

Updating and extending carbon budget trajectories

A review of the evidence



Report for Committee on Climate Change

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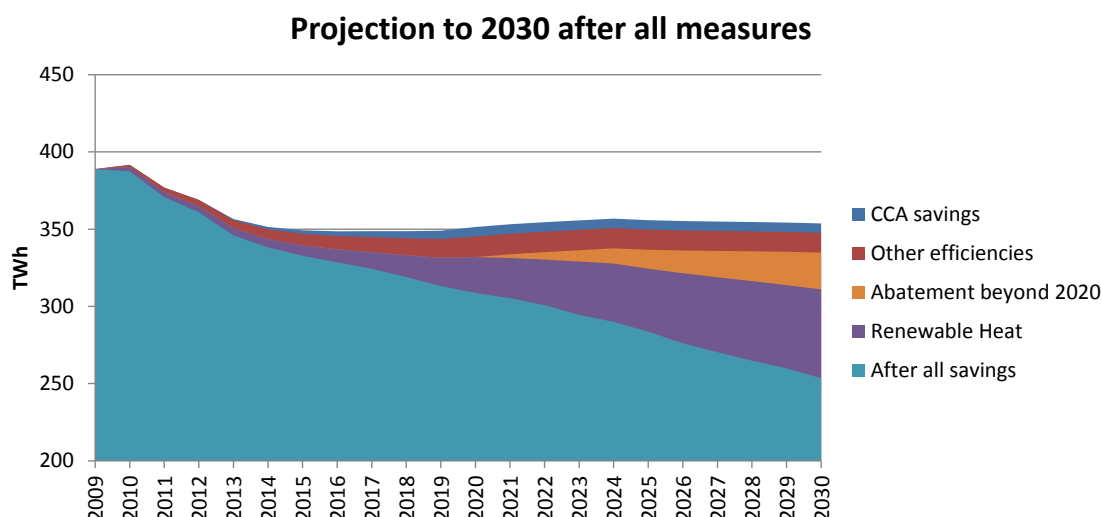
Executive summary

We have reviewed the carbon budget trajectories for industry produced in 2010 by the Committee on Climate Change and updated them to take consideration of policy and new information. In particular we have considered the potential impact of the CCA and EU ETS interventions up to 2020 and we have reviewed the potential savings for longer-term abatement through efficiencies and renewable heat up to 2030. The focus of the study was on energy efficiency and did not cover other abatement options such as carbon capture and storage, product substitution and materials efficiency. It should be noted that this study was a brief review and update only; no substantive new research has been undertaken.

The results of the study, showing the abatement potential in energy and carbon terms are shown in the figure and table below. These results have been reviewed with representatives of the major sectors and they have identified significant barriers to this potential after 2020, particularly in the Steel and Refineries sector. These barriers affect up to 85% of the efficiency potential (identified as 'Abatement beyond 2020' in the figure below). There are also barriers to the deployment of renewable heat.

The barriers that have been identified are principally economic in nature and they can be (and will need to be) overcome if the full carbon abatement potential is to be realised. More work will need to be done to understand and find solutions to these barriers but it is also worth noting that additional opportunities for abatement have also been identified through consultation with industry representatives as part of this work and additional studies are already underway that are expected to show others.

Graph of all savings in energy to 2030



Note that the energy scale begins at 200 TWh, not zero, to aid visibility.

All savings in Carbon terms by 2020 and 2030

Total Savings in MtCO ₂					
2020			2030		
Traded	Non Traded	Total	Traded	Non Traded	Total
6.7	3.2	9.9	19.7	4.6	24.3

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1 Introduction

1.1 Background

The Committee on Climate Change (CCC) was set up as part of the Climate Change Act. It is an independent body tasked with providing advice to government on climate change issues, and particularly the setting of carbon budgets for the UK.

In its first report (December 2008) the CCC reported that there was an opportunity for industry to reduce emissions through low-cost incremental energy efficiency measures by 6 MtCO₂ by 2020. Subsequently, the CCC's 2010 advice on the fourth carbon budget (2023-2027) concluded that there is the opportunity for significant industry abatement beyond 2020 through additional carbon and energy efficiency measures for carbon intensive sectors (a further 12 MtCO₂). At the same time the CCC noted that, even for industries where energy constitutes a substantial part of their costs, barriers exist that may prevent them taking up cost-effective measures.

In its 2013 Progress Report, the CCC reported its intention to continue the development of the carbon budget trajectories for industry, including an update on the assumptions underpinning the abatement options. This recognises the difficulty there is in estimating abatement potential and the extent to which it has occurred.

1.2 Review and Update

This project has been carried out to support the development of the industry carbon budget trajectories by reviewing the evidence base and updating it where possible to take account of new economic and policy developments since 2010.

The approach taken to carry out this work has been to:

1. Review the existing CCC data and analysis from 2010
2. Examine policy and economic changes since 2010 and their potential impact on abatement options for industry
3. Develop a model of these impacts for the key industry sectors
4. Report on the outcomes and review them with key industry sector representatives

It is important to note that the work carried out on this project has been a brief review and update of previous studies and no substantial new research has been undertaken. The review has concentrated on energy efficiency potential and has not included other abatement options such as carbon capture and storage (CCS), product substitution and materials efficiency.

The development of the trajectories will be a continuing activity. Further updates to the evidence on abatement technologies, impact and costs will continue to be made, in particular through: work recently commissioned by the Department for Energy and Climate Change (DECC) and the Department for Business, Innovation and Skills (BIS) to develop roadmaps for industrial decarbonisation to 2050; work for the UK Energy Research Centre (UKERC) by the University of Bath; and additional abatement potential identified by industry sectors in their own studies. The outputs from these and other studies will enable further updates and revisions to the industry trajectories in future.

The following sections of this report outline in detail the work carried out for the steps listed above, including a report on a sector-by-sector basis of the modelling results and the engagement with the sector representatives.

2 Industry Trajectories in 2010

As a first step in updating the assumptions and options underlying the carbon budget trajectories, we have reviewed the existing data and analysis previously carried out by CCC in 2010.

Figure 1 shows in summary the approach taken to develop the carbon budget trajectories for industry in 2010, through the impact of abatement options identified from a range of modelling and studies commissioned by CCC in that year.

Each of the steps involved in developing these trajectories is outlined briefly below and is reviewed and examined in greater detail in the later sections of this report. In total the measures identified result in a reduction in non-renewable energy use (i.e. electricity and fossil fuels) of 100 TWh by 2030 (approximately 25%), from the baseline energy projection for that year.

Baseline: the baseline used for the trajectories was the baseline scenario from DECC's Updated Energy and Emissions Projections in 2010 (UEP40). These projections are regularly updated and the baseline scenario gives an indication of the likely final energy consumption in the absence of any additional policy impacts beyond those in the Low Carbon Transition Plan (15 July 2009).

Abatement to 2020: abatement potential for industry to 2020 was analysed using Enusim (the industry End Use Simulation model). This is a least-cost end-use uptake model that contains detailed information about options for the industrial sector of the economy.

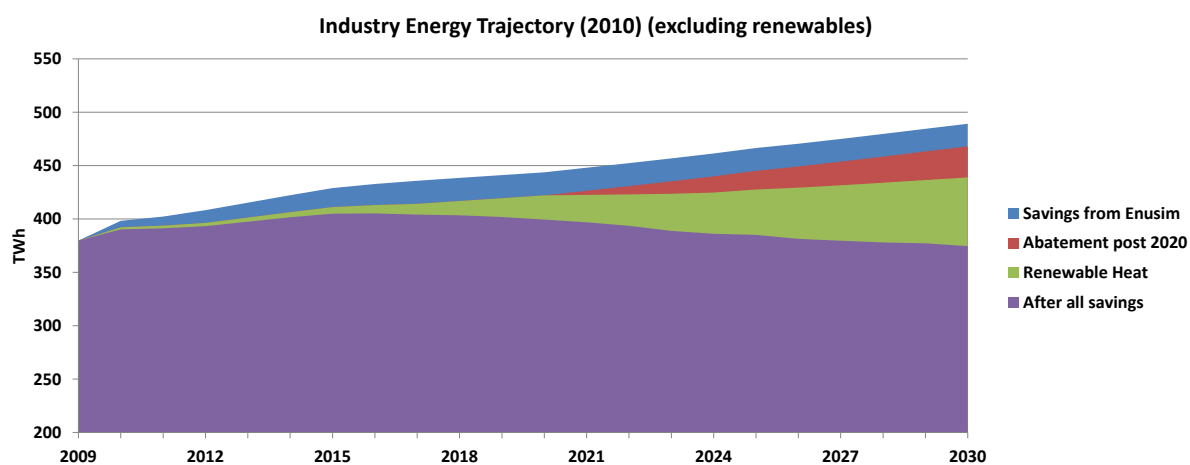
Abatement beyond 2020: in 2010 the CCC commissioned AEA to carry out a study of further abatement opportunities that would become available after 2020¹. This study identified that there is substantial abatement potential from a range of activities in the key industrial sectors of refineries, iron & steel, cement, chemicals, food and drink and glass. In the technically feasible core scenario, the total abatement potential available in 2030 was found to be 37 MtCO₂. Of this potential, 22 MtCO₂ is cost-effective and 10 MtCO₂ is considered realistic after barriers to implementation have been taken into account.

Renewable Heat: in 2010 the CCC also commissioned NERA and AEA to carry out a study into the potential for decarbonising heat² through the use of renewable heat sources including ground and air source heat pumps, district heating and the use of bioenergy (both biogas and biomass). This identified the potential to switch up to 39% of fossil fuel use in industry to renewables by 2030 to generate heat. In developing the trajectory in Figure 1 an additional assumption was made that renewable heat would achieve an aspiration figure of 14% penetration by 2020.

¹ "Analysing the Opportunities for Abatement in Major Emitting Industrial Sectors", AEA 2010

² "Decarbonising Heat: Low-Carbon Heat Scenarios for the 2020s", NERA and AEA 2010

Figure 1: Industry Trajectory in 2010



Note that in this and later charts the energy scale begins at 200 TWh, not zero, in order to make the impact of different actions more visible on the chart.

3 Baseline

3.1 2010 Baseline

The Department of Energy and Climate Change (DECC) regularly updates projections of energy demand, supply and greenhouse gas emissions in its Updated Energy and Emissions Projections (UEP). The UEP model takes account of data including fossil fuel and carbon prices projections, growth projections from the Office for Budget Responsibility and cost estimates for the power sector. These data include gross value added (GVA) projections for industry sectors.

The UEP model is used to evaluate various scenarios, including a 'Baseline' scenario, which includes policies introduced in or announced before the Low Carbon Transition Plan (LCTP) on 15 July 2009. For industry this includes Carbon Trust measures (including small business energy efficiency interest-free loans) and the impact of Building Regulations Part L (2002 & 2005/6).

For the carbon budget trajectories for industry in 2010, the UEP Baseline scenario was used to set a baseline for future final energy demand from industry. This took the 2010 update, known as UEP40³.

UEP40 was also used as the baseline for the AEA study of further abatement beyond 2020. The NERA/AEA study of heat decarbonisation used UEP38 (from 2009) as a baseline.

3.2 Updated Baseline

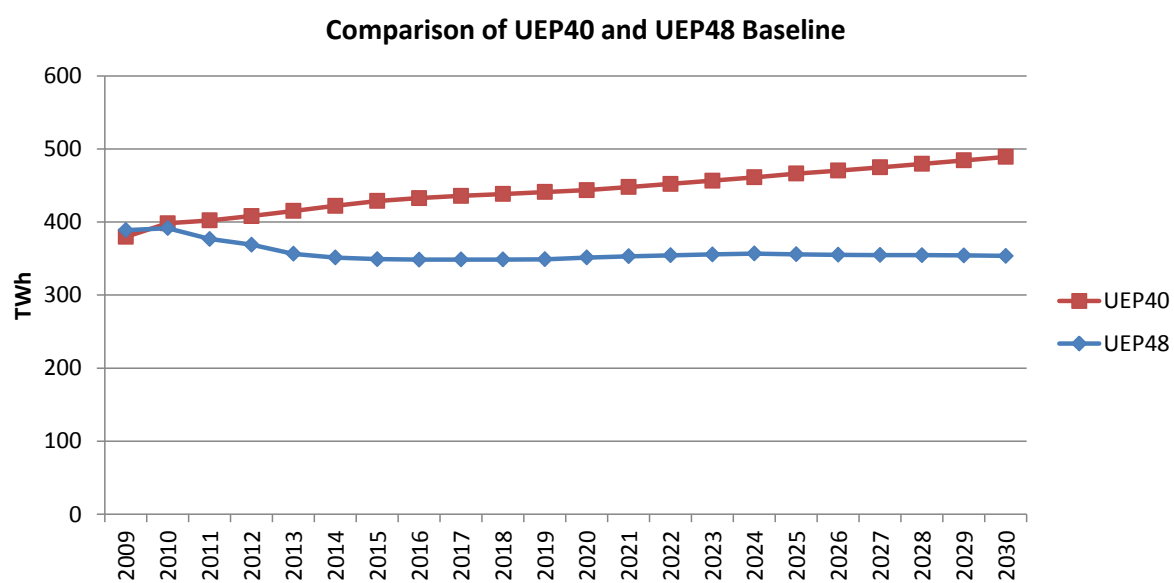
As a first step in reviewing the evidence base for the industry trajectories, we have updated the baseline to the most up-to-date version of UEP (UEP48 published by DECC in September 2013⁴). In addition to the published data, DECC have provided additional information to the CCC for this project on the disaggregation of the projections for industry at the sector level.

Appendix 3 shows the breakdown by fuel source of the UEP48 projections for industry. For the purposes of its modelling activity DECC disaggregates the data to major industry groupings as shown in the table. We have termed these the '**UEP Sectors**' and have used them as the basis for further evidence review in the remainder of this report. Figure 2 shows the total baseline energy graphically from UEP40 (2010) and UEP48 (2013).

³ Updated Energy and Emissions Projections 2010: http://webarchive.nationalarchives.gov.uk/20130106105028/http://www.decc.gov.uk/en/content/cms/about/ec_social_res/analytic_projs/en_emis_pr_ojs/en_emis_projs.aspx#2010-projections

⁴ Updated Energy and Emissions Projections 2013: <https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2013>

Figure 2: UEP48 Baseline Energy Projection for Industry



4 Savings to 2020

In this section we consider the potential abatement in energy and carbon to 2020. The study begins with a review of potential identified with the Enusim model in 2010 and then considers the potential impact of the two major policy instruments that will affect energy end-use consumption in industry to 2020, namely the Climate Change Agreements (CCAs) and the European Union Emissions Trading Scheme (EU ETS) Phase 3. In particular we examine the likely measures that industry will employ to meet the requirements of these policies.

4.1 Review of Enusim savings

4.1.1 Background

Enusim is a technology based, “bottom up”, model originally developed in the 1990s to model the uptake or retrofit of energy saving and/or fuel switching technologies in industry, considering both economic and behavioural factors which affect investment in new technology. The model is complex and disaggregates industry into a number of sectors, sub-sectors, devices and technologies.

For each technology Enusim has data on capital and operating costs. The model calculates the annual saving for each technology option and orders them so that the technology providing the most cost-effective annual saving appears at the top of the list. The model works by retrofitting technology options to the base device in order of most cost-effective to least cost-effective.

The data for each sector in Enusim has been updated at different times and to different degrees of detail, depending on the availability of information on technologies, abatement potential and costs.

4.1.2 Issues with Enusim

Enusim has been used at various times to estimate energy abatement potential, notably in the development of industry policy such as the CCAs. There have, however, been some issues highlighted with the model. In particular these include:

- Lack of transparency in the data and operation of the model
- Difficulty in using the model
- The poor quality of the data underlying the model
- The basic methodology used to model technology take-up

These issues have led to a lack of confidence in the model from industry sectors and for this reason it was not used in the development of new CCA targets in 2012 (discussed further in section 4.2).

Some of these criticisms (particularly on the quality of the data) are, in part, due to the limited ability (and in some cases willingness, given commercial considerations) of industry to provide more accurate and up-to-date information. The existing data for many of the sectors dates from 2002 (including some of the largest industry sectors like Steel, Chemicals and Paper), and most have not been seriously updated since 2006.

As will be seen below, however, the outputs from Enusim still provide the best available information on abatement at this time, underlining the need for the development of new data sources.

4.1.3 Use of Enusim for carbon budget trajectories

In 2010 the CCC used Enusim to identify potential for abatement to 2020 in the major industrial sectors (including all the main UEP Sectors except Refineries and Unclassified). The savings identified, based on the UEP40 projections in 2010, are summarised in Table 1.

Table 1: Summary of Energy Savings in 2020 from Enusim

Sector	Savings in 2020 (TWh)		UEP40 2020 Baseline (TWh)		Savings as %		
	Electricity ⁵	Fossil fuel	Electricity	Fossil fuel	Electricity	Fossil fuel	Total
Chemicals	-0.41	-5.54	23.88	30.85	-1.7%	-18.0%	-10.9%
Construction & Other Industry	-0.60	-0.41	23.33	43.75	-2.6%	-0.9%	-1.5%
Engineering & Vehicles	-1.26	-3.10	27.41	21.71	-4.6%	-14.3%	-8.9%
Food, Drink & Tobacco	-0.43	-1.55	12.45	40.36	-3.5%	-3.8%	-3.8%
Iron & Steel	-0.44	-1.66	4.64	14.67	-9.5%	-11.3%	-10.9%
Mineral Products	-0.09	-1.68	10.08	17.64	-0.9%	-9.5%	-6.4%
Non-Ferrous Metals	-0.55	-0.17	7.97	2.91	-6.9%	-6.0%	-6.7%
Paper, Printing & Publishing	-0.20	-3.99	23.69	16.31	-0.8%	-24.5%	-10.5%
Textiles, Leather & Clothing	-0.04	-0.31	3.29	9.12	-1.2%	-3.4%	-2.8%
TOTAL	-4.03	-18.42	136.74	197.32	-2.9%	-9.3%	-6.7%

The detailed information from the Enusim model run used in 2010 has been analysed to understand what abatement measures contribute to these savings.

The overwhelming majority of the savings (> 90%, excluding impulse drying, see below) can be attributed to the following basic activities:

- Gradual replacement of plant with more efficient technologies (e.g. high efficiency motors, insulation, more efficient lighting)
- Optimisation and improved control of existing processes
- Energy management (including monitoring and targeting)
- Waste heat recovery

There is one exception to this, which is the saving attributed to the use of Impulse Drying in the Paper sector (which accounts for 15% of the total saving calculated with Enusim above). As discussed further below, the sector representatives do not believe that this saving is likely either before 2020 or even before 2030. If it is excluded then the summary of energy savings becomes as shown in Table 2.

Table 2: Summary of Energy Savings in 2020 from Enusim, excluding Impulse Drying

Sector	Savings in 2020 (TWh)		UEP40 2020 Baseline (TWh)		Savings as %		
	Electricity	Fossil fuel	Electricity	Fossil fuel	Electricity	Fossil fuel	Total
Chemicals	-0.41	-5.54	23.88	30.85	-1.7%	-18.0%	-10.9%
Construction & Other Industry	-0.60	-0.41	23.33	43.75	-2.6%	-0.9%	-1.5%
Engineering & Vehicles	-1.26	-3.10	27.41	21.71	-4.6%	-14.3%	-8.9%
Food, Drink & Tobacco	-0.43	-1.55	12.45	40.36	-3.5%	-3.8%	-3.8%
Iron & Steel	-0.44	-1.66	4.64	14.67	-9.5%	-11.3%	-10.9%
Mineral Products	-0.09	-1.68	10.08	17.64	-0.9%	-9.5%	-6.4%
Non-Ferrous Metals	-0.55	-0.17	7.97	2.91	-6.9%	-6.0%	-6.7%
Paper, Printing & Publishing	-0.20	-0.62	23.69	16.31	-0.8%	-3.8%	-2.0%

⁵ 'Electricity' here and throughout this report is electricity 'delivered' to the end user, not 'primary' electricity generated.

