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In partnership with LEO Local Energy Oxfordshire

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Oxfordshire Programme Trial Strategy

Scottish & Southern Electricity Networks

ATKINS

Technical Report Deliverable
Project TRANSITION WP6 Phase 1

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1. Strategic Journey to a Distribution System Operation (DSO)

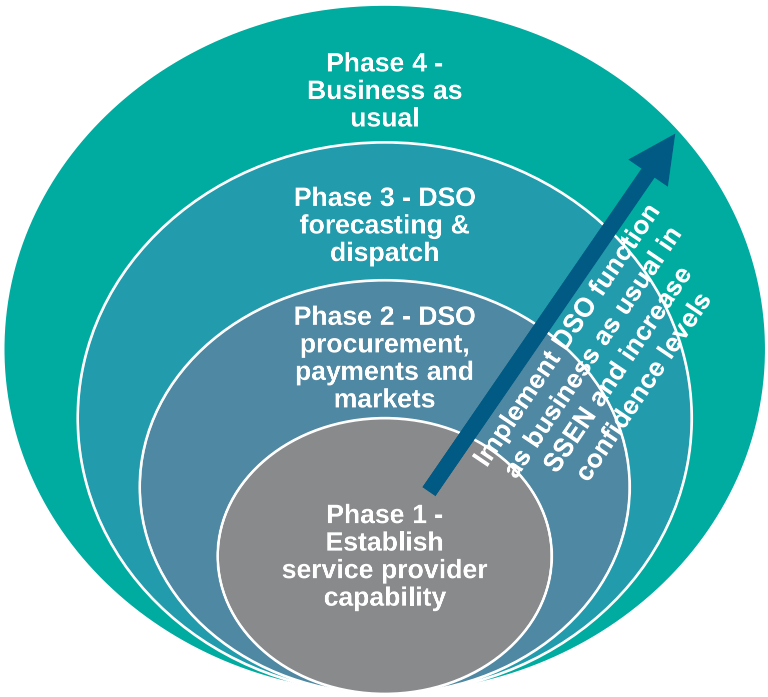


Figure 1 Distribution System Operation journey

The journey for any Distribution Network Operator (DNO) to a Distribution System Operation (DSO) (either separated or integrated) will consist of a number of stages to be completed, as seen in Figure 1.

Phase 1 - Establish service provider capability
The first step is to understand the desire and the capability of local service providers to provide the flexibility services. At this stage the DSO (not in an established form) will work with service providers to develop the services and products that they need to deliver. The learning at this stage is bi-directional:

a. The DSO will need to draft services (most likely in several iterations) and conduct workshops to understand whether the services can be delivered as planned.
b. Potential service providers will get familiar working with a system operator and install all necessary systems to allow them to provide the required services. This is likely to be a pragmatic approach to ensure that the need to implement systems for potential providers of flexibility does not create a barrier to their participation. Suppliers will need to understand aspects such as testing, compliance and technical delivery on a day-to-day basis. Some providers will be familiar with this if they are providing services to the Electricity System Operator (ESO).

Phase 2 - DSO procurement, payments and markets

Once the capability of service providers is well understood, the DSO will need to establish an appropriate commercial offer, procurement methodology and DSO markets. During this phase, the ESO and other local DSOs will need to be engaged to establish:

- The effects of service provision on the wider network and whether any of the services can affect the other parties.
- Opportunities for peer to peer trading.

Phase 3 - DSO forecasting & dispatch
During this phase, the DSO will need to establish appropriate service forecasting to understand the optimal volumes of services to be procured and the level of over procurement.

Phase 4 – Business as usual
The final phase of this process will be to develop a ‘business as usual’ approach to DSO services.

2. Trial Philosophy

The trial philosophy is to test all five services that have been proposed in WP4 (in a trial environment). The main objective is to deliver flexibility services in a trial environment and to test roles, responsibilities and basic market rules, there are:

- Ability of service providers to deliver the proposed flexibility services as described in the methodology section of this document.
- Test market rules through the delivery of trials and obtain feedback from participants.
- Monitoring of service delivery on the wider DNO network.
- Provide learnings and future work recommendations for the Open Networks Project.

2.1. Assumptions and Exclusions for the Trials

The main assumptions in the trials are:

1. The trials will include both large[1] (MW size) and small (kW size) demand and generation flexibility providers. The possibility of using aggregators of smaller flexibility providers in the trials will also be considered.
2. At present the following list of Bulk Supply Points (BSPs) and their associated Primary Substations are seen as the most likely trial locations: Cowley Local (Main), Cowley Local (Reserve), Drayton, Headington, High Wycombe, Osney, Witney, Yarnton and Bicester North. However, the list is based on a set of criteria that will be updated over time so the list of substations may change.
3. It is envisaged that the Neutral Market Facilitator (NMF) and Whole System Coordinator (WSC) will not be available until the beginning of 2021 (Appendix 4 – IT Project Roadmap). Hence, it is assumed that at least the initial trials (trials in 2020 and some in 2021) will be conducted via an alternative communication approach (e.g. SMS or internet signal). The exact approach will be confirmed at a later stage.
4. The general approach for trials will be to avoid adding risk on existing assets. The trials will be based on assumed capacity challenges rather than real ones. For example, it can be assumed that the rating on a cable or a transformer is lower than the actual, so the trials will

[1] The list of providers that was supplied by SSEN to Atkins in Appendix 2 – Distribution Generation Data
The Distribution Generation Data was supplied by SSEN on 18/11/2019 will used be for the trial design.

deliver flexibility services that are designed to mitigate the assumed lower rating. This assumption will cause no damage to the existing assets in case of a service failure. This approach will enable the behavioural aspects related to the availability of flexibility translating into actual dispatch.

5. The main aim is to get as many generation and demand flexibility providers involved as realistically practical in the trials.

The trial will test a number of aspects but will exclude the following:

1. Establishing the most cost competitive types of flexibility providers.
2. Establishing engagement practices between DSO and ESO or DSO and DSO.
3. Establishing different procurement models and DSO markets.
4. Establishing a DSO function in SSEN.
5. Determining the volume of services required to the DSO to manage the network (such as volume forecasting).

3. Programme Methodology

3.1. Methodology for Constraint Management trials

3.1.1. Capability Testing

Capability testing will aim to verify the flexibility providers' ability to alter kW loading levels upon the provision of an external signal. This testing should not be performed at any specific time of the day/week and will be self-certified by the flexibility provider. Delivery of the service will be measured from the following perspective:

- Ability of the flexibility provider to manage the time delay for provision of the service within defined timescales. This includes the time between issuing the trigger signal from the DSO and the measured kW change on the metering equipment of the contracted flexibility asset. The acceptable time delay and other measurement requirements are defined in the List for Services that is delivered in WP4 of Project TRANSITION.
- Ability of the flexibility provider to sustain the loading level in line with the DSO instruction during all periods of the capability test.
- Ability of the flexibility provider to provide power readings at the flexibility asset (via appropriate sub metering).

An example test for both generation and demand is shown in

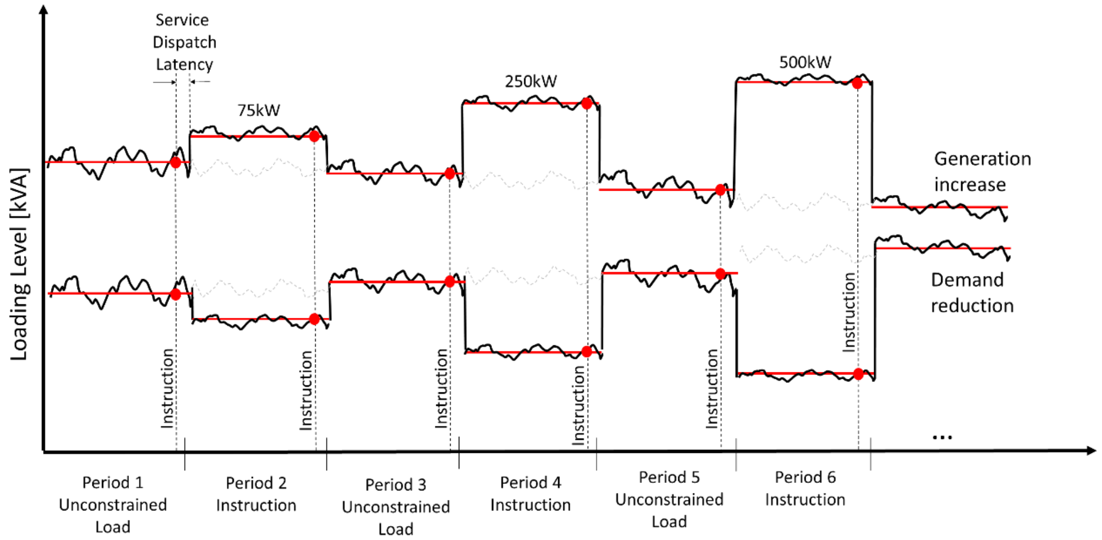


Figure 2. As shown in the figure, the test will conduct a series of step change instructions that define the loading limit of the contracted capacity for a defined time period. A signal provided by the DSO will instruct the flexibility provider to manage its loading level to:

- Unconstrained loading - service provider will maintain its loading as it would normally in absence of any instruction from the DSO.
- Intent to Dispatch - would be issued ahead of actual dispatch, would stand unless rescinded by the DSO.
- Instruction - the DSO will instruct the service provider to amend its loading to a new loading position. The new loading position will be step change of power generation/demand.

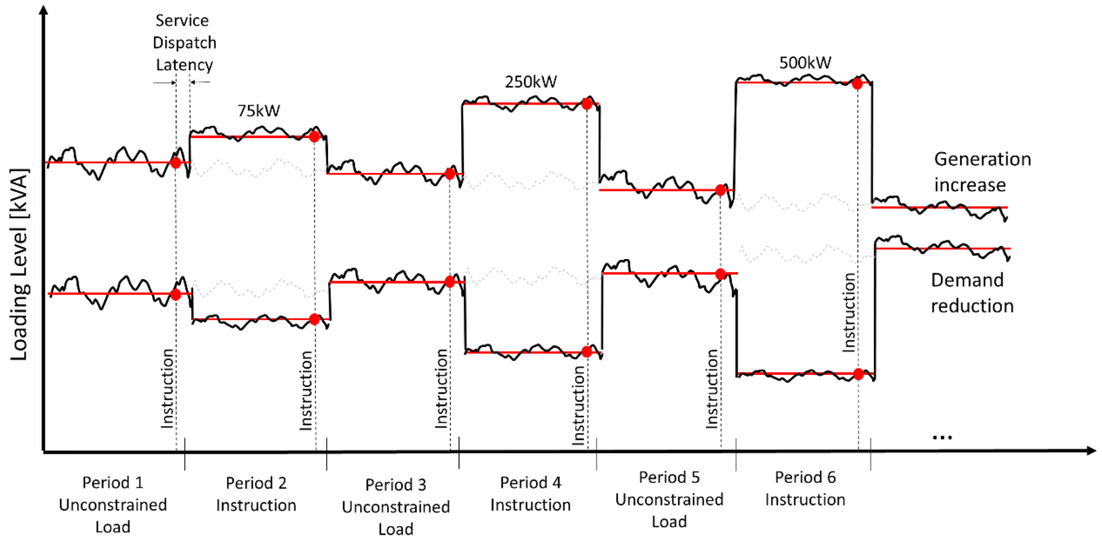


Figure 2 Example visualisation of the capability test for running generation/demand

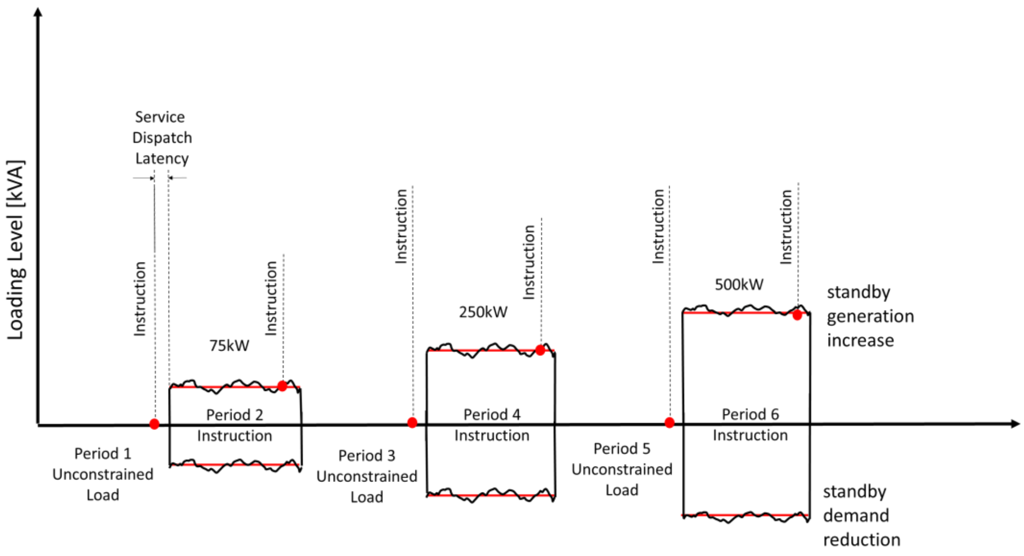


Figure 3 Example visualisation of the capability test for standby generation/demand

Table 1: Example schedule for capability test for a generator

Instruction	1	2	3	4	5	6	7	8	9	10	11	13	14
Start Time [min]	0	30	60	90	120	150	180	210	240	270	300	330	360
Instruction [kW]		XX		XX		XX		XX		XX		XX	

3.1.2. Trial Schedules

This phase will test the capability of the service provider to execute specified flexibility services. The test instructions will be provided to the flexibility providers at a short notice. The exact latency requirements for a full dispatch have not been agreed at present and will be defined at a later stage of the project.

