

VISIONS, FUNCTIONS AND IMPLEMENTATION OF DSOS – A UK PERSPECTIVE

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ABSTRACT

This paper summarises the key aims and objectives of four major DSO projects in the UK, analysing their scopes, methodologies, and expected outcomes. The paper criticises the alignment between the UK DSO projects and their alignment with that of the Europe. The paper concludes by showing how the vision, roles, functions, responsibilities evolve as our understanding of DSO improves.

1. INTRODUCTION

The drive to decarbonize our energy system has substantially increased the penetration of low carbon technologies at homes and businesses, creating growing distributed energy resources (DERs) at the edge of the supply system. Introducing distribution system operator (DSO) is a key step to mobilise DER in optimising both network and customer assets, introducing commercial arrangements to connect local producers and consumers and/or connect community energy with system operators.

Prior to 2017, significant effort has been made in the UK to trial commercial arrangements to procure DER services to address a variety of network needs, including thermal, voltage, fault current constraints [1-5]. As the volume of DERs increase, a point will be reached where network based markets cannot absorb sufficient DERs, nor do they provide sufficient incentives for DERs to thrive and grow. It will be a necessity to introduce energy based markets at the distribution level to substantially improve the utilisation of distributed generation, thus creating major value for DERs.

Post 2017 saw the pace of change has stepped up very substantially, moving fast forward from concepts, roles, functions to practice. In the second half of 2017 alone, there were four multi-million industrial projects to specifically trialling energy markets at the distribution sector [6-9]. This is addition to the industrial's collective efforts to identify roles and functionalities of DSO particularly in view of increasing interactions between TSO and DSO [7] [10].

This paper summaries the key aims and objectives of each of the UK DSO projects, analysing their scopes, methodologies, and expected outcomes. The paper criticises the alignment of the UK DSO projects and their alignment with the development in Europe. The paper

concludes by showing how the vision, roles, functions, responsibilities evolve as our understanding of DSO improves.

The rest of the paper is organized as follows: Section 2 introduces the four UK DSO projects; Section 3 compares the development with that of the Europe; Section 4 summarises the evolution of vision, the roles and functions for DSO; Section 5 concludes the paper.

2. UK'S FOUR DSO PROJECTS

Four major DSO projects were started between the end of 2017 and the start of 2018 in the UK; these projects were carried out by different companies with various budget. A summary of the four projects is shown in the Table 1 followed by a discussion of each project.

Table 1. Brief summary of the projects

Title	Company	Budget	Duration
TRANSITION	SSEN	£14.7k	2017-2019
Customer-Led Distribution System	NPG	£1.9m	2017-2021
Electricity Flexibility and Forecasting System	WPD	£4.3m	2018-2020
FUSION	SPD	£7.1m	2018-2023

2.1 TRANSITION [7] [11]

The key aim of TRANSITION is to define a cooperative role of DSO because of the increasing interactions between DSO and TSO. The project also aims to accelerate the transition from DNO to DSO while minimising the uncertainties and risks to both customers and industries. The objectives include the design, development and demonstration of the Neutral Market Facilitator (NMF) Platform which enables infrastructure, communication and commercial arrangements. The market models that were produced by the Open Networks Project will be tested in the NMF Platform so that future improvement of the market model can be proposed to the industry. The method using by TRANSITION project is to develop functional tools priori to demonstration for different network scenarios to ensure that the proposed models are suitable in technical and commercial aspects. The NMF is expected to benefit network customers by millions of pounds by 2050.

2.2 Customer-Led Distribution Systems [9]

The CLDS project examines radically different trading arrangements, and the co-evolution required between technical and commercial innovations. It aims to identify the most appropriate future industrial structure to accommodate large volumes of DERs at minimum cost while providing easy access to energy markets for customers. The main objectives include optimising network and DER resources, enabling third party providers to gain benefits from energy and network products, and reducing the complexity and uncertainty of supply by using both network and market solutions. The CLDS project will take a holistic approach to exploring distribution sector structures and pathways that can accommodate an uncertain and evolving landscape of network users and network operation. The CLDS project considers innovative customised products for both energy and network services in designing markets. The project will also explore the roles and functions of future DSO to identify the coordinative operations between the market and network. The values for introducing energy market to the distribution system will be quantified.

