SIF Beta Project Registration

Date of Submission

Dec 2023

Project Reference Number

10070764

Project Registration

Project Title

Crowdflex - Beta

Project Reference Number

10070764

Project Licensee(s)

National Energy System Operator

Project Start

Dec 2023

Project Duration

25 Months

Nominated Project Contact(s)

Dozie Nnabuife

Project Budget

£22,530,137.00

Funding Mechanism

SIF Beta - Round 1

SIF Funding

£18,610,355.00

Strategy Theme

Flexibility and market evolution

Challenge Area

Whole system integration

Lead Sector

Electricity Transmission

Other Related Sectors

Electricity Distribution, Electricity Transmission

Lead Funding Licensee

NG ESO - National Grid ESO

Funding Licensees

NGED - National Grid Electricity Distribution, SSEN - Southern Electric Power Distribution Plc

Collaborating Networks

Technology Areas

National Grid Electricity Distribution

Commercial, Demand Response, Electric Vehicles, Modelling, Stakeholder Engagement

Summary

CrowdFlex will meet the aims of the SIF Innovation Challenge by developing digital tools to help unlock full chain flexibility. Following the successful world-first Demand Flexibility Service (DFS) trial, we will be further exploring domestic flexibility as a novel, reliable flexibility resource of national significance, capable of competing alongside BAU alternatives in system balancing services, generation capacity, or network reinforcement. Our objective is to build a forecasting model of domestic demand and flexibility, informed by large-scale consumer trials, to validate domestic flexibility as a firm resource and inform new product design. This will feed into the Virtual Energy System (VirtualES) programme.

VirtualES will enable secure and resilient sharing of energy data across organisational and sector boundaries, facilitating complex scenario modelling for optimal whole-system decision making. Whole-system decisions will result in better societal, economic, and environmental outcomes, balancing the needs of users, electricity/gas systems and other sectors.

Since the original CrowdFlex:NIA (2021), CrowdFlex has been aligned with SIF Whole System Integration innovation challenges. Earlier stages proved fundamental principles, clarified the opportunity, developed the scope, and de-risked Beta plans, which aim to:

- Develop a comprehensive understanding of domestic flexibility by building forecasting models of domestic demand and flexibility, integrated into the VirtualES, and improve ESO confidence in domestic demand and flexibility, advancing "coordination of emerging innovations across the system."
- Demonstrate that simple incentives, reflecting whole system challenges, can "reduce complexity, bureaucracy, and barriers to entry" for aggregators to deliver domestic flexibility.
- Trial consumer interventions (financial and informational) targeting different system challenges to "clarify consumers' preferences and inform future market designs."
- Trial the service primacy rules developed with ESO and DSO stakeholders in previous phases to "Improve coordination between networks and other system participants."

CrowdFlex:Alpha laid the foundations, scoped and de-risked Beta, by clarifying the immediate market opportunity:

- Identified Thermal Constraint Management (transmission and distribution) and Energy Balancing as key Beta use cases.
- Tested primacy and stacking implications for domestic consumers participating in flexibility in constrained areas of the distribution network.

Furthering innovation:

- Developed a specification for predictive models of statistically expressed domestic demand and flexibility, to be developed in Beta within the VirtualES framework, to ensure interoperability.
- Identified how the full value of statistically declared flexibility can be recognised by the ESO, to be pursued in Beta.

Focussing the scope:

- The consumer segments and key behavioural research questions to be investigated.
- Identified white goods, electric vehicles (EVs), and electrified heat as the project technologies (and their technical requirements).
- Confirmed the inclusion of manual and automated response.
- Developed a trial specification to ensure that consumer incentives reflect system requirements and balances cost and statistical power to give significance at good value for money.

The Alpha phase responded to insights generated by CrowdFlex:NIA, CrowdFlex:Discovery, and the outcomes from the Demand Reserve Scarcity Trial and DFS. The apparent success of the DFS has confirmed the potential of domestic flexibility to address system scarcity stress events. DFS was an enhanced action for winter 2022/2023 and not a full commercial service, meaning more work through CrowdFlex is needed to support full adoption in both system stress and routine events.

CrowdFlex:Alpha's work on the statistical nature of domestic flexibility has highlighted the opportunity for, and commercial value of, probabilistic forecasting to increase reliability. This is critical to the VirtualES and will improve the economics of existing network assets and target future system investments through reliable modelling of domestic demand and flexibility.

The requirement for domestic flexibility is increasingly apparent. The Ukraine invasion led to increasing energy prices, highlighting the precariousness of international gas trade and the need for alternative flexibility sources. FES 2021 projects a 19% system peak increase from 2020-2030. Domestic flexibility has a vast potential (~7GW turn-down and \>10GW turn-up, CrowdFlex:NIA) to offset this

increase and address operational challenges as well as capacity and network investment planning.

CrowdFlex brings together partners spanning the energy system, from system and network operators to energy suppliers and technology providers, directly interacting with consumers who will be the users of the services emerging by CrowdFlex. The CrowdFlex consortium has experience working together and is best placed to address whole system challenges. The consortium partners are (the Project Management Book provides further details on partners and subcontractors):

- ESO: system operator for the GB transmission network.
- SSEN and NGED: DSOs with \>1GW of flexibility services contracted.
- Octopus and OVO: energy suppliers offering customers innovative tariffs and services encouraging flexibility.
- Ohme: home EV Charge-Point Operator providing smart charging and flexibility services.
- CNZ: NfP consultancy providing expertise in modelling, data science, and consumer engagement.
- Element Energy: leading low-carbon energy consultancy, providing subject matter expertise and analysis on energy system needs.

ESO/DSOs can use the new flexibility resources and the associated modelling to lower operational costs and reduce capacity and network investments. Benefits will be passed down to consumers via energy bill reductions.

Project Description

CrowdFlex aims to establish domestic flexibility as a novel, reliable flexibility resource of national significance, competing alongside BAU alternatives and accelerating decarbonisation. As more Variable Renewable Energy (VRE) and Low Carbon Technologies (LCTs) are added to the network, it will become increasingly difficult to balance supply and demand. Domestic flexibility provides a huge opportunity during this transition to build a smart flexible energy system by enabling consumers to act as a new source of flexibility.

