Department for
Business, Energy
& Industrial Strategy

Non-Domestic Smart Energy Management Innovation Competition

Technical report accompanying the overall impact evaluation report from NDSEMIC's Research and Evaluation Programme

Technical Report

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Chapter 1 Introduction to this report

The Non-Domestic Smart Energy Management Innovation Competition (from here on referred to as 'the Competition') was an £8.8 million competition led by the Smart Metering Implementation Programme (SMIP) within the UK Department for Business, Energy and Industrial Strategy (BEIS), which ran from 2018 to 2020. It aimed to maximise the potential for energy saving in three priority sectors (retail, hospitality and schools). To do this, it developed energy management products and services that use smart meter data to help smaller organisations to manage their energy consumption better.

Nine pilot projects were selected as part of the Competition to receive initial development funding. Seven of these passed through to the next 'feasibility and initial testing' stage. All seven project developers ('Competition Partners') also went through to the final stage of the Competition (from February 2019 to January 2020) during which the innovations were piloted with small businesses and schools in a real-world setting.

The Research and Evaluation Programme (REP) was a two-year programme running alongside the Competition to extract meaningful learnings and support broader market transformation. The REP was led by Ipsos MORI along with the Carbon Trust and representatives from Technopolis and Loughborough University.

This technical report describes the methodological approach taken to the Competition's evaluation. It is part of a package of reports published as products of the Competition, which also includes seven pilot evaluations, an overarching impact evaluation report and user impact case studies. These are available on www.gov.uk.

For further information and resources related to the Competition please visit: www.gov.uk/government/publications/non-domestic-smart-energy-management-innovationcompetition

This report comprises a description of the evaluation approach and methodology (Chapter two), further detail on the methodology for the energy consumption analysis (Chapter three) and a detailed description of the mixed-methods framework used to assess the contribution of the tools to energy savings (Chapter four).

The report also includes annexes of one of the online survey questionnaires (see annex one) and qualitative interview topic guides (see annex two) used to collect data from tool users, as well as example energy consumption analysis reports (annexes three and four).

Chapter 2 The evaluation approach and methodology

This section describes the main elements of the evaluation: the research team who conducted it, its scope and objectives, the overall approach and the primary data sources and data collection and analytical methods applied. It also comments on the strengths and limitations of the methodology.

The research team

The research for this evaluation was conducted by Ipsos MORI in conjunction with their consortium partner the Carbon Trust. Ipsos MORI designed the evaluation approach and designed and delivered all aspects of the methodology, except for the energy consumption analysis which was designed and conducted by the Carbon Trust and quality assured by Technopolis Group. The evaluation for each pilot was led by a dedicated evaluator from Ipsos MORI who followed the implementation of the tool through its design phase (Phase 1), feasibility and initial testing (Phase 2) and roll-out and further testing (Phase 3).[1] The reports for each of the seven case studies are available on the Government's website.

Evaluation objectives

The purpose of the evaluation was to improve the evidence base around the effectiveness of smart energy management products and services within smaller non-domestic organisations. It sought to generate learning on what works in terms of encouraging energy efficient behaviours and key dependencies underpinning market development of such products.

The objectives of the evaluation were to:

1. Understand whether the tools piloted were effective in achieving their expected outcomes.
2. Explore and conclude upon the factors supporting and hindering the realisation of outcomes.
3. Extrapolate from this, a set of implications and lessons for diverse key stakeholders - innovators, industry associations, schools, small businesses and Government - around the role energy consumption data can play in driving better energy management.
4. Draw conclusions about what still needs to happen for the Competition to achieve its longer-term goal of market transformation by 2030.

[1] The evaluation lead met regularly with the tool's design team, liaising with them on the evaluation plan, designed the evaluation's methodology, managed the team of data collectors and the development of this report.

The scope of the evaluation

The Competition was evaluated at the level of the piloted tools (the seven individual pilot evaluation reports have been published separately) and the Competition (in the form of an overall impact evaluation report). An internal process evaluation was also conducted for BEIS' ongoing learning. The overall impact evaluation was informed by the findings of the seven pilot evaluations, as well as evidence gathered through action research conducted in parallel to the evaluation.[2] During the Competition, action research carried out included activity-based learning with Competition Partners and industry actors to support market development, in the form of workshops, webinars and other interactive learning processes.

Key elements of the evaluation approach

This evaluation aimed to assess the extent to which each of the tools generated anticipated outcomes and impacts, as well as the circumstances in which these were achieved. At the Competition level, the evaluation assessed evidence of progress towards longer term outcomes (as set out in the Competition theory of change, described in Chapter two of the Overall Impact Evaluation Report) by considering evidence of market dependencies underpinning the future development of the market for smart energy management tools.

The evaluation approach comprised three key elements:

- **Theory-based**: Both the overall evaluation and the seven pilot-level evaluations took a theory-based approach. Under this approach, data collection and analysis are designed in such a way as to provide evidence (qualitative and quantitative) that support, refute or refine the 'theory' of how a programme's inputs are intended to lead to its desired outcomes.[3]

- **Case-based**: The evaluation assessed and compared different 'cases' within the Competition in order to explore why certain changes happened and the role of different features of the Competition and its pilots in contributing to these observed changes. Case-based evaluations are often used in circumstances where there are too few cases overall to conduct quantitative analysis and when the emphasis is on causal analysis.[4] Here, cases refer to the seven distinctive pilots which each tested distinct user contexts and tool functionalities and complementary packages.

- **Data triangulation**: A key question for the evaluation was: do smart energy management products and services contribute towards energy consumption reductions? Evidence from several qualitative and quantitative sources (see below) was brought together and rated for robustness and validity to provide an overall analysis. In most cases, through such triangulation, the team was able to draw conclusions, with a high level of confidence, as to the tool's contribution to energy savings.

[2] Within the context of this Competition, action research comprised: best practice sharing, shared problem solving, creating communities of learning and activity-based learning towards cross-programme themes.
[3] More information on theory-based and case-based approaches to evaluation can be found here: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/67427/design-method-impact-eval.pdf
[4] https://www.intrac.org/wpcms/wp-content/uploads/2017/01/Case-based-evaluation.pdf

Synthesis across all data sources enabled the evaluation team to assess, for each pilot, whether behaviour change and energy savings were achieved, in what context and for whom, and the extent to which any observed changes in outcomes could be attributed to the tools. The analytical framework for assessing energy savings is described in annex 3.

Sources of evidence

Primary sources of evidence

The pilot evaluations were developed upon the following **primary sources of evidence**.

Site visits to schools and businesses piloting the tools

These were conducted on-site by experienced Ipsos MORI researchers with pilot participants in their school or business, using a discussion guide tailored to the tool's features and intended outcomes. The visits covered:

Qualitative interviews with the main user of the tool and other staff with relevant energy or education attributions where possible, with the intent of gauging a more complete picture of the tool's impact on the school or business. Discussion guides included sections to understand how participants monitored energy use, and any impacts and benefits of the tool to them and their schools. These on-site qualitative interviews typically lasted between 30-60 minutes. An example topic guide used during site visits is available in Annex 3.[5]

Observation to understand how users interacted with the tool and their interpretation of which appliances and equipment used energy in their school or business, and to observe energy use and energy management behaviours in practice.

Within three schools piloting the Energy Sparks tool, **paper surveys** were administered to pupils to assess impacts on their energy awareness. This comprised ten closed questions on topics such as whether they had interacted with the tool, learned from it, or changed their energy use as a result.

Telephone interviews with tool users

These were conducted mainly with people who had signed up to receive access to the tool, but then did not actually make use of / engage with it. The interviews were semi-structured and typically lasted 15-30 minutes. The topics covered were tailored to the experience of the person interviewed. Where the interviewee had engaged with / used the tool, 'slimmed down' versions of the site-visit topic guide were used. Where the interviewee had engaged very little or not at all with the tool, the interview focussed principally on the reasons for no / low engagement.

Surveys amongst tool users

The surveys questions covered tool usage habits, attitudes to energy, energy management behaviours, actions taken following engagement with the tool and other questions to understand the context of the business or school and the user (such as the business size, user

[5] Given that on-site topic guides were tailored according to each pilot and type of site visited, one illustrative example is included to manage volume. Others are available upon request.

role). Two versions of the survey were administered, with additional sub-question variation depending on the type of organisation piloting the tool and question routing:

- **Type A Survey**: This survey was conducted in two waves:
    - Baseline wave completed by participants before their pilot started. This was administered between January and October 2019 (depending on when the organisation was on-boarded); and
    - End line wave completed a minimum of three months after participants had been given access to the tool. This was administered in January and February 2020.

  The impact of the tool was evaluated through analysis of any changes in attitudes and behaviours pre and post intervention. Type A baseline surveys were sent to all users who had signed up to use the tools. End line surveys were sent to those pilot participants who had (i) completed the baseline survey; and (ii) agreed to be re-contacted for research.

- **Type B Survey**: This survey consisted of a single wave conducted post-pilot and was administered to pilot participants who had not completed a baseline survey. As a baseline measurement was not available, participants were asked to self-report on any changes in attitudes or behaviours in relation to energy management over the course of the pilot, and whether the tool was a factor in these changes.

An example Type A survey questionnaire is available in Annex 2.[6]

Energy consumption data analysis

Data on energy use during the pilot was collected by Competition Partners from businesses and schools registered to use the tools. Where available, historical energy consumption data was collected to enable a before-and-after analysis at the aggregate level (i.e. for all user sites) and at specific user-sites where triangulation with other data sources was feasible. The energy consumption analyses were undertaken in two stages:

- Controlling for weather and sector-specific seasonal changes in energy use (e.g. more energy being used in schools during term-time and in the hospitality sector during the holiday seasons), analysis of energy use for all participating sites, before and after using the tools, was undertaken to determine whether any reductions in energy use could be identified that might be attributable to the tool (Stage 1 analysis).
- ‘Deep dives’ into energy use over the pilot period at specific sites were undertaken to assess whether any dips in use matched the timings of self-reported changes in energy use (identified via surveys and interviews) (Stage 2 analysis).
- The outcome measures for Stage 1 and Stage 2 analysis were changes in annualised energy consumption, average daily consumption (day, weekday, or weekend), and peak hourly load (general, weekday, weekend).

Further details of the energy consumption analysis are provided in Chapter three.

[6] Given that both Type A and B surveys were tailored according to each pilot, one illustrative example is included to manage volume. Others are available upon request.

Interviews with Competition Partners

These were conducted at the start and end of the evaluation to understand key aspects of tool design and delivery, their views on the support provided to them through the Competition, progress towards commercialisation, and their views on market enablers and barriers.

Secondary sources of evidence

The evaluation made use of the following **secondary sources of evidence**.

Regular observation of the tool's development and delivery along with a review of **project and programme documentation**

Competition Partners regularly updated BEIS and the Ipsos MORI evaluation team on their delivery progress and learnings via milestone deliverables and project documentation. This was reviewed by Ipsos MORI and has supported the analysis in this report. Additionally, the evaluation team had regular bi-weekly updates with the Competition Partner to establish progress with the project and collate necessary information (such as recruitment challenges, partnership relationships). Further documentation was made available to the Ipsos MORI evaluation team through the Competition Partner's end-of-Competition reports and in most cases provided useful supplementary information directly to the evaluation team. Indeed, several Competition Partners conducted their own research including user testing and user feedback, and one (Samsung, for Energy in Schools) conducted its own evaluation activities. These Competition Partner-produced materials were made available to the evaluation team and were analysed as part of the evaluation.

Action research outputs

Additionally, the evaluation made use of evidence gathered through various events and support activities ran during the Competition to further market engagement and learning (action research activities).

- **Four REP-led workshops** involving stakeholders to encourage shared learning, were delivered on the following topics:
    - **"Complementary Interventions"**: A workshop to share learnings on the types of supporting services or resources that could drive engagement and behaviour change.
    - **"Educational complementary interventions and behaviour change"**: A workshop to learn about schools' organisational structures and effective ways of engaging schools.
    - **"User-centric Design"**: A workshop with Competition Partners to give guidance on best practice principles, methodologies and analysis techniques for user testing.
    - **"Data Access"**: A workshop to understand barriers to achieving access to data.
- Two series of market awareness and engagement **webinars**: The first one provided an overview of the programme to trade bodies and business associations. The second aimed to identify and engage trial sites for the pilot phase.
- **Two local authority events** on 'Innovation solutions for energy management in schools' targeted at a regional level (one in Manchester, one in Hampshire) with

decision makers and local authorities to help Competition Partners to identify and engage target schools and stakeholders for trial sites.

