Digital Technologies for Energy Management

Final Report

May 2019

Acknowledgements

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ClimateWorks

A non-governmental organization that works globally, ClimateWorks collaborates with funders, regional and research partners, and other climate leaders to strengthen philanthropy's response to climate change

The Carbon Trust

The Carbon Trust is an independent, expert partner of leading organisations around the world, helping them contribute to and benefit from a more sustainable future through carbon reduction, resource efficiency strategies and commercialising low carbon technologies.

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Digital Technologies for Energy Management

EXECUTIVE SUMMARY

Digital Technologies for Energy Management Executive Summary - 1 of 5

- Energy efficiency and energy management are crucial to combating climate change, as well as bringing financial benefit to the businesses that employ them. Measurement and control are key steps in improving energy management and reducing consumption. This review of Digital Technologies for Energy Management (DTEM) has found that DTEM are an essential component to support organisational energy strategies and, where correctly tailored to the organisation's need, can bring about significant carbon, energy and financial savings.
- For the purpose of this study we define DTEM to include smart energy meters, and tools that gather data from energy meters or sub-meters and use software to report and/or analyse that data, as well and using information collected to automatically control the building/process. They include both the software itself and the physical infrastructure (e.g. sensors) that enable management.
- DTEM can transform how we measure, monitor, and save energy. Energy management systems increasingly make use of digital technologies to make the process simpler, faster, and more effective. Advances in data, analytics and a greater degree of connectivity are leading to greater digitalisation, which increase accessibility, ease of use and the potential benefits.

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- Uptake and use of DTEM is inconsistent especially in developing economies, and in smaller organisations globally. And where DTEM are employed, systems may not be working to their full potential, or may be left in place unused or overridden.
- This study has examined five categories of DTEM: Energy Metering, Monitoring and Targeting; Building Automation Systems; Fault Detection and Diagnostic Systems; Automated System Optimisation; and Optimised Process Control.
- We have explored what could lead to higher user uptake of DTEM and increased energy savings. Specifically we considered whether improved information sources, such as buyers' guides, user guides, or comparison websites, would help overcome the barriers to uptake:
  - We examined the policy and market context for energy management in seven major developed and developing countries.
  - We reviewed awareness and attitudes to energy management via an online survey (301 respondents) plus 28 interviews across China, Germany, and South Africa.
  - We interviewed DTEM suppliers, and carried out a desktop review of widely available DTEM products.
- We have grouped the findings and conclusions into three key themes, which are the subject of the key sections of the report. These themes are summarised on the following three pages.

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Theme 1 - Better information would help convert the many potential DTEM buyers into actual users

- According to our survey non-users of DTEM typically monitor energy use manually, if at all, using manual meter readings and spreadsheet records. They are however aware of and interested in DTEM, but struggle to decide on the most appropriate products to choose, and to justify the required investment.
- We noted that even existing users of DTEM don't use the equipment to its full extent, and would benefit from advice on making best use of it, as well as when to upgrade.
- Potential (and current) users of DTEM told us that improved access to information would encourage uptake. There was a strong appetite for a buyer/users' guide and comparison websites for energy management technologies to help ensure they select the best solution. As part of this work a buyer/users' guide the Carbon Trust has created a microsite, which will serve as a hub for relevant information for prospective DTEM users.

Visit the DTEM buyers'/users' guide at www.carbontrust.com/DTEM

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Theme 2 - DTEM suppliers can facilitate increased uptake by demystifying the technology

- There are various challenges that companies face to make a robust business case for DTEM. Suppliers of DTEM can play an important role in overcoming these barriers, especially in relation to bridging the information gap.
- There is a wide diversity of suppliers and products, and DTEM presents a complex landscape for buyers to navigate. There can be confusion amongst buyers around the systems types, their features, benefits, and applicability, and who to approach for guidance. But there are opportunities for suppliers, both large and small, that can clearly articulate their product applications, tailor their offer and marketing to specific sectors, and provide tailored cost-benefit assessment calculators.
- Direct contact with service providers is not only the most popular source of information but also, by some margin, the most useful source for potential users considering DTEM. Trade shows are also important, as they offer face to face contact with suppliers. Direct contact can give the best opportunity to obtain a bespoke calculation of benefits to a particular company.

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Theme 3 - Targeted policy interventions would complement information provision, and facilitate higher uptake of DTEM

- Filling the information gap will not on its own guarantee higher uptake of DTEM. Supporting policy interventions are needed to increase DTEM adoption.
- Current and potential policy measures have been categorised as:
  - **Financial and mandatory**: To reduce energy price distortions or improve financial drivers to support the business case for energy efficiency and energy management.
  - **Financial and voluntary**: Financial incentives or subsidies for products or technical assistance to support companies implementing DTEM or wider energy management systems.
  - **Non-financial and mandatory**: For example, regulations that require organisations to report energy consumption, adopt energy management practices, or set targets for energy savings.
  - **Non-financial and voluntary**: These measures include education, capacity building, and awareness raising.
- Policy makers should take a structured approach to policy design to tackle the key challenges and increase the chances of success. At the same time increased uptake of DTEM can ease the successful implementation of further energy efficiency policies.

Digital Technologies for Energy Management

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1

Introduction

Energy efficiency and energy management are crucial to combating climate change

- Inefficient use of energy presents a critical source of GHG emissions, and much higher global energy efficiency is crucial to meet the emissions reduction goal set out in the UNFCC's Paris Agreement. The IEA estimates that to achieve a 2°C scenario, energy efficiency must account for 38% of total cumulative emissions reductions to 2060 (greater than the 32% projected for renewables)[1]. Global industry accounts for one third of global GHG emissions and 37% of the world's total final energy consumption, yet 60% of identified energy efficiency potential is still to be realised[2].

- Energy efficiency measures also have the potential to save trillions of dollars across the global economy. The many benefits of deploying energy efficiency include boosting industrial productivity, reducing energy poverty, and contributing to economic development. Crucially, energy efficiency brings the potential to decouple energy demand from economic growth. Over the past decades some of the major economies have shown that decoupling is possible. The energy intensity of the global economy continues to decrease. These positive developments represent an additional USD 2.2 trillion of value created from global energy reductions, which corresponds to twice the size of the Australian economy[3].

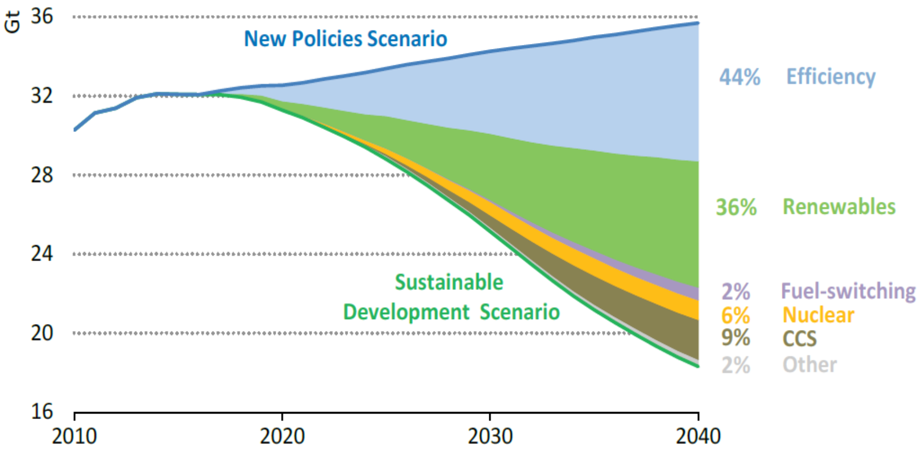


Fig 1. Global carbon dioxide (CO_2) emissions reductions in the WEO 2017 New Policies and Sustainable Development Scenarios

[1] IEA, 2017. Energy Technology Perspectives 2017. [2] IEA, 2012. World Energy Outlook 2012 (Potential based on efficiency scenarios to 2035). [3] IEA, 2017. Energy Efficiency

Measurement is a necessary first step in better energy management

> **Energy management is an increasingly important topic. It's implemented in our business strategy. However, we want to improve our energy management constantly**
>
> *Survey respondent, Germany*

- **Energy management** is a systematic approach to the management of energy use, which combines behaviour change among all employees, objective use of energy data to identify performance improvements, and technical improvements. This is important because it enables an organisation to reduce costs, reduce GHG emissions and minimise cost-related implications of carbon reduction policies e.g. carbon taxes. It simultaneously reduces risks connected to energy price increases or supply shortages, which all together influence a business' profitability[1].
- **Energy management systems (EnMS)** broadly refer to the structures and processes for industrial or commercial organisations to monitor energy use and improve their energy efficiency. It helps companies to systemise their energy management activities by utilising the Plan-Do-Check-Act process (see Figure 2). This approach includes, among others activities, setting up an energy strategy, monitoring and following up energy use, and raising competence and awareness of the energy issue among all employees[1].
- **ISO 50001** represents the global standard for energy management systems and is designed to be implemented by any organisation (public or private sector), irrespective of size, activity or geographical location. The standard does not set specific targets for improving energy performances. This means that any organisation, regardless of its current level of energy performance, can implement the standard to establish a baseline, which it can improve on at its own rate.

