approach or oversimplified assumptions for the technical modelling while the system becomes increasingly more complex
- Identify the most desirable features for a new framework that can consider more integrated technical and economic modelling as well as better incorporate uncertainty and risk in planning
- Outline a roadmap and the required steps for actual implementation of the identified framework.

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

Project Activities

National Gird ESO (NGESO) is responsible for the secure operation of the UK's electricity system today and in the future. One of our key roles is performing the Network Options Analysis (NOA). This is our yearly analysis of proposed options by the transmission owners and our recommendations for which options provide the most benefit to the consumer. This is a vital step which helps to save billions of pounds of consumer value over the next 20 years whilst aiming to reduce risk as much as possible in an uncertain environment. The NOA process is a year-long annual process with a tight schedule. Each year projects to improve the process are identified and implemented if they are relatively straightforward. However, if the suggestion has a potentially larger impact then it poses a high risk to the NOA decisions and could affect the network reinforcement recommendations, which involve billions of pounds of investment decisions. For such large changes further insight is needed, calling for proper scientific research and feasibility studies before we can consult with the stakeholders on any big decisions.

Each publication of our NOA methodology is sent to Ofgem for approval, this is an opportunity for Ofgem to highlight certain areas that could be improved in future years. In their approval letter of the NOA 19/20 methodology they had several recommendations related to reviewing our approach for planning under uncertainty. These recommendations touch upon a core aspect of the NOA process, and so following this feedback, this NIA project was launched and a team of academics from the University of Melbourne (UoM) were tasked with performing a thorough review of our decision-making approach within the NOA process, and to identify areas for improvement. We tasked UoM with performing a literature review of the different methods which system operators around the world use in planning their transmission expansions, then to compare the ESO's processes alongside these. The UoM then investigated our decision-making technique Least Worst Regret (LWR) to compare it with the possible new techniques available.

In the second part of the project UoM were also tasked with reviewing the boundary analysis techniques used as inputs in the NOA process, specifically the ongoing work in the ESO of considering more network uncertainties, adopting risk indices and moving towards probabilistic thinking. They were tasked with process mapping the probabilistic analysis, suggest improvements and better data visualization techniques using state-of-the-art methodologies.

Several academics from the UoM spent several weeks with NGESO in order to study and analyse techniques, they also investigated the approaches adopted by several other countries. Two detailed reports of their findings were released in January 2021 and are available on the Smarter Networks Portal, www.smarter.energynetworks.org/projects/nia_ngso0028/:

- Part 1: Review of frameworks and industrial practices for decision making in transmission network planning
- Part 2: Review of power transfer capability assessment and investment flexibility in transmission network planning

One major outcome of the project was the creation of a new technique for decision making called Least Worst Weighted Regret (LWWR). Which was trailed in NOA 2020/21 as part of the ESO's network planning report.

The project was extended for 6 months in order to develop a user-friendly tool to perform the LWWR technique. The tool has many features, it allows users to perform the LWWR analysis on input files, presenting the LWR results as well as the LWWR results. This is performed in 2D and 3D, and one has a multitude of options for how to display the data. This can be performed in individual mode or batch mode to save time. There is also the possibility to customize more freely the outputs to fit the users' preferences. Furthermore, there are two metrics for interpreting the data, the line metric and ball metric, which allow users to have a quick gauge on the output of the results.

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

The project was extended by 6 months to develop and refine the LWWR tool.

Lessons Learnt for Future Projects

The report provided by UoM is a review by an independent party of the NOA methodology. It shows an outside perspective of the ESO's approach and compares it to that adopted by other countries. The report contains recommendations on new tools and ideas to perform the NOA CBA and technical probabilistic analysis and includes roadmaps to implement them. Furthermore, the report provides a very detailed description of ESO methods and will be a useful resource for interested readers to better understand the work the NGESO undertakes.

More generally, the learnings demonstrate that there are several ways the NOA process can be improved, these vary in scale and ease of application. Some are implementation-ready, such as the LWWR technique and tool, while others will require further consideration, research or follow on projects.

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

Two detailed reports were prepared by UoM which provide several recommendations for the ESO. The reports were released in January 2021 and are published on the Smarter Networks Portal (see link above). The extension of the project enabled the development of a new tool to perform the LWWR analysis. This tool has since been embedded in the business; included in the NOA process as well as being utilized throughout the year in various CBAs.

Recommendations from the 1st report

In terms of possible improvements to the current NOA process and more general aspects that might be worth exploring, the following are recommended:

- Additional operational snapshots could be included in the technical analysis besides the current winter peak assessment. This is in light of increasing operational complexity and uncertainty that might drive worst case flows across boundaries at different times of the year. Similarly, inclusion of new operational characteristics and constraints, such as associated with low-inertia conditions, could be desirable.
- The use of LWR or similar approaches could be adopted to inform the optimality of interconnector assessment across scenarios too. This would allow a more consistent and integrated approach between selection of (internal) boundary reinforcement and optimal level of interconnectors.
- A Least Worst Weighted Regret (LWWR) approach, in which scenarios have explicitly assigned weights could be proposed as the generalised version of LWR (where equiprobable scenarios are implicitly assumed).
- The implicit equiprobable scenario representation of the current LWR approach can be interpreted as a special case of the more general LWWR whereby it is intrinsically believed that all current scenarios are similarly plausible and likely to happen28. However, if there are reasons to consider asymmetry in the likelihood of the considered scenarios, consideration might be given to a more detailed assessment that might explore different probability weights.
- While we are aware that the selection of probability weights to assign to scenarios may be difficult and controversial, our proposed unified framework provides a consistent and comprehensive view that could seamlessly compare and assess the outcomes of (apparently) different methodologies (i.e., probabilistic, LWWR and min-max weighted cost), with scenario weights being considered as a natural component. This could eventually provide more transparency and robustness to the investment process and the selected

options, thus resulting in reduced risk of spurious solutions and reduced risk of decisions being driven more by specific scenarios than methodologies, and in general enhanced hedge against potential uncertainty. Furthermore, by modulating the value of the scenario weights, the impact of different degrees of risk-aversion may also be explored.

