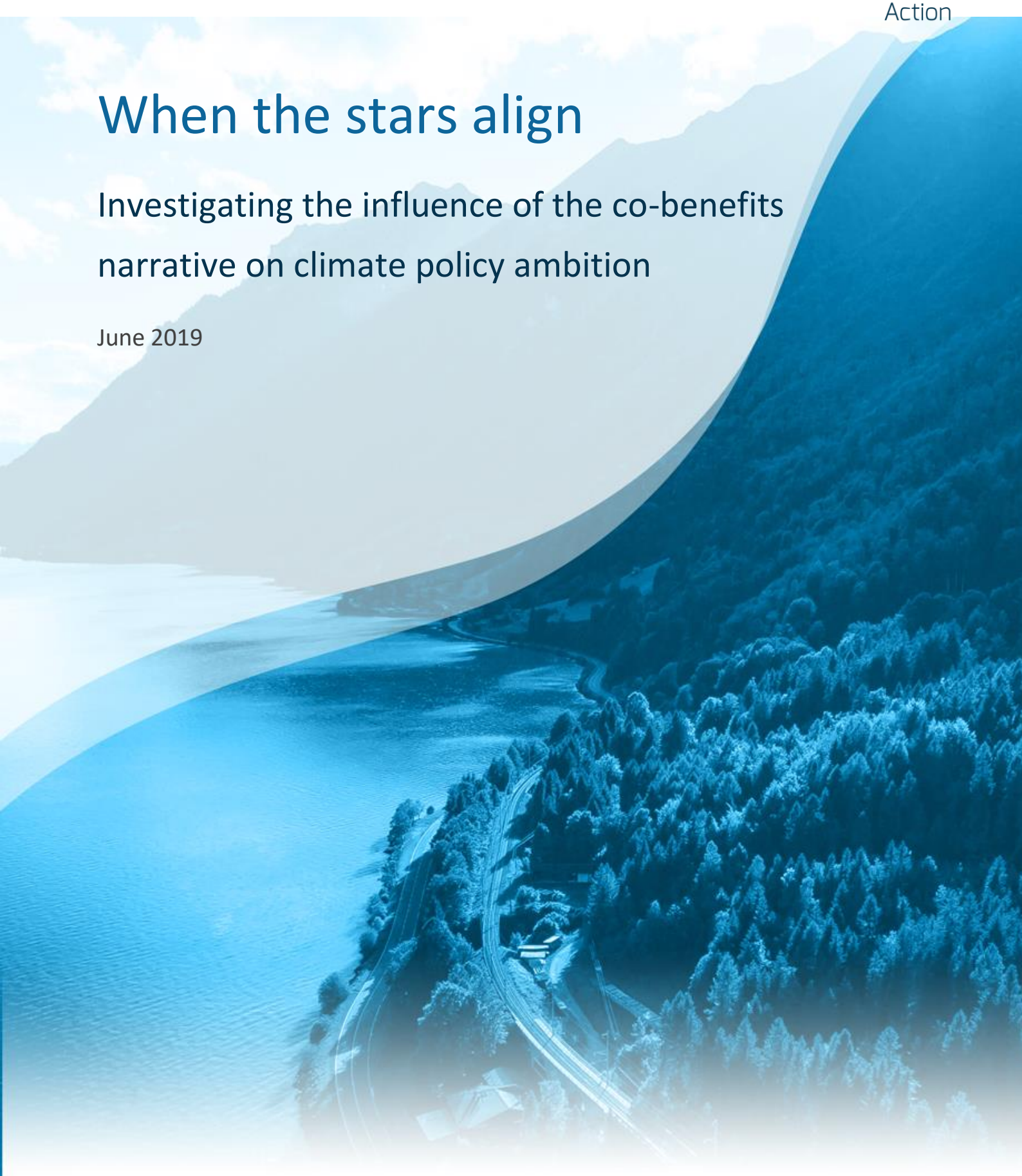
Ambition to Action

# When the stars align

## Investigating the influence of the co-benefits narrative on climate policy ambition

June 2019



ECN | TNO innovation for life

NEW CLIMATE INSTITUTE

# When the stars align

## Investigating the influence of the co-benefits narrative on climate policy ambition

June 2019

**Authors:** James Rawlins

**Contact:** james.rawlins@tno.nl

**Acknowledgements:** This paper benefitted from review and comments from Xander van Tilburg and Jasper Donker (ECN part of TNO) and Harry Fearnehough (New Climate Institute). The author would also like to extend a special thanks to the following experts who were interviewed for this paper:

**Ankit Bhardwaj**, Senior Research Associate, Centre for Policy Research, India
**Brett Cohen**, Associate Professor, University of Cape Town
**Jolene Cook**, Head of Climate Science – International, UK Department for Business, Energy and Industrial Strategy
**Jos Delbeke**, Director-General DG Climate Action, European Commission (2010-18), and Director for Climate Change, DG Environment (2003-2008)
**Sam Fankhauser**, Director, Grantham Research Institute on Climate Change and the Environment, and member of UK Committee on Climate Change (2008-16)
**Luis Janeiro,** Renewable Energy Roadmap Programme Officer, IRENA
**Ruud Kempener**, Policy Officer, DG Energy, European Commission
**Patrick Kinney**, Professor of Environmental Health, School of Public Health, Boston University
**Laurie Laybourn-Langton**, Director, UK Health Alliance on Climate Change
**Carina Lindberg**, Policy Coherence for Sustainable Development Unit, OECD
**Anil Markyanda**, Professor, Basque Centre for Climate Change
**Annabelle Workman**, Australian-German Climate and Energy College, University of Melbourne
**Tim Yeo**, Chairman of UK Parliamentary Select Committees for Environment (2005-10) and Energy and Climate Change (2010-15)



This project is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the German Bundestag.

