SMART GRID CONSULTANCY
SMART THINKING FOR A BRIGHTER FUTURE

NATIONAL GRID ELECTRICITY DISTRIBUTION

FLEXIBLE OPERATION OF WATER NETWORKS ENABLING RESPONSE SERVICES (FLOWERS)

D6-2 FINAL REPORT

VERSION FINAL 1.0 - 31/01/2023 (D. PENFOLD)

FLOWERS D6-2 FINAL REPORT

1 TABLE OF CONTENTS

Document Control	Name	Date
Authored & revised by:	David Penfold	26/01/2023
Reviewed by:	Gary Swandells Jade Kennerley	31/01/2023 31/01/2023
Approved by:	Nick Devine	02/02/2023

Revision History		
Date	Issue	Status
26/01/2022	0.1	DRAFT
31/01/2023	1.0	FINAL

2 Document Purpose

This document is the final one published throughout the projects' lifecycle. The specific intention of this document and the contained sections is to describe the actions taken during the project and to summarise the findings.

3 Project Scope

The FLOWERS project's aim was to increase the understanding of capacity embedded within water networks to deliver flexibility for distribution networks. Water utilities are one of the largest consumers of electrical power, about 1TWh of demand across NGED's four licence areas. South West Water contributes 300GWh of this demand. Developing new operational processes and removing commercial and regulatory barriers for water networks to deliver flexibility therefore presents a significant opportunity for unlocking of flexibility capacity which is value for money to customers.

The project builds on an NIA project delivered by National Grid ESO to investigate the potential flexibility capacity in storm drains and wastewater catchments, which quantified capacity but did not create a commercial model for accessing it. It has expanded the search for capacity on water networks, quantifying the available capacity across both wastewater and drinking water systems within the inherent latency of their pumping operations. As such, it was expected to uncover a greater level of capacity and also develop a cost-saving commercial model for its delivery.

4 Problem Statement

Water networks are one of the largest demands for electrical power supplied on distribution networks, estimated at 1TWh across WPD's four licence areas. However, Water and Sewerage Supply licence holders only deliver limited flexibility capacity to distribution networks to manage their electrical demand.

Water network operational processes are dictated by weather, water supply and demand need and do not align with electricity network requirements. As such, there is unexplored potential to embed capacity within these processes to flexibly shift the electricity demand of water pumps to relieve constraints on distribution network for both demand and generation connections. However, neither the technical and operational requirements to deliver this kind of flexibility, nor the forecasting or commercial arrangements necessary for procuring it are well understood.

5 Details Of Work Carried Out

The FLOWERS project, which was primarily a desktop-based analysis, has investigated the potential ability of South West Water's (SWW) network to embed energy flexibility capacity in the time difference (latency) between when drinking water and wastewater is pumped, stored, and treated. It has explored methods of delivering latency flexibility and analysed the feasibility of implementing it on SWW's systems.

The project has also defined the regulatory compliance and commercial viability requirements for the creation of a latency flexibility product, which could be embedded within National Grid Electricity Distribution's (NGED) electricity network control rooms. A recommendation for follow on actions document has been produced identifying the next steps for the development of latency flexibility capacity in ED2.

The project consisted of 6 work packages as follows:

5.1 LFA1. Feasibility of latency flexibility

This work package explored methods of delivering latency flexibility and analysed the feasibility of implementing it on SWW's system. A series of workshops were held with SWW data and process engineers to identify SWW flexible assets and processes to map against WPD constraint requirements.

The output of this work package was the following deliverable:

D1-1. Feasibility report - A report which captured the outcomes of the workshops and produced service availability capacity curves for potential latency flexibility, categorised by time of day, seasonality, and dependencies.

This work package also had an additional milestone:

M1-1. Stage gate for LFA 2 - A stage gate was included in this work package as an interim assessment of whether the initial outcomes of the workshops suggest there is enough technical feasibility to begin examining the legal feasibility of latency flexibility.

Work Package Actions Summary

During this work package the project team gathered knowledge and perspectives from the separate areas of SWW operations on how they could potentially reduce the energy usage of the various sites across their estate, be it on demand or for total energy consumption.

The three main areas that were interacted with were:

- Drinking Water Services (DWS)
- Wastewater Services (WWS)
- Control Room (CR)

A series of online workshops were held with the DWS and WWS teams to explain the project objectives and gather initial perspectives on potential initiatives to enable the reduction or shifting of energy use. Personnel operating in the Control Room were also shadowed on site, with additional interviews with some to understand how the CR currently operates and capture their viewpoints.

Workshop 1, which included all departments, was held online on 2nd March 2022. Workshop 2, which was also held online between 2nd and 4th March 2022, was split into two separate events for DWS and WWS to allow more time for detailed discussions. A Control Room surveillance was carried out face to face across 22nd & 23rd March 2022.

5.1.1 D1-1. Feasibility Report - Summary of Information Gathered

This document summarised and described the actions that were taken to collate a primary perspective from the SWW team on flexibly using energy at different times, or energy reduction initiatives, and the steps that we have taken to identify which SWW sites are connected to constrained substations or future constrained substations

This also classified the relevant opportunity quality of each initiative identified and also identified initiatives that fall outside of the project's brief that are worthy of bringing to SWW's and/or NGED's attention.

This document also contained the results of an early, in-depth analysis on the energy usage of a specific SWW site, where it is connected to a WPD constrained substation. This analysis indicated which of the initiatives identified during the discussions with SWW could be implemented to deliver a mutual benefit to both utilities.

There were several feasible interventions identified that could be implemented to enable shifting of when energy is used within DWS and WWS, with the strongest implementable initiatives from each sector as below:

1. DWS & WWS - 3 to 4 hours turndown/switch off of pumps
2. WWS - Increasing and reducing aeration blowers for biological treatment
3. DWS & WWS - Produce a pumping profile based on a model that creates a schedule for control room.
4. DWS - Drinking water reservoir pre-filling
5. WWS - Re-Profiling levels of storage
6. DWS & WWS - Review all set points are as needed for current demand and operating as expected

It was also determined that the CR currently has a lack of visibility of energy information which could enable them to make informed decisions on when to implement pump or blower turn-up or turn-down.