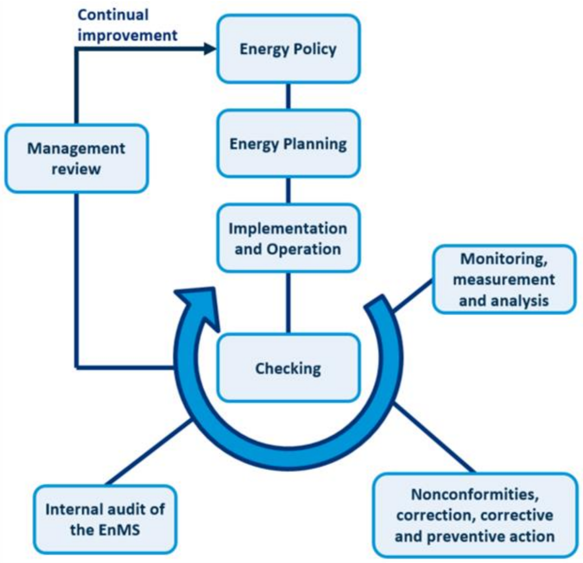


Fig 2. The Plan-Do-Check-Act process of an EnMS

[1]UNIDO, 2017. Energy Management System (EnMS)

Digital technologies for energy management (DTEM) can transform how we measure, monitor and save energy

- Consumers and businesses first need to understand their energy use and where opportunities for making savings lie, before they can make lasting energy efficiency improvements. Energy management systems can increasingly make use of digital technologies – harnessing the power and convenience of interconnection to make most aspects of energy management simpler, faster, and more effective. Advances in data, analytics and a greater degree of connectivity have supported the trend towards greater digitalisation, as have other key building blocks such as robotics, artificial intelligence and the Internet of Things[1].
- For the purpose of this study we define digital technologies for energy management (DTEM) as smart energy meters, and tools that gather data from energy meters or sub-meters and use software to report and/or analyse that data, as well and using the information collected to automatically control the building/process. They include both the software itself and the physical infrastructure (e.g. sensors) that enable management. DTEM have transformed how we measure and monitor energy use – and how we identify and make savings. Therefore, DTEM are key for an effective energy management system and energy strategy[1].
- Typically energy savings of approximately 5-10% are possible from engaging staff and changing behaviours, but these changes can be difficult to identify and/or execute and can be hard to maintain[2]. DTEM not only facilitate easily accessible energy monitoring but can identify and even automate some energy savings opportunities. By continually monitoring and optimising energy performance – and where feasible automating control and savings – DTEM help make energy savings more resilient to organisational changes[1].

[1] IEA, 2017. Digitalization & Energy. [2]Kahlenborn et al.,2012. Energy Management Systems in Practice.

For the purposes of this study, we have considered 5 categories of DTEM

Building on work done by the IEA[1] and Lawrence Berkley National Laboratory[2] a taxonomy comprising the following five categories was developed for this study. Market research determined awareness and uptake across the various categories.

	Buildings	Industry	
	✓	✓	**Energy Metering, Monitoring and Targeting** illustrates where and how energy is used in order to provide a defined baseline of energy consumption. It can identify opportunities for potential savings and give early warnings of unexpected excess consumption caused by e.g. equipment malfunction.
	✓		**Building Automation Systems** are computer-based systems that assist in controlling, monitoring, measuring and optimising energy consumption of devices (such as lighting and HVAC - Heating, Ventilation & Air conditioning) used in a building.
	✓	✓	**Fault Detection and Diagnostic Systems** typically monitor data points within HVAC and industrial control systems in real-time (temperature, flows, pressures, etc.) and automatically detect faults in the systems - and provide advice about how to address these problems.
	✓		**Automated System Optimisation** allows the modification of control parameters within building automation systems in order to adapt in real time to needs or constraints, and thereby reduce possible system inefficiencies.
		✓	**Optimised Process Control** is designed to keep variations in industrial processes to a minimum and maintain the process at desired operating conditions while considering process constraints.

[1] IEA, 2017. Digitalization & Energy. [2]Lawrence Berkley National Laboratory, n.d. EMIS Technology Classification Framework

We have explored what could lead to higher user uptake of DTEM and increased energy savings

For this study, we have set out to answer the question:

What is needed to support greater uptake of DTEM, ultimately leading to better energy management and carbon savings?

- Specifically, we examined whether improved information sources, such as buyers' guides, user guides, or comparison websites would lead to greater uptake and energy savings.
- To help answer this question we have:
  - Examined the policy and market context for better energy management in seven major developed and developing countries.
  - Reviewed awareness and attitudes to better energy management via an online survey (301 respondents; 30% DTEM users and 70% potential users of such tools) plus 28 interviews in three countries (China, Germany, and South Africa).
  - Interviewed DTEM suppliers, and carried out a desktop review of specific, widely available DTEM products.

	Policy review	Survey	In-depth interviews
South Africa	✓	✓	✓
China	✓	✓	✓
Germany	✓	✓	✓
USA	✓		
Brazil	✓		
India	✓		
Mexico	✓		

Key findings

Based on our critical analysis of the outputs from the literature review, online survey, and in-depth interviews, we have grouped the findings and conclusions into three key themes, which are the subject of the following sections.

Better information would help convert the many potential DTEM buyers into actual users

DTEM suppliers can facilitate increased uptake by demystifying the technology

Targeted policy interventions would complement this information and facilitate higher uptake of DTEM

2

Better information would help convert the many potential DTEM buyers into actual users

Non-users are generally aware of and interested in DTEM. Many users deploy DTEM widely in their organisations

> **We need to automate processes including the digitising of energy and carbon reporting data to minimise delays in reporting. Access to accurate data in real time will also enable early warning detection in order to prevent system failure.**
>
> **We are looking for real time data collection systems than can integrate several different data sources, specific to our industry.**

Through our survey we examined the level of awareness and use of DTEM across a range of countries, sectors and sizes of business.

Non-users (n=210)				Users (n=91)	
1. Not aware	2. Aware - not considering	3. Considering, but no firm plans	4. Trialling / planning to adopt	5. Adopted at some sites / parts of the organisation	6. Adopted across most / all of the organisation
9%	8%	26%	57%	48%	52%

Fig 3. Thinking about digital tools for energy management, which of the following statements best describes the current situation at your organisation? (n=301)

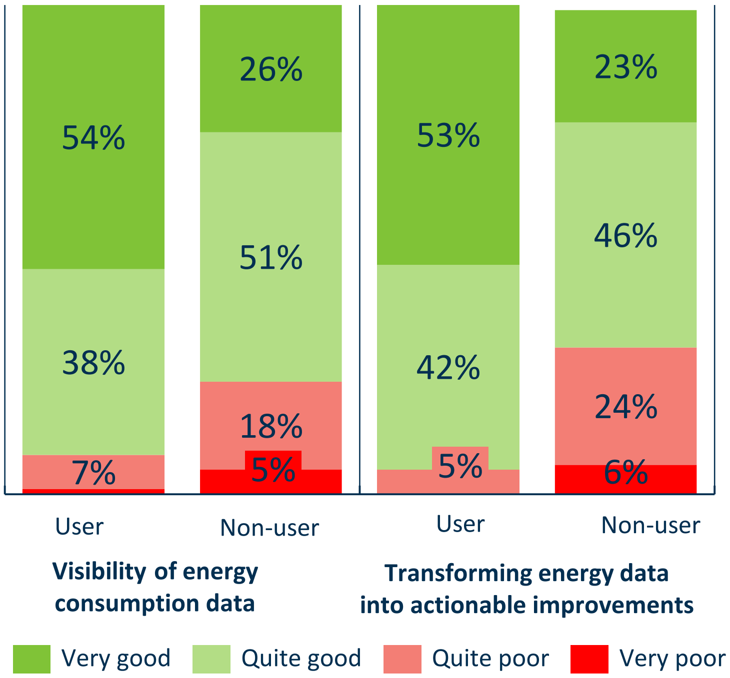
- Amongst the 210 survey respondents who do not currently use DTEM ("non-users"), the vast majority are aware of the technologies, and show a keen interest in investigating them further. More than half the non-user respondents said they are currently trialling or planning to adopt such tools in the near future. This indicates a good appetite for these products.
- It was evident that only 9% of the non-users indicated that they are not aware of these digital solutions. This suggests that awareness is not one of the key barriers to any future uptake. Nevertheless, further in-depth questioning indicated that respondents were not as strongly aware about the differences between the different types of tools available.
- Regarding respondents that already deploy DTEM ("users"), 52% of them claimed to be using them across most or all of their organisation. This suggests that there is still scope for expansion amongst the remaining half of users.

DTEM users better understand their energy use, and turn that understanding into action

These self-assessed values for visibility of data and taking action are higher than our observed experience would suggest. There may be some positive response bias, for example respondents evaluating their organisation as one category better than an outside observer might rank them.

Nevertheless, the relative proportions are likely to be representative.

Fig 4. Please rate your organisation's current performance on each of the following issues (n=301)



- The most common way for 'non-users' to monitor their energy use is by manually inputting data from energy bills into spreadsheets. 61% of all non-users indicated this as their current method. They typically read consumption data manually from energy meters, which is time intensive and subject to error and omissions. Most of the time this data is used solely to validate energy bills. Almost half of the non-users surveyed indicated that they keep paper records of energy supply bills, often not digitising any of their energy consumption data.
- DTEM users rank themselves better than non-users regarding their visibility of energy consumption data, and when it comes to transforming their energy data into actionable improvements. DTEM users are twice as likely to say that they a have "very good" visibility of their energy consumption data, whereas almost 25% of non-users assess their visibility as "quite", or "very poor". A similar picture is evident when it comes to implementing actual improvements. Almost all DTEM users assess themselves as "quite good" or "very good", whereas one third of non-users said their ability is "quite", or even "very poor".

DTEM users make use of the energy management tools but not always to full extent

We have basic energy meters and a pool of 20 employees distributed across our site, who manually read meters in each of our stores and send me the results monthly

I have no doubt that conducting analysis and using the energy data more effectively could benefit our organisation, and help reduce energy consumption.

- Even though DTEM help users to gain a better understanding of their energy data it is likely that they are not being used to their full extent, to reap all the potential benefits. Only 30% of DTEM users measure energy consumption data at device level. This suggests that some of the claimed "users" of DTEM actually use only basic energy management tools.
- Chinese respondents reported less device-level monitoring than German and South African respondents.