Supported by:

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

based on a decision of the German Bundestag

# Executive summary

One objective of the Ambition to Action project is to help countries to develop and use evidence about the co-benefits of climate change mitigation actions to help raise their climate ambition and accelerate implementation. This paper attempts to support this aim by seeing what conclusions and lessons can be drawn from three case studies exploring the role of co-benefits in influencing climate ambition, supported by interviews and a review of relevant academic literature.

**The co-benefits evidence base**

The co-benefits evidence base is now well established, and continues to grow. Several recent systematic or detailed reviews have been undertaken, including as part of the latest IPPC Special Report.

There is now a wealth of evidence for some co-benefits, with air pollution and health being most strongly represented, along with ecosystem impacts (water, land and biodiversity). The largest benefits are estimated for air pollution and health, with numerous studies suggesting that the health benefits will largely offset the costs of climate change mitigation for many regions. For many impact areas (e.g. economic growth and jobs, water, biodiversity, food security) there are negative impacts associated with implementing measures to reduce emissions, as well as co-benefits.

Overall, however, the reviews of co-benefits evidence agree that the positive co-benefits identified in papers substantially outweigh the negative impacts identified. They agree that co-benefits should be included in decision-making, and that they would generally provide additional motivation for climate action. However, the importance of context is noted, and that there can be losers as well as winners, especially at sub-national scales.

**The literature on the impact of co-benefits evidence**

While the literature on the use of co-benefits evidence in policymaking is not extensive, several papers have noted that co-benefits are seldom properly considered in climate policy impact assessments, which typically have a narrow focus on the costs of achieving a certain level of greenhouse gas reduction, and do not incorporate broader economic, social or environmental impacts. A small body of work focusses on health co-benefits in particular, noting that they have had limited policy impact despite the large scale of potential benefits. A range of challenges identified in the literature include the complexity and resource demands of robust co-benefits assessments; a focus in governments on minimising costs rather than maximising benefits; a failure to involve all relevant stakeholders and institutions at the right time; and uneven distribution of gains and losses across stakeholder groups and the influence of vested interests.

**Co-benefits and national climate policy ambition: three case studies**

The degree to which co-benefits have been instrumental in setting climate ambition and how they have been used varies greatly across the three cases of the EU, UK and China. But all three have made use of the existence of co-benefits to advance mitigation action. The UK seems to have been mainly motivated to adopt – at the time world-leading – climate targets by the desire to avoid dangerous climate change and to show leadership to help secure a global climate deal, and then has used co-benefits as a framing narrative and justification (and in a flexible manner, emphasising different co-benefits at different times). Similarly

the EU (at an institutional level) was first motivated by the importance of taking action on climate change for its own sake, and then used the energy security co-benefit in particular to get more reluctant Member States on board. The story in China is almost exactly the opposite: the alignment between mitigation actions and actions to address its key challenges of extreme air pollution, worsening energy security and slowing economic growth are so strong that climate action was likely motivated mainly by those other objectives, with climate change mitigation a happily co-incidental co-benefit.

**Conclusions and future work**

One way or another, all three cases have taken advantage of the existence of substantial alignment between key policy goals to advance real mitigation action. Other countries that benefit from such alignments between climate and other objectives should therefore exploit them to support their NDC development and implementation, and in particular to raise ambition.

The cases studies suggest that energy security in particular has been more influential than the other co-benefits in influencing climate action. Energy security perhaps has certain 'advantages' as an issue, compared to other co-benefits, which help explain its greater impact so far: for example, it is directly linked to economic progress, and failure manifests quickly and is highly visible. The interplay between climate ambition and energy security needs further study to understand how energy security can support climate ambition, or in countries where it seems difficult to align these two goals, how to manage such an important trade-off. Additionally, the limited impact of the health co-benefit needs to be fully understood so that this potentially powerful driver of climate ambition can be harnessed.

Looking beyond the case studies, it is not certain that there will be sufficiently large-scale positive co-benefits to help motivate the substantial increase in climate ambition that is required in nearly all countries to deliver on the temperature goals of the Paris Agreement. While the health case is likely to be strongly supportive in all countries, it has so far largely been weak in terms of policy influence, and the energy security and economic case may be marginal or even negative in many countries.

Countries should analyse potential co-benefits at a sufficient level to give them credible and robust evidence about the impacts of different mitigation options and ambition levels. Where there are alignments (i.e. co-benefits), countries should exploit them, both to make decisions and also to communicate and build support for implementation. And where there are misalignments (or negative impacts), they will need to recognise and manage them. And the co-benefits research community can support them by continuing to develop and communicate robust and useful co-benefits evidence, and by working to address the challenges that have been identified as hindering policy impact.

# Contents

# 1. Introduction and objectives

The Ambition to Action project, of which this research paper is an output, has a particular interest in how the 'co-benefits' of climate change mitigation actions can support ambitious climate policy and can thus play a positive role in helping countries achieve their Paris Agreement commitments. Chapter 4 of the November 2017 edition of the project's flagship publication, the NDC Update Report, highlighted some of the most striking recent estimates of the scale of co-benefits, and briefly outlined some ways in which co-benefits evidence could help support the achievement of Nationally Determined Contributions (NDCs): building stakeholder support for NDC implementation and ambition, identifying trade-offs and losers, prioritizing options and pathways, and helping to mobilise climate and development finance (Ambition to Action, 2017). It also suggested some initial steps countries could take to begin to develop and make use of evidence about co-benefits, including some activities with which the Ambition to Action project is directly supporting its partner countries.