For example:

1. Choosing to increase pump volumes, allowing subsequent latency during high stress periods for the electricity network, depending on the forecast amount of SWW own PV or green gas CHP electricity generation.
2. Choosing to increase pump volumes during peak renewable energy generation which is causing stress on the wider electricity network or is being curtailed via Active Network Management (ANM).
3. Holding off pumping or modulate aeration at times of peak demand where generation is lacking.
4. Increasing or decreasing energy usage by having visibility of day-ahead energy prices.
5. Participating in behind the meter demand side response (DSR) programs for the ESO and or the DSO. In particular, programs like demand turn up.

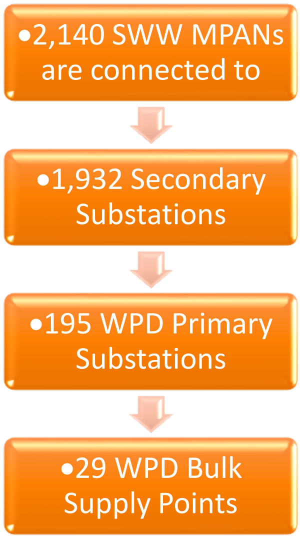
The opportunities identified during the workshops and control room surveillance were then classified into one of 5 groups.

- **Low hanging fruit** – opportunities that are achievable, feasible and have clear benefits.

- **More challenging** – opportunities that require some further investigation. It may be concluded these are too limited or risky, or are possible but require internal SWW investment (for which FLOWERS outcomes may support the business case).
- **Worthwhile with focus** – opportunities where focus needs constraining to identify the mutual electricity and water network benefits.
- **Energy management/efficiency** – opportunities that align with energy management rather than flexibility.
- **Out of scope** – opportunities which relate to other projects but could be of interest.

It was evident however that it would be more feasible to turn down pumping within the DWS function than it would be within the WWS function. This is largely due to the biological treatment process within the WWS treatment sites requiring a constant minimum flow of liquid to maintain the health of the biology.

The project team then undertook data evaluation of SWW MPANS, energy usage and identified which NGED substations each of the SWW sites were linked to. The initial sweep of the SWW and WPD data highlighted the following numbers.



From these MPANs the four-year average annual electricity usage was identified as 301,494,894 kWh. The annual kWh usage of the SWW sites was summarised as below.

Annual kWh Usage	Site count
2,000,000 - 9,999,999	19
1,000,000 - 1,999,999	31
500,000 - 999,999	49
100,000 - 499,999	174
50,000 - 99,999	153
10,000 - 49,999	509
5,000 - 9,999	252
1,000 - 4,999	736
100 - 999	65
< 100	141

It was determined that the initial outcomes of the workshops suggested that there is enough technical feasibility to progress to LFA2 and begin examining the legal feasibility of latency flexibility.

5.2 LFA2. Regulatory feasibility and development of commercial and regulatory relationships

This work package defined the regulatory compliance and commercial viability requirements for creation of a latency flexibility product which could be embedded within the 1st tier of flexibility to be accessed by electricity network control rooms. NGED and SWW legal teams were engaged to assess the legal feasibility of creating the latency flexibility product.

The outputs of this work package were the following deliverables:

D2-1. Interim LFA2 report - A report capturing the work to date developing the commercial and regulatory relationships and identifying next steps and challenges.

D2-2. Latency flexibility commercial proposal document - A document which established the regulatory precedents to enable or eliminate this type of collaborative approach and outlines the proposed commercial framework for latency flexibility.

This work package also had an additional milestone:

M2-1. Stage gate for LFA 3-4 - An interim assessment of whether the initial engagement with legal suggest that latency flexibility is legally feasible before proceeding with work packages 3 and 4.

Work Package Actions Summary

5.2.1 D2-1. Interim Report Commercial and Regulatory Relationships

This document provided an overview of the current regulatory regime and identified the elements of the project that presented challenges to the status quo to realise benefits through a ‘utilities whole-system’ approach to efficiencies and tackling issues. By working together in specific areas, we discovered underlying efficiencies across water and electricity utilities that are technically feasible but blocked by current policies and governance structures.

Phase 1 of the project saw close engagement with the regulator at the early stages to get informal feedback on potential proposals. This was focused on the Ofgem innovation team in the first instance (and other colleagues as appropriate, e.g. at Elexon, BEIS etc.).

To prepare for regulatory engagement, the report considered the costs and benefits of potential changes, and the impact on stakeholders in the market when developing proposals under the FLOWERS project. These were generated in FLOWERS forums/workgroups and captured to support engagement with the regulator.

It was identified that in order to ensure the proposal receives regulatory support, our future regulatory engagement should include:

- **Demonstrating the benefit to consumers** – i.e. demonstrating and quantifying the benefits which will be passed onto consumers
- **Establishing the precedent for the FLOWERS intervention** – i.e. showing where there are similar approaches used in other parts of the market
- **Having a Plan B** – i.e. showing that alternative arrangements could be used

A key risk to this engagement is therefore likely to be related to not securing sufficient time with, or feedback from, the regulator.

This report then went on to discuss the following areas:

- **Key concerns** for regulators being the impact of changes on stakeholders, markets and the end consumer.
- **Arguments for and against** the FLOWERS approach with perceived benefits and concerns being detailed.
- **Potential outcomes** and **specific regulatory considerations** of the collaboration between NGED and SWW that could be a new type of bespoke flexibility service, to be used in addition to existing DNO flexibility services.
- **Payment for the service,** how the service is to be paid for, or whether it is offered as quid pro quo in exchange for increased headroom.
- **Other mechanisms** that could realise the flexibility from water companies, and/or whether the FLOWERS approach could impact other areas of the market.
- **Areas of the market that could be impacted**. Water companies providing their flexibility via the FLOWERS approach could impact or distort other areas of the market.

It was determined that the initial engagement with legal suggested that latency flexibility is legally feasible. Therefore, the project proceeded with work packages LFA3 and LFA4.

5.2.2 D2-2. Latency Flexibility Commercial Proposal Report

This document outlined the services that could be established with the water industry, through the methods for accessing latency within processes and unutilised assets as set out in the 'D4-1 Specification and High-Level Architecture' document which is reviewed later in this report.