Textiles, Leather & Clothing	-0.04	-0.31	3.29	9.12	-1.2%	-3.4%	-2.8%
TOTAL	-4.03	-15.04	136.74	197.32	-2.9%	-7.6%	-5.7%

These basic energy efficiency measures have been utilised by industry for many years and sector representatives have agreed that they will underpin any likely abatement to 2020 in discussion with the author. The uncertainty is how much each measure will contribute and how much can be saved overall. This is discussed further in the following sections.

4.2 Impact of CCA

4.2.1 Approach

The Climate Change Levy (CCL) is a tax on specific energy products used by business consumers (including the public sector) introduced on 1 April 2001, including electricity, gas, coal, coke, petroleum coke and liquid petroleum gas (LPG).

Climate Change Agreements (CCA) allow eligible businesses to receive 65% discount from the CCL on levied fossil fuels and a 90% discount on electricity. The initial CCAs were agreed in 2000, running to 31 March 2013. A second phase of CCAs has now been agreed, running from 1 April 2013 to 31 March 2023. Participants are eligible for a CCA if they meet one of the sector definitions agreed between industry and government, based on activities regulated by the Environmental Permitting Regulations 2010 or the energy intensity of operations.⁶

The agreements currently cover a total of 51 sectors. Four of these are agricultural but the other 47 can be mapped to the UEP Sectors considered in this project. Appendix 1 gives a full list of the CCA sectors with the mapping that has been carried out.

Each CCA sector has a series of target commitments to improve energy efficiency, with targets at 2014, 2016, 2018 and 2020. The majority of the targets are from a base year of 2008 and are 'relative', i.e. they require a reduction in the energy consumption per unit of production, rather than in absolute energy consumption.

CCAs do not apply to all the energy use in a sector but only to that which is eligible. In addition the CCA targets do not apply to any energy which is also covered by the EU ETS. This means that for many sectors the targets apply effectively only to grid electricity consumption and not to direct fuel consumption. It is worth noting that CCAs also apply to non-EU ETS renewable fuel use (e.g. biomass) and so there is an incentive to reduce the consumption of this.

The potential impact of CCAs has been modelled as part of this project. In order to do this an estimation has been made of the energy in each UEP Sector covered by CCAs (both electricity and fossil fuels) and an average 'target' has been calculated for each UEP Sector for each year, interpolating the targets linearly between CCA target periods.

Since CCA targets are predominantly 'relative' the saving from the baseline (UEP48) is calculated as a percentage reduction from the baseline value. For example, if the 2020 CCA target commitment is a reduction in relative energy consumption of 10% then the saving from baseline is calculated as the baseline 2020 projection multiplied by 0.9. This will be true if a later updated to UEP results in a higher baseline figure.

In practice the savings from the CCA baseline of 2008 and 2012 may already have been made and will be incorporated in the baseline projections, so for the purposes of modelling the impact of CCAs the targets for the years 2013 to 2020 have been scaled accordingly.

⁶ <https://www.gov.uk/government/policies/reducing-demand-for-energy-from-industry-businesses-and-the-public-sector--2/supporting-pages/climate-change-agreements-ccas>

Table 3 summarises the impact of CCAs by UEP Sector and Figure 3 shows the overall impact on projected energy consumption to 2020 if the CCA targets are met. As can be seen in the table, whilst the agreements cover a significant amount of the UEP Sector energy, the CCA targets only cover a fraction of the total energy used.

In total the CCA targets are estimated to apply to approximately 16% of the energy in the UEP Sectors (including Refineries); applying to approximately 38% of the electricity but only 9% of the fossil fuel use.

For the energy actually covered by CCAs the overall target is estimated to be a reduction of 12%. However, it is estimated that the overall impact on energy consumption in 2020 for the UEP Sectors as a whole from CCAs (assuming the targets are met) is a reduction of only 1.7%.

Figure 3: Impact of CCA targets on projected energy to 2020

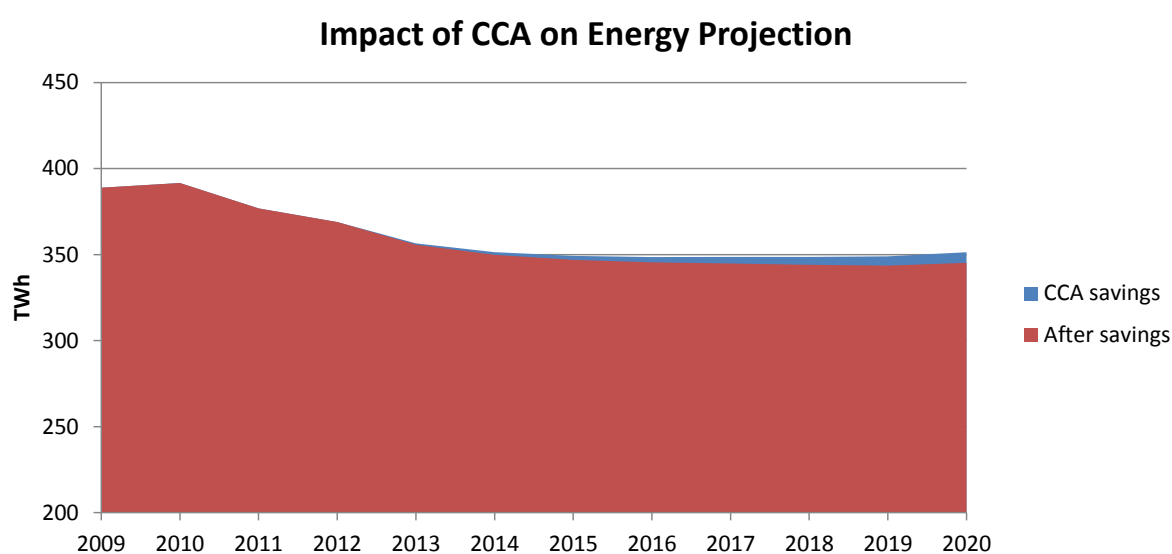


Table 3: CCA Impact by UEP Sector in 2020

UEP Sector	Estimated % of UEP Energy covered by CCA	Estimated % of UEP Energy covered by CCA Target	Estimated UEP Sector CCA target
Chemicals	96%	6.5%	-10%
Construction & Other Industry	10%	0.8%	-12%
Engineering & Vehicles	28%	9.6%	-13%
Food, Drink and Tobacco	97%	39.1%	-15%
Iron & steel	100%	2.2%	-5%
Mineral Products	38%	5.1%	-6%
Non-Ferrous Metals	37%	17.6%	-4%
Paper, Printing & Publishing	77%	4.6%	-8%
Textiles, Leather & Clothing	17%	11.2%	-15%
Unclassified	8%	3.9%	-18%
Refineries*	0%	0%	0%

*Note that Refineries are not covered by CCAs

4.2.2 Discussion

CCA sectors can use any measure they deem suitable in order to meet their CCA targets. The targets were agreed with DECC via a process of negotiation during which most of the sectors analysed the potential abatement measures and provided information on these to DECC. These negotiations and the data involved are confidential to DECC and the industry sectors. However, it is anticipated that the bulk of the savings will come from the same core abatement measures that have been previously analysed with Enusim (above). The abatement from individual measures may differ to Enusim because of different information provided by industry on the levels of penetration and cost-effectiveness.

4.3 Other efficiencies

As discussed above, the CCA policy does not cover all the energy consumed in industry in the UK. This is particularly the case in sectors such as Construction and Engineering & Vehicles, where there are a large number of small to medium size operators and large operators whose energy use is not eligible. Table 4, below, summarises the estimated percentage of each UEP Sector (in energy terms) that is not covered by CCA. It can be seen that there is more fossil fuel use which is not covered because most of this is covered by EU ETS and not subject to CCA targets.

Table 4: Percentage of Energy not covered by CCA

UEP Sector	%Electricity NOT covered	% Fossil fuel NOT covered
Chemicals	4.0%	92.5%
Construction & Other Industry	89.7%	98.7%
Engineering & Vehicles	71.7%	84.8%
Food, Drink and Tobacco	3.3%	45.7%
Iron & steel	0.0%	97.9%
Mineral Products	61.7%	94.1%
Non-Ferrous Metals	62.7%	74.8%
Paper, Printing & Publishing	23.3%	94.3%
Textiles, Leather & Clothing	83.4%	83.7%
Unclassified	91.8%	91.8%
Refineries	0%	0%

Further efficiencies in the use of this energy can be expected to 2020. The abatement opportunities that have previously been analysed apply equally to these operations. Moreover, since these activities have not been covered by CCA in the past, they have had less incentive to improve efficiency than others and the potential savings may be relatively greater.

In 2012 DECC commissioned a study by McKinsey to examine the potential for efficiency potential in electricity use in the UK⁷. This study identified three key measures for industry, reflecting pump, motor and boiler optimisation that could generate savings of 24 TWh a year by 2030. The scale of these savings is questionable for the UK, however. The figure of 24 TWh corresponds to almost 23% of all industry electricity use in the UK in 2030 as projected

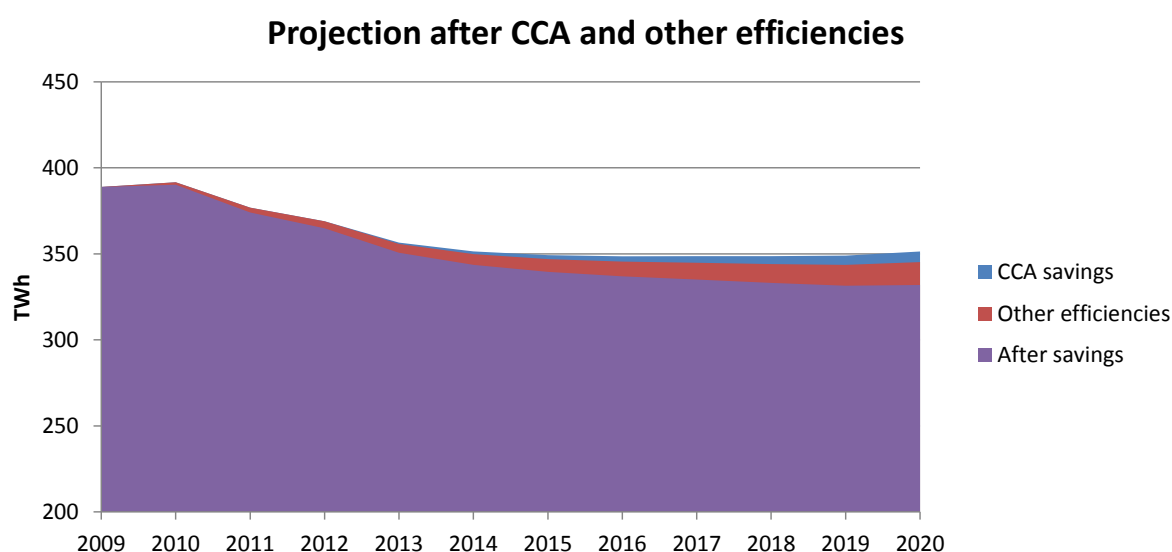
⁷ "Capturing the full electricity efficiency potential of the UK", DRAFT report July 2012, DECC.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48456/5776-capturing-the-full-electricity-efficiency-potential.pdf

in UEP. Moreover, the McKinsey report draws on international data on electricity use and it is believed that UK industry is likely to be considerably more efficient than the international average, in part because of the policies such as CCA since 2000. The true potential for electricity consumption reductions is therefore likely to be much less.

In order to allow for the fact that some savings in energy consumption are to be expected by 2020 in areas not covered by CCA, we have made the assumption that the savings previously calculated using Enusim (see Table 3) will still apply to this energy, in the absence of more up-to-date information on the potential in these areas.

Figure 4 shows the overall impact on energy consumption of taking this approach, in addition to the CCA effects modelled above.

Figure 4: Projected energy after CCA, EU ETS and other efficiencies



Note that the energy scale begins at 200 TWh, not zero, to aid visibility.

4.4 Renewable Heat

As discussed in section 2 of this report, in 2010 the CCC modelled the impact on grid electricity and fossil fuel consumption in industry of a move to the use of more renewables to generate heat.

In the UK Renewable Energy Roadmap⁸ published in 2011, DECC lay out the evidence to support the UK target to generate 15% of energy demand from renewable sources by 2020. Most of this is attributed to electricity generation from renewables, but the Renewable Heat Incentive scheme is still projected to stimulate as many as 124,000 renewable heat installations in the UK by 2020.

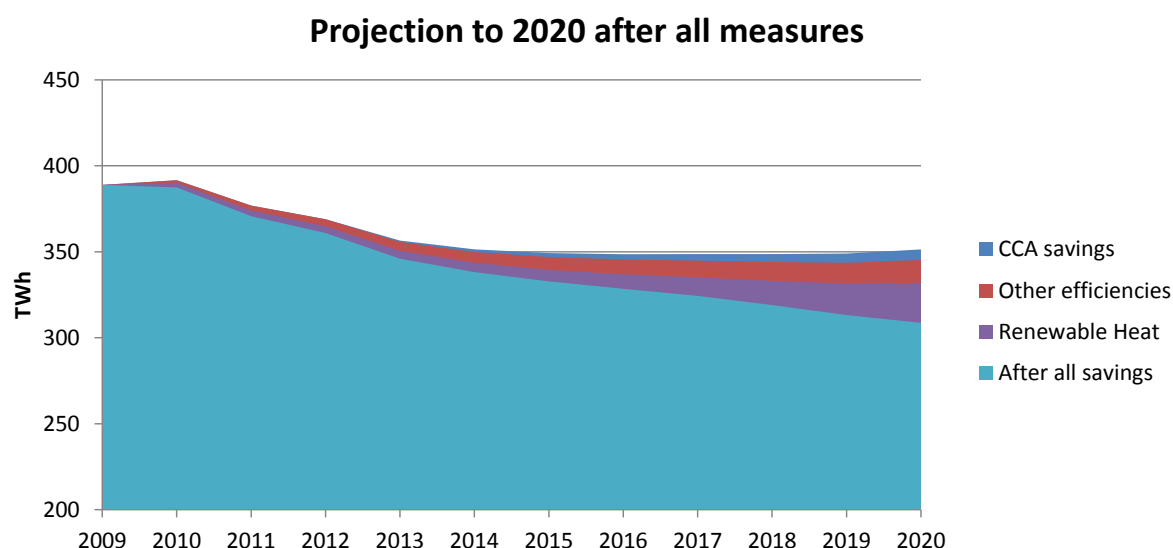
In the absence of direct evidence to attribute potential renewable heat savings to specific industry sectors, in 2010 the CCC estimated the potential to 2020 by assuming the penetration would increase exponentially from zero to an aspirational target of 14% by 2020.

In carrying out this work we have followed the same approach. Figure 5 demonstrates the impact of these savings in addition to CCA and other energy efficiency measures described above. In the later sections of this report we discuss the potential implications for each UEP Sector. In particular, feedback from industry representatives indicates that there are potential

⁸ "UK Renewable Energy Roadmap", DECC 2011, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48128/2167-uk-renewable-energy-roadmap.pdf

constraints on the take-up of renewable heat in industry that may prevent this level of savings being possible by 2020 (or beyond – see section 5.2 below).

Figure 5: Projections to 2020 after all measures



Note that the energy scale begins at 200 TWh, not zero, to aid visibility.

4.5 Summary of savings to 2020

In this section of the report we have shown the potential energy savings for industry to 2020, including the measures that are available and the potential impact of key policy initiatives.

4.5.1 Comparison to 2010 analysis

In the 2010 analysis supporting the carbon budget trajectories for industry, the CCC estimated a total saving potential in 2020 of 45 TWh per annum from the UEP baseline, a reduction of 10%. In this work we estimate a total saving of 42 TWh (12%). In absolute energy terms these figures are smaller because the UEP baseline energy for 2020 is now projected to be significantly less than in 2010 (reduced from 444 TWh to 351 TWh) due to changes in economic and price projections. It is also worth noting that the CCA savings are relative and would be larger for a higher baseline energy figure.

Table 5 shows how the savings figures are broken down in the 2010 analysis and in our new analysis, in percentage terms, for direct comparison.

Table 5: Split of savings in 2020 by measure

	2010 analysis		2013 analysis
Enusim	5%	CCA	2%
		Other efficiencies	4%
Renewable Heat	5%	Renewable Heat	6%
TOTAL	10%	TOTAL	12%

Overall, therefore, the result of the new analysis is that the potential to 2020 is broadly the same relative to the baseline as it was in 2010.

4.5.2 Cost of abatement

The core abatement opportunities previously analysed with Enusim are still considered to be the main route to efficiency improvements to 2020, as agreed in discussion with industry sector representatives.

Data on costs for these measures is difficult to obtain from industry. A recent literature review carried out by Ricardo-AEA and Imperial College for DECC⁹ has shown that there is a general lack of specific data on the cost of carbon abatement measures both in the UK and internationally.

In the light of this lack of more up-to-date evidence, the data in the Enusim model on the cost of implementation of efficiency measures is probably still the best available. This equates to a negative average net cost of abatement of -£86 /tCO₂ by 2020 based on data provided by the CCC for this project.

4.6 Impact of EU ETS Phase 3

4.6.1 Introduction

The European Union Emissions Trading System (EU ETS) operates in the 28 EU countries plus Iceland, Liechtenstein and Norway. It is a “cap and trade” system. A cap is set on the total amount of certain greenhouse gases that can be emitted in the system, which is reduced over time so that total emissions fall. Within this cap companies receive or buy allowances which they can trade as needed, so that emissions are cut where it costs least to do so.¹⁰

Analysis carried out for this project shows that the EU ETS applies to operators in all of the UEP Sectors, except ‘Unclassified’. Phase 3 of the scheme runs from 2013 to 2020 and most (but not all) of the operators have been given free allocations of allowances based on ambitious EU-wide benchmarks of emissions performance. These are intended to drive operators to reduce emissions to the level of the top 10% of EU operators for each activity.

Operators covered by EU ETS can use a range of measures to meet their allocations. Moreover, given that the underlying purpose of EU ETS is to encourage carbon reduction in the most cost-effective way overall, some operators may actually find it more cost-effective to buy allowances from others, rather than make savings through efficiencies. It is even possible that UK industry as a whole would need to purchase net allowances from elsewhere in Europe. Earlier performance in Phases 1 and 2 of EU ETS and other studies of EU ETS (including DECC’s analysis supporting UEP48) indicate that it is more likely that UK industry as a whole will have a surplus of allowances in Phase 3 and that energy consumption overall will reduce.

In meeting EU ETS allocations to 2020 carbon savings are likely to come from a mixture of the energy efficiency saving measures discussed above and the use of renewable energy sources. It is worth noting that the actions made to meet CCA targets may not make significant contribution here as they deliberately apply to energy use that is not covered by EU ETS.