An example of a testing schedule is provided in Table 2.

Table 2: Example schedule for service delivery where instructions for executing the service are provided without notice and hence the delivery delays will be only driven by signalling and process times.

	Daily Period 1			Daily Period 2			Daily Period 3			…
Instruction	1	2	3	1	2	3	1	2	3	…
Start Time [hh:mm]	01:00	03:00	-	05:00	-	-	09:00	-	-	…
End Time [hh:mm]	02:00	04:00	-	05:30	-	-	12:00	-	-	…
Instruction [kW]	XX	XX	-	XX	-	-	XX	-	-	…

3.2. Methodology for Peak Management Trials

3.2.1. Capability Testing

Capability testing will aim to verify the flexibility providers ability to provide kVAr or kW service upon provision of an external signal. This test can be performed at any time of the day/week and will be self-certified by the flexibility provider. Delivery of the service will test:

- Ability of the flexibility provider to manage the latency of the service within defined timescales. This includes the time between issuing the trigger signal from the DSO and the measured kVAr or kW change on the metering equipment. The acceptable time delay and other parameters for this service are defined in the List for Services that is output of WP4 of Project TRANSITION.
- Ability of the flexibility provider to sustain kVAr and/or kW loading level in line with the DSO instruction during all periods of service delivery.
- Ability of the flexibility provider to provide reactive power output readings at a single or group of assets (via appropriate sub-metering)
- It is important to note that the provision of kVAr for this specific service must not be undermined by a separate system that is available at the site (e.g. reactive power compensation or power factor correction schemes that controls the voltage).

As shown on Figure 4, the test will conduct a series of steps change instructions that define the loading limit of the service provider for a defined time period. A signal provided by the DSO will instruct the flexibility provider to manage its loading level to:

- Unconstrained loading - the service provider will manage its loading as it would normally do in absence of an instruction from the DSO.
- Instruction - the DSO will instruct the service provider to execute the contracted service.

Graphical example is provided in Figure 4.

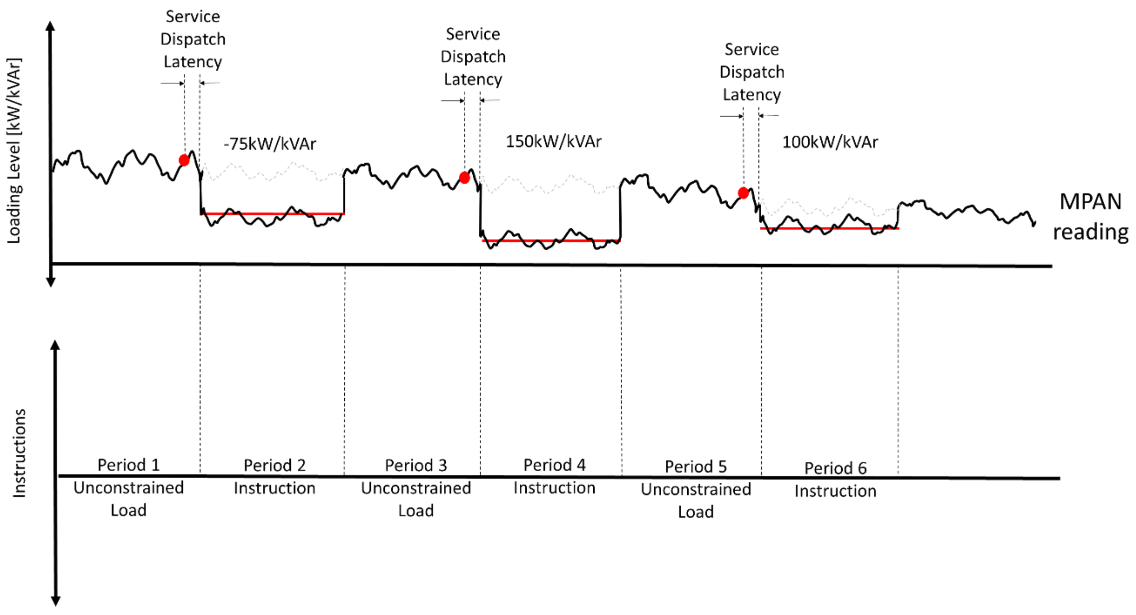


Figure 4 Example visualisation of the capability test

Table 3: Example schedule for capability test

Instruction	1	2	3	4	5	6	7	8	9	10	11	13	14
Start Time [min]	0	30	60	90	120	150	180	210	240	270	300	330	360
Instruction [kW/kVAr]		XX		XX		XX		XX		XX		XX	

3.2.2. Trial Schedules

This phase will test the capability of the service provider to execute the specified flexibility services during a specified time of the day or week.

The test will conduct a series of step change instructions that define the loading limit of the service provider for a pre-defined time period.

Table 4: Example schedule for service delivery

	Daily Period 1			Daily Period 2			Daily Period 3			…
Instruction	1	2	3	1	2	3	1	2	3	…
Start Time [hh:mm]	01:00	03:00	-	05:00	-	-	09:00	-	12:00	…
End Time [hh:mm]	02:00	04:00	-	05:30	-	-	12:00	-	14:00	…
Instruction [kW/kVAr]	XX	XX	-	XX	-	-	XX	-	XX	…

3.3. Methodology for Short-Term Operating Reserve (STOR) Trials

The definition of STOR services provided by National Grid is: Short-Term Operating Reserve is a contracted Balancing Service, whereby the service provider delivers a contracted level of power when instructed by National Grid, within pre-agreed parameters. The main capability requirements for the service as defined by the ESO are:

- Minimum Contracted MW capability of 3MW. Since this is an ESO requirement, it will not apply to flexibility providers under the DSO.
- Contracted MW must be achievable no later than 240 minutes after instruction from National Grid.
- Contracted MW must be deliverable for no less than 2 hours[2].

The trials will aim to test aggregated services, and learnings from it will be used to determine whether service providers can provide STOR to National Grid ESO. Hence, the ESO's general service requirements will be used for individual service providers.

The capability testing and service delivery are described in the following sections.

[2] https://www.nationalgrideso.com/document/85441/download

3.3.1. Capability Testing

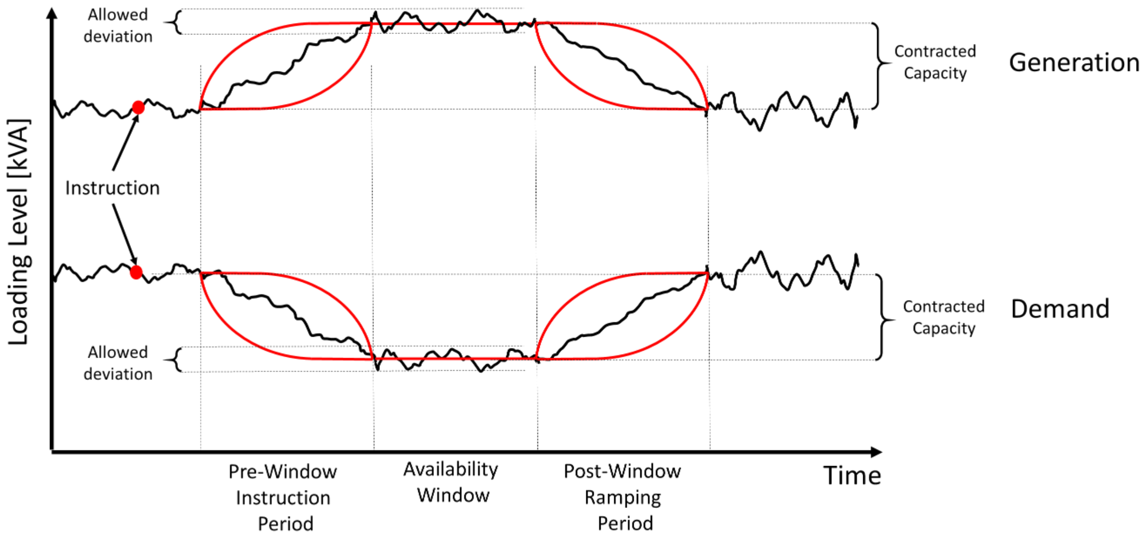


Figure 5 Example visualisation of the capability test

Table 5: Description of the Service

Test Period	1			
Sub-Period	Instruction	Pre-Window Instruction Period (PWIP). This is equal to the Response Time, which is a tendered parameter. Response Time is defined as being the time that it will take a unit/site to reach the Contracted MW level after the Reserve Provider receives an Instruction	Availability Window (AW). This is defined as the period where the Reserve Provider is required to be available to operate at Contracted MW	Post-Window Ramping Period (PWRP). This is the time required for a unit/site to return to its default state following Instruction
Start Time		-	Start time of the availability window will be provided at the point of instruction which will be no less than 240min prior to the start of the AW (standard STOR requirement). However, the expected point of instruction for the trials will be 20 minutes or less prior to the start of the AW.	-
Time		The length of the PWIP will vary between Test Periods and will be between 1 and 20 minutes.	The time for AW will vary between Test Periods and will be between 2 and 5.5 hours	The time for PWRP will vary between Test Periods and will be between 1 and 20 minutes
Instruction	An instruction will be given in kW. The ramp-up rate delivery of the contracted capacity is expected to be as gradual as possible.		To determine capability with the instruction target, the average loading level will be calculated over the instruction period with 1 second resolution. The average must be within ±10% of the instruction target.	The ramp-down rate delivery of the contracted capacity is expected to be as gradual as possible.

Table 6: Example for STOR capability test schedule

Test Period	1			
Sub-Period	Instruction	PWIP	AW	PWRP
Start Time [hh:mm on dd/mm/yy]		09:40 on 28/05/20	10:00 on 28/05/20	12:00 on 28/05/20
Time [min]		20 min	120 min	10 min
Instruction	08:40 on 28/05/20	XX kW	-	-

Table 7: Example schedule for availability windows[3]

Working Day Availability Windows (Mon-Sat)	Non-Working Day Availability Windows (Sun & BH)
07:00 – 13:30	10:30 – 13:30
16:30 – 21:00	16:30 – 21:00

3.3.1. Trial Schedules

Service delivery will be a multiple repetition of the STOR service capability testing where the DSO will instruct multiple flexibility providers to deliver the service in the same time period. The main objective is to test whether the service delivered by different flexibility providers can be coordinated (aggregated) and provided as package to the ESO.

3.4. Methodology for Authorised Supply Capacity Sharing Trials

Authorised Supply Capacity (ASC) sharing is a peer-to-peer service to allow customers supplied from the same substation to share their authorised supply capacity (generation or demand) for a period of time. The service requires prior approval from the DSO.

