Verco

Feasibility study on improving the evidence base for industrial energy efficiency

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Summary

Background

This report has been commissioned by the Department of Energy and Climate Change (DECC), which required a review of the UK industrial energy efficiency evidence base. The project comprised two phases. **Phase 1** provided a survey of all significant evidence that contributed to answering three key questions:

- what are the existing trends in industrial process energy use;
- what is the technical and economic energy efficiency potential over the coming decades; and
- what are the barriers to uptake of energy efficiency improvements, including the question of what evidence exists that quantifies or compares barriers.

The outcomes of Phase 1 have been described in a separate report. The purpose of **Phase 2** was to identify any gaps in the overall coverage of the evidence base on UK industrial energy efficiency (in terms of the above questions) and identify opportunities for making cost-effective improvements.

This report presents the Phase 2 work. It includes a description of the methodology used and the results of the gap analysis, based on the current evidence base and also accounting for the impact of planned initiatives. Following this, the remaining gaps (after allowing for the impact of planned initiatives) were reviewed and potential methods for resolving them assessed. Verco, an energy consultancy, was the lead contractor for project. The team was supported by Databuild, a market research firm.

Approach

The following approach to Phase 2 was taken:

- Definitions for an achievable quality threshold needed in a satisfactory evidence base were set out. This accounted for the technical and practical limits on evidence gathering for each of the relevant criteria, and therefore what an effective “best quality” data set might look like.

- Gaps were then identified. By comparing the theoretical, best quality evidence base with the quality of the current evidence base, by sector and by parameter, it was possible to identify the gaps in data availability and quality.

- The impact of planned initiatives were then considered, including Government schemes (such as ESOS, NEED, NDEEM, EDR pilots, etc), as well as academic programmes, which are likely to improve the evidence base. The potential impact of these initiatives was assessed, against each of the industrial sectors, key questions and quality criteria covered by the study.

- Assessment of options to address the remaining gaps. A series of options was then considered on how the remaining gaps in the evidence base could be remedied. The viability of each approach was assessed, including an estimation of the relative cost-effectiveness of each measure.

The majority of data was sourced through desk-based research and a stakeholder workshop involving representatives from Government, industry and academia. The desk-based research included further analysis of the evidence base developed by the research team in Phase 1, along with further review of any additional schemes or methodologies that the team was made aware of during the second phase of the project.

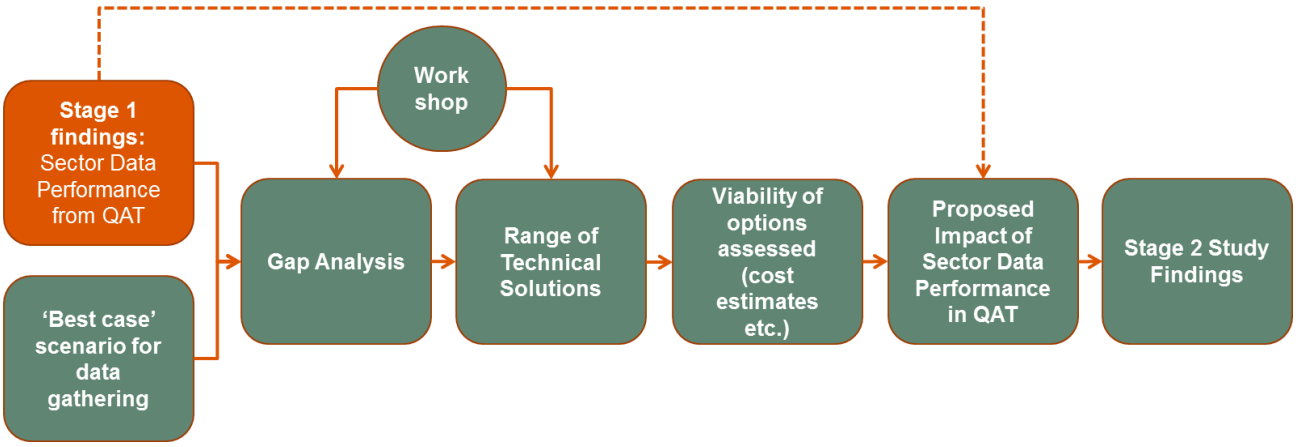

Figure E1: Phase 2 approach

Findings

As outlined above, the comparison of the current evidence base on UK industrial energy efficiency (developed in Phase 1 of the study) with a theoretical, best practicable quality evidence base, identified a number of thematic gaps, as shown in the second column of the table below.

The potential impact of the following planned initiatives was then examined:

- Changes to Climate Change Agreements to capture more detailed registry data
- Carbon Roadmaps: Government-commissioned studies to map out baseline emissions to 2050
- Electricity Demand Reduction pilot: a scheme to encourage organisations to deliver firm, verifiable energy savings
- SusTEM (Sustainable Thermal Energy Management network): an academic network whose objective is to enhance the study and utility of efficient thermal energy management in the process industries
- UK INDEMAND (RSUK Energy): a five year programme mapping current forecasts for material and energy demand across sectors, highlighting opportunities for reduction

The impact of these initiatives is summarised in the third column of the table below.

Table S1: Summary of changes in the evidence base with inclusion of planned initiatives

Research question	Thematic gaps	Impact of planned initiatives
Energy trends	Site specific energy consumption	Small improvement
	Product substitution	Possible improvement
Abatement potential	Sector applicability	Significant improvement in few sectors
	Technology maturity	Significant improvement in few sectors
	Condition of current plant	Significant improvement in few sectors
	Technology cost data	Significant improvement in few sectors
Barriers	Sector specific barriers	Some improvement in few sectors
	Sector specific enablers	No change
	Technology specific barriers	Some improvement in few sectors

It may be possible to achieve more significant improvements in the evidence base from these initiatives. For example, the project team's understanding of the current scopes of INDEMAND and the Carbon Road Maps initiatives is limited. Both could in theory offer significant benefits beyond those recognised in this study.

Recommendations

Despite the impact of relevant planned initiatives, a series of gaps in the evidence base are likely to remain. There are two categories of data collection method by which remaining gaps can be addressed: through an administered scheme; or through research. The latter relates to a targeted data collection and analysis conducted at a single point in time. The former refers to programmatic regular data collection, often administered by one or many central coordinating bodies that could be linked to wider disclosure requirements.

It is important to consider existing initiatives and to retain flexibility to minimise administrative burden. As a result, the analysis considers whether existing schemes could be modestly amended and the improvements that this might achieve. Some methods are also better to implement as voluntary rather than mandatory schemes.

The choice of an approach will be dependent on technical suitability and the usefulness of the data being collected. The more valuable the data, the more justifiable it is to make more significant interventions. A summary of the key recommendations is included in the following table.

Table S2: Summary table for recommendations

Gap	Recommendation	Type	Description	Cost
Site specific energy consumption	Amend CCA data to cover site level information	Administrative	Gather site data in CCA submissions as opposed to bubbled CCA data	High
	Remote surveys targeting energy managers	Research	Gather site data using a remote survey exercise	Medium
Sector applicability of abatement measures and their performance and cost	Site condition survey	Research	Undertake site condition surveys	High
	Remote surveys targeting energy managers	Research	Gather site data using a remote survey exercise	Medium
	Coordinated research with trade associations	Administrative	Work with industry stakeholders to gather information on technology costs/performance	Medium
	Energy technology database	Administrative	Sets in place a standard method for capturing information on technology performance	Medium
Barriers and enablers	Case study development	Research	Undertake site interviews to develop case studies	Medium
	Remote surveys targeting energy managers	Research	Gather barrier and enable data using a remote survey exercise	Medium
	ECA applicant survey	Research	Target ECA applicants to understand rates of implementation by technology type	Medium
	Planned industry/technology workshops	Administrative	Sets in place a standard regular industry consultation events	Low
Lack of input – output data	Gather input – output data	Administrative	Initiate a policy change to re-introduce input-output data requirements	Very High
	Generate input – output data substitute methods	Research	Undertake academic research exercises to gather and model useable data that substitutes for input-output data	Medium

Gap	Recommendation	Type	Description	Cost
Compounding of errors	Setting out a clear protocol to improve transparency of calculation process	Administrative	Set in place a consistent policy to aide documentation and communication of key assumptions and the cumulative effect on uncertainty	Low
Improved classification	Improved classification	Research	Initiate research to assess the impact of coarse classification and identify sectors most affected	Medium

The table below sets out how individual recommendations combine into "packages" with different cost levels.

Table S3: Preferred methods by cost bracket

Gap	Best dataset		
	Low cost	*Medium cost*	*High and very high cost*
Site-specific energy consumption	N/A	Remote surveys targeting energy managers	For CCA sectors: Amended CCA data to cover site level information For non-CCA sectors: Remote surveys targeting energy managers
Sector applicability and technology performance	Coordinated research with trade associations	Remote surveys targeting energy managers	Site condition survey
Technology maturity	Coordinated research with trade associations	Remote surveys targeting energy managers	Remote surveys targeting energy managers
Condition of current plant	Coordinated research with trade associations	Remote surveys targeting energy managers	Site condition survey
Sector specific barriers	Planned industry/ technology workshops	Remote surveys targeting energy managers	Remote surveys targeting energy managers
Sector specific enablers	Planned industry/ technology workshops	Remote surveys targeting energy managers	Remote surveys targeting energy managers
Technology specific barriers	Planned industry/ technology workshops	Remote surveys targeting energy managers	Remote surveys targeting energy managers

- **Low cost packages** primarily focus on harnessing industry engagement exercises to encourage collaboration and enable collective agreement on appropriate common methods for the recording of data. Whilst cost-effective, this could lead to significant bias in some instance and may only lead to limited quantification of key parameters. There is also a reasonable cost that participants would have to bear and the entire approach is very much dependent on industry and academia being engaged and supportive.
- **Medium cost packages** focus on the implementation of structured remote surveys. The Food and Drink Federation showed in their preparation for the CCA target setting process that it is possible to construct a reasonable evidence base using data submitted from sites. It is worth emphasising however, that the negotiation provided a pressing driver for engagement within the industry. This may not be the case if an initiative was primarily research-driven and participants received genuinely useful outputs as part of the engagement process. Such an approach will also be significantly restricted in the complexity of data that

can be gathered and/or the degree to which data can be validated. It is likely that there would be a number of significant concerns raised on the sensitivity of the data being gathered.

- **The high cost packages** are a blended solution of remote surveys, on-site surveys and also improved administrative data where it is available. In this final arrangement, site surveys provide the detailed energy abatement data. Other sources provide the representative data on energy consumption and barriers.

Government may consider taking a programmatic approach to improving the evidence base. This would cover an initial data gathering exercise where a set of common, appropriate and proportionate data collection methods are used initially to gather point in time data. It is noted that many key parameters associated with the evidence base will vary significantly over time. As part of the programmatic approach it might be desirable therefore to initiate an ongoing evidence base review process.

The team conclude that it is difficult to analyse industrial energy efficiency issues in any way other than by taking a sectoral approach. The key reason for this is that much of the literature in the field is presented on a sectoral basis. Building on the current evidence base therefore reinforces the need for a sectoral approach as opposed to an alternate means of understanding the energy efficiency, for example on a technology- or process-specific basis. Where an alternative approach is taken therefore, it is likely to be at slightly greater cost, to overcome legacy structural effects

1. Introduction

This report has been commissioned by the Department of Energy and Climate Change (DECC). The client required a review of the UK industrial energy efficiency evidence base.

The project comprised two phases. **Phase 1** provided a survey of all significant evidence that contributed to answering three key questions: *what are the existing trends in industrial process energy use*; *what is the technical and economic energy efficiency potential over the coming decades*; and *what are the barriers to uptake of energy efficiency improvements*, including the question of what evidence exists that quantifies or compares barriers. **Phase 2** provided a report that identifies any gaps in the overall coverage and indicates where there are opportunities for making cost-effective improvements to the evidence base.

This report presents the Phase 2 outputs. It includes a description of the methodology; the gap analysis is then presented, based on the current evidence base and also accounting for the impact of planned initiatives. Following this the remaining gaps are reviewed and potential methods for resolving them are assessed. Verco, an energy consultancy, was the lead contractor for project. The team was supported by Databuild, a market research firm.

1.1 Background

Improving the evidence base for industrial energy efficiency is a key deliverable for the Energy Efficiency Strategy published on 12 November, 2012. At the EEDO Strategy launch event at the Royal Society on 4 February, 2013 the Prime Minister said: “The economies that will prosper, are those that are the greenest and the most energy efficient…making energy consumption more efficient is a vital part of the growth and wealth that we need.” Analysis suggests energy savings of 20-63TWh by 2020 and 28-68TWh by 2025 may be possible from industrial energy efficiency improvements. This includes processes across all industrial sectors, and the use of electricity, gas and other fuels within processes.

To deliver this, the Energy Efficiency Strategy sets out a need for a stronger and more developed evidence base to underpin and guide the development of targeted, evidence-based policies. This will help drive further energy efficiency improvements in a number of areas including the industrial sector. The current evidence points to energy efficiency potential particularly in the medium energy intensive sectors. However, the evidence that is currently used to assess the energy efficiency of industry and to calculate future potential has a number of shortcomings including reliability and extent of coverage. This limits the strength of the conclusions that can be drawn from it, and the extent to which it can provide a basis for design of new policy instruments.

1.2 Purpose

The overall purpose of the research is to provide a basis on which Government can best target cost-effective measures to improve the evidence base on industrial energy efficiency. This feasibility study includes setting out a comprehensive overview of existing research evidence relating to answering key questions on energy use trends, energy efficiency potential and barriers. This also includes an assessment on the information available from each evidence source and a judgement on quality and reliability. Researching the evidence base in this way will make it possible to highlight areas where improvements can most cost-effectively be made.

