The **purpose** of this paper is to clarify the forecasted impact on SHE Transmission of the transition to a Distribution System Operator (DSO) model. The **scope** of this paper is to identify and quantify impacts of the transition stemming from interaction with the Transmission System Operator (NGESO), SHEPD the local Distribution Network Operator (DNO), future network connectees and existing customers fed either directly or indirectly from the SHE Transmission network.

The paper contains:

1. **DSO Background**
2. **Future DSO worlds**
3. **Analysis**
4. **Conclusion**

Supporting the transition through the RIIO T2 period aligns with SSEN DSO transition strategy principles[1].

1. DSO Background

The way in which we design, build and operate GB's electricity network is changing due to a range of factors, which are causing a move away from how we have traditionally produced and consumed electricity. These factors are also driving a change in the way that the transmission and distribution networks work together to build and manage the overall system. These factors include:

- Increasing uptake in distributed renewable generation, both at a large and small scale;
- Increasing uptake in electric vehicles;
- Increasing uptake in new technology that affects existing demand usage such as ground and air source heat pumps and electric heating;
- Shifting demand and diversity patterns driven by the uptake in smart meters, smart appliances, Demand Side Response (DSR) and the role of aggregators; and
- The connection and use of electrical energy storage, both at a large and small scale.

These are not new considerations for the SHE Transmission, the local Transmission Owner (TO) and SHEPD area where these factors have already been seen in specific pockets for some time. SSEN has shown genuine innovation in dealing with these issues through development and deployment of new connections methods (both technical and commercial), whole system planning, through engagement with SHEPD and NGESO, and the trialling of commercial constraint management services.

The scale of the change in the way we produce and consume electricity, and the variability in impact across different areas, is now spreading across the whole of GB and is posing the industry with new challenges and opportunities to manage the system more efficiently and reliably. This has been

[1] https://www.ssen.co.uk/SmarterElectricity/

recognised by government who have consulted and developed a plan called the 'Smart Systems and Flexibility Plan'. The network elements of the plan are being addressed and co-ordinated through the ENA Open Networks Project[2], which is structured into 5 workstreams. Those workstreams cover:

1. transmission and distribution processes;
2. customer experiences;
3. DNO to DSO transition;
4. commercial charging; and
5. Open Networks communications

Workstreams 1 and 2 are focused on understanding what improved transmission and distribution processes are needed and how they relate to the customer experience. Workstream 4 covers what the charging requirements are of that future electrical energy system. Workstream 5 seeks to coordinate all communications related to the Open Networks Project. The products coming from 1, 2 and 4 will then require arrangement into a future world where the DSO is an operational entity. Details of the various permutations are arranged into five different worlds and are being developed through workstream 3.

2. Future DSO Worlds[3]

A DSO is seen as a role that will address the challenges coming from decentralised and democratised distributed energy by unlocking flexibility on the distribution network and allowing for better whole system design and operation. The Open Networks Project has defined a Distribution System Operator (DSO) as an entity which 'securely operates and develops an active distribution system comprising networks, demand, generation and other flexible Distributed Energy Resource (DER).' This is a role not currently in existence as there is a single System Operator for all of GB at transmission but not at distribution. There are no established timescales for the creation of the role as it is uncertain who will do it let alone when. It may be a role that DNOs transition to, or it is one that NGESO fulfils, or it may be the role of new third party. The five different worlds in Workstream 3 of the Open Networks cover each possible outcome of how the DSO may work and the associated roles and responsibilities of all involved network parties.

The table below lays out the high level differences between each world.

World	Description
World A	**DSO Coordinates** – a World where the DSO acts as the neutral market facilitator for all DER and provides services on a locational basis to National Grid in its role as the Electricity System Operator (NGESO)
World B	**Coordinated DSO-ESO** procurement and dispatch – a World where the DSO and ESO work together to efficiently manage networks through coordinated procurement and dispatch of flexibility resource.