Since the publication of that report, the body of evidence suggesting that there are significant synergies between climate mitigation and other development goals has continued to grow. In October 2018, the IPCC published its 'Special Report on Global Warming of 1.5˚C', which dedicated a chapter to the 'interplay' between sustainable development (in the form of the Sustainable Development Goals, or SDGs) and climate actions, and which observed with 'very high confidence' that "The number of synergies between mitigation response options and sustainable development exceeds the number of tradeoffs in energy demand and supply sectors, Agriculture, Forestry and Other Land Use (AFOLU) and for oceans" (IPCC, 2018).

**Box 1. Co-benefits terminology**

'Co-benefit' is just one among of a number of terms currently in use to describe the various effects (be they economic, social or environmental) which may result from a climate change mitigation action or policy. Some of the other terms, such as 'co-impacts' or 'multiple impacts' are more neutral, in that they do not imply that the effects are positive, or by removing the 'co-' they do not imply that mitigation is the most important objective and thus that co-benefits are side-effects of lesser importance. The term 'synergy' is also increasingly used to indicate instances where an action or policy may positively influence several priority issues, and where an action or policy may have negative impacts, the term 'trade-off' is sometimes used. Because it still seems to be the most widely understood term, and because this paper is anchored in climate policy first and foremost, for the remainder of this paper, the term 'co-benefits' is used.

Co-benefits related to air pollution and human health continue to attract the most focus and to produce some of the most striking findings: the IPCC report cites a 2018 paper from Anil Markyanda[1] et al which presents the results of a modelling study which assessed the degree to which health co-benefits could

[1] *NB Anil Markyanda was one of the experts interviewed for this paper.*

offset the cost of achieving the targets of the Paris Agreement, and which found that 'the costs of reducing greenhouse gas emissions could be compensated with the health co-benefits alone for China and India, whereas the proportion the co-benefits covered varied but could be substantial in the European Union (7–84%) and USA (10–41%)' (Markyanda et al, 2018). In other words, the health co-benefits of mitigation are so large for China and India that *on their own* they would justify very ambitious climate policy in those countries, and in the EU and USA they could reduce the net cost very substantially indeed.

And human health is but one of many co-benefits that are estimated to be potentially very significant. Other positive impacts relate to energy security, job creation, innovation and industrial development, reduced water scarcity, resource efficiency and environmental degradation.

However it is not the aim of this paper to summarise the co-benefits evidence or to point out the value of including co-benefits evidence in cost-benefit assessments and policy decisions. That has been done comprehensively elsewhere, including by the IPCC in its Assessment Reports and most recently in the Special Report referenced above, and several of these reviews are considered in the following chapter.

Instead this paper arose from the observation that despite the large body of evidence about the scale of co-benefits (which is several decades old now), and growing recognition that they are well aligned to countries' own priorities, and manifest locally and in the shorter-term, collective mitigation ambition still falls far short of what is needed to achieve the Paris Agreement goals. It raises the question of whether the co-benefits message is getting through, or if it is, why it is not having the effect that co-benefits advocates hope for – showing that climate ambition is an opportunity, not a burden, something to be grasped, not something to be pushed away.

Because one of the aims of the Ambition to Action project is to help its partner countries (and by extension, a far wider group of developing countries) to use co-benefits evidence to raise their climate ambition and accelerate their implementation of ambitious mitigation actions, we felt it was important to investigate this question and to try to explore whether co-benefits evidence really has been positively influencing climate ambition, and to see what lessons might be drawn from the experience so far.

This paper thus attempts, through interviews, a review of academic literature, and three case studies, to assess the degree to which an understanding of (positive) co-benefits has positively influenced climate ambition, to identify if any particular co-benefits have been more influential than others, and to draw out some observations and lessons that might be useful to those hoping to use co-benefits in support of ambitious climate action.

The following chapter looks at the co-benefits evidence base as a whole, summarising a number of recent systematic reviews. Chapter 3 reviews the small body of literature that has explicitly addressed the question of the policy impact of co-benefits. Chapter 4 presents three case studies, exploring the role of co-benefits in the evolution of climate policy ambition in the EU, UK and China. Finally, Chapter 5 attempts to draw some observations and conclusions.

# 2. Considering the co-benefits evidence base

***Is the co-benefits evidence base comprehensive, robust, and does it allow clear conclusions to be drawn? Does it point to synergies that might support increased ambition?***

The evidence base on co-benefits of climate action, comprising mainly academic papers and publications from governments and international organisations such as the OECD, extends back to the mid-1990s. Various papers provide an overview of the evolution of the concept, and discuss its relevance to mitigation and its strengths and weaknesses (see for example Ürge-Vorsatz et al, 2014).

A large proportion of the literature is principally concerned with estimating the potential size (and value) of specific co-benefits, often based on modelling exercises, at various geographical scales. These papers are frequently produced by independent researchers and although they may make brief observations about the 'policy relevance' of their findings, they usually do not have a direct link to policymaking institutions, and they normally do not discuss whether their findings have been used to inform policy. While these papers are relevant, because along with evidence produced directly by governments and their agencies, they form the bulk of the body of co-benefits evidence, they do not directly help to answer the question of whether co-benefits are successfully influencing climate policy. However, the nature of the evidence base for each specific co-benefit – the volume of evidence, the degree of consensus, whether it points to co-benefits or negative co-impacts, the scale of the impact, etc. – will have a considerable bearing on whether it influences policy. A small evidence base showing both positive and negative results is naturally likely to be less influential in supporting climate ambition than a large evidence base pointing to mainly positive impacts with a high level of consensus.

**Recent reviews of the co-benefits evidence base**

Conducting a systematic review of the co-benefits evidence base is very much beyond the scope of this research paper; fortunately, several reviews have been undertaken in the last few years that provide some useful summary information about the co-benefits evidence base as a whole. These are discussed in turn.