CrowdFlex explores how domestic flexibility can be utilised to align demand to generation, improve coordination across the network and reduce stress on the system, while reducing consumer energy bills via incentives. The objective of Beta is to build a forecasting model of domestic demand and flexibility, informed by large-scale consumer trials, to establish domestic flexibility as a firm resource and inform new product design. CrowdFlex is the first use case for the ESO's Virtual Energy System (VirtualES). The VirtualES aims to develop an ecosystem of interoperable digital twins representing the entire GB energy system, for a flexible energy system with increased visibility and more accurate forecasting, and ultimately optimising costs for the end user.

Domestic flexibility is inherently statistical in nature. To fully understand and reliably quantify domestic flexibility, CrowdFlex: Beta will:

- Develop probabilistic modelling of domestic demand and flexibility to improve forecasting of baseline domestic demand and flexibility.
- Conduct large-scale consumer trials to enable the model development and a greater understanding of domestic flexibility's potential and technical capabilities.
- Establish a pathway to rapidly accelerate domestic flexibility to Business as Usual (BAU), following the project's completion.

If successful, CrowdFlex has the potential to deliver value across the energy system. Enabling ESO and DSOs to utilise domestic flexibility to reduce operational costs (namely constraints and energy balancing) and capacity and network reinforcement investments. This will lower consumer bills and support the deployment of VRE and uptake of LCTs, accelerating whole system decarbonisation.

Preceding Projects

10037410 - Crowdflex: Alpha

Nominated Contact Email Address(es)

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Project Description And Benefits

Applicants Location

To understand demand flexibility from domestic customers and assets across the GB power system, CrowdFlex:Beta will develop models of demand flexibility based on outputs from a series of large-scale consumer trials, recruiting Octopus, OVO, and Ohme customers from across GB. The trials will be our demonstration project. As such, the demonstration project will be carried out over the entire of GB. The analysis of the trials will be carried out by the partners at their business addresses.

Project Short Description

CrowdFlex aims to establish domestic flexibility as a reliable energy and grid management resource. CrowdFlex will understand the role domestic flexibility can play in addressing system challenges by modelling consumer behaviour. Building upon existing domestic flexibility trials, CrowdFlex explores how domestic flexibility can be further leveraged to align demand to unflexible generation, improve network coordination, reduce system stress, while reducing consumer energy bills.

Innovation Justification

Current state-of-the-art ESO flexibility is dominated by large, carbon intensive thermal power stations, which have reduced load factors to operate flexibly, increasing cost. Recent events show how exposed this market is to gas supply interruptions, further increasing costs to the consumer (constraint management cost £174.12/MWh in 2021/22). In 2021-22, ESO spent £1.41Bn on thermal constraint management, and £580Mn on energy balancing, including Reserve, with a total operational cost of £2.2Bn (NGESO, Balancing Costs, 2021-22). DSOs primarily reinforce areas of the network that are constrained; CrowdFlex will therefore focus on Constraint Management Zones (CMZs) and Load Managed Areas (LMAs) where deploying flexible solutions can mitigate/delay reinforcement.

The DFS is the only ESO domestic flexibility service and is an enhanced action that focusses on system scarcity events. It was run 15 times in 2022/23 and cost up to £3,000/MWh, totalling £4.73m (NGESO, 2023). System scarcity does not represent the full potential for domestic flexibility. Without further development it is highly likely this first use case would remain its only contribution to meeting system needs.

CrowdFlex goes beyond incremental innovation by using a large-scale (2-years; ~150,000 customers) trial to develop a statistical basis to underpin modelling and deploying domestic flexibility. We will combine automated and manual responses from diverse technologies to understand how flexible capacity varies between households. By utilising a randomised control trial approach, CrowdFlex:Beta's breadth, granularity, and statistical confidence will be unprecedented and mature this nascent asset, **which could provide ~7GW turn-down and \>10GW turn-up.**

CrowdFlex builds on two previous trials, CrowdFlex:NIA and the Domestic Reserve Scarcity Trial. While both were large-scale, they did not answer the whole system integration questions associated with domestic flexibility. CrowdFlex:Alpha showed for the first time how statistical declaration of domestic flexibility capacity avoids deeply sub-optimal derating associated with deterministic declaration. CrowdFlex:Beta will set a pathway for adoption of this transformative system view, which could provide system savings of ~£228m by 2035.

CrowdFlex:Beta will address the key research questions surrounding domestic flexibility that remain unanswered. We will develop a probabilistic model of domestic flexibility, significantly improving the system value and reliability standards of domestic flexibility. Currently unknown behavioural parameters such as price elasticity, duration, seasonality, and fatigue of domestic response will be vital outputs of the trials to inform this modelling. Finally, confirming the primacy rules for domestic flexibility in a large-scale trial will ensure that domestic flexibility meets the future needs of the whole system.

The scale of the CrowdFlex project is necessary, as:

- A large trial size is required to ensure outcomes carry statistical power and represent the widespread commercial rollout of domestic flexibility post-CrowdFlex.
- Multiple incentive levels are needed to establish price elasticity and cost-optimal incentives.
- The trial extends over multiple years to test seasonal supply, fatigue, and to deliver system stakeholder confidence.

Domestic flexibility is nascent, with the first customers engaging with time-of-use tariffs, DSO flexibility markets, and the DFS. The technical capacity of domestic assets to supply flexibility is better explored than the commercial profitability. **As such, the current commercial readiness level** (CRL) of domestic flexibility is CRL3/CRL4 and the integration readiness level (IRL) is IRL4. Post-

CrowdFlex we estimate improvement to:

- **CRL7**: Large-scale trials enable initial service entry from consumers. All stakeholders are involved in the trial. Trial data and flexibility models will provide the insight needed to confirm the economical deployment scenarios.
- **IRL6**: The integrating technologies (models) can accept, translate, and structure information for its intended application. CrowdFlex includes a Business-As-Usual (BAU) and exploitation plan to rapidly integrate domestic flexibility as a resource.

CrowdFlex improves market competitiveness by increasing electricity market depth of supply. Households represent a large fraction of electricity demand, but have limited participation in electricity markets. CrowdFlex:Beta will develop the frameworks to integrate domestic flexibility into competitive marketplaces and encourage participation from many Flexibility Service Providers (FSPs), improving consumer choice.