The study is focused on three research questions:

- Research Question 1: What are the existing (and, where appropriate for context, historic) trends in industrial process energy use?
- Research Question 2: What is the technical and economic energy efficiency potential over the coming decades and resultant carbon emissions reductions?
- Research Question 3: What are the barriers to uptake of energy efficiency improvements?

2. Methodology

In this section, the overarching method that has been adopted in Phase 2 of the study is outlined. It provides details on the analyses that have been conducted and how they support the overall findings.

2.1 Approach

To achieve the study's aim the following approach was undertaken:

- The definitions for the quality needed in a satisfactory evidence base are set out. This accounts for the technical and practical limits on evidence gathering and therefore what the effective "best quality" is.
- Gaps are then identified. By comparing the best possible performance with the quality of the current evidence base by sector and by parameter it is possible to identify the gaps.
- The impact of planned initiatives is also considered. There are a number of government schemes (such as ESOS, NEED, NDEEM, EDR pilots etc), as well as academic programmes, which are likely to improve the evidence base. The impact of these need to be accounted for and the effects on the sectors and technologies concerned modelled.
- Assessment of options for remaining gaps. A series of options is then considered on how the remaining gaps could be remedied. The viability of each approach is assessed.

The majority of data was sourced through desk-based research and a key sector workshop. The desk-based research included the analysis of the evidence base database that the research team developed in Phase 1, along with further review of any additional schemes or methodologies that the team was made aware of during the project.

The key sector workshop was an event attended by representatives from industry and academia. The Phase 1 findings were presented and feedback was sought on data gaps, the impact of future initiatives and the method for resolving these gaps.

The flow chart below summarises the Phase 2 approach.

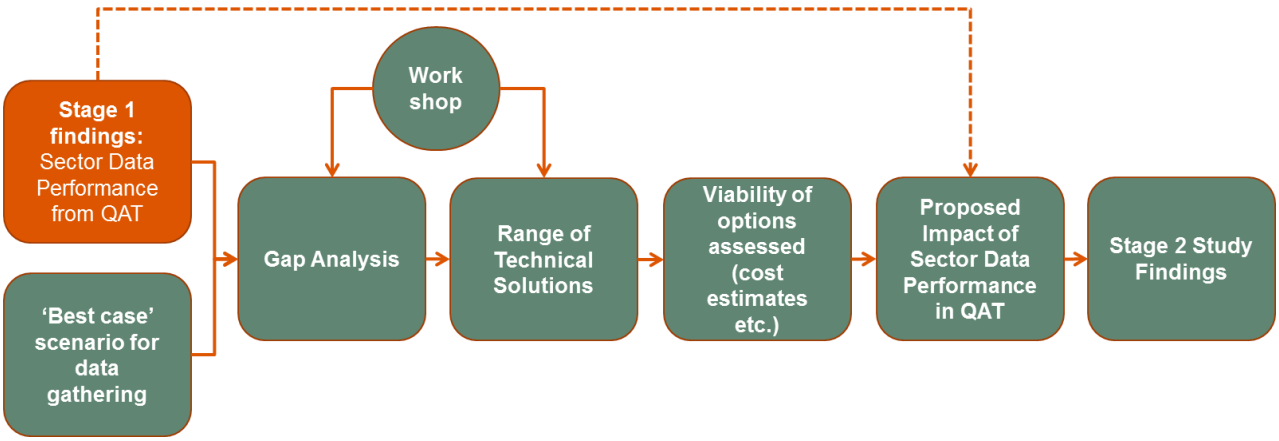

Figure 1: Phase 2 approach

2.2 Gap analysis

The gap analysis compared current data quality on industrial energy efficiency on a sector-by-sector basis against a realistically achievable "best case" scenario. This took into account the impact of known upcoming initiatives that could lead to improvements in the evidence base.

The resulting analysis identified the gaps where the evidence was weak. Following this exercise it was possible to identify what type of research activities could be undertaken to remedy these weaknesses.

The steps in the gap analysis are summarised in the following sections.

2.2.1 Construct a "best case" evidence scenario

The first step in the gap analysis was to construct a best case scenario for the quality of the data that could feasibly be collected. This used the same adapted Maryland quality framework as in Phase 1 of the study (summarised in Table 3, below) and a similar tool (a version of the Quality Assessment Tool [1](QAT) spreadsheet used in Phase 1).

"Best case" scores were estimated for each parameter by the Verco project team. The scores by parameter are set out in Table 1 along with a supporting explanation of why the values have been chosen.

The scores assigned take into account practical limits for that parameter. For example, it may not be possible to collect independent equipment capital cost figures. Often such data is sourced from suppliers of the equipment. In these instances the data will therefore be naturally prone to bias.

2.2.2 Gaps in the evidence base from Phase 1 analysis

Gaps have been identified through comparison of the output from the QAT generated in Phase 1 – the current evidence base – and the" best case" scenario developed in the previous step. This analysis has been conducted on a sector-by-sector basis. When viewed on an aggregate, whole industry basis, a number of consistent gaps have emerged.

For each dataset the combined quality scores were used to identify the strongest source of information for a given parameter. For instance, on a particular parameter there might be a number of different sources, but some might be weaker in terms of key quality parameter, such as coverage or degree of parameter quantification.

In order to adequately differentiate dataset performance sufficiently, it was necessary to weight the data quality scores so that the best overall dataset for that given parameter was selected. Weighting factors have been applied to each of the quality criteria. On this basis a single preferred dataset could be selected.

The weighting favoured the performance of a dataset in the 'adapted Maryland rating' and 'scale of data coverage', as shown in Table 1. This is because effective quantification of data and the scale of the sample population were considered the most important attributes when assessing the quality of data.

Table1: Weighting factors by adapted Maryland quality category

Adapted Maryland rating	Research design quality		Research delivery quality	Independence of study	Source of data
	Scale/ robustness in terms of coverage	Representative-ness			
2	1.5	1	1	1	1

[1] The Quality Assessment Tool is a database of evidence stored in MS Excel. The contribution of each evidence source towards each key parameter by sector is evaluated. Using this tool it is possible to "map" the effective evidence base for a sector based on the patchwork of underlying source material

Table 2: Quality scoring system

Code	Fit for our purpose (relevance)	Adapted Maryland rating	Research design quality		Quality of research delivery	Independence of study from delivery	Source of data
			Scale/robustness in terms of coverage	Representative?			
1	All aspects are relevant to our objectives	Quantified direct impacts (e.g. measures installed)	Total industry	Comprehensive representation of target group (Census)	Conducted in line with good practice (ISO20252 or similar) or subject to independent peer review	Independent study	Primary auditted data
2	Some aspects are relevant to our objectives	Quantified as part of an aggregate	Sample-based research/evaluation	Randomly selected sample, representative of the population (Limited or no bias)	Subject to internal peer review and commissioned by third party	Some aspects are independent	Primary data
3	Limited relevance to our objectives	Partially quantified	Case study approach	Sample selection is non-random and may not be representative of the population (either through non-random design or bias e.g. non-response bias)	Steps taken to ensure quality either not undertaken or not reported	Non-independent study	Primary and secondary data
4		Qualitatively appraised					Secondary data

Table 3: Theoretical "best case" achievable evidence base

Research question	Factor	Adapted Maryland rating	Research design quality		Research delivery quality	Independence of study	Source of data	Justification
			Scale/robust-ness in terms of coverage	*Represent-ativeness*				
What are the existing (and, where appropriate for context, historic) trends in **industrial process energy use**?	Total consumption	1	1	1	1	1	1	Data can be gathered on consumption at a site-by-site basis. It should be possible to cover the whole sector. Data in theory could be from an auditable source and collected by an independent, non-biased body.
	Core process energy consumption	1	1	1	1	1	1	
	Non-core energy consumption	1	1	1	1	1	1	
	Non-energy process emissions	1	1	1	1	1	1	
	Site-specific energy consumption	1	1	1	1	1	1	
	Heat generation	1	1	1	1	1	1	
	Heat usage	1	1	1	1	1	1	
	Activity (market)	1	1	1	1	1	1	
	Product substitution	1	1	1	1	1	1	
What is the technical and economic **energy efficiency potential** over the coming decades and resultant carbon emission reductions?	Sector applicability	2	1	1	1	1	3	Being able to determine sector applicability of a given measure is likely to incur limitations in terms of maintaining up to date records on the scope of implementation and also in many cases there is likely to be a reliance on secondary data
	Capital costs	1	2	2	1	2	3	Capital and operational cost is in part influenced by the context in which the measure is implemented (ie, scale, type of operation); hence it is difficult to find data that fully represents all cost scenarios. Cost data is also predominantly sourced from suppliers and therefore is rarely free from bias. In many instances the data will not be sourced from primary sources.
	Operational costs	1	2	2	1	2	3	

Research question	Factor	Adapted Maryland rating	Research design quality		Research delivery quality	Independence of study	Source of data	Justification
			Scale/robust-ness in terms of coverage	*Represent-ativeness*				
	Expected lifetime of plant	1	2	2	1	2	3	To gather this data the sample would have to be representative of the whole sector/ technology and identify the range of likely operational scenarios that could arise. Data is likely to be sourced from suppliers and hence may be biased. In many instances the data will not be taken from primary sources.
	Technology maturity	2	2	2	1	2	3	Technology maturity will often be limited to qualitative judgement unless cost curves could be constructed. To gather fully representative data will often require substantial detail on sector operating characteristics as well as the technology. Data is likely to be sourced from suppliers and hence may be subject to bias. In many instances data will not be from primary sources.
	Penetration / uptake rate	2	2	2	1	1	3	Uptake rates will often be difficult to quantify for each technology. Instead uptake rates may be viable to quantify as an aggregate for a group of measures/ technologies. In theory such information could be sourced via an independent study which assesses sector measure uptake via remote surveys or site audits. In contrast data might be gathered from suppliers; in these cases it could be biased.
	Condition of current plant	1	2	2	1	1	3	In theory it is possible to undertake site condition surveys to assess condition of current plant in a target sector, but to undertake such an exercise for a whole sector is likely to be prohibitive.

Research question	Factor	Adapted Maryland rating	Research design quality		Research delivery quality	Independence of study	Source of data	Justification
			Scale/robust-ness in terms of coverage	*Represent-ativeness*				
	Cost effective abatement performance	1	2	2	1	1	3	In theory it would be possible to undertake site condition surveys to assess the abatement potential by technology in a target sector. To undertake such an exercise for a whole sector is likely to be prohibitive.
	Technical abatement performance	1	2	2	1	1	3	
What are the **barriers** to uptake of energy efficiency improvements?	Sector specific barriers	2	2	2	1	1	3	Detailed quantification of all barriers and enablers is unlikely to be possible, in part because some barriers and enablers simply cannot be effectively quantified i.e. cultural factors. There are also limits in terms of sector coverage that could be achieved. It might be possible to capture information on a proportion of the sector through case studies, workshops or surveys. However this is unlikely to be representative of the total industry.
	Sector specific enablers	2	2	2	1	1	3	
	Technology specific barriers	1	2	2	1	1	3	Detailed quantification of all technology barriers is unlikely to be possible, in part because some barriers simply cannot be effectively quantified i.e. resource capacity factors. As above, there are also limits in terms of sector coverage that could be achieved.

2.2.3 Impacts of planned government policies and initiatives

Following the completion of the original gap analysis an assessment of the impact of planned initiatives was completed. This includes government schemes (such as ESOS, BEES, EDR pilots, etc.) and academic programmes (such as SusTEM and UK INDEMAND).

The possible impact on the quality and availability of new data on industrial energy efficiency has been added to the "best case" version of the Verco analysis tool. The net effect of planned policies and initiatives on the "best case" evidence base was evaluated to identify the remaining gaps in the evidence once these had been take into account.

2.3 Workshop

The desk-based research provided an initial indication of the key gaps. This was then tested in an industry workshop. Key stakeholders in government, academia and industry were invited.

The workshop agenda was structured around gathering information on:

1. Project method and findings to date
2. Impacts of planned initiatives
3. Identification of further data gaps
4. Identification of further relevant datasets
5. Recommendations on possible solutions to address the data gaps

For each stage an interactive brainstorming tool was used, where participants were able to anonymously contribute their views. These were then recorded and displayed on a screen to all participants. Each point was then discussed collectively. These insights have been integrated with the findings from the gap analysis.

Following the workshop, the "best case" version that was initially developed was updated.

2.4 Range and feasibility of technical solutions

There were a number of residual gaps in the evidence base which remained after the analysis of the impact of planned initiatives. To address these remaining gaps, a number of potentially cost-effective data improvement measures have been defined. These were informed by the workshop and also through a further internal Verco review meeting. Desk-based research matched technically possible options to each of the remaining thematic gaps.

The feasibility of proposed solutions was reviewed. The key considerations were cost (direct financial costs) and administrative burden (indirect costs of compliance). Following this exercise a proposed tiered set of solutions was considered for remedying the evidence base gaps.

The anticipated improved datasets resulting from the proposed approach have also been added to the database. This allows the team to model the impact of different levels of intervention.

3. Gap analysis

As outlined in the method statement of Section 2, the purpose of the gap analysis was to establish the best quality of data that could feasibly be obtained for a particular sector, and the degree to which this is captured within the existing evidence base. The difference between these two scenarios is indicative of the data gaps.

3.1 Gaps in the current evidence base

The gaps in the evidence base have been evaluated on a sector-by-sector basis using outputs from the database. The quality rankings from the best available dataset by parameter have been subtracted by the “best case” scenario rankings. The “gap” by parameter is then the weighted sum of the difference between the two.

The results from this process are summarised in Tables3, 4 and 5. Green indicates that no gap exists or it is insignificant; red indicates that the difference is substantial.