[3] https://www.nationalgrideso.com/balancing-services/reserve-services/short-term-operating-reserve-stor

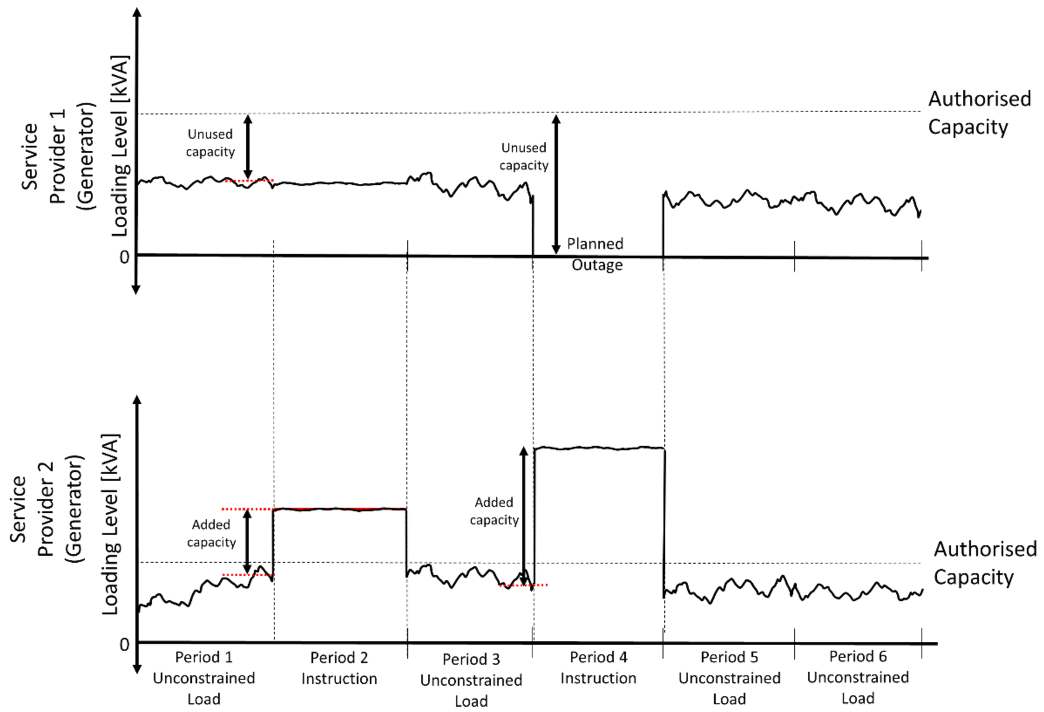


Figure 6 Example visualisation of ASC transaction

3.4.1. Capability Testing

Example for authorised capacity sharing capability testing is given in Table 8.

Table 8: Example for trial instruction between two generators for capability testing

Participants	Type of Customer	Notice to DSO	Start Time	Finish time
Customer 1 (capacity seller)	Generator	09:00 on 28/05/20 Peer to peer agreed capacity sharing volume of 3MVA	11:00 on 28/05/20 Manage generation 3MVA below authorised capacity limit	16:15 on 29/05/20 Manage generation within the authorised capacity limit
Customer 2 (capacity buyer)	Generator		11:15 on 28/05/20 Increase generation up to 3MVA above authorised capacity limit	16:00 on 29/05/20 Manage generation within the authorised capacity limit

3.4.2. Trial Schedules

Service delivery will be a multiple repetition of the service capability testing, where the customers will notify the DSO for agreed transactions.

3.5. Methodology for Offsetting Trials

Offsetting is to allow any demand, storage and generation customers supplied from the same substation to offset the increase in demand of one customer with an equivalent increase in export of the other customer. This is a peer to peer service subject to prior DSO approval. The net effect of the transaction is zero so there is no impact on the constrained substation. An example transaction is provided in Figure 7.

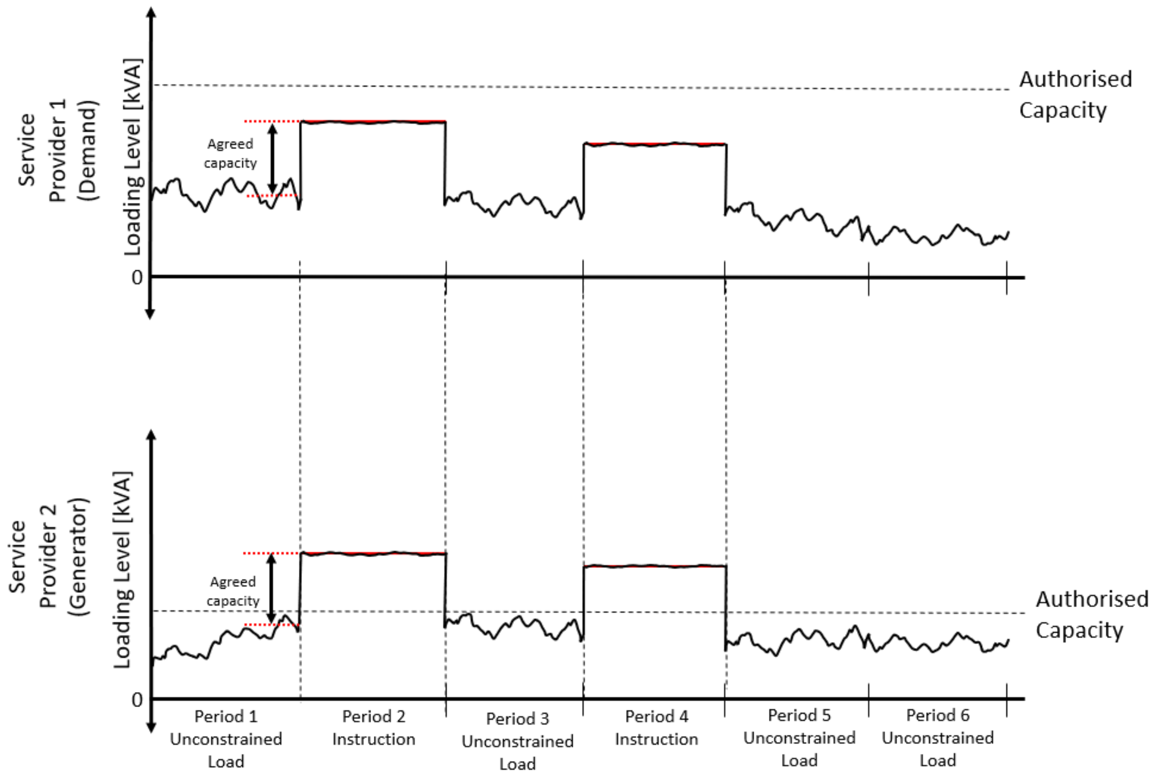


Figure 7 Example visualisation of Offsetting transaction between Generator and Demand customers

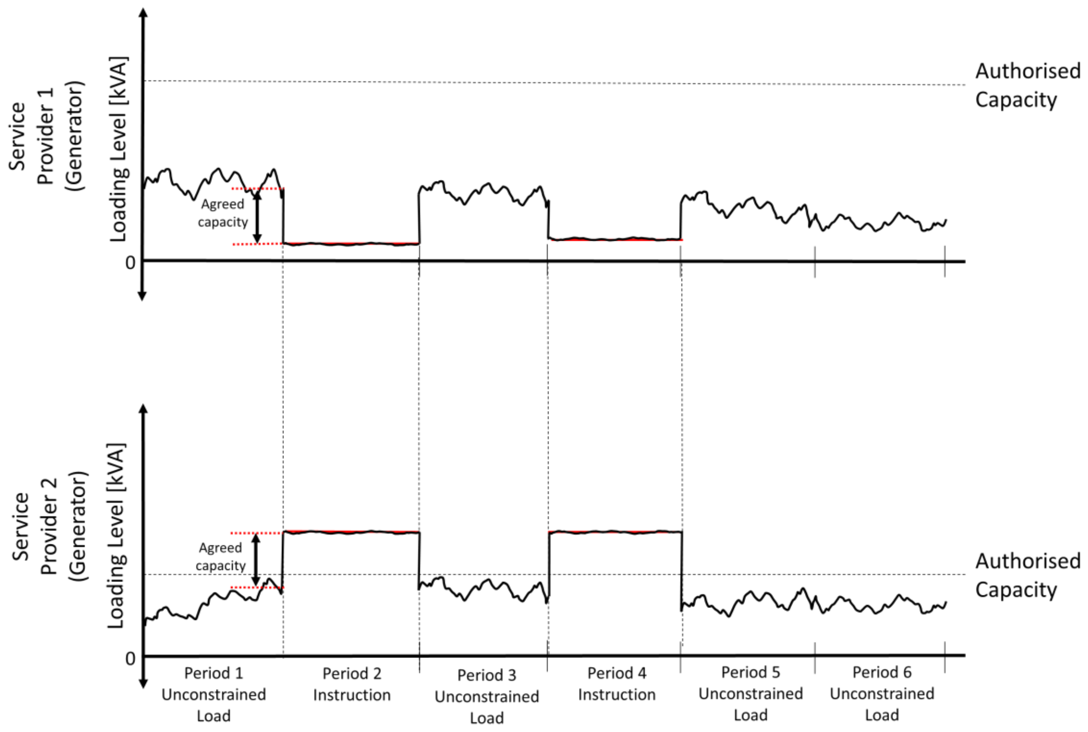


Figure 8 Example visualisation of Offsetting transaction between two Generators customers

3.5.1. Capability Testing

Table 9: Example for trial instruction for transaction between Generator and Demand for capability testing

Participants	Type of Customer	Notice to DSO	Start Time	Finish time
Customer 1 (capacity seller)	Demand	09:00 on 28/05/20 DSO instruct 300kVA offsetting capacity	11:00 on 28/05/20 Increase demand according to instruction	14:30 on 28/05/20 Unconstrained. Manage demand within the authorised capacity limit
Customer 2 (capacity buyer)	Generator		11:01 on 28/05/20 Increase generation according to instruction	14:29 on 28/05/20 Manage generation within the authorised capacity limit

3.5.2. Trial Schedules

Generally, the service delivery will be a multiple repetition of the capability testing. The exact details on the service delivery will be confirmed once the list of flexibility providers participating in the trials is confirmed.

4. Draft Trial Sequencing

4.1. Number of Trial Instructions and Confidence Levels

The process to determine the error within a number of instructions is based on methodology described within 'Adequacy of Sample Size in Heath Studies[4]. This is a recognised World Health Organisation published statistical methodology which details analysis and applications for health-related studies. The use of this method within engineering is described in 'Probability & Statistics for Engineering and the Sciences'[5], published by California Polytechnic State University. This book discusses statistical methods and applications within the context of engineering and science.

The method above can be applied for estimating margins of error under Project TRANSITION to determine the number of instructions (or trials).

For the purpose of estimation, a standard distribution was assumed. This describes the possible range of values for a given number of instructions by accounting for margin of error.

The ± margin of error with the number of instructions is estimated using the following equation:

$$\pm d = \sqrt{z^2 * \frac{P(1-P)}{n}} \tag{1}$$

Where:

- d is the range of error within a number of instructions (See Figure 9).
- n is the number of trial instructions.
- P is the population proportion that represents a reference point within the distribution. The function is maximised at 0.5 (50%) – the mean of a standard distribution (See Figure 9). It is a recognised industry practice to use this value as it represents the worst-case scenario.
- z is the z - score. This is the number of standard deviations from value, P, to represent a percentage of total instruction estimations. i.e. the range described by 2* d (See Figure 9). A confidence level of 95% is generally used in practice[6].

A T-distribution table[7] is used to compare the number of instructions to a desired percentage confidence level (probability that a value sits within a range, as defined in 'z - score' above). The output from this table is the z - score.