In 2015, von Stechow et al published a paper including a useful synthesis of co-benefits evidence, in the form of a 'qualitative meta-analysis' of the several hundred studies that were assessed for the IPCC's Fifth Assessment Report. This paper includes a particularly clear (qualitative) summary of the 'direction' (i.e. positive or negative) and scale of co-benefits, covering 9 different co-benefits across the economic, social and environmental dimensions, and 15 different mitigation actions across 4 sectors (energy supply, transport, buildings and industry), replicated in Figure 1 below. Because of its clarity and simplicity this table was presented as the main summary of the co-benefits evidence base in the NDC Update Report chapter mentioned earlier. As we reported in that publication, of the 93 impacts shown in the synthesis table, 64 are positive, 18 show both positive and negative results, and only 11 are negative. The paper makes several observations based on the meta-analysis: firstly, for demand-side measures, the co-benefits outweigh the trade-offs, while for low carbon energy supply measures (e.g. nuclear, renewables or CCS) 'the balance depends to a larger degree on the specific measure'; secondly they observe that there is 'a wealth of evidence of the different coeffects on many policy-relevant objectives. In fact, the scientific


*Figure 1: Synthesis of impacts studies assessed in the IPCC's Fifth Assessment Report in 2014 (analysis from von Stechow et al. 2015, graphic from Ambition to Action, 2017)*

literature covers the coeffects of most sectoral mitigation measures on energy security and reduced health and ecosystem impacts.' For other co-benefits the evidence base is less comprehensive (von Stechow et al, 2015).

Deng et al undertook a different kind of review of co-benefits evidence, published in 2017. Their paper presents the results of a systematic review of c. 1,500 co-benefits papers published between 2001 and 2016. While it does not discuss the findings of those papers (direction or magnitude of results for example), the paper does present the results of a classification of the 1,500 papers across various dimensions, including which co-benefits are focused on, providing some additional insights about the nature and balance of the co-benefits evidence base. Their review also provides some concrete evidence that this is indeed a growing evidence base: their review identified 9 papers published on co-benefits in 2001, increasing to 344 in 2016, with more or less consistent year on year increases over the 15 year period (Deng et al, 2017).

Deng et al categorised the reviewed papers into ten co-benefit categories (and 'other'). The most commonly covered co-benefit area was 'ecosystem' (including water pollution) with 309 (19%) of papers. The next most common were 'economic' (including employment) with 285 (17%), 'health' with 220 (13%) and then resource efficiency with 177 (11%). Together these 4 benefit areas accounted for 60% of the total reviewed papers. The authors categorised 'air pollution' as a separate category to 'health'; it had the fifth largest number of papers at 171 (10%). Combining 'air pollution' and 'health' into one category would have made it the most commonly covered topic with 24% of the total. In contrast to von Stechow et al, they found energy security to be among the least well represented co-benefits, with just 70 (4%) of the papers. Taking a mitigation sector view, AFOLU is the most represented, with 513 papers, followed by electricity with 400. Together these two sectors account for 60% of the total papers. They also categorised the geographic focus of the papers: 608 (37%) were 'international' (either global or covering two or more countries), 574 (35%) were national (one country), 297 focussed on sub-national regions and 143 were city-level studies.

The third broad review of co-benefits evidence considered here was undertaken for the UK Government by consultancy Aether during 2016 (though only published in 2018). The report (entitled 'Scoping study on the co-benefits and adverse side-effects of climate change mitigation') was based on a systematic literature review of over 400 co-benefits papers, and found that 'There is strong evidence that well-designed climate mitigation action can provide substantial co-benefits for health, energy security, economic development, social capital and natural capital. The economic value of these co-benefits can exceed the cost of the climate mitigation action'. Considering the evidence base, the review found that 'For climate mitigation policy as a whole, the available evidence indicates that co-benefits far outweigh any adverse side-effects, but the balance varies depending on the mitigation action and the context, and there may be winners and losers'. In common with von Stechow et al's 2015 review, the authors observed that demand reduction measures have predominantly positive impacts, while energy supply measures lead to both co-benefits and adverse impacts (Aether, 2016).

However the Aether report also notes that 'although there is strong evidence on certain benefits, notably the air quality benefits related to reduced use of fossil fuels, and growing evidence in other areas including the health benefits of active travel, there is still a shortage of robust, quantified evidence in many other impact areas – especially empirical evidence on the impacts of real world, rather than purely theoretical, mitigation actions'.

The Aether study also considered the geographical and sectoral coverage of the evidence base, and the prominence of specific co-benefits[2]. Geographically, 'the literature is dominated by papers from China, India, Europe and North America, with some papers from Australasia and Brazil, but very few from other regions'. For some of the larger developing countries (Brazil, Indonesia, Mexico) the majority of papers were focused on land-use related co-benefits, and indeed AFOLU was found to have the highest number of papers overall, but had the highest proportion (around a third) of papers with 'weak' evidence (i.e. general discussion rather than robust quantitative evidence). The power and transport sectors were well represented with papers with 'strong' evidence.

Of the c. 400 papers reviewed, the most commonly studied impact by far was outdoor air quality, with almost double the number of papers as the next most common impact, cost savings (mainly energy but also other inputs). Biodiversity, employment and livelihoods, and energy security, were the next most studied. In all cases the number of papers describing positive impacts outnumbers the ones describing adverse impacts; in most cases there are 8-10 times as many positive as negative papers, and the negative papers are quite concentrated in the areas of biodiversity, food security, cost savings, and water security.