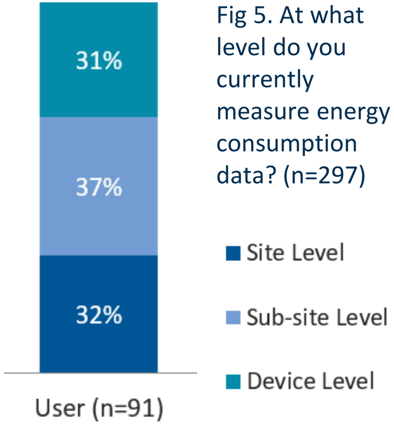


Fig 5. At what level do you currently measure energy consumption data? (n=297)

- When it comes to accessing their energy consumption data only 27% of DTEM users claimed to have access to this data more often than daily, i.e. real-time, 15 minutes, or half-hourly. This is consistent with our wider experience of working with organisations on energy management. It is very common to find companies with even sophisticated energy monitoring systems, which are installed and then left virtually unused, with no regular monitoring of the data and little review and updating of any control functionality.
- Levels of access to real-time and half-hourly data were reported to be much lower in China than Germany or South Africa.

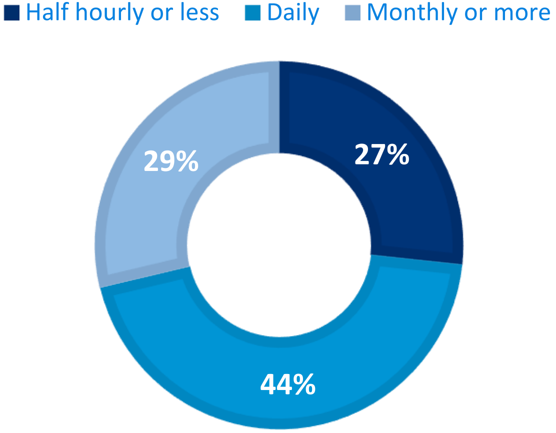


Fig 6. At what interval do you currently have access to energy consumption data? (n=91)

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Organisations struggle to decide on the best tools, and to justify investment

- There is good awareness that DTEM give organisations better visibility of their energy consumption data and help them convert this data into improvement actions. However, non-user companies find themselves confronted with challenges that hinder them from developing and implementing a business case to purchase DTEM. The most cited challenge is to identify the products that are most relevant and suited to their business. Interviewees told us that a lack of easy to use information on selecting and justifying appropriate DTEM products is a major barrier to uptake, particularly given the potentially high upfront costs of a sophisticated system.

What are the major reasons why your organisation does not use DTEM? (n=210)	
Difficult to understand the best tools for businesses	43%
Concerned about data security	33%
Do not have the internal knowledge to use the tools	27%
Unable to calculate the return on investment	25%
They are too expensive	22%
Energy efficiency is not a priority	19%
Don't know the benefits of these tools	19%
Energy costs are a low proportion of expenditure	17%
Features do not offer what my organisation needs	14%
Not aware of the existence of such tools	10%

- There are a wide range of products available with very wide ranging functionality, even within the separate categories of DTEM identified in this report – and indeed overlap between the categories. This can make the market difficult to navigate and information gathering can be difficult and time consuming. Finding simple, practical, impartial information appears to be a major hurdle to purchasing DTEM amongst non-users.
- Further barriers relate to financial concerns. Respondents reported finding it hard to have confidence in the level of energy savings likely, which leads to difficulty in calculating the potential return on investment. It is very difficult to provide even 'rule of thumb' estimates, as costs and returns are both dependent on many factors including energy spend, energy intensity, type of premises and operations/processes, and the extent of previous energy saving programmes.
- Lack of internal knowledge on how to use DTEM was also named as a significant barrier to the uptake.
- There were some variations by country in barriers to update. In particular, Chinese respondents were more likely to report data security concerns as a barrier, along with energy efficiency not having sufficient priority.

There are some interesting differences in the research findings between the survey participants

- The survey results presented throughout this report quantitative are based on the results of both quantitative and qualitative market research studies
- In general there was a reasonable level of consistency between the results across the three main countries studied (Germany, China and South Africa), but there were also some interesting areas of divergence.
- A summary of insights from the research for the three main countries can be found on the following 3 pages.

Insight: China

- Across the board, energy efficiency is a strong priority. Out of the three surveyed countries, Chinese respondents seem the most enthusiastic about energy efficiency. In China, there are lower penetration rates of DTEM overall, but the DTEM market is likely to grow rapidly in the future given that the vast majority of respondents report that they were trialling or planning to adopt various types of DTEM in the next few years. It is also the country that is most likely to have adopted DTEM across most or all of its sites. Even though such a large number of Chinese organisations claim to be testing DTEM, only a small proportion of Chinese respondents state that they currently have real-time access to energy consumption data.

- When it comes to energy supply and energy management, a large majority of Chinese organisations (71% of Chinese survey respondents) see managing and monitoring energy supply and stability, and security of energy supply as their main concern.

- According to the Chinese respondents the three top benefits of installing DTEM are:

Ability to identify energy inefficiencies and areas for improvement

Showing energy consumption in real-time

Dynamic energy measurement

- Help with calculating the payback period, assistance carrying out a cost-benefit analysis, and reassurance about data security are the most important factors stated by Chinese organisations in order to assist them build a business case for procuring DTEM.

For us, saving energy cost is of the highest importance rather than building reputation. To make us more competitive in price, we would hope to save energy costs.

- Operation Manager, China

One of the main barriers is that we do not have specialists to do the market research on what DTEM products we should buy, what is the most suitable device for us and what are some brands to choose from.

- Senior Management, China

Insight: Germany

- When it comes to energy supply and energy management half of all organisations surveyed in Germany see managing and monitoring energy supply and high energy costs as their main challenges.
- Of the system types studies, Building Automation Systems have the highest level of usage in Germany, whilst Energy Metering, Monitoring and Targeting and Fault Detection and Diagnostic systems are likely to see higher penetration in future as they are currently being considered or trialled to a high extent. Approximately one-third of all German respondents access their energy consumption data more often than daily.
- According to the German respondents the three top reasons for installing DTEM are:

Ability to identify energy inefficiencies and areas for improvement

Showing energy consumption in real-time

Fault detection

- In Germany the most important aspect for support with preparing a business case for procuring DTEM is providing an assurance of the energy cost savings that can be achieved, along with good information on the features and benefits.

Currently we are not doing any analysis. Everything is recorded, but then nothing is done with it, or identifying what could be improved. We are currently about to sort it through, by organising and capturing everything.
– Senior Management, Germany

I have no doubt that conducting analysis and using the energy data more effectively could benefit our organisation, and help reduce energy consumption.
– Energy Manager, Germany

At the moment no analysis is conducted because we are lacking the personal capacities, money and time.
– Executive Level, Germany

Insight: South Africa

- In South Africa, high energy costs and managing/monitoring energy consumption are perceived as the main challenges related to energy supply and energy management. More than half of all respondents from South Africa identified these as their main challenges.
- The main reason named by every second respondent in South Africa, for not using a DTEM system is that they feel it is difficult to understand which tool fits best to their business. According to the South African respondents the three top reasons for installing DTEM are:

Ability to identify energy inefficiencies and areas for improvement

Fault detection

Showing energy consumption in real-time

- In South Africa, the most important area for support in preparing a business case for procuring DTEM is providing an assurance of the energy cost savings that can be achieved, alongside case studies and financial incentives.

> We see a need for real time monitoring systems as it is an opportunity to gain more visibility what is happening at our plant and allows us to respond accordingly when necessary. It will also enable more effective optimisation.
> *- Process Engineer, South Africa*

> We need a full proof business case that shows significant savings in costs to the business if we implement any energy saving initiatives otherwise no one in the group will listen to us.
> *- Senior Management, South Africa*

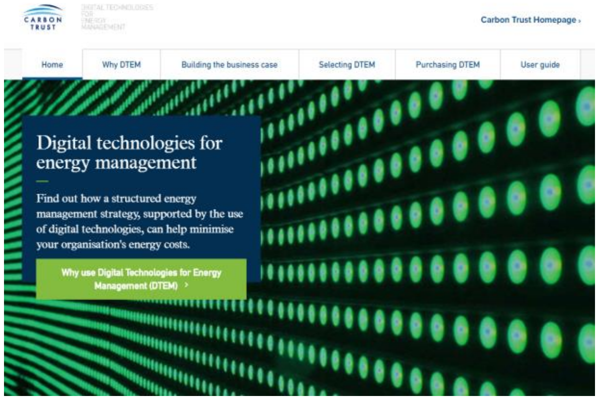
We are creating a web-based buyer/user guide to help overcome the information barrier

> **For me it would really simplify the process of looking around and finding options, if information on selecting tools was more easily accessible**

- During this study, it became evident that one of the biggest challenge is knowing what type of product to buy, what features to look for, and how to navigate the maze of supplier offerings to ensure that the investment is suited to the customer's particular situation. DTEM users lack the expertise and confidence to quiz suppliers in-depth on the suitability of their systems, and the potential pros and cons. They 'don't know what they don't know'. This then makes it more difficult to be confident that they will achieve the required return on investment.
- To help overcome those barriers, we have developed a concise 'buyer's guide' to support potential DTEM users to find the relevant information, so they can better understand which kinds of tool best suit their business. This will help buyers to shortlist the most suitable product types, and then offer key intelligence which will transform them into a more informed buyer. This guide provides practical and actionable information and guidance for non-expert prospective DTEM users, which will increase the likelihood of not just purchasing DTEM, but selecting the most suitable system to meet their needs, and ultimately maximising the savings achieved.

The buyers' guide includes the following features:

- Description of the key categories of DTEM
- Benefits of DTEM: energy related and other financial and non-financial benefits
- Understanding of key characteristics: what potential customer's might need for their application
- Support for the potential buyer in building a robust business case for DTEM
- Questions to ask suppliers when purchasing DTEM
- Recommendations on incorporating DTEM within a wider company energy strategy
- User guide – to capitalise on the opportunities once you have invested in DTEM



There are many examples of DTEM systems not achieving the benefits that are promised - a user guide is needed.

We have included a user guide section within the buyer's guide to help both new and existing DTEM users to maximise the effectiveness of their technologies.

Many of these issues can be addressed within an effective energy strategy.