- **One matchmaking event** from across Government, retail, hospitality, education and energy sectors to provide a preview of the Competition Partners' innovations, to facilitate partnerships between Competition Partners and energy suppliers, and to introduce Competition Partners to potential customers and Trade Associations / sector bodies who could provide a connection to customers.
- Presentations and exhibition stands at **key sector events**, including the Schools & Academies Show, School Commercialisation, Future of Utilities, National Convenience Show and a HOSPA members event.
- **Four sector-specific workshops**: Two workshops were focused on the school sector (one in London, one in Cardiff), and one each focused on the small retail and small hospitality sectors (both held in London). The workshops brought together policy makers, Competition Partners and other innovators, industry representatives (e.g. Trade Associations), school representatives (e.g. local authorities, energy managers, teachers), energy supplier representatives and relevant charities and activists (for schools). The workshops explored in-depth the different barriers and enablers to market development within these sectors and considered what policy developments and other factors might influence market development.

Sample selection and sample sizes achieved

The surveys were administered to all users registered to pilot the Competition tools, excluding those who had either (i) requested not to be contacted for the research or (ii) withdrawn from the pilot before the post-intervention evaluation fieldwork took place. The surveys were distributed to participants by email, either by Ipsos MORI or the Competition Partner (depending on whether participants had consented for their contact details to be shared with Ipsos MORI).

The sampling for on-site visits and qualitative telephone interviews was purposive with a number of sites contacted (fitting a range of profiles to represent the different profiles of pilot schools or businesses for each tool as far as possible) and the final sample being dependent also on response rates. Depending on the tool, participants were selected to give variation in terms of school or business size, sector, energy meter type, governance set up (chain or independent), school type, user role, region, and level of engagement with the tool.

A summary of the sample sizes and the responses achieved for each research strand is provided in Table 1 overleaf.

Table 1: Primary data collection summary

Research activity	Persons consulted	Date completed	Total Sample[7]	Number responses achieved	Modality
Online surveys of users	Main tool users - typically the business owner or manager (retail and hospitality) or headteacher or energy/facility manager (schools).	April - October 2019	300[8]	113	Longitudinal survey - Pre-pilot online survey (Survey A)
		January - February 2020	60[9]	20	Longitudinal survey - Post-pilot online survey (Survey A)
		January - February 2020	243[10]	42	Post-pilot online survey (Survey B)
Surveys of pupils in schools	Pupils in 3 primary schools piloting Energy Sparks (Energy Sparks).	February 2020	*No info*[11]	41	Paper survey - post pilot
Qualitative interviews with users	Tool Users. Within retail and hospitality, this comprised: business owners, business/facility managers, chain managers. Within schools it comprised headteachers, teachers,	December 2019 - end of	155[12]	51	In-depth structured telephone or face-to-face interviews

[7] The *total sample* for online surveys and qualitative interviews is based on the number of pilot sites for which contact details were provided to the REP by Competition Partners, excluding pilot sites who had (i) withdrawn from the trial or (ii) refused to have their contact details shared with the REP for the purposes of the evaluation.
[8] Given rolling on-boarding of pilot sites during the time the survey was live, it was not possible to establish a fixed target.
[9] This is the number who completed the baseline survey and agreed to be re-contacted for a follow-up survey. Only these sites were sent survey A post-pilot, therefore the 'total sample' for this survey was smaller for the end line surveys.
[10] Includes those who did not reply to the baseline survey and any others recruited post baseline survey.
[11] The total sample for pupil surveys was the total number of pupils in each class. This information was not collected as part of the evaluation
[12] This sample comprises all tool users (472 in total) who consented to be contacted for qualitative research (155).

Research activity	Persons consulted	Date completed	Total Sample[7]	Number responses achieved	Modality
	facility/energy managers, parents, local authority staff (within and outside schools), multi academy trust representatives.	February 2020			
	Qualitative research (through telephone interviews) was conducted with users registered to pilot the tools who did not engage at all / much with the tools.			12	In-depth semi-structured telephone interviews
In-depth interviews with key BEIS stakeholders	Relevant staff from BEIS Smart Metering Implementation Programme.	December 2019	5	5	In-depth structured telephone interviews
In-depth interviews with Competition Partners	Phase 2 project developers (and partners, where applicable).	January 2019	7	7	In-depth structured telephone interviews
		December 2019 - January 2020	7	7	In-depth structured telephone interviews
Schools market transformation workshop	Competition Partners and other innovators, and representatives from schools (e.g. energy managers, teachers), local authorities, relevant charities, BEIS and DfE.	July 2019	N/A[13]	c. 25	Face-to-face stakeholder workshop (in-depth structured group and plenary discussions)
Schools market transformation workshop	Competition Partners and other innovators, and representatives from schools (e.g.	January 2020	N/A	c. 55	Face-to-face stakeholder workshop (in-depth structured

[13] For workshop activities, the sample was not based on a known population and as such a total sample is not provided

Research activity	Persons consulted	Date completed	Total Sample[7]	Number responses achieved	Modality
	energy managers, teachers), local authorities, relevant charities and BEIS. Held in London.				group and plenary discussions)
Schools market transformation workshop	Competition Partners and other innovators, and representatives from schools (e.g. energy managers, teachers), local authorities, relevant charities, BEIS and Welsh Government. Held in Cardiff.	January 2020	N/A	c. 50	Face-to-face stakeholder workshop (in-depth structured group and plenary discussions)
SME market transformation: retail and hospitality workshop	Representatives from BEIS.	October 2019	N/A	c.20	Face-to-face stakeholder workshop (in-depth structured group and plenary discussions)
SME market transformation: retail workshop	Competition Partners and other innovators, and representatives from industry (e.g. trade associations and bodies), and BEIS.	January 2020	N/A	c.25	Face-to-face stakeholder workshop (in-depth structured group and plenary discussions)
SME market transformation: hospitality workshop	Competition Partners and other innovators, and representatives from industry (e.g. trade associations and bodies), and BEIS.	January 2020	N/A	c.25	Face-to-face stakeholder workshop (in-depth structured group and plenary discussions)

Notes: *Includes an interview with one Competition Partner | ** Given rolling on-boarding of pilot sites, it was not possible to establish a fixed target

Strengths and limitations of the evaluation approach and methodology

The theory and case-based approach taken, which also involved a tailored framework for synthesis and triangulation (see Chapter four for more information), enabled the evaluation to provide answers to the key evaluation questions on competition and pilot outcomes and lessons learned around how these outcomes were achieved.

By using this approach, the evaluation team developed a rich evidence base that has not only answered the high level evaluation questions, but also enabled the validation of specific hypotheses tested by the Competition (e.g. around the need to tailor tools by sector, or the need for complementary support packages, or the utility of providing educational packages alongside tools being marketed to schools). The **main strengths** of the evaluation can be summarised as follows:

- **The evaluation was designed to test the theory of change developed by BEIS and (at the tool level) by Competition Partners**. By taking this theory-based approach, the evaluation explicitly and transparently collected evidence for BEIS and Competition Partners on the aspects of the Competition and tool design that worked well / less well in different sectoral and organisational settings. For Competition Partners (and future innovators), this provided a valuable evidence base for ongoing and future commercialisation of their tools and market development. For BEIS, this provided a solid evidence base for ongoing and future market interventions and Competitions.

- **The evaluation made use of a diversity of data sources**. This increased the validity of the evidence base, by allowing triangulation between types of data sources (i.e. between quantitative and qualitative data, between observed and self-reported data) and between the perspectives of different stakeholders. Whilst it was not always possible to reach a large number of users and whilst there were some challenges to analysing energy data (see limitations listed below), by triangulating between different sources of information, any gaps in evidence or weaker data could be validated or further tested and assessed.

- **The in-depth, exploratory, case-based approach enabled the evaluation team to delve deep into specific questions** around how things worked and respond to test emerging hypotheses.

- **The evaluation collected data on - and was able to compare - the experiences of tool users with common characteristics** (e.g. similar businesses, schools of a similar size, stage or ‘cultural outlook’ (e.g. schools interested in sustainability or not)). This helped the evaluation team to generalise the findings. Indeed, user sites visited / selected for interview were purposively sampled so as to obtain as wide a range of schools and businesses as possible.

The **main limitations** to the evaluation methodology are summarised below. These vary by Competition tool and are covered in detail in the seven pilot-level reports.

- **The evaluation achieved an overall low survey response rate**. The response rate for the ‘Type A’ survey was low (42 out of 300 participants, or 14%, completed both survey waves). Response rates for site visits and telephone interviews were better, however despite the use of incentives and multiple recontacts, recruitment targets were not

achieved at all sites (with lowest securing 80% of planned interviews / visits). This meant that for some pilots the breadth of user perspectives captured was low (limited to 6-12 users). The primary (negative) effect of having smaller-than-anticipated sample sizes is a limited ability to evaluate impacts among key sub-groups for some tools. Further, for the few pilots where survey responses were comparatively high, this did provide an additional, stand alone, source of data which increased validity. However, as the evaluation has taken a heavily case-based approach, the low survey response rates have had little negative impact overall.

- **It was not possible to assess 'the counterfactual'** – i.e. the extent to which patterns of energy use would have changed amongst pilot sites *without* the intervention of using smart energy management tools. Several comparator groups (e.g. chain sites where some sites may be using a Competition tool and others not) were contacted, but they did not consent to participate in this evaluation. The Carbon Trust were therefore limited to modelling the counterfactual (i.e. what energy use patterns would have been) based upon analysis of pilot period (and where possible, historic) energy consumption data.
- **Many of the users consulted had been involved in the pilot for a short time only, meaning some of the effects of pilot participation / tool use may not yet have been observable**. Some pilot organisations only had access to the tools for 3 to 4 months before the evaluation fieldwork was completed. This relatively short timeframe limited the ability of the evaluation team to determine trends in energy consumption, and to evaluate outcomes that may only be realised over a longer timeframe, such as the adoption of more efficient technologies, which requires a significant investment from the business that may not be immediately available and a longer time period to implement.
- **Energy data was often incomplete, meaning the energy consumption analysis was not always conclusive as to the tools' contribution to energy savings**. A key limitation of the energy consumption analysis was a lack of historical data for many organisations, from which year on year comparisons could be made to robustly estimate consumption patterns in the absence of the intervention, i.e. the 'counterfactual'. Some organisations also did not have data on a start date for when they started interacting with the tools, which also limits the ability to attribute any observed changes to the impact of the tools. Further details of the limitations of the energy consumption analysis are provided in Chapter three.

Research Ethics

Ipsos MORI are compliant with the highest regulatory standards for the legal and safe processing of personal and/or sensitive data, including the European General Data Protection Regulation (EU) 2016/679 (GDPR), the UK Data Protection Act 2018, Market Research Society Code of Conduct and the international standards for information security (ISO 27001), market research (ISO 20252) and company quality (ISO 9001). As part of these commitments, we have had appropriate data protection policies, procedures and processes in place for many years, and these form a vital and integral part of our quality, compliance and information security management system (our 'Business Excellence System (BES)').

In conducting this evaluation, Ipsos MORI:

- Ensured that the information provided to participants about the research and how data would be used was comprehensive and transparent and that a privacy notice was available.

- Made it clear to participants that participation in research was entirely voluntary and that they could stop the interview or survey at any time.
- Obtained consent from participants to process personal data, processed and stored it securely, notified participants of the date it would be securely destroyed, and provided contact details for participants to request personal data be destroyed ahead of that date.
- Obtained consent from participants before attributing quotes from qualitative interviews to them or their business.
- Obtained consent from participants before audio-recording interviews.
- Provided any incentives to participants within a reasonable timeframe and in the format requested (cash, vouchers or a donation to a charity).

Chapter 3 Energy Consumption Analysis (ECA) methodology

This chapter provides more information on the approach, methodology (including quality assurance) and limitations of the ECA.

The **aims** of the ECA were to

1. Assess whether energy use changed over the duration of the pilot (ideally compared to the pre-pilot situation).

2. Assess whether any observed consumption reductions could be attributed to the tools piloted (by controlling for other factors within the analysis) which might (also) explain the change.

Energy consumption data was collected by NDSEMIC Competition Partners and shared with Ipsos MORI. Ipsos MORI shared the energy data with the Carbon Trust through a secure SharePoint account. The data was provided in a half hourly format. Where more granular data was provided, this was processed into a half hourly format for analysis. The data was analysed (by the Carbon Trust) in two stages, examples of which are presented in the 'Stage 1: Overall Trends' and 'Stage 2: Deep Dive' templates (included in Annex 4 and Annex 5). Independent quality assurance of the ECA was conducted by Technopolis (who had not been involved in other aspects of the pilot evaluations) using the BEIS quantitative data analysis quality framework (more information provided below).

The ECA was composed of two stages:

- **Stage 1 (trend analysis)** measured overall consumption trends across all pilot sites (where energy data was available). The aim of this analysis was to assess whether energy use changed over time and – specifically from when the user received access to the tool. Such analysis was completed for all pilots, except one (GlowPro), as the energy data for the businesses that piloted their tool was of insufficient quality. The outcome measures for Stage 1 analysis were changes in annualised energy consumption, average daily consumption (day, weekday, or weekend), and peak hourly load (general, weekday, weekend).