4.6.2 Analysis of EU ETS

As part of this review we have carried out an analysis of the EU ETS Phase 3 allocations for the UEP Sectors and compared them to the energy efficiency and renewable heat potential to 2020 described above.

⁹ “Decarbonisation of heat in industry, a review of the research evidence”, Ricardo-AEA and Imperial College for DECC, July 2013.

¹⁰ <http://ec.europa.eu/clima/policies/ets/>

The data for EU ETS has been drawn from two sources:

1. The National Implementation Measures published by DECC¹¹, which contains details of each installation and the free allocation for each year from 2013 to 2020.
2. The Community Independent Transaction Log (CITL)¹², which contains details of the regulated activity for each installation.

By matching the data from these two sources, the allocations can be lined up against the activity (e.g. manufacture of ceramics) to identify which UEP Sector each installation corresponds to. Many of the installations are in other sectors of the economy (for example universities and hospitals) or in the oil and gas industry and these have been discounted.

EU ETS allocations are for all greenhouse gas emissions, both those corresponding to energy use and those from process activity. We have therefore estimated the allocations for energy use by subtracting an amount for process emissions for the relevant sectors. Process emissions have been estimated using values provided by DECC, as used in UEP48. Table 6 shows these values. We recognise that these process emissions may in practice be quite different for some sectors, depending on the level of production achieved, and this is discussed further in the individual sections for each UEP Sector later in this report.

Table 6: Process Emissions from Industry (DECC UEP48 values)

MtCO ₂	2012	2013	2014	2015	2016	2017	2018	2019	2020
Iron & Steel	4.083	4.171	4.241	4.216	4.217	4.234	4.247	4.260	4.280
Non-metallic minerals	5.119	4.793	4.628	4.518	4.448	4.390	4.336	4.284	4.234
Chemicals	0.863	0.788	0.758	0.743	0.738	0.734	0.731	0.729	0.729
Non-ferrous metals	0.130	0.121	0.114	0.111	0.110	0.111	0.112	0.113	0.114
TOTAL	10.194	9.872	9.740	9.588	9.513	9.468	9.425	9.386	9.357

After deducting for process emissions, the allocations have been converted into energy terms in order to allow comparison with the UEP baseline. This has been carried out using carbon factors as detailed in Appendix 2 of this report. For each year from 2013 to 2020 a weighted carbon factor has been calculated for each UEP Sector using the factors for each fuel and the fuel split in the UEP baseline projections. Table 7, below, summarises the total energy 'allocation' for each sector resulting from these calculations. This corresponds only to fossil fuel consumption and does not include electricity or any fuel not producing CO₂ (e.g. biomass).

Table 7: EU ETS allocation for energy use emissions in energy terms

TWh	2013	2014	2015	2016	2017	2018	2019	2020
Chemicals	37.61	36.97	36.17	35.31	34.58	33.77	32.87	32.14
Construction & Other Industry	3.15	2.97	2.82	2.69	2.55	2.42	2.29	2.16
Engineering & Vehicles	3.39	3.15	2.92	2.71	2.51	2.31	2.11	1.92
Food, Drink & Tobacco	10.84	10.13	9.48	8.87	8.28	7.71	7.17	6.64
Iron & Steel	52.35	50.71	48.93	47.01	46.33	45.16	43.25	41.95
Mineral Products	27.28	26.93	26.37	25.66	24.90	24.12	23.33	22.53
Non-Ferrous Metals	1.95	1.95	1.93	1.90	1.86	1.81	1.76	1.71
Paper, Printing & Publishing	7.82	7.68	7.54	7.40	7.26	7.12	6.97	6.83

¹¹ <https://www.gov.uk/participating-in-the-eu-ets>

¹² <http://ec.europa.eu/environment/ets/>

Textiles, Leather & Clothing	1.36	1.34	1.31	1.29	1.26	1.23	1.21	1.18
Refineries	46.32	45.52	44.70	43.88	43.05	42.21	41.36	40.51

Further discussion of these allocations is given in the sections for each UEP Sector. In particular for Iron & Steel the allocation includes covers coke production as well as final energy use and the Refineries sector is known to be under-allocated.

For each UEP Sector an estimate has then been made of the potential impact on energy use if the industry were to reduce its fossil fuel energy consumption to meet this allocation.

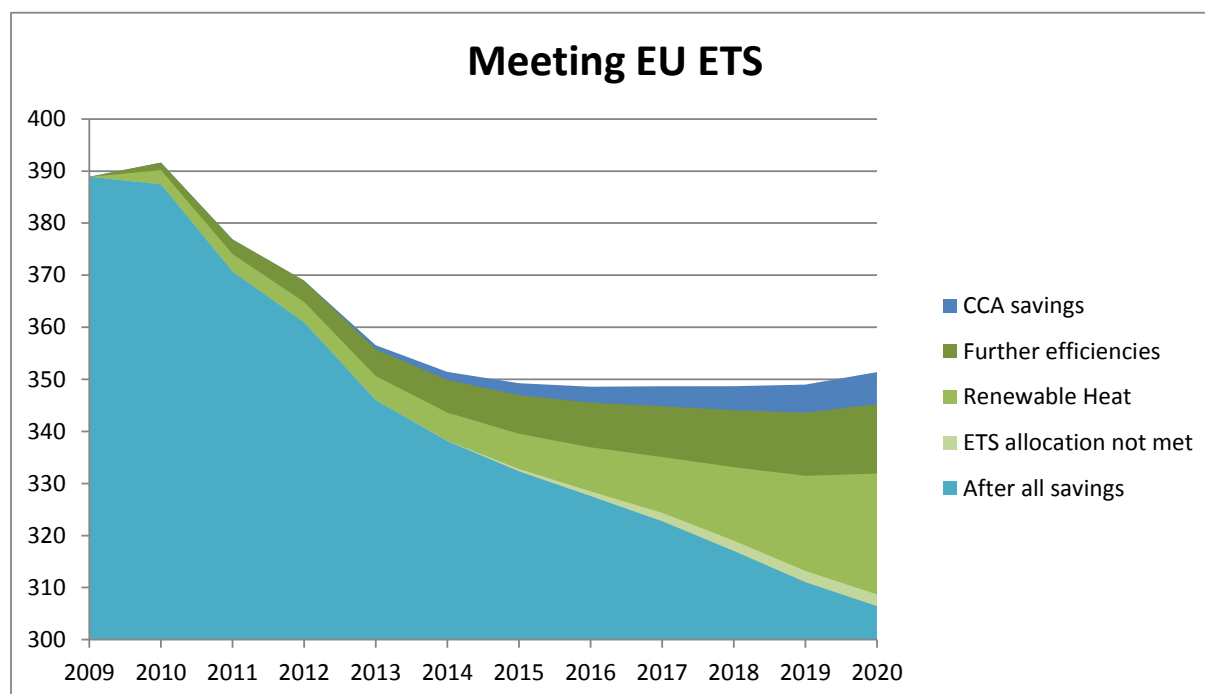
To estimate the potential impact on energy use for each UEP Sector it has been assumed that:

- Energy covered by EU ETS is capped at the allocation level OR the UEP baseline, whichever is lower
- Energy not covered by EU ETS is allowed to vary as in the UEP baseline.

In practice the EU ETS allocation is an 'absolute' figure and may actually be higher than the UEP baseline projection figure. It is believed, however, that some sectors are over-allocated (i.e. have been allocated more than they require). Further discussion on allocation levels is given for each UEP Sector later in this report.

Figure 6 shows the overall impact if the EU ETS allowance allocations were not to be exceeded, by a mixture of the energy efficiency measures (from Enusim) and renewable heat discussed above. Note that this is in addition to the CCA targets, which affect energy not covered by EU ETS. The chart shows that, even if all the efficiency and renewable heat savings are made there may still remain a small amount of action to be made.

Figure 6: Meeting the EU ETS allocation



Note that the energy scale begins at 300 TWh on this graph to aid visibility.

Table 8 shows a breakdown of this data by UEP sector for 2020. This shows the renewable heat savings as a total across all sectors as they have not been disaggregated to sector level.

Table 8: Meeting the EU ETS allocation by sector

TWh	2020				
Sector (UEP)	ETS allocation level	After CCA+ Further efficiencies	Remainder		
Chemicals	36.4	40.1	3.7		
Construction & Other Manufacturing	31.6	33.4	1.8		
Engineering & Vehicles	36.6	39.9	3.3		
Food, Drink & Tobacco	26.9	32.0	5.1		
Iron&steel	12.6	13.8	1.2		
Mineral Products	26.5	29.5	3.0		
Non-Ferrous Metals	2.6	2.7	0.1		
Paper, Printing & Publishing	22.4	25.2	2.8		
Refineries*	71.0	71.0	0.0		
Textiles, Leather & Clothing	6.3	7.0	0.7		
Unclassified	33.6	37.3	3.7		
				After Renewable Heat	Remainder
TOTAL	306.4	331.9	25.4	308.7	2.3

*Note: Refineries has been modelled differently here as it is known to be under-allocated and will have to purchase allowances for more than 30% of its needs.

The analysis above indicates that, for every sector, basic energy efficiency improvement do not appear to be enough, on their own, for industry sectors to remain within their EU ETS allowances. Further action, probably including renewable heat, will be required.

5 Savings beyond 2020

5.1 Energy efficiency and Fuel Switching

For the purposes of this study we have considered the potential for savings after 2020 separately from those before 2020. The main reason for this is that the main policy instruments of CCA and EU ETS, while they may continue beyond this date, do not currently have any targets (for CCA) or allocations (for EU ETS) beyond this point.

It is likely that further energy efficiency savings will be made in the 2020s, following on from those modelled to 2020 above. This is particularly likely to be the case in sectors which have not been as regulated as others in the past (e.g. by CCA from 2000) and where there may be more inefficiency. However, for this exercise we have not attempted to model these general efficiencies but have concentrated on the potential for larger cost-effective savings, as previously studied by AEA in 2010 for CCC and described in section 2 above.

The study carried out in 2010 identified a range of cost-effective abatement measures in the key industry sectors of cement, glass, refineries, chemicals, food & drink and iron & steel, as summarised in Table 9 below. This shows those measures that have the potential to reduce energy consumption through process improvement or fuel switching.

Table 9: Cost-effective abatement potential from a range of industry measures at 2030

Abatement Opportunity Name	New Process	Cumulative Abatement at 2030 (tonnes CO ₂)	EAC of Abatement (£ per tonne CO ₂)
AO-01 - Cement	Clinker Substitution	1,426,531	37
AO-08 - Cement	Install ORC to recover waste heat from clinker cooler	3,090	196
AO-09 - cement	Belite Aluminate Clinker System	212,225	-1
AO-01 - Refineries	Whole Refinery Optimisation	3,490,410	123
AO-02 - Refineries	Reduced Fouling	229,932	158
AO-03 - Refineries	Separation Technologies	216,751	35
AO-01 - Glass	Pre-heating of Cullet	16,145	75
AO-02 - Glass	Oscillating Combustion	35,467	140
AO-04 - Glass	Submerged Combustion	6,311	133
AO-06 - Glass	Batch Reformulation	37,865	140
AO-07 - Glass	Batch Consolidation	56,797	147
AO-08 - Glass	Waste Heat Recovery	31,526	140
AO-01 - Chemicals	Improved Distillation	394,674	155
AO-02 - Chemicals	Chlor Alkali	108,562	318
AO-04 - Chemicals	Bioprocessing	328,895	252
AO-02 - Food & Drink	HT Heat Recovery	95,892	129
AO-03 - Food & Drink	LT Heat Recovery	57,535	119
AO-04 - Food & Drink	Membrane Technology	186,329	112
AO-05 - Food & Drink	Chilling & Freezing	-31,517	301
AO-01 - Iron & Steel	Top Gas Recycling BF + CCS	7,254,704	-46
AO-02 - Iron & Steel	Incremental Imp	52,739	37
AO-03 - Iron & Steel	EAF - Incremental Imp	3,903	136

AO-04 - Iron & Steel	EAf - Continuous Charging	6,457	296
AO-05 - Iron & Steel	EAf - Endless Strip	11,777	318
AO-06 - Iron & Steel	EAf - Increased Recycling	4,753,001	29

Note that the savings for increased recycling in the iron & steel sector include a reduction in coal use in coke manufacture. This has not been included in the modelling of final energy use for steel making in the figures below but does result in a saving of 4.3 MtCO₂ in 2030.

As part of this review we have updated the energy and carbon price projections in the 2010 model to the DECC projections produced in December 2012¹³. The result of these changes is to change the calculated potential abatement. The technically feasible potential changes from 37 MtCO₂ to 34 MtCO₂, the cost-effective potential from 22 MtCO₂ to 20 MtCO₂ and the potential after barriers have been taken into account from 10 MtCO₂ to 9.4 MtCO₂. The equivalent annual cost (EAC) of abatement values in Table 10 have also been updated. We have not updated the underlying cost data for the measures (either capital or operational costs) because this would require new research.

In practice these updates have resulted in little change to the potential energy savings.

The 2010 model generates values for the change in demand for each fuel type as a result of implementing the measures. These values are from a UEP40 (2010) baseline, so for the purposes of this review we have scaled them to the new UEP48 (2013) baseline such that the percentage saving in 2030 is the same.

We have calculated savings for each year from 2021 to 2029 by assuming a linear change from zero in 2020 to the full potential in 2030, assuming the full cost-effective potential is achieved. We recognise that for some of the measures this linear approach will not be accurate, as the measures may only become available commercially late in the 2020s.

The results of applying these savings can be seen in Figure 7, below, which also shows the impact of further renewable heat savings beyond 2020. Overall, if all the savings from these measures are taken into account, they result in a reduction in energy consumption in 2030 of 24 TWh or 7% of the UEP baseline energy projection for that year.

5.1.1 Barriers to further efficiencies

In section 6 of this report we discuss in greater detail the uncertainties surrounding some of these measures for particular sectors, based on consultation with the sector representatives. The most important of these are in the steel, refinery and mineral products sectors, where by far the largest cost-effective potential has been identified.

The barriers identified are almost all economic/policy barriers that can be met through appropriate actions. However, in some cases the financial cost of overcoming them may be very high and time will also be required to complete research, development and demonstration of some of the technologies. This means that there is a risk to these measures being implemented before 2030.

It is difficult to quantify the scale of the barriers but the abatement measures affected in steel, refineries and minerals account for 17 MtCO₂, i.e. 85% of the total cost-effective reduction.

5.2 Renewable Heat

As discussed in section 2 above, the CCC also commissioned a study in 2010 of the potential for decarbonisation through renewable heat by NERA and AEA. This study concentrated on potential in the 2020s from measures including ground and air source heat pumps, district heating and the use of bioenergy, both biogas use in the gas grid and

¹³ <https://www.gov.uk/government/policies/using-evidence-and-analysis-to-inform-energy-and-climate-change-policies/supporting-pages/policy-appraisal>

biomass for direct use in supplying heat to industry. CCC applied the data resulting from this study to estimate the potential changes in electricity and fossil fuel consumption in the 2020s.

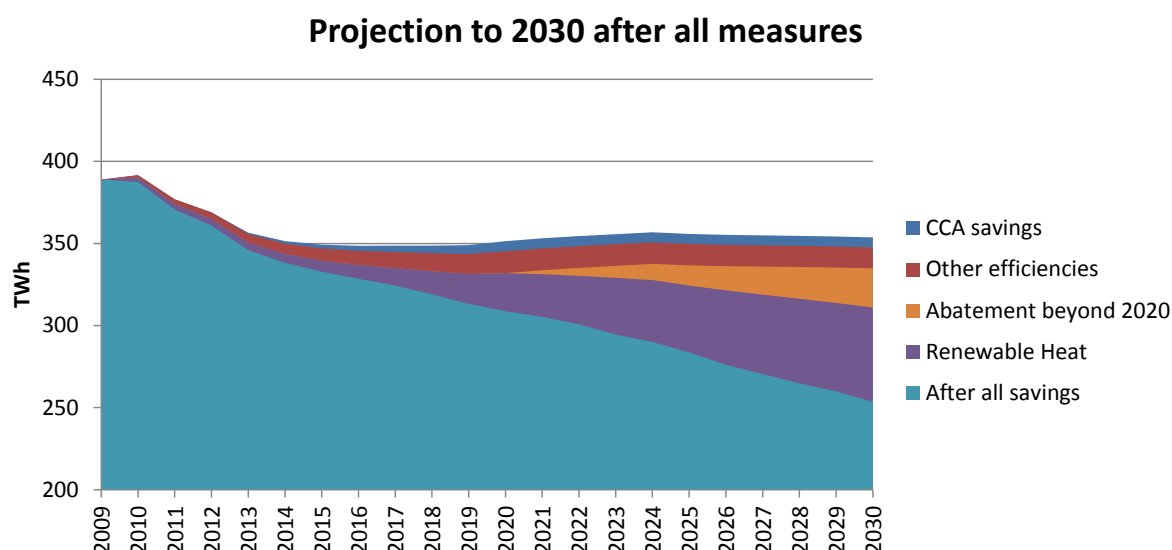
New cost or abatement potential data is not available to update the NERA/AEA model without significant new research. So, for the purposes of this review we have applied the renewable heat potential in the same way but scaled to the UEP48 baseline, rather than the UEP40 baseline used in 2010.

Overall this results in energy savings from electricity and fossil fuel use of 48 TWh in 2030 (14% of the UEP baseline energy projection for that year).

The cost of abatement from renewable heat was identified in the NERA/AEA study in 2010 at a net average of approximately +£20 per tonne CO₂.

Figure 7 shows the combined results from the application of all the policies and measures outlined in sections 4 and 5, both before and after 2020.

Figure 7: Energy projection to 2030 after all measures



Note that the energy scale begins at 200 TWh, not zero, to aid visibility.

5.2.1 Barriers to Renewable Heat

As discussed in section 4.5 above, feedback from sector representatives indicates that there are potential constraints on the take-up of renewable heat in industry that may prevent this level of savings being possible without further intervention. These are discussed in more detail for each sector in section 6.

The principal barriers raised by industry include:

- **Security of supply:** the chief concern of most sectors was over whether the supply of biomass will be secure enough to support investment. This was underlined by concerns in the Food & Drink sector over competition for land use between food and fuel crops.
- **Alternative use for biomass:** a lot of biomass already produced, in the form of waste material in the food sector, is already used for other purposes (in particular animal feed) and may not be available for energy use.
- **Transport and storage concerns:** use of renewable heat on-site may require the transport and storage of considerable amounts of biomass. This is already meeting public resistance in some places and sites have been refused planning permission.

An alternative solution is to site the renewable heat generation close to the source of the material but this requires action from third-party suppliers.

- Inadequate policy support: concerns were expressed over the longevity of government renewable heat policy and whether it unfairly disadvantages industrial heat users as opposed to electricity generators.
- Lack of a market for waste heat: several of the largest industry sectors have significant amounts of waste heat available (including refineries, steel and food) which could be used for alternative purposes. For example, waste heat from refineries is used extensively for district heating in Scandinavia. Industry representatives noted that there is currently insufficient market for this heat in the UK or third-parties prepared to invest in utilising it.

None of these barriers are technical or physical but economic/policy ones. They do, however, imply that industry will not achieve the levels of penetration of renewable heat that are possible on its own. Overcoming the barriers can be (and will need to be) achieved through policy actions.

5.3 Further potential savings

The potential for abatement in the medium to long-term is not limited to the opportunities discussed above and modelled in this review.