'Do-Nothing" is the key counterfactual to domestic flexibility. In this scenario, decarbonisation continues with flexibility provided by large-scale thermal assets. As electrification and renewables deployment increase, thermal load factors reduce, and the cost of providing flexibility from these thermal sources would increase significantly. Vast investment in new capacity and network reinforcement will be necessary to meet increasing demand from low carbon technologies. This alternative will have very high costs and long lead times compared to domestic flexibility, meaning CrowdFlex will accelerate decarbonisation. Greater use of energy storage will offer an alternative to thermal capacity and network reinforcement; however, solving seasonal supply issues would require uneconomic investment in batteries or in hydrogen storage, which will not deliver system improvements at scale in the timeframe that CrowdFlex can.

With its many unknowns and uncertainties, domestic flexibility is unlikely to attract significant private/BAU investment to fund the trial scale required to develop the necessary forecast modelling to mature the technology and **cannot be funded by the price control mechanism.**

Impacts and benefits

Our CBA demonstrates that domestic flexibility, following the completion of CrowdFlex: Beta, has a **NPV of -£0.81m in year 1 (2026), £30.1m in year 3, £203m in year 5, and £1.48b in 2035 (year 10)** at full roll-out. These benefits continue to increase out to 2050 when the annual net benefit of CrowdFlex is £2.2b/yr, leading to a NPV of £12.0b. CrowdFlex delivers Whole System net benefits by reducing system operational costs, mitigating/delaying generation capacity and network investments, and accelerating decarbonisation.

The CBA identifies both operational savings we well as reduced capital investments for the ESO and DSOs. The CBA includes domestic consumers providing energy balancing via the Balancing Mechanism and thermal constraint management on the transmission and distribution networks reducing operational and network investment costs. These are the largest expenditures at ESO level, £580m/yr (27%) and £1.4b/yr (67%) of ESO costs respectively (2021/22). The NPVs of these benefits in years 1, 3, 5, and 10 (2035) are the following:

- Reduction in ESO operational costs via energy balancing: £2.2m, £13.0m, £47.0m, £232.3m
- Reduction in transmission network reinforcement investment, realised as reduction in ESO thermal constraint management costs: £1.7m, £39.8m, £150.7m, £740.6m
- Reduction in distribution network reinforcement investment: £0.3m, £7.7m, £31.0m, £156.8m

In addition, through the development of a probabilistic forecasting model of domestic demand and flexibility, deratings of residential capacity will be avoided, prediction accuracy improved, and additional savings will be generated for the ESO. We plan to begin implementation into the Control Room from 2026, subject to trial success. **Leveraging this model will deliver additional and highly innovative processes and services that will benefit the whole energy system.** First, the moderate benefit of improving the forecast of domestic demand will be introduced, reducing Reserve requirements. By 2030, once confidence in probabilistic modelling of domestic flexibility has been demonstrated, it will stimulate a shift towards the statistical procurement of. Despite high upfront costs to implement the modelling, it will encourage the full benefits of domestic flexibility to be captured. The NPV of the additional benefits from the modelling undertaken in CrowdFlex is -£0.6m, -£8.9m, £64.8m, £216.8m in years 1, 3, 5, and 10 respectively, continuing to increase to £439.7m in 2050. This excludes the potential value in exporting these digital assets to electricity networks worldwide.

As the users of network services, flexibility service providers (FSPs) (e.g. energy suppliers and aggregators), stand to generate new revenues from aggregating their domestic customers' flexible capacity to participate in the flexibility services that emerge from CrowdFlex. Assuming a 25% margin, CrowdFlex will provide FSPs with a total net benefit of -£0.1m (2026), £27.8m (2028), £135.2m (2030), £841.0m (2035). The FSP modelling of domestic demand and flexibility, which will be scoped in CrowdFlex (and developed by FSP partners as a contribution-in-kind) is essential to forecast domestic flexibility to access new markets.

System savings from CrowdFlex will be passed down to consumers through energy bill reductions. However, by directly participating in domestic flexibility, consumers will be able to generate revenue from ESO and DSO services. This will come in the form of a reduction in participating consumers electricity bills or direct payments, via the FSP. Based on our CBA, from 2026, the cumulative net benefits for consumers in the years 1, 3, 5, and 10 are £0.8m, £64.9m, £255.3m, £1.3b.

Currently participation in domestic flexibility services is extremely limited, only available nationally via the enhanced action of the Demand Flexibility Service. The FSP and ESO models that will be developed in CrowdFlex:Beta will be transformational in our understanding of domestic flexibility, vastly improving confidence in domestic demand and flexibility forecasting. **This development will unlock the application of flexibility products and services to domestic flexibility**, enabling this large but nascent sector to participate in "routine" events as well as improving confidence during system stress events. Furthermore, adopting a statistical approach to forecasting and eventually procuring flexibility would represent a paradigmatic shift in how system operators manage networks. It would improve network security, while reducing the cost of reserve and capacity procurement.

CrowdFlex will help accelerate decarbonization, reducing the need for thermal generation to support VRE dispatch and provide energy balancing. From 2026, this equates to a cumulative discounted benefit of avoided CO2 emissions equating to 0.13MtCO2eq, 0.57MtCO2eq, 1.40MtCO2eq, and 5.91MtCO2eq in years 1, 3, 5, and 10 respectively. This calculation is based on the assumption that the counterfactual is "Do-nothing", i.e. flexibility continues to be primarily large Open-Cycle Gas Turbines (OCGTs) as variable renewable energy roll-out continues. We are aware that the "Do-nothing" approach leads to residual emissions of the counterfactual in 2035, which is contrary to the Government's Net Zero target. However, we felt that zero carbon options (e.g. battery storage and H2GT) introduced another layer of cost assumptions. Therefore, we have selected the "Do-nothing" approach to be transparent on cost and emissions.

Project Plans And Milestones

Project Plans, Milestones & Risks

The aim is for CrowdFlex to take a dynamic, iterative approach, using evolving ESO requirements to develop the model and inform the design of trialling to generate data for modelling and feed back into requirements development. **CrowdFlex:Beta will therefore be divided into three workstreams:**

- Workstream A: User Requirements, Scoping and Plan for Implementation
- Workstream B: Model development
- Workstream C: Trialling

WP0 (Project management) will provide governance, oversight, engagement, data management/security, and the overall ESO lead for each workstream.