[4] 'Adequacy of Sample Size in Health Studies' by Stanley Lemeshow, David W. Hosmer Jr, Janelle Klar, and Stephen K. Lwanga - Part 1; Page 1.
[5] Probability and Statistics for Engineering and the Sciences by Jay L. Devore. Page 280.
[6] Confidence level selection https://www2.gov.scot/Topics/Statistics/Browse/Health/scottish-health-survey/ConfidenceIntervals
[7] Table found at http://www.sjsu.edu/faculty/gerstman/StatPrimer/t-table.pdf

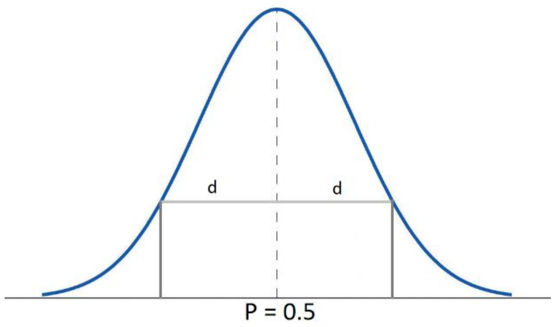


Figure 9: Standard Distribution for P = 0.5

Subsequently, Figure 10 can be created using formula (1) above to describe the margin of error compared to the number of instructions during the trials. A consistent z -score was assumed to be 1.96 as described within the T-distribution table, this is standard for a 95% confidence level calculation.

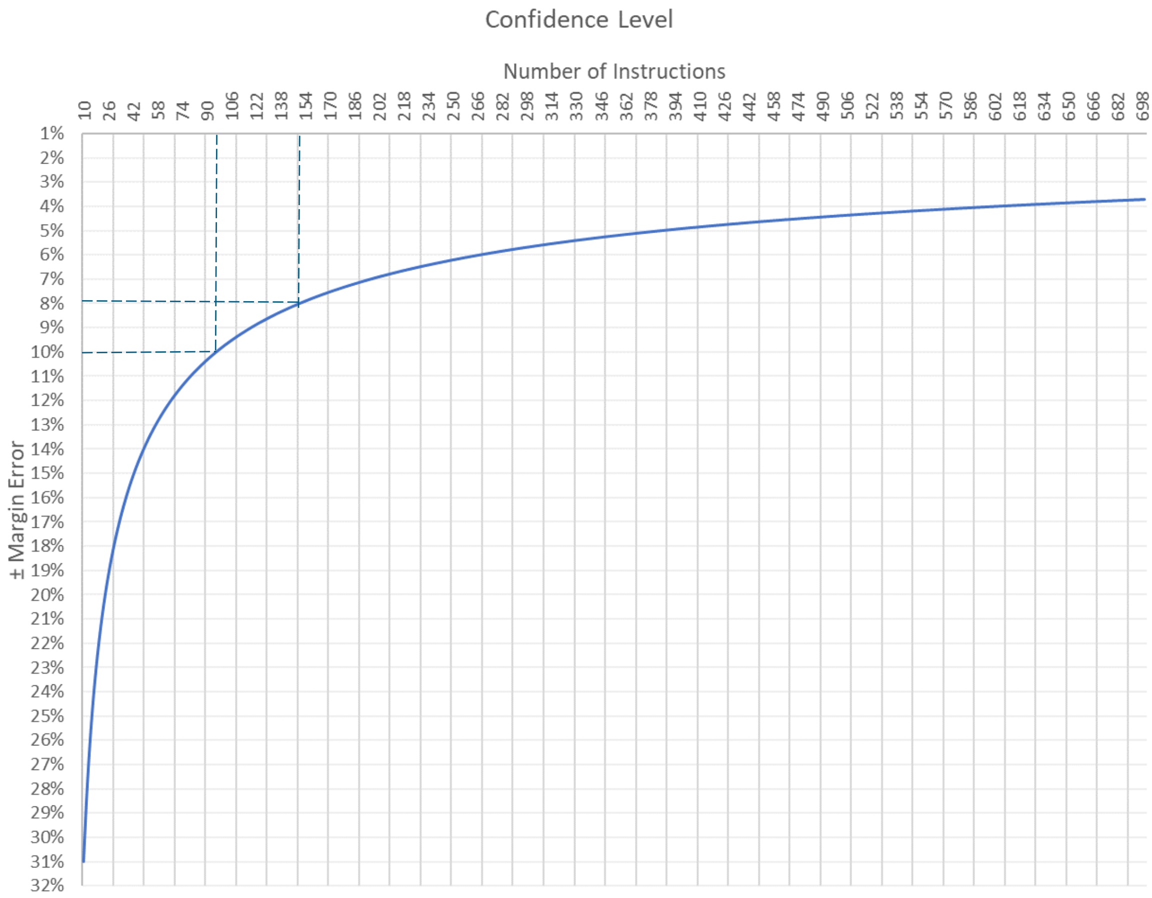


Figure 10: Relationship between the number of instructions against the margin of error based on Formula (1)

The "knee point" shown on Figure 10 is between ±8% and ±10% margin of error which is recommended as it demonstrates the best value for money with number of instructions compared to margin of error. The curve's gradient following the "knee point" on the graph demonstrates that using extra instructions provides minimal additional value when compared to the additional cost to conduct the trials.

4.2. Trial Strategy

Table 10: Trial Strategy for LEO/TRANSITION

	Authorised Supply Capacity Trading[8]	Constraint Management	Offsetting[8]	Peak Management	Short-Term Operating Reserve
Summer-20 LEO	Small Trial 10 instructions			Small Trial 10 instructions	1-day Event 1 instruction
Winter-20 LEO					
Summer-21 LEO	Large Trial 20 instructions	Small Trial 10 instructions	Small Trial 10 instructions	Large Trial 20 instructions	4-day Event 4 instructions
Winter-21 TRANSITON	Large Trial 20 instructions	Large Trial 20 instructions	Large Trial 20 instructions	Full Trial 20 instructions	10-day Event 10 instructions
Summer-22 TRANSITON	Large Trial 30 instructions	Large Trial 30 instructions	Large Trial 30 instructions	Full Trial 30 instructions	10-day Event 10 instructions
Winter-22 TRANSITON	Full Trial 40 instructions	Full Trial 40 instructions	Full Trial 40 instructions	Full Trial 40 instructions	
Total number of instructions / margin of error	120 / ±8.9%	100 / ±9.8%	100 / ±9.8%	120 / ±8.9%	25 / ±19.6%
Average number of instructions per type[9] / margin of error	12 / ±28%	10 / ±31%	10 / ±31%	12 / ±28%	2.5 / ±62%

The assumed technology types are:

1. Gas
2. Photovoltaic (PV)
3. Battery Storage
4. Waste to Energy (WtE) (WtE/ Landfill Gas/ Biomass)
5. Hydro-Electric and Pumped Storage
6. Combined Heat and Power (CHP)
7. Wind
8. Diesel
9. Energy Demand (Domestic/ Commercial/ Industrial)
10. Fuel Cells

The high-level trial programme is shown in Table 10 and following assumptions have been made:

- Trials for Constraint Management and Peak Management services can be conducted in parallel. This is possible because they are based on active and reactive power. However, the exact dispatch of the services must be designed in a way that delivery of one service does not affect the delivery of the other.

[8] One instruction for Authorised Capacity Trading and Offsetting will dispatch two flexibility providers.
[9] Assuming that that there are 10 generation technology types.

- We have assumed three seasonal periods for the trials based on the similarities of the GB electricity demand between March/April and September/October which are shown in Figure 12 (Appendix 1 - Daily and Seasonal Periods for DSO Constraint Management and Peak Management Services).

5. Academic Rigour

5.1. Winter trials

There will be 3 rounds of summer trials in 2020, 2021 and 2022 before any winter trials take place according to the recommendations from Origami. The results from the summer trials within Project TRANSITION will inform the following winter trials. Project risks are introduced by doing only one set of winter trials. The risk arises as service providers may perform differently depending on the winter weather conditions, especially weather dependant renewable technologies like PV. Hence, Atkins recommends two sets of winter trials in 2021 and 2022 to mitigate this risk, as shown in Table 10: Trial Strategy for LEO/TRANSITION.

5.2. Weather dependent service providers

A risk is introduced by only having two sets of winter trials with regards to weather dependent service providers e.g. PV, Wind and Hydro-electric. Weather dependent service providers would be less willing/capable to participate in trials if weather conditions are undesirable or cannot be predicted. Hence, by having only two winter sets of trials, a risk is taken as there is no opportunity to gain confidence in these service providers prior to the first winter trials in 2021.

5.3. State of service provider

In the report we assumed that the service providers will be in a state ready to dispatch the services. For example, if a Gas generator is expected to dispatch on instruction with certain latency (i.e. Constraint Management service) from a cold start; it would likely not meet the required latency for this instruction-based service.

5.4. Aggregation

Use of aggregators should be considered in the trials as the capacities from demand type service providers may be a challenge during low demand periods (e.g. summer). If they are not aggregated, it could lead to a reduction of participating service providers and therefore impose a limit to the trials (e.g. increased margin of error).

5.5. Replicability

Replicability may be a risk for the winter trials as there is only two rounds of winter trials to be taken - compared to the three rounds of summer trials. This introduces a risk to the results on a replicability basis since there is no opportunity to gain confidence doing winter trials before 2021.

The SSEN IT Project Roadmap (Appendix 4 – IT Project Roadmap) shows how SSEN plan to integrate an IT platform into their network that will be used to control the trial instructions. We assume that the IT platform will be available circa late Q1 in 2021, and will be in use for the summer 2021 trails and all trials thereafter. Prior to the introduction of the IT platform, the instruction to dispatch will be done via an alternative communications approach: either SMS or internet signal. This could introduce a risk in terms of replicability as there will be no opportunity to gain confidence using the IT platform before 2021.

5.6. Technology Assessment

The generation technology type capability ranking adopted from highest to lowest are shown below:

- Highly capable
- Capable
- Marginally Capable
- Not Capable

Table 11: Summary Technology Assessment capability. Detailed table is presented in Appendix 3 – Detailed Version of The Technology Assessment of Capability

Type Number	Technology Type	Authorised Supply Capacity Trading	Constraint Management	Offsetting	Peak Management	Short-Term Operating Reserve (STOR)
1	Gas	Highly Capable	Highly Capable	Highly Capable	Highly Capable	Highly Capable
2	PV	Highly Capable	Highly Capable	Capable	Capable	Capable
3	Battery Storage	Highly Capable	Highly Capable	Highly Capable	Capable	Highly Capable
2	PV & Battery Storage	Highly Capable	Highly Capable	Highly Capable	Capable	Highly Capable
4	Waste to Energy (WtE)	Highly Capable	Highly Capable	Highly Capable	Highly Capable	Highly Capable
5	Hydro-electric	Highly Capable	Marginally Capable	Capable	Capable	Capable
6	Combined Heat and Power (CHP)[10]	Not Capable	Marginally Capable	Marginally Capable	Marginally Capable	Marginally Capable
4	Landfill Gas	Highly Capable	Highly Capable	Highly Capable	Highly Capable	Capable
1	CHP & Gas	Highly Capable	Highly Capable	Highly Capable	Highly Capable	Highly Capable
7	Wind	Highly Capable	Highly Capable	Capable	Capable	Marginally Capable
8	Diesel	Highly Capable	Highly Capable	Highly Capable	Highly Capable	Highly Capable
4	Biomass	Highly Capable	Highly Capable	Highly Capable	Highly Capable	Highly Capable
9	Domestic Demand	Not Capable	Marginally Capable	Marginally Capable	Marginally Capable	Marginally Capable
9	Commercial Demand	Marginally Capable	Capable	Capable	Capable	Capable
9	Industrial Demand	Highly Capable	Highly Capable	Highly Capable	Highly Capable	Highly Capable

[10] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/345189/Part_2_CHP_Technology.pdf

5.7. Operational Restrictions (Seasonal)

As part of Phase 2 of WP6 the information below was provided by SSEN in relation to known (generation and demand) constraints in each selected BSP. In the last column we assessed the suitability for running trials at each substation taking into account its operational restrictions. This consideration is per the considerations listed in the Trial Philosophy.

Table 12: Suitability of Substation Assessment based on the data supplied by SSEN to Atkins in November 2019. These results are very likely to change over the next couple of years hence the table will be kept active and updated regularly.