As a result of consultation with the industry sectors further opportunities for carbon abatement were identified. These are discussed in detail in section 6, but some particular examples include:

- An increase in waste recycling as a feedstock in chemical manufacture (though this would require an improved national waste strategy)
- Major energy savings in the motor industry as paint shops are replaced (which happens only when major rebuilds take place)
- New processes in the cement sector to produce low-carbon cement products (this is product substitution rather than simple efficiency of production)

There are also a range of other studies currently in progress. These include the development of roadmaps by industry sectors themselves, work for the UKERC at the University of Bath and a major study for DECC and BIS to develop roadmaps for the decarbonisation of industry to 2050. All of these are likely to identify additional opportunities.

6 Review by Sector

In this section we have detailed the specific outputs from the review for each UEP Sector. This includes the outputs from the modelling and the results of consultation with the sector representatives. Consultation was carried out by 'phone with representatives of individual sectors and via a joint workshop held at CCC on 15 October 2013. Representatives were consulted from the largest industry sectors, including iron & steel, chemicals, engineering & vehicles, food & drink, mineral products (cement, lime, glass and ceramics), refineries and paper.

6.1 Iron & Steel

6.1.1 Results from the model

Figure 8 shows the output from the review described in sections 4 and 5 specific to the Iron & Steel sector. A chart is given for each of total energy (excluding renewables), fossil fuel (excluding renewables) and electricity.

CCA – as can be seen in the charts, the impact of CCAs on the energy use in this sector is fairly minimal, as they only apply to a small fraction of the sector energy use (approximately 2.2%).

EU ETS – for this sector the ETS allocations also include emissions from coke manufacture and there is also believed to be over-allocation of allowances for Phase 3.

Other efficiencies before 2020 – all the electricity use in this sector is covered by CCA but only a small amount of fossil fuel use (which is covered by EU ETS). So for this sector further efficiencies only impact the fossil fuel use significantly.

Abatement beyond 2020 – the study carried out by AEA in 2010 identified very large abatement potential in this sector, most particularly through a switch from blast furnace to electric arc furnace melting and increased recycling of steel scrap (this explains the sharp increase in electricity use in the chart below). This includes a large reduction in coal use for coke manufacture, which has not been included in the energy figures here, which are for final energy use only and do not include transformation. The sector has very strong reservations about this potential, as outlined in the feedback section below.

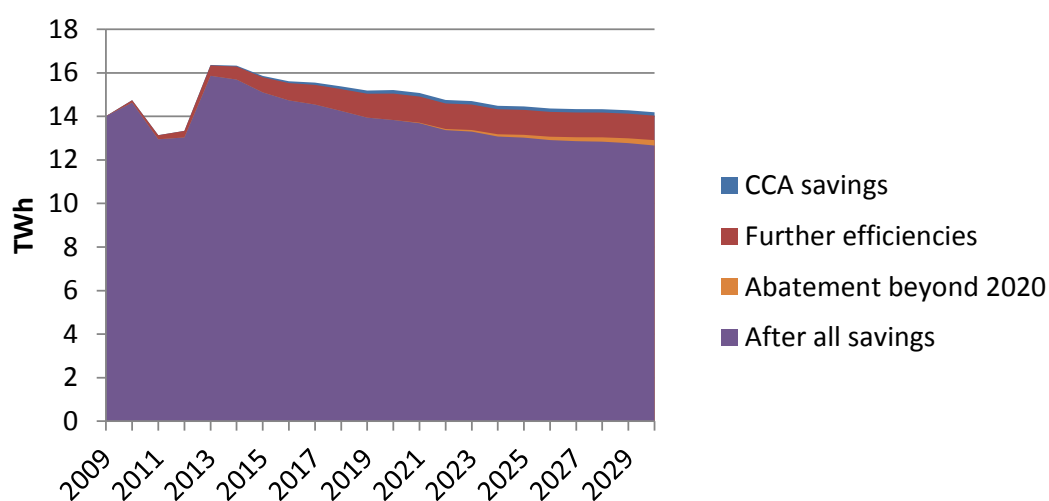
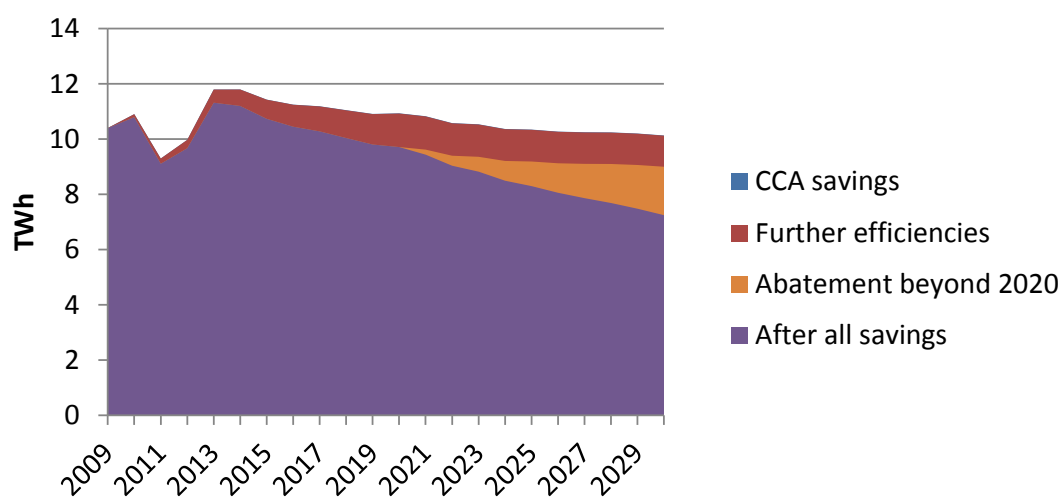
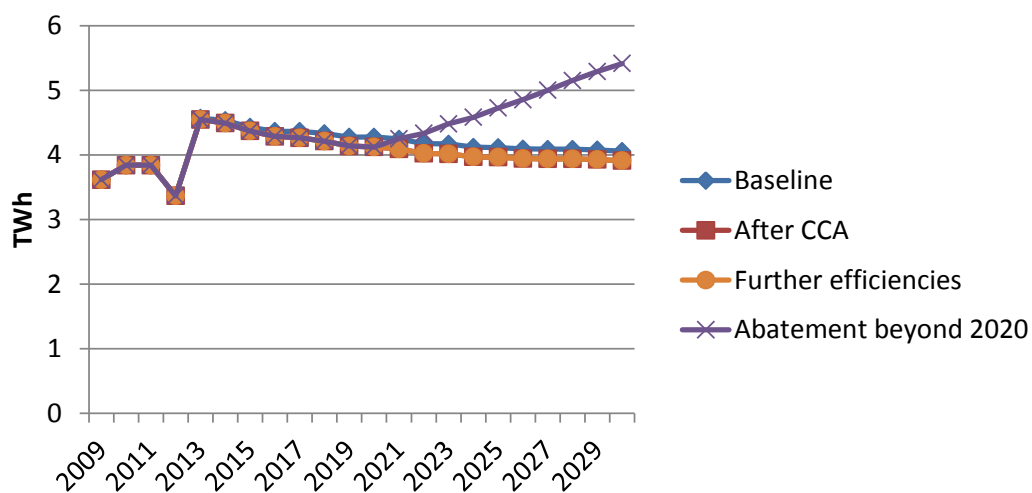
Renewable Heat – the sector representatives have reservations about the potential for renewable heat, discussed below.

Table 10 summarises the saving potential modelled for this sector in 2020 and 2030 from efficiency measures.

Table 10: Savings potential in final energy use (TWh) for the Iron & Steel sector

TWh	2020	2030
Baseline	15.21	14.19
CCA	-0.16	-0.16
Other Efficiencies	-1.21	-1.12
Abatement after 2020	0	-0.25
Total after abatement	13.84	12.66

Figure 8: Results for the Iron & Steel sector

Steel: Energy excluding renewables**Steel: Fossil Fuel****Steel: Electricity (delivered)**

6.1.2 Feedback from the sector

Consultation was held for this sector with the Engineering Employers Federation (EEF), representing UK Steel, both by 'phone and at the sector representatives' workshop.

The sector has expressed reservations about some of the findings from this work, in particular the figures for abatement beyond 2020 and for renewable heat.

In particular, considering the opportunities identified by AEA in 2010, the sector has doubts about the viability of the measures:

- Top gas recycling in Blast Furnaces is an as yet unproven technology so timescales may be ambitious. Moreover, as was described in the AEA 2010 report, the timing of this technology is linked to blast furnace rebuilds. These tend to take place about every 15-20 years and all the major blast furnaces will have been through a re-build by about 2015. This has the effect of 'locking-in' carbon until at least the late 2020s.
- The Continuous Charging process has been found in other countries to increase dioxin and pollutant levels, requiring energy-using abatement that replaces any saving in energy. This means that a new type of solution needs to be developed in the UK, which may not be achieved before the late 2020s. Most UK EAFs have short production runs before changing the grade of steel produced, which may also limit the impact of this measures.
- The Endless Strip technique has been used but there have been issues with surface quality and the process hasn't been found to be significantly more efficient.
- Increased recycling (the largest saving measure) would require a significant increase in scrap availability to the industry (most UK steel scrap is exported) and there are concerns about the purity of the scrap (in some cases pure enough scrap does not exist). The AEA 2010 project calculated a technical potential to increase recycling from 37% to 52% but a more realistic scenario was an increase to only 41%.
- There are also concerns about the impact on the electricity grid of a move away from Blast Furnace to Electric Arc Furnace melting due to the significant increase in demand.

These barriers are largely economic rather than technical (although bringing forward blast furnace rebuilds would be extremely expensive – the Port Talbot furnaces were rebuilt between 2005 and 2010 at a cost of over £300m). Overcoming them would require significant investment in both new plant and research and development, in addition to policy intervention to improve scrap recycling.

The sector also believes the potential use of renewable heat in this sector is limited. There is a considerable amount of high temperature waste heat from the sector but making use of it will require external intervention. The sector are engaged in work with DECC to review the potential for renewable heat.

6.2 Chemicals

6.2.1 Results from the model

Figure 9 shows the output from the review described in sections 4 and 5 specific to the Chemicals sector. A chart is given for each of total energy (excluding renewables), fossil fuel (excluding renewables) and electricity.

CCA – as can be seen in the charts, the impact of CCAs on the energy use in this sector is fairly minimal, as they only apply to a small fraction of the sector energy use (approximately 6.5%).

EU ETS – for this sector the ETS allocations also include process emissions and there is also believed to be over-allocation of allowances for Phase 3.

Other efficiencies before 2020 – almost all the electricity in this sector is covered by CCA but only a small part of the fossil fuel use (which is covered by EU ETS). So for this sector further efficiencies only impact the fossil fuel use significantly.

Abatement beyond 2020 – the study carried out by AEA in 2010 identified some abatement potential in this sector. The sector has some reservations about this potential, as outlined in the feedback section below.

Renewable Heat – the sector has reservations about the potential for renewable heat, discussed below.

Table 11 summarises the saving potential modelled for this sector in 2020 and 2030 from efficiency measures.

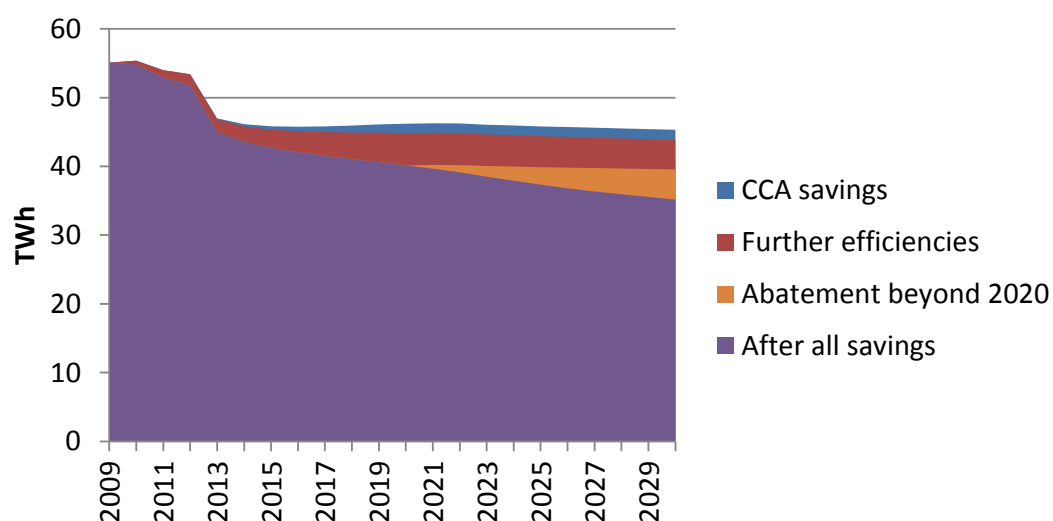
Table 11: Savings potential in TWh for the Chemicals sector

TWh	2020	2030
Baseline	46.2	45.33
CCA*	-1.38	-1.48
Other Efficiencies	-4.69	-4.29
Abatement after 2020	0	-4.39
Total after abatement	40.13	35.17

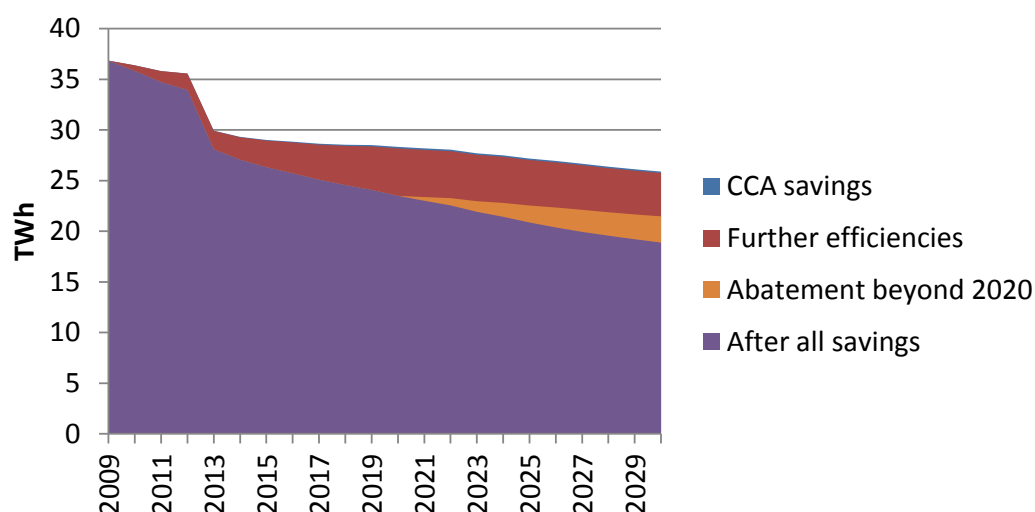
*Note that the percentage saving from CCA is assumed to be the same in 2030 as 2020 but the absolute saving is larger because the baseline electricity figure increases for this sector.

Figure 9: Results for the Chemicals sector

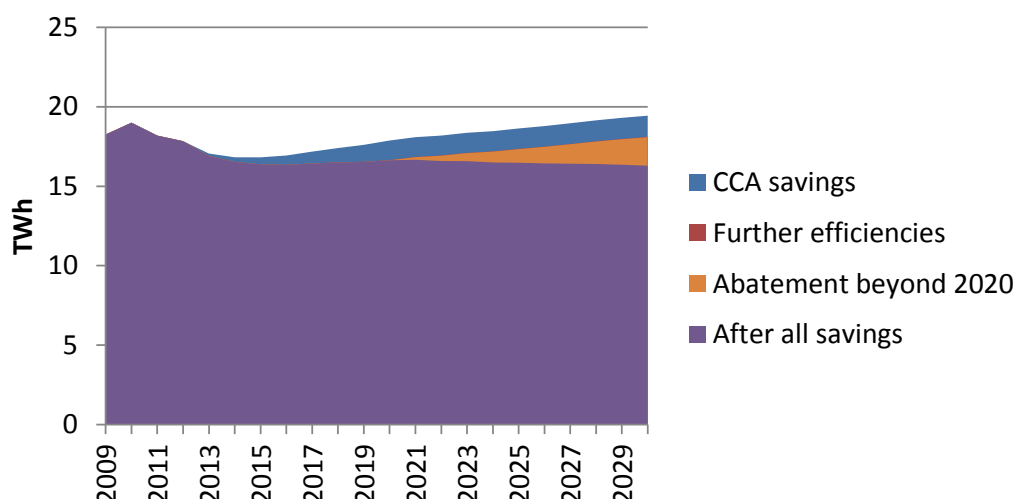
Chemicals: Energy excluding renewables



Chemicals: Fossil Fuel



Chemicals: Electricity (delivered)



6.2.2 Feedback from the sector

Consultation was held for this sector with the Chemical Industries Association (CIA), both by 'phone and at the sector representatives' workshop.

The sector has expressed reservations about some of the findings from this work, in particular the figures for abatement beyond 2020 and for renewable heat.

The level of EU ETS allocation for this sector will prove to be too low if the sector achieves its growth ambitions. Many opportunities for carbon abatement elsewhere in the economy require greater use of chemicals that may increase production emissions.

All the opportunities outlined in the 2010 report by AEA for this sector are accepted by the industry but there are concerns over the timescale for implementation. There are further potential savings for this sector (particularly beyond 2030), of which one is an increase in waste recycling. This would, however, require a better national waste strategy.

The sector believes that the potential for renewable heat is much more limited than discussed above and it needs further support. In particular there are concerns about the security of supply of biomass.

The sector also noted that the manufacture of basic chemicals in the UK will become uncompetitive without shale gas exploitation to replace North Sea gas as a feedstock.

6.3 Engineering & Vehicles

6.3.1 Results from the model

Figure 10 shows the output from the review described in sections 4 and 5 specific to the Engineering & Vehicles sector. A chart is given for each of total energy (excluding renewables), fossil fuel (excluding renewables) and electricity.

CCA – approximately 9.6% of the energy use in this sector is covered by a CCA target.

EU ETS – for this sector the ETS allocations do not include process emissions. It is estimated that only a small fraction of the sector is covered by EU ETS.

Other efficiencies before 2020 – 72% of the electricity use and 85% of the fossil fuel use in this sector is not covered by CCA. For this reason some further saving has been modelled for potential further energy efficiencies before 2020.

Abatement beyond 2020 – the study carried out by AEA in 2010 did not identify any additional abatement potential in this sector.

Renewable Heat –the sector has reservations about the potential for renewable heat, discussed below.