3.1.1 Energy trends

Total consumption and market data was readily available. However, in some cases the quality definitions used within the study were restrictive. Sectors where ECUK data, for instance, were available would have classed as good quality (“green”) below. In reality the team has limited insight on the quality of source data used for the purpose of ECUK calculations and the underlying assumptions that may be being applied.

The key gaps are in **site-specific energy consumption data** and the **product substitution** evidence. On the former this is believed to be a genuine gap of data which could be highly valuable. The only exceptions relate to highly regulated sectors, which are wholly covered by the EU ETS. The case for product substitution is weaker. The team believe that the search terms used within the study favoured the identification of research papers or sources that targeted energy efficiency measures as opposed energy efficiency trends. The lack of data in this area is a result of specification errors for search terms (although “product substitution” by sector was one of the terms looked for).

The data gaps for remaining parameters are reasonable. In many cases the source quality is limited by the data not necessarily being from primary sources (heat analysis) or the data is not necessarily fully representative of the entire industry (CCA data).

Table 4: RAG assessment of data gaps by sector and parameter – current evidence base, energy trends

Sector	Energy trends								
	Total consumption	Core process energy consumption	Non-core energy consumption	Non-energy process emissions	Site-specific energy consumption	Heat generation	Heat usage	Activity (market)	Product substitution
Processing and preserving of meat and production of meat products				N/A					
Processing and preserving of fish crustaceans and molluscs				N/A					
Processing and preserving of fruit and vegetables				N/A					
Manufacture of vegetable and animal oils and fats				N/A					
Manufacture of dairy products				N/A					
Manufacture of grain mill products starches and starch products				N/A					
Manufacture of bakery and farinaceous products				N/A					
Manufacture of other food products				N/A					
Manufacture of prepared animal feeds				N/A					
Manufacture of beverages				N/A					
Manufacture of tobacco products				N/A					
Manufacture of textiles				N/A					
Manufacture of wearing apparel				N/A					
Manufacture of leather and related products				N/A					

Sector	Energy trends								
	Total consumption	Core process energy consumption	Non-core energy consumption	Non-energy process emissions	Site-specific energy consumption	Heat generation	Heat usage	Activity (market)	Product substitution
Manufacture of wood and of products of wood and cork except furniture manufacture of articles of straw and plaiting materials				N/A					
Manufacture of paper and paper products									
Printing and reproduction of recorded media				N/A					
Manufacture of coke and refined petroleum products									
Manufacture of chemicals and chemical products									
Manufacture of basic pharmaceutical products and pharmaceutical preparations				N/A					
Manufacture of rubber and plastic products									
Manufacture of other non-metallic mineral products									
Manufacture of basic metals									
Manufacture of fabricated metal products except machinery and equipment				N/A					
Manufacture of computer electronic and optical products				N/A					
Manufacture of electrical equipment				N/A					

Sector	Energy trends								
	Total consumption	Core process energy consumption	Non-core energy consumption	Non-energy process emissions	Site-specific energy consumption	Heat generation	Heat usage	Activity (market)	Product substitution
Manufacture of machinery and equipment n e c				N/A					
Manufacture of motor vehicles trailers and semi-trailers				N/A					
Manufacture of other transport equipment				N/A					
Manufacture of furniture				N/A					
Other manufacturing				N/A					

Further details on the key gaps in the evidence on energy trends are set out below.

3.1.1.1 Site specific energy consumption

Data on site energy consumption is typically only sourced from sector-specific studies, which gathered data at a particular point in time. Examples of these are the Industrial Energy Efficiency Accelerator programmes commissioned by the Carbon Trust, or ULCOS academic programme on the iron and steel sector. Due to the administrative burden of gathering site data, the sample is often a small portion of the overall sector, and therefore not necessarily representative. The commercial sensitivity of site-specific data means that even though it may have been collected, it is only publically available in aggregated, sector-wide form.

As identified in the Phase 1 report, the number of sites increases significantly as the energy intensity of the sector decreases. This trend means that for lower intensity sectors, gathering site-specific data can be particularly burdensome.

Knowledge of the energy consumption distribution by site would allow for more targeted energy reduction within the sector as the areas where consumption is particularly high would be better understood.

3.1.1.2 Product substitution

Product substitution data is typically sourced from sector or process-specific academic studies. It was also one of the data points for the recent CCA sector negotiations. In almost all examples identified by this study, the data has been restricted to qualitative statements on instances of product

substitution, rather than quantified impact on abatement. In the case of CCA target setting process, submissions were only made by a limited number of sectors and there are inconsistencies in the representativeness of the data.

In this data gathering exercise, good quantified data on product substitution trends has been identified for the non-metallic minerals sectors only. Anecdotally, the team believed that data coverage in other sectors should be stronger, particularly for iron and steel, chemicals and plastics; however, the search terms did not identify any source material. There are also a number of sectors where the scope for product substitution is limited or non-existent – for example, the tobacco industry.

Quantified data on product substitution is important. It enables the projection of sector emissions based on market trends

3.1.2 Abatement potential

Generally there were substantial gaps in the data for abatement potential. Whilst information in some sector was particularly strong (heavy industry) in general data was weak across the board. Particularly weak parameters included the quantification of the scope for particular opportunities by sector, data on technology maturity and technology trends over time and the current conditions of plant within industry.

It is important to be aware that the quality definitions were not related to the degree of quantification for a given parameter. Often the issues related to source data not being representative or not necessarily being gathered through primary data collection exercises.

Table 5: RAG assessment of data gaps by sector and parameter – current evidence base, aabatement potential

Sector	Abatement potential								
	Sector applicability	Capital costs	Operational costs	Expected life time of plant	Technology maturity	Penetration / uptake rate	Condition of current plant	Cost effective abatement performance	Technical abatement performance
Processing and preserving of meat and production of meat products									
Processing and preserving of fish crustaceans and molluscs									
Processing and preserving of fruit and vegetables									
Manufacture of vegetable and animal oils and fats									
Manufacture of dairy products									

Sector	Abatement potential								
	Sector applicability	Capital costs	Operational costs	Expected life time of plant	Technology maturity	Penetration / uptake rate	Condition of current plant	Cost effective abatement performance	Technical abatement performance
Manufacture of grain mill products starches and starch products									
Manufacture of bakery and farinaceous products									
Manufacture of other food products									
Manufacture of prepared animal feeds									
Manufacture of beverages									
Manufacture of tobacco products									
Manufacture of textiles									
Manufacture of wearing apparel									
Manufacture of leather and related products									
Manufacture of wood and of products of wood and cork except furniture manufacture of articles of straw and plaiting materials									
Manufacture of paper and paper products									
Printing and reproduction of recorded media									
Manufacture of coke and refined petroleum products									
Manufacture of chemicals and chemical products									

Sector	Abatement potential								
	Sector applicability	Capital costs	Operational costs	Expected life time of plant	Technology maturity	Penetration / uptake rate	Condition of current plant	Cost effective abatement performance	Technical abatement performance
Manufacture of basic pharmaceutical products and pharmaceutical preparations									
Manufacture of rubber and plastic products									
Manufacture of other non-metallic mineral products									
Manufacture of basic metals									
Manufacture of fabricated metal products except machinery and equipment									
Manufacture of computer electronic and optical products									
Manufacture of electrical equipment									
Manufacture of machinery and equipment n e c									
Manufacture of motor vehicles trailers and semi-trailers									
Manufacture of other transport equipment									
Manufacture of furniture									
Other manufacturing									

Further details on the key gaps in the evidence on abatement potential are set out below.

3.1.2.1 Sector applicability

Sector applicability of a particular technology or abatement measure is quantified in a limited number of sector specific studies, such as the Carbon Trust's IEEA programme. These studies have been conducted by independent third parties reducing the bias on data outputs. The percentage of sector engagement is often not comprehensive, leading to data which is not necessarily representative. Qualitative statements on sector applicability are provided in the Technology Innovation Needs Assessment (TINA) studies and some of the industrial models.

Better data on sector applicability provides useful context. This allows more informed projections on the abatement potential for a particular technology or abatement measures to be made.

3.1.2.2 Technology related parameters: Plant condition, technology performance and cost data

Data on plant condition is limited to qualitative statements on the sectors featured in the TINA studies and quantified assumptions from models. The data arising from the models is believed to be based on assumptions, and there is limited visibility on what basis these have been formed. Much of the data for many of the models is aggregated and not representative for most of the covered sectors.

Quantifying a given technology performance is difficult. This is because it requires a wider narrative to set the figure in context. Data is typically sourced from sector specific studies – for example IEEA and Horizon 2050. These are often based on methods which are not necessarily representative and are also the product of research from secondary sources.

Cost data is highly variable. One of the major difficulties with cost data is that it is often produced in many different units and for different scopes (even within the same source document). Constructing a complete picture from a variety sources is problematic. Quantified data is often from secondary sources (supplier data or industry consultation) and it is difficult to determine if the figures are truly representative of the sector.

Data on the all of the above parameters provide the basis for understanding asset replacement cycles and also the case for moving beyond those to make early investments in energy efficiency.

3.1.3 Barriers and enablers

Overall, data on barriers and enablers is weak. The only exceptions relate to certain sectors which have been subject to recent in-depth research. Even in these cases, however, the research typically only assessed the relative significance of barriers or enablers qualitatively, or was based on a fairly small sample size.

An in-depth study on barriers was completed under the EU BARRIERS programme in 2000. This targeted two industrial sectors (brewing and metal manufacturing) and included extensive remote surveying and direct interviews to construct key case studies. This produced a detailed qualitative appraisal of key barriers for the two sectors. Whilst the barriers were not quantified they were ranked against each other.

Table 6: RAG assessment of data gaps by sector and parameter – current evidence base and barriers

Sector	Barriers		
	Sector specific barriers	Sector specific enablers	Technology specific barriers
Processing and preserving of meat and production of meat products			
Processing and preserving of fish crustaceans and molluscs			
Processing and preserving of fruit and vegetables			
Manufacture of vegetable and animal oils and fats			
Manufacture of dairy products			
Manufacture of grain mill products starches and starch products			
Manufacture of bakery and farinaceous products			
Manufacture of other food products			
Manufacture of prepared animal feeds			
Manufacture of beverages			
Manufacture of tobacco products			
Manufacture of textiles			
Manufacture of wearing apparel			

Sector	Barriers		
	Sector specific barriers	Sector specific enablers	Technology specific barriers
Manufacture of leather and related products			
Manufacture of wood and of products of wood and cork except furniture manufacture of articles of straw and plaiting materials			
Manufacture of paper and paper products			
Printing and reproduction of recorded media			
Manufacture of coke and refined petroleum products			
Manufacture of chemicals and chemical products			
Manufacture of basic pharmaceutical products and pharmaceutical preparations			
Manufacture of rubber and plastic products			
Manufacture of other non-metallic mineral products			
Manufacture of basic metals			
Manufacture of fabricated metal products except machinery and equipment			
Manufacture of computer electronic and optical products			
Manufacture of electrical equipment			
Manufacture of machinery and equipment n e c			
Manufacture of motor vehicles trailers and semi-trailers			
Manufacture of other transport equipment			
Manufacture of furniture			
Other manufacturing			

Further detail on the key gaps in the evidence on barriers and enablers is set out in the following sections.

3.1.3.1 Barriers and enablers

In the "best case" data gathering scenario, *quantification* of barriers and enablers has been set as the benchmark. In the current evidence base, there are limited examples of this. Data is almost exclusively a *qualitative* statement of the known barriers and enablers at play in the industry.

Good data on barriers and enables are critical for projecting realistic energy savings. Many abatement measures which are technically feasible do not get implemented for a variety of reasons (section 2.2.2). Quantification of barriers will lead to far better projections in modelled consumption and emission reduction scenarios.

3.1.4 Summary findings from desk-based gap analysis

In summary the following gaps were identified in the desk-based research.

Table 7: Summary of gaps from desk-based research

Research question	Gaps
Energy trends	Site specific energy consumption
	Product substitution
Abatement potential	Sector applicability and penetration rates
	Technology maturity
	Condition of current plant
	Technology cost data
Barriers	Sector specific barriers
	Sector specific enablers
	Technology specific barriers

3.2 Workshop findings on gaps

The gap findings were presented at the workshop. They were critiqued by the attendees and the potential data solutions were considered (see Section 4). In addition to the gaps identified through the desk-based analysis, a number of additional ones were identified at the workshop. These gaps are summarised in the following table.

Table 8: Summary of thematic gaps from the workshop

Research question	Gaps
Energy trends	Stock level data
	Inappropriate application of datasets
Abatement potential	Asset condition
Barriers	Commercial drivers
Wider data or study issues	Compounding of errors
	Capability and approaches within Government
	Inappropriate application of datasets
	Upstream emissions
	Dataset typologies

Further details on the identified gaps are set out in the following sections.

3.2.1 Data typology

A standard data typology is needed to distinguish between data collection mechanisms. A division should be made between administrative data (broader) versus very targeted data collection (specific for purpose).

3.2.2 Commercial drivers/opportunity costs of energy efficiency investment

Further information is needed on alternative investment strategies available to corporates. Investment decisions in energy measures are not made in isolation and firms have restricted budgets. Whilst the use of appropriate investment hurdle rates will account for this in part, in reality firms will often favour making investments into core business activities which lead to direct scalable growth opportunities. Improving understanding of the opportunity costs faced by firms will enable government to determine the correct price incentives to use.

The workshop also acknowledged that regularity uncertainty affects the risk associated with an investment. Firms may be cautious investing in a solution where a key revenue stream is dependent on government support. Industry believed this has a significant impact and that further data is needed to understand the effect of regulatory uncertainty on investment hurdle rates.