BSP. All BSPs are under Cowley GSP except Bicester North that is under East Claydon	Installed Capacity (MVA)	Firm Capacity (MVA)	Maximum Load 2017/18	Minimum Load 2017/18	Total Accepted Generation Capacity	Contracted Generation @ Upstream BSP (MW)	Known/Forecast Constraints (Load)	Known/Forecast Constraints (Generation)	Substation suitability (High/Medium/Low)
Cowley Local (Main) 132/33kV	180 MVA (2x90)	117 MVA	70.7 MVA	20 MVA	25.08 MW	Diesel - 0.5MW PV - 8.8MW PV - 3.12MW CHP - 1.6MW BS - 11MW **Total: 25MW**		High export capacity. Increase in generation could reach 100MVA.	High. Due to variety of generation types.
Cowley Local (Reserve) 132/33kV	180 MVA (2x90)	117 MVA	28.3 MVA	4 MVA	21.69 MW	PV – 2MW PV – 6.33MW Gas – 12MW PV – 1.36MW **Total: 22MW**		High export capacity. Increase in generation could reach 80MVA.	High. Due to variety of generation types.
Drayton 132/33kV	270 MVA (3x90)	228 MVA	103.7 MVA	21.8 MVA	145.53 MW	Diesel – 3.3MW Other S – 1.68 PV – 12.2MW PV – 21.25MW Gas – 13MW PV – 35.00	Increase of load by more than 12 MVA would require Cowley GSP to be run at a solid configuration at 132kV, leading to requirement for replacement of 10x 132kV	Increase of generation by more than ~10 MW would require requirement for up to 2x 7.7km 132kV circuit reinforcements between Drayton - Culham tee.	Medium. Due to variety of generation types in combination is known site constraints.

BSP. All BSPs are under Cowley GSP except Bicester North that is under East Claydon	Installed Capacity (MVA)	Firm Capacity (MVA)	Maximum Load 2017/18	Minimum Load 2017/18	Total Accepted Generation Capacity	Contracted Generation @ Upstream BSP (MW)	Known/Forecast Constraints (Load)	Known/Forecast Constraints (Generation)	Substation suitability (High/Medium/Low)
						BS - 20MW L Gas – 13MW L Gas – 14.1MW L Gas – 10MW **Total: 144MW**	feeder circuit breakers due to increased fault level.		
Headington 132/33kV	180 MVA (2x90)	114 MVA	87.7 MVA (49.4MW maximum expected in 2019/20 after completion of Bicester North)	28.2 MVA (15.2MW maximum expected in 2019/20)	102.26 MW (31.85 MW after completion of Bicester North)	PV – 8MW PV – 12MW Gas – 5MW CHP/Gas – 3.6 **Total - 29MW** (29 MW after completion of Bicester North)		High export capacity. Increase in generation could reach 100MVA.	High. Due to variety of generation types.
High Wycombe 132/33kV	180 MVA (2x90)	114 MVA	96.5 MVA	28.4 MVA	21 MW	L Gas – 1MW PV – 20MW **Total - 21MW**		Increase of generation by more than ~28 MW would require up to 10.635km 132kV circuit reinforcements between High Wycombe - Cowley.	Low. Due to small verity of generation types combined with generation constraints.
Osney 132/33kV	180 MVA (2x90)	102 MVA	85.1 MVA	26.7 MVA	0 MW	0MW		Increase of generation by more than ~59 MW would require Cowley GSP to be run at a solid configuration at 132kV, leading to requirement for replacement of 10x 132kV feeder circuit breakers due to increased fault level.	Low. Due to small verity of generation types combined with generation constraints.
Witney 132/33kV	180 MVA (2x90)	114 MVA	80.9 MVA	18.3 MVA	113.1 MW (Yarnton & Witney combined)	PV – 35MW PV – 9.99MW PV – 10MW PV – 4.95MW PV – 4.98MW Diesel – 4.30MW		Increase of generation by more than ~20MW would require up to 2x 2.14km 132kV circuit reinforcements between Yarnton - Headington	Medium. Due to variety of generation types in combination is known site constraints.

BSP. All BSPs are under Cowley GSP except Bicester North that is under East Claydon	Installed Capacity (MVA)	Firm Capacity (MVA)	Maximum Load 2017/18	Minimum Load 2017/18	Total Accepted Generation Capacity	Contracted Generation @ Upstream BSP (MW)	Known/Forecast Constraints (Load)	Known/Forecast Constraints (Generation)	Substation suitability (High/Medium/Low)
Yarnton 132/33kV	180 MVA (2x90)	114 MVA	70.7 MVA	20.1 MVA	113.1 MW (Yarnton & Witney combined)	Diesel – 1MW Diesel – 9.90MW Diesel – 4.98MW BS – 20MW PV/BS – 6MW L Gas – 2MW **Total - 113MW**		Increase of generation by more than ~20MW would require up to 2x 2.14km 132kV circuit reinforcements between Yarnton - Headington	
Bicester North 132/33kV	180 MVA (2x90)	117 MVA	0 MVA (54.2MW maximum expected in 2019/20)	0 MVA (13MW maximum expected in 2019/20)	5.29 MW (75.7 MW after completion of Bicester North)	PV – 17.16MW PV - 5MW PV – 10MW CHP/Gas – 0.9 CHP/Gas – 3.17 L Gas – 3.24MW L Gas – 1.57MW L Gas – 1MW Waste – 31.62MW **Total – 74MW**	Increase of load by more than 60 MVA would require transformer reinforcements	Increase of generation by more than ~44 MW would require transformer reinforcements as well as reinforcements on a 132kV circuit to East Claydon.	Medium. Due to variety of generation types in combination is known site constraints.

5.8. Considerations from Project TRANSITION Partners

5.8.1. Engagement with ENWL on simulation trials

The following information was obtained after an engagement with ENWL in their offices in Manchester on 26/11/2019.

ENWL's Simulations are concentrating on:

- Mostly large flexibility providers (MW scale). Trials for small size provides (kW size) are not planned at present.
- Large demand customers (e.g. large factory units).
- Simulation trials are limited to active power.
- The trials that ENWL is conducting will be similar to:
  - Constraint Management
  - ASC trading

  The trials that ENWL is not doing are:
  - STOR
  - Peak Management (kVAr related)
- ENWL is planning to use IPSA software

Additional generic considerations about ENWL's simulated trials:

- ENWL will aim for a confidence level of less than ±5%.
- ENWL will adopt a service dispatch latency of 30s for unplanned services.
- ENWL currently have the following generation types connected across their Greater Manchester network: PV, Battery Storage, Hydro-electric, CHP, Biogas, Onshore Wind, Diesel, Natural Gas and Fuel Oil.
- ENWL is choosing not to include their Hydro-electric capability in their simulations.
- The SCADA control system used currently is a bespoke control system based on the Ferranti model from the late 1990's which is linked to the Thales SCADA system. They expect to transition onto the Schneider NMS in early 2020.

5.8.2. Use Cases/Services engagement with Origami Energy

Following an engagement with Origami that was held in their offices in London on 05/12/2019 attended. Attended by Nikola Gargov (Atkins), Katie Bennett (Atkins), David Plunkett (Atkins) and Timur Yunusov (Origami). All recommendations raised by Origami associated with this report have been added as comments in the working version of the report and appropriate changes were implemented.

5.9. IT Communication requirements for trials

It is envisaged that the NMF and WSC will not be available until the beginning of 2021. Hence, it is assumed that at least the initial trials (trials in 2020) will be conducted via an alternative communication approach (e.g. SMS or internet signal). The exact approach will be confirmed at a later stage.

6. Governance

Atkins has been requested to review the governance surrounding the trial philosophy and programme methodology against publicly available information for TRANSITION, Electricity Flexibility and Forecasting Systems (EFFS), and Fusion (collectively known as TEF); the Network Innovation Competition (NIC) and Local Energy Oxfordshire (LEO). The sources of the publicly available information for TEF, NIC and LEO that have been requested to review are provided in Table 13, a review of this information is then presented.

Table 13 - TEC, NIC and LEO Information Sources

Information	Source of Information
TEF	https://www.ofgem.gov.uk/system/files/docs/2018/10/nic_2017_compliance_document_v2_public_1.pdf https://www.ofgem.gov.uk/system/files/docs/2018/10/nic_2017_compliance_document_appendices_v2_public.pdf
NIC	https://www.ofgem.gov.uk/system/files/docs/2017/07/electricity_network_innovation_competition_governance_document_version_3.0.pdf
LEO	https://www.gov.uk/government/news/four-leading-edge-demonstrators-to-jumpstart-energy-revolution https://project-leo.co.uk/

6.1. Review of TEF

Three projects were submitted for the NIC that supported the transition from DNO to DSO. These 3 projects were:

- TRANSITION, submitted by Scottish and Southern Electricity Networks and Electricity North West;
- Electricity Flexibility and Forecasting Systems (EFFS), submitted by Western Power Distribution; and
- FUSION, submitted by SP Energy Networks.

Collectively the projects are known as TEF and the three projects look at different aspects of the DSO transition with differing aims and areas of focus.

Conditions were imposed on TEF to reduce the risk of unnecessary duplication, improve delivery, efficiency and ensure the projects deliver complementary learning. A summary of these conditions are provided below:

1. Individual project programmes have been better aligned. This is to ensure that the early learning and products from any project can be incorporated into the other projects at the earliest opportunity.

   Suggested action: All TEF programmes should be shared with the respective projects to review possible impacts on each other and / or take account of any learning to date.
2. Efficiency and benefit to customers. This is to ensure that one of the projects is not repeating work that has already been undertaken by the other two. It is also a requirement to have a clear understanding of the commonality and difference between the projects. This is to include additional cross-project peer reviews of requirements, and attendance at regular joint project meetings as part of the new governance arrangements.

Suggested action: The Stage Gate should review the scope of the 3 TEF projects to identify where any items have changed. And where this might be the case, if the scope areas cross over and if there is opportunity to increase project efficiency. This would also be an opportunity to check against any wider industry changes in the transition to DSO.

3. Engaging and communicating with wider industry stakeholders. This is to ensure that a clear and consistent message on the projects' objectives and progress is provided to industry stakeholders. Stakeholder engagement should include national stakeholder dissemination, local stakeholder engagement, market participant recruitment and wide industry engagement and consultation on proposed platform.
   Suggested action: All 3 TEF projects to review the overall stakeholder map for TEF to make sure it is still current / add or remove stakeholders as required. Review stakeholder information requirements, how these fit with the communications plan and when these were last actioned.
4. Engaging with the Open Networks project. There is a requirement to engage with the ON project throughout the life of the 3 TEF projects to make sure that TEF is building on the outputs of the ON project. TRANSITION needs to demonstrate at least one market model defined by ON and building on ON outputs, developing specific DSO requirements suitable for using in open procurement exercise.

   Suggested action: Check that the engagement with the ON project is current and relevant communications are being provided. Document how TEF is building on the outputs of the ON project.
5. Trial definitions. This is to ensure no unnecessary duplication between projects and similar requirements to Point 2 above. Up to two trial locations across GB are required, each with three trial phases within two-year duration. Trial requirements and locations to be determined based on final design of ON market models.

   The list below shows a selection of the expected outcomes from the trials.

   - Measure forecasting accuracy and time horizons.
   - Measure asset response time and service delivery.
   - Assess suitability of market & directly connected interfaces to assets.
   - Assess co-ordination method with other third parties (Suppliers, TSO, DSO).
   - Validate that the selection of flexibility assets by the software is optimal.
   - Compare the actual impact on the network to the modelled impact to inform strategies for flexibility service procurement and deployment.
   - Validate the expected operating costs of flexibility services.
   - Provide output on the impact of flexibility on fault restoration to inform the P2/6 review.
   - Inform the likely operating costs of flexibility services.
   - Demonstrate different service provision technologies i.e. DSR, generation and storage.
   - Investigate different control options i.e. directly controlled or controlled via third parties.
   - Trial over all Network types (Overhead and Ground Mounted/ Underground), rural and urban locations.
   - Test software optimisation by trialling in areas with a high number of flexibility service providers.

   Suggested action: Hold a review of the high-level trial definitions for the 3 projects to ensure no unnecessary duplication, with a commitment to ensure alignment as further trial details are determined. Check that the expected outcomes of the trials align with the above expectations.

6. Collaboration, benefits and learning outcomes. This is to ensure the TEF projects are identifying and sharing outcomes and lessons learned to add efficiency and deliver better value compared to an independent project approach.