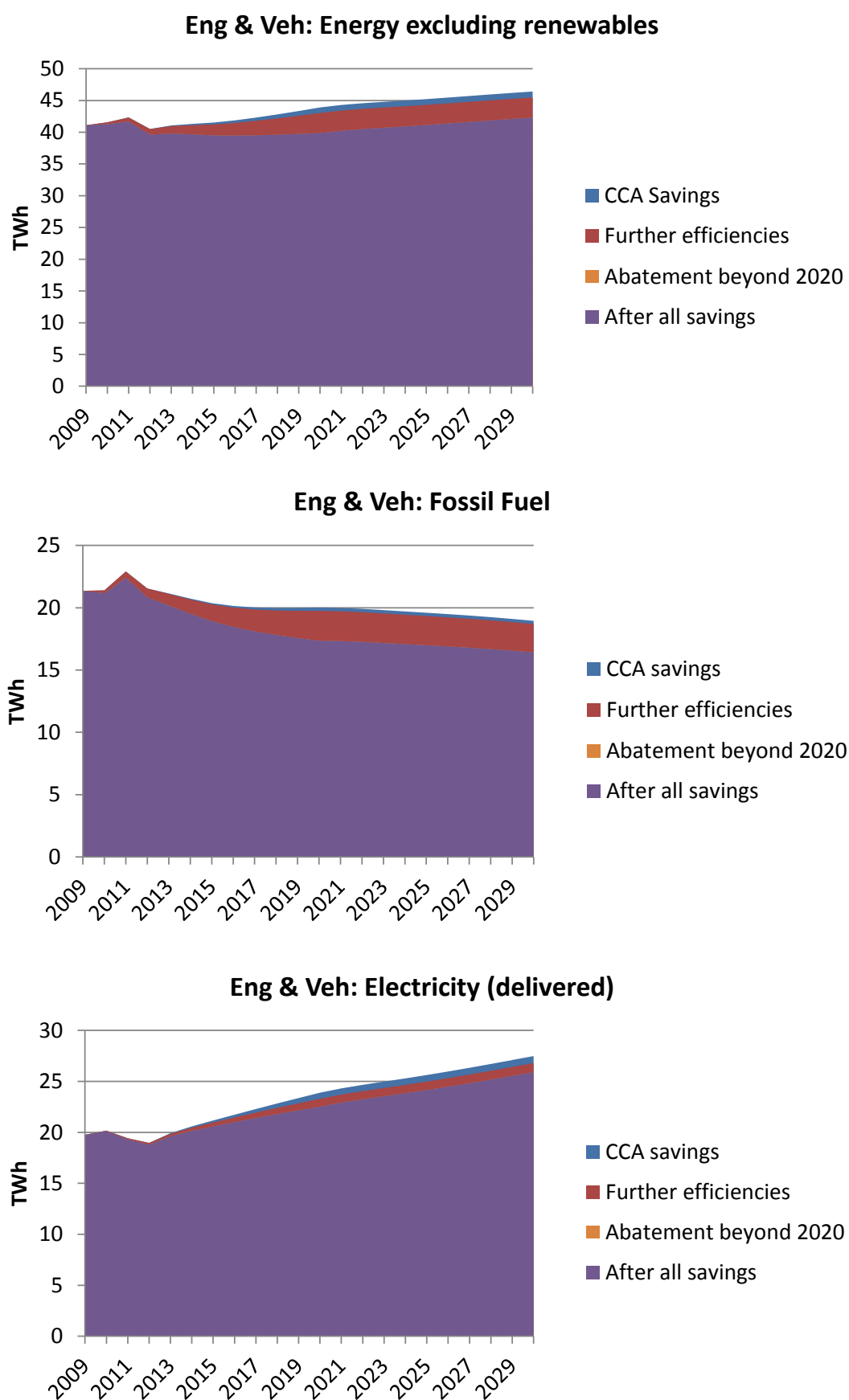
Table 12 summarises the saving potential modelled for this sector in 2020 and 2030 from efficiency measures.

Table 12: Savings potential in TWh for the Engineering & Vehicles sector

TWh	2020	2030
Baseline	43.9	46.41
CCA	-0.86	-0.94
Other Efficiencies	-3.17	-3.15
Abatement after 2020	0	0
Total after abatement	39.87	42.32

Note that the percentage saving from CCA is assumed to be the same in 2030 as 2020 but the absolute saving is larger because the baseline energy figure increases for this sector.

Figure 10: Results for the Engineering & Vehicles sector



6.3.2 Feedback from the sector

Consultation was held for this sector with the Society of Motor Manufacturers and Traders (SMMT), both by 'phone and at the sector representatives' workshop. SMMT is only one of a number of sub-sectors; others include Aerospace, Surface Engineering, Metal Packaging and Metal Forming.

The sector has expressed reservations about the potential for renewable heat, in particular before 2020. Various organisations are exploring the potential but have concerns over security of supply.

Before 2020 the sector expects to continue making improvements of 1-2% per annum through small measures. There are some opportunities for larger savings as paint shops in the motor industry are replaced (30% of site energy use).

6.4 Food, Drink & Tobacco

6.4.1 Results from the model

Figure 11 shows the output from the review described in sections 4 and 5 specific to the Food, Drink & Tobacco sector. A chart is given for each of total energy (excluding renewables), fossil fuel (excluding renewables) and electricity.

CCA – approximately 39.1% of the energy use in this sector is covered by a CCA target.

EU ETS – for this sector the ETS allocations do not include process emissions. It is estimated that about 40% of the sector energy may be covered by EU ETS.

Other efficiencies before 2020 – 3% of the electricity use and 46% of the fossil fuel use in this sector is not covered by CCA. For this reason some further saving has been modelled for potential further energy efficiencies before 2020.

Abatement beyond 2020 – the study carried out by AEA in 2010 identified some additional abatement potential in this sector. The sector has some reservations about this, discussed in the feedback section below.

Renewable Heat – the sector has strong reservations about the potential for renewable heat, discussed below.

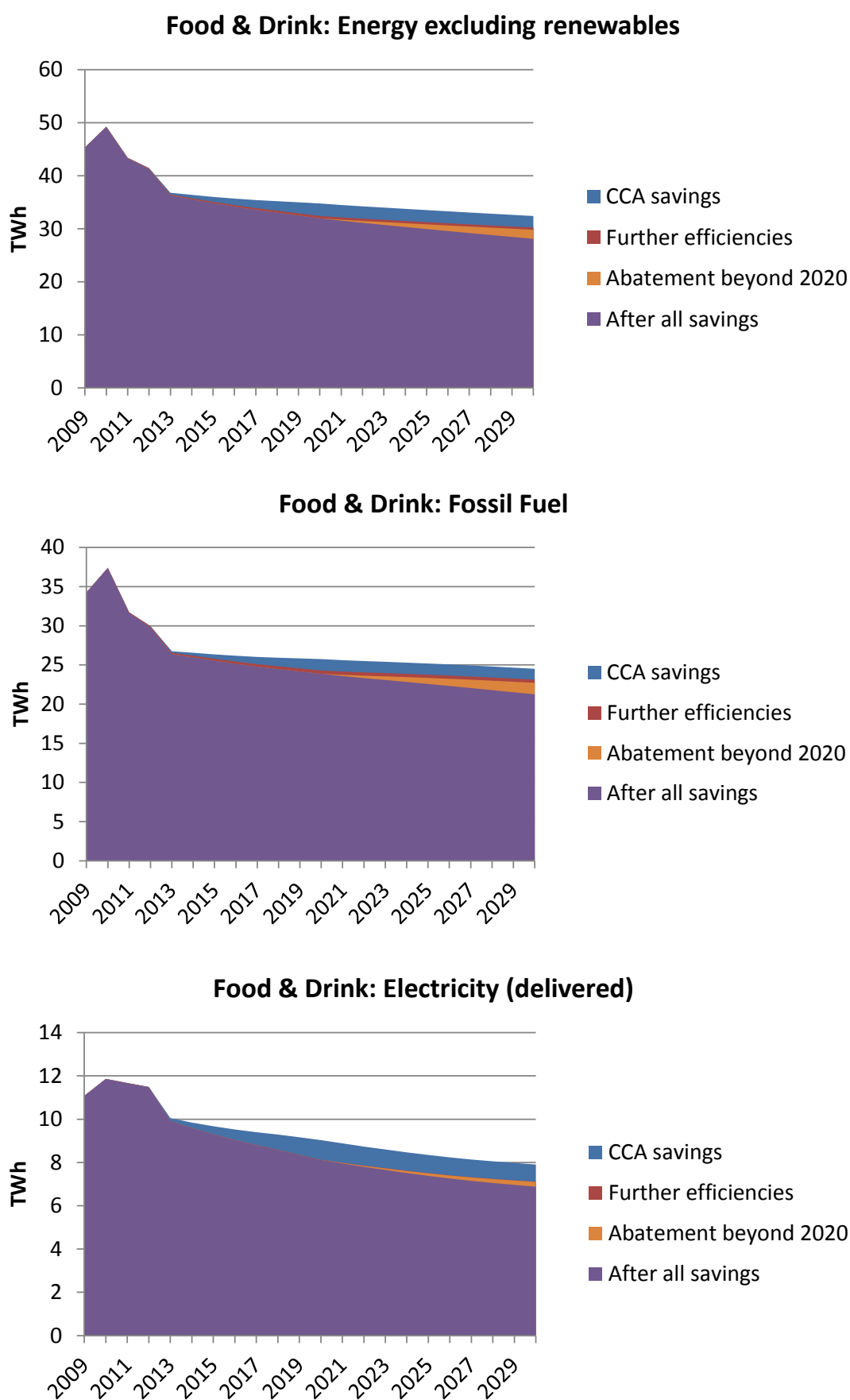
Table 13 summarises the saving potential modelled for this sector in 2020 and 2030 from efficiency measures.

Table 13: Savings potential in TWh for the Food, Drink & Tobacco sector

TWh	2020	2030
Baseline	34.78	32.41
CCA	-2.37	-2.18
Other Efficiencies	-0.43	-0.41
Abatement after 2020	0	-1.71
Total after abatement	31.98	28.11

Note that the percentage saving from CCA is assumed to be the same in 2030 as 2020 but the absolute saving is smaller because the baseline energy figure decreases for this sector..

Figure 11: Results for the Food, Drink & Tobacco sector



6.4.2 Feedback from the sector

Consultation was held for this sector with the Food and Drink Federation (FDF), both by 'phone and at the sector representatives' workshop. This is the largest association in this sector.

The sector has expressed reservations about abatement beyond 2020 and for renewable heat. The sector also has concerns about some of the baseline (UEP) figures between 2009 and 2013.

The AEA report in 2010 suggested significant potential through heat recovery in the sector (both low and high temperature heat). The sector's chief concern is the lack of demand for this heat externally and the need for intervention to promote district heating, for example. Membrane technology was also proposed as an abatement measure. The sector accepts this but the technology is still in infancy and the timescale for implementation is uncertain.

The food sector's also questioned the potential for renewable heat. The principal issues are: the competition for waste material between biomass fuel and animal feed, the competition between food and fuel crops (driven by population growth worldwide) and the problems with storage of biomass. There are also concerns about the current system of renewable heat tariffs and whether they provide adequate support to overcome some of these issues.

6.5 Mineral Products

6.5.1 Results from the model

Figure 12 shows the output from the review described in sections 4 and 5 specific to the Mineral Products sector. A chart is given for each of total energy (excluding renewables), fossil fuel (excluding renewables) and electricity. This is a complex sector that includes the cement, lime, glass and ceramics industries.

CCA – approximately 5.1% of the energy use in this sector is covered by a CCA target, so this impact from this policy is small.

EU ETS – for this sector the ETS allocations include process emissions (e.g. from cement production, some glass production and brick production). EU ETS is estimated to cover virtually all fossil fuel energy use in the sector. The sector has reservations about the level of allocation in Phase 3, as discussed in the feedback section below.

Other efficiencies before 2020 – 62% of the electricity use and 95% of the fossil fuel use in this sector is not covered by CCA. For this reason further saving has been modelled for potential further energy efficiencies before 2020.

Abatement beyond 2020 – the study carried out by AEA in 2010 identified significant additional abatement potential in this sector for cement and glass production. The sector has reservations about this, discussed in the feedback section below.

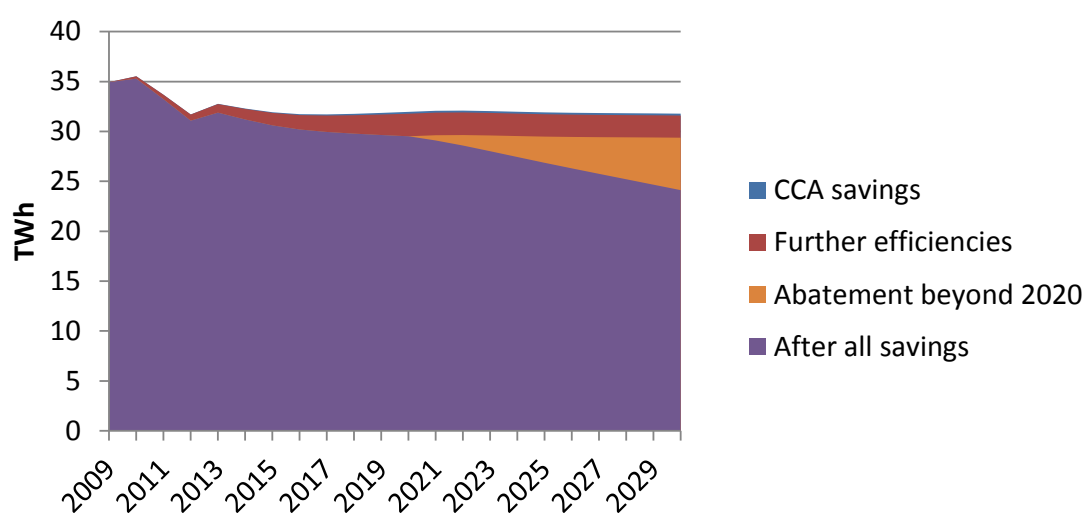
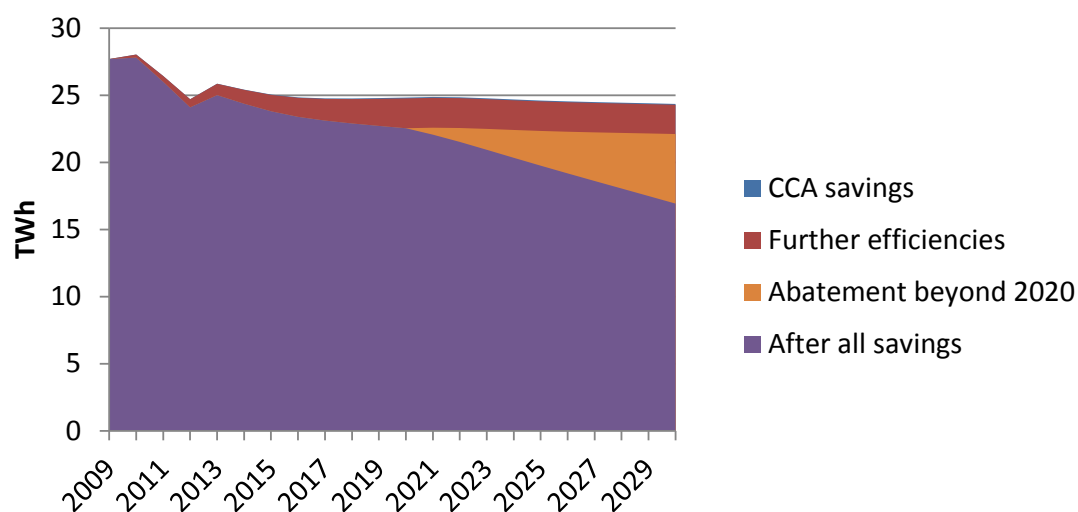
Renewable Heat – the sector also has reservations about the potential for renewable heat, discussed below.

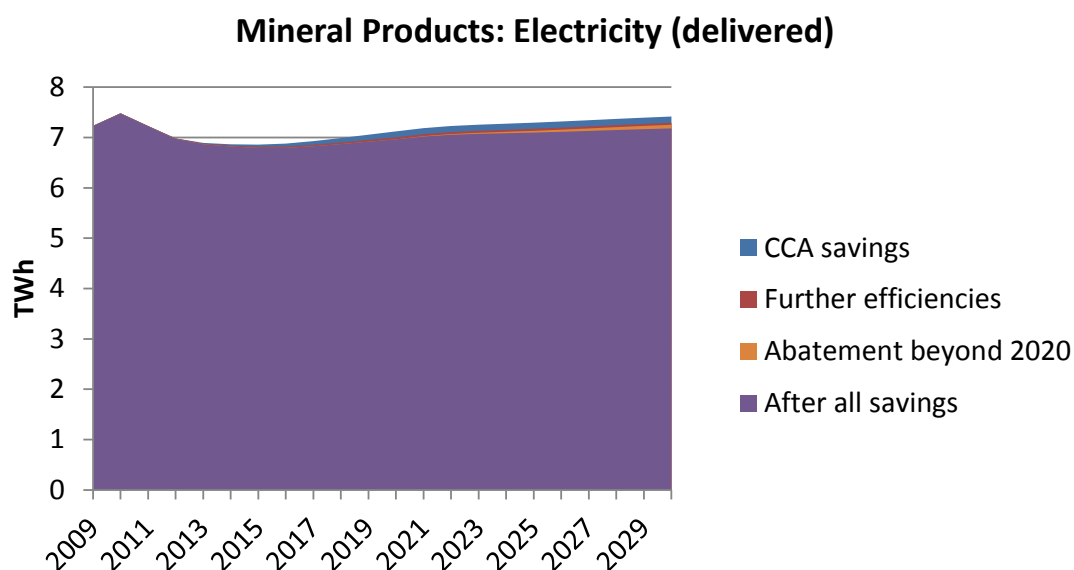
Table 14 summarises the saving potential modelled for this sector in 2020 and 2030 from efficiency measures.

Table 14: Savings potential in TWh for the Mineral Products sector

TWh	2020	2030
Baseline	31.96	31.78
CCA	-0.19	-0.19
Other Efficiencies	-2.26	-2.22
Abatement after 2020	0	-5.26
Total after abatement	29.51	24.11

Figure 12: Results for the Mineral Products sector

Mineral Products: Energy excluding renewables**Mineral Products: Fossil Fuel**



6.5.2 Feedback from the sector

As noted above, this is a complex sector and consultation was held, both by 'phone and at the sector representatives' workshop, with representatives of different sub-sectors: the Mineral Products Association (for cement and lime), British Glass, and the British Ceramics Confederation.

The sector has expressed reservations about some of the findings from this work, in particular the figures for abatement beyond 2020 and the potential for renewable heat.

The sector believes that it is under-allocated allowances for EU ETS Phase 3. In particular the glass sub-sector may be under-allocated by 33% and the cement sector is directly linked to construction and its emissions (both process and energy use) will increase significantly if demand returns to pre-2008 levels.

There are several abatement opportunities for the glass sub-sector identified in the 2010 report by AEA. All of these are considered technically possible by the sector but most are not currently financially viable. The greatest potential is seen in cullet pre-heating and waste heat recovery but these are not technically applicable to all sites (e.g. no flat glass companies use cullet pre-heating anywhere at present).

There are three opportunities identified for the cement sub-sector in the 2010 report. All of these are seen as having issues:

- Clinker substitution – requires the availability of substitutes which are in decline (in particular ground granulated blast furnace slag from the steel industry and pulverised fly ash from coal-fired electricity generation). Clinker substitution in the UK also takes place at concrete works rather than cement works controlled by British standards. A further increase in clinker substitution would require the various product standards to be updated and a detailed programme of testing and analysis by a BSi committee that could take many years to complete.
- Organic Rankin Cycle on clinker coolers – new air emissions regulations requiring bag filters make this measure technically impossible (the temperature has to be much lower than ORC requires). In addition the sector have reported that usable waste heat from clinker coolers is already effectively utilised in the drying and pre-heating of raw materials going into the kiln. Where waste heat is still available, current legislation makes it unattractive to use for electricity generation as the reject heat is largely

derived from coal use and it would not attract any incentives and be charged carbon prices support taxes/levies.

- Belite Aluminate Clinker System – this is one of a range of potential new or alternative cement types but there are barriers to these as described below.