**Climate action and the SDGs: the IPCC Special Report**

In October 2018 the IPCC published its much anticipated 'Special Report on Global Warming of 1.5˚C'. Chapter 5 explores the relationship between climate action and sustainable development, often expressing this specifically in terms of the SDGs, i.e. instead of referring only to co-benefits such as 'reduced air pollution', some of the references are to specific SDGs (e.g. 'SDG3 (health)'). This presents some additional complexity and hinders a simple interpretation of the results due to the composite and overlapping nature of some of the SDGs. However the report does present an up-to-date and (presumably) comprehensive overview of the linkages between climate action and the SDGs, and goes further than most other such overviews because in addition to summarising the strength and direction of the relationships, it also assesses the amount of evidence (and agreement) for a particular linkage. This is of interest because as noted above, it seems probable that a co-benefit relationship is more likely to be influential in policy decisions if there is a sizeable body of evidence pointing to a clear positive or negative relationship (or synergy or trade-off, to use the language of the IPCC report). The IPCC report provides one of the most relevant assessments of which positive or negative mitigation action-co-benefit relationships are backed up by extensive evidence.

In the Executive Summary to Chapter 5, 'robust synergies' are highlighted between 1.5°C pathways and SDG 3 (health), SDG7 (energy), SDG12 (responsible consumption and production), and SDG14 (oceans), all with 'very high confidence'. For SDGs 1,2,6 and 7 (relating to poverty, hunger, water and energy,

[2] *NB this analysis was limited to the 427 papers selected for priority review rather than the full set of over 1200 papers identified as potentially relevant (and papers relating to major emitting or fast industrialising countries were prioritised for inclusion).*

respectively), a risk of negative impacts (trade-offs) is noted, however with 'medium evidence, high agreement'. The sub-sections on specific mitigation areas highlight five observations about co-benefit relationships based on 'robust evidence, high agreement': for energy demand, synergies outweigh trade-offs across all SDGs; actions to accelerate energy efficiency in all sectors have synergies with numerous SDGs; in energy supply, deployment of renewables supports SDG1 (poverty), SDG10 (inequality), SDG11 (cities and communities) and SDG12 (consumption and production); land-based mitigation options (including bioenergy and afforestation & reforestation) may lead to negative impacts for SDG1 (poverty), especially among rural poor and indigenous communities. Concerns about negative economic impacts for countries with economies dependent on fossil-fuel use or export are also founded on 'robust evidence, high agreement' (IPCC, 2018).

Turning to specific co-benefit areas, sub-section 5.4.2 of the IPCC report summarises the evidence about some specific implications of 1.5°C pathways. Four areas are discussed: air pollution and health; food security and hunger; lack of energy access/energy poverty; and water security. 'Economic' co-benefits such as employment or impact on GDP are not discussed at this level. For air pollution, significant synergies are reported, with greater synergies from higher mitigation ambition, and higher synergies in the developing world, especially Asia. No trade-offs are mentioned. For food security, both trade-offs and synergies are mentioned; on the negative side, as noted above, land-based mitigation options can compete with food production, and GHG pricing policies may affect food prices and incomes. Synergies include reduced pressure on food security from low energy and low (food) demand pathways. On energy access, only a negative relationship is mentioned, where stringent climate policies that affect energy prices may slow down the transition to cleaner cooking fuels. The last area discussed is water security, where both synergies (reduced water demand from most renewables and energy efficiency) and trade-offs (bioenergy and some other renewables and other low carbon generation options such as nuclear can increase water use) are discussed.

Chapter 5 also contains a large and complicated table (Table 5.2) which presents different kinds of information about the linkages between mitigation actions and the SDGs, combining assessments of the direction and strength of the linkage with an assessment of the amount of evidence and level of agreement and confidence. As far as we are aware, this combination of information has not previously been put together into one summary overview[3]. 23 types of mitigation action are included across 7 mitigation sectors[4], with information included about 231 linkages (out of a possible maximum total of 361). Of most interest to this paper is the assessment of the 'weight' of evidence for a particular linkage, and with some additional analysis it is possible to make some further observations about the relative weight of SDG/co-benefit evidence that are not discussed in the report itself. In the table the 'weight' of evidence is rated on a scale of 1-4. Just over two-thirds of the linkages are rated 1 or 2 for evidence (equally split across 1 and 2); around a quarter are rated 3, and just 17 (4%) are rated as 4, the highest volume of evidence. Figure 2

[3] *NB there are numerous small errors in the text in the table, for example unfinished sentences, missing text, or descriptions that seem unlikely to best reflect the evidence shown. The analysis in this chapter makes the assumption that these are superficial proof-reading errors, and that the fundamental conclusions of the table are based on careful and systematic literature review and assessment.*

[4] *8 mitigation 'sectors' are actually included: Industry; Buildings; Transport; Replace coal; Advanced coal; Agriculture & livestock; Forest; Oceans. For the purposes of this paper, 'Replace coal' (RES, biomass, nuclear etc) are combined with 'Advanced coal' (CCS) and referred to as 'energy'. The 'Oceans' sector includes blue carbon as well as several CO2 removal options; far fewer linkages are included for this sector.*

below shows the weight of evidence about linkages between the SDGs and the 23 mitigation actions included in the IPCC report table (the value is the sum of the evidence ratings for each linkage, so an SDG with 5 linkages each with an evidence rating of 2 would score 10). The colours indicate whether the linkage was assessed to be a synergy (green), a trade-off (red) or a mix of both synergies and trade-offs (amber).