  Degree day data provided a representation of outside air temperature in a local area and how this differs from a 'base' temperature (the temperature at which additional heating or cooling in buildings is not expected to be needed). Across both Stage 1 and Stage 2, electricity and gas[14] data for both the pilot period and pre-pilot period was checked against degree-day datasets for any correlation between both (which then indicates that higher or lower energy consumption can be expected during unusually warm or cold days or periods). Where a correlation was identified, the energy consumption was then normalised with degree day data. Stage 1 used UK averaged degree day data, while Stage 2 used local degree day data (where information was available on the postcode or region of the site).

[14] Analysis of gas consumption was completed for sites piloting the Samsung, Hoare Lea and Energy Sparks tools. The Element Energy, Considerate Group, AND TR and Hildebrand tools did not include features to monitor gas, and as such gas data was not collected or analysed for their pilot sites.

- **Stage 2 (deep-dive analysis)** was conducted for specific pilot sites (a sample of 21 sites across all tools, with at least one site analysed per tool). For this analysis, energy data was assessed in greater detail. Two approaches were taken:
    - **Bottom-up modelling** involved the matching of qualitative data on changes in energy behaviour during the pilot period to the actual energy consumption data. For example, if a lighting upgrade was reported, the expected impact of this on consumption and loads (based on best estimates from benchmarking the site's load profiles and the known typical impact of the measure on that system) would be estimated, and then the actual energy data reviewed to see if a similar impact was observed in the consumption patterns at the time of the intervention (thus verifying the impact of the measure).
    - **Before-and-after comparison of baseline and historic energy use data** was used to model the business-as-usual energy consumption over the pilot period (with no treatment). This modelled usage was then compared with observed actual energy use during the pilot. Where data was available, this approach was based on pre-pilot data, but where unavailable, a comparison of early vs. late pilot consumption was undertaken.

  As for Stage 1 analysis, Stage 2 outcome measures were changes in annualised energy consumption, average daily consumption (day, weekday, or weekend), peak hourly load (general, weekday, weekend). Regression analysis and more detailed inspection of half hourly data patterns was undertaken to pinpoint shifts in consumption that might align with the timing and types of energy efficiency measures implemented at the site.

  Sites selected for deep dive analysis were those which had half hourly data available for both pre-intervention and post-intervention periods, as well as good information on the operation of the site and the energy efficiency measures undertaken. Based on this data, it was possible to make a more detailed assessment of the energy consumption reductions achieved (or not) throughout the pilot, and the extent to which this could be attributed to the piloted tools. With user consent, the evaluation team linked information about the organisation's building and energy use to time-points in the ECA in order to assess any observable shifts in energy consumption. Information on the building (its occupancy levels, operating hours, size) was then used to control for factors that might affect energy consumption. Weather data (publicly available) was also used to the same effect. Then, energy use behaviour (any changes to energy use ascribed to using the tool, as reported in the survey or interviews) was reviewed to assess whether (controlling for other factors) this could explain any changes.

Quality assurance involved checks on the raw data, how (accurately) it had been transferred into analytical tools and presented in the analytical templates, and the analytical processes followed. Since Technopolis did not have permission to access identifiable energy data, steps were taken to ensure that quality assurance could take place without breaking permissions for the processing of energy data.

Quality Assurance was conducted in line with the principles set out in BEIS 'Quality Assurance: Guidance for models' (July 2018),[15] and using the BEIS QA Log,[16] as well as in line with Aqua Book principles for producing quality, which states that analysis should be done with RIGOUR:

[15] https://www.gov.uk/government/publications/quality-assurance-guidance-for-models
[16] https://www.gov.uk/government/publications/model-quality-assurance-full-log-template

Repeatable, Independent, Grounded in reality, Objective, have understood and managed Uncertainty and that results should address the initial question Robustly.

To provide context to the findings and ensure the implications of the ECA were correctly interpreted and presented in the report, the quality of the energy data available for each tool (i.e. the ability of the ECA to detect impacts where they had occurred) was assessed against a red-amber-green (RAG) rating framework. This ECA RAG rating was factored into the overall 'energy savings analysis framework' (detailed in Chapter four). An overview of the energy consumption data available for pilot sites for each Competition Partner, along with an overall RAG rating and description of the limitations, is provided in Table 2 overleaf (for Stage 1 analysis) and in Table 3 (for Stage 2 analysis).

Table 2: Stage 1 ECA data available per Competition Partner

Competition Partner	Historical data period (pre-pilot)[17]	Pilot data period	Sector	#sites	Energy supply monitored (Electricity/Gas)	ECA RAG rating	ECA RAG Rating reasoning
AND TR	4 months	6 months	Retail/ Hospitality	57	Electricity	Red / Amber Poor / Moderate	Intervention start dates and historical data were available for most sites, which increased data quality, the period of historical and pilot data was relatively short and so did not allow for comparison of pre and post intervention consumption at the same times of the year reducing the ability of the ECA to detect impacts.
Considerate Group	2 months	6 months	Hospitality	51	Electricity	Red – Poor	Only a short period of historical and pilot period data was available, significantly reducing the ability of the ECA to detect impacts. Uncertainty around the intervention start date for many sites also reduced the ability of the ECA to detect impacts.[18]
Element Energy	2 months	2-6 months	Retail (39), Hospitality (17) and Schools (12)	68	Electricity	Red – Poor	The short period of historical and pilot period data significantly reduced the ability of the ECA to detect impacts. Uncertainty around

[17] For Stage 1 analysis, to enable comparative analysis, data periods that could be commonly applied across a majority of sites were used.
[18] The analysis relies on the assumption that the pre/post intervention threshold is determined by when sites started using the piloted tools. Definite dates for this were only available for 10 sites, the remainder were estimated based on typical lead in times from data initiation (when users first had access to the tool) to tool use.

Competition Partner	Historical data period (pre-pilot)[17]	Pilot data period	Sector	#sites	Energy supply monitored (Electricity/Gas)	ECA RAG rating	ECA RAG Rating reasoning
							the intervention start date for pilot period data also affected this.[19]
Energy Sparks	12 months	13 months	Schools	64	Electricity and Gas	Green (Elec) Amber (Gas)	Most sites had electricity data stretching back into 2018, which allowed for a like for like comparison to be made between equivalent months from one year to the next, increasing the ability of the ECA to detect impacts. Gas data also covered a similar time period, but it was more challenging to draw strong conclusions as to the contribution of the tool to any change in use, as gas is much more affected by weather than electricity.
Hildebrand[20]	N/A	N/A	Retail/ Hospitality	31	Electricity only	N/A	N/A
Hoare Lea	12 months	12-13 months	Schools	30+	Electricity and gas	Amber – Moderate	Most sites had data stretching back into 2018, which allowed for a like for like comparison to be made between equivalent months from one year to the next, increasing the ability of the ECA to detect

[19] The assumed start date creates a trend from early pilot to later pilot, which may not be the reality for how the tool was used on site.
[20] Data for Hildebrand pilot sites had too many gaps which meant there would be little merit in undertaking a Stage 1 analysis. Instead, a wider mini-trend analysis was conducted in two of the Stage 2 sites, which were chain businesses, analysing the data across 3 locations in each chain.

Competition Partner	Historical data period (pre-pilot)[17]	Pilot data period	Sector	#sites	Energy supply monitored (Electricity/Gas)	ECA RAG rating	ECA RAG Rating reasoning
							impacts. However, the absence of defined intervention start dates precludes clear use of a pre- and post- period, reducing the ability of the ECA to detect impacts.
Samsung	4 months	1 month	Schools	20	Electricity and gas	Red – poor	Very short period of historical and pilot period data, as well as absence of clear intervention dates and a relatively small sample size which significantly reduced the ability of the ECA to detect impacts.

Table 3: Stage 2 ECA data available per Competition Partner

Competition Partner	Historical data period[21]	Pilot data period	Sector	#sites	Energy supply monitored (Electricity / Gas)	Clarity on Metering arrangement (Whole site / Sub-meter)	Postcode area of sites available?	Details available of energy management actions undertaken at site
AND TR	4-7 months	4-6 months	Retail/ Hospitality	3	Electricity	No	Yes	For 1 of 3 sites
Considerate Group	9-60 days	4-5 months	Hospitality	3	Electricity	Yes, only whole sites	Yes	No
Element Energy	3 months	2-12 months	Retail/ Hospitality	4	Electricity	Yes, only whole sites	Yes	Yes
Energy Sparks	12 months	12-13 months	Schools	4	Electricity and Gas	Yes	Yes	Yes
Hildebrand	No data	1.5-10 months	Retail/ Hospitality	7 sites in 3 businesses[22]	Electricity only	Yes	Yes	Yes, for survey respondents
Hoare Lea	5 months	7 months	School	1	Electricity only	Yes	Yes	Yes
Samsung	No data	4-5 months	Schools	3	Electricity and gas	Yes	Yes	Yes, for survey respondents

[21] As per footnote 22, for Stage 1 analysis, the time period shared by the majority of sites was used. For the Stage 2 analysis, actual data periods were used; some of which might have been longer than in the Stage 1 analysis.

[22] Given the inability to undertake a Stage 1 analysis, the Stage 2 analysis covered multiple sites within two chain businesses

Chapter 4 Energy savings analysis framework

This chapter describes in detail the framework used to assess the contribution of each tool piloted to energy savings at user sites, and the methodology used to calculate each tool's overall energy savings confidence rating.

Assessing the energy saving potential of smart energy management tools was central to the evaluation, however in the context of the Competition it was not possible to collect a single definitive estimate of impacts and there were a range of challenges in using and interpreting energy consumption data for pilot sites. In recognition of the circumstances involved (limited access to historical data, small sample sizes, no control groups), a mixed-methods approach to evaluating energy savings was taken. This approach would:

1. Bring together and triangulate all evidence gathered through the evaluation that would indicate energy savings (eight evidence types in total). This comprised the quantitative ECA, as well as self-reported energy savings, qualitative evidence of behaviour change (towards more energy efficient behaviours) inferred to lead to energy savings, and theory-based evidence.[23]
2. Assign 'scores' for each of the evidence types according to the validity and 'strength' of that data (see Table 5 overleaf). These scores would then be aggregated to derive a total score that could then be converted into an average confidence rating (see Table 4 below).

Table 4: Energy savings confidence ratings

0- 1	Low level of confidence that the tool has contributed to energy savings at any site*
1 – 1.99	Medium level of confidence that the tool has contributed to energy savings in at least some sites
2 – 2.99	High level of confidence that the tool has contributed to energy savings in at least some sites
3 to 4.5	Very high level of confidence that the tool has contributed to energy savings in at least some sites

* A low level of confidence does not preclude the tool from working in the future, if some adjustments / lessons learned are taken on board.

Table 5 overleaf presents the framework used to score each of the eight evidence types per tool. The scores depended on (a) whether the evidence was available; (b) whether it indicated a contribution of the tool to energy savings; and (c) the quality of that evidence. In principle, a higher score was given to evidence which was observed (e.g. energy consumption data) and

[23] Comprising: (1) Analysis of the validity of the tool's theory of change (where a valid theory of change would be indicative of tool contribution to energy savings) and (2) Analysis of alternative explanations for effects observed / identified.

triangulated (displaying a convergence in qualitative evidence and energy consumption data) or identified at a larger number of sites.

Table 5: Evidence types and the ratings available (per tool evaluation)

Evidence type	Ratings available	Comments
Stage 1 ECA (trend analysis over time – all sites).	No Stage 1 analysis – this evidence type was discounted from the overall score. 'Contribution not evident' – assigned a score of 0. Contribution evident but data quality poor (scores 1). Contribution evident and data quality moderate (scores 3). Contribution evident and data quality good (scores 4.5).	Evidence from Stage 2 analyses was assigned a higher score than evidence from Stage 1 analyses. Stage 2 analysis looks at specific cases and triangulates objectively observed data (on energy consumption) with self-reported data of how and when energy was being used – i.e. when equipment or time of use or operational processes were changed.
Stage 2 'deep dive' ECA (for some sites only).	No Stage 2 analysis – this evidence type was discounted from the overall score. 'Contribution not evident' – assigned a score of 0. Contribution evident but data quality poor (scores 2). Contribution evident and data quality moderate (scores 4). Contribution evident and data quality good (scores 6).	
Self-reported energy savings.[24]	'Contribution not evident' – assigned a score of 0. Contribution evident at 1-2 sites (scores 2). Contribution evident at more than 1-2 sites (scores 4). Contribution evident at most sites consulted (scores 6).	The evaluation did not uncover examples of contradictory evidence – i.e. users at one site disagreeing that behaviour had changed following use of the tool(s).
More than one user at a single site reports changes in behaviour towards more energy efficient behaviour.		
One user reports at a single site reports such behaviour change.		
Survey respondents report (via open text) energy efficient actions (e.g.	No survey responses received / no survey conducted – this evidence type was discounted from the overall score.	Survey data was considered of lower 'strength' (i.e.