There are new processes becoming available in the cement sector, such as the Lafarge “Aether” low carbon cement project but this is essentially product replacement (replacing ordinary Portland cement with a new product). This (along with Belite Aluminate) is one of a range of new cement types. These are all in the research and demonstration stage of development and it is unlikely that significant deployment will take place in the short to medium term, firstly because of the high capital costs involved in developing new manufacturing capacity, secondly because of the need for global distribution of the necessary raw materials and thirdly because of the long lead times in gaining acceptance for such products in the construction sector. New cements will need to meet stringent test to demonstrate that they do not impose any risks of structural failure and develop a ‘track record’ before being accepted in codes of practice and national construction regulations.

These barriers are economic/policy ones rather than technical but overcoming them will require investment and policy intervention if savings are to be achieved in the 2020s.

The sector has concerns about the potential for renewable heat, particularly around the security of supply, transport of biomass and, for the glass sector, the need to have the right flame characteristics for melting as well as just heat.

6.6 Refineries

6.6.1 Results from the model

Figure 13 shows the output from the review described in sections 4 and 5 specific to the Refineries sector. A chart is given for each of total energy (excluding renewables), fossil fuel (excluding renewables) and electricity.

CCA – the Refineries sector is not eligible for CCA so it has not been modelled for this sector.

EU ETS – for this sector EU ETS is likely to cover all fossil fuel use. In practice the sector has been under-allocated for Phase 3 and will have to purchase allowances to meet its needs.

Other efficiencies before 2020 – no further efficiencies have been modelled for this sector before 2020 because no data is available from previous work with Enusim.

Abatement beyond 2020 – the study carried out by AEA in 2010 identified significant additional abatement potential in this sector. The sector has very strong reservations about this, discussed in the feedback section below.

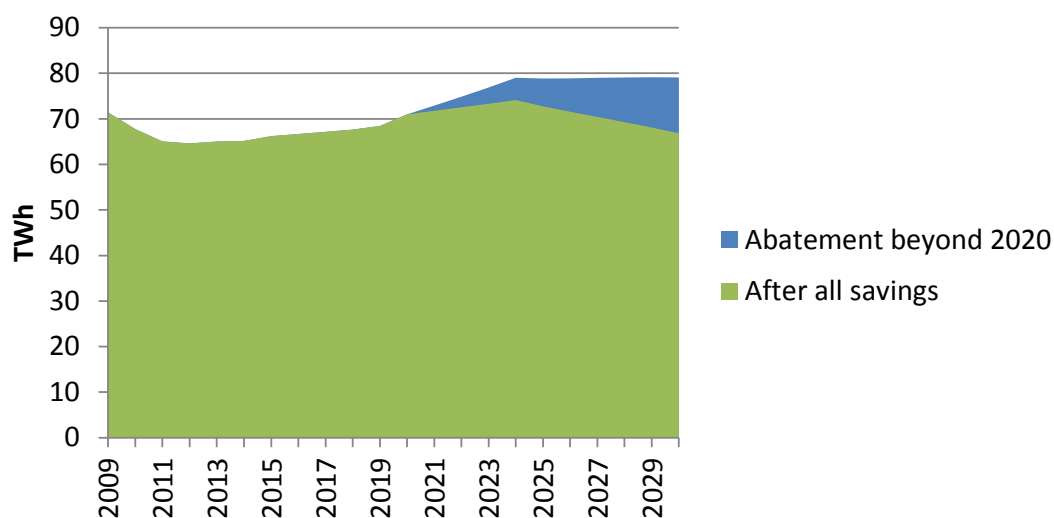
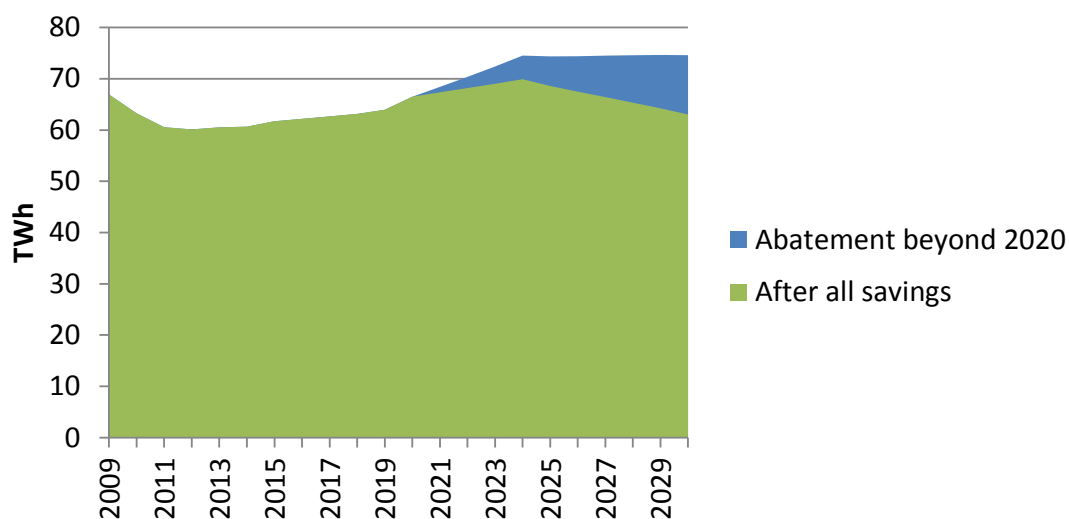
Renewable Heat – the sector believes there is renewable heat application for this sector as it would have to replace the use of non-commercial fuel products from the refineries themselves.

Table 15 summarises the saving potential modelled for this sector in 2020 and 2030 from efficiency measures.

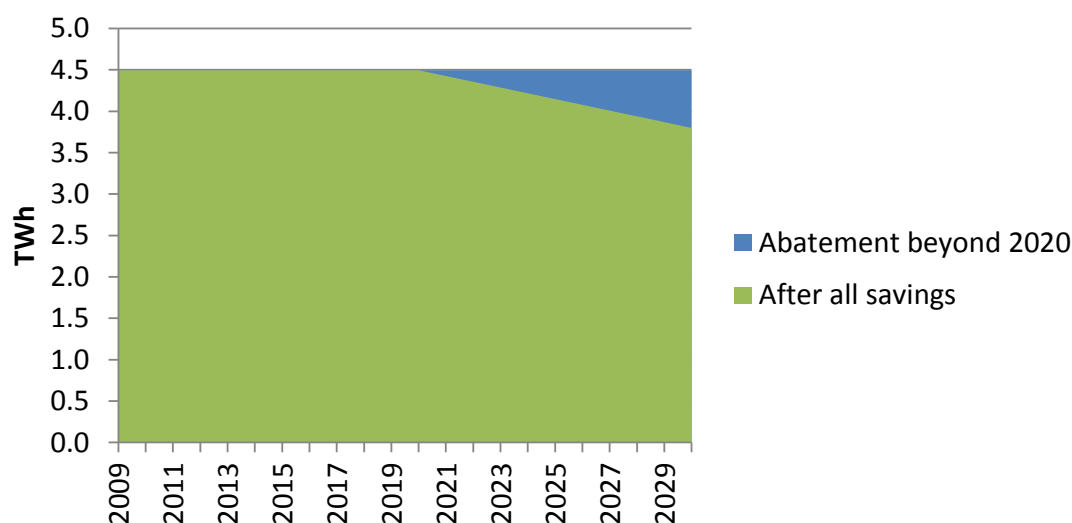
Table 15: Savings potential in TWh for the Refineries sector

TWh	2020	2030
Baseline	70.99	79.09
CCA	0	0
Other Efficiencies	0	0
Abatement after 2020	0	-12.26
Total after abatement	70.99	66.83

Figure 13: Results for the Refineries sector

Refineries: Energy excluding renewables**Refineries: Fossil fuel energy**

Refineries: Electricity (delivered)



6.6.2 Feedback from the sector

Consultation was held for this sector with the UK Petroleum Industries Association (UK PIA), both by 'phone and at the sector representatives' workshop.

The sector has expressed reservations about abatement beyond 2020. The sector also has concerns about the baseline (UEP) figures which it believes show too high an energy consumption figure.

This sector is under-allocated EU ETS allowances in Phase 3 and expects to purchase more than 30% of its needs. The sector is anticipating considerable rationalisation across Europe, with the closure of about 40% of refineries. At the same time the emissions per unit of product are expected to rise because of higher quality requirements and a continued switch from petrol to diesel and jet fuel. The UK industry believes it is often unfairly compared to apparently more efficient but different (less complex) operations elsewhere.

Three major abatement opportunities were identified for this sector in the AEA report in 2010 but the sector has strong reservations with all of them:

- Whole refinery optimisation – this is one of the largest abatement opportunities identified for any sector (3.5 MtCO₂). The sector believes that the potential is limited by physical/technical and operational constraints and the level of investment required. They believe this level of integration is already higher than the AEA 2010 report indicates, with waste heat recovery from unit rundown used to pre-heat adjacent units, and the use of CO boilers and power expanders to recover energy from flue gases. Pinch analysis is also widely used to identify cost-effective options for additional optimisation. Higher levels of integration may only be feasible for new build refineries, but there are also operational concerns that high levels of integration make the whole refinery more susceptible to expensive (and damaging) unplanned shutdowns if single units were to fail.
- Reduced fouling – this is already carried out during maintenance cycles where possible but is restricted due to availability of space
- Separation technologies – distillation column internals are upgraded periodically during crude unit turnarounds but advanced distillation and separation technologies leading to major savings would require complete refitting of the heart of a refinery or new build refineries

The exact impact of these barriers on carbon abatement potential by 2030 is difficult to quantify at this time without further research (which will be examined during DECC's 2050 roadmaps project). It is clear, however, that they are largely economic barriers, although the cost of meeting them could be very high.

There is also considerable potential for the use of waste heat from refineries, as is currently done in Scandinavia with wide use of district heating, but there is currently no market in the UK for the heat, a heat distribution market or a move to co-locate users of low grade heat. Investment from outside the industry would be needed to achieve this.

6.7 Paper, Printing & Publishing

6.7.1 Results from the model

Figure 14 shows the output from the review described in sections 4 and 5 specific to the Paper, Printing & Publishing sector. A chart is given for each of total energy (excluding renewables), fossil fuel (excluding renewables) and electricity.

CCA – approximately 4.6% of the energy use in this sector is covered by a CCA target (principally electricity in the Paper and Printing sectors).

EU ETS – for this sector the ETS allocations do not include process emissions. EU ETS is estimated to cover approximately half of the fossil fuel energy use in the sector.

Other efficiencies before 2020 – 23% of the electricity use and 94% of the fossil fuel use in this sector is not covered by CCA. For this reason an amount of further saving has been modelled for potential further energy efficiencies before 2020.

Abatement beyond 2020 – the study carried out by AEA in 2010 did not identify any additional abatement potential in this sector.

Renewable Heat – the sector is already making some use of renewable heat, as described in the feedback section below..

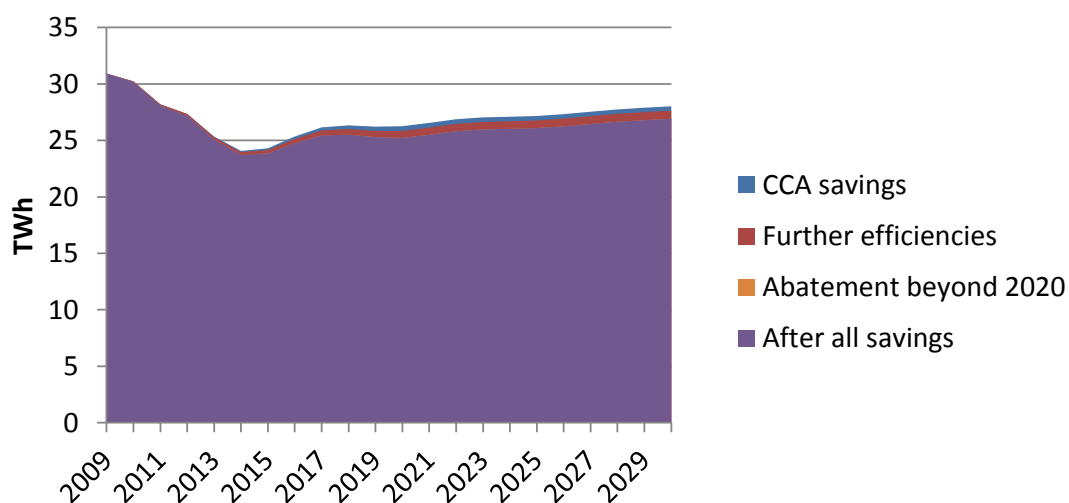
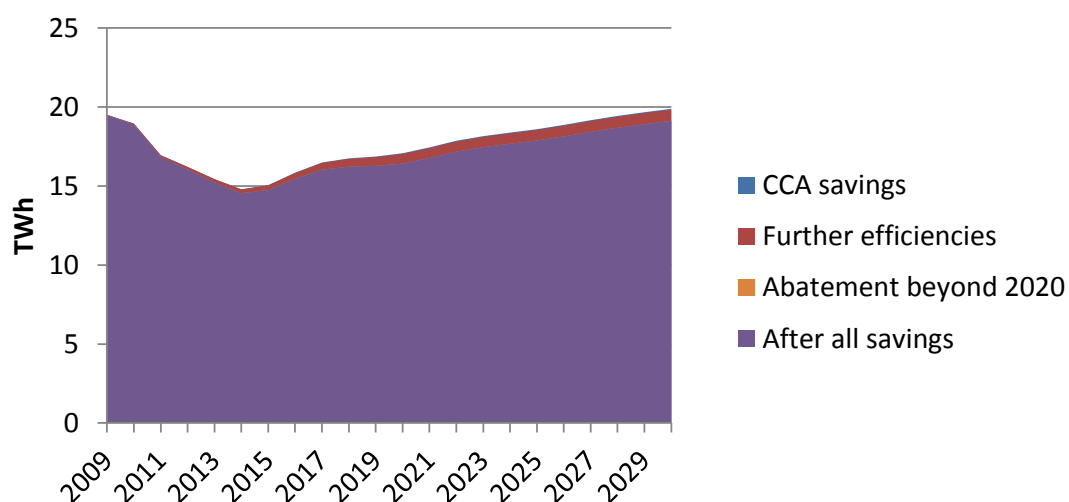
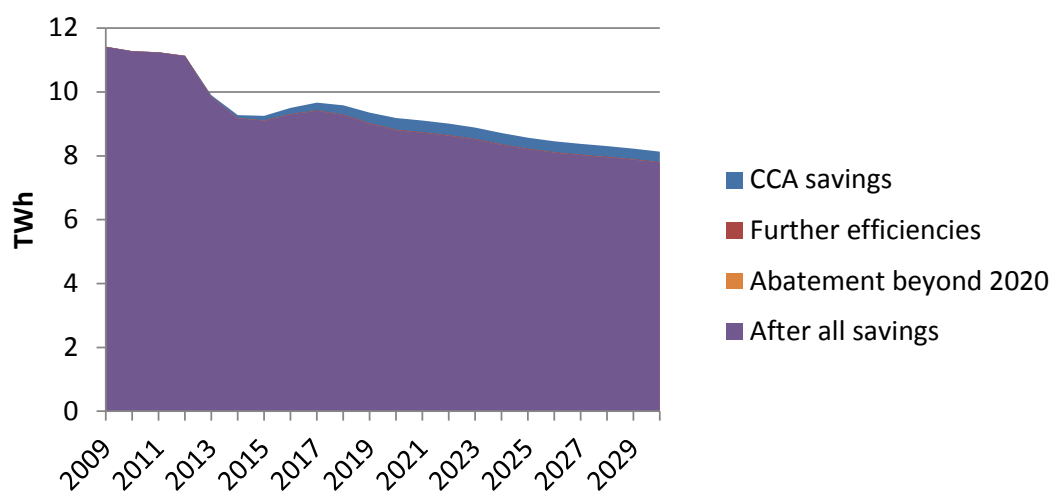
Table 16 summarises the saving potential modelled for this sector in 2020 and 2030 from efficiency measures.

Table 16: Savings potential in TWh for the Paper, Printing & Publishing sector

TWh	2020	2030
Baseline	26.26	28.01
CCA	-0.42	-0.38
Other Efficiencies	-0.62	-0.72
Abatement after 2020	0	0
Total after abatement	25.22	26.91

Note that the percentage saving from CCA is assumed to be the same in 2030 as 2020 but the absolute saving is smaller because the baseline electricity figure decreases for this sector.

Figure 14: Results for the Paper, Printing & Publishing sector

Paper: Energy excluding renewables**Paper: Fossil Fuel****Paper: Electricity (delivered)**

6.7.2 Feedback from the sector

Consultation was held for this sector with the Confederation of Paper Industries (CPI), both by 'phone and at the sector representatives' workshop.

The sector believes it is under-allocated for EU ETS Phase 3 by about 33% (though its allocations have been increased through applications to the New Entrant Reserve; this has been demonstrated through data provided confidentially by the sector).

Renewable heat potential is already being explored in this sector though the development of new biomass CHP before 2020.

A key item in the Enusim modelling carried in 2010 was Impulse Drying in the Paper sector. The industry believes this technology was described as theoretically possible in the past but has never been commercialised and the sector believes it is not technically feasible. There have been two new paper mills in the UK in the last five years and they have not picked up this technology. Further research on this topic indicates that results from pilot operations in other countries show limited energy efficiency improvements when compared to state-of-the-art efficient paper machines¹⁴.

6.8 Other Sectors

For the remaining sectors (non-ferrous metals, textiles, construction and unclassified) no consultation with sector representatives took place. So for these sectors we just present the output from the review with comments.

6.8.1 Non-Ferrous Metals

Figure 15 shows the output from the review described in sections 4 and 5 specific to the Non-ferrous metals sector. A chart is given for each of total energy (excluding renewables), fossil fuel (excluding renewables) and electricity.

CCA – approximately 17.6% of the energy use in this sector is covered by a CCA target.

EU ETS – for this sector the ETS allocations include process emissions. EU ETS is believed to cover all the fossil fuel energy use in the sector. The sector is believed to be over-allocated for Phase 3.

Other efficiencies before 2020 – 63% of the electricity use and 75% of the fossil fuel use in this sector is not covered by CCA. For this reason an amount of further saving has been modelled for potential further energy efficiencies before 2020.

Abatement beyond 2020 – the study carried out by AEA in 2010 did not identify any additional abatement potential in this sector.