- Such analysis could also be supported by visual tools that could identify decision-stability regions with win-win solutions from different methodologies and suggest what solutions might require further analysis, for example in terms of expected costs and regrets.
- Irrespective of the formal use of probability weights, multi-parametric scenario sensitivity studies could be performed to provide insights into the benefits and risks of different proposed solutions under different possible future occurrences, with for example expected costs and expected regrets (a measure of risk) analysis for different methodologies able to clearly assess all the implications of using different approaches, risk-aversion degrees, and scenario weights.

Recommendations from the 2nd report:

- The uncertainty brought by increasing penetration of renewable energy might require network planners to redefine their planning methodology, so that it can account for the impact of this uncertainty in the evaluation of network's technical performance, and consequently accommodate these changes in the cost-benefit analysis which decides the worthiness of a network investment. NGESO has already been actively developing a probabilistic analysis to enhance the existing deterministic one which only derives boundary capability in winter peak snapshot. We have made recommendations which can enhance the current methodology from several perspectives, such as using different sampling techniques to derive boundary capability setpoints, proposing reliability indices and risk metrics to monitoring network performance, and using machine learning techniques to perform network security assessment and predict boundary capability contribution from reinforcement options.
- Although the computational time of NOA's CBA could be substantially reduced by using static37 boundaries to represent network constraints in system operational modelling, with more and more variable power flows it may introduce more inaccuracy in measuring constraint cost reduction contributed by reinforcement options. Therefore, it may be beneficial to integrate the network technical modelling into the CBA's economic dispatch analysis; this would consequently enable a more precise calculation of network constraint costs in NOA's CBA.
- Commercial solutions can be a great complement to network-based options for network reinforcement, as these solutions feature significant technical and economic flexibility. Taking grid-scale battery as an example, it might be able to provide different ancillary services (e.g., frequency response, balancing mechanism) besides reducing network congestions. Commercial solutions have a more flexible service contract length (e.g., 5-10 years), which could be shorter than the lifetime of network-based options (e.g., 30-40 years from transmission lines). This feature represents a valuable factor in investment flexibility. NGESO has also been developing commercial solutions which are included in the reinforcement options list published in NOA. However, the methodology of commercial solutions evaluation, which is explained in 2.3, could be further improved by integrating it into the NOA framework to evaluate the constraint costs under a unified framework.

Regarding the current methodology of NOA's CBA, it was analysed in detail in the first report, focusing on discussing the core elements of the decision-making process. In this report we delved deeper in the aspects related to the identification of investment options that would provide more flexibility across scenarios:

- The structure of decisions associated with each reinforcement option seems to provide sufficient flexibility to initiate, hold or stop a project. However, this structure of decisions is used in the context of a two-stage decision process where many of the decisions are fixed based on the deterministic assessment of the scenarios. This is reducing the space of investment strategies that can be selected by the LWR to a point where possibly very little flexibility can be captured.
- Seeking more flexibility is a process that in general has very high computational requirements because many combinations of options have to be assessed under different operation conditions; in this context, in the short-term, we recommend to focus in automatising the deterministic assessment of each scenario as much as possible, reduce computational burden by finding the right periods of operation of the system that capture the system behaviour for each year and each scenario, and improving the selection of the reinforcements that enter the LWR in order to be able to capture more flexibility.
- In the long run the CBA assessment should aim to evolve into a multistage integrated model that can evaluate network and non-network solutions without the need to first assess the operation of the system for all combinations of investment options in all scenarios. These integrated models are currently available for risk-constrained stochastic approaches; however, no efficient solutions exist, to our knowledge, in the realm of multistage LWR. Not evolving into an integrated approach in the long run might render the current methodology inadequate to fully assess flexible investment options and incorporate more complex representations of future decisions; this, in turn, might generate larger regrets than those that the current methodology is capable to prevent.

Data Access

Details on how network or consumption data arising in the course of a NIC or NIA funded project 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/future-energy/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

The following reports have been developed as part of the project and are available on the Smarter Networks Portal:

Part 1: Review of frameworks and industrial practices for decision making in transmission network planning

Part 2: Review of power transfer capability assessment and investment flexibility in transmission network planning

The tool developed in the course of this project will not be made public, it will be used in house to support decision making processes and the NOA methodology.

Planned Implementation

The output of the reports gave several recommendations for improving the NOA Process. The LWWR technique recommended in the first report has been adopted by the business. This technique was initially tested during NOA 2020/21, where a prototype of the tool was developed and proved to be a successful in providing further insight into the results. Following on from this, a project extension was approved to develop a fully functioning tool to perform the LWWR in a robust and efficient manner. The tool has now been adopted by the business, forming part of the NOA process, as well as being used by the Network Development team for the development of CBAs .

Other recommendations from the project are being considered internally and the ESO is in discussions with UoM to look at further improvements to the process. Future work may be carried out under a new project.

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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