An important finding from our research, and experience of carrying out energy audits within organisations internationally over many years, is that DTEM systems are rarely used to their maximum effect. This can be illustrated through a variety of examples:

- Fit and forget: sophisticated energy monitoring and building automation systems can be installed and left collecting data that are rarely used – or controls set up that are not monitored or optimised as working patterns or building use changes.
- Facilities management: DTEM control may be given to teams that are responsible for comfort or energy purchasing, but not energy consumption.
- Staff move on: we frequently find that a committed member of staff has ownership for energy management strategy and tools; but when they move on to another role or company, the ownership and engagement can be lost.
- Controls are overridden: it is very common for building control systems to be overridden to provide for a temporary need, or to overcome a fault, and then never be returned to optimised automated operation.
- Poor system communication: where different components of DTEM systems have been installed over time, particularly from different suppliers, it is common to find problems with getting the systems to reliably 'talk to each other'. This can reduce the accuracy of data and control, and increase the risk of systems being overridden.

3

DTEM suppliers can facilitate increased uptake by demystifying the technology

Suppliers are the most important source of information regarding DTEM for users and potential users

We wouldn't really know where to start sourcing a DTEM solution.
Seeing our industry is very risk averse to new technologies, it needs to be tested and proven technology.

- As detailed in the previous section, providing better information could facilitate greater uptake of DTEM and can support energy reduction strategies. However, this relies heavily on potential users pro-actively looking for the necessary information. There is a limit to how much a generic information source can pinpoint the exact solution for a particular organisation considering their individual needs. Direct contact with service providers is shown below to be not only the highest source but also, by some margin, the most useful source for potential users to obtain information when considering DTEM. Trade shows were the next most important, which also offer face to face contact with suppliers as well.
- This is not surprising given the in-depth interview findings that this is a complex marketplace, and direct contact gives the best opportunity to obtain a bespoke calculation of benefits to a particular company. Of the DTEM users in this study, only half had implemented a DTEM system across their whole site/company. And in the case of non-users, many are planning to adopt DTEM or at least considering it. Overall, this indicates a real opportunity for suppliers to expand the market.

Which of the following are/would be your main sources of information about digital tools for energy management? And which is/would be the most useful source of information? (n=301)

Sources of information to learn about DTEM	Sources used	Most useful source
Direct contact from service provider	50%	22%
Internet: website comparison tool	47%	10%
Specialist energy management publications	43%	13%
Peers/colleagues	42%	13%
Service providers' brochure/leaflet/website	41%	12%
Internet: general searches	40%	11%
Trade shows or events	38%	14%
Newspaper/magazine	21%	6%

There are a wide range of suppliers and products, and DTEM presents a difficult landscape to navigate

- Five categories of DTEM were grouped to define the types of DTEM system available for this study. We have reviewed the features of a number of widely available products to determine those available within each category. Potential users were asked about their knowledge and experience of the different types of system and we found, unsurprisingly, that energy metering, monitoring and targeting (MM&T) and building automation systems were the most well known. However, even at this end of the spectrum there was some confusion about the exact definition of those systems. This ambiguity was illustrated by some companies claiming to use MM&T who were in practice reading meters and recording data manually.
- Building automation systems are in place at many commercial premises, and the benefits of monitoring and control were well recognised. However, they are often not suitably configured for maximum energy saving, and are often overridden.
- In the survey, non users claimed to be considering the use of all of the advanced systems but based on the lack of differentiation in responses between the types and interview discussions, we believe this may be attributed to a lack of understanding of what some of the more sophisticated systems are and how they work. This is backed up by our review of supplier literature in which a lot of jargon is commonly used, and there is often a lack of clear description of features and benefits.
- The DTEM landscape is characterised by many different suppliers of energy management tools. Of the 91 users that were surveyed, over 45 different suppliers were mentioned. Of the well-known names, most were only mentioned 3 or 4 times, with many smaller and local companies identified. Most frequently mentioned were: IBM, Microsoft, Siemens, Wago, Enke, Eskom, SAP, Schneider Electric, and Innogy. The diversity of brands mentioned shows that, whilst there has been some consolidation, the market is not dominated by one or two players, and there are opportunities for a whole range of suppliers. However it does reinforce why there might be confusion amongst buyers around the systems types, their features, benefits, and applicability, and who to approach for guidance.

Energy metering, monitoring and targeting and building automation systems are the best understood types of DTEM

High awareness — Low awareness

Energy metering, monitoring and targeting

- This was the most common system in use in our survey
- But there was still confusion as many who claimed to have this also said they read meters manually
- We commonly find that systems are installed and collect data, but it is not used to maximum effect.

Building automation systems

- These systems are also widely used
- They are seen to help control energy consumption & identify areas of energy saving potential
- We commonly find they are programmed for comfort, poorly configured and over-ridden.

Fault detection and diagnostic systems

- Organisations place a lot of value in being able automate fault detection
- There was little evidence of widespread use from our survey, although considerable interest from China
- It was seen as a way to easily improve energy consumption.

Automated system optimisation

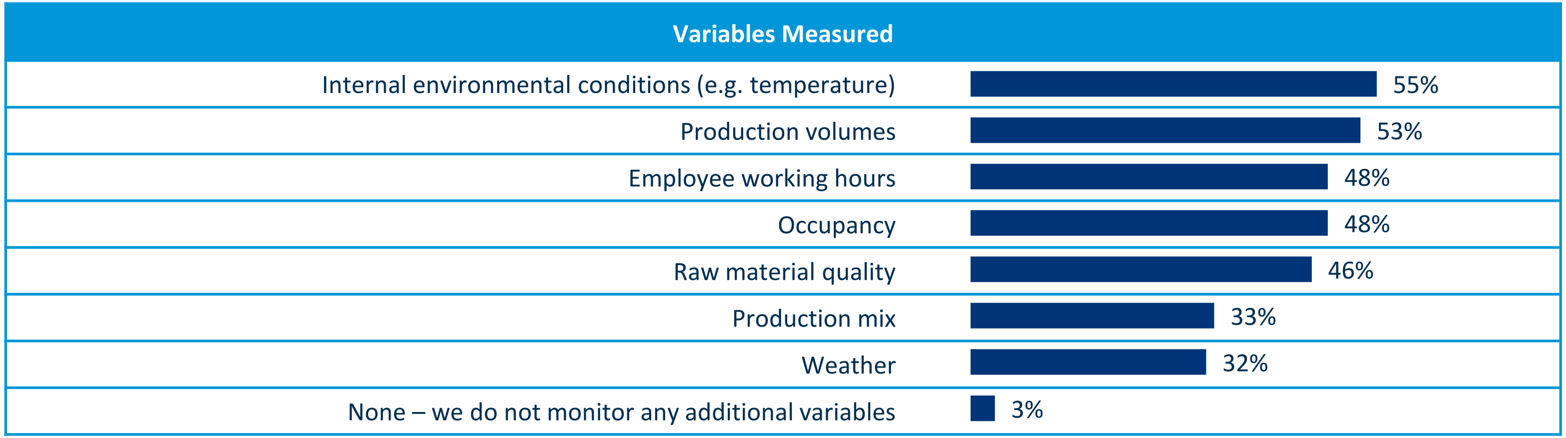
- There is lower awareness of these type of tools
- The modification of control parameters however sparked interest
- Users would need to better understand the features and impact of these types of system, and the potential cost-benefit analysis.

Optimised process control

- There was limited awareness of the functionality of optimised process control in our survey
- The level of sophistication can vary, as can the extent of manual over-ride used
- Manufacturers are often nervous about handing operator control to software and tools.

Businesses claim to measure a wide range of additional variables, though use and integration of data is unclear

- In order to utilise the full potential of a DTEM system it needs to measure not just the energy use, but a range of other variables in order to be able to analyse consumption, determine trends, and in some cases, adjust controls.
- This chart shows that respondents do measure a number of the variables that influence energy consumption. However, many of these are measured manually and occasionally, and not necessarily in a form that can be fed directly, frequently and automatically into DTEM systems. Nevertheless, it is encouraging that the data that can help DTEM to operate effectively is routinely monitored by organisations.



Which additional variables does your organisation monitor to supplement energy monitoring and management? (n=91)

Data security and reliability are key decision-making factors for users, and suppliers should consider this in design of sales information

- To better understand what factors customers look for when considering DTEM, we asked them to rank a range of factors. It is noteworthy that data security is at the top of the list for most frequently cited factors, but not the most important one, which was the reliability of the system. Based on the in-depth interviews data security appears to be more of a hygiene factor – it has to be there, but is unlikely to be the deciding factor. Reliability can be measured numerically by indicators such as system up/down time. As expected the cost and savings are near the top of the list. However, it is not easy to get a good idea of the cost of a system from supplier literature and websites. This could be a significant barrier to companies moving from considering, to planning, and purchasing of DTEM.

Decision Making Factors	Factors Considered	Most Important Factors
Data security	57%	13%
Reliability	54%	23%
Cost	46%	12%
Potential energy savings	44%	12%
Usability	40%	9%
Features available	37%	5%
Availability of customer support	37%	5%
Supports ISO50001 accreditation	35%	7%
Consultation to advise ways to reduce energy usage	32%	8%
Good customer reviews	29%	5%

Which factors did you consider when evaluating which digital energy management tool(s) to implement? Overall, which was the most important factor in your decision? (n=91)

What could suppliers be doing to stimulate greater uptake of DTEM?

There appears to be considerable potential across developing markets to roll out DTEM more widely, particularly with the rapid and widespread propagation of mobile communication networks.

Case studies on users of similar technologies in my industry would be beneficial as they influences the decision-making process at the company.