[24] This means the user can point to energy savings in their energy bills or in the data presented by the tool.

introduction of energy efficient equipment) which they state were due to using the tool.	'Contribution not evident' – assigned a score of 0. Contribution evidenced by 1-2 respondents (scores 1). Contribution evidenced by more than 1-2 respondents (scores 2). Contribution evidenced by most survey respondents (scores 3).	validity) than interview data, because it was not possible to further probe and explore causation through the survey as it was through the interviews.
Evidence that the assumptions considered necessary for change to occur (as per the theory of change) have occurred as anticipated (thus suggesting all of the necessary conditions for energy savings are available).	Fieldwork too limited to draw conclusions – this evidence type was discounted from the overall score. 'Contribution not evident' – assigned a score of 0. Contribution evident at 1-2 sites (scores 1). Contribution evident at more than 1-2 sites (scores 2). Contribution evident at most sites consulted (scores 3).	No comments.
No evidence of alternative theories of change for observed, reported or hypothesised energy savings.	Fieldwork too limited to draw conclusions – this evidence type was discounted from the overall score. 'Contribution not evident' – assigned a score of 0. Contribution evident at 1-2 sites (scores 1). Contribution evident at more than 1-2 sites (scores 2). Contribution evident at most sites consulted (scores 3).	No comments.

The maximum score that a tool could obtain through the framework was 37.5. The total score was then divided by the number of evidence types – i.e. by eight, or by a lower number if any of the evidence types were marked as N/A - in order to give an average confidence rating in the evidence available. The scores and associated confidence ratings are outlined in Table 4 above.

Annex 1 Sample selection and sample sizes achieved per pilot

Table 6: Primary data collection summary (pilot level)

Competition Partner	Total Sample (*Equal to number of Pilot participants in Phase 3*)	Number responses achieved				
		Online user Survey (Survey A)	Online user Survey (Survey B)	In-depth structured telephone interviews	In-depth structured F2F interviews conducted on-site	Surveys of pupils in schools
AND TR	66	0	1	2	6	N/A
Considerate	63	3	2	0	5	N/A
Element Energy	69	10	6	2	7	N/A
Hildebrand	75 (covering 120 sites)	3	9 (representing 7 businesses)	4	4	N/A
Hoare Lea	49	0	1	3	2 (representing 1 school)	N/A
Samsung	20	N/A	18 (representing 13 schools)	0	13 (representing 6 schools)	N/A
Energy Sparks	65	4	5	6 representing 3 schools and 3 councils)	9 (representing 4 schools)	41 (representing 3 schools)

*Each response represents a unique pilot site for the data collection method, unless otherwise specified; in some cases, several interviews were completed at a single site.

Annex 2 Example survey questionnaire

This annex presents the survey questionnaire used in one of the tool-specific end line (type A) surveys. All surveys were administered and completed online. A small number of the questions below are tool-specific, but most were asked of all tool users (irrespective of the tool). Other tool-specific questionnaires can be made available upon request.

NDSEMIC Phase 3 trial survey: Follow-up survey questionnaire (TYPE A)

ASK ALL

0.1 Before we start, please indicate approximately when your [“IF SCHOOL, “school” / IF RETAIL /HOSPITALITY “organisation”] first had access to [TOOL NAME]

[Drop down month] | [Drop down year (2015-2020)]

ALLOW DK

0.2 Please also indicate how often you personally have interacted with the [TOOL NAME] since your [“IF SCHOOL, “school” / IF RETAIL /HOSPITALITY “organisation”] first had access to it.

- Daily
- Weekly
- Fortnightly
- Monthly
- Quarterly
- Annually
- Less often than annually
- Never

To what extent, if at all, do you agree or disagree that your [IF SCHOOL “school’s” / IF RETAIL OR HOSPITALITY “organisation’s”] spending on energy (including both electricity and gas) is an area of expenditure in which you could make cost savings? (Single code)

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree

- Strongly disagree
- Don't know

ASK ALL

I'd now like you to think about how your [IF SCHOOL "school" / IF RETAIL OR HOSPITALITY "organisation"] uses energy (including both electricity and gas if relevant). On a scale of 1 to 10, how confident or not would you say you are in knowing each of the following? A score of 1 means "not at all confident in knowing this" and a score of 10 means "extremely confident in knowing this."

Single code – NUMERICAL RESPONSE BETWEEN 1 AND 10 FOR EACH STATEMENT

REVERSE STATEMENTS
A. What activities or pieces of equipment require a lot of energy in your [IF SCHOOL "school" / IF RETAIL OR HOSPITALITY "organisation"]
B. What changes you could make to your own behaviour to reduce the amount of energy used by your [IF SCHOOL "school" / IF RETAIL OR HOSPITALITY "organisation"]
C. What changes could be made to your [IF SCHOOL "school's" / IF RETAIL OR HOSPITALITY "organisation's"] equipment, processes or building(s) to save energy
D. The times of day or night on which your [IF SCHOOL "school" / IF RETAIL OR HOSPITALITY "organisation"] uses the most energy
E. The days of the week on which your [IF SCHOOL "school" / IF RETAIL OR HOSPITALITY "organisation"] uses the most energy
F. How much energy is used by your [IF SCHOOL "school" / IF RETAIL OR HOSPITALITY "organisation"] out-of-hours [IF BUSINESS "(i.e. after trading)" IF SCHOOL "(over closed periods such as the weekend or school holidays)"
G. How the energy use of your [IF SCHOOL "school" / IF RETAIL OR HOSPITALITY "organisation"] compares to that of other similar [IF SCHOOL "schools" / IF RETAIL OR HOSPITALITY "organisations"]
H. Which tariff /payment plan you have with your energy supplier (i.e. how much you pay for each unit of energy at different times of day and night)

5.1 [SCHOOLS ONLY] Compared with before your engagement with [TOOL NAME], has there been any change in how confident pupils are in knowing each of the following?

- Much more confident now
- A little more confident now
- As confident as they were before

- A little less confident now
- Much less confident now

REVERSE STATEMENTS
A. What activities or pieces of equipment require a lot of energy in your [IF SCHOOL “school”]
B. What changes they could make to their own behaviour to save the amount of energy used by your [IF SCHOOL “school”]
C. Changes that could be made to your [IF SCHOOL “school’s”] equipment, processes or building to save energy
D. The times of day or night in which your [IF SCHOOL “school”] uses the most energy
E. The days of the week on which your [IF SCHOOL “school”] uses the most energy
F. How much energy is used by your [IF SCHOOL “school”] out-of-hours [IF BUSINESS “(i.e. after trading)” IF SCHOOL “(over closed periods such as the weekend or school holidays)”
G. How the energy use of your [IF SCHOOL “school”] compares to that of other similar organisations
H. Which tariff /payment plan you have with your energy supplier (i.e. how much you pay for each unit of energy at different times of day and night)

ASK ALL

Which, if any, of the following channels do you currently use to find out about the amount of energy that your [IF SCHOOL “school” / IF RETAIL OR HOSPITALITY “organisation”] is using? Please tick all that apply (multicode)

- A paper or email energy bill from your energy supplier
- An online account with your energy supplier
- An online account (not through your energy supplier)
- An app from your energy supplier
- An app (not through your energy supplier)
- A smart energy display from your energy supplier
- A smart energy display (not through your energy supplier)
- By taking a meter reading
- [SCHOOLS ONLY] Energy management software provided by your Local Authority e.g. SystemsLink, TEAM, STARK

- Other (specify what and how often)
- None – I do not use any information about my organisation's energy use
- Don't know / Can't remember

ASK ALL

[REPEAT FOR EACH OPTION CODED AT Q6] And which of the following best describes how often you personally look at information about your [IF SCHOOL "school's" / IF RETAIL OR HOSPITALITY "organisation's"] energy use through [INSERT CHANNELS USED, INFORMED IN PREVIOUS QUESTION (6)]? (single code)

- Daily
- Weekly
- Fortnightly
- Monthly
- Quarterly
- Annually
- Less often than once a year
- Never

Which of these statements best describes how you think about the energy market and energy pricing? Please select one option only. (single code)

- A1. There are marginal differences in price between the tariffs any given supplier offers to customers
- A2. There are big differences in price between the tariffs any given supplier offers to customers

9.1 Since engaging with [TOOL NAME], have you done any of the following in relation to your energy contract? (multicode for A and B ok)

- Looked into tariffs offered by other suppliers
- Looked at other tariffs with my current supplier
- None of these
- Don't know / Can't remember

ASK ALL

How would you rate the level of priority placed on energy management within your [IF SCHOOL "school"/ IF RETAIL OR HOSPITALITY "organisation"] on a scale of 1 to 10? (single code)

1 – Not a priority	2	3	4	5	6	7	8	9	10 – Highest priority

ASK ALL

Please indicate to what extent you agree or disagree with the following statement: My [IF SCHOOL “school” / IF RETAIL OR HOSPITALITY “organisation”] has tried to reduce the amount of energy used at our site(s) since we started to engage with [TOOL NAME]. (single code)

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don’t know

11.1 Please indicate to what extent you agree or disagree with the following statement: My [IF SCHOOL “school” / IF RETAIL OR HOSPITALITY “organisation”] has tried to change the times of the day or week during which energy is used at our site(s) since we started to engage with [TOOL NAME]. (single code)

- Strongly agree
- Tend to agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree
- Don’t know

ASK ALL

[FOR RETAIL AND HOSPITALITY ONLY] How often, if at all, do you and the members of your organisation discuss the following…? (single code for each statement)

RANDOMISE STATEMENTS	Very often	Sometimes	Not very often	Never	Don’t know
A. How your organisation can save energy					
B. What activities or pieces of equipment					

in your organisation use the most energy					
C. When your organisation uses the most energy					

[FOR SCHOOLS ONLY] How often, if at all, do you and other staff in your school discuss the following? (single code for each statement)

RANDOMISE STATEMENTS	Very often	Sometimes	Not very often	Never	Don't know
A. How your school can save energy					
B. What activities or pieces of equipment in your school use the most energy					
C. When your school uses the most energy					

15.3 Does your [IF SCHOOL "school" / IF RETAIL OR HOSPITALITY "organisation"] have a set target for the amount of energy it uses in a certain time period (for example, over a given month, quarter or year)? (single code)

- Yes
- No
- Don't know

15.4 [if code 1 at 15.3] Have there been any changes in this target since starting to engage with [TOOL NAME]?

- Yes, we didn't have a target before engaging with [TOOL NAME]
- Yes, it has become more ambitious since engaging with [TOOL NAME]
- Yes, it has become less ambitious since engaging with [TOOL NAME]
- No, it's been unchanged since engaging with [TOOL NAME]
- Don't know

15.5 [if codes 1-3 at 15.4] And to what extent was this [IF code 1 at 15.4 "new"/ IF code 2 at 15.4 "increase to the" / IF code 3 at 15.4 "decrease to the"] target a result of using [TOOL NAME]

- To a great extent
- To some extent
- Not very much
- Not at all
- Don’t know

ASK ALL

Does your [IF SCHOOL “school” / IF RETAIL OR HOSPITALITY “organisation”] have an allocated budget for making energy efficiency or clean energy improvements? (single code)

- Yes
- No
- Don’t know

16.1 [If yes – Code 1 at Q16] Have there been any changes in this allocated budget since starting to engage with [TOOL NAME]? (single code)

- Yes, we didn’t have a budget before engaging with [TOOL NAME]
- Yes, it has increased since engaging with [TOOL NAME]
- Yes, it has decreased since engaging with [TOOL NAME]
- No, it’s been unchanged since engaging with [TOOL NAME]
- Don’t know

16.2 [if codes 1-3 at 16.1] And to what extent was this [increase to the/ decrease to the/ new] budget a result of using [TOOL NAME]

- To a great extent
- To some extent
- Not very much
- Not at all
- Don’t know

ASK ALL

Since engaging with [TOOL NAME], have you looked for any additional information or advice on energy management or energy efficiency measures beyond that provided through [TOOL NAME]?

- Yes
- No

- Don’t know

18.1 [If code 1 to 18] To what extent was this interest in energy management/energy efficiency advice prompted by your engagement with [TOOL NAME]?