[2] http://www.energynetworks.org/electricity/futures/open-networks-project/open-networks-project-overview/

[3] http://www.energynetworks.org/electricity/futures/open-networks-project/future-worlds/future-worlds-consultation.html

World C	**Price-Driven Flexibility** – a World where changes developed through Ofgem's reform of electricity network access and forward-looking charges have improved access arrangements and forward-looking signals for Customers.
World D	**ESO Coordinate(s)** – a World where the ESO is the counterparty for DER with DSOs informing the ESO of their requirements.
World E	**Flexibility Coordinator(s)** – a World where a new national (or potentially regional) third-party acts as the neutral market facilitator for DER providing efficient services to the ESO and/or DSO as required.

Table 1- Future DSO World Options

As part of Workstream 3 the five different worlds have been mapped using the Smart Grid Architecture Model (SGAM). This model has built a picture, through industry consultation, of the key actors (parties) involved and what new processes or information exchanges will be required to operate each world from the perspective of the network owner or operators.

Limitations to this work include individual processes between generators or to markets not being modelled, neither are interconnectors and it doesn't incorporate any existing functions carried out by network companies that are not only required by the transition.

The processes/information exchanges are broken down to into the following functions:

Function	Description
System coordination	Whole system coordination for efficient planning and operation
Network operation	Safe and secure operation of networks
Investment planning	Efficient design and development of the system
Connection and connection rights	Providing fair and cost-effective options that meet Customer requirements and system needs
System defence and restoration	Ensuring coordinated emergency response and system resilience
Services/market facilitation	Facilitation of markets for flexibility
Service Optimisation	Ensuring system needs can be met efficiently
Charging	Ensuring fair recovery of network and operational costs.

Table 2 - Future World Functions with TO Impact

3. Analysis[4]

Taking the SGAM output from Workstream 3 it has been analysed to quantify the total number of processes or information exchanges that involve a TO in comparison to all the other actors. The **impact varies** from a minimum of 6.5% in World D to 7.6% in World E which, when compared with the total industry DSO impact, is small.

[4] This analysis is based on the SGAM work completed by Workstream 3. That work was effectively a snap shot from industry of the view of how DSO would progress and is open to change in the future and with it the outcome of this analysis.

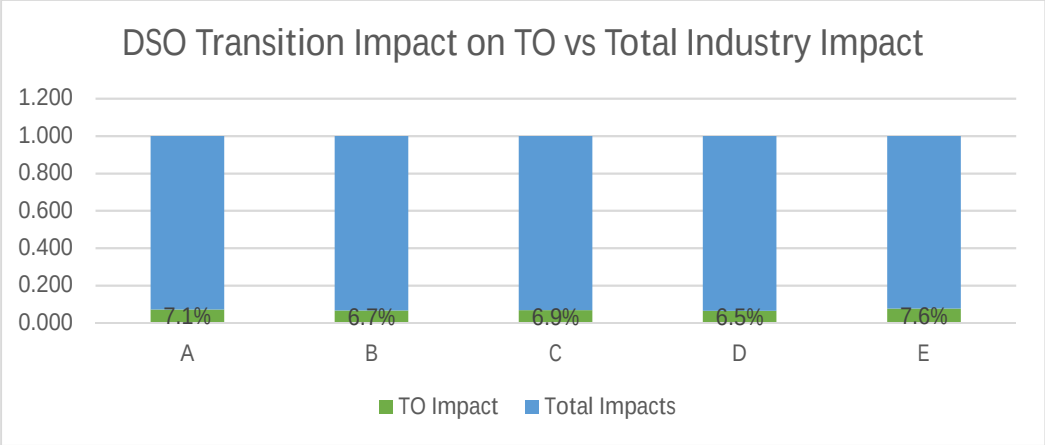

Figure 1 - DSO Transition Effects on TOs

To put that into perspective and highlight the scale of the task to enable a DSO to be established, an average of 1091 new processes or information flows need to be established per world. Each of these would need to go from or to a current network party. The eight main impact categories, shown in Table 2, cover at a high level where each of the 1000 plus processes and information flows sit. For example, the specifics on how to identify and manage outage scenarios once there are DSO service providers operating, through to how to implement and operate whole system planning and defining network services requirements to defer reinforcement at all levels.