The D2-2 document discussed the following areas:

- **Mechanisms for Water Industry Flexibility.** The FLOWERS approach may offer a number of benefits compared to the other flexibility products:
  - FLOWERS flexibility would in most cases become an embedded service capability on offer to DNO/DSO during periods of need preceding the need for going to the wider market for flexibility providers and defer associated costs that are recovered from customers.
  - FLOWERS Demand Turn Up (DTU) services could be employed to absorb export generation on the distribution network.

  - FLOWERS use cases create a number of service types ranging from pre-emptive use that can operate on a scheduled basis over entire seasons, through to quick response short duration services for addressing acute constraint or post fault conditions. This broad requirement would create many opportunities for participation by the water industry and its wide portfolio of latent processes and assets.
  - Water Companies would not face the same barriers to entry compared to other flexibility products. This is important given the size of water companies demand and importance of multi-vector alignment for the net zero transition.
- **Indirect Remuneration 'Quid Pro Quo'.** This section outlined the areas of FLOWERS that was believed could impact the wider market.
  - It is expected the basis of most objections will relate to how the additional capacity offered by the water industry could impact flexibility providers from all other industries and how they are likely to be rewarded for that capacity.
  - This section also proposed some suggestions how the non-fiscal remuneration may be structured but this will ultimately be the subject of follow-on work to establish a more detailed understanding that incorporates the views of regulators and key stakeholders.
- **Areas of the Market That Could Be Impacted.** Water companies providing their flexibility via the FLOWERS approach could impact or distort other areas of the market including:
  - Markets for flexibility– where water companies' FLOWERS flexibility could be seen a substitute or distortion to these markets.
  - Active Network Management – where DNOs could use FLOWERS flexibility as an alternative to ANM should be generally recognised as a benefit.
  - The existing DNO connection and queue management process – where assets pay connection charges to connect to the system, potentially with ANM conditions. FLOWERS could give water companies another route to connecting generating assets compared to the traditional connection route.
  - The DNO connection process, with Ofgem Access Significant Code Review (SCR) changes – assets could have alternative connection options, which could vary based on firmness or time (e.g. peak or off-peak).

5.3 LFA3. Mapping and case study selection

This work package created and implemented a methodology to quantify and map the capacity for latency flexibility from LFA1 onto SWW's networks and NGED's constraint map to identify areas of greatest potential benefit. From this a shortlist of potential case study areas was produced, from which six representative sites were selected.

The outputs of this work package were the following deliverables:

D3-1. Capacity report - Quantifying the expected specific value and benefits of latency capacity within South West Water's network.

D3-2. Case study selection report - Capturing the case study selection process and identifying the area for study.

Work Package Actions Summary

5.3.1 D3-1. Anticipated Southwest Water Available Capacity Report

The intention of this report was to focus on the anticipated flexibility capacity that could be realised based on the research carried out during LFA1, and the influences that have been identified which affect the amount of energy consumed (currently over 300 GWh) by SWW's demanding Drinking Water (DW) and Wastewater (WW) processes.

The report discussed the analysed data and quantified the capacity for latency flexibility available across SWW's networks and NGED's constraint zones to pinpoint areas of greatest potential benefit. From this, a shortlist of potential case study sites was produced, from which six were selected.

It should be noted that at this point in the project timeline all the flexibility capacity numbers within this document were estimates based on discussions and meetings held with the SWW personnel as identified in LFA1.

We sought to quantify the amount of flexibility that could be available if the interventions identified in the D1-1 Feasibility Report during the LFA1 phase were implemented.

During the analysis it became apparent that, out of the SWW circa **2,207** electricity grid connected sites, only **468 (21%)** were connected via Half Hourly (HH) main meters. The remainder are Non-Half Hourly (NHH) main metered sites, which do not have any half hourly supplementary metering. These sites have relatively low electricity demand and there is also no method of identifying their Maximum Demand (MD). For these reasons these sites were excluded from analysis.

It was found that the HH SWW sites have an MD of roughly **64.8MW** and overlaying the current NGED Constraint Management Zones (CMZ) with the SWW site locations it was identified that **79** of the 468 HH SWW sites sit in current NGED CMZ's and have a combined MD of **12.5MW**.

This report then went on to discuss the following areas

- **Data Approach –** Each SWW site's locational and energy usage data was overlaid with the NGED network substation locational data to identify which NGED substations were serving each of the SWW sites. This merged data was then used to identify which of the SWW sites were serviced by a substation within an identified NGED CMZ.
- **Potential Flexibility Capacity Approach –** In parallel to the data mapping exercise, an assessment was carried out to evaluate the potential flexibility capacity that could be realised by the initiatives as identified within the previously released D1-1 Feasibility Report.
    - All SWW HH sites were categorised using SWW nomenclature. Then for each site type it was identified which of the flexibility initiatives could be suitable.

Site Type	Abbreviation
Drinking Water – Water Treatment	DW WT
Drinking Water – Water Distribution	DW WD
Drinking Water – Power Generation (Hydro)	DW PG
Wastewater – Mains Distribution	WW MD
Wastewater – Sewage Treatment	WW ST

- Each site's maximum demand was further itemised into the maximum demand for the types of operation being undertaken at each site depending on the type of site, e.g. Pumping, Aeration & UV Treatment. By doing this, it was feasible to estimate a maximum energy demand for each type of operation on each type of site thus creating a baseline for each operation.
- The above approach taken assumes the below maximum demand for each site category, as advised by SWW.

Site Category	Proportion of total maximum demand		
	Pumping	Aeration	UV LED
DW WD	90%	-	-
DW WT	30%	-	-
WW MD	90%	-	-
WW ST	30%	30%	30%

- **Southwest Water Site Groups and Energy –** SWW sites' respective energy demand was identified for each category of site.
- **SWW sites within current CMZs summary –** The above grouping of SWW sites was overlaid with NGED CMZs, providing the resulting maximum demand of SWW sites in CMZs by site type.
- **External Impacts On Maximum Demand** – It was identified that the maximum demand of a SWW site at any point in time is influenced by various external factors. This section attempted to describe these with potential implications.
  - **Impact of Weather** – Notably when a rainfall event occurs, especially when the storage tanks are 'on duty/called upon', energy consumption increases significantly. A positive correlation exists between rainfall events and energy demand. Analysis indicated that the impact on energy demand of rain events is in the region of an 18% increase from the steady state.
  - **Impact of Location** – It was determined that:
    - Coastal zones incur water ingress from the sea. This dramatically increases energy demand due to the need to pump sea water from the wastewater sewage mains and/or treatment works.
    - In urban areas, runoff is much higher as the built environment significantly reduces the ability for the soil to absorb the rainfall event. This again results in an increased amount of rainwater entering the wastewater network.
    - Topography also has an impact on SWW's energy consumption, for example the need to pump water over hilly terrains. High-level analysis indicates that the impact of this on energy demand sees rural sites having a 5% higher energy demand than urban sites.