2.3 Electricity Flexibility and Forecasting System [8]

The Electricity Flexibility and Forecasting System (EFFS) project explores and trials the new system functionality required for DNO transition to DSO by developing understanding on forecasting and communication requirements. It aims to deliver a practical robust and accurate system capability to ensure DNO can manage the provision of flexibility services that is required for transition. EFFS will provide a coordination interface to GBSO and enable the configuration and utilisation of multiple different types of optimised distribution orientated services and could potentially allow a wider participation in the balancing market. The EFFS will be capable of harnessing multiple services and allowing future DSOs to manage the distribution network actively. The EFFS will enable quick fault restoration of power supplies by using the flexibility services. The conflicts with the TSO will also be mitigated so that balancing costs can be reduced at a national scale.

2.4 FUSION [6]

The FUSION project aims to develop local energy market that can use resources from multiple vectors to realise peak shaving of the energy consumption. A few objectives were indicated by the project: 1) evaluating the flexibility market framework to manage local distribution network constraints; 2) investigating commercial mechanisms to encourage DERs to provide flexibility to the distribution network and 3) accelerating the localised demand-side flexibility utilisation and new demand connections. FUSION will develop and implement the flexibility market from three broad phases:

quantification, regulatory establishment and technical and commercial implementation of the flexibility market. The project will save customers over £236m by presenting a positive and realistic business case.

3. COMPARISON WITH THE DEVELOPMENTS IN EUROPE

DSOs already exists in Europe, therefore, industries are investigating the development of the current DSO roles. Traditional European DSO is a natural entity that is responsible for operating, maintaining and developing the distribution system [12]. Recently, the DSOs are required to perform more active management of the distribution network due to the high penetration of DERs.

There are no conclusions about the new roles and functions for the DSOs; various projects from different European countries are publishing different opinions on DSO evolution based on their national regulations. It is generally believed that future DSOs will evolve to facilitate the energy market effectively, effectively adding the role of an NMF. DSOs will also interact and cooperate with TSOs, consumers and communities [13] [14] [15] [16].

Generally speaking, European and UK views on DSO roles match. It is agreed that DSO will actively manage the distribution network and use network services to address network problems. Some documents mentioned that a new energy market should be created to support the distribution market operation.

European projects are mainly presenting visions rather than actions. On the contrary, UK has more experimental projects, such as the CLDS. The projects with experiments will be able to trial the proposed DSO models on specific scenarios. Therefore, the results will be more reliable and validated than theoretical visions.

4. EVOLUTION OF VISION, THE ROLES AND FUNCTIONS FOR DSO

The vision of DSO can be categorised into two parts:

- 1) the transition from DNO to DSO;
- 2) the evolution of the future DSO.

The transition part includes a detailed description of the DSO roles and functions while the evolution part concerns the developing trend of DSO roles.

4.1 DNO to DSO

In order to analyse the roles and functions of the DSO, the fundamental science of the distribution system needs to be clear. The distribution system includes three main features: planning, operation and coordination. The roles

of DSO were identified as: distribution network planning, distribution network operation, distribution market operation and coordination; each role is related to several main functions.

The role of distribution network planning includes two main functions: the traditional and non-traditional investment planning; and the commercial arrangements that includes both connection agreement and use of system charges.

The distribution network operation ensures that the network operates within technical constraints, i.e. voltage limits, thermal limits and security requirement.

Traditional DNO only focuses on the distribution network planning and operation, however, the explosive growth of DERs requires DSO to pay more attention to the distribution market operation and the coordination of all the participants in the distribution system. The role of distribution market operation concerns the operation and management of central market as well as local market. The majority of current projects are trying to address network problems by using network services. There are very limited projects on the energy market, especially the local energy market. The penetration of DERs facilitate the development of local energy market at the distribution level. Consequently, the form, design and operation of the energy market will become one of the main tasks for the DSOs. Establishing the energy market will bring financial benefits to all market participants and increase the system efficiency.

The roles and functions of the DSOs are analysed from various aspects. Therefore, the coordination among all the roles and functions will be extremely important to ensure a safe and efficient operation. According to the structure of the distribution system, the role of coordination needs to include but is not limited to four scenarios:

- 1) The coordination between distribution system planning and distribution system operation.
- 2) The coordination between service market and energy market.
- 3) The coordination between investment planning and commercial planning.
- 4) The coordination between distribution network operation and distribution market operation.