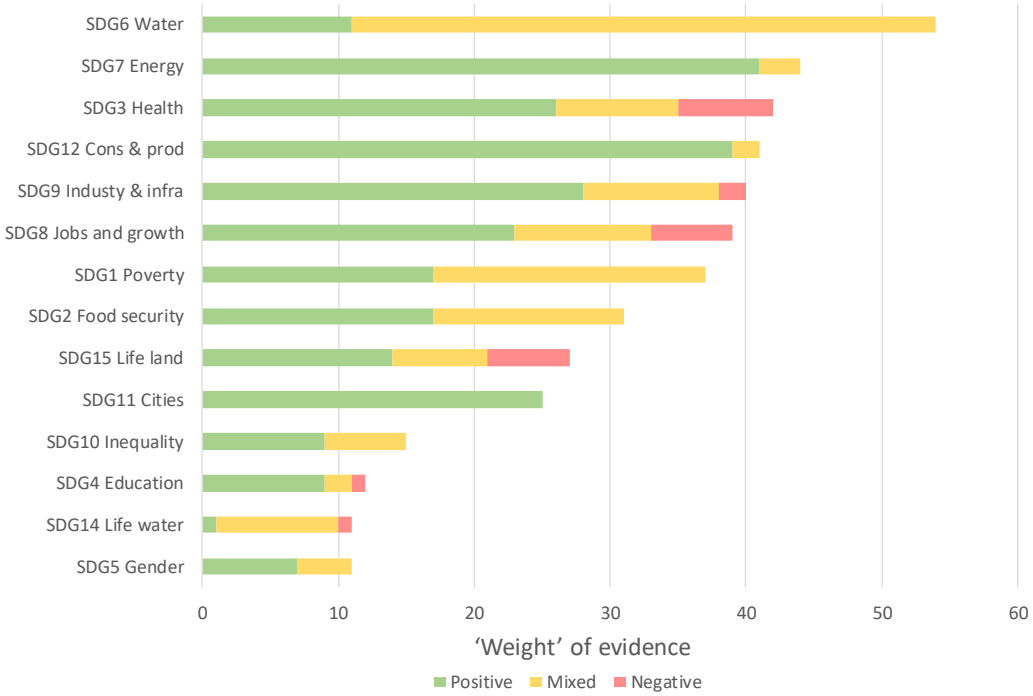



*Figure 2: SDG linkages by 'weight' of evidence and direction of interaction (Source: IPCC 2018 and author's analysis)*

As can be seen, there is most evidence about SDG6 (water), though most of this evidence points to both synergies and trade-offs (as highlighted in the report and noted above). There is also a large volume of evidence about synergies between mitigation actions and SD7 (energy), though this is perhaps partly explained by the fact that two of SG7's three sub-targets relate to increasing energy efficiency and the share of renewable energy, which are not really co-benefits and are naturally well aligned with many mitigation actions. SDG3 (health) is also rated highly for evidence, with the third highest total. Several SDGs relating to more economic aspects (consumption & production; industry & infrastructure; jobs and growth) follow. Comparing this analysis to the four SDG/co-benefit areas highlighted by in the report text, it seems apparent why water and health were discussed, less clear is why food security was highlighted. Nor does the focus on energy access align with the table: most of the SD7/energy linkages relate to increased energy efficiency or renewable share, and very few to SDG7.1 on affordable energy access.

Figure 3 repeats the analysis but including only linkages where the volume of evidence was rated as 3 or 4 (collectively around a third of the total number of linkages). Water stays at the top, with energy and health remaining highly ranked as well, but SDG12 rises up to second place. Another notable shift is that several of the more economic SDGs (9/industry & infrastructure and 8/jobs& growth) drop down the rankings, with the evidence for SDG8 on jobs and growth almost balanced between synergies and trade-offs. Given the importance of the jobs & growth narrative to many national climate policy debates, this seems an important observation.