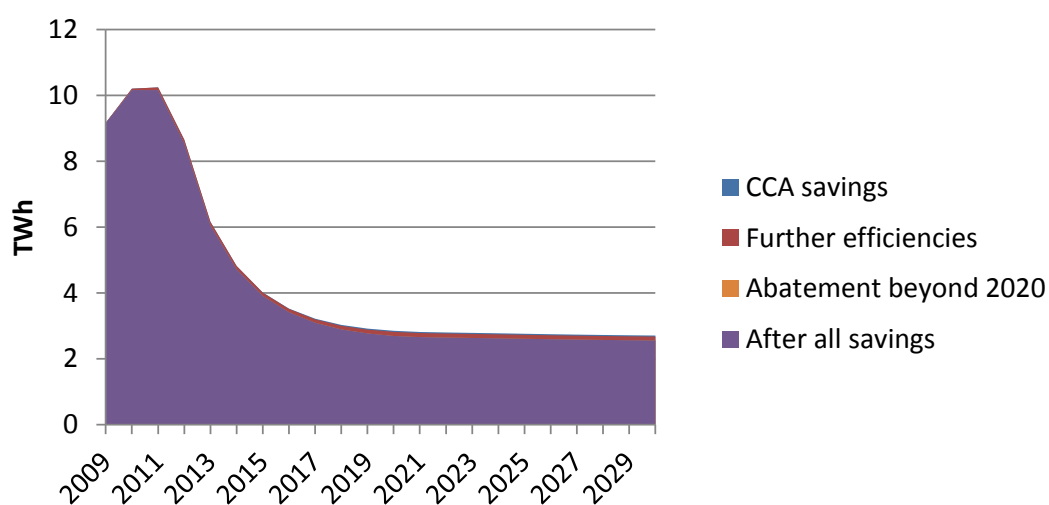
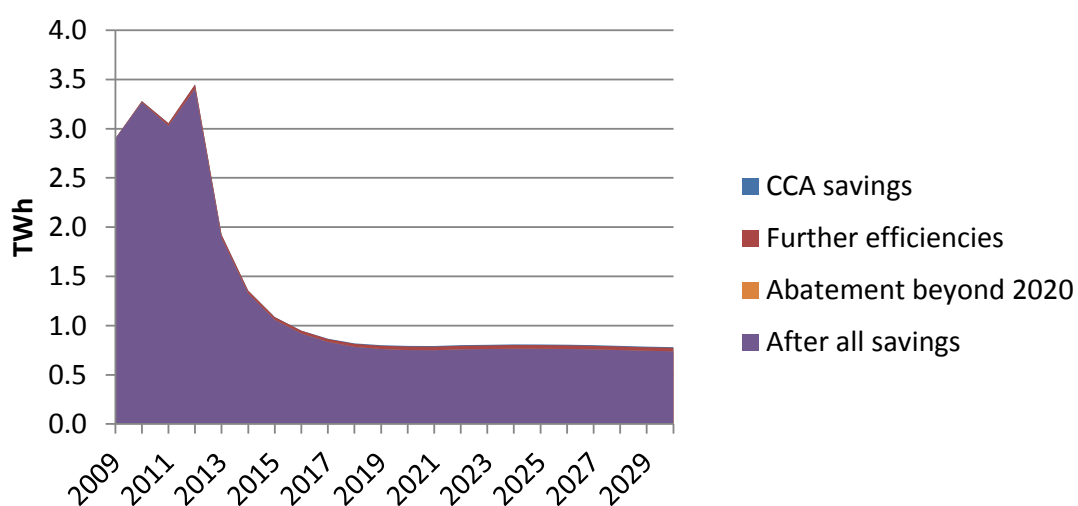
Table 17 summarises the saving potential modelled for this sector in 2020 and 2030 from efficiency measures.

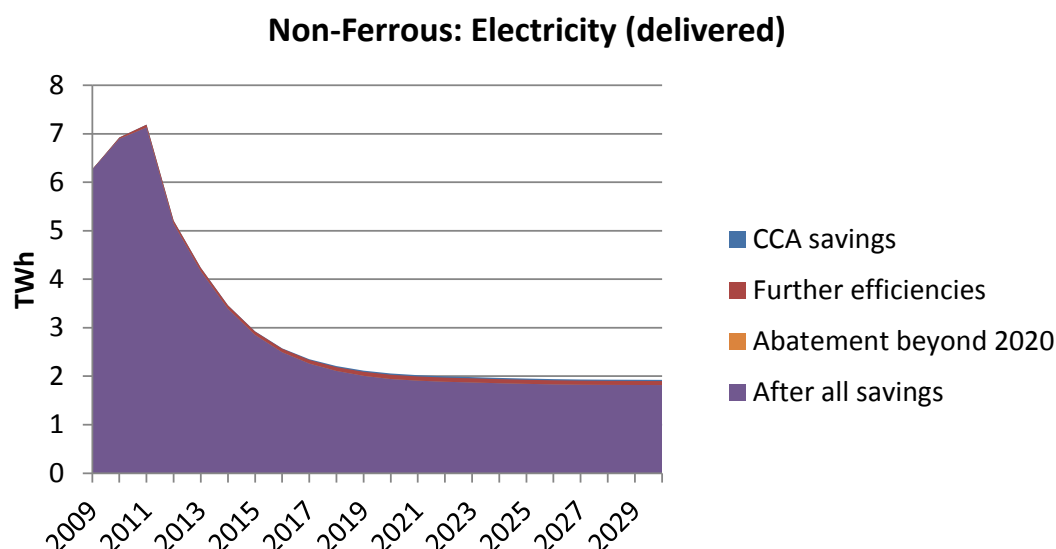
¹⁴ http://www.energystar.gov/ia/business/industry/downloads/Pulp_and_Paper_Energy_Guide.pdf

Table 17: Savings potential in TWh for the Non-Ferrous Metals sector

TWh	2020	2030
Baseline	2.85	2.71
CCA	-0.03	-0.04
Other Efficiencies	-0.13	-0.11
Abatement after 2020	0	0
Total after abatement	2.69	2.56

Figure 15: Results for the Non-Ferrous Metals sector

Non-Ferrous: Energy excluding renewables**Non-Ferrous: Fossil Fuel**



6.8.2 Textiles, Leather & Clothing

Figure 16 shows the output from the review described in sections 4 and 5 specific to the Textiles, Leather & Clothing sector. A chart is given for each of total energy (excluding renewables), fossil fuel (excluding renewables) and electricity.

CCA – approximately 11.2% of the energy use in this sector is covered by a CCA target.

EU ETS – for this sector the ETS allocations do not include process emissions. EU ETS is estimated to cover approximately 20% of the fossil fuel energy use in the sector. The sector is believed to be over-allocated for Phase 3.

Other efficiencies before 2020 – 83% of the electricity use and 84% of the fossil fuel use in this sector is not covered by CCA. For this reason an amount of further saving has been modelled for potential further energy efficiencies before 2020.

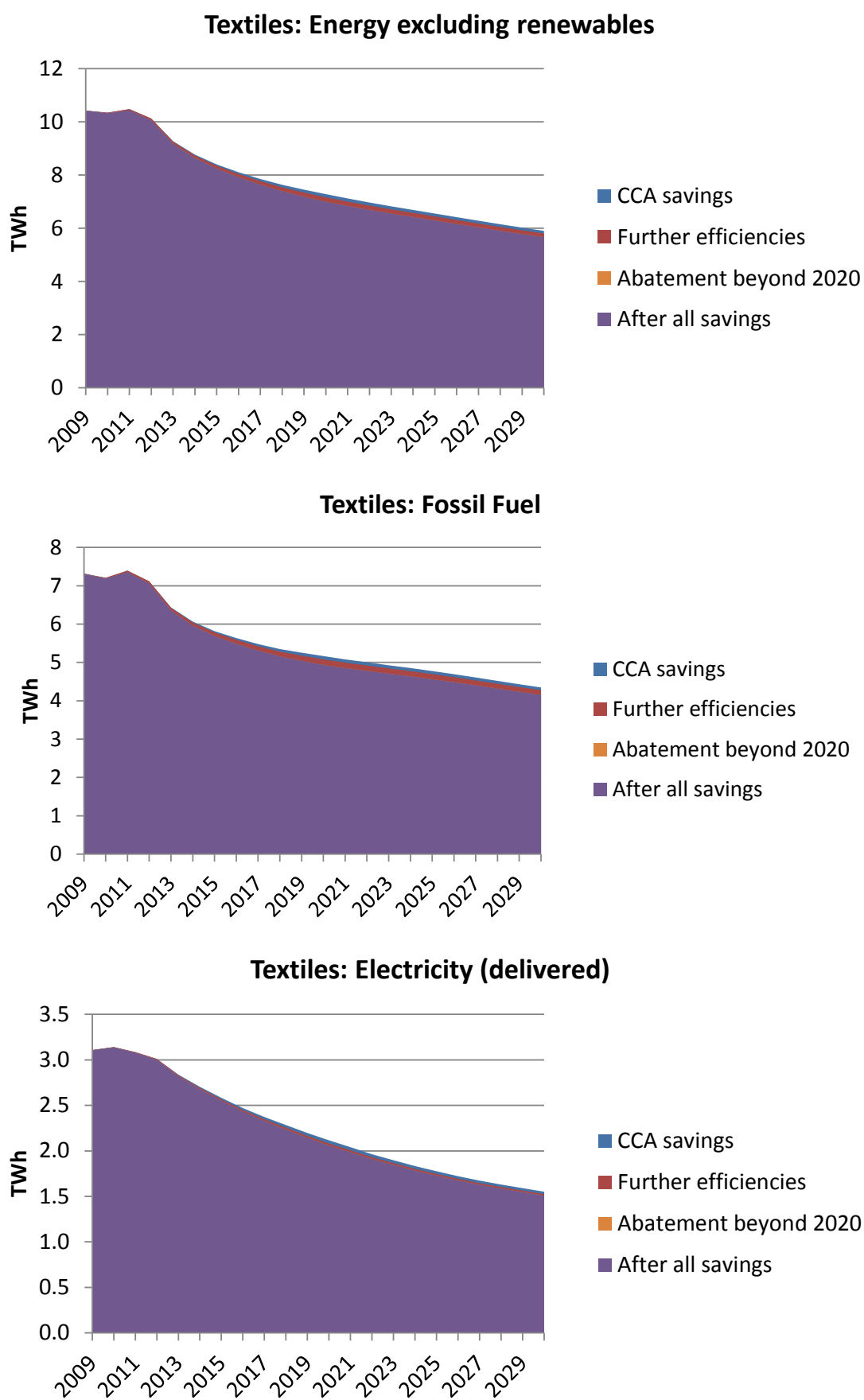
Abatement beyond 2020 – the study carried out by AEA in 2010 did not identify any additional abatement potential in this sector.

Table 18 summarises the saving potential modelled for this sector in 2020 and 2030 from efficiency measures.

Table 18: Savings potential in TWh for the Textiles, Leather & Clothing sector

TWh	2020	2030
Baseline	7.28	5.9
CCA	-0.12	-0.10
Other Efficiencies	-0.17	-0.14
Abatement after 2020	0	0
Total after abatement	6.99	5.66

Figure 16: Results for the Textiles, Leather & Clothing sector



6.8.3 Construction & Other Industry

Figure 17 shows the output from the review described in sections 4 and 5 specific to the Construction & Other Industry sector. A chart is given for each of total energy (excluding renewables), fossil fuel (excluding renewables) and electricity.

CCA – approximately 0.8% of the energy use in this sector is covered by a CCA target.

EU ETS – for this sector the ETS allocations do not include process emissions. EU ETS is estimated to cover approximately 20% of the fossil fuel energy use in the sector.

Other efficiencies before 2020 – 90% of the electricity use and 99% of the fossil fuel use in this sector is not covered by CCA. For this reason an amount of further saving has been modelled for potential further energy efficiencies before 2020.

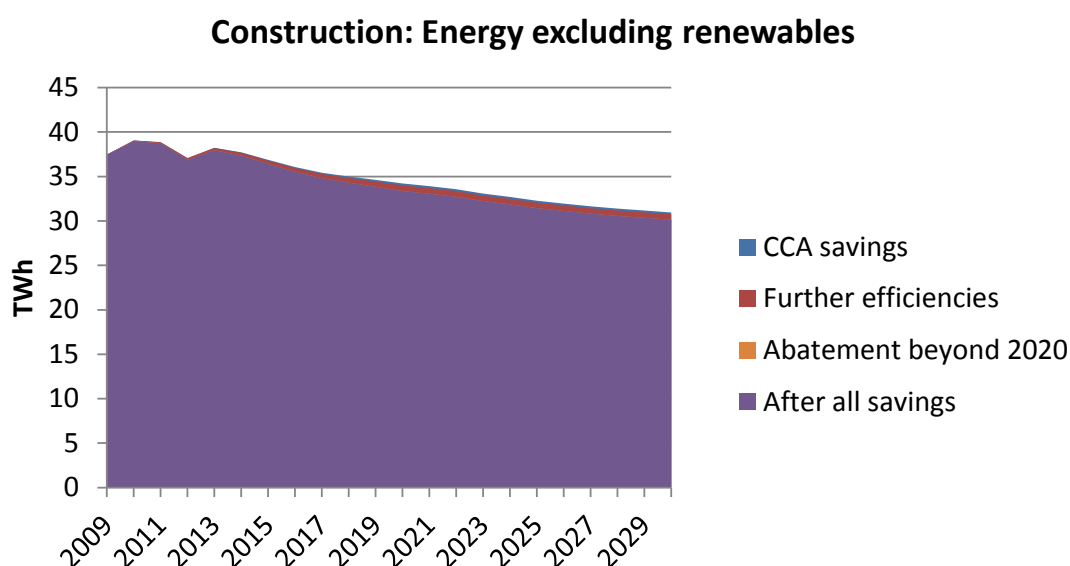
Abatement beyond 2020 – the study carried out by AEA in 2010 did not identify any additional abatement potential in this sector.

Table 19 summarises the saving potential modelled for this sector in 2020 and 2030 from efficiency measures.

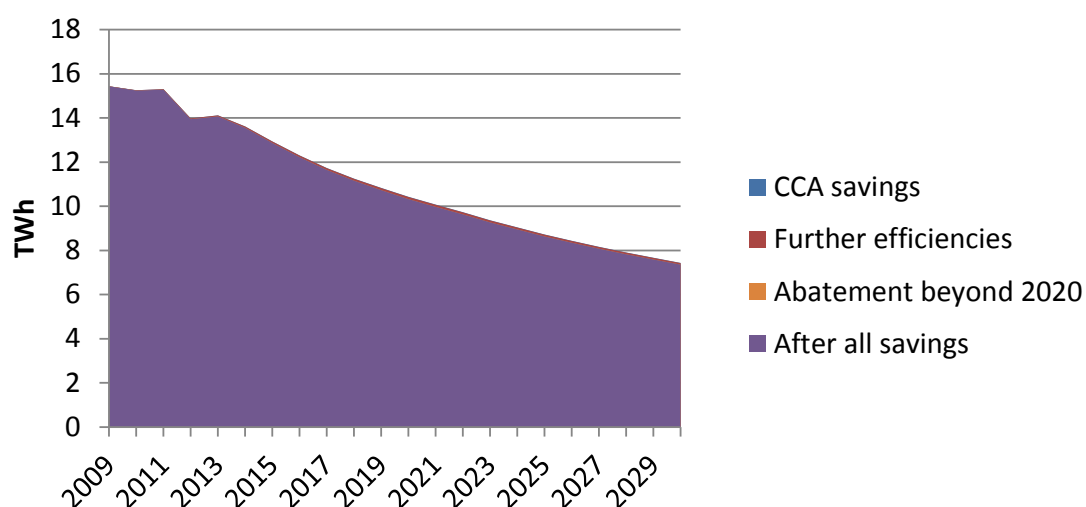
Table 19: Savings potential in TWh for the Construction & Other Industry sector

TWh	2020	2030
Baseline	34.22	30.95
CCA	-0.22	-0.21
Other Efficiencies	-0.64	-0.61
Abatement after 2020	0	0
Total after abatement	33.36	30.13

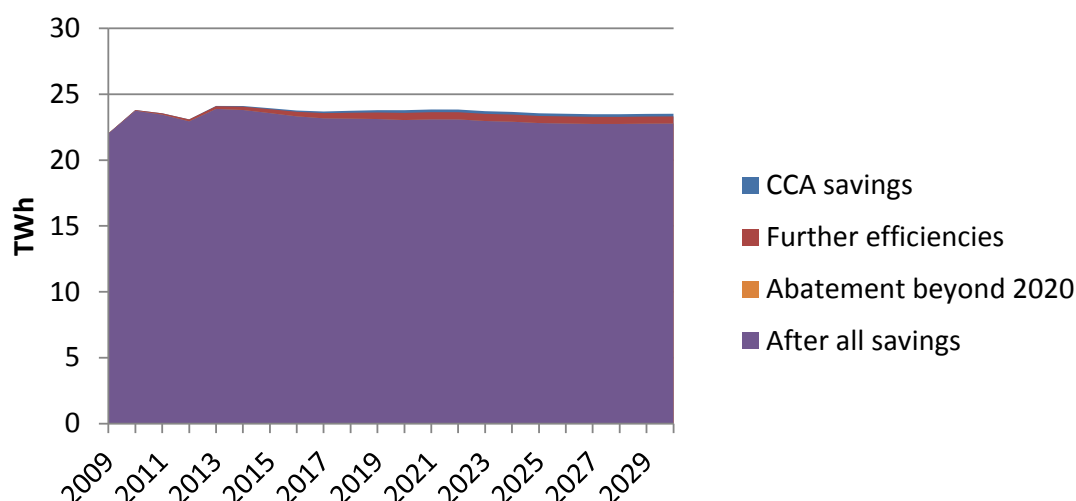
Figure 17: Results for the Construction & Other Industry sector



Construction: Fossil Fuel



Construction: Electricity (delivered)



6.8.4 Unclassified

Figure 18 shows the output from the review described in sections 4 and 5 specific to the Unclassified sector. It is believed that this sector probably includes data that could not be appropriately allocated to other sectors in the UEP model but it has been included here for completeness as it is also believed to include some data for CCA sectors not captured elsewhere. A chart is given for each of total energy (excluding renewables) and fossil fuel (excluding renewables). No data is given for electricity for this sector in UEP48 so no chart has been provided.

CCA – approximately 3.9% of the energy use in this sector is covered by a CCA target.

Other efficiencies before 2020 – 92% of the electricity use and 92% of the fossil fuel use in this sector is not covered by CCA but no savings were projected by Enusim for this sector, so no further savings have been included here.

Abatement beyond 2020 – the study carried out by AEA in 2010 did not identify any additional abatement potential in this sector.

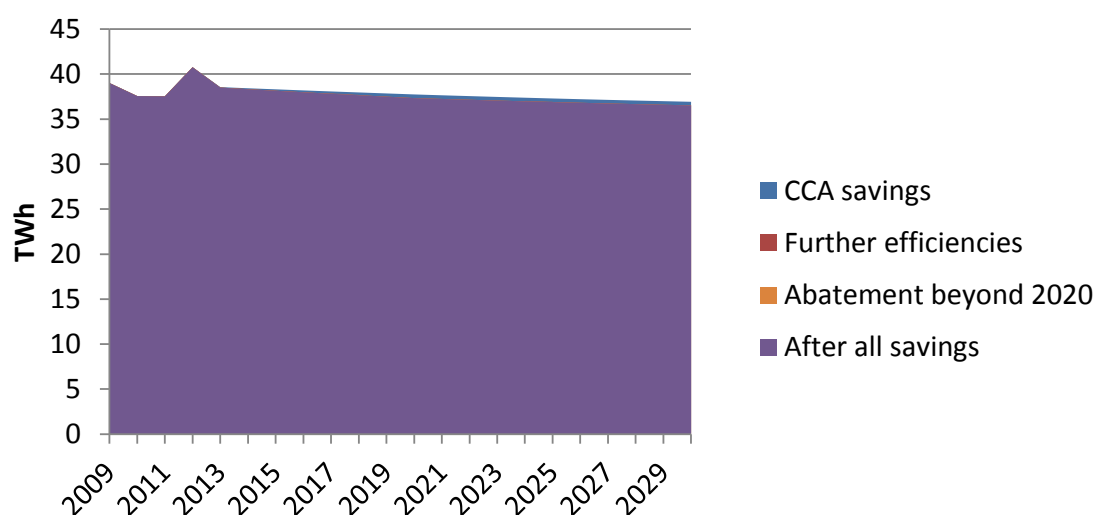
Table 20 summarises the saving potential modelled for this sector in 2020 and 2030 from efficiency measures.