  - **Impact of Population** – It is likely to be true that a difference exists in SWW energy demand when population changes in urban versus rural areas.
    - Analysis indicated that the impact on energy demand when seasonal population grows is in the region of a 16% increase.

- **Initiatives Estimated Energy Avoidance Attainable –** The opportunities that were identified and classified in LFA1 were further categorised with what type of site they could be implemented at and given an energy demand reduction category i.e. Pumping Energy Demand, Aeration Blowers Ramping & UV LED
  - This was done to avoid duplication of energy demand reduction by unintentionally implementing an initiative on the same piece of equipment at the same time and overestimating the available demand reduction.
- **Summary of Energy Demand Reduction Categories –** Analysis was undertaken to identify the amount of energy flexibility which could be realised from each of the Energy Demand Reduction Categories.
  - The common assumption used across all the energy demand calculations was that each initiative would only be available for implementation 50% of the time.
  - Pumping - Nearly all SWW sites have some form of pumping, whether they are a treatment plant or purely a pumping station. SWW sites that are facing existing CMZs have the potential to shift **3.6MW** from a total max demand of 12.5MW at 50% implementation.
  - Aeration Blowers Ramping - This initiative can only be implemented at wastewater sewage treatment plants and could impact the biology of the treatment plant so for the remainder of the project this initiative was omitted.
  - UV LED - This initiative again can only be implemented at wastewater sewage treatment plants. On further investigation this was identified as an energy efficiency initiative so was omitted.

5.3.2 D3-2. Case Study Selection Report

This specific document focussed on the methodology used, and the outcome of, identifying SWW sites that could be used for desk top case studies in relation to implementing the initiatives identified as part of LFA 1.

This report discussed that the sites selection needed to consider that most of the identified initiatives are based around pumping operations.

- **Selection Criteria –** The selection criteria set out several “Must Haves” and “Nice to Haves” along with ensuring a spread of site types from Drinking Water Treatment (DW WT), Drinking Water Distribution (DW WD), Waste Water Sewage Treatment (WW ST) and Wastewater Distribution (WW MD) with at least one of each type needing to be identified. The team also tried to identify case study sites that were linked to each other i.e., a pumping station for a treatment works.

- **Southwest Water Shortlist Case Study Sites –** This section detailed the shortlisted sites which had more than average maximum demand of the specific site category and were within current constraint management zones. The red highlighted sites are the final selected sites.
    - *Wastewater – Sewage Treatment*

SITE NAME	POSTCODE	CURRENT MAX DEMAND (KW)
HAYLE_STW_HAYLE	TR27 6LA	1,735
ASHFORD_STW_BARNSTAPLE	EX31 4BR	795
CAMBORNE_STW_CAMBORNE	TR14 0BN	505
LORDS MEADOW_STW_CREDITON	EX17 1ER	333
HELEBRIDGE_STW_BUDE	EX23 0JA	259
ILFRACOMBE_STW_ILFRACOMBE	EX34 9QG	188

    - *Wastewater – Mains Distribution*

SITE NAME	POSTCODE	CURRENT MAX DEMAND (KW)
CHYANDOUR_SPST_PENZANCE	TR18 2NG	851
PORTHGWIDDEN_SPST_ST IVES	TR26 1PP	612
POTTINGTON ESTUARY_SPST_BARNSTAPLE	EX31 1NP	511
NORTHAM FSCN_SPST_WESTWARD HO	EX39 1TW	460
BRIDGE_SPST_PORTREATH	TR16 4NF	435
CASTLE_SPST_BUDE	EX23 8LG	251

    - *Drinking Water – Water Treatment*

SITE NAME	POSTCODE	CURRENT MAX DEMAND (KW)
PYNES_WTW_EXETER	EX5 5EQ	1,549
DRIFT_WTW_PENZANCE	TR19 6AA	341
PYNES_PRI_BRAMPFORD SPEKE	EX5 5DY	245

    - *Drinking Water – Water Distribution*

SITE NAME	POSTCODE	CURRENT MAX DEMAND (KW)
DUNSFORD HILL_WPS_EXETER	EX2 9PJ	438
PILTON_WPS_BARNSTAPLE	EX31 1QL	210
BLAKEWELL PUMP_WPS_BARNSTAPLE	EX31 4ET	130

- To complete the case study site selections each of the red highlighted sites in the above tables were visited to ensure suitability.

5.4 LFA4. Technical and operational system specification

This work package documented the technical and/or operational solutions necessary to implement latency flexibility based on the requirements defined in LFA1. The document aimed to discuss the required revised standard operating procedures, process solutions, software solutions and (if necessary) hardware.

The outputs of this work package were the following deliverables:

D4-1. Specification and high-level architecture document - Identifying the requirements and high-level architecture of the system which would deliver latency flexibility including Operational requirements, Process requirements and Technical requirements.

This work package also had an additional milestone:

M4-1. Stage gate on next steps for D6-1 - Included to assess if the outcomes of the project so far justify recommendation of a follow-on project or BAU endeavour. Deliverable 6-1 would be produced as part of LFA6.

Work Package Actions Summary

5.4.1 D4-1. Specification and High-Level Architecture Report

This report was written to discuss the development of methodologies that harness the potential flexibility when the proposed perturbations are applied to the SWW estate and thereafter the wider industry as a whole. To initially estimate how water authorities, and more specifically what South West Water could contribute to embedded flexibility, 16 use cases have been identified. These have been separated initially by the timeframe it can be reasonably expected to achieve the behaviour change that would achieve the flexible capacity delivery.

This D4-1 document considered the key capabilities which need to be developed for a system that could access the flexibility embedded within water networks. The necessary technical capabilities were identified as primarily informed by timescale. A seasonal approach to flexibility is substantively different from attempting to access flexibility post-fault.