- Suppliers are the first port of call when it comes to purchasing digital technologies for energy management – indeed for most energy efficiency investments. This is not an area where the buyer has a good knowledge of what they are buying, the range of features available, and new developments - such as increased data visualisation that is now becoming available.
- Whilst the measures in Section 2 such as provision of a user guide, and the promotional activity being undertaken as part of this project will help raise awareness and inform purchasers, the industry itself has considerable scope to enhance its reputation and prospects, at a time of great change (with the advent of big data, artificial intelligence, internet of things etc).
- The first set of actions recommended relate to improved information provision:
  - Provision of simpler, clearer, segmented information – sales and promotional material and supplier websites don't always recognise that customers often aren't experts. Work through trade bodies to describe and promote the technology.
  - Providing detailed information when needed - some users, particularly energy professionals in larger companies are highly knowledgeable and do need access to more in-depth information on the technical capabilities of products.
  - More clearly differentiate system types, features, and ideal applications - making clearer which products and features suit particular applications would help to direct buyers to the most relevant products e.g. providing more selection tools.
  - Sector focused customisation and promotion – even where the same products are relevant to multiple sectors, it can help to produce sales literature tailored to each key market sector, with relevant case studies where possible.
  - Focus on the return of investment – DTEM can be seen as expensive, and the financial benefits may not be understood or believed. Rules of thumb may not be realistic, so provide simple calculators to determine potential savings, based on the individual company's need.
- Beyond information provision, we recommend:
  - Ensuring that finance is available to fund the DTEM products – e.g. providing easy access to third party finance, and assisting with business case development. Taking on some of the project risk in return for a share of savings can help overcome the hurdles to implementing energy saving technologies, including DTEM.

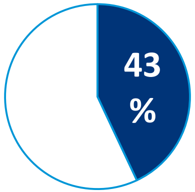
Respondents also stated that a comparison website would assist them to choose the right system

Whilst potential users would value a comparison website that it independent and impartial, and not funded by the companies it lists, it may not be cost effective to set up a new website when good market players already exist.

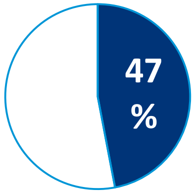
Instead there may be scope to work with existing sites to further reflect site user needs, based on the research findings.

A comparison website would be of interest as this would reduce the burden involved in identifying DTEMs.

- As part of the survey, the idea of a comparison website for DTEM was tested. Almost half of non-users selected this from a list of sources they would be likely to use when researching possible DTEM solutions.



With 43% of respondents, “difficult to understand which is the best DTEM” was the most-cited reason for not using DTEM



With 47% of respondents, a “web comparison tool” was the second-most cited potential source of information for DTEM

- A number of comparison websites were identified, although these are limited specifically to energy management software rather than DTEM more widely. Energy and sustainability software comparison tools include those from Capterra, GetApp and Software Advice. These sites are all owned by Gartner, but each have slightly different coverage and comparison tools. The categories of information include typical prices, applicable sectors, availability of demonstrations, deployment platforms supported, level of support available etc. They all feature user reviews, which give readers confidence that the assessments are impartial, although reviews are of course subjective. However, there are fewer filters available than those requested by our survey, and not all filter data is populated for all of the products. There are hurdles to overcome to maximise the usefulness of comparison tools. The needs of potential user companies can differ significantly and filters and user reviews can only go some way to addressing these. It is also difficult to benchmark price, due to the wide variation in requirements.
- The search criteria which users would find most helpful within a search tool vary according to the country of survey respondents. Robustness of data security and analytics capabilities are considered more important in China. Respondents in Germany and South Africa were more price conscious, although data security is also a key factor.
- There were conflicting views on the importance of data/cyber security as a critical factor when deploying a cloud supported solution. It is particularly difficult to assess this for a website comparison tool, and it is unlikely purchasers would choose one product over another based on a basic web tool assessment.

4

Targeted policy interventions would complement this information and facilitate higher uptake of DTEM

Targeted policy interventions would complement this information and facilitate higher uptake of DTEM

- As previously discussed, potential DTEM customers do not feel they have enough of the right information to build a robust business case and to make well-informed purchase decision. But filling this information gap would not on its own guarantee higher uptake. Supporting policy interventions are needed to complement improved information and increase the chances better DTEM adoption.
- This chapter characterises the range of possible policy interventions and identifies those that may help to drive higher uptake of DTEM and better energy management. We consider the policy measures that countries are already implementing, and draw out possible lessons for future policies based on our understanding of the barriers and drivers that affect users and potential users of DTEM.
- We have categorised policy approaches as either: 1) financial or non-financial; and 2) mandatory or voluntary. This framework is useful for ensuring the discussion of potential policies considers the full range of possible interventions, and for recognising similarities between different interventions.
  - **Financial and mandatory**: these measures can, for example, reduce energy price distortions or increase financial drivers to improve the business case for energy efficiency and energy management.
  - **Financial and voluntary**: these measures can include financial incentives or subsidies for products or technical assistance that support companies that want to implement DTEM or wider EnMS.
  - **Non-financial and mandatory**: these measures include, for example, regulations that require organisations to report energy consumption, adopt energy management practices, or set targets for energy savings.
  - **Non-financial and voluntary**: these measures include education, capacity building, and awareness raising.

There are many different policy interventions that can support the uptake of EnMS and DTEM

This table highlights a range of potential interventions, classified according to whether they are mandatory or not, and whether they are financial or non-financial measures.

	Mandatory	Voluntary
Financial	• Energy or carbon pricing measures • Financial penalties for inadequate energy management or energy efficiency practices • Elimination of energy price distortions	• Subsidised equipment/tools • Financial incentives (e.g. loans) for energy efficiency investment • Subsidised technical assistance / EnMS support • Tax breaks for businesses implementing an EnMS and achieving energy savings
Non-financial	• Mandatory implementation of energy management practices/technologies • Mandatory energy consumption reporting and target-based energy savings • Energy performance codes and standards • Mandatory third party verification of energy savings to provide businesses with a transparent system	• Certification schemes • Educational events, capacity building or direct outreach depending on the level of pre-existing knowledge • Information and awareness-raising campaigns • Training, accreditation, and qualification for suppliers

Financial and mandatory

Prices or penalties to improve the overall business case

Identified barriers

- Companies are facing the issue of high upfront costs. Often, especially in less energy mature organisations, there is no dedicated energy manager and companies generally see monitoring and reporting of energy consumption data as a challenge.
- Energy and carbon costs are too low for organisations to take actions to adopt energy management practices and reduce their energy use.

Examples on how to overcome these barriers:

- Energy or carbon pricing measures, especially mandatory emissions trading schemes, which directly require organisations to monitor and report energy use and carbon emissions
- Financial penalties for inadequate energy management or energy efficiency practices
- Minimisation or elimination of energy price subsidies that weaken the business case for energy efficiency.

Region and country examples:

- EU Energy Taxation Directive requires energy taxes to be applied where reductions are possible
- The Chinese national carbon trading scheme includes intensity-based targets to reduce emissions per unit of GDP

> It is a very important topic, the priority has risen in the last few years…we want to improve. If the revenue allows it we will create new and concrete plans for energy management in the future.
>
> *Office Manager, Manufacturing*

Financial and voluntary

Incentives and subsidies to encourage specific actions

Identified barriers

- A perception of high upfront costs combined with the complexity of how to find a tailored DTEM are the main reasons that companies currently do not use any DTEM. Moreover, they often have difficulties calculating the return on investment of such a tool.

Examples on how to overcome these barriers:

- Financial incentives (e.g. loans) for energy management or energy efficiency investments
- Subsidising technical consultants to assist companies in implementing EnMS and help them in identifying new energy savings opportunities
- Voluntary agreements between industry and government
- Introducing tax breaks for businesses implementing energy management systems and achieving energy savings

Country examples:

- Germany: Energy Efficiency Fund (public funding scheme) or KfW's Energy Efficiency Programmes providing loans (up to EUR 25m) for the financing of energy saving investments for private companies
- United States: the US DoE's Loan Guarantee Program provides loan guarantees for among others industrial energy efficiency projects
- South Africa: The Energy Efficiency Savings Tax Incentive (Section 12L of the Income Tax Act) provides a tax deduction for savings achieved on a kilowatt-hour equivalent basis
- Germany: Voluntary agreements with German industry leads to rebate on energy and electricity tax for energy intensive companies

Non-financial and mandatory

Minimum requirements that normalise good practice

Identified barriers

- Monitoring of energy consumption data is seen as a big challenge faced by companies regardless of the maturity of their energy management. More than half of all companies surveyed name it as one of their biggest challenges.
- Less energy mature companies monitor data manually, which is often labour intensive and expensive. Manually collecting information means that data is not easily accessed or available.

Examples on how to overcome these barriers:

- Mandatory qualifications for energy auditors, equipment providers, and installers
- Mandate for energy suppliers to provide free or subsidised energy management or energy efficiency support
- Regulation requiring organisations to implement energy management practices or technologies
- Government requirements to report on energy consumption and target-based energy savings
- Required third party verification of energy savings

Country examples:

- South Africa: the post-2015 NEES includes mandatory preparation and submission of energy management plans for enterprises whose annual energy consumption exceeds 180 TJ
- India: under the Energy Conservation Act, large industrial energy consumer have to implement energy audits, appoint certified energy managers and report energy consumption data
- China: under the Top 1,000 and Top 10,000 programme Chinese companies need to establish an EnMS and report energy savings to local government

Non-financial and voluntary
Tools, information, and networks to support improvement

Identified barriers

- Companies see the task of setting up an energy management function as difficult, costly, and time consuming. They also often lack the experience and expertise on how to build it.
- Moreover, there is a prevailing lack of trust in the claims of DTEM suppliers about their product.

Country examples:

- United States: the 'Better Buildings, Better Plants Program' invites industrial businesses to take a company-wide voluntary pledge to reduce their energy intensity
- South Africa: as part of the National Energy Efficiency Leadership Network, companies voluntarily pledge to develop a roadmap for improved energy efficiency (incl. EnMS, set energy savings targets, and publicly report on their progress)

Examples on how to overcome these barriers:

- Voluntary pledges to enhance energy efficiency
- Educational events, capacity building or direct outreach depending on the level of pre-existing awareness
- Information and awareness-raising campaigns highlighting specific opportunities for energy management or energy efficiency
- Peer networks for sharing best practice on energy management or energy efficiency
- Training local suppliers, or installing entities capable of transferring skills to implement energy efficiency solutions
- Certification schemes, implementing energy efficiency codes and standards

> At the moment no analysis is conducted, because we are lacking the personal capacities, money and time.
>
> *Executive Level, Insurance*

There are no "silver bullets": policies must tackle the key challenges if they are to be effective

A review of policies in place in other countries can be found in the Annex.