- To a great extent
- To some extent
- Not very much
- Not at all
- Don’t know

ASK ALL

Since engaging with the [TOOL NAME] has your [IF SCHOOL “school” / IF RETAIL OR HOSPITALITY “organisation”] implemented (or does it have plans to implement) any energy efficiency or clean energy measures? This could be, for example, energy control devices (temperature valves, thermostats, light sensors), more efficient lighting, a more efficient boiler, insulation, double or triple-glazed windows, or new energy efficient equipment. (single-code)

- Yes
- No
- Don’t know

[IF Yes, Code 1 at Q0] The table below lists out some key types of energy efficiency and clean energy measures that [IF SCHOOL “schools” / IF RETAIL OR HOSPITALITY “organisations”] might undertake. Please indicate if your [IF SCHOOL “school” / IF RETAIL OR HOSPITALITY “organisation”] has implemented (or has plans to implement) any measure within each of these categories. (single code for each measure)

- Implemented/Under implementation
- Planned
- Not implemented or planned
- Don’t know
- Not applicable – my [IF SCHOOL “schools” / IF RETAIL OR HOSPITALITY “organisations”] is not able to make these types of changes

SCRIPT TO ROTATE MEASURES

1 Upgrades to heating and/or hot water system (including changes to boilers, pumps, controls, insulation or fuels)

2 Upgrades to cooling system (including changes to chillers, pumps or controls)

3 Lighting upgrades (including changes to fittings, lamps or controls)

4 Upgrading other types of equipment / appliance to more energy efficient models (beyond heating, cooling or lighting)

5 Upgrades to building fabric, including walls, windows and doors

6 Upgrades to ventilation system (including changes to fans or addition of heat recovery)

7 Servicing equipment

21.1 [IF CODES A-B IN Q21] To what extent were these measures introduced as a result of engaging with [TOOL NAME]?

- To a great extent
- To some extent
- Not very much
- Not at all
- Don't know

[ONLY SHOW MEASURES SELECTED IN Q21] SCRIPT TO ROTATE MEASURES

1 Upgrades to heating and/or hot water system (including changes to boilers, pumps, controls, insulation or fuels)

2 Upgrades to cooling system (including changes to chillers, pumps or controls)

3 Lighting upgrades (including changes to fittings, lamps or controls)

4 Upgrading other types of equipment / appliance to more energy efficient models (beyond heating, cooling or lighting)

5 Upgrades to building fabric, including walls, windows and doors

6 Upgrades to ventilation system (including changes to fans or addition of heat recovery)

7 Servicing equipment

21.2 [SCHOOLS ONLY BUT NOT ELEMENT ENERGY / IF CODES A-B IN Q21.1 or IF CODES 1-2 AT 15.5 or IF CODES 1-2 16.2] To what extent have pupils influenced the changes to the way the school manages energy?

- To a great extent
- To some extent
- Not very much
- Not at all
- Don't know

21.3 [SCHOOLS ONLY / IF CODES 1-2 IN Q21.2] Please provide more information on the energy-management changes that pupils have influenced.

OPEN TEXT

ASK ALL

[IF SCHOOL “school” / IF RETAIL OR HOSPITALITY “organisation”] characterisation

We would now like to ask you a few final questions to understand the size and profile of your [IF SCHOOL “school” / IF RETAIL OR HOSPITALITY “organisation”] .

This will help us interpret your responses to this survey and the energy data trends from your [IF SCHOOL “school” / IF RETAIL OR HOSPITALITY “organisation”].

ASK ALL

37.1. Which of the following best describes how your [IF SCHOOL “school” / IF RETAIL OR HOSPITALITY “organisation”] pays for its premises? (single code)

- Rented
- Leased
- Lease purchase
- Owned – outright
- Owned – Mortgage
- [SCHOOLS ONLY] State owned
- Other (please specify)
- Mixture (please specify)
- Don’t know
- Prefer not to say

ASK ALL

37.2. Since you started engaging with [TOOL NAME], have there been any significant changes in your [IF SCHOOL “school’s” / IF RETAIL OR HOSPITALITY “organisation’s”] facilities and its use? (multicode ok)

Please tick all that apply

- Yes, we have built new/decommissioned buildings
- Yes, there has been a change in our building(s) operating hours
- [FOR SCHOOLS] Yes there has been a big change the number of students we have in our school
- [FOR RETAIL/HOSPITALITY] Yes, there has been a change in the size of our business

- Yes, we have changed our heating system
- Yes, other
- No, there have been no significant changes
- Don't know

37.3 [If any except code g or h in Q37.2] Please explain what this/these change(s) was (were) in terms of scale (e.g. percentage difference from what it was before), approximate date when change was implemented, whether permanent or temporary, etc., and any reasons that led to it.

OPEN TEXT

37.4 Please indicate your trial site by: confirming the name and first two letters of the postcode of your [IF SCHOOL "school" / IF RETAIL OR HOSPITALITY "organisation"]

This is to help us understand and interpret the energy consumption trends within your [IF SCHOOL "school" / IF RETAIL OR HOSPITALITY "organisation"].

TEXT BOX

DROP-DOWN OF POSTCODE AREAS

38b. [RETAIL/HOSPITALITY ONLY] What sector does your business fall under?

- Hospitality
- Retail
- Other (please specify)
- Respondent characterisation

Which of the categories below best describe your current job position? (single code)

[FOR SCHOOLS]

- Headteacher or Deputy Head
- Curriculum or Key Stage Lead
- Teacher
- Other student-facing role (e.g. teaching assistant / Educational Psychologist/ Learning Mentor/ Counsellor)
- Facilities manager
- School treasury / Bursar / Finance Director
- Other non-student facing (e.g. administration, maintenance, technician)
- Other – please specify
- Prefer not to say

[FOR RETAIL OR HOSPITALITY]

- Business owner
- Manager
- Employee
- Other – please specify
- Prefer not to say

ASK RETAIL AND HOSPITALITY ONLY

[IF NOT BUSINESS OWNER] In which department do you work? (single code)

- Finance
- Procurement
- Operations/Facilities
- Health & Safety
- Sales
- Food & Beverage
- Housekeeping [Hospitality only]
- Front of house
- Other – please specify
- Prefer not to say
- Permission questions

ASK ALL

Annex 3 Example Qualitative Interview Topic Guide

This annex presents the topic guide (questions) used in one of the tool-specific end-of-pilot qualitative interviews (used for on-site visits and in some telephone interviews). Several of the questions below are tool-specific, but most were asked of all tool users (irrespective of the tool). Other tool-specific topic guides can be made available upon request. Text highlighted in grey signifies instructions to the interviewer not to be read out.

Overview of sections in guide (for reference)

Section 1: Background and Role (5 mins)
Section 2: Site Observation (5 mins)
Section 3: Monitoring of Energy Use (10 mins)
Section 4: Usage of [TOOL] (10 mins)
Section 5: Impacts and Benefits (15 mins)
Section 6: Overall experience / next steps (8 mins)

Questions

Section 1: Background and Role (5 mins)

Before we start:

1. Could you tell me when your [school / business] first started using the tool?
    a. Are you the main user of the tool?
    b. Is there anyone else in the [school / business] who uses it?
    c. Who made the decision to trial it in the [school / business]?

I'd like to find out a bit more about your [school / business] and your role here. This will just help us contextualise some of the answers you give in the rest of the interview:

2. Please tell me a little bit about your role at the [school / business]?
    a. What is a typical day for you?
    b. What are your main responsibilities when you are at work?

c. Do you have a role in the operations or management of the building and its facilities?

3. Have there been any substantial changes to your [school / business] over the last 6 months, in terms of:

   a. (businesses) The size of the business, the premises you occupy or type of products / services you sell?

   b. (schools) The number of students, the facilities you have, or the equipment you use?

4. Do you own or rent the property?

If rent,

   a. Do the owners place restrictions on what you are able to do in the property? PROBE ON: building upgrades, new facilities / equipment?

   b. Which decisions, if any, do you need to run through the owner?

   c. (If mention building upgrades, new facilities / equipment etc): How does the decision-making for building upgrades or new facilities / equipment work in practice?"

Section 2: Site Observation (5 mins)

5. What do you think uses the most energy in your [school / business]? Can you show me? (ask participant to guide you around the premises and indicate)

WHILE BEING SHOWN AROUND, PROBE ON:

   a. Why do you think this uses a lot of energy? How do you know this?

   b. How long have you known this?

   c. Does knowing this make you do anything differently/ more or less often than you otherwise would?

6. Has your understanding of how your [school / business] uses energy, and where, changed at all in recent months?

   a. If yes, what do you think has led to this change in your understanding?

Section 3: Monitoring of Energy Use and Managing Bills (10 mins)

7. Are you responsible for dealing with energy bills in the [school / business]?

If yes:

   a. What is your normal process for reviewing and paying energy bills? If anyone else is involved, please explain what responsibilities each of you have in relation to bills?

If no:

   a. Who deals with the energy bills within the business/school?

b. Are you aware of the current cost of energy to the business? (interviewer clarify if this is monthly / annually and if covers both electric and gas if needed)

8. Are you responsible for keeping track of how much energy the [school / business] uses?

If yes:

a. What information specifically do you track? Why?

b. Do you track how energy use changes over time?

c. How long have you done this for?

d. Has the way you keep track of energy use changed at all over the last year?

e. PROBE if respondent mentions [TOOL]: What did you use before the [TOOL] trial?

f. Has the way you monitor energy changed since you started using [TOOL]? In what ways?

If no:

a. Who is responsible for monitoring energy use in the business?

b. What information do they use?

c. PROBE if respondent mentions [TOOL]: What did they use before the [TOOL] trial?

Interviewer to listen out to any attributions to the engagement with the NDSEMIC tool.

9. Are there any other key people in the [school / business] who play a role in?

Businesses:

a. monitoring how energy is used within the business

b. choosing your energy provider / tariff

c. making decisions over purchases for the business that may affect energy use (such as new equipment, setting up the heating/lighting systems etc)

Schools:

a. monitoring energy spend

b. monitoring how energy is used within the school

c. procuring energy contracts

d. making decisions over purchases for the school that may affect energy use

e. making decisions over, or launching, campaigns or activities that aim to reduce how much energy is used by people in the school

10. [CHECK FOR SURVEY ANSWERS BEFORE THE INTERVIEW] Do you set targets for the amount of energy your [school / business] uses, or budgets for the amount you spend on energy?

If yes:

   a. How long have you been setting targets / budgets for?
   b. How has your [school / business] performed against these targets?
   c. For what reason does your [school / business] set these targets / budgets? [How] does it help your business?

If no:

   a. Is it something you have considered doing? What has stopped you doing it?

Section 4: Usage of [TOOL] (10 mins)

11. What do you typically do during your working time/shift in terms of monitoring or managing energy-using appliances or equipment? PROBE e.g. turning things on and off, closing up / shutting down, checking things are working properly, refrigeration / heating / lighting settings.
   a. Are these things you have always done? If not, when did you start doing these things? Why?
   b. Do you manage the activities of other staff in relation to energy and equipment?
12. Can you tell me overall how useful or not you think [TOOL] has been?
   a. For your [school / business] overall? PROBE: What makes you say this? What in particular have you found most useful / when / why?
   b. For you in your specific role? PROBE: What makes you say this? What in particular have you found most useful / when / why?
13. Have you noticed any change in attitude towards energy use among the other staff in the [school / business] since [TOOL] was introduced?
   a. If yes, what has changed? What bought about this change? PROBE ON: awareness, understanding of energy use [if school: “across: teachers, staff, students, parents”]
   b. If no, why do you think this is? Were you expecting any changes in attitudes to energy in your business following the introduction of [TOOL]?
14. Has your attitude to energy use changed in any way since [TOOL] was introduced?
   a. If yes, what has changed? What bought about this change? PROBE ON: awareness, understanding of energy use, external influences such as school climate strikes, etc.
15. [FOR SCHOOLS ONLY] Have you noticed students in the schools doing anything differently since you/ they started using [TOOL]?

Allow for spontaneous responses, then probe on each of the following:

a. Using any specific appliances differently

b. Changed their routine

c. Discussing more about energy issues with their peers and school staff, in or outside of the classroom

d. Adopting new habits (such as switching lights off)

e. Encouraging their parents to take energy-related actions outside of the school/ at home

If Yes,

a. what prompted this change?

b. What did they do before [TOOL] was introduced?

c. To what extent if at all, has [TOOL] contributed to this change?

- Have your students set up energy targets for their school on [TOOL]? Have they tracked their progress against those targets using [TOOL]? Has it been motivating for them to take actions?
- Have your students compared their school's performance against that of other schools (e.g. energy usage; progress against targets)? What did they notice about your school's position in the leader board? Has it been motivating for them to take actions? Why/why not? Have they engaged with the schools national league table accessible via [TOOL]?

16. Can you show me [TOOL]? Please walk me through how you use it.

INTERVIEWER READ TO RESPONDENT: This isn't to test you or check that you are using it correctly, we are just interested to understand how people tend to use the tool, and what bits of information they tend to look at, if anything.

INTERVIEWER TO OBSERVE:

a. what [TOOL] is loaded on to: e.g. their phone, someone else's phone, a shared computer.