As such, five broad methodologies for flexibility were defined, which would inform the technical requirements of a system. These are discussed below:

- **Method A (Use Cases 1-4)** – The lowest effort method is a pre-emptive seasonal approach intended to reflect the generally recognised demand and generation patterns for electricity. Flexibility would be scheduled manually based on shared operational guidance and electricity and water forecasting. Services may only be required some seasons each year, likely for generation peaks in the summer and demand in the winter under normal conditions, although planned maintenance could also trigger requirements outside of typical periods. Delivery should be a minimum of 50kW within a network zone for at least 60 minutes per day.

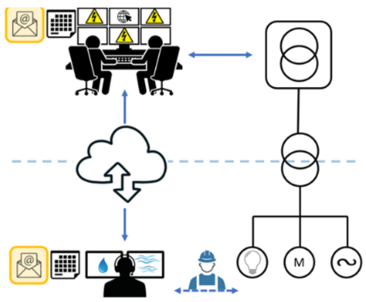


Figure 5-1 Seasonal arrangements scheduled manually with no direct communications

- **Method B (Use Cases 5-8)** – A moderate increase in complexity and improved value could be achieved by shifting from a seasonal approach to a more targeted method. Rather than basing perturbation on a seasonal basis, the requirement would be reduced to weekly applications of flexibility delivery. This can feasibly be achieved through email or a secure messaging service for the DSO to indicate the relevant periods. These would still be subject to a minimum duration of 60 minutes, but due to the additional resource burden of weekly administration the minimum capacity per zone increases to 100kW.

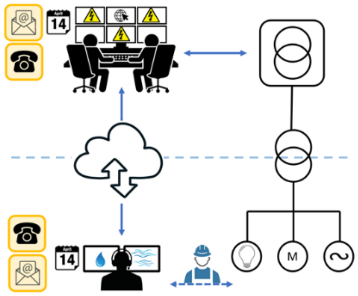


Figure 5-2 Weekly arrangements scheduled manually with simple communications

- **Method C (Use Cases 9-11)** – Reduces the weekly schedule to a 30 minute dispatch requirement with a dedicated dispatch capability is necessary through a secure API. The API endpoint will need to be monitored and able to provide an alert to an employee to commence the event on time. Any process changes would be implemented manually on site or via SCADA if the API is to a central control facility. A return signal by the API would acknowledge receipt and confirm dispatch of assets.

  In order to justify the added effort associated with this method and the reduced frequency of usage, the minimum capacity ranges between 100-200kW to help ensure that the effort associated with commissioning is validated.

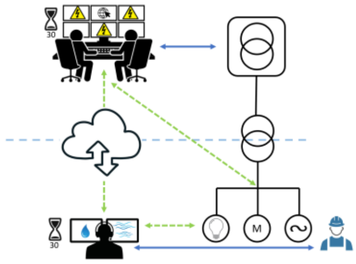


Figure 5-3 Dispatchable within 30 minutes notice requiring API to site or central control

- **Method D (Use Cases 12-14)** – Introduces an automation requirement, reducing the response time to 15 minutes. With the introduction of automation as a prerequisite it would be pragmatic to require feedback which includes confirmation that that dispatch has been received and enacted. The preferable solution to this would be the addition of metering from the active sites.

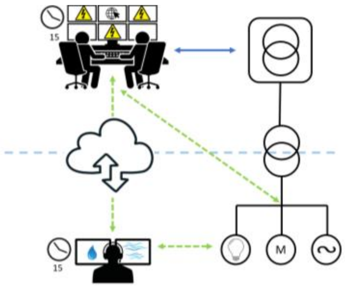


Figure 5-4 Dispatchable within 15 minutes notice requiring API direct to assets with no manual interventions

- **Method E (Use Cases 15 & 16)** – A post-fault service that requires some form of automation to achieve due to the response time of 1 minute. Likely to be applicable to a subset of the assets that already participate in Method D, but with the ability to respond quicker and therefore only applicable where automation is available. The technical solution is otherwise identical.

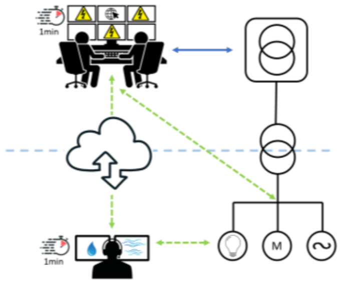


Figure 5-5 Dispatchable under 1 minute notice requiring API direct to assets with no manual interventions

The report then went on to discuss a summary of the key capabilities that need developing and the key challenges that need overcoming to enable realisation of the embedded flexibility within the SWW network.

- **Key Capabilities That Need Developing** – All methods described above would require development of the following capabilities:
    - Half-hourly sub-metering of the separate operational loads to confirm each operational loads' demand.
    - Pump workload forecasting using weather and demand data to enable future planning for provision of energy flexibility.
    - Live storage tank fill levels and forecast fill levels for all sites visible to the control room to enable confirmation of flexibility and to enable the management of storage between linked sites.
    - A common centralised approach for the remote control of pumping at all sites.
    - A close to real time methodology to confirm to the DSO the sites' ability to be dispatched (this is needed due to the exponential impact recent and forecast weather has on energy demand).

  Method specifics (all of the above plus):

    - Method A and B would require on-site energy storage to ensure the energy demand perturbation could be implemented regardless of weather impact.
    - Method C would require the establishing of a monitored 'endpoint' to receive API notifications.

  - Method D and E would require automated implementation of energy perturbations and confirmation of implementation back to the DSO.
- **Key Challenges –** There would be a number of technical barriers to overcome to achieve these ambitions:
  - The delivery of flexibility, greater than day ahead of real time, will fundamentally be impacted by: recent weather; forecasts for weather, DWS demand and WWS treatment volumes; and current water volumes being processed and stored at relevant sites.
  - The rates and volumes of water it is mandatory to treat, as stipulated by the relevant licences, could impact the ability to deliver flexibility.
  - The main energy load centres, the treatment works, will not necessarily be able to be perturbed in isolation of the pumping stations upstream and downstream.
  - The level of drinking water storage of the distribution reservoirs needs to align with forecast demand before pumping of the treated water from the treatment plant can be turned down.
  - For pre-planned flexibility, months ahead, the only firm perturbation method would be to source the electricity needs from an alternative source than the electricity network.