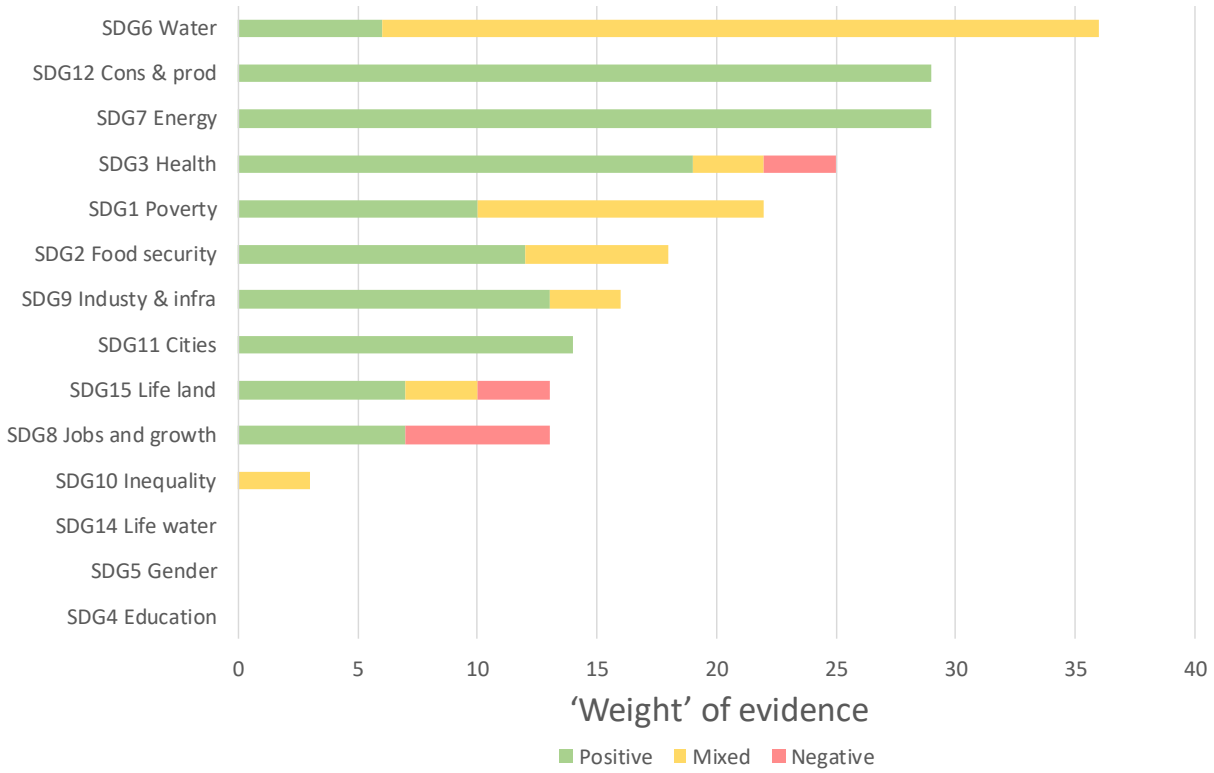



*Figure 3: SDG linkages by 'weight' of evidence (only including evidence ratings of 3 & 4) and direction of interaction (Source: IPCC 2018 and author's analysis)*

Comparing these results about 'weight' of evidence to the analysis undertaken by Deng et al and described above shows good consistency at the upper levels of the ranking, especially considering the fact that SDGs and 'co-benefits' do not map perfectly against each other. The co-benefits that featured most in their survey, air pollution and health (when combined), ecosystem (including water), resource efficiency (which combines the energy efficiency aspect of SDG7 along with SDG12), and 'economic' co-benefits (combining most aspects of SDGs 8 and 9) also all occupy high rankings based on analysis of the IPCC overview.

**Detailed assessment of specific co-benefits evidence**

The last overview source considered for this section is not a broad systematic review along the lines of the above references but is a more detailed assessment of what is known about potential co-benefits. In their 2017 policy report 'Multiple benefits from climate change mitigation: assessing the evidence', Hamilton et al discuss in some detail a range of co-benefits and what conclusions can be drawn from the evidence. They concur with the other sources that air pollution and health is the most widely studied co-benefit, with 'generally strong evidence for environmental co-benefits', and they observe that 'the largest co-benefits of climate change mitigation are associated with air pollution emissions'. They describe a much more mixed picture for economic co-benefits, with a summary conclusion that 'the evidence for 'macro' co-benefits is not strong'. They devote considerable attention to the 'Porter hypothesis', which posits that strict environmental regulations can induce innovation and increased competitiveness, concluding that while there is strong empirical evidence for the 'weak' variant of the hypothesis (that environmental regulation induces innovation to reduce compliance costs) and the 'narrow' variant (flexible regulations increase the level of innovation), there is mixed empirical evidence for the 'strong' variant (that environmental

regulation leads to increased profitability), and as a result 'governments should not assume that green innovation on climate change will yield co-benefits' (though noting that in individual circumstances this can happen). On green job creation, they conclude that 'the evidence suggests that any gains or losses of jobs are likely to be small', mainly because green jobs replace brown jobs. In common with other reviews – and the wider narrative about the potential importance of co-benefits – they state that governments have followed a 'blinkered' approach to climate policy by focusing only on the costs and the 'global public good nature of any benefits', and that inclusion of co-benefits can change this dynamic (Hamilton et al, 2017).

**In conclusion:**

- The co-benefits evidence base is now well established, and continues to grow. Several recent systematic or detailed reviews have been undertaken.
- There is a wealth of evidence for some co-benefits, with human health (via reduced air pollution) being most strongly represented, along with ecosystem impacts (water, land and biodiversity)
- The largest benefits are estimated for air pollution and health, while the evidence for economic impacts is more mixed, and needs work in some areas. For some impact areas (e.g. water, biodiversity, food security) there are negative impacts as well as co-benefits
- For demand side measures (reducing demand for energy or other inputs) the impacts are almost all positive whereas for supply side measures (e.g. substitution of fossil power with renewables) there are generally both positive and negative impacts
- Overall, the reviews agree that the volume of positive co-benefits identified in papers substantially outweighs the negative impacts identified, and they agree that co-benefits should be included in decision-making, and that they would generally provide additional motivation for climate action. However, the importance of context is noted, and that there can be losers as well as winners.

Several of the interviews undertaken for this paper touched on the nature of the evidence, largely agreeing with the literature, especially regarding the robustness (and large benefits) of air pollution evidence and the more varied nature of the economic evidence. Several experts also noted the potentially uneven distribution of benefits and negative impacts across different regions or societal groups.

# 3. Assessing impact and identifying challenges – the academic literature

***Does the academic literature consider whether co-benefits evidence is being used in policy decisions and whether it is achieving policy impact? What challenges does the literature identify that make using co-benefits evidence difficult?***

This chapter considers what the academic literature has to say about the impact of co-benefits on climate policy ambition. Several papers consider the evolution of the topic of co-benefits and discus the ways in which it might play a useful role in supporting climate ambition. In particular, the papers by Ürge-Vorsatz et al (Ürge-Vorsatz et al, 2014) and Mayrhofer & Gupta (Mayrhofer & Gupta, 2015) are frequently cited. Both papers note how inclusion of co-benefits can address several of the barriers generally thought to hinder action on climate, namely that they occur locally rather than globally, and because the benefits are felt in the short rather than the longer term. Most relevantly to the core interest of this paper, both papers note that co-benefits are frequently not included in cost-benefit analyses undertaken to inform policy decisions. Ürge-Vorsatz et al suggest this is in part to do with a lack of data, and the large effort required to undertake robust co-benefits analyses, and Mayhrofer and Gupta conclude with a call for a broader engagement with the concept, saying that 'Sociologists, anthropologists, geographers, lawyers and political scientists have yet to engage productively with this concept and give it the multi-disciplinary treatment it needs if it is to rise above incrementalism and sterile policy recommendations'.