   Suggested action: Hold a regular review between the three TEF projects to build collaboration and document the benefits and learning outcomes.

7. Deliverables

Ref	Project Deliverables	Evidence
1	WP6 Trial specification. Produce and apply the site selection methodology and select the Trial networks.	1. Publish on the TRANSITION website a report detailing the site selection methodology, and a map of Trial areas. 2. Selection of networks to install monitoring (if required).
2	WP2 Requirements Design Development Data Exchange requirements and updated data governance processes specified.	1. Publish report detailing learning from relevant international DSO experience relating to trial objectives. 2. Functional specification for connectivity model, data exchange and governance requirements.
3	Stakeholder feedback event (Stage Gate)	1. Stakeholder feedback event to disseminate and gather feedback on outputs from WP 2-6.
4	WP7 Deployment Develop appropriate Commercial arrangements and contract templates for flexibility services. Network adaptation for trial deployment.	1. Publish contract templates for flexibility services and commercial arrangements learning. 2. Publish equipment specifications and installation reports.
5	WP7 Deployment Platform Full Acceptance Testing completed	1. Publish interface and configuration specifications and commissioning reports.
6	WP8 Trials stage 1 Completion of one stage of trials	1. Publish monitoring and analysis results for Trials on TRANSITION website. 2. Stakeholder dissemination event showcasing learnings.
7	WP8 Trials stage 2 Completion of second stage of trials	1. Publish monitoring and analysis results for Trials on TRANSITION website 2. Stakeholder dissemination event showcasing learnings.

   Suggested action: Continue to review deliverables throughout the project to ensure that they are on track.

8. Other notable requirements include:
   - Procurement - Run a procurement exercise for provision of a trial's platform
   - Software development - Develop a beta platform suitable for trials which integrates with SSEN and ENWL existing infrastructure

- Any one project will not commence the deployment stage without prior approval of the Authority
- T.E.F. will not proceed unless there are clear benefits for consumers and a clear consensus from stakeholders, industry and regulators.

6.2. Review of NIC

The full submissions for the three projects were judged against the following criteria:

- Accelerates the development of a low carbon energy sector and/or delivers environmental benefits whilst having the potential to deliver net financial benefits to future and/or existing Customers;
- Provides value for money to electricity customers;
- Generates knowledge that can be shared amongst all relevant Network Licensees;
- Is innovative (i.e. not business as usual) and has an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness;
- Involvement of other partners and external funding;
- Relevance and timing; and
- Demonstration of a robust methodology and that the Project is ready to implement.

The Funding Licensee will be required to provide a Project Progress Report (PPR), which contains sufficient detail to allow Ofgem to evaluate the progress of the Project and a Close down report for each finished project - the Close Down Report must provide sufficient information for third parties to understand what has been learnt from the Project.

Suggested action: Continue to review the project against the NIC criteria that the project was originally submitted against. Regular meetings, updates, progress and results of trials can be used to produce progress reports and the final close out report.

6.3. Review of LEO

Project LEO will take a DSO approach to implementing new energy projects and facilitate future forecasting and planning. A local energy marketplace will be created to enable virtual aggregation of loads, dispatch of flexibility across a range of projects, and execute local peer-to-peer trading. The project takes a very community-centric approach and has a large portfolio (~90) of low carbon energy projects which could be on-boarding to the distribution network.

Project TRANSITION delivers the network management system to facilitate the market developed in Project LEO and allows the value of these projects to be realised by local communities. Project LEO delivers a much larger number of participants than would otherwise be available, allowing the outputs of TRANSITION to be more robust and impactful to network operators as they transition to DSO.

LEO consists of 6 work packages, of which Project TRANSITION is one of the work packages. The work packages are:

WP1 – Programme Management

WP2 – Flexibility Exchange Developers

WP3 – Plug-in Projects

WP4 – Future System Planning

WP5 – TRANSITION Project

WP6 – Learning and Dissemination

Priority projects as part of WP3 are to include: a community hydro project, an EV transport hub and heat network proposals.

TRANSITION will explore several models with reference to “price flexibility”, and “contracted flexibility”. There are different actions to achieve prices which reflect the value of the service to the wider system (‘system value pricing’) for different types of flexibility. One of the key outputs from Open Networks will be a Smart Grid Architectural Model of the key elements of a DSO.

7. Appendix 1 - Daily and Seasonal Periods for DSO Constraint Management and Peak Management Services

As shown in Figure 11 (34Appendix 1 - Daily and Seasonal Periods for DSO Constraint Management and Peak Management ServicesAppendix 1) every day is divided on five daily periods. The daily profile for national demand was used to define the daily periods. The DSO will issue at least one service instruction during every daily period to test the capability of the service provider to deliver the service in different times of the day.

Similarly, to daily periods, seasonal periods are also defined based on the national electricity demand. The DSO will issue at least one service instruction during every Seasonal Period to test the capability of the service providers to deliver the service in different times of the year.

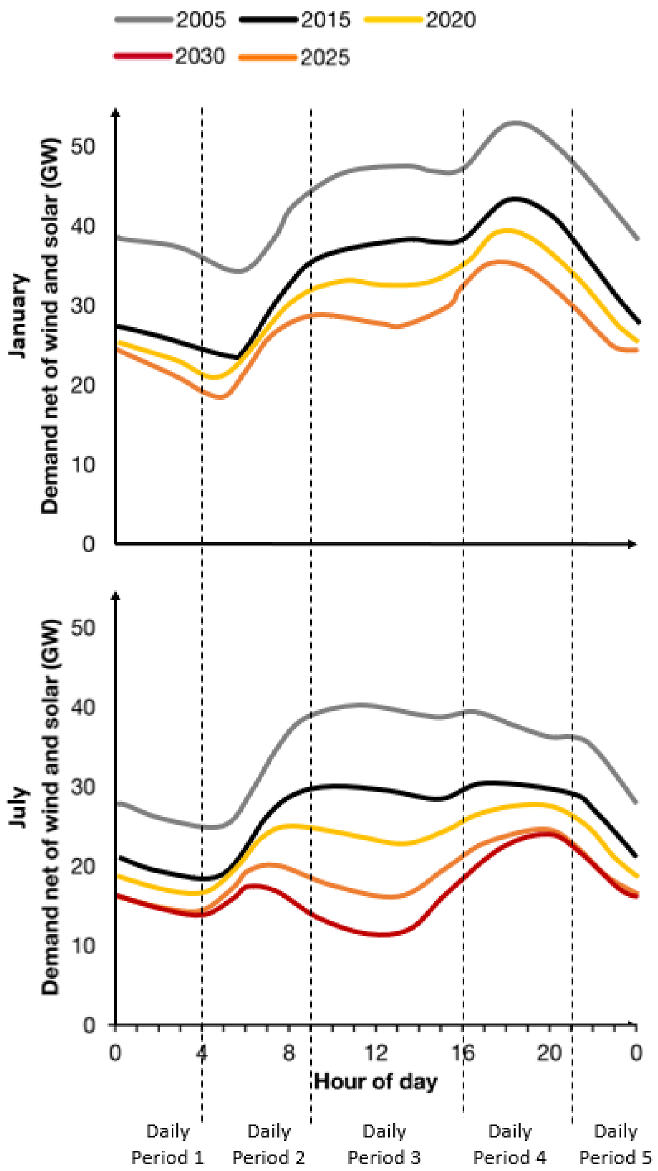


Figure 11 Daily periods for Continues Service Provision test[11]. January (top graph) and July (bottom graph)

The figure shows the total GB demand January (top) and July (bottom). Solid lines show the mean across all days in the month.

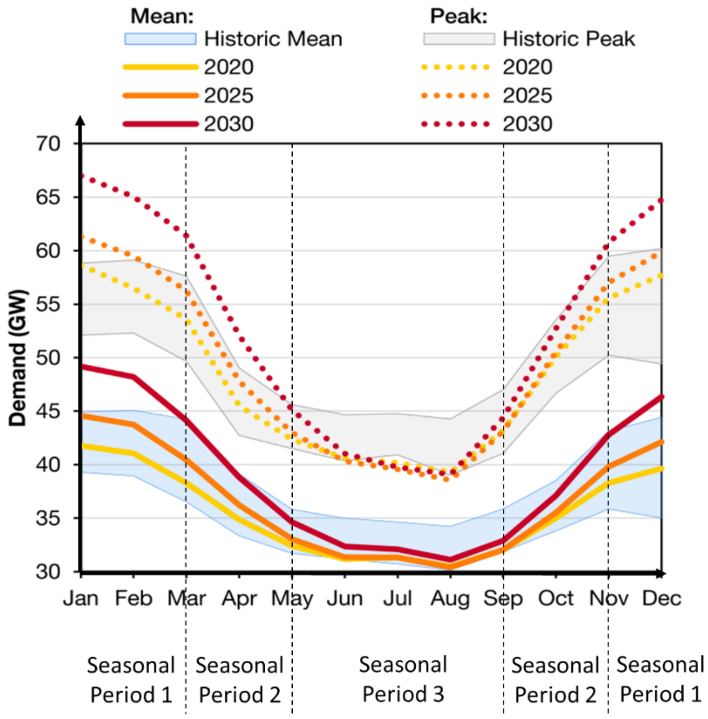


Figure 12 Seasonal periods for Continues Service Provision test[11].

The figure shows the seasonal variation in historic and estimated (future) demand:

- Solid lines and light blue shaded area refer to mean demand, where the solid lines are estimates and the shaded area shows the historic range from 2005 to 2015.
- Similarly, dotted lines and light grey shaded area refer to peak demand, where the solid lines are estimates and the shaded area shows the historic range from 2005 to 2015.

[11] https://reader.elsevier.com/reader/sd/pii/S0360544217320844?token=79FB5AEF1DB3D1C0963735912103AE9BC91555B900A7B39C77413878721F320BF4465999FB3DEE2F308C07FAD8E66528

8. Appendix 2 – Distribution Generation Data

The Distribution Generation Data was supplied by SSEN on 18/11/2019. This data is likely to change over the course of next couple of years and the Table will need to be updated.

GSP	BSP	Primary	Generator connected at Voltage level	Technology	Installed Capacity Large embedded generation capacity (MW scale)	Installed Capacity small embedded generation capacity (kW scale)
Cowley	Bicester North	Bicester North	11kV	Gas	5.29	187.59
Cowley	Cowley Local (Main)	Cowley Local	11kV	Diesel	0.56	358.6
Cowley	Cowley Local (Main)	Cowley Pressed Steel	11kV	PV	8.80	
Cowley	Cowley Local (Main)	Cowley Pressed Steel	11kV	PV	3.12	
Cowley	Cowley Local (Main)	Cowley Pressed Steel	11kV	CHP	1.60	
Cowley	Cowley Local (Main)	Wheatley	33kV	Battery Storage	11.00	
Cowley	Cowley Local (Reserve)	Berinsfield	11kV	PV	2.00	29.6
Cowley	Cowley Local (Reserve)	Berinsfield	11kV	PV	6.33	
Cowley	Cowley Local (Reserve)	N/A	33kV	Gas	12.00	
Cowley	Cowley Local (Reserve)	Wallingford	11kV	PV	1.36	
Cowley	Drayton	Milton	11kV	Diesel	3.30	201.74
Cowley	Drayton	Milton	11kV	Other Synchronous	1.68	

GSP	BSP	Primary	Generator connected at Voltage level	Technology	Installed Capacity Large embedded generation capacity (MW scale)	Installed Capacity small embedded generation capacity (kW scale)
Cowley	Drayton	N/A	33kV	PV	12.20	
Cowley	Drayton	N/A	33kV	PV	21.25	
Cowley	Drayton	N/A	33kV	Gas	13.00	
Cowley	Drayton	N/A	33kV	PV	35.00	
Cowley	Drayton	N/A	33kV	Battery Storage	20.00	
Cowley	Drayton	N/A	33kV	Landfill Gas	13.00	
Cowley	Drayton	N/A	33kV	Landfill Gas	14.10	
Cowley	Drayton	N/A	33kV	Landfill Gas	10.00	
Cowley	Headington	Arncott	33kV	PV	8.00	126.92
Cowley	Headington	Arncott	11kV	Gas	5.00	
Cowley	Headington	Headington	11kV	CHP & Gas	3.60	
Cowley	Headington (to be moved to Bicester North)	N/A	33kV	PV	17.16	187.59
Cowley	Headington (to be moved to Bicester North)	N/A	11kV	CHP & Gas	0.90	
Cowley	Headington (to be moved to Bicester North)	Upper Heyford	11kV	Landfill Gas	3.25	
Cowley	N/A	Harwell South	11kV	Diesel	1.67	N/A
Cowley	N/A	N/A	132kV	Gas	49.99	