It was determined that the outcomes of the project so far justified recommendation of a follow-on project. Therefore, the deliverable D6-1 Recommendation for Follow-On Activities Document was produced as part of LFA6.

5.5 LFA5. Case study modelling, simulation, and cost-benefit analysis

This work package took the outputs of work packages 2-4 and modelled the implementation and procurement of latency flexibility in the case study sites. It has analysed the flexibility capacity that could feasibly be procured over a set time period and performed analysis to identify the potential benefits of the system.

The output of this work package was the following deliverable:

D5-1. Case study report - a report on the outcomes of the case study activities.

Work Package Actions Summary

5.5.1 D5-1. Outcomes of the Case Study Activities Report

The specific intention of this document was to focus on the desk top study undertaken on the 6 sites nominated sites. The document discusses the analysed data and quantifies the capacity for latency flexibility available at the identified sites and the fit with NGED’s constraint zones requirements, to pinpoint areas of greatest potential benefit.

For each of the case study sites the following has been determined regarding the potential pumping flexibility opportunities identified in the D1-1 Feasibility Report:

1. The practical feasibility of implementing flexibility

2. Specific site half hourly (HH) **total** and **pumping** energy demand
3. The SWW site specific NGED CMZ HH demand reduction requirements
4. Potential HH demand flexibility available at each site
5. Feasible HH demand flexibility available from SWW sites to the NGED CMZ

The analysis shows that the six sites have a combined MD of circa **2.9 MW,** with **1.6 MW** assessed as being due to pumping operations. Therefore, if all the LFA1 suggested pumping perturbations were implemented at the same time then an estimated **1.6 MW** per hour of flexibility could be realised.

The report also highlighted the complexity of the Water Treatment network and the interdependencies that need to be understood to enable energy flexibility to be realised. The case study sites were investigated in further detail with the aim of identifying these interdependencies and what if anything could be implemented to enable the flexibility and what the value of this may be. The specific NGED CMZs were also scrutinised to assess whether the SWW sites could be called upon to reduce the CMZ requirements.

The report then went on to discuss the following areas:

- **Data Approach –** Energy usage data for each site was sourced and summarised as average HH demand for each month of the year.
    - The requirements of the case study sites' CMZs were sourced and summarised for comparison to the specific sites' operational energy demand.
    - As determined during the LFA 1 workshops and interviews, the assumption at treatment plants is 30% of the maximum site demand is pumping and for pumping stations 90% of the sites maximum demand is pumping.
    - Following the more detailed investigation and desk top study it was identified that pumping at Drinking Water Treatment Works would account for an estimated 66% of the total site energy demand.
- **Perturbation Impacting Factors** – The report considered the Key Capabilities and Key Challenges as seen in the document D4-1
- **Demand Analysis Of Case Study Sites –** The project evaluated the HH demand of the six case study sites to ascertain usage patterns by year, by month and by time of day. The project team have then identified the specific NGED CMZ each is connected to, and the associated flexibility requirements of the CMZ. These two data sets have been cross-referenced to identify where the SWW site could be utilised to assist the CMZ and the potential benefit to NGED of this.
- **Sites HH Energy Demand Heat Maps** – The project team have been able to review HH main meter demand data for the years 2017 – 2021 and as a check of energy demand trends the team separately reviewed the data for 2022.
    - This data has been converted to a mean average demand for each half hour of the day for every day of the year and evolved into heat maps showing a green colour, indicating the lowest demand, amber indicating average demand and red showing highest demand. Example Table 5-1 below shows a month on month comparison to show which months have the highest average demand.

Table 5-1 Total Site HH Energy Demand (Monthly Comparison)

Month	00:30	01:00	01:30	02:00	02:30	03:00	03:30	04:00	04:30	05:00	05:30	06:00	06:30	07:00	07:30	08:00	08:30	09:00	09:30	10:00	10:30	11:00	11:30	12:00
Jan	554	556	541	535	545	537	546	529	537	537	536	527	539	545	551	555	567	579	583	587	580	575	578	588
Feb	532	527	526	529	523	532	530	525	522	526	522	527	520	537	554	547	572	590	588	581	576	584	567	564
Mar	526	521	515	513	506	511	515	498	502	504	504	504	500	515	528	531	544	557	561	556	556	555	555	546
Apr	510	490	496	496	490	492	497	482	500	494	511	526	525	519	524	556	567	551	559	548	549	560	546	551
May	540	542	532	542	538	536	537	534	534	535	541	557	547	569	581	582	577	576	577	577	588	574	577	580
Jun	533	534	527	531	524	522	520	509	520	529	541	550	557	564	578	574	567	566	559	568	567	572	574	554
Jul	462	464	466	462	460	456	453	456	459	456	480	486	496	493	495	498	507	504	504	497	507	513	510	513
Aug	483	477	475	478	470	470	471	465	466	478	486	494	494	502	517	521	528	521	529	518	527	520	517	513
Sep	535	517	522	523	515	522	513	520	519	526	527	549	550	562	566	571	576	568	574	577	560	567	569	559
Oct	518	502	513	516	514	520	513	509	508	513	518	525	532	544	549	552	562	558	557	557	543	547	555	549
Nov	547	537	544	549	554	542	540	539	548	541	550	547	552	556	566	569	573	569	561	569	571	571	567	566
Dec	542	543	546	532	530	536	533	534	534	532	545	536	544	561	560	565	576	575	574	578	565	557	570	550