3.2.3 Capability and approaches within government

Some participants in the workshop believed that data is not currently sufficiently shared across and within government departments. If increased data sharing is possible, it will reduce the administrative burden of the data gathering process and improve the quality and quantity of available data. One workshop respondent noted that it is possible to promote ways of gathering evidence while maintaining confidentiality by using research tools such as ONS Virtual Micro Lab or UK Secure Data Service. They recommended that as part of the policy development process a set of legal instruments be adopted that allow evidence to be used for research.

3.2.4 Inappropriate application of datasets

It was said that there is a lack of understanding around the energy scope associated with economic datasets. The data may not automatically align with standard assumptions.

3.2.5 Compounding of assumptions

There is a lack of transparency where data has been processed. At times data might be sourced from weak initial sources. It is also difficult to assess the compounding effect of a sequence of assumptions with differing confidence levels on the final output parameter. This a particular issue where outputs are used from models.

3.2.6 Improved sector/ product classification

In some sectors the official classification methods are inappropriate for energy analysis. The ceramics sector, for instance, cited official statistics stating the existence of 200 tile manufacturers, whereas in reality there are five. These disconnects need to be acknowledged and have accompanying narratives.

3.2.7 Stock level data

There is currently little information available on stock levels. There could be a lot of potential for recovery of product and therefore a reduction in the need of virgin material.

3.2.8 Upstream emissions

Upstream emissions are often not reported along with process emissions. The analysis needs to be holistic. A major part of a product's emissions can be upstream or downstream from the manufacturing process.

The team fully recognises the importance of applying a systems approach to resolving wider long term goals in achieving a sustainable economy. The scope of this study is explicitly on the evidence base for analysing the scope for process energy use abatement potential.

3.3 Impact of planned initiatives

The impact of planned initiatives was subject to a review at the workshop and subsequent desk-based research. The outputs by initiative are set out in the following sections.

3.3.1 Details on initiatives

There are a number of government schemes and academic programmes that are scheduled to report in the next one to three years that will improve the current evidence base. The key datasets are highlighted in the below.

Changes to CCAs to capture more detailed registry data			Government scheme - Voluntary initiative		
Adapted Maryland rating	Scale/robustness in terms of coverage	Representative-ness	Research delivery quality	Independence of study from delivery	Source of data
2	1	1	2	1	1

Comment:

- Annually sourced primary data on sector performance
- The next round of data collection will include CCA bubbled facility data across an organisation

View of industry and academia:

- Industry was strongly against gathering site data, citing commercial risks and administrative burden. They also stated that site data in many cases would not be useful. Sites can rarely be easily compared and benchmarking processes might be more appropriate. Generally it was recognised that this issue was sector specific and views differed on whether site level data was valuable

Carbon roadmaps			Government scheme - Publicly funded study		
Adapted Maryland rating	Scale/robustness in terms of coverage	Representative-ness	Research delivery quality	Independence of study from delivery	Source of data
1	2	2	1	1	3

Comment:

- Government commissioned studies to map out baseline emissions to 2050 and what interventions could be made by government or industry to reduce this baseline.
- Study will address eight energy intensive sectors; food & beverage, paper, refineries, chemicals, cement, glass, ceramics and iron & steel.
- Data on energy consumption, abatement measures and barriers to achieving the saving potential.

View of industry and academia:

- The aggregates sector has already completed its own carbon roadmap. The trade association was unsure as to whether the study would identify further savings.
- The food and beverage trade association recognised that the sector is highly heterogeneous. The aggregation of data will need to reflect this. They were particularly keen to explore renewable heat opportunities, i.e. scope for biomass as a heat source or electrification of heat.
- The glass sector believed the carbon roadmaps help formalise sector thinking on abatement potential
- The overlaps between adjacent sectors should be picked up. For example, cross-cutting technologies

and competing demands for biomass and other finite resources.

Electricity Demand Reduction pilots			Government scheme - Publicly funded study		
Adapted Maryland rating	Scale/robustness in terms of coverage	Representative-ness	Research delivery quality	Independence of study from delivery	Source of data
1	2	3	1	1	1

Comment:

- Pilot for a scheme where businesses and other organisations which install measures that deliver verifiable reductions in electricity demand will be able to bid for a financial incentive.
- More efficient motors and lighting are examples of measures that could receive support.

View of industry and academia:

- Pilots are likely to be too site specific and hence unlikely to be representative of a sector at large.

SusTEM: Sustainable Thermal Energy Management Network			Other sources - Academia		
Adapted Maryland rating	Scale/robustness in terms of coverage	Representative-ness	Research delivery quality	Independence of study from delivery	Source of data
1	2	2	1	1	Range

Comment:

- A network of academic researchers with the objective to enhance the study and utility of efficient thermal energy management in the process industries. This covers system design, waste heat recovery and assessing barriers to implementation.
- Aim is to effectively forge close links between academia, industry, government (local and national) and NGOs and disseminate knowledge.
- Highly focused research means wider applicability of findings across other sectors is restricted.

UK INDEMAND (RSUK Energy)			Other sources - Academia		
Adapted Maryland rating	Scale/robustness in terms of coverage	Representative-ness	Research delivery quality	Independence of study from delivery	Source of data
1	2	2	1	1	3

Comment:

- A five year £37 million programme mapping current forecast for material and energy demand across sectors highlighting opportunities where manufacturing processes could reduce end-use demand for material.
- Involves 20 researchers and 40 PhD students. the Department for Business, Innovations and Skills (BIS), Department of Energy and Climate Change (DECC) and other departments are involved.

View of industry and academia:

- Study is more about systems and streams. If the interest is focused on equipment condition i.e. the potential for more effective motors etc., then the study will not be appropriate.
- Study is about the market structure, the material flows, the 'bigger picture' – macro rather than micro.

3.3.2 Impact on the evidence base

The new datasets from these planned initiatives have been incorporated into the QAT. The resultant gaps in the evidence base are summarised in Tables 9, 10 and 11

3.3.2.1 Energy trends

The main improvements relate to site-specific energy consumption data. The improvements in CCA data reporting should mean that site data is more accessible. In some sectors this information may however be hidden under aggregate agreements which "bubble" underlying facility emissions.

Product substitution trends could be assessed within the INDEMAND programme. However, this study has only been able to take into account product substitution trends to a limited degree.

Table 9: RAG assessment of data gaps by sector and parameter – planned interventions and energy trends

Sector	Energy trends								
	Total consumption	Core process energy consumption	Non-core energy consumption	Non-energy process emissions	Site-specific energy consumption	Heat generation	Heat usage	Activity (market)	Product substitution
Processing and preserving of meat and production of meat products				N/A					
Processing and preserving of fish crustaceans and molluscs				N/A					
Processing and preserving of fruit and vegetables				N/A					
Manufacture of vegetable and animal oils and fats				N/A					
Manufacture of dairy products				N/A					
Manufacture of grain mill products starches and starch products				N/A					
Manufacture of bakery and farinaceous products				N/A					
Manufacture of other food products				N/A					
Manufacture of prepared animal				N/A					

Sector	Energy trends								
	Total consumption	Core process energy consumption	Non-core energy consumption	Non-energy process emissions	Site-specific energy consumption	Heat generation	Heat usage	Activity (market)	Product substitution
feeds									
Manufacture of beverages				N/A					
Manufacture of tobacco products				N/A					
Manufacture of textiles				N/A					
Manufacture of wearing apparel				N/A					
Manufacture of leather and related products				N/A					
Manufacture of wood and of products of wood and cork except furniture manufacture of articles of straw and plaiting materials				N/A					
Manufacture of paper and paper products									
Printing and reproduction of recorded media				N/A					
Manufacture of coke and refined petroleum products									
Manufacture of chemicals and chemical products									
Manufacture of basic pharmaceutical products and pharmaceutical preparations				N/A					
Manufacture of rubber and plastic products									
Manufacture of other non-metallic mineral products									
Manufacture of basic metals									

Sector	Energy trends								
	Total consumption	Core process energy consumption	Non-core energy consumption	Non-energy process emissions	Site-specific energy consumption	Heat generation	Heat usage	Activity (market)	Product substitution
Manufacture of fabricated metal products except machinery and equipment				N/A					
Manufacture of computer electronic and optical products				N/A					
Manufacture of electrical equipment				N/A					
Manufacture of machinery and equipment n e c				N/A					
Manufacture of motor vehicles trailers and semi-trailers				N/A					
Manufacture of other transport equipment				N/A					
Manufacture of furniture				N/A					
Other manufacturing				N/A					

3.3.2.2 Abatement potential

The main improvements relate to the data arising from the Carbon Roadmaps. This is expected to either provide new additional data on abatement potential in key sectors or refresh existing evidence in those sectors that have been well studied. The roadmaps are restricted to a small of number of large sectors. For the remainder the evidence base remains as before.

Table 10: RAG assessment of data gaps by sector and parameter – planned interventions, abatement potential

Sector	Abatement potential								
	Sector applicability	Capital costs	Operational costs	Expected life time of plant	Technology maturity	Penetration / uptake rate	Condition of current plant	Cost effective abatement performance	Technical abatement performance
Processing and preserving of meat and production of meat products									
Processing and preserving of fish crustaceans and molluscs									
Processing and preserving of fruit and vegetables									
Manufacture of vegetable and animal oils and fats									
Manufacture of dairy products									
Manufacture of grain mill products starches and starch products									
Manufacture of bakery and farinaceous products									
Manufacture of other food products									
Manufacture of prepared animal feeds									
Manufacture of beverages									
Manufacture of tobacco products									
Manufacture of textiles									
Manufacture of wearing apparel									
Manufacture of leather and related products									
Manufacture of wood and of products of wood and cork except furniture manufacture of articles of straw and plaiting materials									
Manufacture of paper and paper products									

Sector	Abatement potential								
	Sector applicability	Capital costs	Operational costs	Expected life time of plant	Technology maturity	Penetration / uptake rate	Condition of current plant	Cost effective abatement performance	Technical abatement performance
Printing and reproduction of recorded media									
Manufacture of coke and refined petroleum products									
Manufacture of chemicals and chemical products									
Manufacture of basic pharmaceutical products and pharmaceutical preparations									
Manufacture of rubber and plastic products									
Manufacture of other non-metallic mineral products									
Manufacture of basic metals									
Manufacture of fabricated metal products except machinery and equipment									
Manufacture of computer electronic and optical products									
Manufacture of electrical equipment									
Manufacture of machinery and equipment n e c									
Manufacture of motor vehicles trailers and semi-trailers									
Manufacture of other transport equipment									
Manufacture of furniture									
Other manufacturing									

3.3.2.3 Barriers and enablers

The main improvements relate to the data arising from the Carbon Roadmaps. This is expected to provide further qualitative data on barriers affecting target sectors. It is currently not clear to what degree enablers will be considered and also the same issue as with the abatement potential analysis applies, where the restricted scope of the carbon roadmap exercise means only some sectors benefit.

Table 11: RAG assessment of data gaps by sector and parameter – planned interventions and barriers

Sector	Barriers		
	Sector specific barriers	Sector specific enablers	Technology specific barriers
Processing and preserving of meat and production of meat products			
Processing and preserving of fish crustaceans and molluscs			
Processing and preserving of fruit and vegetables			
Manufacture of vegetable and animal oils and fats			
Manufacture of dairy products			
Manufacture of grain mill products starches and starch products			
Manufacture of bakery and farinaceous products			
Manufacture of other food products			
Manufacture of prepared animal feeds			
Manufacture of beverages			
Manufacture of tobacco products			
Manufacture of textiles			
Manufacture of wearing apparel			
Manufacture of leather and related products			
Manufacture of wood and of products of wood and cork except furniture manufacture of articles of straw and plaiting materials			
Manufacture of paper and paper products			

Sector	Barriers		
	Sector specific barriers	Sector specific enablers	Technology specific barriers
Printing and reproduction of recorded media			
Manufacture of coke and refined petroleum products			
Manufacture of chemicals and chemical products			
Manufacture of basic pharmaceutical products and pharmaceutical preparations			
Manufacture of rubber and plastic products			
Manufacture of other non-metallic mineral products			
Manufacture of basic metals			
Manufacture of fabricated metal products except machinery and equipment			
Manufacture of computer electronic and optical products			
Manufacture of electrical equipment			
Manufacture of machinery and equipment n e c			
Manufacture of motor vehicles trailers			
Manufacture of other transport equipment			
Manufacture of furniture			
Other manufacturing			

3.3.3 Summary impacts of planned initiatives

The following table summarises the impacts of the planned initiatives.

Table 12: Summary of changes in the evidence base with inclusion of planned initiatives

Research question	Thematic gaps	Impact of planned initiatives
Energy trends	Site specific energy consumption	Small improvement
	Product substitution	Possible improvement
Abatement potential	Sector applicability	Significant improvement in few sectors
	Technology maturity	Significant improvement in few sectors
	Condition of current plant	Significant improvement in few sectors
	Technology cost data	Significant improvement in few sectors
Barriers	Sector specific barriers	Some improvement in few sectors
	Sector specific enablers	No change
	Technology specific barriers	Some improvement in few sectors

3.3.3.1 Scope for further improvements

It may be possible to achieve more significant improvements from the planned measures. For instance the project team's understanding of the scope of INDEMAND and the Carbon Road Maps initiatives is limited. Both could in theory offer significant benefits beyond those recognised in this study.

IN DEMAND, in principle, might be able to provide a reasonably complete understanding of product substitution trends across a range of industries. The study is approaching the entire question of energy consumption at a system level and part of this could include assessing the impact of changing product mixes.

The Carbon Road Maps could significantly improve understanding of sector barriers in the target sectors. The ability to engage with industry deeply on the topic of energy efficiency should allow for the issue of key barriers and enablers to evaluated in depth; possibly taking a case study or workshop approach to do this.

4. Approach for addressing the remaining gaps

In spite the planned initiatives, a series of gaps in the evidence base remain. This section considers approaches to overcoming these gaps.