INTERVIEWER TO PROBE (if not mentioned):

b. Screens looked at – when and why?

c. (if not mentioned) How do you use:

- Live usage electricity (PROBE: daily / weekly / monthly data)
- Benchmarks (PROBE: daily / weekly / monthly data)
- Tips and recommendations (PROBE: which tips / type of tips). PROBE: relevance of tips to business? PROBE: Tips are realistic?

d. On Benchmarks, [INTERVIEWER TO ASK ALL]

- How does your business' energy use compare to 'typical establishments'?
- How does that make you feel?
- Does knowing this make you do anything differently in the business?
- How do you feel about the comparison to 'efficient establishments'?
- Does this level of energy usage seem achievable for your business?
- Are comparisons to other businesses helpful? Why/ why not?
- Have you used these comparisons to 'typical establishments' or 'efficient establishments' to set targets on energy use for your business?

e. How often do you look at [TOOL]?

- Has this changed since you started using it?
- Any specific times you look at [TOOL]?
- Is your use of [TOOL] linked to any other activities? PROBE ON: budgeting, purchase decision for new equipment

17. Are there any parts of the tool or bits of information that you don't tend to look at?

    a. Why do you think you don't use this as much? PROBE: is it useful? Is it easy to understand? do you think it's accurate / believable?

18. Has [TOOL] told you anything about your [school / business] energy use that you didn't know before?

    a. Have you noticed any specific times where usage is lower / higher? Did this prompt you to change anything in your business?

    b. Have you identified any activities or pieces or equipment that use a lot of energy since using the tool? Did this prompt you to change anything in your business?

19. Do you share the information you get from [TOOL] with anyone else in the [school / business]?

    a. What do you discuss with them?

    b. Does anyone else report to you about information they have looked at on [TOOL]?

    c. (for schools) Any educational campaigns or initiatives for the students? Do they use information from [TOOL]?

Section 5: Impacts and Benefits (15 mins)

20. Have you started doing anything differently within the [school / business] since you started using [TOOL]?

PROBE:

a. Using any specific appliances or equipment differently

b. Changed your routine

c. Adopted new habits (such as switching lights off)

d. Made any general changes in the [school / business] to help you less energy

e. Instructions given to other staff / students about what they are doing

f. (Schools) Any new energy-related initiatives with the students or teachers?

g. If Yes, what prompted this change? Has it been successful so far?

h. What did you do before [TOOL] was introduced?

21. Have you noticed anyone else in your [school / business] doing anything differently since you started using [TOOL]?

PROBE:

a. Using any specific appliances or equipment differently

b. Changed their routine

c. Adopting new habits (such as switching lights off)

d. Made any general changes in the [school / business] to help you less energy

e. (schools) Teachers discussing energy with students

f. If Yes, what prompted this change?

g. What did they do before [TOOL] was introduced?

22. Since you started using [TOOL], have you purchased any new equipment for your [school / business]?

a. How did you make the decision on which specific piece of equipment to purchase?

b. Did you use any information to inform this decision to purchase?

c. Was energy efficiency rating considered? If not, why not?

d. Are there any new pieces of equipment that you are considering purchasing?

23. Since using [TOOL], has your [business / school] taken any action to encourage [staff / staff or pupils] to change their behaviours in ways that would save energy?

a. Who led this action?

b. what motivated it?

c. how successful was this in leading to energy savings?

d. was this action sustained?

e. What plans, if any, are there to take action in future? PROBE: what action is planned, what they believe the motivation behind the plan is.

24. Have you implemented any of the tips provided by the tool?

If yes,

a. Which tips did you implement?

b. How did you go about taking action on the tips? How easy were they to implement?

c. Is this something you were considering before you started using the [TOOL] tool?

d. Did you look for information from anywhere else before deciding to act?

e. Do you think acting on these tips has had any impact on your energy use?

If no,

a. Why not? Probe on; cost limitations, restrictions on what upgrades can be made to building, capacity / expertise of staff

b. Do you think the tips are relevant to your business?

c. Do you have enough information to be able to implement the tips?

d. Do you think the estimated reductions in energy use are realistic / believable?

e. Are there any other resources that would encourage you to take “next steps”? E.g. information on where and how to buy energy saving bulbs

25. Are there any tips provided by the tool that you are considering implementing in the [school / business] in the near future?

a. What has prevented you from implementing them up until this point?

b. Are there any tips from [TOOL] that you would like to implement but don’t think you’ll be able to? Why?

c. What would you need in order to be able to implement the tips? PROBE on; more information, buy-in from other staff, budget, limitations from property arrangements (if renting)

26. Have you noticed any changes in the amount of energy you use since you started using [TOOL]?

a. What has changed? Do you know why this has changed?

b. Would you say you’re generally using more or less energy than you did before you started trialling the tool?

27. Have you noticed any changes in your energy bills since you started using [TOOL]?

If yes:

a. What has changed?

b. Do you know the reason for this change?

c. Have the changes been in line with your expectations?

d. Has using [TOOL] had any effect on budgeting or financial planning?

If not;

a. Were you expecting a change in your bills?

b. Why do you think there has been no change to your bills?

c. Has using [TOOL] has any effect on budgeting or financial planning?

28. Since you started using the tool, have you made any changes to your energy supplier or tariff?

If yes,

a. What prompted this change? What benefits were you expecting from making the change? Were you planning on doing this anyway?

b. Did you use information from the tool to help make this decision?

c. Has changing had any impact so far on your bills?

d. Has changing had any impact so far on your operations (e.g. the times in the day when equipment is used)?

If no,

a. is this something you are considering? Why / Why not?

29. What, if anything, prevents your [school / business] from becoming more energy efficient?

a. PROBE on: Lack of information, cost barriers, difficulty getting staff / teachers / students to adopt new habits or routines

30. What, if anything, would help your [school / business] become more energy efficient?

a. Is there anything missing from the tool that would help you become more energy efficient?

31. Besides reducing energy use, are there any other impacts that [TOOL] and the information it gives you have had on your business?

PROBE ON:

a. improved work environment

b. improved/upgraded equipment

c. efficiency of operations

d. control over processes

e. brand image

f. customer experience

g. education

h. General management

i. (if mention other impact) How has the tool helped with this? Is there a specific aspect of the tool that led to this impact?

32. Did you receive sufficient support from [CP] in learning how to use [TOOL]?

    a. If yes – Did this support help you to take energy saving action?

    b. If no - What additional support would you have liked in order to take energy saving action?

Section 6: Overall experience / next steps (8 mins)

33. For what reasons did you decide to participate in the trial of [TOOL]?

    a. Which of the suggested benefits of the tool, if any, was most important in your decision to trial the tool?

    b. Were you expecting any other benefits?

    c. Has the tool been in line with your expectations?

    d. Anything that you think could be improved about the tool?

34. Have you spoken to any other [schools / businesses] about the tool?

    a. Have you recommended it to other [schools / businesses]?

    b. Would you recommend tools like this to other businesses? What would you tell them? why would they/why wouldn't they recommend?

    c. Do you think [schools / businesses] similar to yours should invest in tools like this? if yes, what would be the main reason to invest?

35. How do you think [TOOL] will be used when your free trial ends?

    a. Will it be used more or less often than currently?

    b. Are there any specific times or business/school milestones when you think [TOOL] will be useful? PROBE ON: buying new equipment, changing energy supplier / choosing tariffs, budgeting,

    c. Will anyone else start using [TOOL] in your business?

36. If you were not part of a free trial, would you consider paying for an energy management tool such as this?

If yes,

    a. how would you justify using some of your budget for a tool such as this? PROBE ON; the educational benefit, potential cost saving, environmental agenda/targets etc.

    b. What do you see as the key reasons to pay for [TOOL]?

c. What would be the maximum budget you would be able/willing to set aside for a tool like [TOOL]? Probe: is that one-off, monthly, weekly etc? IF THEY DON'T KNOW, PROBE ON: why they are unable to say this is of interest

d. Are there any particular payment arrangements that would make you more willing to pay for a tool like [TOOL]? [If unsure prompt on one-off, subscription, as part of your energy tariff]

e. What, if anything, would make you more likely to pay for an energy management tool like this?

If no,

a. Why would you not consider paying for an energy management tool such as this?

b. What, if anything, would make you more likely to pay for an energy management tool like this?

c. If in future you were given a tool like this for free (for example alongside another product you'd purchased or as part of your broader electricity/gas contract), to what extent do you think you would make use of it? Would it be something you would use long-term?

37. Who within the [school / business] would be responsible for making payment decisions for an energy management tool such as this?

    a. Would anyone else influence or input into the decision on whether or not to pay for it?

    b. What information would you / they use to make the decision on whether or not to pay or it?

    c. Are there any times of year when you / they would be more likely to spend money on a tool like [TOOL]?

38. Before we finish, is there any other feedback you would like to give about the tool or your experience using it?

Annex 4 Example Stage 1 Energy Consumption (trend) Analysis

This annex presents an example of one of the seven Stage 1 analyses conducted. The example site presented here is a school site, for which electricity only was monitored.

The Carbon Trust used a green-amber-red rating system to illustrate their overall assessment of the quality of the energy consumption available per site. In the example presented here the data was considered to be of moderate (amber) quality.

BEIS NDSEMIC Energy Consumption Analysis

Stage 1 – Overall Trend Analysis - Electricity

This section analyses the overall electricity consumption trends across all pilot sites for each of the Competition Partners (CPs) to establish general trends observed during the energy monitoring period for pilot sites.

Competition Partner 1

Partner Name:	[anonymous]
Technology/Intervention Name:	[anonymous]
Number of meter points:	[70-80]

Electricity Consumption Trends

				Average time period for historic data (months)			Average time period for pilot data (months)		
Sector	Number of meter points	Pilot data source	Number of sites with historic energy data	Typical start date	Typical end date	Number of months	Typical start date	Typical end date	Number of months
Unknown	[70-80]	HH meters	59	01/01/18	31/12/2018	12	01/01/19	31/01/20	13

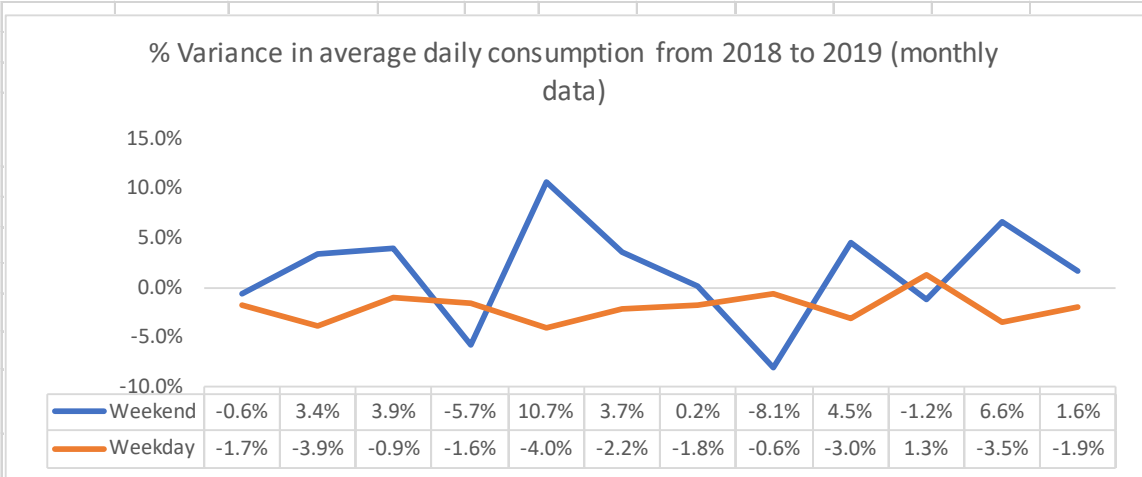
Sector 1 Analysis

Overview: The below information compares changes in average consumption and average peak from historic data periods to pilot data periods. A majority of sites demonstrated minimal influence from external weather changes therefore a direct comparison was considered valid. Those sites that did demonstrate some correlation between weather and energy (sometimes higher consumption in winter, sometimes higher in summer) were excluded from the averages below.