Month	12:30	13:00	13:30	14:00	14:30	15:00	15:30	16:00	16:30	17:00	17:30	18:00	18:30	19:00	19:30	20:00	20:30	21:00	21:30	22:00	22:30	23:00	23:30	00:00
Jan	579	583	579	581	591	583	577	558	545	521	485	488	497	551	571	554	557	551	558	557	550	562	556	556
Feb	571	569	570	573	574	584	572	565	561	550	557	558	541	559	555	553	548	553	548	564	546	546	529	531
Mar	542	538	532	531	527	525	528	526	519	522	526	535	524	524	520	527	525	524	526	529	515	513	510	516
Apr	550	538	549	532	531	531	505	504	507	495	513	513	500	503	498	496	501	504	501	512	505	506	510	496
May	573	572	569	559	570	558	558	561	560	566	558	556	558	565	559	563	559	553	566	550	556	548	554	539
Jun	565	568	559	563	560	558	548	539	551	545	552	550	550	554	557	558	558	547	539	546	549	544	544	529
Jul	512	504	515	509	506	497	486	476	483	489	488	492	475	479	486	480	477	464	465	467	474	465	470	463
Aug	522	522	525	516	516	508	511	513	514	508	504	507	513	516	514	512	505	502	496	498	490	496	490	486
Sep	554	560	545	547	556	532	546	546	527	530	524	532	548	538	545	544	544	547	547	533	541	535	523	533
Oct	546	536	524	545	544	535	538	536	528	541	539	545	549	538	535	550	538	536	534	520	525	541	526	527
Nov	565	566	569	569	566	565	563	560	560	570	558	561	554	556	566	565	557	556	552	548	551	551	548	553
Dec	562	562	553	574	562	561	567	548	547	542	545	543	539	545	568	561	556	560	547	555	541	542	548	533

- The total site energy demand data was further refined to indicate the energy associated with site pumping operations only. This was again evolved into a heat map. Example Table 5-2 below shows when pumping energy demand is above average (red) or below average (green)

Table 5-2 Pumping Only HH Energy Demand (In Month Comparison)

Month	00:30	01:00	01:30	02:00	02:30	03:00	03:30	04:00	04:30	05:00	05:30	06:00	06:30	07:00	07:30	08:00	08:30	09:00	09:30	10:00	10:30	11:00	11:30	12:00
Jan	183	183	179	177	180	177	180	175	177	177	177	174	178	180	182	183	187	191	192	194	191	190	191	194
Feb	175	174	174	175	173	176	175	173	172	174	172	174	172	177	183	180	189	195	194	192	190	193	187	186
Mar	173	172	170	169	167	169	170	164	166	166	166	166	165	170	174	175	179	184	185	183	183	183	183	180
Apr	168	162	164	164	162	162	164	159	165	163	169	173	173	171	173	183	187	182	185	181	181	185	180	182
May	178	179	176	179	178	177	177	176	176	177	178	184	180	188	192	192	190	190	190	190	194	189	190	191
Jun	176	176	174	175	173	172	172	168	172	174	178	182	184	186	191	189	187	187	184	188	187	189	189	183
Jul	152	153	154	152	152	151	150	150	151	150	158	160	164	163	163	164	167	166	166	164	167	169	168	169
Aug	159	158	157	158	155	155	155	153	154	158	160	163	163	166	171	172	174	172	174	171	174	172	171	169
Sep	177	171	172	173	170	172	169	172	171	174	174	181	181	185	187	188	190	188	189	190	185	187	188	184
Oct	171	166	169	170	170	172	169	168	168	169	171	173	176	180	181	182	186	184	184	184	179	181	183	181
Nov	181	177	179	181	183	179	178	178	181	179	182	180	182	183	187	188	189	188	185	188	189	189	187	187
Dec	179	179	180	175	175	177	176	176	176	176	180	177	180	185	185	186	190	190	189	191	186	184	188	181

Month	12:30	13:00	13:30	14:00	14:30	15:00	15:30	16:00	16:30	17:00	17:30	18:00	18:30	19:00	19:30	20:00	20:30	21:00	21:30	22:00	22:30	23:00	23:30	00:00
Jan	191	193	191	192	195	192	191	184	180	172	160	161	164	182	188	183	184	182	184	184	182	185	184	183
Feb	188	188	188	189	189	193	189	187	185	181	184	184	179	184	183	182	181	182	181	186	180	180	175	175
Mar	179	178	176	175	174	173	174	174	171	172	173	176	173	173	172	174	173	173	174	174	170	169	168	170
Apr	182	178	181	175	175	175	167	166	167	163	169	169	165	166	164	164	165	166	165	169	167	167	168	164
May	189	189	188	184	188	184	184	185	185	187	184	184	184	187	185	186	184	182	187	182	183	181	183	178
Jun	187	187	184	186	185	184	181	178	182	180	182	181	182	183	184	184	184	180	178	180	181	180	180	174
Jul	169	166	170	168	167	164	160	157	159	161	161	162	157	158	160	158	158	153	154	154	156	153	155	153
Aug	172	172	173	170	170	168	169	169	170	168	166	167	169	170	170	169	167	166	164	164	162	164	162	160
Sep	183	185	180	181	183	176	180	180	174	175	173	176	181	178	180	179	179	181	181	176	179	176	173	176
Oct	180	177	173	180	180	176	178	177	174	178	178	180	181	177	176	182	178	177	176	171	173	179	174	174
Nov	186	187	188	188	187	187	186	185	185	188	184	185	183	183	187	186	184	184	182	181	182	182	181	182
Dec	185	186	183	189	185	185	187	181	180	179	180	179	178	180	187	185	184	185	180	183	178	179	181	176

- **Energy Demand Flexibility Available for the CMZ –** The team then identified the specific NGED CMZ for the sites to ascertain when the CMZ requires demand reduction. The average HH estimated flexibility capacity, Table 5-2, was compared against the forecast daily HH requirements for CMZ flexibility turn down by month. This resulted in table 5-3 below, the redder areas show where need can be largely (or in some cases entirely) be met by SWW flexibility.

Table 5-3 % of CMZ Requirements that could be fulfilled by the site.