GSP	BSP	Primary	Generator connected at Voltage level	Technology	Installed Capacity Large embedded generation capacity (MW scale)	Installed Capacity small embedded generation capacity (kW scale)
Cowley	N/A	N/A	132kV	Gas	99.99	
Cowley	N/A	N/A	132kV	Gas	100.00	
Cowley	N/A	N/A	132kV	Gas	40.00	
Cowley	Yarnton - Witney	Carterton	33kV	PV	35.00	594.46
Cowley	Yarnton - Witney	Charlbury	11kV	Diesel	4.30	
Cowley	Yarnton - Witney	Eynsham	11kV	Diesel	1.00	
Cowley	Yarnton - Witney	N/A	33kV	PV	9.99	
Cowley	Yarnton - Witney	N/A	33kV	PV	10.00	
Cowley	Yarnton - Witney	N/A	33kV	Diesel	9.90	
Cowley	Yarnton - Witney	N/A	33kV	Battery Storage	20.00	
Cowley	Yarnton - Witney	N/A	33kV	PV	4.95	
Cowley	Yarnton - Witney	N/A	11kV	PV	4.98	
Cowley	Yarnton - Witney	N/A	33kV	Diesel	4.98	
Cowley (to be moved to East Claydon)	Headington	N/A	33kV	PV	12.00	187.59
Cowley (to be moved to East Claydon)	Headington (to be moved to Bicester North)	Bicester	33kV	Waste to Energy	31.62	
Cowley (to be moved to East Claydon)	Headington (to be moved to Bicester North)	Cottisford	33kV	PV	5.00	

GSP	BSP	Primary	Generator connected at Voltage level	Technology	Installed Capacity Large embedded generation capacity (MW scale)	Installed Capacity small embedded generation capacity (kW scale)
Cowley (to be moved to East Claydon)	Headington (to be moved to Bicester North)	N/A	33kV	PV	10.00	
Cowley (to be moved to East Claydon)	Headington (to be moved to Bicester North)	N/A	11kV	CHP & Gas	3.17	
Cowley (to be moved to East Claydon)	Headington (to be moved to Bicester North)	Upper Heyford	11kV	Landfill Gas	1.57	
Cowley (to be moved to East Claydon)	Headington (to be moved to Bicester North)	Upper Heyford	11kV	Landfill Gas	1.00	
Cowley (to be moved to East Claydon)	High Wycombe	High Wycombe	11kV	Landfill Gas	1.00	
Cowley (to be moved to East Claydon)	High Wycombe	Watlington	33kV	PV	20.00	
East Claydon	Yarnton - Witney	N/A	33kV	PV & Battery	6.00	187.59
East Claydon	Yarnton - Witney	Standlake	11kV	Landfill Gas	2.00	

9. Appendix 3 – Detailed Version of The Technology Assessment of Capability Matrix

Type Number	Technology Type	Authorised Supply Capacity Trading (peer-to-peer)	Constraint Management	Offsetting (peer-to-peer)	Peak Management	Short-Term Operating Reserve (STOR)
1	Gas[12]	Highly Capable **Suitability:** Gas generation output is flexible as fuel input can be regulated and therefore highly suitable for this service. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	Highly Capable **Suitability:** Gas generation output is flexible and can be increased when required. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	Highly Capable **Suitability:** Gas generation output is flexible as fuel input can be regulated and therefore highly suitable for this service. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	Highly Capable **Suitability:** Gas is a flexible generation type this allows a flexible control on its kW and kVAr output. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	Highly Capable **Suitability:** Gas generation can provide extra capacity upon instruction. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity. Another limit may be imposed by the gas supply availability.
2	PV	Highly Capable **Suitability:** Developers may have capability to generate power beyond the plant's authorised capacity. This is subject to appropriate weather conditions and the individual design of every PV plant. **Limits:** The PV panels' output power is dependent on the weather conditions	Highly Capable **Suitability:** Potentially highly controllable array network. Solar power can be easily disconnected from grid or power export limited when required. **Limit:** There may not be any power export from this type of technology due to intermittent weather conditions. When there is power being generated,	Capable **Suitability:** Developers may have capability to generate power beyond the plant's authorised capacity. This is subject to appropriate weather conditions and the individual design of every PV plant. **Limits:** The PV panels' output power is dependent on the weather conditions and varies incautiously.	Capable **Suitability:** Depending on design the PV may be able operate above the contracted capacity. PV can also provide reactive power at night time[13]. **Limits:** The weather conditions may not be suitable at the prearranged peak time, so	Capable **Suitability:** Developers may have the capability to generate power beyond the plant's authorised capacity. This is subject to appropriate weather conditions and the individual design of every PV plant. **Limits:** The weather conditions may not be suitable at the time that the service is called on, so there is limited reliability in the supply that can be achieved.

[12] Assuming gas generators are in a state ready for dispatch within the expected timescales.
[13] Source: https://www.nationalgrideso.com/document/96401/download

Type Number	Technology Type	Authorised Supply Capacity Trading (peer-to-peer)	Constraint Management	Offsetting (peer-to-peer)	Peak Management	Short-Term Operating Reserve (STOR)
		and varies incautiously. Hence, intermittency can be a challenge to service delivery.	energy will go unused or wasted since generation is based on instantaneous solar intensity.	Hence, intermittency can be a challenge to service delivery.	there is limited reliability for service delivery.	
3	Battery Storage	Highly Capable **Suitability:** Highly controllable only limited by the battery capacity and converter. This type of flexibility provide can be a generator as well as demand. **Limits:** Depending on the individual design capacity can be a limiting factor.	Highly capable. **Suitability:** Battery storage is a highly controllable system which can lower or disconnect power output when required. Excess power can also be used to charge batteries when there is spare capacity to help meet constraints. **Limits:** Design capacity and stored capacity of the battery storage system could be a limiting factor for this technology when acting as a demand.	Highly Capable **Suitability:** Highly controllable only limited by the battery capacity and converter. This type of flexibility provide can be a generator as well as demand. **Limits:** Depending on the individual design capacity can be a limiting factor.	Capable **Suitability:** The stored energy would be available instantaneously. The storage unit would need to be prepared in advance to provide the service. **Limits:** The designed capacity of the battery and the discharge time sequence may limit the service delivery.	Highly Capable **Suitability:** The stored energy would be available instantaneously; this is useful for this service but not mandatory. The parameters of delivery are prearranged and called upon so the storage reserves should be suitable if they agreed to the prearrangement with the ESO. **Limits:** The designed capacity of the battery and the discharge time sequence may limit it.
2	PV & Battery Storage	Highly Capable **Suitability:** Developers may have capability to generate power beyond the plant's authorised capacity. This is subject to appropriate weather conditions and the individual design of every PV plant. Battery storage used in conjunction with PV will enhance the reliability of the service provision. **Limits:** The storage unit size may introduce operation limitations.	Highly Capable **Suitability:** PV resource can be easily switched off or limited from highly controllable array network. Battery storage can act as a demand to store solar generation when not being exported to grid. Battery storage can also act as a demand and store excess power from grid when solar resource is not sufficient. **Limits:** Design capacity and stored capacity of the battery storage system could be a limiting factor for this technology when acting as a	Highly Capable **Suitability:** Developers may have capability to generate power beyond the plant's authorised capacity. This is subject to appropriate weather conditions and the individual design of every PV plant. Battery storage used in conjunction with PV will enhance the reliability of the service provision. **Limits:** The storage unit size may introduce operation limitations.	Capable **Suitability:** PV may be able to operate above its contracted capacity which would be useful for occasions of peak demand. With the addition of battery storage there would be more security in supply when there are unsuitable weather conditions. **Limits:** A limiting factor is the available storage capacity. Also, if the weather patterns have not been suitable to store the	Highly Capable **Suitability:** Addition of battery storage can help solar PV meet the required demand of the service if solar intensity is not enough at the time of instruction. The battery storage will provide reliability in supply to meet the prearranged kWs needed. **Limits:** A limiting factor is the available storage capacity. Also, if the weather patterns have not been suitable to store the energy reserves needed for this application.

Type Number	Technology Type	Authorised Supply Capacity Trading (peer-to-peer)	Constraint Management	Offsetting (peer-to-peer)	Peak Management	Short-Term Operating Reserve (STOR)
			demand. Solar resource could also be a limiting factor since energy may be generated and not utilised effectively.		energy reserves needed for this application.	
4	Waste to Energy (WtE)[14]	<u>Highly Capable</u> **Suitability:** WtE generation output is flexible as fuel input can be regulated and therefore highly suitable for this service. **Limit:** The limit of the generator may be aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	<u>Highly Capable</u> **Suitability:** Generation output is flexible and can be lowered when required to meet constraints. **Limit:** The limiting factor for this technology is the power rating on the generator.	<u>Highly Capable</u> **Suitability:** WtE generation output is flexible as fuel input can be regulated and therefore highly suitable for this service. **Limit:** The limit of the generator may be aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	<u>Highly Capable</u> **Suitability:** WtE is a flexible generation type this allows a flexible control on its kW and kVAr output. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	<u>Highly Capable</u> **Suitability:** WtE generation can provide extra capacity upon instruction. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity. Another limit may be imposed by the waste supply availability.
5	Hydro-electric	<u>Highly Capable</u> **Suitability:** Generation is flexible in proportionality to the controllable flow of water through the turbines. **Limit:** Operation limits may be introduced by the water volumes stored in the reservoirs.	<u>Marginally Capable</u> **Suitability:** Controllable system to vary flow rate to limit or stop power output. Reservoir can be completely closed to stop power to grid **Limit:** There might be limitations associated with the flow rate that may affect/limit the power output.	<u>Capable</u> **Suitability:** Generation is flexible in proportionality to the controllable flow of water through the turbines. **Limit:** Operation limits may be introduced by the water volumes stored in the reservoirs.	<u>Capable</u> **Suitability:** As there may be multiple generator units at single hydro site, they can be utilised flexibly to produce power when required by either turning on a generator or increasing the water flow rate. The instruction being at prearranged times also allows for the site operator to prepare in advance. **Limit:** The technology unlikely operate above its	<u>Capable</u> **Suitability:** Typically, there is multiple generators at one hydro-electric site, and they can be utilised flexibly to produce power when required by either turning on a generator or increasing the flow rate. **Limit:** The technology cannot operate above its authorised capacity. There may also be limitations introduced by the levels of water available in the upper and lower reservoirs.

[14] Assuming steam turbine generators are in a state ready for dispatch within the expected timescales.

Type Number	Technology Type	Authorised Supply Capacity Trading (peer-to-peer)	Constraint Management	Offsetting (peer-to-peer)	Peak Management	Short-Term Operating Reserve (STOR)
					authorised capacity. There may be also other limitations introduced by the levels of water available in the upper and lower reservoirs.	
6	Combined Heat and Power (CHP)[15 16]	Not Capable **Suitability:** CHP generation output is flexible as fuel input can be regulated however limitations may be introduced by heat requirements. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	Marginally Capable **Suitability:** Generation output is flexible and can be altered when required. **Limit:** Limitations associated with heat requirements may be a limit for the delivery of the services.	Marginally Capable **Suitability:** CHP generation output is flexible as fuel input can be regulated however limitations may be introduced by heat requirements. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	Marginally Capable **Suitability:** Can supply extra kW/kVAr. The score is driven from restrictions on the electrical output associated with heat generation. **Limit:** The limit of the generator can be aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	Marginally Capable **Suitability:** CHP generation output is flexible as fuel input can be regulated however limitations may be introduced by heat requirements. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.
4	Landfill Gas[18 17]	Highly Capable **Suitability:** Gas generation output is flexible as fuel input can be regulated and therefore highly suitable for this service. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation	Highly Capable **Suitability:** Generation output is flexible and can be altered when required. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	Highly Capable **Suitability:** Gas generation output is flexible as fuel input can be regulated and therefore highly suitable for this service. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate	Highly Capable **Suitability:** Landfill gas is a flexible generation type this allows a flexible control on its kW and kVAr output. **Limit:** The limit of the generator can be aligned with the contracted capacity hence it's unlikely for this type of generation	Capable **Suitability:** Landfill Gas generation can provide extra capacity upon instruction. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity. Another limit may be imposed by the landfill gas supply availability.