4.2 DSO evolution

As indicated above, DSOs are expected to have four roles. However, this will change with time as a result of developments and improvements to the distribution system. The evolution process of DSO is shown in the Figure 1.

- 1) The four roles in the top are all coloured in yellow, which means that the DSO will fulfil

them all.

- 2) In the near future, the DSOs are likely to focus on improving the value and efficiency of network planning and operation (as shown in middle of Figure 1). At the same time, other operators will manage the market operation and coordination. Another possible evolution of the DSO is to focus on the operation of the distribution system as shown in the bottom right.
- 3) At final stage, as indicated in the bottom of the Figure 1, the DSO will only be in charge of coordination in the distribution system. This is because that coordination is a vital part for managing and operating the system. In order to achieve the role of coordination, the DSOs need to have a good understanding of the whole system operation as well as the characteristics of all participants.

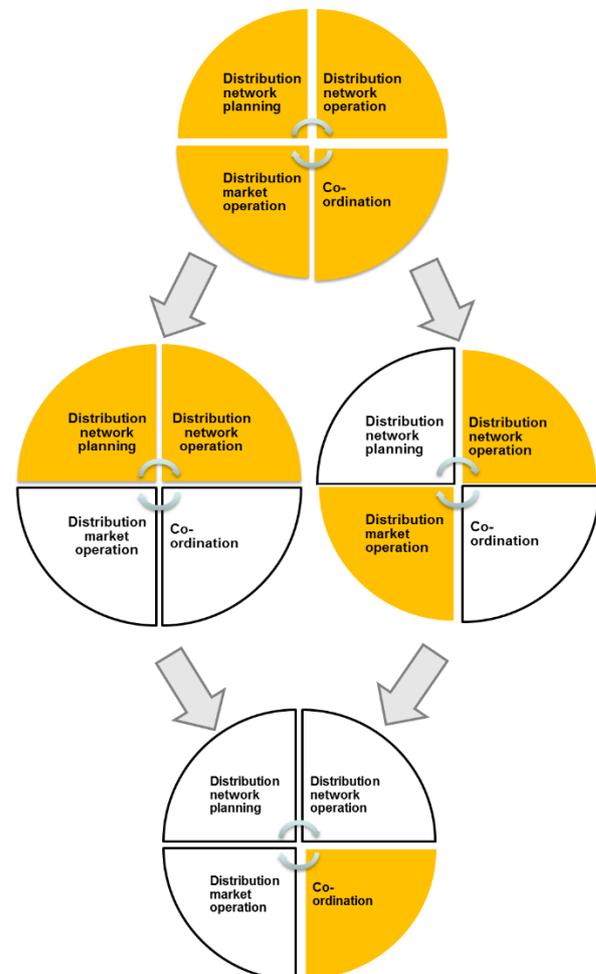


Figure 1. The evolution of future DSO roles

5. CONCLUSION

This paper reviewed four recent UK DSO projects from the aspects of aim, objective, methodology and expected outcomes. These projects provide their understandings of DSOs and will run trials on the energy market at the distribution level. The view of DSO from UK and Europe were compared, where both expected DSOs to become NMF to facilitate local energy market and DSOs should take care of the interactions with TSOs and customers. The dissimilar point is that Europe focuses on visionary projects to give concepts of DSO roles and functions. However, UK projects contributes in demonstrating the proposed market mechanisms and DSO functions with lab based test fields and real test fields. It should be noted that demonstrations need to consider realistic situations such as the connections of DERs and the development of DERs. Hence, the practical UK projects will give more valuable results that are more suitable for the future scenarios, for example, the increasing need of flexibility and the growing penetration of various DERs.

The evolution of DSO roles is also discussed in this paper. Four new roles of DSO are defined for the transition from traditional DNO, i.e., distribution network planning, distribution network operation, distribution market operation and coordination. Each role is associated with several functions. It is believed that the DSOs will take full responsibility of the four roles at first but slowly change with the development of new technologies and changing of customer needs. Two possible situations for the near future are DSOs taking two roles instead of four. Eventually, the DSO may only work as a coordinator among different players of the distribution system.

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