Workstream A will identify the model user/owner, confirm requirements and then develop the implementation plans for model transition from demonstration to BAU. ESO overall lead; WPs as follow:

- WP1: User requirements [ESO lead]: will establish the ESO model user/owner to confirm key model requirements to enable development to commence, outputting initial model specifications as 'living' documents.
- WP2: System impact analysis [Element Energy lead]: will determine the impact of the trials on ESO/DSO operations. By extrapolating the analyses to a post-commercialised deployment of domestic flexibility we will finalise the CBA of BAU domestic flexibility.
- WP3: Implementation strategy [Ohme lead]: will initialise the implementation of the model into BAU routine. We will identify remaining barriers for BAU service participation, and make recommendations on integrating the model (and statistical nature of domestic flexibility) into BAU operations in the long term.

Key deliverables:

- Requirements
- System impact and CBA report
- Post-Beta roadmap to BAU and implementation strategy.

Success: Workstream enables development and accelerates the commercialisation of domestic flexibility into BAU.

Workstream B will develop the models of domestic demand and flexibility. ESO overall lead; WPs as follows:

- WP4: Iterative development of FSP models of domestic demand [Octopus lead]: FSPs will develop and integrate domestic demand models with the ESO domestic flexibility model via API access.
- WP5: Iterative development of ESO model of domestic flexibility [ESO lead]: will develop and integrate an ESO model of domestic demand and flexibility, a key use case for the VirtualES. Outputs the API Specification for WP2.
- WP6: Model monitoring, feedback, and reporting [OVO lead]: will monitor the performance of the CrowdFlex models, identify gaps, and develop trial updates to address any gaps. Outputs: final model development report and ongoing requirements.

Key deliverables:

- API specification.
- Final functional FSP Demand models and ESO Domestic Demand Flexibility Model.
- Reporting on CrowdFlex's model development.

Success: ESO model can reliably forecast domestic flexibility participation in system events and is adopted by the Control Room to predict demand and deploy domestic flexibility.

Workstream C will conduct the large-scale consumer trialling of domestic flexibility and subsequent trial analysis to feed data into the models. ESO overall lead; WPs as follows:

- WP7: Trial design, planning, and scheduling [CNZ lead]: will develop the customer engagement strategies and technical integration required (including automation). It will finalise ESO/DSO primacy, event scheduling, and payment frameworks to ensure successful trials.
- WP8: Trial Delivery [ESO lead]: will deliver the trials, collect trial data, and monitor the ongoing performance of the trials, adjusting as needed for changing modelling requirements.

- WP9: Trial analysis and reporting [CNZ lead]: will report the trial results to provide insights for dissemination and feed back into the modelling.

Key deliverables:

- Successful trial delivery and data gathering.
- Analysis and reporting.

Success: The trial datasets are sufficient to develop the models.

Key Beta and BAU adoption risks are:

- The statistical nature of domestic flexibility may be too uncertain to confidently forecast. Level: High. Mitigations/Contingency: Investigate different approaches to forecasting and prediction and use accuracy metrics to measure improvements. Adapt learnings from other/previous studies (e.g., 2022/23 DFS) to improve our understanding of domestic flexibility from the outset.
- Customer recruitment falls short of requirements for trialling and data gathering. Level: Medium. Mitigations/Contingency: Dedicated tasks in WP7&8 will recruit consumers with additional tranches should engagement drop off. Previous studies have demonstrated that consumers will opt-in and respond to events.
- Risk: Domestic assets may be inappropriate for BM participation. Level: Low. Mitigations/Contingency: We plan to move trial participants to elective half-hourly (HH) settlement (to be actively managed by suppliers who already have some customers settled in this way) enabling BM participation. CrowdFlex will also liaise with ESO to enable the reporting of domestic assets as an aggregated portfolio to meet operational criteria.

To manage risks, the risk register will be treated as a living document, updated at bi-weekly progress meetings where new risks will also be identified with mitigation/contingency plans. Most of the consortium has experience working together. We are therefore confident we can manage emerging risks and deliver this ambitious work programme.

Proposed stage-gates/breakpoints are aligned with key trialling decisions on 30/11/23, Tue 30/04/24 and Thu 31/10/24. They precede tranches of trialling to enable assessment before significant investment in further trialling/modelling.

Regulatory Barriers

CrowdFlex:Alpha worked to identify and address any regulatory barriers that may hinder the delivery of CrowdFlex:Beta. The primary barrier identified was associated with settlement in the Balancing Mechanism (BM), which is currently half-hourly (HH). However, most domestic households are not HH settled. CrowdFlex:Beta will have a dedicated task to explore shifting trial participants to elective HH settlement to overcome this barrier. Having liaised with our supplier partners we think that this route will be sufficient to satisfy BM settlement requirements. Failing this, we will seek a derogation from Ofgem (detailed below). Additionally, asset level meters to be used in automated services may not be MID certified, despite fulfilling the requirements set out by Elexon. It is not clear whether MID specification is necessary to comply with CoP11 requirements, so this remains a project risk. We are confirming the requirements with Elexon and have included a plan for addressing any issues in the project.

During CrowdFlex:Alpha we held discussions with BEIS (as was), Ofgem, and Elexon to explore derogation options and how to establish a Sandbox to enable non-HH settled meters to participate in the BM. However, these discussions revealed that we should first explore the option of using elective HH settlement to comply with the Settlement Code. If enough CrowdFlex customers cannot be switched to elective HH settlement, a derogation will be required to allow non-HH settled assets to be used in the BM. However, a similar derogation has already been acquired by the Centrica Sandbox trial, and only a single derogation of a given type is allowed at one time. Should CrowdFlex need to pursue this option, we would need to show CrowdFlex can provide additional settlement learnings. This represents a risk for CrowdFlex trials and will be monitored as such. It is mitigated by the fact that, at the close of the Centrica trials (2024) they will need to either apply for the derogation to come into code or 'release' the derogation.

A trial entering domestic assets directly into the post-gate closure BM would not commence until mid-2024. Therefore, pursuing an alternative strategy before returning to Ofgem/Elexon, if unsuccessful, should not cause delays to the project.

To incorporate domestic flexibility into BAU, the BM also requires assets to fulfil operational metering requirements that give the ESO control room real-time visibility. These have been designed with traditional large assets in mind, domestic assets cannot currently fulfil them entirely. The operational metering requirements that are particularly difficult to overcome for domestic assets are high read frequency and accuracy requirements (1Hz and ±1%, respectively). As the operational metering requirements are set by ESO, a derogation is not required to remove the barriers that currently would prohibit domestic participation. CrowdFlex aims to enable a divergence from the standard operational metering requirements for the BM with ESO through a Bilateral agreement. The ESO have some discretion on these standards. The key changes to the standard requirements that CrowdFlex will request are:

- Enabling small assets to provide operational data as an aggregated portfolio, leading to efficiencies in both portfolio accuracy and read frequency reporting; or,

- Loosening the requirements for small assets around accuracy, read frequency, and latency, to enable domestic assets to meet the requirements for operational reporting without new and expensive metering equipment.