4.1 Overview of options

There are two categories which have been adopted by this study to group data collection methods. Either information can be collected through an administered scheme or it can be gathered through research. The latter relates to a targeted data collection and analysis conducted at a single point in time. The former refers to a programmatic regular data collection routine, often administered by one or many central coordinating bodies that could be linked to wider disclosure requirements.

It is important to consider existing initiatives already in place and to retain flexibility where possible. This minimises the administrative burden. As a result the analysis considers whether existing schemes could be modestly amended and the improvements that this might achieve. Some methods are also better to implement as voluntary schemes rather than enforcing them.

The choice of an approach will be dependent on technical suitability and the usefulness of the data being collected. The more valuable the data, the more justifiable it is to make more significant interventions . Examples of different levels of intervention are set out in the following figure.

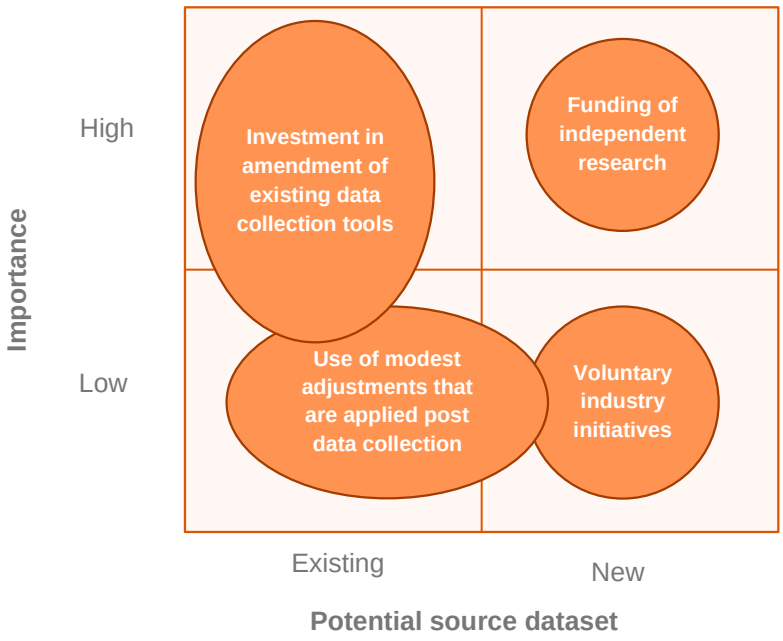

Figure 2: Example framework when considering methods to apply by parameter

An important aspect of driving engagement with any solution is ensuring appropriate incentives are incorporated. This might be the only means of gathering key information in some areas where data collection is arduous or sensitive.

4.1.1 Research options

Research options can generally be split into two categories: quantitative and qualitative approaches. The former is numerically based whilst the latter is non-numerical. The suitability of each approach is often linked to the degree to which quantifying a particular attribute is possible, coupled with any budgetary constraints that affect the extent of research. An overview of the main distinctions between the methods is included in the following table.

Table 13: Major distinctions between types of primary research

Research type	Quantitative	Qualitative
Type of research enquiry	Targeted, numeric	Exploratory, descriptive, explanatory
Nature of questions and responses	Who, what, when, why, how many? Relatively superficial and rational responses Measurement testing and validation	What, when, where, why? Exploration, understanding and idea generation
Sampling approach	Probability and non-probability methods	Non-probability methods (purposive)
Sample size	Relatively large	Relatively small
Data collection flexibility	Not very flexible Interviews and observation Standardised Structured More closed questions	Flexible Interviews and observation Less standardised More open ended and non-directive questions
Data collection scale	Numbers Less detail/ depth Context poor High reliability, low validity Statistical inference possible	Words, diagrams etc. Detailed and in-depth Context rich High validity, low reliability Statistical inference not possible
Cost	Relatively low cost per respondent Relatively high project cost	Relatively high cost per respondent Relatively low project cost

Examples of each method are set out below.

Table 14: Available primary research tools

Research Type	Quantitative	Qualitative
Research tools	Surveys (telephone, online, face to face, site surveys) Cross sectional studies Longitudinal studies Experimental studies Observation	Surveys (in-depth interviews - telephone, face to face) Case studies Workshops/ focus groups

There is little quantitative costs data available in the public domain for these types of data gathering exercises, as this information tends to be commercially confidential. Furthermore, the costs of research are tailored according to a wide variety of factors concerning individual projects, such as the research questions posed, target audience, methodology, levels of analysis and reporting amongst others. This means that applying cost estimates on as-yet-undefined research projects is of limited value.

What is possible is to provide some guidance on the relative magnitude of project costs associated with differing options, and these have been detailed in the sub-sections below as:

1. **Low** – for example, including qualitative research (e.g. case studies) and online surveys.
2. **Medium** – for example, quantitative research such as telephone surveys (e.g. with energy managers).
3. **High** – for example using site surveys to answer quantitative research questions.

In addition to this guidance, there are other sources of information available to DECC, but not in the public domain which would be of assistance in estimating the likely costs of research, which could be explored in order to help inform the development of future research. These include

1. **UK Shared Business Services Market Research framework**[2]: In July 2013 the UK SBS announced a call for the development of a market research framework, available for UK public bodies. Many commercial research providers working in the UK market have applied to be on this framework, and have submitted costs for numerous research methods through it. DECC could explore working with UK SBS to obtain an understanding of current research costs for basic methods through this route.
2. **DECC commissioned research**: DECC could work with their procurement teams to explore the costs of previously commissioned research of a similar nature. An advantage of this approach is that DECC has access to the costs of all submitted tenders, including the selected contractor, which would provide an excellent understanding of the range of costs from suppliers working on projects with similar scope and questions. Some recent, example studies, which would be of use include:
    - Pilot Research to update the evidence base for energy use and abatement in non-domestic buildings (2012/13).
    - Research to update the evidence base for energy use and abatement in non-domestic buildings (2013 – current).
    - Evaluation of the Renewable Heat Incentive (2013 – current).
    - Evaluation of the Green Deal (2013 – current)
    - Evaluation of the Carbon Reduction Commitment (2014 – current)

[2] UK SBS Market Research Framework 2014.

4.1.2 Administrative scheme options

An alternative to commissioning research is to harness data captured through mandatory or voluntary reporting schemes. Examples of current ongoing initiatives include European Union Emission Trading Systems (EU ETS), Climate Change Agreements (CCAs), Carbon Reduction Commitment Energy Efficiency Scheme (CRC) and Carbon Disclosure Project (CDP).

There are a number of major positives where data is gathered through such a scheme. All information captured will be consistent in terms of its scope, units and timescales etc. Much of the information submitted, particularly where it is for compliance, will be subject to quality assurance exercises. The information is also commonly submitted in regular time intervals i.e. annual or biennial, enabling trend analysis.

Such initiatives also have a number of weaknesses. These schemes are often prohibitively costly. There can be significant formal administration and wider running costs that are borne by the central administrator, as well as major hidden data collection and training costs that impact the scheme participants. Implementation of such schemes often requires extensive investment in the development of supporting guidance material and training. Marketing will also be needed to improve initiative awareness. Once set up these programmes are also difficult to change in terms of core routines and scope, without further significant investment.

4.2 Approaches to remaining gaps

4.2.1 Site-specific energy consumption

Understanding site characteristics (i.e. site processes, capacity etc.) coupled with energy usage and output statistics can be extremely useful. It enables the identification of trends and determining the significance of the impact of particular attributes on energy usage. It also allows sector distribution to be analysed, with outliers or performance clustering often providing strong case studies on how improvements can be achieved. Whilst the improved CCA reporting requirements should in theory provide some additional site-specific data, the overall impact on the evidence base will be small.

At the Phase 2 workshop approaches to remedying this gap were discussed. Opinions varied significantly on the approach to take. The main proposal was to undertake a remote data collection exercise targeted at site engineers. This would gather data remotely on the subsectors concerned and attempt to capture the information needed for site classification purposes as well as the energy data.

A number of concerns were raised however. Industry stressed that confidentiality and data sensitivity would be a major barrier to engagement. This would be a particular issue in those sectors which are relatively homogenous and concentrated. Competitors might be able to identify companies even where data is anonymised. Industry representatives also noted that in some cases the level of contextual detail needed to classify a site would effectively be impossible to gather remotely. Some respondents also believed further research on the smaller, less significant sectors would never justify the effort required to gather the information.

The recommendations, following the workshop and further investigation, are summarised in the following table.

Table 15: Site data recommendations

Recommendation	Type	Description	Cost	Further considerations
Amend CCA data to cover site level information[3]	Administrative	Gather site data in CCA submissions as opposed to "bubbled" CCA data	High – This introduces immediate scheme design costs as well administrative costs on scheme participants. It should be noted however that facility level data will already be being gathered by participants.	Industry were concerned with confidentiality risks Would only affect sectors covered by CCAs
Remote surveys targeting energy managers	Research	Gather site data using a remote survey exercise. This would rely on data collection using a data collection sheet, in MS Excel for instance, as opposed to other remote surveying techniques, such as tele-surveying. A data collection sheet is preferred because it allows the respondent time to gather the relevant data. Much of the information will also be highly technical and hence difficult to communicate over a phone. Each data collection sheet would need sector tailoring.	Medium - Remote survey data collection methods can be implemented relatively cost effectively. It should be noted that often further primary data collection (site surveys) are required to authenticate data. The remote survey costs alone might range between £50 to £150 per data point. These costs do not include wider programme delivery costs, which will be significant. Such exercises need to have minimal industry cost. Remote surveying activity would have to be limited to information that could be gathered within 1 – 2 hours.	Industry were concerned with confidentiality risks. They were also uneasy because the information needed would have to be very detailed and tailored to sector Part of FDF preparation for CCA target setting process they successfully and efficiently undertook a data collection exercise gathering similar information to that which would be sought. The team consider this to be a strong case study on how to implement the method. Incentivising participation is the key challenge, along with finding means to minimise response bias. In the absence of industry wide support Government could instead try to engage a smaller representative number of firms. Data collection could be combined with a few site surveys. These could also be used as an incentive.

[3] As of the Budget 2014 the CCL exemption for Mineralogical and Metallurgical processes could lead a significant loss in data coverage

4.2.2 Sector applicability of abatement measures

The condition of current plant, technology applicability and their performance by sector are essential to modelling abatement potential. This information enables government to determine what reductions each measure could achieve by mapping out current stock conditions. It also ensures savings are not overstated where sector specific attributes restrict the extent or effectiveness of a particular measure.

All participants of the workshop recognised the importance of these datasets. Several recommendations were made on how data could be sourced:

- **Site condition survey:** One respondent emphasised the need for detailed site condition surveys. There are precedents for such initiatives in the UK (those led by the former Energy Technology Support Unit, for instance) and although expensive they can be hugely informative. Industry representatives cautioned that for such analysis to include all the significant permutations of differing operational characteristics, it will be necessary to undertake a substantial number of audits.
- **Working through trusted partners:** For energy technology costs participants recommended approaching industry/ trade associations for input. Manufacturers of technologies were considered to be biased. Manufacturers also do not include all the costs of implementation (e.g. civil engineering, foundations, costs of stopped/interrupted production).
- **Setting in place best practice:** One workshop participant recommended disseminating guidance on how to collect expert views. This would mean the information could be catalogued and added to the evidence based rather than being done in isolation. Others agreed adding that this could be done in connection with plant condition data. This helps in understanding the scope for new technologies.

The recommendations, following the workshop and further investigation, are summarised in the following table.

Table 16: Technology performance recommendations

Recommendation	Type	Description	Cost	Further considerations
Site condition survey	Research	Undertake site condition surveys	High – Estimating cost of site condition surveys is dependent on the outputs required and the complexity of the operations being assessed. On small scale light industrial activities a basic audit could cost between £3,000 to £5,000. In contrast, costs for a comprehensive audit for more complex or larger more energy intensive sites are likely to be between £25,000 to £35,000.	Industry were concerned with confidentiality risks Industry were also concerned that the information needed would have to capture a significant range to cover all operational variances Considered the most robust technical method to gathering information

Recommendation	Type	Description	Cost	Further considerations
			For heavy industry the costs could be an order of magnitude greater again. These costs do not include wider programme delivery costs.	
Remote surveys targeting energy managers	Research	Gather site data using a remote survey exercise	Medium - Remote survey data collection methods can be implemented relatively cost effectively For a fuller analysis, please refer to table 15.	Industry were concerned with confidentiality risks Industry were also concerned that the information needed would have to be very detailed and tailored to sector
Coordinated research with trade associations	Administrative	Work with industry stakeholders to gather information on technology costs/ performance	Medium – Requires establishment of central administration body to gather information	Overcome biases typically associated with data sourced from manufacturers
Energy technology database	Administrative	Sets in place a standard method for capturing information on technology performance	Medium- Requires the establishment of a central database and communication of the scheme	Creating an open platform could become strong basis for wider data sharing on energy efficiency

4.2.3 Barriers and enablers

Understanding barriers and enablers allows government to pinpoint which policy interventions are likely to result in implementation of energy efficiency opportunities. The more it is possible and viable to quantify the effect of a particular factor, the more proportionate the associated policy measure can be.

All workshop attendees recognised that understanding of barriers and enablers remained an area where progress was limited and discussions often felt repetitive.

Overall attendees favoured qualitative methods for data collection. Several cited past work involving industry case studies or remote surveys through which rankings could be used to identify the relative significance of barriers and enablers.

One workshop attendee cautioned against attempting to quantify all barriers. Whilst in principle some barriers are quantifiable (hidden costs, payback periods etc), most were considered not. Even those that could be quantified often need extensive qualitative context (e.g. on capital budgeting procedures, physical plant layout, sector growth prospects).