- In our experience, the most common failing of energy efficiency and energy management policies is taking a siloed approach and ignoring the fact that many aspects need to fall into place simultaneously to successfully encourage investment and improvement.
- An energy or carbon pricing scheme might improve the business case, but will have little effect if the supply chain is not in place, finance is not available, or indeed if the overall costs of energy and carbon remain too small to attract significant management attention.
- Mandatory reporting or certification might increase the amount of data gathered or practices adopted, but it will drive little more than box-ticking compliance if organisations do not have the motivation and capabilities to follow through.
- We do not offer a single rigid prescription for policies to encourage uptake of DTEM or EnMS. Rather, we suggest that policy makers consider a series of questions as summarised in the opposite figure. Answering these questions comprehensively, and implementing various policies to tackle the key challenges, will significantly increase the chances of success.
- We have applied this approach to our target countries on the following pages.

Figure: Key questions when designing an energy efficiency programme

Insight: China

Current policies implemented in China enhancing energy efficiency

In China energy efficiency and energy conservation has been a priority for a long time. The industrial sector represents 75% of the national energy consumption and hence, most energy savings have been realised in this sector. Since 2006, a mandatory, target-based energy savings programme has been in place for the largest, most energy intensive enterprises (initially Top 1,000, now Top 10,000 programme). The 13th Five Year Plan (2016-20) includes among others concrete goals for the promotion of energy efficiency in industry. China is aiming to reduce energy intensity by 15% from 2015 levels (6.7 MJ/USD 2011 PPP GDP) by 2020. It also sets a cap on China's total energy consumption at 3,500 Mtoe by 2020, which corresponds to a 16.3% increase in consumption compared to 2015 levels. At the same time, China plans to increase the efficiency of coal plants by enforcing national energy standards, and limiting the construction of new coal fired power plants.

What else could China do to increase the uptake of DTEM and increase energy efficiency?

- The programme was originally extended from Top 1,000 to Top 10,000 because of its success. Opening up the initiative to even more companies could raise awareness of the importance of energy efficiency in China. The success of this programme could become a even bigger when training for energy auditors and managers is provided to all companies independently of their energy consumption.
- Ensure that the data submitted as part of the Top 10,000 programme is collected on the most granular level possible and using best practice. Further capacity building for energy auditors is needed, in order to enforce enhances energy assessment practices.
- Financial incentives to support companies to conduct energy audits, training, implementing energy management, and energy data collection are missing in China. We have seen in the German example that financial incentives (e.g. tax rebates, subsidies) can make a difference.

Insight: Germany

Current policies implemented in Germany enhancing energy efficiency

Almost 10 years ago, Germany initiated a far-reaching transformation of its energy system, the so-called “Energiewende”. The country has set targets of 20% reduction in primary energy consumption by 2020 and 50% reduction by 2050 (compared with 2008 levels). To achieve these ambitious goals the government has implemented a comprehensive set of complementary policies, grant and loan schemes, e.g. KfW’s Energy Efficiency Programmes which offer loans up to EUR 25m per project. Germany has almost 50% of the world’s ISO 50001 certifications. The German government decided to intensify the accompanying legal framework around this standard in four steps. Firstly, in 2011, companies were offered tax rebates and subsidies when implementing ISO 50001. In 2014, the implementation of ISO 50001 became mandatory for companies with energy demand larger than 10 GW per year (in 2015 the threshold was lowered to 5GW per year). Lastly, since 2016, it is mandatory for all non-SMEs without a valid energy audit. In 2016, the German Federal Ministry for Economic Affairs and Energy (BMWi) launched the ‘Energy Savings Meter’ pilot programme, incentivising ESCOs to provide companies with access to digital energy savings meter platforms and services. The ‘Energy Savings Meter’ combines the funding of a digital energy service with a remuneration based on energy savings achieved.

What else could Germany do to increase the uptake of DTEM and increase energy efficiency?

- Providing tax rebates and subsidies proved most successful as all energy intensive industries had implemented ISO 50001 early to save on taxes and receive subsidies. As using financial incentives have worked well in the past, incentive programmes for e.g. the use of digital energy management technologies to better monitor the effectiveness of the various grant and loan schemes should be increased and further promoted.
- Larger companies are required to conduct energy audits. The obligation to implement the findings from the energy audits could unlock further energy efficiency potential for German industries.
- Provide capacity building to ESCOs in order for them to provide better services to their clients helping them achieve higher levels of energy efficiency.

Insight: South Africa

Current policies implemented in South Africa enhancing energy efficiency

The first National Energy Efficiency Strategy (NEES) set an overall reduction target in energy intensity of 12% by 2015 based on 2000 levels (10 MJ/USD 1000 GDP). A National Energy Efficiency Action Plan was developed in 2012 describing the implementation of this strategy. The post-2015 NEES aims to build on this, stimulating further energy efficiency improvements through a combination of fiscal and financial incentives. The target for the industrial sector is set to be a 16% reduction in energy consumption in manufacturing by 2030 (relative to 2015 baseline). In June 2019, South Africa will implement a carbon tax, which imposes a levy per tonne of CO_2 equivalent above certain tax free allowances. The carbon tax should motivate businesses and households to take the price of greenhouse gas emissions in their production, consumption, and investment decisions into account.

What else could South Africa do to increase the uptake of DTEM and increase energy efficiency?

- Ensure the enforcement of the carbon tax and avoid any possible double counting regarding other energy efficiency savings tax incentives (e.g. section 12L of the Income Tax Act).
- Introduction of mandatory energy management requirements for energy intensive companies. These requirements could include:
  - The mandatory appointment of an energy manager
  - Conducting energy audits combined with the obligation to implement recommendations that come out of the energy audit
  - Monitoring and reporting on annual energy use and greenhouse gas emissions
  - Submitting energy efficiency improvement plans on an annual basis
  - Benchmarking: government to provide a comparison of industrial/commercial companies with their peers

5

Conclusion and recommendations

Conclusion

- This review of Digital Technologies for Energy Management has found that DTEM are an essential component to support organisational energy strategies and where correctly tailored the organisation's need, can bring about significant carbon, energy and financial savings, along with other tangible and intangible benefits. However, global uptake is by no means universal, and older systems are often not working to their full potential, or are left in place unused or overridden.
- This report structured around the three key recommendation that could lead to increased up take of DTEM:

Better information would help convert many potential DTEM buyers into actual users

- Potential (and current) users of DTEM would value more information. There is strong appetite for a buyer/users' guide and comparison websites for energy management technologies in order facilitate an increased uptake. A buyer/users' guide has been created as a microsite and will serve as a hub for relevant information to prospective DTEM users.

DTEM suppliers can facilitate increased uptake by demystifying the technology

- There are several different challenges companies are facing to make a robust business case for DTEM and suppliers of DTEM can play an important role in overcoming these barriers, especially overcoming the information gap.

Targeted policy interventions would complement this information and facilitate higher uptake of DTEM

- Targeted policy interventions will complement the additional information required for the further uptake of DTEM. At the same time an increased uptake of DTEM can ease the successful implementation of certain energy efficiency policies.

Visit the DTEM buyer/users' guide at www.carbontrust.com/DTEM

Recommendations (1 of 2)

Here we have proposed some recommendations for further activity to develop this research, and to advance the broader uptake of DTEM.

Digitalisation is expanding rapidly, and will have a far reaching impact on energy management. Improved connectivity is already facilitating cheaper and wider roll out of DTEM across companies, but so far the impact of more advanced smart technology, 'big data' and artificial intelligence has been limited. There is a need to further monitor developments in this space and influence how more powerful data collection, analysis and control can work for both SMEs, as well as large, complex, multi-premises organisations, to manage and reduce energy use and carbon emissions.

However, we must also remember in designing and proposing future solutions that humans are still important to the process. People will continue to be involved in specifying the needs, designing systems, making buying decision, monitoring the outputs and outcomes, and implementing further improvement projects.

In view of the worldwide potential, it is recommended that the ClimateWorks Foundation and other NGOs partner with government and philanthropic donors to continue funding further DTEM research and development programmes. In particular, competitions can be a cost effective mechanisms for accelerating the development of technologies. Convening networks of stakeholders with a common purpose to accelerate DTEM uptake and potentially inform and influence policy would also be an effective approach.

Recommendations (2 of 2)

Here we have proposed some recommendations for further activity to develop this research, and to advance the broader uptake of DTEM.

Specific options might include:

Competitions to stimulate uptake of DTEM in SMEs that currently have none, by facilitating funding and breaking down information barriers, possibly through project aggregation.

Competitions or accelerators to facilitate developing of smarter DTEM systems, incorporating ‘big data’ analysis and artificial intelligence techniques to improve system controls, and provide more intelligent feedback to system operators/owners.

Partnerships between DTEM suppliers and policymakers to enable the analysis of anonymous DTEM data to better understand commercial energy use, in order to more effectively tailor policies to particular sectors.

Work with existing energy management software comparison sites to develop their offering to better meet purchaser needs e.g. add extra categories of DTEM, actively collate supplier data, encourage more user feedback - maybe with additional moderation/validation.

Convene improved networks between DTEM equipment and service suppliers with a view to agreeing more standardised terminology within the DTEM market, and clearer consistent marketing to generate more informed purchasers.

Undertake policy studies within specific regions to develop tailored policy measures that would stimulate effective DTEM uptake.

Develop further information resources for using DTEM across different geographies, to ensure both new and established DTEM users make the most of their systems – and ensure they don’t fall out of use.