The Powerloop trial conducted by ESO's Markets team also looked at the question of operational metering for EVs. While the final report is still pending, this work may create the route for changes to operational metering and bringing EVs into the BM. CrowdFlex would therefore benefit from this as we seek to include both EVs and other automated assets in our trials.

The current iteration of the Demand Flexibility Service (DFS) restricts households from participating in other auxiliary balancing services, including the BM. During this summer, CrowdFlex will be able to liaise with the DFS team to include an exemption for CrowdFlex participants before next winter's run of DFS events.

In the long term, shifting the procurement of flexibility to a statistical approach, to benefit a decentralised energy system of aggregated assets, would require significant divergence from the current method used to procure services as a derated firm capacity. In the short term it is likely that flexibility services will remain deterministic. Therefore, CrowdFlex:Beta will explore how statistical portfolios can be collapsed to a derated firm capacity. However, CrowdFlex:Beta will lay out an approach to establishing a new stochastic flexibility service, where flexibility is procured via a probability distribution function, to encourage ESO to innovate on the way they procure services. In discussion with BEIS/DESNZ and Ofgem on this matter, they highlighted that the legacy performance of deterministic procurement of service made it currently preferable for ESO.

Business As Usual

CrowdFlex:Beta will take the steps required to accelerate domestic flexibility to a mature resource alongside traditional forms of flexibility. As a result of CrowdFlex, from 2026, ESO aims to routinely deploy domestic flexibility commercially to solve system needs and reduce costs.

ESO will achieve this primarily by taking new statistical approaches for forecasting domestic demand and flexibility. Following CrowdFlex, FSP-owned models of domestic demand will feed directly into ESO (and potentially DSO) models of domestic demand/flexibility, providing enhanced forecasting and the ability to plan flexibility actions. Integrating this forecasting with ESO's VirtualES will enable more direct management of demand, based on a whole system approach to system needs. The VirtualES will be interoperable with FSPs to provide a two-way information flow, enabling FSPs to access flexibility event requirements, with mechanisms to prevent gaming of the system. This will make entry into the market simpler and more efficient for new providers. Developing these initial processes and systems in CrowdFlex:Beta will enable rapid adoption in BAU.

Beta will include an exploitation strategy directly following the CrowdFlex trials and model integration. Based on the findings of Beta, we will roadmap the development of flexibility markets to enable the participation of domestic flexibility. The goal is for CrowdFlex to combine ESO/DSO needs into one consumer facing proposition. This will be offered by FSPs, reducing variation of products, complexity, and barriers to entry.

This project will support wider adoption of flexibility by publishing trial evidence and modelling approaches. Learnings will be disseminated through planned engagement, published reports and presenting findings to future FSPs and wider industry stakeholders. This will prepare wider industry for the rapid scale-up of CrowdFlex during commercialisation.

CrowdFlex:Beta will deliver a system impact analysis to evaluate the physical, environmental, and economic impacts across ESO/DSOs. Control Room operational impacts will be assessed via counterfactual actions to domestic flexibility. Work includes:

An extrapolation for integration into BAU: the potential impact of future BAU domestic flexibility forecasting and operations for ESO/DSOs.
Confirming the routine and system stress events when the deployment of domestic flexibility is beneficial to the system. Research questions will include identifying price sensitivity and year-round capacity.

The ESO innovation team will champion CrowdFlex. They have successfully delivered £7.3Mn of funding across 32 individual projects in 2020-21 and integrated projects into BAU activities such as the machine learning solar forecast now used in the Control Room. CrowdFlex will engage the ESO Market Development and National Control Future Design teams, responsible for rolling out market/operations developments, to incorporate findings.

DSO partners are motivated to access domestic flexibility as BAU within ambitions set out in their Action Plans. Their innovation teams will contribute integration knowledge and engage the DSO Transition and Flexibility Services teams to ensure the continued alignment of ESO and DSO needs in the development of domestic flexibility. Both NGED and SSEN currently use the Flexible Power platform to deliver services, which will be used in Beta to transition to BAU efficiently.

Beyond dissemination, Octopus, OVO and Ohme will, as FSPs, directly adopt learnings, processes, and models into their commercialised domestic flexibility offering following Beta. The FSP/ESO API specification will be socialised across the industry to

ensure widespread compatibility and acceptance before publication. Having multiple FSPs in the project will allow models to be built at multiple levels, aggregate different forecasts from different providers, and improve learnings for adoption into BAU competitive marketplaces.

The continued involvement of markets and operational teams is critical so that their interests are addressed from the outset. By gathering technical and commercial evidence from trials and modelling, teams can be confident that system needs will be reliably and commercially met, encouraging quick implementation into BAU. Ongoing market development work will remove barriers in existing services or develop new technology-neutral services to enable BAU adoption of domestic flexibility services.

CrowdFlex will directly engage DESNZ/Ofgem policy and regulatory teams to identify potential blockers. See Q10 for how the project will reduce regulatory and operational barriers.

Crowdflex:Beta funding will prove the commercial case for all partners. BAU implementation work for ESO and DSOs is included in Beta as part of WP3 and will therefore not require further funding. The FSPs involved will fund their own development of the modelling capabilities and consumer engagement tools required for scale-up in Beta. This should put them in a position to commercialise domestic flexibility following CrowdFlex, while sharing learnings to support future providers.

As CrowdFlex seeks to address whole system challenges, there has been interest from other DSOs in adopting the project innovations. SPEN have shown interest in the CrowdFlex trialling and understanding the primacy implications for their network. Our DSO partners have expressed interest in utilising the modelling of domestic demand and flexibility, as well as the VirtualES, to improve their visibility of domestic demand and the opportunity for flexibility on their networks.

Commercials

Consumer interaction and engagement

Through a large-scale trial of domestic flexibility, CrowdFlex:Beta is directly engaging with domestic consumers of electricity to encourage them to play a more active role in the energy system.