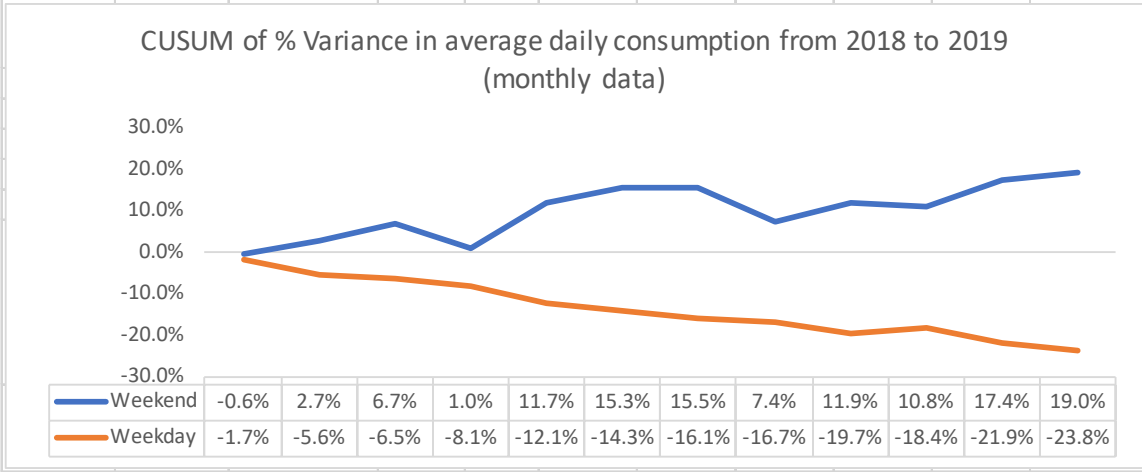
	% Average Variation Pre/Post Pilot
	%
Average Daily Consumption (kWh)	0.7%
Average weekday consumption (Mon-Fri) (kWh)	-0.7%
Average weekend consumption (Sat-Sun) (kWh)	3.6%
	%
Average Hourly Peak Load Over Monitoring Period (kW)	-8.9%
Average weekday hourly peak load over monitoring period (kW)	-9.4%
Average weekend hourly peak load over monitoring period (kW)	-6.8%

Monthly comparison

Most sites had data stretching back into 2018, which allows for a like for like comparison to be made between equivalent months from one year to the next. The following table shows the variation in consumption when comparing 2018 to 2019 (-ve = saving, +ve = increase). As above, this analysis excludes sites with patchy or inconsistent data. However, sites with weather dependence are included in the monthly analysis due to the like for like comparison of monthly weather variations.



Weekend	-0.6%	3.4%	3.9%	-5.7%	10.7%	3.7%	0.2%	-8.1%	4.5%	-1.2%	6.6%	1.6%
Weekday	-1.7%	-3.9%	-0.9%	-1.6%	-4.0%	-2.2%	-1.8%	-0.6%	-3.0%	1.3%	-3.5%	-1.9%



Weekend	-0.6%	2.7%	6.7%	1.0%	11.7%	15.3%	15.5%	7.4%	11.9%	10.8%	17.4%	19.0%
Weekday	-1.7%	-5.6%	-6.5%	-8.1%	-12.1%	-14.3%	-16.1%	-16.7%	-19.7%	-18.4%	-21.9%	-23.8%

Overall Observations

Negligible changes in average daily consumption were observed when comparing energy data from pre-pilot to data collected during pilot. Weekend consumption appears to increase slightly, but hourly peaks show a reasonable reduction. When comparing equivalent months in 2018 to 2019, a reduction in average weekday consumption was observed for a majority of months, weekend consumption tended to show signs of increased consumption. Sites where significant weather dependence was observed were omitted from the overall trend analysis (not the monthly comparison analysis), however some influence on remaining sites cannot be ruled out. Although the long before and after data provided in this case allows for a reasonably robust year-on-year comparison, the absence of defined intervention start dates is a limitation on this analysis.

RAG Rating for finding	Amber - Moderate
Primary reasoning	Lengthy datasets in this case provide the opportunity for year-on-year comparisons of consumption, however the absence of defined intervention start dates precludes clear use of a pre- and post- period, limiting the utility of the results.

RAG rating composition		
Weekday month on month analysis		Good year on year data, but occasionally patchy
Weekend month on month analysis		Fewer weekend data points mean analysis less robust
Overall analysis		Good historical data but lacks intervention date

Notes:	1 site omitted from trend analysis due to weather dependence, 18 sites/meters omitted due to poor data quality or lack of historical data.

Methodology

- Half hourly data was obtained for each site as a single column of half hourly data and converted to the format shown, showing all 48 half hourly data points per day (for electricity only). The daily total was then calculated.
- As the sector of the sites was unknown, it was anticipated that occupancy variations over days of the week would have a significant influence on consumption. Therefore, weekdays and weekends were identified.
- Each Competition Partner site generally provided a start date for the data, although no intervention start date was recorded. Instead, given the length of the historic datasets provided, year-on-year comparisons of consumption before and during the pilot period[25] were used to evaluate the impact of the interventions. 2018 data was used for pre-intervention comparisons, with 2019 data used to compare to post-intervention consumption.
- Daily Heating and Cooling Degree Days (for a uniform site at Birmingham Airport) were provided to permit a regression check for each site's daily consumption total vs degree days. An R squared and a correlation check was included to check for alignment with degree days. Postcodes were provided to permit local degree days to be used for deep dives, but for a general check of alignment a single location was deemed sufficient.
- Weekday averages and weekend averages for daily consumption and peaks for the pre and post pilot period were calculated.
- For anomalously high values[26] a mid-point (or mid-points) of the meter readings before and after the anomalously high value were calculated.
- For data gaps, daily totals were not calculated for that given day to avoid any inaccurate data reaching the trend analysis.
- Additionally, anomalous data was removed from the trend analysis for five sites. These sites were excluded either because of significant issues with either electricity or gas data.
- Average daily consumption for both weekdays and weekends was calculated for months in 2018 and 2019 for direct comparison of consumption for equivalent months of the year. The variance between these averages was then calculated to show the change in consumption between the equivalent periods.
- It was generally assumed that all data provided by the Competition Partners was an accurate reflection of consumption for the site or system being monitored. Clear and obvious meter read errors were to be expected, but general consumption trends were considered a true representation of consumption at the site.
- Intervention start dates were used to define pre-post data transition where provided for all sites and assumed to be accurate.

[25] The dates and timespan of the pilot period differed from tool to tool (and in some cases from site to site).
[26] For example, these could be caused by gaps in meter readings, where the first subsequent reading includes the missed consumption.

Annex 5 Example Stage 2 (deep dive) energy consumption analysis

This annex presents an example of one of the 23 stage 2 analyses conducted. The example site presented here is a school site, for which electricity and gas were monitored. A description of the site energy use profile is provided in sections 1 and 2 with the energy consumption analysis (ECA) being provided in sections 3 and 4. Section 5 presents the conclusions of the ECA.

The Carbon Trust used a green-amber-red rating system to illustrate their overall assessment of the quality of the energy consumption available per site. In the example presented here the electricity was of good (green) quality, whereas the gas data was of moderate to good (amber/green) quality.

BEIS NDSEMIC Energy Consumption Analysis

Stage 2 – Example Deep Dive Analysis - Electricity

This section explores the energy consumption profiles at a sample pilot site in order to better understand the impact of the Competition Partners (CPs) intervention.

Competition Partner 1

Partner Name:	[anonymous]
Technology/Intervention Name:	[anonymous]
Description of deep dive pilot site:	[anonymous]
Metering arrangements for historic data and pilot:	Metering covers whole site

1. Overall energy data and benchmarking

Historic energy data		Total consumption during period	Annualised consumption	Pilot energy data		Total consumption during period	Annualised consumption	Variance in annual consumption
Start date	End date	kWh	kWh	date	End date	kWh	kWh	%
01/01/18	31/12/18	18,833	18,833	01/01/19	31/12/19	15,184	15,184	-19%

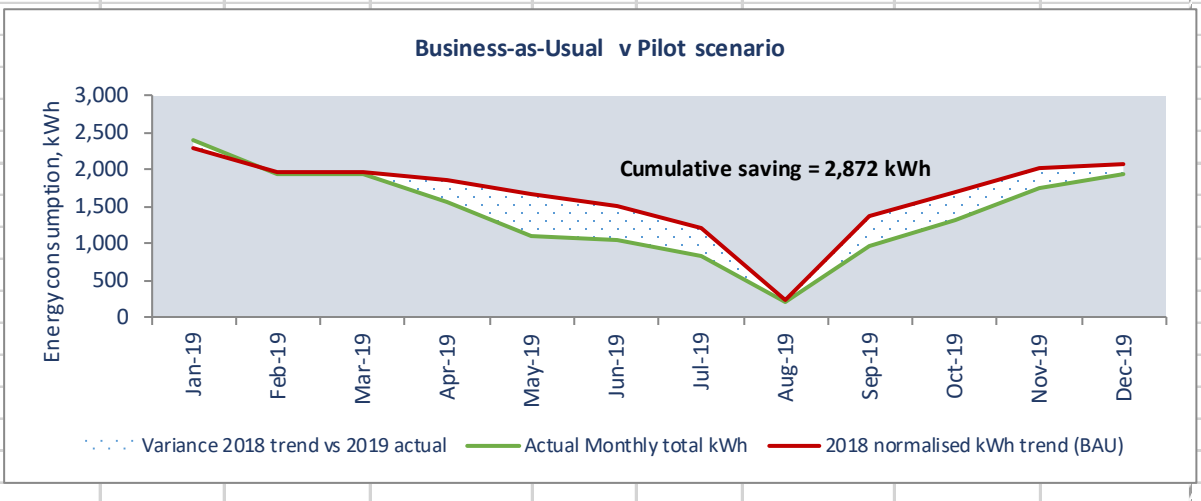
Floor area of pilot site	250	sq.m	
Energy performance pre-pilot	75.3	kWh/annum/sq.m	
Energy performance during pilot	60.7	kWh/annum/sq.m	
Relevant Industry Benchmark	43.0	kWh/sq.m/annum	(Benchmark source: CIBSE online benchmarking tool, typical practice, based on DECs)

2. Known efficiency interventions during pilot

Description of intervention	Date of intervention	Estimated annual energy saving potential (kWh)
~25 Staff and pupil engagement activities during 2018/19 (~5% saving)	Sep-18 to Mar-19	942
Carry out a spot check to see if lights or electrical items are left on at lunch time (~2% saving)	05/10/2018	377
Upgrade kitchen appliances to higher efficiency alternatives and engage kitchen staff on energy efficiency (saving ~5%)	date completed: 17/10/2018	942
Ask electrician to adjust timer on WC lighting sensor (~0.5% saving)	04/03/2019	94
Total		**2,354**

3. Business-As-Usual (BAU) vs Pilot Consumption Analysis

Overview: On site interventions have been undertaken throughout the pilot period. Site energy is impacted by weather, so regression analysis shall be used to determine how pilot period consumption compared against the energy trends established from historical data.

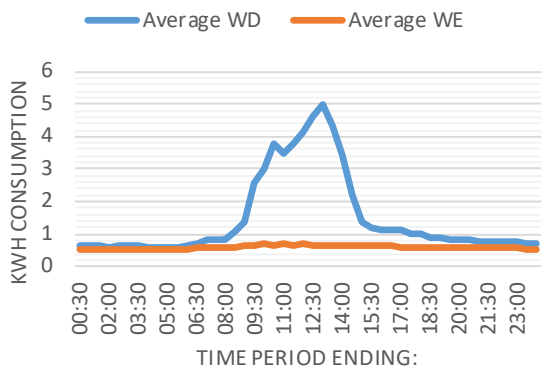


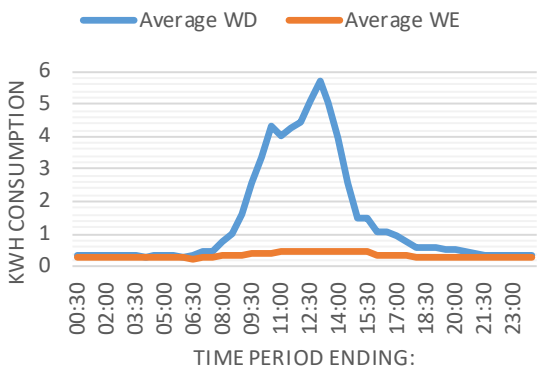
Observations

Applying 2018 energy consumption trends to 2019 heating degree days (via regression) and comparing actual and forecast consumption shows consistent savings between April and December. For the most part these align with anticipated savings from reported actions, through further information would be needed to understand the lack of (modelled) impacts in Q1.