Table 20: Savings potential in TWh for the Unclassified sector

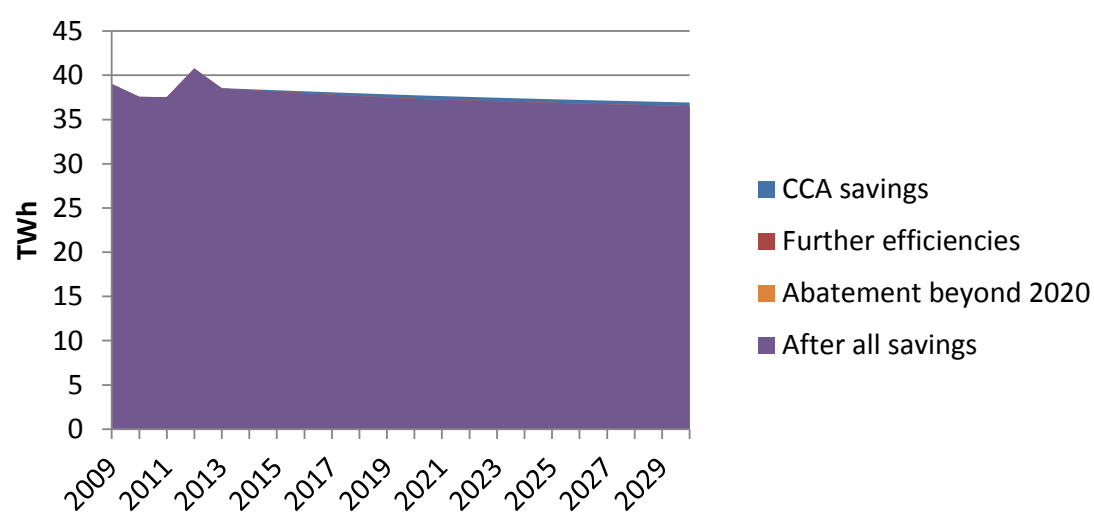
TWh	2020	2030
Baseline	37.74	36.92
CCA	-0.40	-0.39
Other Efficiencies	0	0
Abatement after 2020	0	0
Total after abatement	37.34	36.53

Figure 18: Results for the Unclassified sector

Unclassified: Energy excluding renewables



Unclassified: Fossil Fuel



7 Conclusions

In this study we have reviewed the carbon budget trajectories for industry produced in 2010 and updated them to take consideration of policy and new information. In particular we have considered the potential impact of the CCAs up to 2020 and we have reviewed the potential savings for longer-term abatement through efficiencies and renewable heat up to 2030.

Our principal conclusion is that the technologies available to 2020 will be broadly unchanged from those modelled with the Enusim model in 2010 (with the exception of impulse drying in the Paper sector) and that similar levels of abatement can be achieved (relative to the revised baseline).

We have also reviewed the potential impact of the EU ETS as a driver of carbon abatement to 2020 and shown that meeting the current allocation of allowances for Phase 3 will require at least all of the energy efficiency and renewable heat measures modelled if operators are to avoid purchasing allowances (with the exception of the refineries sector, which is known to be under-allocated for Phase 3).

Beyond 2020 the position is less clear. We have updated the analysis of abatement measures carried out by AEA in 2010 in our model and reviewed the results for this and the potential for renewable heat with the industry sectors. There are considerable doubts expressed by industry about some of this potential.

The largest areas of abatement potential identified in 2010 were in the Steel and Refineries sectors. Industry has barriers to the implementation of these measures, which are mainly economic, in particular to whole refinery optimisation and the expansion of the use of electric arc furnaces in steel manufacture. These barriers affect 85% of the cost-effective abatement potential identified.

Table 21 below shows the total carbon savings identified from this study for each sector in 2020 and 2030, with a split of traded and non-traded emissions. This implies savings potential of 10 MtCO₂ in 2020 and over 24 MtCO₂ in 2030 from energy use. The scale of the latter figure is open to some doubt, however, based on the barriers identified by the sectors above.

In addition barriers have been identified by all sectors to the potential savings using renewable heat. In particular there are barriers both to the generation of heat through security of supply, transport and storage of biomass, and to the use of waste heat through the lack of an adequate market or distribution system. These are, however, all economic or policy barriers that can be (and will need to be) overcome.

Through consultation with industry it has become clear, however, that there are additional opportunities in some sector for savings post-2020 that have not previously been studied and that will require further research to quantify. In addition there are various studies underway that are likely to identify further potential.

In conclusion, therefore, whilst considerable potential for abatement has been identified, more work will need to be done to understand and find solutions to the barriers to this implementation.

Table 21: Maximum carbon savings identified in 2020 and 2030

	With no Abatement (Baseline)						With all Abatement						Savings					
MtCO ₂	2020			2030			2020			2030			2020			2030		
Sector	Traded	Non Traded	Total	Traded	Non Traded	Total	Traded	Non Traded	Total	Traded	Non Traded	Total	Traded	Non Traded	Total	Traded	Non Traded	Total
Chemicals	12.2	0.0	12.2	11.3	0.0	11.3	10.7	0.0	10.7	8.9	0.0	8.9	-1.4	0.0	-1.4	-2.4	0.0	-2.4
Construction & Other Manufacturing	2.4	8.3	10.7	2.0	6.8	8.8	2.3	8.1	10.4	1.9	6.6	8.6	-0.1	-0.2	-0.3	-0.1	-0.2	-0.2
Engineering & Vehicles	2.0	10.5	12.5	2.0	10.3	12.2	1.8	9.6	11.5	1.8	9.4	11.2	-0.2	-0.8	-1.0	-0.2	-0.8	-1.0
Food, Drink & Tobacco	3.5	5.1	8.5	3.0	4.4	7.5	3.2	4.7	7.8	2.6	3.8	6.4	-0.3	-0.4	-0.7	-0.4	-0.6	-1.0
Iron&steel	4.8	0.0	4.8	4.3	0.0	4.3	4.4	0.0	4.4	3.7	0.0	3.7	-0.4	0.0	-0.4	-0.6	0.0	-0.6
Mineral Products	8.5	0.0	8.5	8.1	0.0	8.1	7.9	0.0	7.9	6.1	0.0	6.1	-0.6	0.0	-0.6	-2.0	0.0	-2.0
Non-Ferrous Metals	0.9	0.0	0.9	0.7	0.0	0.7	0.8	0.0	0.8	0.7	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Paper, Printing & Publishing	3.4	3.3	6.6	3.2	3.1	6.3	3.2	3.1	6.4	3.1	3.0	6.1	-0.1	-0.1	-0.3	-0.1	-0.1	-0.3
Refineries	20.0	0.0	20.0	22.0	0.0	22.0	20.0	0.0	20.0	18.6	0.0	18.6	0.0	0.0	0.0	-3.4	0.0	-3.4
Textiles, Leather & Clothing	0.4	1.4	1.8	0.3	1.1	1.4	0.4	1.4	1.8	0.3	1.1	1.3	0.0	-0.1	-0.1	0.0	0.0	-0.1
Unclassified	9.3	0.0	9.3	9.1	0.0	9.1	9.2	0.0	9.2	9.0	0.0	9.0	-0.1	0.0	-0.1	-0.1	0.0	-0.1
RENEWABLE HEAT SAVING (TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	-3.4	-1.5	-5.0	-10.3	-2.8	-13.1	-3.4	-1.5	-5.0	-10.3	-2.8	-13.1
TOTAL	67.2	28.6	95.8	66.1	25.8	91.9	60.5	25.4	85.9	46.4	21.1	67.5	-6.7	-3.2	-9.9	-19.7	-4.7	-24.4

Note that the carbon savings for Iron & Steel do not include savings from the use of coal in coke manufacture displaced by greater use of Electric Arc Furnaces for scrap recycling.

Appendices

Appendix 1: Climate Change Agreements

Appendix 2: Carbon Factors used in this study

Appendix 3: Disaggregation of UEP48 energy projections

Appendix 1 – Climate Change Agreements

The following is a map of the Climate Change Agreement sectors to the UEP Sectors and SIC (2007) codes used for this work.

CCA Code	CCA Sector Name	SIC code (2007)	Mapping to UEP
CIA	Chemicals	20	Chemicals
BCGA	Industrial Gases	20	Chemicals
BTMA	Rubber	22	Construction & Other Industry
WPIF	Wood Panel	16	Construction & Other Industry
PIFA	Packaging and Industrial Film	22	Construction & Other Industry
BPF	Plastics	22	Construction & Other Industry
ADS	Aerospace	30	Engineering & Vehicles
CBM	Metal Forming	25	Engineering & Vehicles
MPMA	Metal Packaging	25	Engineering & Vehicles
SMMT	Motor Manufacturers	29	Engineering & Vehicles
NMI	Semiconductors		Engineering & Vehicles
SEA	Surface Engineering	25	Engineering & Vehicles
SEHT	Contract Heat Treatment	25	Engineering & Vehicles
NAMB	Craft Baking	10, 11	Food, Drink and Tobacco
BLRA	Brewing	10, 11	Food, Drink and Tobacco
DIAL	Dairy Industry	10, 11	Food, Drink and Tobacco
BEPA	Egg Processing	10, 11	Food, Drink and Tobacco
FDF1	Food & Drink	10, 11	Food, Drink and Tobacco
MAGB	Malting	10, 11	Food, Drink and Tobacco
BPC2	Poultry Meat Processing/Feed	10, 11	Food, Drink and Tobacco
BMPA	British Meat Fedtn	10, 11	Food, Drink and Tobacco
SEEC	Spirits	10, 11	Food, Drink and Tobacco
FDFS	Supermarkets	10, 11	Food, Drink and Tobacco
AIC	Agricultural Supply	10, 11	Food, Drink and Tobacco
UKRA	Rendering	10, 11	Food, Drink and Tobacco
CAST	Foundries	24	Iron & steel
UKSA	Steel	24	Iron & steel
BCA	Cement	23	Mineral Products
BCC	Ceramics	23	Mineral Products
EUR	Eurisol (Mineral Wool)	23	Mineral Products
BGMC	Glass	23	Mineral Products
GPDA	Gypsum Products	23	Mineral Products
BLA	Lime	23	Mineral Products
SGS	Slag Grinders	23	Mineral Products
BCCF	Calcium Carbonate	23	Mineral Products
KABC	Kaolin and Ball Clay	08	Mineral Products
AFED	Aluminium	24	Non-Ferrous Metals
NFA	Non-Ferrous	24	Non-Ferrous Metals
CPI	Paper	17	Paper, Printing & Publishing
BPIF	Printing	18	Paper, Printing & Publishing
AWM	Wallcoverings	17	Paper, Printing & Publishing

UKLF	Leather	15	Textiles, Leather & Clothing
BATC	Textiles	13	Textiles, Leather & Clothing
BATE	Textiles - EI	13	Textiles, Leather & Clothing
BNMA	Geosynthetics	13	Textiles, Leather & Clothing
CSDF	Cold Storage	Unknown	Unclassified
TSA	Laundries	Unknown	Unclassified
BPC1	Poultry Meat Rearing	1	Agriculture
NFU1	Pigs	1	Agriculture
NFU4	Horticulture	1	Agriculture
NFU5	Eggs & Poult Meat	1	Agriculture

Note that the last four CCA sectors correspond to Agriculture and they have not be included in the modelling of energy use in the UEP Sectors.

Appendix 2 – Carbon Factors used in this study

The following table shows the carbon factors in ktCO₂ per GWh used in this study.

Fuel	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Blast Furnace Gas	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Coal	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Coke	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Coke Oven Gas	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Electricity	0.41	0.41	0.42	0.40	0.47	0.45	0.45	0.44	0.39	0.37	0.37	0.36	0.36	0.35	0.36	0.35	0.37	0.37	0.37	0.37	0.35	0.35	0.31
Electricity (ARC)	0.41	0.41	0.42	0.40	0.47	0.45	0.45	0.44	0.39	0.37	0.37	0.36	0.36	0.35	0.36	0.35	0.37	0.37	0.37	0.37	0.35	0.35	0.31
Fuel oil	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Gas	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Gas (ARC)	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Gasoil	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66	2.66
Oil	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
OPG (refineries)	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Pet coke	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Sinter coke	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Solid	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33

Appendix 3 – Disaggregation of UEP48 energy projections

Disaggregation of UEP48 energy projections to industry sector (all data in kilotonnes of oil equivalent)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Iron & Steel (ktoe) (see note below)																						
Electricity	311	330	330	289	393	390	381	375	375	372	368	368	365	359	359	354	354	352	352	352	351	349
Gas	433	501	479	417	556	541	513	493	490	478	460	457	449	431	432	420	419	414	414	415	413	409
Oil	8	6	4	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Blast Furnace Gas	29	87	64	24	49	49	50	54	48	46	49	49	49	49	48	48	49	49	49	49	49	49
Coke	5	5	5	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke Oven Gas	49	97	60	55	48	56	53	53	55	56	58	60	59	58	56	55	54	53	53	52	51	50
Sinter coke	327	199	150	311	313	320	318	318	319	321	322	324	323	322	320	319	319	318	317	317	316	315
Coal	44	43	38	36	42	43	43	43	43	43	44	44	44	44	43	43	43	43	43	43	43	42
Chemicals (ktoe)																						
Electricity	1570	1634	1564	1534	1467	1446	1446	1456	1477	1496	1514	1537	1555	1564	1579	1588	1602	1615	1631	1646	1660	1672
Gas	2691	2556	2574	2407	2251	2202	2169	2144	2133	2119	2101	2091	2075	2047	2026	2000	1981	1962	1946	1931	1916	1898
Oil	242	339	215	342	133	128	126	124	121	118	118	114	111	109	104	101	96	93	89	84	81	77
Solid	235	232	290	309	189	191	199	211	209	217	232	230	237	256	251	263	259	262	258	252	249	250
Construction & Other Manufacturing (ktoe)																						
Electricity	1894	2046	2025	1985	2073	2073	2058	2043	2037	2042	2046	2045	2050	2050	2039	2034	2025	2022	2019	2019	2021	2022
Gas	1091	1061	1032	1009	983	939	895	860	830	806	784	762	742	720	696	674	652	632	613	595	578	561
Oil	94	111	158	95	109	106	104	103	102	101	99	97	94	92	89	86	84	81	79	76	74	71
Solid	142	140	125	98	122	126	113	94	77	61	48	38	30	25	21	17	15	12	11	9	8	7
Engineering & Vehicles (ktoe)																						
Electricity	1699	1734	1670	1631	1713	1770	1820	1868	1916	1963	2009	2054	2090	2120	2148	2175	2203	2233	2264	2296	2329	2362
Gas	1494	1691	1741	1768	1680	1618	1582	1565	1558	1558	1562	1568	1570	1568	1563	1559	1554	1549	1543	1536	1527	1518
Oil	290	94	175	33	94	121	126	125	122	119	115	112	108	105	101	97	94	90	87	84	81	78
Solid	52	54	54	52	44	44	43	42	42	41	41	41	40	39	39	38	37	37	36	35	35	34

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Food, Drink & Tobacco (ktoe)																						
Electricity	952	1020	1004	988	864	846	832	819	808	799	788	777	764	751	740	728	718	708	700	692	686	680
Gas	2034	2067	2085	2047	1726	1650	1600	1570	1550	1539	1533	1529	1522	1519	1515	1512	1507	1503	1497	1490	1482	1474
Oil	863	1104	594	481	535	597	630	647	654	657	657	654	649	644	640	634	630	625	620	615	611	607
Solid	49	45	48	47	39	37	35	34	33	32	31	30	30	29	29	28	28	28	27	27	27	27
Mineral Products (ktoe)																						
Electricity	622	643	622	600	593	590	590	591	596	601	607	612	618	621	624	625	627	629	631	634	636	638
Gas	1380	1398	1328	1377	1263	1234	1219	1212	1212	1216	1221	1228	1234	1237	1237	1237	1237	1237	1238	1239	1240	1241
Oil	280	299	238	54	286	283	271	260	251	243	236	229	222	215	207	200	193	186	179	173	167	161
Solid	722	714	708	693	675	669	666	665	667	670	674	679	683	685	686	687	687	688	689	690	691	692
Unclassified (ktoe)																						
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas	74	69	70	71	71	70	70	70	70	69	69	68	68	68	68	68	68	68	69	69	69	69
Oil	3064	2951	2964	3244	3060	3057	3054	3051	3048	3045	3042	3040	3037	3034	3031	3029	3026	3024	3021	3019	3017	3014
Solid	216	209	193	190	184	177	169	163	156	150	144	138	132	127	122	117	112	108	104	99	95	92
Non-Ferrous Metals (ktoe)																						
Electricity	539	595	618	448	364	298	252	221	202	190	182	177	174	172	170	169	168	167	166	166	166	166
Gas	219	255	237	272	154	110	89	78	72	68	67	66	67	67	68	68	68	68	68	67	67	66
Oil	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Solid	28	26	25	24	10	6	4	3	2	2	1	1	1	1	1	1	0	0	0	0	0	0
Paper, Printing & Publishing (ktoe)																						
Electricity	982	970	967	957	851	797	796	817	831	824	804	790	783	775	764	749	737	727	720	714	707	699
Gas	1463	1442	1314	1249	1184	1140	1166	1233	1289	1315	1329	1351	1385	1424	1452	1474	1495	1521	1549	1575	1597	1618
Oil	137	110	67	70	76	68	65	64	62	59	55	52	50	47	45	42	40	38	36	34	32	30
Solid	76	77	76	74	68	64	64	66	67	67	66	65	65	65	65	64	63	63	63	62	62	61
Textiles, Leather & Clothing (ktoe)																						
Electricity	267	270	265	259	244	232	222	212	204	196	189	182	175	169	163	158	153	148	144	140	137	133

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Gas	475	485	471	459	419	396	379	367	357	348	342	336	331	326	320	316	310	305	299	293	286	281
Oil	102	85	117	106	89	81	77	74	72	70	68	67	65	64	62	61	60	59	57	56	55	54
Solid	52	50	48	46	45	44	43	43	42	42	41	41	41	41	41	40	40	40	40	40	40	39
Refineries (ktoe)																						
OPG (refineries)	3517	3324	3142	3119	3141	3147	3202	3226	3251	3276	3318	3450	3550	3651	3756	3867	3858	3860	3866	3870	3873	3871
Electricity	387	387	387	387	387	387	387	387	387	387	387	387	387	387	387	387	387	387	387	387	387	387
Fuel oil	629	611	594	590	594	595	605	610	614	619	627	652	671	690	710	731	729	730	731	731	732	732
Pet coke	1213	1179	1146	1138	1146	1148	1168	1177	1186	1195	1210	1258	1295	1332	1370	1410	1407	1408	1410	1412	1413	1412
Gas	168	203	246	244	245	246	250	252	254	256	259	270	277	285	294	302	302	302	302	302	303	303
Gasoil	189	122	79	79	79	79	81	81	82	83	84	87	89	92	95	97	97	97	97	98	98	98

Note that in this table the energy shown for the Iron & Steel sector is only that used in final production and doesn't show that in Transformation or Energy Production (including the manufacture of Coke).

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