CrowdFlex:Alpha has conducted primary analysis of domestic behaviour and consumption to develop a consumer engagement roadmap to recruit, maintain, and incentivise domestic consumers. Flexibility Service Providers (FSPs) (Octopus, Ohme, and OVO) will be responsible for recruiting consumers via open, but targeted invitations, to enable a diverse and representative sample of domestic consumers in GB. Emphasis will be given to participants to opt-in to the trial and, unless the consumer specifically opts out of specific events or the overall trial, participation in the subsequent trial events will be assumed, simulating a "routine" service offering. The general guidelines of consumer engagement have been set out in CrowdFlex:Alpha; however, the specific branding and tone will be up to the FSPs themselves, again reflecting a realistic commercial rollout of such a service.

The language used will be jargon-free, educating participants about the trial, incentives, and expectations about participation, performance, and potential bill savings. Information provided will involve measures to maintain consumer engagement during the trial. This means that notice periods for trial events that include manual actions will be at least hours ahead of delivery, as well as providing simple steps to show how to reduce energy consumption. Incentives will be financial, but also include education on how consumers' demand response is beneficial to the electricity system, driving a net-zero future. Financial incentives will be simple, such that one household member will be able to explain the structure to another.

CrowdFlex:Beta will reduce the energy bills of consumers participating in the trials, rewarding consumers for providing services that benefit the system. During the project trial, participants will be able to reduce their energy bills by successfully participating in trial events. The trial plan involves two forms of payments to consumers.

- A utilisation payment (i.e., £/kWh) will be made for the scheduled constraint management service for turning up/down demand (via both automated and manual means). These will be called upon hours-day ahead of delivery. In the first mini-trial we will be exploring three payment levels (£0.05/kWh, £0.40/kWh, & £1.25/kWh).
- An availability payment will be made for the post-gate closure service for making their automated assets available. In the first mini-trial we will explore three payment levels (£3/asset/month, £7/asset/month, £13/asset/month).

Following CrowdFlex, as domestic flexibility becomes BAU, future energy bills will be reduced both from direct participation in domestic flexibility, but also indirectly by reducing the operational cost of the electricity system, affecting all domestic consumers. If all net savings were passed down to consumers, this would amount to £1.5b/yr in 2035, increasing to £12.0b/yr in 2050, which equates to £90/household/yr in 2035 and £150/household/yr in 2050 if socialised among all CrowdFlex participants. Further details of savings have been provided in Q6 and the Project Management Book.

Participation in the CrowdFlex:Beta trial will not necessitate any major changes in contractual arrangements of consumers with energy suppliers. As part of the trial, we plan to explore entering domestic assets into the Balancing Mechanism (BM) for post-gate closure energy balancing. One approach to this would include shifting trial participants to elective half-hourly settlement. This would only be done where it does not significantly change the contractual arrangements of a consumer with its energy supplier, nor the consumer's tariff, and it would only be done with explicit consent.

Normal supply of energy will continue during the trial period; however, consumers will be able to decide if/how they change their demand according to trial events. For how we will mitigate any risk of supply interruptions see Q9.

All guidance material will be reviewed by "Voice of Customer" representatives, including the Citizens Advice Bureau and local authorities, who will help ensure that the messaging in CrowdFlex is appropriate for consumers and no accidental harm comes to trial participants, particularly low income and vulnerable persons. Participants will not be penalised for non-participation or non-compliance.

Supply shortages and interruptions

Overall, we do not expect any shortages or interruptions in domestic consumers energy supply during CrowdFlex:Beta. This also includes the access and quality of energy services provided during participation in the trial.

Participation in the trials involve either/both manual and automated trial actions and for both, consumers will have the option to opt out:

- During trial events involving manual actions, consumers are asked to turn up or down their demand. However, they will have the option to opt-out if the invitation to participate in a specific trial event does not suit the participants energy needs.

- During trial events involving automated actions, participants must allow their FSP to dispatch an optimised consumption profile, but will still have the option to opt-out at any given moment. In CrowdFlex:Beta, the technologies that will be included in automated services will predominantly be electric heating and EV charging with some smart white goods. To minimise disruptions in comfort levels, turn down of heating will be limited to comfortable temperature levels, set by the consumer. Ensuring comfort levels in heating during automated trial events is most likely the biggest risk to security of supply that needs to be controlled during CrowdFlex trial planning. Surveying will be used to monitor this throughout the trial. Automated EV charging will have the risk of incomplete charging if the participant decides to unplug the vehicle early. The literature review completed during CrowdFlex:Alpha showed that, if consumers understand how "smart" charging functions, they do not experience any barriers in their day-to-day use of the EV.

Supply interruptions caused by constrained Low Voltage (LV) or High Voltage (HV) lines on the distribution network are very unlikely. The CrowdFlex:Beta trial includes turn-up events, which can increase loads on the distribution network. These will be called on in the transmission thermal constraint management service to reduce renewable curtailment, for example. The chance of this causing interruptions is very unlikely because CrowdFlex:Alpha has tested the guidelines from the ENA Open Networks Project to guide primacy rules for ESO and DSO services. These propose that, generally, DSO needs will supersede ESO needs due to the illiquid markets accessible to DSOs. By adopting these primacy rules in CrowdFlex:Beta and using automated prioritisation to implement them, we will ensure that actions for ESO will not lead to any problems for DSOs. This will be beneficial and important for the rollout of large-scale domestic flexibility to prevent any conflicts caused by differing needs of network operators.

Supply interruptions caused by impacts on the transmission network are extremely unlikely. The scale of CrowdFlex:Beta will not be significant enough to cause interruptions of energy supply due to unforeseen faults on the transmission network. ESO will be coordinating the trial events, as such ESO and the DSOs will be able to forecast the impact that any events will have. CrowdFlex:Beta is attempting to solve grid needs, and therefore should improve grid stability, rather than reduce it.

As hardware installation in participants homes has been ruled out due to cost and recruitment barriers, there will be no risk of interruption of supply caused by this.

Overall, there are no expected interruptions in supply caused by the trial in CrowdFlex:Beta. Trial events are voluntary and participants can always opt out. The adoption of primacy rules set out by the ENA Open Networks Project and forecasting of the impact of flexibility trial events will ensure that no interruptions will be caused in constrained networks.