Further analysis based on the SGAM work shows that for TOs:

- There is **little variance** on the effect regardless of the world. This is because in each world the TO are depicted behind the ESO. The biggest divergence between worlds is between World D and World E. World E is where the ESO takes on a lot more by becoming a larger ESO which can be argued is simply an expansion of a set or relationships that the TO has currently, thus not unexpected that it would have the smallest impact. The largest impact is from world E where a new third party becomes the DSO, again not surprisingly as it involves the largest change to existing industry arrangements.
- The **largest impacts** are felt in System Planning and System Defence and Restoration for all worlds and are similar across all worlds. For System Planning the impacts are all equal across Worlds A, B, C and E with the variance for World D being driven by an increased requirement on whole system planning. For System Defence and Restoration all impacts are the same for A, B, C and D with the very slight variance being an increase in requirements under black start for E. Again understandable as E is a new DSO entity that would require extra information from a TO in a 'lights out' scenario.
- Of the eight different categories of impact defined in the SGAM work, only charging does not have an impact on the TO. That is likely due to the little involvement that TOs currently have under network charging. Additionally, although the scope for Workstream 4 does include transmission cost recovery, it only does so at GSP level as that is seen as the main change in a future DSO world, i.e. who was paying for that access or remunerating accordingly. This assumes no fundamental change to the existing transmission charging setup.

SHE Transmission has undertaken an initial impact assessment of the DSO Worlds on it using the following categorisation and applying it to each identified impact on the TO:

Low	Basic process/exchange exists already
Medium	New process/exchange or material change to existing process/exchange requiring resource to develop
High	Multi-party liaison, development and implementation of codes to facilitate new ways of processes/exchanges

Table 3 - DSO Impact Categories

This analysis showed that:

- Again System Planning carried the **largest amount of high impacts** across each world. The table below shows the three highest impacted categories, using the impact categorisation in Table 3, on the SGAM identified TO impacts from moving to each world. The figures are the number of new processes or information flows that are scored as high impact.

World	Investment Planning	System Defence and Restoration	Service Optimisation
A	7	2	0
B	7	2	6
C	7	2	6
D	7	2	0
E	7	2	6

Table 4 - High impacts on TOs of establishing DSO

  This was due to the requirement to assess or contribute towards whole system planning which will require a lot of effort to develop and codify. Similarly, there were a number of high impacts under security of supply where a lot of work was required to develop new whole system planning standards and codify them. These will need to include what specifications are used to drive and support flexible provision by various parties to meet existing transmission planning standards where appropriate. This impact will be most felt by System Planning as they will be required to develop and codify new principles and processes.
- In the initial piece of analysis System Defence and Restoration had the second most impacts in terms of volume. However, in Table 4 it can be seen that for Worlds B, C and E that Service Optimisation has the second largest impact in terms of effect. These impacts are all categorised as regulatory or legal where DG services have to be developed to provide last resort services, which the TO will need to be involved with. Again this will most effect System Planning though Operations will also have an involvement.
- The third highest set of impacts are seen in System Defence and Restoration and are driven by the requirement for new parameters and processes that will allow the network to remain operational in the face of increased energy decentralisation and democratisation. This affect will impact on Operations the most where network operation and crisis resolution will require new participants to be included in existing and new processes.

4. Conclusion

When considering all the impacted network parties, including those taking supply from and giving to the networks, the impact on the TOs of transitioning towards a DSO world is small in comparison. There is little deviation between worlds, with the impact consistently being felt mainly by the SHE Transmission System Planning and Operations Departments, although other activities will be impacted. SHE Transmission would welcome comments on the analysis and conclusions of this paper as it seeks to develop its business plan for the RIIO-T2 period. Our initial view is that the workings and resources of the Transmission System Planning and Operations Departments will need to be assessed in light of the DSO transition, and additional capability is required if SHE Transmission is to proactively support the DSO transition for the benefit of SHE Transmission and our customers.