6

ANNEX

- Online survey: profile of respondents
- Policy review: summary of relevant policy in the three countries studied, and other representative regions

The profile of respondents for the online survey is shown below

301
Views Heard

Germany
100 respondents

South Africa
100 respondents

China
101 respondents

Sites:

Single site	11%
2-10	55%
11-20	19%
21-100	12%
100+	3%

Employees:

50 - 249	22%
250 - 499	12%
500 - 2499	45%
2500 - 4999	14%
5000 - 10,000	8%

Role in energy management:

Involved in technical / operational decisions	45%
Involved in financial / procurement decisions	24%
Involved in both	31%

Job Role:

Exec Level	16%
Energy Management	48%
Facilities/ Estate…	8%
Other Management	13%
Finance and…	14%
Other	2%

Age:

54 – 65 years	6%
39 – 53 years	37%
29 – 38 years	40%
18 – 28 years	18%

Time in Role:

0 - 2 years	11%
3 - 5 years	35%
6 - 10 years	44%
11 - 20 years	8%
20 + years	2%

Brazil

Geography & People	Population (in 2017)[1]	207,353,000
	Urbanisation (in 2017)[1]	86.20%
	Land area[1]	8,358,140 km^2
	Climate[1]	Tropical in the north and temperate in the south
Economy	Economic structure (GDP by sector of origin in 2017)[1]	Agriculture: 6% Industry: 21% Services: 73%
	Major industries[2] (by energy consumption)	Food & beverage Iron & steel Paper & pulp Chemicals
	Economic development[3]	Upper middle income country
	GDP/capita (PPP) (in 2017)[1]	USD 15,500
	Average GDP growth rate (2012 – 2016)[3]	- 0.39%
Energy	Total final energy consumption (2015)[4]	226.87 Mtoe
	Supply mix (in 2015)[4]	40.1% Oil 29.3% Biofuels/waste 11.9% Natural gas 11.4% Renewables 6.0% Coal 1.3% Nuclear
	Net imports (in 2015)[4]	25.28 Mtoe
	Cost of energy (industrial)5	USD 157.43/MWh
	ISO 50001 certifications in 2016[6]	22 certificates

[1]CIA Factbook, 2017 [2]Borgstein, 2016b [3]World Bank, n.d. [4]IEA, 2015 [5]Climatescope, 2017 [6]ISO, 2016

Brazil

Relevant policies/regulations

- Energy policies largely emphasise renewable energy production. This focus on energy production means a great deal of Brazil's energy efficiency potential remains untapped. The government has not implemented a national energy savings policy, but a proposed national action plan aims to reduce electricity consumption by 10% by 2030 (= saving up to 106 TWh of accumulated savings between 2010 and 2030). The country has also submitted an NDC, which outlines a commitment to reduce GHGs emissions by 37% from 2005 levels by 2025. The government hopes to achieve some of these targets through programs implemented by PROCEL (national energy conservation scheme, running since 1986).

Energy efficiency/energy management

- The recent rise in energy costs for Brazilian industry should make improved energy management a higher priority in many areas. Energy distributors have carried out pilot smart metering projects in several areas, but the roll-out program is largely stalled. Limited number of software systems for remote energy management (measurement and monitoring) are available. More advanced software for EnMS and low cost hardware for measurement of energy consumption and energy quality are lacking. High-end or large new buildings often have complex building management systems. Simple, low cost systems that can be easily retrofitted to existing buildings and identify energy saving opportunities are needed. Internet of things devices and software solutions for demand management are largely unknown to the Brazilian market.

China

Geography & People	Population (in 2017)[1]	1,379,000,000		
	Urbanisation (in 2017)[1]	57.90%		
	Land area[1]	9,326,410 km[2]		
	Climate[1]	Extremely diverse: tropical in the south to subarctic in the north		
Economy	Economic structure (GDP by sector of origin in 2017) [1]	Agriculture: 8%	Industry: 40%	Services: 52%
	Major industries[2] (by energy consumption)	Iron & Steel Cement & Glass		Chemicals Non-ferrous metals
	Economic development[2]	Upper middle income country		
	GDP/capita (PPP) (in 2017)[1]	USD 16,600		
	Average GDP growth rate (2012 – 2016)[2]	7.30%		
Energy	Total final energy consumption (2015)[3]	1,905.68 Mtoe		
	Supply mix (in 2015) [3]	66.7% Coal 17.9% Oil	5.3% Natural gas 4.8% Renewables	3.8% Biofuels/waste 1.5% Nuclear
	Net imports (in 2015) [3]	488.98 Mtoe		
	Cost of energy (industrial)[5]	USD 82.74/MWh		
	ISO 50001 certifications in 2016[5]	1,015 certificates (besides ISO 50001 country specific EnMS standards in place)		

[1]CIA Factbook, 2017 [2]Myllyvirta, n.d. [3]World Bank, n.d. [4]IEA, 2015 [5]Climatescope, 2017 [6]ISO, 2016

China

Relevant policies/regulations

- In China energy efficiency and energy conservation have been a long term priority. The industrial sector represents 75% of the national energy consumption and hence, most energy savings have been realised in this sector. Since 2006, a mandatory, target-based energy savings programme has been in place for the largest, most energy intensive enterprises (initially Top 1,000, now Top 10,000 programme). The 13th Five Year Plan (2016-20) aims to set, for the first time, a cap on China's total energy consumption of 3,500 Mtoe by 2020 (2015 level: 3,000 Mtoe), corresponding to a 15% reduction of energy use per unit of GDP (2015 level: 6.7 MJ/PPP GDP). To reach these goals, China's energy production mix is set to diversify and shift away from coal and towards greater share of renewable sources. At the same time, China plans to increase the efficiency of coal plants, shut down coal-fired boilers that fail to meet certain national standards, and limits the construction of new coal fired power plants.

Energy efficiency/energy management

- China accounted for half of the global energy demand growth between 2000 and 2015. This, in combination with the country's legacy of inefficient energy infrastructure and industrial capacity, presents significant sources for energy efficiency. EnMS piloted in the 11th Five Year Plan (FYP) in a small group of enterprises in Shandong province. Shandong issues its own EnMS standard, implementation guidelines and training programs. The Central Government issued a broad national EnMS standard in 2009 (revised in 2012 to follow ISO 50001 more closely). Since 2013 EnMS implementation guidelines for specific sectors have been issued. The implementation of EnMS is a key part of the Top 10,000 program as part of the 12th FYP. The 13th Five Year Plan forecasts that energy efficiency measures will account for 196 Mtoe (corresponding to 35%) of all energy savings in 2016-2020.

Germany

Geography & People	Population (in 2017)[1]	80,594,000
	Urbanisation (in 2017)[1]	75.70%
	Land area[1]	348,672 km[2]
	Climate[1]	Cold temperate
Economy	Economic structure (GDP by sector of origin in 2017)[1]	Agriculture: 1% Industry: 30% Services: 69%
	Major industries (by energy consumption)[2]	Chemicals Iron & steel Non-metallic minerals Paper
	Economic development[3]	High income country
	GDP/capita (PPP) (in 2017)[1]	USD 50,200
	Average GDP growth rate (2012 – 2016)[3]	1.32%
Energy	Total final energy consumption (2015)[4]	220.17 Mtoe
	Supply mix (in 2015)[4]	32.3% Oil 25.5% Coal 20.9% Natural gas 9.6% Biofuels/waste 7.7% Nuclear 4.0 Renewables
	Net imports (in 2015)[4]	198.31 Mtoe
	Cost of energy (industrial)[5]	USD 170/MWh
	ISO 50001 certifications in 2016[6]	9,024 certificates

[1]CIA Factbook, 2017 [2]Myllyvirta, n.d. [3]World Bank, n.d. [4]IEA, 2015 [5]Climatescope, 2017 [6]ISO, 2016

Germany

Relevant policies/regulations

- In 2010, Germany initiated a far-reaching transformation of its energy system with its energy concept, the so-called 'Energiewende'. The country has set targets of 20% reduction in primary energy consumption by 2020 and 50% reduction by 2050 (compared with 2008 levels). The government identifies energy efficiency as crucial to reach these targets. To achieve these ambitious goals the government has implemented a comprehensive set of complementary policies, grant and loan schemes. The KfW's Energy Efficiency Programmes which offers loans up to EUR 25m per project. It is subdivided into three thematic categories (production facilities and processes, waste heat, energy efficient construction and refurbishment)

Energy efficiency/energy management

- Germany dominates the overall number of ISO 50001 certifications, accounting for 63.8% of the total number of certified organisations. The German EnMS market has been developing quite dynamically over the last few years as it experienced a push from the combination of technological innovations and regulatory developments. Public funding schemes are in place to support businesses in implementing EnMS. The Federal Ministry for Economic Affairs and Energy is promoting the implementation of EnMS under the Energy Efficiency Fund (EEF). The EEF was established in 2011 with initial funding of EUR 90m, and rose to EUR 462m in 2017. The program supports the initial certification of either an EnMS (fulfilling ISO 50001) or an energy monitoring system. The total market volume of energy management related services reached EUR 210m in 2016. About two-thirds of the market can be attributed to the acquisition and operation of EnMS software including the installation of sensors and meters.

India

Geography & People	Population (in 2017)[1]	1,282,000,000		
	Urbanisation (in 2017)[1]	33.50%		
	Land area[1]	2,973,193 km^2		
	Climate[1]	North: alpine/temperate and south: tropical		
Economy	Economic structure (GDP by sector of origin in 2017)[1]	Agriculture: 17%	Industry: 29%	Services: 47%
	Major industries[2] (by energy consumption)	Iron & Steel Chemicals		Brick Cement
	Economic development[3]	Lower middle income country		
	GDP/capita (PPP) (in 2017)[1]	USD 7,200		
	Average GDP growth rate (2012 – 2016)[3]	6.89%		
Energy	Total final energy consumption (2015)[4]	577.68 Mtoe		
	Supply mix (in 2015)[4]	44.5% Coal 24.2% Oil	23.1% Biofuels/waste 5.1% Natural gas	2.0% Renewables 1.1% Nuclear
	Net imports (in 2015)[4]	306.84 Mtoe		
	Cost of energy (industrial)[5]	USD 100.84/MWh		
	ISO 50001 certifications in 2016[6]	570 certificates		

[1]CIA Factbook, 2017 [2]IEA, 2015b [3]World Bank, n.d. [4]IEA, 2015a [5]Climatescope, 2017 [6]ISO, 2016

India

Relevant policies/regulations

- In the framework of the Energy Conservation Act (2001), large industrial energy consumers in 13 sectors have to implement energy audits, appoint certified energy managers and report energy consumption data. The Government has introduced a number of noteworthy policies and schemes to drive energy efficiency. For instance, the National Mission on Enhanced Energy Efficiency (NMEEE) aims to strengthen the energy efficiency market by creating a regulatory and policy regime to foster innovative and sustainable business models in the energy efficiency sector. Under the NMEEE, four key initiatives were launched to enhance energy efficiency in energy intensive industries: Perform, Achieve and Trade (PAT), Market Transformation for Energy Efficiency (MTEE), Energy Efficiency Financing Platform (EEFP), Framework for Energy Efficiency Economic Development (FEEED). The implementation and effectiveness of these measures is varied.