Commercialisation

CrowdFlex's primary beneficiaries are domestic customers who will be able to generate value through participating in commercial flexibility services. Access will be through flexibility service providers (FSPs) who contract these services directly from the ESO/DSOs and aggregate domestic customers to generate a flexible response. As such, **FSPs (energy suppliers, and other aggregators of domestic assets) will be the primary customer segment** for the outputs of CrowdFlex.

FSPs will develop a portfolio of domestic assets to deliver flexibility based on forecasted and "real time" ESO/DSO requirements. The FSPs bring domestic flexibility to market by directly dispatching domestic assets or by issuing an instruction to customers to adjust their demand. Payment to FSPs comes directly from the ESO/DSOs and they are then responsible for passing on the revenue to customers.

The VirtualES enables the integration and interoperability of the forecast/prediction models on both sides of this transaction. FSP demand models will be accessed by ESO/DSOs to predict demand and determine when/what type of flexibility is required.

The consumer-level value proposition that will be explored in CrowdFlex will offer consumers savings to their energy bills, or direct payments, to either respond to dispatch signals or make their assets available to provide flexibility (Q8 for details). Operational modelling in CrowdFlex:Alpha indicates that consumers with Low Carbon Technologies (LCTs) in their homes have the potential to reduce their annual electricity bills by 38-60%.

CrowdFlex will identify consumer price sensitivity and align this discovered price with the system price in WP3. This will inform the FSPs' commercial offering following the trial to bring these savings to consumers. FSPs will need to ensure that their offering reflects the system cost while being sufficient to engage consumers. To be a viable value proposition, FSPs will need to apply a suitable margin to cover their cost and profits.

CrowdFlex:Beta will provide a route to market by conducting a detailed system impact analysis (WP2) to explore the key performance indicators and value (both economic and environmental) of flexibility at commercialisation. This inputs to WP3, Implementation Strategy, which develops both system and FSP level go-to-market strategies. We will confirm the commercial viability of the services identified in CrowdFlex:Alpha, and begin the process of bringing the services and products into BAU.

CrowdFlex contributes to solutions for the technical and operational challenges that have created barriers for small assets participating in flexibility. This includes demonstrating the viability of reporting as an aggregated unit and overcoming operational metering

requirements. CrowdFlex will also develop a detailed plan for market developments that are required for domestic flexibility to reach its full potential, representing the route-to-market for FSPs.

CrowdFlex recognises the need for new partnerships and collaboration to enable the actions of domestic consumers to have a material benefit on the needs of the system operator. By engaging with FSP partners, Octopus, OVO, and Ohme, CrowdFlex will ensure that the products developed are interoperable, and encourage new FSP partnerships in the future and the development of competitive marketplaces for domestic flexibility. This will ensure the most value for the ESO/DSOs and the consumer. We will ensure that key industry stakeholders are aware of the opportunities of CrowdFlex's commercialisation through ongoing engagement in WP0.

No significant capital requirements are expected, though the requirement to develop models and hold data would incur hosting (cloud-based) and personnel costs (developers/data scientists) for any FSP wishing to participate. The benefits of VirtualES will be considerable, and the project will work to minimise the cost of entry and provide evidence that costs and profit are viable for day-to-day flexibility services.

CrowdFlex:Beta has been designed with scalability in-mind. The ESO model of domestic demand and flexibility is a key use case of the VirtualES. It will start providing the ESO with enhanced visibility of demand and the flexibility of that demand from the first trial. CrowdFlex:Beta outputs will also demonstrate viable domestic flexibility scenarios. The model itself will be developed using a modular approach facilitating its integration into BAU systems post-project.

Through our User Requirements, Scoping and Plan for Implementation workstream, we will prioritise areas that should be fast tracked to integrate domestic flexibility into BAU operations. CrowdFlex is working with the partners required to mature domestic flexibility, and will enable them to rapidly integrate domestic flexibility into BAU and scale across the customer base. Sharing findings such as the API requirements and recommendations on baselining approaches publicly, will allow other FSPs to integrate quickly.

CrowdFlex will develop digital innovations such as the probabilistic forecast modelling and statistical approaches to domestic demand and flexibility. By publishing the model specifications, input and output frameworks, and trial results and analysis, we will accelerate the uptake of domestic flexibility both in other ESO/DSO markets not explored in CrowdFlex and in energy systems internationally.

Intellectual Property Rights

Each of the CrowdFlex consortium partners have confirmed they will comply with the default IPR conditions in Chapter 9 of SIF Governance Document as far as possible. Any potential deviations are set out below.

Given that the CrowdFlex consortium now comprises of two suppliers (Octopus & OVO) and three Flexibility Service Provider's (Octopus, OVO, Ohme), there will be an increased need for project partners to protect their background IP within the project from competitors. The Project Management work package will dedicate specific resources to establishing a data management process and privacy protocols to ensure that we are GDPR compliant when handling consumer data and protecting background IPR between partners.

For the modelling of domestic demand and flexibility that is central to CrowdFlex, FSPs will be encouraged to develop their own model of domestic demand to feed into a central ESO-led model of domestic demand and flexibility. While the ESO model of domestic demand and flexibility will be foreground IP in CrowdFlex, the FSP models of domestic demand will be developed independently, adapting pre-existing models, and will therefore be background IP. To ensure that this complies with IPR as laid out in Chapter 9 of the SIF Guidance Document, the FSP models of domestic demand will not be funded through SIF, and instead be funded through partner contributions in kind. The APIs/other mechanisms to feed into the ESO model of domestic demand and flexibility will be foreground IP, as will the ESO model. Both components will also comply with the IPR set out in chapter 9.

Reporting on FSP model performance, or any other submissions to the project, may contain information which the FSP would regard as commercial sensitive and not wish to be shared either publicly or with other partners (both project partners and non-project partners) without the FSP's prior written consent due to this information being both commercially sensitive and potentially creating risk for the FSP from a Competition Law perspective, given that some of the participants are direct competitors. This information may include (but is not limited to):

- Names and addresses of the FSP's customers;
- Granular model performance information;
- MPAN data;
- Granular model inputs;
- Granular (customer-specific) trial behaviour
- Any other information which would put a FSP in breach of either the UK Competition Act 1998 or any other relevant laws relating to Competition and anti-competitive behaviour (including, without limitation, any guidance from the Competition and Markets Authority;

CMA).

The above list is not exhaustive and, once more information is known about the ESO model and the project generally, FSPs may identify additional categories of information and data to add to this list.