[15] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/345189/Part_2_CHP_Technology.pdf
[16] Assuming gas generators are in a state ready for dispatch within the expected timescales.
[17] Assuming the reserve of Landfill Gas stored is enough to supply the service.

Type Number	Technology Type	Authorised Supply Capacity Trading (peer-to-peer)	Constraint Management	Offsetting (peer-to-peer)	Peak Management	Short-Term Operating Reserve (STOR)
		to operate beyond its contracted capacity.		beyond its contracted capacity.	to operate beyond its contracted capacity.	
1	CHP & Gas[18]	Highly Capable **Suitability:** CHP & Gas generation output is flexible as fuel input can be regulated and therefore suitable for this service. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	Highly Capable **Suitability:** Generation output is flexible and can be altered. **Limit:** The limiting factor for this technology is the time it takes to lower power output on generator since it takes time to react to instructions when flexibility service is required.	Highly Capable **Suitability:** CHP & Gas generation output is flexible as fuel input can be regulated and therefore suitable for this service. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	Highly Capable **Suitability:** CHP and gas can provide extra generation. The score is higher than CHP and gas alone as this is a combined technology type. **Limit:** The limit of the generator can be aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	Highly Capable **Suitability:** CHP and gas can provide extra generation due the second type (and unit) at the site. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.
7	Wind	Highly Capable **Suitability:** Wind generation is dependent on the weather conditions and so it may not be able to provide spare generation, even at prearranged times. It can decrease generation output for peer to peer by curtailing generation. **Limit:** The service delivery is dependent on weather conditions.	Highly Capable **Suitability:** Power output from wind turbine technologies can be deliberately curtailed to limit output when the service is required. **Limit:** Curtailment practices vary depending on turbine design and may vary from technology to technology. Wind resource energy is also wasted through curtailment.	Capable **Suitability:** Wind generation is dependent on the weather conditions and so it may not be able to provide spare generation, even at prearranged times. It can decrease generation output for peer to peer by curtailing generation. **Limit:** The service delivery is dependent on weather conditions.	Capable **Suitability:** Wind is a weather dependent technology and so may not be able to alter its output (kW/kVAr) at the specified peak time. **Limit:** Due to the weather dependent output, even at a prearranged time there may not be the capacity to provide for the DNO.	Marginally Capable **Suitability:** Wind is a weather dependent technology and so may not be able to increase its output when required. **Limit:** Due to the weather dependent output, there may not be the capacity to provide for a maintained time of more than 2 hours.
8	Diesel[18]	Highly Capable. **Suitability:** Diesel generation output is flexible as fuel input can	Highly capable **Suitability:** Generation output is flexible and can be altered when required.	Highly Capable. **Suitability:** Diesel generation output is flexible as fuel input can be	Highly Capable **Suitability:** Diesel is a flexible generation type this allows a flexible	Highly Capable **Suitability:** Diesel generation can provide extra capacity upon instruction.

[18] Assuming diesel generators are in a state ready for dispatch within the expected timescales.

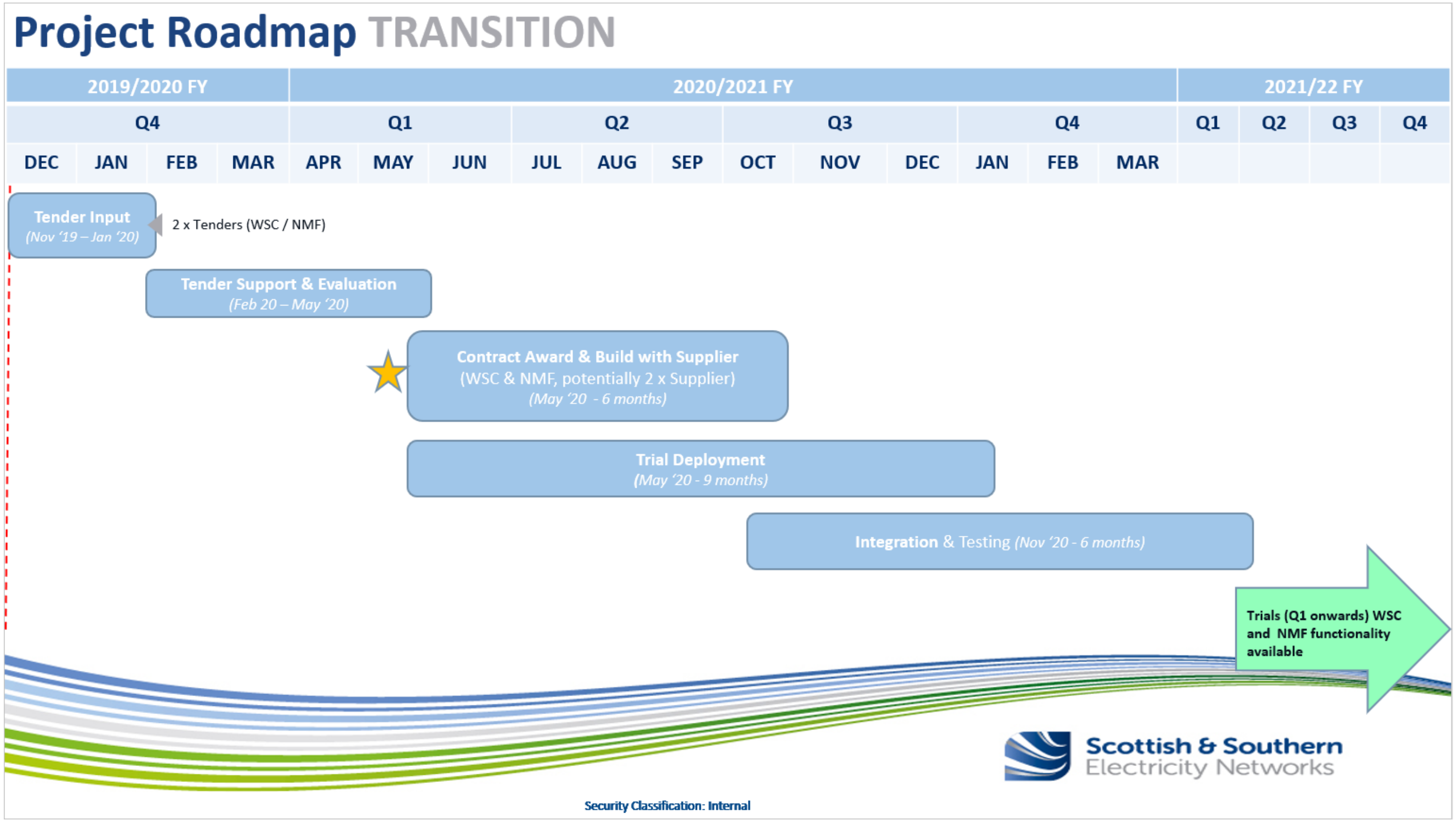
Type Number	Technology Type	Authorised Supply Capacity Trading (peer-to-peer)	Constraint Management	Offsetting (peer-to-peer)	Peak Management	Short-Term Operating Reserve (STOR)
		be regulated and therefore highly suitable for this service. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	**Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	regulated and therefore highly suitable for this service. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	control on its kW and kVAr output. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	**Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity. Another limit may be imposed by the diesel supply availability.
4	Biomass[19]	<u>Highly Capable.</u> **Suitability:** Biomass generation output is flexible as fuel input can be regulated and therefore highly suitable for this service. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	<u>Highly capable</u> **Suitability:** Generation output is flexible and can be altered when required. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	<u>Highly Capable.</u> **Suitability:** Biomass generation output is flexible as fuel input can be regulated and therefore highly suitable for this service. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	<u>Highly Capable</u> **Suitability:** Biomass is a flexible generation type this allows a flexible control on its kW and kVAr output. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity.	<u>Highly Capable</u> **Suitability:** Biomass generation can provide extra capacity upon instruction. **Limit:** Normally the limit of the generator is aligned with the contracted capacity hence it's unlikely for this type of generation to operate beyond its contracted capacity. Another limit may be imposed by the gas supply availability.
9	Domestic Demand	<u>Not Capable</u> **Suitability:** There is no capability to provide this service through domestic demand or domestic storage systems. **Limit:** Domestic demand has no authorised capacity and hence cannot provide this service.	<u>Marginally Capable</u> **Suitability:** There is limited capability to provide this service through domestic demand or domestic storage systems. **Limit:** There is limited capability to supply power from generation or storage system if required and would need many domestic demand suppliers (e.g. houses) providing this service for substantial impact. Hence the service will be highly dependent an aggregation for the supply. Origami estimated that the flexibility may be within the range of 5-10%.		<u>Marginally Capable</u> **Suitability:** There is limited potential for domestic demand. **Limit:** Domestic demand includes number of technology types, making it relatively challenging to control. The service would need a large amount of homes and businesses to	<u>Marginally Capable</u> **Suitability:** There is limited capability to provide this service through domestic demand or domestic storage systems. **Limit:** There is limited capability to supply power from generation or storage system if required and would need many domestic demand suppliers (e.g. houses) providing this service for

[19] Assuming steam turbine generators are in a state ready for dispatch within the expected timescales.

Type Number	Technology Type	Authorised Supply Capacity Trading (peer-to-peer)	Constraint Management	Offsetting (peer-to-peer)	Peak Management	Short-Term Operating Reserve (STOR)
					aggregate enough capacity to provide flexibility services.	substantial impact. Hence the service will be highly dependent an aggregation for the supply. Origami estimated that the flexibility may be within the range of 5-10%.
9	Commercial Demand	<u>Marginally Capable</u> **Suitability:** There is marginal capability to provide this service through commercial demand. **Limit:** The service would be dependent on aggregation for service provision.	<u>Capable</u> **Suitability:** There is some capability to provide this service through commercial demand. **Limit:** There is capability to alter demand if required but this would require some commercial demands providing this service. The service will be somewhat dependent on aggregation for service provision. Origami estimated that the flexibility may be within the range of 10-15%.		<u>Capable</u> **Suitability:** Commercial loads have some flexibility with their demand and so would be able to provide kVAr or kW into the system. **Limit:** The available flexibility of the demand depends on the size and purpose of the commercial site. Further, the commercial demand would also require a degree of aggregation (generally less than domestic demand).	<u>Capable</u> **Suitability:** Commercial loads have some flexibility with their demand. An example of the flexible strategies commercial demands can utilise is the demand shifting capabilities of refrigeration systems in supermarkets. **Limit:** Commercial demand is not as easy to control as industrial. Further, the commercial demand would also require a degree of aggregation (generally less than domestic demand).
9	Industrial Demand	<u>Highly Capable.</u> **Suitability:** There is high capability to provide this service through industrial demand due to its flexibility. **Limit:** Due to high flexibility, demand can be altered as required and the high demands means that this service will not necessarily dependent on aggregation for provision. Origami estimated that the flexibility may be within the range of 15-20%.			<u>Highly Capable.</u> **Suitability:** Industrial customers can provide an increase in kVAr or kW. **Limit:** If the instruction was made in the day when an industrial load, for example a factory, would be operational – this could create problems with reducing the demand as the typical machines may be being utilised at that time. Further, the industrial	<u>Highly Capable.</u> **Suitability:** Industrial demand is highly controllable. **Limit:** If the instruction was made in the day when an industrial load, for example a factory, would be operational – this could create problems with reducing the demand as the typical machines may be being utilised at that time. Further, the industrial demand may also require a degree of aggregation (generally less than

Type Number	Technology Type	Authorised Supply Capacity Trading (peer-to-peer)	Constraint Management	Offsetting (peer-to-peer)	Peak Management	Short-Term Operating Reserve (STOR)
					demand may also require a degree of aggregation (generally less than domestic and commercial demand).	domestic and commercial demand).

10. Appendix 4 – IT Project Roadmap



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