Month	00:30	01:00	01:30	02:00	02:30	03:00	03:30	04:00	04:30	05:00	05:30	06:00	06:30	07:00	07:30	08:00	08:30	09:00	09:30	10:00	10:30	11:00	11:30	12:00	12:30	13:00	13:30	14:00	14:30	15:00	15:30	16:00	16:30	17:00	17:30	18:00	18:30	19:00	19:30	20:00	20:30	21:00	21:30	22:00	22:30	23:00	23:30	00:00
Jan															32%	4%	3%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	1%	1%	1%	1%	1%	1%	1%	2%	3%	10%						
Feb															94%	7%	3%	2%	2%	1%	1%	2%	2%	2%	1%	1%	1%	2%	2%	3%	3%	2%	1%	1%	1%	1%	1%	1%	1%	1%	2%	5%	35%					
Mar															12%	5%	4%	4%	2%	2%	2%	3%	3%	3%	2%	3%	3%	6%	9%	12%	15%	5%	2%	1%	1%	1%	1%	1%	1%	1%	2%	5%	69%					
Apr																48%	12%	5%	5%	7%	9%	9%	11%	100%	100%	100%								15%	7%	4%	4%	5%	7%	8%	8%	21%						
May																		100%	19%	5%	5%	11%	33%	26%	36%	100%								100%	5%	4%	5%	5%	15%	77%								
Jun																				99%		100%	44%	98%													100%											
Jul																			100%	70%		8%					16%									10%	84%	10%	13%									
Aug																			42%	8%	19%	14%	10%	9%		95%									28%	12%	10%	17%	44%									
Sep																			100%	15%					18%	50%	35%							28%	8%	4%	5%	6%	7%	10%	41%							
Oct																48%	8%	6%	4%	5%	7%	8%	11%	10%	9%	9%	10%	36%	54%	3%	32%	3%	1%	1%	1%	1%	1%	1%	1%	3%	7%	88%						
Nov																68%	10%	10%	6%	5%	6%	7%	7%	6%	4%	3%	8%	24%	22%	26%	19%	5%	2%	1%	1%	1%	1%	2%	2%	5%	18%							
Dec																6%	3%	3%	2%	2%	2%	3%	4%	3%	3%	2%	3%	5%	5%	4%	4%	2%	1%	1%	1%	1%	1%	1%	1%	2%	5%	13%						

The above analysis was carried out for all 6 case study sites and their respective CMZs and the findings are summarised below.

- **Potential Network Benefit –** It was determined that by SWW implementing the perturbations i.e. holding pumping off, via the use cases (methods) as explained in the D4-1 Specification and High-Level Architecture Document, the case study sites could generate a potential maximum demand shift of **1.6 MW** from a total max demand of 2.9 MW.
  - It is unlikely that all the perturbations could be implemented at the same time everywhere. Therefore the SWW case study sites, when matched with their relevant NGED CMZs requirements and implementing a 50% pumping perturbation, could feasibly provide, between **53kW** and **696kW** of flexibility prior to NGED going out to the market.

5.6 LFA6. Recommendation for follow-on project

This work package produced a report that analysed the outcomes of the preceding five work packages and produced recommendations for the follow-on project to FLOWERS.

The outputs of this work package were the following deliverables:

D6-1. Recommendation document for follow-on activities - A one to two-page document with recommendations for the follow-on to FLOWERS.

D6-2. Final report - A report capturing the entirety of the activities described above (**this report**)

<u>Work Package Actions Summary</u>

5.6.1 D6-1. Recommendation for Follow-On Activities Document.

The purpose of this document was to outline several areas that have been identified within the FLOWERS project that could potentially be taken forward in subsequent innovation activities that provide a platform for radical and disruptive change. It is likely that these will face many barriers including regulatory limitations as well as more practical challenges including technology, operational practices, and existing policies.

The document has considered the following areas

- **Recommended Approach for Follow-On Projects** – Any follow-on project should take the solutions identified from concept to trial and develop these with multiple water utilities, and potentially other DSOs.
    - NGED could look to progress the wider development of the initial discovery phase with SWW by applying for funding via:
        1. The Ofgem Strategic Innovation Fund (SIF)
        2. The Ofwat Innovation Funding
        3. The internal NGED Innovation funding
        4. Move elements of the FLOWERS project to NGED BaU
- **Strategic Innovation Fund (SIF) –** The project would meet the challenge of Preparing for a Net Zero Power System, specifically accessing novel grid/system support from the operations of the drinking and wastewater networks of water utilities. The aim of the project would be to innovate and demonstrate the interoperability between electricity and water networks to embed whole systems thinking and flexibility in the connections of water network sites to the distribution network. It would design and trial the commercial and technical process required to access operational flexibility in the pumping demand of water networks.

- **Ofwat Innovation Funding** - The Ofwat Innovation Fund is a £200m programme to drive innovation in the water sector and tackle some of the major challenges – delivering transformative benefits for consumers, society, and the environment. The overarching objective of the Fund is that the sector can better meet the needs of, and create long-term value for, customers, society and the environment through innovation.

- **NGED Network Innovation Allowance (NIA) –** Investigate widening the reach of the initial FLOWERS feasibility project by utilising the NIA funding. The scale of this follow-on project would feasibly be limited to NGED licence areas only and the respective water utilities within these areas.

- **NGED BaU –** Possibly embed the simplest element of the FLOWERS findings and methods through NGED BAU business change. For example, focus on communicating flexibility requirements with SWW, anticipating that they develop the processes and deliver the required flexibility with limited technical development requirement.

6 CONCLUSIONS

This project has investigated the feasibility of embedding flexibility into the operations of water utilities. The key conclusions to draw from this are:

- The majority of accessible opportunities involve the planning and control of water pumping.
- Additional opportunities lie in the aeration and UV irradiation processes of wastewater treatment.
- Drinking and wastewater treatment sites are the largest energy consumers, and so initiatives including these sites should be prioritised.
- Even with conservative estimations, the value of the unlocked flexibility in a single water utility could amount to thousands of pounds an hour.
- The key challenges for long-term flexibility are developing the necessary forecasting capability and ensuring firm electricity supply.
- The key challenges for short-term flexibility are obtaining sub-metering data and automating command and control capability of water networks for dispatch and validation.
- Incentives for embedding flexibility could be built into connection agreements for renewable generation at water utility sites.

7 NEXT STEPS

NGED have submitted a bid to the Ofgem SIF Discovery Round 2 to develop a **unique collaboration between electricity and water companies**, embedding flexibility into the operations of water networks through **mutually beneficial connection agreements**.

This project has been submitted with the name **Shifting Currents** with the aim to innovate on the interoperability between electricity and water networks to embed whole systems thinking and flexibility in the connections of water network sites to the distribution network. It will design and trial the commercial and technical process required to access operational flexibility in the pumping demand of water networks.

It will demonstrate a unique collaboration between regulated utilities which can double stack benefits for customers served by both electricity and water networks: adding a widely accessible source of flexibility to reduce constraints on existing and potentially constrained networks, while enabling water networks' drive towards commercially viable net zero. This collaboration would be a template for replication countrywide, allowing all UK water and distribution network connected customers to benefit from this area.