The intellectual property provisions that will apply to the project (in respect of both background IP and foreground IP) will need to have due regard to the issues and concerns set out above. It may therefore be necessary to depart from the default intellectual property provisions set out in Chapter 9 of the SIF Governance Document. This may include additional restrictions on licensing of foreground and background IP, among other things. The detail of these provisions will be worked through by the project partners once a decision on project funding has been received.

ESO will publish project reports publicly on the ENA Smarter Networks Portal. These will not include any commercially sensitive market information or any Critical National Infrastructure (CNI) sensitive operational information. Where findings in reports are based on ESO data, this data will already be in the public domain and reports will be fully publicly accessible to share learnings widely.

The findings generated will be:

- An ESO model of domestic demand and flexibility, with the appropriate infrastructure for FSPs to feed into the model;
- The results from the CrowdFlex trials and the following analyses, both trial outcomes; and,
- The impact on the system; a roadmap for developing CrowdFlex into BAU operations.

Network partners have confirmed that they do not see any IP related constraints or concerns regarding CrowdFlex.

Costs and Value for Money

Total project costs: £22,830,128

Funding requested: (84%)

Total contribution: £3,673,385 (16%)

Balance of costs:

ESO

Total cost: £12,165,008 (53% of total)
Contribution: £1,917,601 (16%)
Funding requested: £10,247,407 (84%)

SSEN (DSO)

Total cost: £181,194 (<1% of total)
Contribution: £18,119 (10%)
Funding requested: £163,075 (90%)

NGED (DSO)

Total cost: £42,372 (<1% of total)
Contribution: £4,237 (10%)
Funding requested: £38,135 (90%)

Octopus Energy (Large Energy Supplier)

Total cost: £2,235,875 (10% of total)
Contribution: £447,175 (20%)
Funding requested: £1,788,700 (80%)

OVO (Large Energy Supplier)

Total cost: £3,266,842 (14% of total)
Contribution: £653,368 (20%)
Funding requested: £2,613,474 (80%)

Ohme (SME Chargepoint supplier)

Total cost: £2,498,050 (11% of total)
Contribution: £375,000 (15%)
Funding requested: £2,123,050 (85%)

Centre for Net Zero (SME NfP Consultancy)

Total cost: £1,940,679 (9% of total)
Contribution: £194,235 (10%)
Funding requested: £1,746,444 (90%)

Element Energy (Large Consultancy)

Total cost: £500,108 (2% of total)
Contribution: £63,650 (12.7%)
Funding requested: £436,458 (87.3%)

Subcontractors, their costs and why they are critical to the project:

ESO subcontracting includes:

TBD Subcontractor- Independent Survey Provider (£200,000): will survey trial participants to gather more detailed information about participants and gather customer feedback on the trial events.
TBD Partner/Subcontractor- Independent Modelling & Analysis Provider (£877,000): will develop an ESO model of domestic demand flexibility and perform a meta-analysis on the trial results.
TBD Partner/Subcontractor- Home Automation Provider (£1,500,000): will develop consumer interaction interfaces through Home Energy Management System (HEMS), home assistant(s) and smart devices. Will also develop the technical infrastructure to automatically dispatch these devices in the trials, or (if not feasible), undertake an Automation horizon scan on future options.

We are working to confirm the organisations and their consortium status before the application interviews in May 2023. Multiple potential providers have been approached in all cases to seek value for money.

- Ohme will use Flexitricity for (routine) BMU registration/participation, covered by Ohme contribution-in-kind.
- Octopus will use CNZ to develop the Octopus domestic demand model. Will be covered entirely by Octopus contribution-in-kind.

All partners are making at least a 10% contribution. These contributions will be funded by:

- ESO and DSOs through their network innovation budgets. ESO also aims to cover some of the trial costs through participation in markets/BAU funding.
- FSPs (Octopus, Ohme, and OVO) through their private funds, which include the development of their domestic demand models.
- CNZ through core organisational funding.
- Element Energy through re-investing profits gained from commercial work.

The costs compare favourably to normal industry rates. Element Energy provided a reduction on commercial rates for innovation work; CNZ are a not-for-profit organisation with lower rates, the ESO and DSOs have benchmarked pay approved by Ofgem, and Octopus, Ohme and OVO have rates competitive with other innovative businesses.

CrowdFlex aims to develop and test domestic flexibility services and modelling capabilities. Currently there is no clear route to utilise domestic flexibility services at scale. Without innovation funding support ESO and DSOs would continue to focus on traditional flexibility sources with an already established business case. This innovation project is therefore required to test approaches which are higher risk but have potential to add value and transform BAU activities. With innovation funding, CrowdFlex could enable domestic flexibility to act as a viable and competitive alternative to traditional sources of flexibility within the ESO/DSOs' BAU operations. The modelling in Alpha phase and the CBA have demonstrated that this could generate net savings across the system of £171m per year by 2030 and accelerate energy system decarbonisation.

If CrowdFlex is not taken forward, domestic flexibility is less likely to be unlocked. General market reform work would continue, but it would be very unlikely to enable ESO-level domestic flexibility in the near-term. This is because it is an inherently different resource (stochastic and small-scale), so existing technical/commercial/framework barriers would remain. The value of domestic flexibility would not be unlocked for the system and consumers, resulting in higher system balancing and network management costs. Modelling to forecast domestic flexibility is unlikely to be undertaken, as it is not currently a commercial resource. Even if it were undertaken, the

outputs would remain private to the organisation developing the model, and the benefits of improved forecasting would not be leveraged by other system actors and so would not be passed onto consumers. Therefore, multiple benefits will not be realised if CrowdFlex is not taken forward.

CrowdFlex cannot be funded under BAU as it is not in the ESO and DSO's Business Plans and is too high risk for BAU funding. Only once domestic flexibility has been de-risked and proven to be commercially competitive, by CrowdFlex:Beta delivery and finalising the Cost-Benefit Analysis (CBA), can BAU funding be used. Other innovation funding, such as ESO's NIA, is not large enough in scale to fund multiple partners for a large-scale trial as envisaged for CrowdFlex:Beta. This is why the SIF funding route has been utilised.

Document upload

Documents Uploaded Where Applicable

Yes

Documents:

Crowdflex Beta SIF Project Direction Material Change Request Decision - Tracked Changes.pdf

Crowdflex Beta_SIF Funding Benefits Map.pdf

SIF Beta Project Registration 2023-12-18 12_53

This project has been approved by a senior member of staff

☑ Yes