All respondents recommended using industry engagement as a means to gather information, but to succeed it is important that any such activities are structured, planned and transparent. One of the issues in previous engagement exercises has been that records have not been readily available to review the scope of what was discussed and thereby better understand the context associated with any recommendations.

One recommendation was that instead of taking a sector perspective, it might be more appropriate to look 'horizontally' across sector specific roadmaps to identify common technologies, e.g. renewable heat. By approaching the issue in such a way it may be possible to focus efforts on key technologies/processes.

One respondent stressed the importance of capturing alternative investment opportunities as a barrier. In many instances energy was not invested in due to a combination of capital scarcity, competing priorities and more immediate available returns from core business activities.

The recommendations, following the workshop and further investigation, are summarised in the following table.

Table 17: Barrier and enabler recommendations

Recommendation	Type	Description	Cost	Further considerations
Case study development	Research	Undertake site interviews to develop case studies	Medium - Such surveys may be more efficient to deliver than technical site audits. A proxy of £3,000 to £5,000 per site should be reasonable.	Demonstrated in past major studies as effective means of gathering barrier data
Remote surveys targeting energy managers	Research	Gather barrier and enable data using a remote survey exercise	Medium - Remote survey data collection methods can be implemented relatively cost effectively. For a fuller analysis, please refer to table 15.	Typical approach to gathering information on barriers and enablers. Analysis is often limited to ranking activities
ECA applicant survey	Research	Target ECA applicants to understand rates of implementation by technology type	Medium – Remote survey data collection methods can be implemented relatively cost effectively	Sample will be restricted to technologies covered by ECAs A similar study, with a wider scope, was previously undertaken successfully by Carbon Trust and should provide indication of cost Data could be used to quantify the impact of barriers and enablers. Similar studies have done so in US and Germany.
Planned industry/technology workshops	Administrative	Sets in place a standard regular industry consultation events	Low - Requires the marketing and hosting of an event	Meeting transcripts will need to be taken and disseminated Workshops could be facilitated with “on the day” surveys of participants

4.2.4 Lack of input – output data

Because the UK does not mandate that companies must disclose information on stock inputs and outputs, modelling sector activity and gross value added is complicated. The lack of this data means that it is difficult to assess which sectors should be prioritised in terms of abatement investment. It also complicates life cycle emission modelling and understanding the role of industrial ecology in introducing more sustainable business models.

A number of workshop attendees stressed the importance of this data for robust macroeconomic analysis. However, it was recognised that data gathering would only begin if there was a fundamental change in policy. One participant did note that in the absence of official data, academic are devising methods of producing intermediary solutions.

The recommendation, following the workshop and further investigation, are summarised in the following table.

Table 18: Lack of input - output data

Recommendation	Type	Description	Cost	Further considerations
Gather input – output data	Administrative	Initiate a policy change to re-introduce input-output data requirements	Very High – Requires a major investment to initiate	
Generate input – output data substitute methods	Research	Undertake academic research exercises to gather and model useable data that substitutes for input-output data	Medium – High – The project team have a limited understanding of what these activities may entail and the degree to which costs may reduce over time	

4.2.5 Compounding of errors

A major issue identified in Phase 1 of the study was the compounding of errors/ assumptions and degree to which this could be adequately quantified. A number of key models often base their inputs from prior work and/ or consultation exercises. Understanding the quality of source information is often difficult to determine. Furthermore, where multiple assumed input parameters affect an output parameter the effect of the uncertainty may not be clearly communicated.

There was not sufficient time at the workshop to discuss mitigating steps to deal with this issue.

The recommendation, following the workshop and further investigation, are summarised in the following table.

Table 19: Compounding of errors recommendation

Recommendation	Type	Description	Cost	Further considerations
Setting out a clear protocol to improve transparency of calculation process	Administrative	Set in place a consistent policy to aide documentation of	Low – This should be considered good practice documentation	Different levels of analysis could be applied. Extensive sensitivity analysis by each parameter could be costly

		key assumptions and the effect on uncertainty		depending on the scope of works recommended

4.2.6 Improved classification

A further technical issue which affects analysis is a lack of appropriate energy-related industry classifications at a number of levels. At the macro-level, serious deficiencies in SIC (2007) codes were noted, where sometimes disparate sectors were aggregated together. The ceramics industry cited that many statistics stated there were several hundred UK tile makers. In reality the market is dominated by a small number of large firms and the remainder are bespoke production outfits. The food and drinks industry cited similar issues where SIC codes could lead to the combining of very different activities.

There was not sufficient time at the workshop to discuss mitigating steps to deal with this issue.

The recommendation, following the workshop and further investigation, are summarised in the following table.

Table 19: Improved classification recommendation

Recommendation	Type	Description	Cost	Further considerations
Improved classification	Research	Initiate research to assess the impact of coarse classification and identify sectors most affected. This could identify how this issue might be accounted for and mitigated against in future analysis	Medium – This would require an expert desk-based review	Workshop participants had cited that similar analysis has already been undertaken for DEFRA in the past but no reference was quoted. If sourced, this project could provide an indication of costs.

4.3 Summary of recommendations

A summary of the key recommendations is included in the following table.

Table 20: Summary table for recommendations

Gap	Recommendation	Type	Description	Cost
Site specific energy consumption	Amend CCA data to cover site level information	Administrative	Gather site data in CCA submissions as opposed to bubbled CCA data	High
	Remote surveys targeting energy managers	Research	Gather site data using a remote survey exercise	Medium
Sector applicability of abatement measures and the performance and cost of these	Site condition survey	Research	Undertake site condition surveys	High
	Remote surveys targeting energy managers	Research	Gather site data using a remote survey exercise	Medium
	Coordinated research with trade associations	Administrative	Work with industry stakeholders to gather information on technology costs/performance	Medium
	Energy technology database	Administrative	Sets in place a standard method for capturing information on technology	Medium

Gap	Recommendation	Type	Description	Cost
			performance	
Barriers and enablers	Case study development	Research	Undertake site interviews to develop case studies	Medium
	Remote surveys targeting energy managers	Research	Gather barrier and enable data using a remote survey exercise	Medium
	ECA applicant survey	Research	Target ECA applicants to understand rates of implementation by technology type	Medium
	Planned industry/technology workshops	Administrative	Sets in place a standard regular industry consultation events	Low
Lack of input – output data	Gather input – output data	Administrative	Initiate a policy change to re-introduce input-output data requirements	Very High
	Generate input – output data substitute methods	Research	Undertake academic research exercises to gather and model useable data that substitutes for input-output data	Medium
Compounding of errors	Setting out a clear protocol to improve transparency of calculation process	Administrative	Set in place a consistent policy to aide documentation and communication of key assumptions and the cumulative effect on uncertainty	Low
Improved classification	Improved classification	Research	Initiate research to assess the impact of coarse classification and identify sectors most affected	Medium

5. Consideration on steps to improve the evidence base

The analysis has considered the current quality of the evidence base, the impact of planned initiatives and also the range of options available for each the remaining data gaps. The findings below will set out how these might be combined to cost effectively improve the evidence base.

5.1 Identification of packages

Each of the recommended methods were incorporated into the database. The impact on each parameter by sector was modelled. Cost indicators were also included to account for the potential constraints in implementing any given method.

The inclusion of cost scenarios enables the modelling different thresholds for intervention and the resultant impact. For instance, the team is able to forecast the effect of implementing only low or medium cost measures versus pursing higher cost intervention.

For each cost bracket it is possible to determine the most effective intervention. Each of the approaches was vetted in terms of the general quality performance, as set out below, and tailored for each parameter. On this it is possible to apply the weighting analysis to determine the recommended approach. The outputs are then subject to a further review by the consultant team to ensure the recommendations seem reasonable.

Table 21: Data quality by option (1 is high, 4 is low)

Gap	Recommendation	Adapted Maryland rating	Research design quality		Research delivery quality	Indepen-dence	Source
			Scale	*Repr.*			
Site data	Amend CCA data to cover site level information	1	1	1	1	1	1
	Remote surveys targeting energy managers	1	2	2	1	1	4
Sector applicability, technology maturity, condition of current plant	Site condition survey	1	1	1	1	1	1
	Remote surveys targeting energy managers	2	2	2	1	1	3
	Coordinated research with trade associations	2	2	2	1	2	4
	Energy technology database	1	2	2	2	2	4
Barriers and enablers	Case study development	4	3	2	1	1	1
	Remote surveys targeting energy managers	2	2	2	1	1	3
	ECA applicant survey	2	2	2	1	1	1
	Planned industry/ technology workshops	4	2	2	1	1	2

Where recommendations did not relate directly to research questions i.e. the implementation of input - output data, it is recommended that these are considered on a case by case basis.

5.2 Preferred methods by cost bracket

The recommended measure in its cost bracket is set out below.

Table 22: Preferred methods by cost bracket

Gap	Best dataset		
	Low cost	*Medium cost*	*High and very high cost*
Site-specific energy consumption	N/A	Remote surveys targeting energy managers	For CCA sectors: Amended CCA data to cover site level information For non-CCA sectors: Remote surveys targeting energy managers
Sector applicability and technology performance	Coordinated research with trade associations	Remote surveys targeting energy managers	Site condition survey
Technology maturity	Coordinated research with trade associations	Remote surveys targeting energy managers	Remote surveys targeting energy managers
Condition of current plant	Coordinated research with trade associations	Remote surveys targeting energy managers	Site condition survey
Sector specific barriers	Planned industry/ technology workshops	Remote surveys targeting energy managers	Remote surveys targeting energy managers
Sector specific enablers	Planned industry/ technology workshops	Remote surveys targeting energy managers	Remote surveys targeting energy managers
Technology specific barriers	Planned industry/ technology workshops	Remote surveys targeting energy managers	Remote surveys targeting energy managers

Low cost methods primarily focus on harnessing industry engagement exercises to encourage collaboration and enable collective agreement on appropriate common methods for the recording of data. This method, whilst cost effective could lead to significant bias in some instance and may only lead to limited quantification of key parameters. There is also a reasonable cost that participants would bear and the entire approach is very much dependent on industry and academia being engaged and supportive of the initiative.

Medium cost methods focus on the implementation of a structured remote survey initiative. The Food and Drink Federation showed in their preparation for the CCA target setting process that it is possible to construct a reasonable evidence base using submitted data from sites. It is worth emphasising however, that the negotiation provided a pressing driver for engagement within the industry. This may not be the case if an initiative was primarily research-driven. Such an approach will also be significantly restricted in the complexity of data that can be gathered and/or the degree to which data can be validated. It is likely that there would be a number of significant concerns raised on the sensitivity of the data being gathered.

The high cost method is a blended solution of remote surveys, sites surveys and also improved administrative data where it is available. In this final arrangement, site surveys provide the detailed energy abatement data. Other sources provide the representative data on energy consumption and barriers.

5.3 Taking a programmatic approach

Government may consider taking a programmatic approach to improving the evidence base. Many key parameters associated with evidence base will vary significantly over time. It might be desirable therefore to initiate an ongoing evidence base review programme, following an initial large scale evidence gathering exercise.

This could take the form of regular planned industry engagement exercises. Once every two years, a substantial workshop could be undertaken which review key parameters used for modelling. This could include information on technology performance, penetration and costs as well as data relating to barriers and enabling factors.

The event findings would be recorded in a structured manner. Many of the issues encountered in the past on such workshops, is that the records cannot be sourced. The evidence base for key parameters may be limited.

Undertaking such exercises could be a cost effective means of ensuring data on the industry remained relevant. It should also have wider benefits of fostering a culture of collaboration between industry and government. It will be however be highly dependent on an active and engaged trade association to support the events success.

5.3.1 Example approach

The study team recommend tailoring the approach to the scale of the sector concerned. For larger, more significant sectors site audits are the only means of truly understanding abatement potential because of the complexity and scale of the operations. For less energy-intensive operations, there is evidence that simpler, lower cost data collection methods would be viable.

The table below and the subsequent graphic outline how these categories could be applied in practice. In this scenario 78% of industrial consumption is subject to high cost intervention measures, 20% to medium cost intervention measures and the remaining 2% to low cost measures.