Energy efficiency/energy Management

- Implementing energy efficiency policies and EnMS for SMEs is difficult due to their diverse nature, lower awareness, the perceived risk of some efficiency technologies, lack of capital and high transaction costs. Guidelines for the implementation of EnMS are missing and there is no obligation for Indian enterprises to introduce such EnMS. Monitoring and targeting is usually not integrated with financial accounting output and is not reported to either users or senior managers in a form they can readily understand and use.

Mexico

Geography & People	Population (in 2017)[1]	124,575,000
	Urbanisation (in 2017)[1]	79.80%
	Land area[1]	1,943,945 km^2
	Climate[1]	Varies from tropical to desert
Economy	Economic structure (GDP by sector of origin in 2017)[1]	Agriculture: 4% Industry: 32% Services: 64%
	Major industries2 (by energy consumption)	Iron & steel Cement Chemical industry Glass
	Economic development[3]	Upper middle income country
	GDP/capita (PPP) (in 2017)[1]	USD 19,500
	Average GDP growth rate (2012 – 2016)[3]	2.52%
Energy	Total final energy consumption (2015)[4]	119.81 Mtoe
	Supply mix (in 2015)[4]	48.4% Oil 34.5% Natural gas 7.3% Coal 4.6% Biofuels/waste 3.6% Renewables 1.6% Nuclear
	Net imports (in 2015)[4]	- 1.57 Mtoe
	Cost of energy (industrial)[5]	USD 67.12/MWh
	ISO 50001 certifications in 2016[6]	18 certificates (besides ISO 50001 country specific EnMS standards in place)

[1]CIA Factbook, 2017 [2]CONUEE, 2016 [3]World Bank, n.d. [4]IEA, 2015 [5]Climatescope, 2017 [6]ISO, 2016

Mexico

Relevant policies/regulations

- Energy efficiency policy is aligned with the National Development Plan (NDP) which includes promotion of energy efficiency throughout the productive chain. Specific energy efficiency actions are set according to the Energy Sectoral Program (PROSENER) with the objective of expanding clean and renewable energy use, promoting energy efficiency and social environmental responsibility. The Energy Transition Law (LTE) represents a keystone in Mexico's new legislation on clean energy, energy efficiency and sustainable use of energy. The LTE mandates the National Commission for the Efficient Use of Energy (CONUEE) to create long term clean energy and energy efficiency goals for the generation and consumption of clean energy electricity in Mexico, as well as measures on the sustainable use of energy. The Roadmap of Energy Efficiency is the guide for implementing actions to meet energy efficiency targets established in the Program for the Sustainable Use of Energy (PRONASE), in accordance with the LTE. It contains strategies to achieve a final energy intensity reduction rate of 1.9% from 2016 (0.09 toe/USD 1000 GDP PPP) to 2030, and 3.7% from 2031 to 2050.

Energy efficiency/energy management

- The National Commission for the Efficient Use of Energy (CONUEE) is the technical organisation responsible for promoting energy efficiency and sustainable use of energy across the country. Mexico currently has 27 official (mandatory) energy efficiency standards for equipment and energy consuming systems. There are also voluntary standards based on international standards, e.g. the ISO 50001, which in 2011 was adopted as a national standard (NMX- J-SAA-50001-ANCE-IMNC-2011). Mexico has no voluntary energy performance agreement program or incentives for businesses in the manufacturing sector to improve energy efficiency. It has no law or regulation requiring industrial facilities to employ an energy manager, and it does not require periodic energy audits.

South Africa

Geography & People	Population (in 2017)[1]	54,841,000		
	Urbanisation (in 2017)[1]	65.80%		
	Land area[1]	1,214,470 km^2		
	Climate[1]	Mostly semiarid and subtropical along east coast		
Economy	Economic structure (GDP by sector of origin in 2017)[1]	Agriculture: 3%	Industry: 30%	Services: 67%
	Major industries[2] (by energy consumption)	Iron & steel Chemicals		Cement Paper
	Economic development[3]	Upper middle income country		
	GDP/capita (PPP) (in 2017)[1]	USD 13,400		
	Average GDP growth rate (2012 – 2016)[3]	1.60%		
Energy	Total final energy consumption (2015)[4]	74.79 Mtoe		
	Supply mix (in 2015)[4]	67.9% Coal 15.5% Oil	11.1% Biofuels/waste 3.0% Natural gas	2.2% Nuclear 0.3% Renewables
	Net imports (in 2015)[4]	- 20.80 Mtoe		
	Cost of energy (industrial)[5]	USD 72.83/MWh		
	ISO 50001 certifications in 2016[6]	10 certificates (besides ISO 50001 country specific EnMS standards in place)		

[1]CIA Factbook, 2017 [2]IEA, 2015b [3]World Bank, n.d. [4]IEA, 2015a [5]Climatescope, 2017 [6]ISO, 2016

South Africa

Relevant policies/regulations

- The first National Energy Efficiency Strategy (NEES) set an overall reduction target in energy intensity of 12% by 2015 based on 2000 levels (10 MJ/USD 1000 GDP). A National Energy Efficiency Action Plan was developed in 2012 describing the implementation of the strategy. The post-2015 NEES aims to build on this, stimulating further energy efficiency improvements through a combination of fiscal and financial incentives. Targets for industry are a 16% reduction in energy consumption in manufacturing by 2030 (relative to 2015 baseline); and for mining, a cumulative total annual energy saving of 40 PJ from energy efficiency interventions.

Energy efficiency/energy management

- With about 0.4toe/USD 1,000 GDP, South Africa is one of the most energy-intensive economies in the word due to the high share of coal in the primary energy mix (68% in 2015), and aging, inefficient infrastructure. For industry and businesses, the Energy Efficiency Savings Tax Incentive (Section 12L of the Income Tax Act), introduced in 2013, provides a tax deduction for savings achieved on a kilowatt-hour equivalent basis. According to the post-2015 NEES mandatory preparation and submission of energy management plans will be introduced for enterprises whose annual energy consumption exceeds 180 TJ. Alongside this, a second phase of the previously successful UNIDO Industrial Energy Efficiency (IEE) programme continues supporting the introduction of EnMS through capacity building, policy development and demonstration projects. Consideration will be given to the development of appropriate schemes to incentivise the introduction of EnMS and ISO 50001 certification, particularly among enterprises that are not directly reached by the IEE programme and are not covered by the regulation for mandatory energy management plans.

United States

Geography & People	Population (in 2017)[1]	327,000,000
	Urbanisation (in 2017)[1]	82.0%
	Land area[1]	9,147,593 km^2
	Climate[1]	Mostly temperate; Alaska: arctic and Florida, Hawaii: tropical
Economy	Economic structure (GDP by sector of origin in 2017)[1]	Agriculture: 1% Industry: 19% Services: 80%
	Major industries[2] (by energy consumption)	Chemicals Refining Mining Paper
	Economic development[3]	High income country
	GDP/capita (PPP) (in 2017)[1]	USD 59,500
	Average GDP growth rate (2012 – 2016)[3]	2.16%
Energy	Total final energy consumption (2015)[4]	1,520.14 Mtoe
	Supply mix (in 2015)[4]	36.4% Oil 29.6% Natural gas 17.1% Coal 9.9% Nuclear 4.5% Biofuels/waste 2.4% Renewables
	Net imports (in 2015)[4]	257.74 Mtoe
	Cost of energy (industrial)[5]	USD 102.7/MWh
	ISO 50001 certifications in 2016[6]	47 certificates

[1]CIA Factbook, 2017 [2] EIA,2017 [3]World Bank, n.d. [4]IEA, 2015a [5]EIA, 2018 [6]ISO, 2016

United States

Relevant policies/regulations

- Implementing energy efficiency actions by manufactures, builders and consumer is strongly linked to policies on both federal and state level. In the U.S., the federal government (in this case the Department of Energy) is directly responsible for energy efficiency policies. Over the years, federal and many state and local governments have adopted a broad array of public policies aimed at increasing energy efficiency and productivity. In 2013, as part of the US Climate Action Plan the Department of Energy has set a target of reducing CO_2 pollution in the country by 3bn tonnes cumulatively by 2030 specifically through energy efficiency standards for appliances and buildings. Despite being one of the world's largest energy consumers the United States has no binding energy reduction plan in place.

Energy efficiency/energy management

- The U.S. remains an energy-intensive economy, mostly due to its large transport sector and high living standards. The U.S. uses codes and standards primarily to govern the efficiency of new products, including buildings (building energy codes) and appliances (appliance standards). Most appliance standards are adopted at the federal level, while building codes are adopted by individual states. Most US states have adopted stringent building energy codes for new residential and commercial buildings and provide tools, training, and resources to support the adoption and maintenance of building codes. The ENERGY STAR labels demonstrate best practices for developing voluntary appliance and equipment standards. Technological advancements coupled with growing commercialisation of innovative products is projected to drive future investments in this sector. Increasing demand for EnMS in the industrial sector mainly in manufacturing and power/energy enterprises for assessing and real-time monitoring of energy consumption pattern is expected to stimulate the market growth in the near future.

CARBON TRUST

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