4. Detailed data analysis

	Pre-Pilot	During Pilot
Daily consumption profiles		

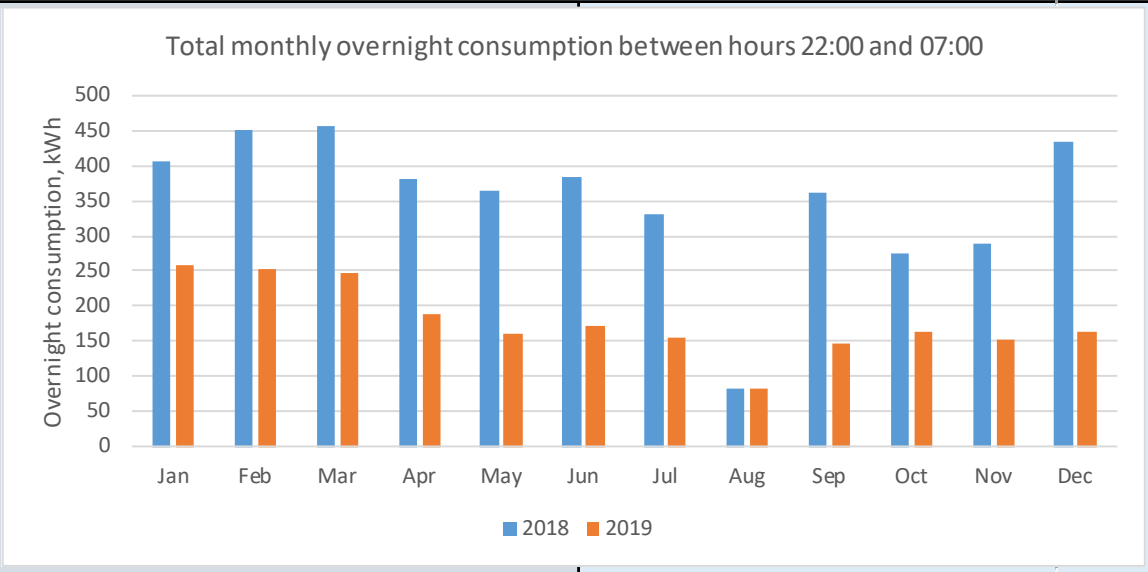




Average weekday hourly load	2.9	kW	2.8	kW
Average weekend/holiday hourly	1.2	kW	0.7	kW
Average daily peak	10.0	kW	11.4	kW
Average overnight hourly load (22	1.2	kW	0.6	kW

Observations

While weekday loading remains relatively consistent, there is a clear reduction in out of hours loading over weekends and overnight, suggesting efficiency activity had an impact on the baseload consumption for the



Observations

Sustained efficiency activity from September 2018 through March 2019 has resulted in a significant reduction in overnight consumption at the site. These savings were sustained throughout 2019.

5. Conclusions

Energy consumption data for a full 12 month period for both 2018 and 2019 was corrected for holiday periods and weather influence, and on comparing the two periods there is a clear trend of reduction. The savings that are observed also align well with the forecast impact of initiatives that have been undertaken on the site. While there has not been a significant reduction in weekday daytime consumption, the sustained energy efficiency activity from Sep-18 through Mar-19 resulted in a marked reduction in out of school hours energy use, clearly demonstrating the impact of site activity. Overall there is very strong evidence to suggest that the energy consumption at this site has been reduced as a direct result of the CP intervention, with annual savings of around 15% energy use.

RAG Rating for finding	Green - Good
Primary reasoning	Full year on year data for comparison, good information about onsite activity and clear indication that CP intervention has impact site consumption.

BEIS NDSEM+V1:AD54IC Energy Consumption Analysis
Stage 2 – Example Deep Dive Analysis - Natural Gas

This section will explore the energy consumption profiles at a sample pilot site in order to better understand the impact of the Competition Partners (CPs) intervention.

Competition Partner 1

Partner Name:	[anonymous]
Technology/Intervention Name:	[anonymous]
Description of deep dive pilot site:	[anonymous]
Metering arrangements for historic data and pilot:	Metering covers whole site

1. Overall energy data and benchmarking

Historic energy data		Total consumption during period	Annualised consumption	Pilot energy data		Total consumption during period	Annualised consumption	Variance in annual consumption
Start date	End date	kWh	kWh	Start date	End date	kWh	kWh	%
01/01/18	31/12/18	20,280	20,280	01/01/19	31/10/19	7,424	9,526	-53%

Floor area of pilot site	250	sq.m
Energy performance pre-pilot	81.1	kWh/annum/sq.m
Energy performance during pilot	38.1	kWh/annum/sq.m
Relevant Industry Benchmark	122	kWh/annum/sq.m

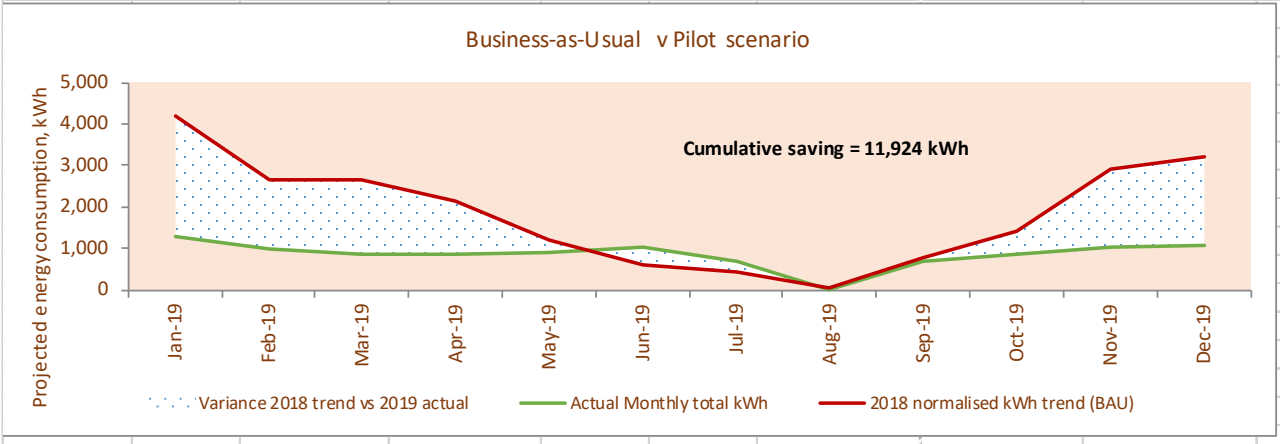
(Benchmark source: CIBSE online benchmarking tool, typical practice, based on DECs)

2. Known efficiency interventions during pilot

Description of intervention	Date of intervention	Estimated annual energy saving potential (kWh)
~25 Staff and pupil engagement activities during 2018/19 (~2% saving)	Sep-18 to Mar-19	406
Switch off heating over holidays, campaign and liaise with caretaker (~5% saving)	08/10/2018	1,014
Introduce school policy limiting classroom temperatures (~5% saving)	04/03/2019	1,014
Total		**2,434**

3. Business-As-Usual (BAU) vs Pilot Consumption Analysis

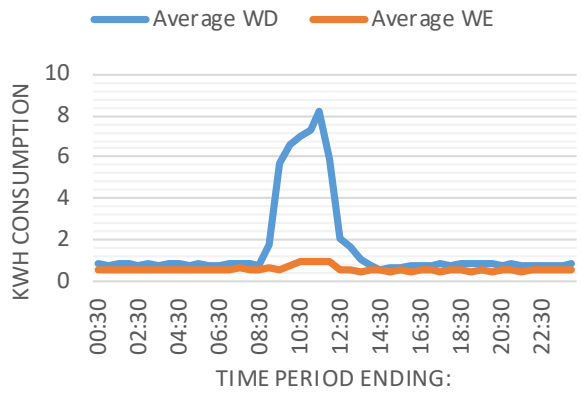
Overview: On site interventions have been undertaken throughout the pilot period. Site energy is impacted by weather, so regression analysis shall be used to determine how pilot period consumption compared against the energy trends established from historical data.

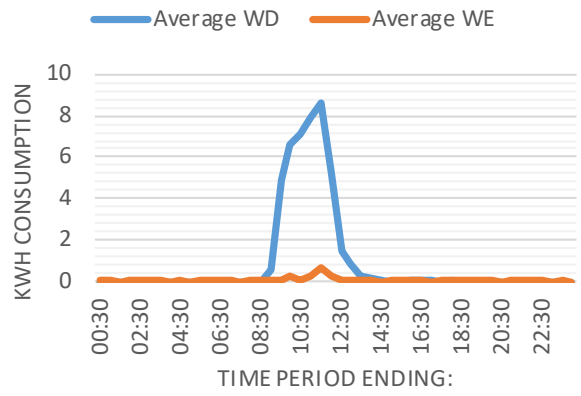


Observations

Applying 2018 energy trends to 2019 heating degree days (via degree day regression) and comparing projected consumption to actual observed 2019 consumption suggests that 2019 energy performance is improved on the previous year. Savings observed were significant, particularly in the early part of 2019 as there appears to be a clear shift in consumption patterns from May 2018 onwards, resulting in much lower consumption through the winter months of 2019.

Pre-pilot			During Pilot		
Daily consumption profiles					



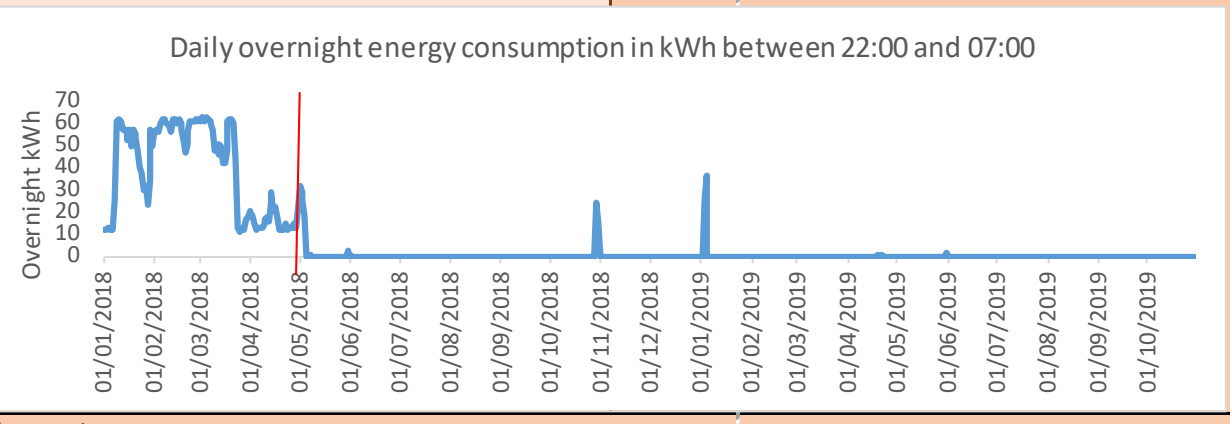


Average weekday hourly load	3.2	kW		1.8	kW
Average weekend/holiday hourly	1.2	kW		0.1	kW
Average daily peak	16.4	kW		17.3	kW
Average overnight hourly load (22	1.4	kW		0.0	kW

Observations

Consumption outside of school operating hours is almost zero in 2019, suggesting that effective out of hours control was implemented during the monitoring period.

Overnight energy consumption at the school



Observations

The overall correlation between consumption and degree days was reasonably consistent across the two years (similar values for R squared) suggesting close control of heating was retained. 2018 consumed slightly more kWh per HDD than in 2019, which may suggest a very slight improvement in heating control in 2019.

5. Conclusions

Energy consumption data for a full 12 month period for both 2018 and 2019 was corrected for holiday periods and weather influence, and on comparing the two periods it is clear that changes made during May 2018 (possibly to heating controls) had a significant impact on out of hours gas consumption. These savings do not appear to have been as a direct result of actions recorded through the CP platform as they take place before the first recorded actions in 2018, however it is possible that the use of the CP platform influenced change that was not recorded. Overall there is very good evidence to suggest that the energy consumption at this site has been reduced as a result of a change of use of energy consuming equipment, but the connection and attribution to recorded site activity is limited. Whatever action created the change in energy use, the savings achieved equate to 53% per year.

RAG Rating for finding	Green/Amber - Good/Moderate
Primary reasoning	Full year on year data for comparison and a clear indication of on site changes resulting in a reduction in consumption would warrant a green rating in isolation, but weak links to recorded on site interventions result in green/amber overall.

Methodology

- Daily average profiles (based on half hourly data) were calculated for weekdays and weekends, pre and post pilot to observe any changes in typical consumption patterns. These allowed the comparison of average weekday, weekend, peak and overnight consumption for each site between 2018 and 2019.
- Where information regarding saving initiatives was provided, estimates were made by the Carbon Trust staff with relevant experience regarding the potential impact of these measures to triangulate predicted savings with patterns observed in the energy data.
- Where detailed information on site energy interventions was provided, specific trend analysis (for example over relatively short periods of time before and after the intervention) was undertaken to identify shifts in consumption. The type of analysis undertaken was designed to identify potential impacts of each measure. Monthly degree days (heating) were compared to consumption patterns at each site to check for correlation (R squared coefficient of determination) between external temperature and energy use. Where alignment was observed (i.e. R squared between 0.5 and unity 1), degree day regression was used to extrapolate annual consumption estimates and to test impact of weather on consumption and saving observations. Where weather alignment was not observed (R squared below 0.5 and closer to zero), a direct comparison of average consumption pre and post pilot was undertaken to highlight any potential savings.

Assumptions

- The sector-specific occupancy variations over days of the week have a significant influence on consumption. For this particular site, weekdays and weekends and any other periods of non-occupancy were identified to filter the analysis. These days are highlighted in the analysis.
- For this tool, no sites provided start dates for specific interventions. Instead, given the length of the historic datasets provided, year-on-year comparisons of consumption before and during the pilot period were used to evaluate the impact of the interventions. 2018 data was used for pre-intervention comparisons, with 2019 data used to compare to post-intervention consumption.
- Data input: It has generally been assumed that all data provided by the Competition Partner is an accurate reflection of consumption for the site or system being monitored. Clear and obvious meter read errors are to be expected, but general consumption trends are considered a true representation of consumption at the site.

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