Table 23: Cost bracket applied by sector

Sector	Energy consumption (ktoe)	Research cost category
Manufacture of Coke, Refined Petroleum Products …	8,550.1	High
Manufacture of Chemicals and Chemical Products	4,595.8	High
Manufacture of Food Products and Beverages	3,300.0	High
Manufacture of Basic Metals	2,727.2	High
Manufacture of Other Non-metallic Mineral Products	2,701.2	High
Manufacture of Pulp, Paper and Paper Products Publishing …	1,991.0	High
Manufacture of Rubber and Plastic Products	1,887.6	High
Manufacture of Motor Vehicles, Trailers and Semi-trailers	934.6	Medium
Manufacture of Fabricated Metal Products, Except Machinery …	899.9	Medium
Manufacture of Wood and Wood Products	887.4	Medium
Manufacture of Textiles	819.6	Medium
Publishing, Printing and Reproduction of Recorded Media	604.9	Medium
Manufacture of Machinery and Equipment …	600.5	Medium
Manufacture of Furniture; Manufacturing Not Elsewhere Classified	547.8	Medium
Manufacture of Other Transport Equipment	447.9	Medium
Manufacture of Electrical Machinery and Apparatus …	436.3	Medium
Other Mining and Quarrying	418.4	Medium
Manufacture of Radio, Television and Communication …	265.2	Low
Manufacture of Medical, Precision and Optical Instruments …	240.9	Low
Manufacture of Wearing Apparel; Dressing and Dyeing of Fur	121.3	Low
Manufacture of Office Machinery and Computers	44.9	Low
Tanning and Dressing of Leather; Manufacture of Handbags…	39.8	Low
Manufacture of Tobacco Products	20.4	Low

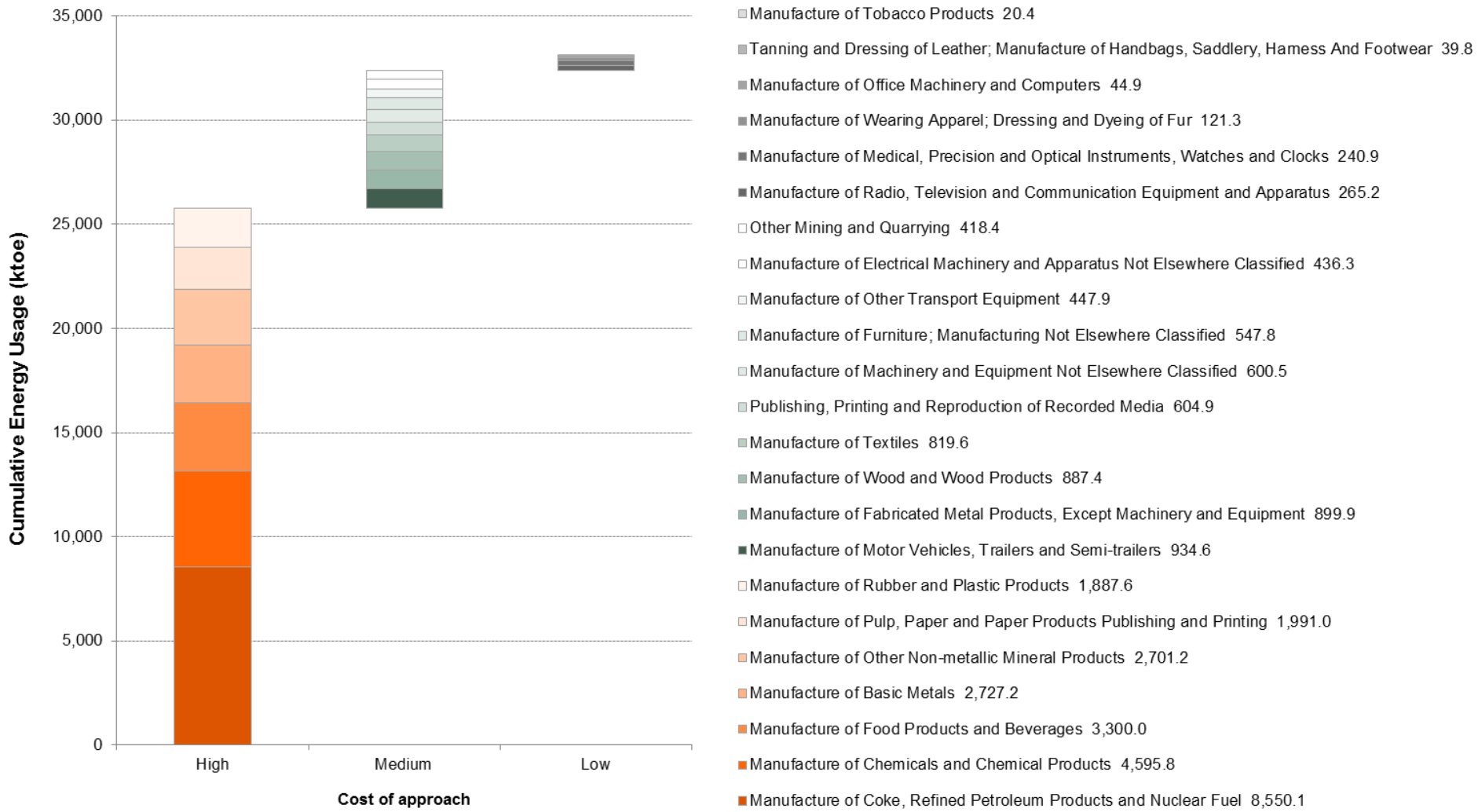

Figure 3: Cumulative energy consumption grouped by research costs

The activity schedule could therefore be as follows;

Table 24: Example of activities by sector

Sector	Initial data collection exercise			Subsequent data maintenance
	Energy trends	*Abatement potential*	*Barriers*	
Processing and preserving of meat and production of meat products	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Processing and preserving of fish crustaceans and molluscs	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Processing and preserving of fruit and vegetables	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of vegetable and animal oils and fats	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of dairy products	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of grain mill products starches and starch products	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of bakery and farinaceous products	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of other food products	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of prepared animal feeds	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of beverages	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years

Sector	Initial data collection exercise			Subsequent data maintenance
	Energy trends	*Abatement potential*	*Barriers*	
Manufacture of tobacco products	Coordinated research with trade associations	Coordinated research with trade associations	Planned industry/ technology workshops	Further workshop every 4 years
Manufacture of textiles	Remote surveys targeting energy managers	Remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of wearing apparel	Coordinated research with trade associations	Coordinated research with trade associations	Planned industry/ technology workshops	Further workshop every 4 years
Manufacture of leather and related products	Coordinated research with trade associations	Coordinated research with trade associations	Planned industry/ technology workshops	Further workshop every 4 years
Manufacture of wood and of products of wood and cork except furniture manufacture of articles of straw and plaiting materials	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of paper and paper products	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Printing and reproduction of recorded media	Remote surveys targeting energy managers	Remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of coke and refined petroleum products	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of chemicals and chemical products	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of basic pharmaceutical products and pharmaceutical preparations	Coordinated research with trade associations	Coordinated research with trade associations	Planned industry/ technology workshops	Further workshop every 4 years
Manufacture of rubber and plastic products	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of other non-metallic mineral products	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years

Sector	Initial data collection exercise			Subsequent data maintenance
	Energy trends	*Abatement potential*	*Barriers*	
Manufacture of basic metals	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of fabricated metal products except machinery and equipment	Site condition survey and remote surveys targeting energy managers	Site condition survey and remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of computer electronic and optical products	Coordinated research with trade associations	Coordinated research with trade associations	Planned industry/ technology workshops	Further workshop every 4 years
Manufacture of electrical equipment	Remote surveys targeting energy managers	Remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of machinery and equipment n e c	Coordinated research with trade associations	Coordinated research with trade associations	Planned industry/ technology workshops	Further workshop every 4 years
Manufacture of motor vehicles trailers and semi-trailers	Remote surveys targeting energy managers	Remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of other transport equipment	Remote surveys targeting energy managers	Remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Manufacture of furniture	Remote surveys targeting energy managers	Remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years
Other manufacturing	Remote surveys targeting energy managers	Remote surveys targeting energy managers	Site case studies survey and remote surveys targeting energy managers	Further workshop every 2 years

In the above recommendations there is a high reliance on remote surveys to gather data. Incentivising participation in this approach is the key challenge, along with finding means to minimise response bias. In the absence of industry wide support Government could instead try to engage a smaller representative number of firms.

By focusing on fewer firms, it could be possible to invest greater resources per organisation in securing buy in. This might make it easier to overcome some of the barriers to engagement, such as data confidentiality, by allowing for the appropriate legal agreements to be setup on a firm by firm basis. Engaged participants could also be provided with bespoke study outputs, which could support their own internal energy management processes.

Remote data collection would need to be supported by a small number of expert site surveys. These could be used as an incentive for participation, with site surveyors producing outputs for the site as well as for the study.

5.4 Scope for cross cutting analysis

The study was unable to analyse energy efficiency issues in any way other than taking a sectoral approach. The key reason for this is that much of the literature in the field is presented on a sectoral basis. The entire evidence base therefore reinforces taking a sectoral approach as opposed to an alternate means of understanding the energy efficiency, such as on technology or on a process basis.

The team gathered data for instance on common technologies across industries, but often it was difficult to compare this data as it would be presented in a sector specific manner. Key performance metrics, for instance, would be normalised against sector specific consumption metrics. This is an endemic problem in sectors where energy usage will be closely linked to production volumes of specific products.

Adopting any approach beyond the sectoral perspective is therefore fundamentally constrained by precedent research to date and the sector characteristics of industrials. In theory, this might be overcome, if reports transparently and consistently presented the underlying data behind key parameters. The protocol for measure reporting should be designed to enable researchers to identify the technology performance potential in a consistent manner across sectors by use of a common metric, possibly Gross Value Added for instance.

6. Conclusions

As outlined above, the comparison of the current evidence base on UK industrial energy efficiency (developed in Phase 1 of the study) with a theoretical, best practicable quality evidence base, identified a number of thematic gaps, as shown in the second column of the table below.

The potential impact of the following planned initiatives was then examined:

- Changes to Climate Change Agreements to capture more detailed registry data
- Carbon Roadmaps: Government-commissioned studies to map out baseline emissions to 2050
- Electricity Demand Reduction pilot: a scheme to encourage organisations to deliver firm, verifiable energy savings
- SusTEM (Sustainable Thermal Energy Management network): an academic network whose objective is to enhance the study and utility of efficient thermal energy management in the process industries
- UK INDEMAND (RSUK Energy): a five year programme mapping current forecasts for material and energy demand across sectors, highlighting opportunities for reduction

The impact of these initiatives is summarised in the third column of the table below.

Table 25: Summary of changes in the evidence base with inclusion of planned initiatives

Research question	Thematic gaps	Impact of planned initiatives
Energy trends	Site specific energy consumption	Small improvement
	Product substitution	Possible improvement
Abatement potential	Sector applicability	Significant improvement in few sectors
	Technology maturity	Significant improvement in few sectors
	Condition of current plant	Significant improvement in few sectors
	Technology cost data	Significant improvement in few sectors
Barriers	Sector specific barriers	Some improvement in few sectors
	Sector specific enablers	No change
	Technology specific barriers	Some improvement in few sectors

It may be possible to achieve more significant improvements in the evidence base from these initiatives. For example, the project team's understanding of the current scopes of INDEMAND and the Carbon Road Maps initiatives is limited. Both could in theory offer significant benefits beyond those recognised in this study.

6.1 Recommendations

Despite the impact of relevant planned initiatives, a series of gaps in the evidence base are likely to remain. There are two categories of data collection method by which remaining gaps can be addressed: through an administered scheme; or through research. The latter relates to a targeted data collection and analysis conducted at a single point in time. The former refers to programmatic regular data collection, often administered by one or many central coordinating bodies that could be linked to wider disclosure requirements.

It is important to consider existing initiatives and to retain flexibility to minimise administrative burden. As a result, the analysis considers whether existing schemes could be modestly amended and the improvements that this might achieve. Some methods are also better to implement as voluntary rather than mandatory schemes.

The choice of an approach will be dependent on technical suitability and the usefulness of the data being collected. The more valuable [4]the data, the more justifiable it is to make more significant interventions. A summary of the key recommendations is included in the following table.

Table 26:Summary table for recommendations

Gap	Recommendation	Type	Description	Cost
Site specific energy consumption	Amend CCA data to cover site level information	Administrative	Gather site data in CCA submissions as opposed to bubbled CCA data	High
	Remote surveys targeting energy managers	Research	Gather site data using a remote survey exercise	Medium
Sector applicability of abatement measures and their performance and cost	Site condition survey	Research	Undertake site condition surveys	High
	Remote surveys targeting energy managers	Research	Gather site data using a remote survey exercise	Medium
	Coordinated research with trade associations	Administrative	Work with industry stakeholders to gather information on technology costs/performance	Medium
	Energy technology database	Administrative	Sets in place a standard method for capturing information on technology performance	Medium
Barriers and enablers	Case study development	Research	Undertake site interviews to develop case studies	Medium
	Remote surveys targeting energy managers	Research	Gather barrier and enable data using a remote survey exercise	Medium
	ECA applicant survey	Research	Target ECA applicants to understand rates of implementation by technology type	Medium
	Planned industry/technology workshops	Administrative	Sets in place a standard regular industry consultation events	Low
Lack of input – output data	Gather input – output data	Administrative	Initiate a policy change to re-introduce input-output data requirements	Very High
	Generate input – output data substitute methods	Research	Undertake academic research exercises to gather and model useable data that substitutes for input-output data	Medium
Compounding of errors	Setting out a clear protocol to improve transparency of calculation process	Administrative	Set in place a consistent policy to aide documentation and communication of key assumptions and the cumulative effect on uncertainty	Low
Improved classification	Improved classification	Research	Initiate research to assess the impact of coarse classification and identify sectors most affected	Medium

[4] The value of the data might be determined by either the proportion of the sector's emissions or energy consumption of the all industrial activities (as is applied later in the report) or by using other metrics such as Gross Value Added per tonne of CO_2 to prioritise sectors.

The table below sets out how these individual recommendations might be combined into “packages” with different relative cost levels.

Table 26: Preferred methods by cost bracket

Gap	Best dataset		
	Low cost	*Medium cost*	*High and very high cost*
Site-specific energy consumption	N/A	Remote surveys targeting energy managers	For CCA sectors: Amended CCA data to cover site level information For non-CCA sectors: Remote surveys targeting energy managers
Sector applicability and technology performance	Coordinated research with trade associations	Remote surveys targeting energy managers	Site condition survey
Technology maturity	Coordinated research with trade associations	Remote surveys targeting energy managers	Remote surveys targeting energy managers
Condition of current plant	Coordinated research with trade associations	Remote surveys targeting energy managers	Site condition survey
Sector specific barriers	Planned industry/ technology workshops	Remote surveys targeting energy managers	Remote surveys targeting energy managers
Sector specific enablers	Planned industry/ technology workshops	Remote surveys targeting energy managers	Remote surveys targeting energy managers
Technology specific barriers	Planned industry/ technology workshops	Remote surveys targeting energy managers	Remote surveys targeting energy managers

- **Low cost packages** primarily focus on harnessing industry engagement exercises to encourage collaboration and enable collective agreement on appropriate common methods for the recording of data. Whilst cost-effective, this could lead to significant bias in some instance and may only lead to limited quantification of key parameters. There is also a reasonable cost that participants would have to bear and the entire approach is very much dependent on industry and academia being engaged and supportive.
- **Medium cost packages** focus on the implementation of structured remote surveys. The Food and Drink Federation showed in their preparation for the CCA target setting process that it is possible to construct a reasonable evidence base using data submitted from sites. It is worth emphasising however, that the negotiation provided a pressing driver for engagement within the industry. This may not be the case if an initiative was primarily research-driven and participants received genuinely useful outputs as part of the engagement process. Such an approach will also be significantly restricted in the complexity of data that can be gathered and/or the degree to which data can be validated. It is likely that there would be a number of significant concerns raised on the sensitivity of the data being gathered.
- **The high cost packages** are a blended solution of remote surveys, on-site surveys and also improved administrative data where it is available. In this final arrangement, site surveys provide the detailed energy abatement data. Other sources provide the representative data on energy consumption and barriers.

Government may consider taking a programmatic approach to improving the evidence base. This would cover an initial data gathering exercise where a set of common, appropriate and proportionate data collection methods are used initially to gather point in time data. It is noted that many key parameters associated with the evidence base will vary significantly over time. As part of the programmatic approach it might be desirable therefore to initiate an ongoing evidence base review process.

The team conclude that it is difficult to analyse industrial energy efficiency issues in any way other than by taking a sectoral approach. The key reason for this is that much of the literature in the field is presented on a sectoral basis. Building on the current evidence base therefore reinforces the need for a sectoral approach as opposed to an alternate means of understanding the energy efficiency, for example on a technology- or process-specific basis. Where an alternative approach is taken therefore, it is likely to be at slightly greater cost, to overcome legacy structural effects.

Appendix A: Research workshop minutes

Industrial Energy Efficiency Evidence Base Review

Research Workshop - Thursday 23rd January 2014, 13:00 – 17:00

Department for Business, Innovation and Skills

Meeting Minutes

1 What are the challenges in maintaining a strong industrial energy efficiency evidence base?

The feedback identified two key areas. Firstly the current set of data sources are either missing key components or are flawed in their design and secondly capturing data on industrial energy use encounters a number of basic practical challenges.

- *The current set of data sources are either missing a key component or are flawed in their design:* A major concern was the lack of input output statistics. Linked to this was the fact that there is no obligation on firms for compulsory data disclosure that would aid the production of such statistics. The UK is exceptional in not having such data or processes.

  It was also recognised that common descriptions of industrial energy use were often restrictive or unhelpful. The SIC system for instance hides much of the underlying diversity.

  The design of existing legislation, each with its own scope, carbon factors and particular rules on reporting. Thisof6ten leads to confusion and has meant that these do not provide a holistic picture either in isolation or collectively.

  Official statistics i.e DUKES, are also increasingly aggregating data. This makes it difficult to attribute data to a particular sector.

- *Practical challenges:*
  The variety of industrial processes and complexity that emerges in "real life" means there is no single solution to the data challenge.
  There was also recognition that data is required at multiple levels i.e. aggregate by industry and then broken down into different product types and different processes. It also important to capture data beyond energy use, such as GVA or the interactions between sectors.
  Some datasets require constant updating to remain relevant and yet the cost to do so is prohibitive.
  Commercially sensitive is a major issue. Companies are therefore reluctant to share information with any external parties.
  One respondent noted that poor data on industrial energy efficiency is a generic problem, experienced globally – "the IEA has identified the industrial sector as particularly opaque in all countries". It is important when trying to understand this issue to determine which problem are UK specific and which are international.

Participants raised two other wider issues. Firstly there was a perceived lack of investment in the academic capabilities in this sector. Secondly, industry representatives highlighted that recent CCA negotiations had

been adversial, impacting on the scope for collaboration between government and industry.

2 Are there any further thematic gaps, which have not been identified?

The following additional gaps/issues were identified in the evidence base;

- *Data typology*
  This point related directly to the methods applied in this study but also more widely. A standard data typology is needed to identify and distinguish between data collection mechanisms. Distinctions should be made between administrative data (broader) versus very targeted data collection (specific for purpose)

- *Asset condition*
  The state of key energy using plant is not well understood. Condition data is needed

- *Commercial drivers*
  Further information is needed on alternative investment strategies available to corporates. Investment decisions in energy measures are not made in isolation and firms have restricted budgets. Furthermore data is needed on the effect of regulatory uncertainty on investment hurdle rates

- *Capability and approaches within Government*
  Some participants believed that data was not sufficiently shared across and within government departments. Furthermore, the approach and methods adopted by energy statisticians were questioned. There is a belief that their methods may not be aligned with standard statistical practices

- *Compounding of errors*
  There is a lack of transparency where data has been processed. At times data might be sourced from weak initial sources. It is also difficult to assess the compounding effect of a sequence of assumptions with differing confidence levels attached on the final output parameter

- *Improved classification*
  In some sectors the official classification methods are inappropriate for energy analysis. The Ceramics sector, for instance, cited the official statistics stating the existence of 200 tile manufacturers, whereas in reality there are 5. These disconnects need to be acknowledge and have accompanying narratives.

- *Stock level data*
  There is little information available on stock levels. There could be a lot of potential for recovery of product and therefore a reduction in the need of virgin material.

- *Inappropriate application of datasets*
  Users of economic datasets need to understand the energy scope associated with the information. The data may not automatically align with standard assumptions

- *Upstream emissions*

The analysis needs to be holistic. A major part of a products emissions can be up or downstream from the manufacturing

3 Are there any further initiatives either in the UK or abroad, from any source that will affect the evidence base?

The following further initiatives were identified and commented on;

- *UK INDemand:*
  A 5 year £37 million programme focused on how to reduce energy demand through changing practices. It includes approximately 20 researchers and 40 PhD students. BIS, DECC and other relevant departments are involved. It covers all industrial activities in terms of scope.
  One participant highlighted that IN DEMAND is more about systems and streams. If the interest is focused on equipment condition i.e. the potential for more effective motors etc., then the study will not be as appropriate. It is about the market structure, the material flows, the bigger picture – macro rather than micro

- *BIS/DECC Techno Economic feasibility study on CCS and CCU*
  Predominantly carbon focussed – but has implications for energy consumption. The study will establish the timeframe for leading technologies coming into commercial viability. Participants also noted that upstream power generation emissions clearly had a significant impact on emissions associated with the industrial sector

- *Glass Industry Roadmap*
  To be published imminently

- *UK Cement industry 2050 GHG Strategy*
  The study has already accounted for this report

- *EU project called "CARBON CAP". European Commission project imported emissions*
  This project is outside the scope of this study, as the report focus is on supply chain emissions. It was stressed by the participants that for some of these issues a systems view is imperative in terms of understanding where to focus

- *UNEP resource efficiency programme*

- *Carbon Disclosure Project*

- *WRAP Product Sustainability Forum*
  This programme considers an LCA approach and identifies hot spots in the supply chain

- *Solomon index for the refining sector*
  An example of where a trusted intermediary is allowed to gather data on an entire sector to produce respected benchmarking analysis

- *ETI programmes*
  It was felt this was more focused on generation (supply side) rather than efficiency (demand side) measures

- *Foresight City projects*
  These are run by the cabinet office

- *Carbon Trust energy audits database*
  Unfortunately this dataset quality is not high

- *RCUK report on industrial research*
  The study considered the initial workshop report but there is now a full report which has been produced

- *European Technology Platforms*

The impact of new initiatives identified by the study was considered to be as follows;

- *Carbon roadmaps*
  The cement sector was sceptical as to whether the study would identify further savings. The sector has already completed its own road maps.
  Food and beverage is a highly heterogeneous sector. The only common theme is that everyone produces edible products. The aggregation of data will need to reflect the heterogeneity. The study could also be a useful opportunity to get to better understand the scope for key technologies, such as biomass as use for a heat source or the electrification of heat
  The glass sector believed the carbon road maps would help formalise sector thinking on abatement potential
  Commonality between adjacent sectors needs to be identified by the study. It is important to ensure that these overlaps are picked up. The study will need to identify common themes and also take account of competing demands, for example, biomass.

- *CCA Changes*
  Industry was strongly against gathering site data, citing commercial risks and administrative burden. They also stated that site data in many case would not be that useful, as rarely can sites be easily compared and benchmarking processes might be more appropriate. Generally it was recognised that this issue was sector specific and views certainly differed on whether site level data was valuable

- *ESOS*
  Participants believed that the fact that data would possibly only need to be disclosed once every four years would mean it is too infrequent to be valuable.
  There were also concerns about potential commercial confidentiality risks, For example, using the temperature of the waste heat – competitors could calculate and infer a number of sensitive data points

- *EDR*
  The pilots are likely to be too site specific and hence unlikely to be representative of a sector at large

- *PROTEM is now called SUSTEM*
  It is a network of academic who are predominantly based in the north-east. It focuses on process technologies within the chemicals sector

4 What techniques or approaches could be applied to which gaps?

A series of questions were posed to identify the remedies for the key data gaps;

- *How can we gather site energy or normalisation data in sectors which are not highly regulated?*
  Some respondents believed these sectors were a distraction, requiring a substantial amount of effort to understand a small proportion of consumption.
  Others believed a crucial solution would lie in the incentives used. It would be imperative to clearly demonstrate the benefits of interaction
  One proposal was to target site engineers E.g. ask an energy manager – what is the distribution of energy use on site – process / space heating / lighting etc. These questions could be sent to the whole of industry. Time would need to be spent investigating who to target with these questions to get the best response rate.
  Industry cautioned however that it would be difficult to provide site data due to commercial sensitivities but aggregate data maybe could be submitted. Others pointed out that in highly consolidated sectors anonymising data alone (or even aggregate data) would not be satisfactory as individual firm performance could still be inferred. This would happen in sectors where there were only 2 or 3 industrial players

- *How can we record current technology performance and how this varies in each sector?*
  Capturing information on current technology condition would be valuable. There are good UK precedents for such studies.
  Participants also recommended capturing data on relative performance metrics, citing a recent UKERC output, “Industrial Energy Database”, as an example. For these normalised outputs to be effective regression analysis is needed to identify the drivers for consumption.
  Industry cautioned however that there was a lot of complexity involved in such analysis and distinctions would need to be made a granular level i.e. between different blast furnace types in the glass sector for instance, for it to be valuable. The ceramics sector also highlighted that product mix produced was also important as the processes vary significantly under different scenarios. The food and drinks sector emphasised the need to focus on common processes, site benchmarking would not be effective due all the previously stated factors
  Following the above comments, others disagreed, saying it was very much down to the sector i.e. its heterogeneity and also the accompanying narrative

- H*ow can we monitor the temporal aspects affecting abatement potential, such technology costs, performance and penetration over time?*
  For technology costs participants recommended approaching industry/ trade associations for input. Manufacturers of technologies were considered to be biased. Manufacturers also do not include all the costs of implementation (e.g. civil engineering, foundations, stopping production)
  On participant recommended disseminating guidance on how to collect expert views. This would mean the information could be catalogued and added to the evidence based rather than being done in isolation. Others agreed adding that this could be done in connection with plant condition data so as to have an idea of the opportunities available for the adoption of new technologies

- Is there some information on barriers which is more readily available than others?
  There was a common view that the discussion on barriers was often repetitive and did not progress substantially. The team recommended reviewing outputs from the EU BARRIERS project (Sorrell, Sussex). This systematically classified barriers and investigated them in 3 sectors: brewing, mech eng. and higher education
  One participant recommended that the best approach to understanding barriers is by using qualitative research. There were several studies in the 1990s, in the context then of "barriers to adoption of clean technologies"
  Others reiterated the lack of research in the alternative investment options open to firms beyond energy efficiency measures.

It was highlighted that Dr Nick Eyre (ECI, University of Oxford) is undertaking research on barriers to industrial energy demand reduction as part of the UKERC Industrial Energy Use Project

- *How can we quantify the impact of barriers/enablers by sector?*
  Industry recommended that collaboration between all parties was essential in improving the evidence base. As part of this Industry recommended that engagement be structured and planned and that consultations allow for sufficient time so that a thorough discussion of issues could be had

- *How can we quantify the impact of barriers/enablers by technology?*
  Some participants questioned the value of quantifying every barrier. Some barriers are quantifiable (in principle): hidden costs, payback periods etc. Most are not. Even the quantifiable ones need a lot of qualitative context, e.g. on capital budgeting procedures , physical plant layout, sector growth prospects. Others recommended looking 'horizontally' across sector specific roadmaps to identify common technologies, e.g. renewable heat.
  One participant recommended ranking barriers. This could be a useful alternative to obtaining insights on relative barriers without addressing need to specifically quantify which would be too difficult

- *How can we gather site heat generation and usage data in sectors?*
  Here workshop participants believed the only means to gather the information would be through site survey. Case studies of past work funded by Energy Technology Support Unit were cited as examples of how to do this

- *Lack of I/O data at aggregate level*
  The only means of beginning this would be through a fundamental change in policy and by instructing the Office of National Statistics to begin gathering data. One participant did note that in the absence of official data, academic are devising methods of producing intermediary solutions

- *Systems view is not taken*
  Some participants felt the entire research questions need to be framed in the context of industrial ecology, which is explicitly concerned with "whole system" approaches

- Energy statistician approaches are not consistent with wider standard statistical methods
  The participants stressed that this was a call for better integration of energy/economic data. This would allow for benchmarking, industry averages, best practice, demand reduction potential etc. They also highlighted that there is a need for better training/capacity building. Some participants believed that the home of integrated energy, material, economic data should be ONS.

- *Integration across stakeholders of work and data*
  One participant recommended a common data centre where information could be deposited. Others agreed but emphasised that it would need to be managed by an independent intermediary. One participant noted that it might be that TSB Energy Systems Catapult could play a role or help with this issue

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