The observation that co-benefits generally do not receive the attention they seem to merit in policy development has been made more forcefully in several papers focusing on health co-benefits. Positive impacts on human health through reduced air pollution are among the most well studied co-benefits, and have been well represented in the co-benefits debate since its early days; indeed many of the most striking co-benefits 'headlines' from the last two decades relate to human health and avoided healthcare costs. Unsurprisingly, there have been more papers considering the influence of health co-benefits than for any other co-benefit.

A widely referenced paper from 2010 by Nemet et al surveyed previous studies estimating the air quality benefits of mitigation and observed that although the results are 'of a similar order of magnitude to abatement cost estimates', they are 'only rarely included in integrated assessments of climate policy'. In the paper Nemet et al reviewed 13 major climate policy assessments based on integrated assessment models used by the IPCC, US and UK governments, and found that only two estimated air quality benefits, of which only one included them in the final valuation. One of the paper's observations (widely referenced in subsequent papers) is that a major challenge for the inclusion of co-benefits is that most climate policy debates are approached with the main objective of minimizing the costs of a certain level of emissions reduction, and do not explicitly consider the benefits of avoided climate change. Thus co-benefits from e.g. reduced air pollution must be compared to the costs of reducing GHG emissions, rather than included along with the benefits of avoided climate change. Co-benefits sit awkwardly in this dominant cost-minimisation framing, and lose some of their influence as a result. Nemet et al go on to ask 'If air quality co-benefits are so substantial and their implications so important, why do they not play a larger role in affecting climate

policy design?'. In addition to the aforementioned issue of comparing benefits with costs, they note several further challenges including larger uncertainty in estimates of avoided damages and abatement costs, which complicates comparisons; a lack of standard approaches for valuing air quality benefits in monetary terms; and institutional separation between the air quality and climate communities (Nemet et al, 2010).

A second paper from 2010, by Jack and Kinney, also addressed the question of why health co-benefits are not having greater impact and what could be done about it. They observed that 'While most studies have found that the magnitude of the ancillary benefits are large, even relative to the vast outlay required by GHG mitigation, recent influential efforts to assess the benefits and costs of climate policy have largely omitted co-benefits. In short, the co-benefits literature has so far failed to leave a mark in the policy realm.' The paper identifies several challenges that lessen the policy relevance of (at the time) recent contributions to the co-benefits literature: failure to select policy scenarios that are relevant to the key current policy debates; and challenges with the modelling of the behavioural response of firms and individuals, and the modelling of pollutant concentrations and human health impacts. On the basis that 'the co-benefits literature is at least partly to blame for the gap [in policy traction]', they propose a number of ways to improve the relevance of future studies, including more retrospective analysis of past policies; a more complete consideration of co-benefits other than air quality; more work focusing on developing countries (where co-benefits may be larger); and involvement of a greater range of expert disciplines in co-benefits studies (Jack and Kinney, 2010).

Several subsequent papers focus more closely on the modelling of health co-benefits and make recommendations for methodological improvements to increase policy uptake. In 2014, Remais et al noted the 'considerable variation in approaches to valuation metrics, discounting methods, uncertainty characterization and propagation, and assessment of low-probability/high-impact events', as well as variable inclusion of negative impacts. Noting that 'the ultimate goal of modeling is policy utility', they identify several useful recommendations which are relevant to future efforts to develop policy relevant co-benefits estimates, including: involvement of policymakers from the start of the modelling exercise, focusing on 'potentially feasible interventions'; careful consideration of time periods and the use of discount rates; consultation with or inclusion of 'decision analysis experts to ensure that the results are useful in formal decision analysis processes' (Remais et al, 2014).

More recently in this strand of research, a 2017 paper by Chang et al reviewed health co-benefit modelling studies published over the preceding eight years, documenting the approaches, scenarios and assumptions to assess 'their utility for policy making and evaluation'. Forty two studies met their criteria. As would be expected, the objectives of the studies varied from estimating co-benefits at a global level to estimating the potential co-benefits of specific policy proposals. Consistent with other synthesis studies, they found that the studies 'consistently demonstrated that the health co-benefits of mitigation policies and technologies offset a significant portion of their implementation costs', however they observed that 'meta-analyses and syntheses of results are stymied by the diversity of approaches, modeling methods, policy scenarios, assumptions, time slices, and evaluation metrics'. Because of this, they suggest that 'greater consistency is needed to conduct syntheses and meta-analyses of the health co-benefits of mitigation policies. Achieving this consistency is critical as nations are developing baskets of mitigation options to achieve their NDCs to the Paris Agreement. As choices are made, policymakers will be ill informed without a holistic view of the

costs and benefits of the options'. They also suggest that local scale co-benefits studies will become increasingly important to provide input into specific policy decisions (Chang et al, 2017).

Staying with the topic of the policy impact of health co-benefits, but moving away from a detailed focus on modelling issues, in a 2018 paper, Workman et al note that 'human health has remained elusive in its influence on the development of ambitious climate change mitigation policies for many national governments' and take a political economy approach to identify additional barriers hindering the policy impact of health co-benefits. Drawing on an extensive literature review they identify four interrelated challenges: discourse; efficiency; vested interests; and structural challenges. 'Discourse' relates to the predominance of economics in government decision-making, and difficulties with incorporating qualitative evidence into decision-making processes. 'Efficiency' refers to the focus on cost-minimisation (echoing observations made by Nemet) and a preference for treating each problem through direct interventions (e.g. air quality policy). 'Vested interests' picks up on traditional political economy themes about the balance of power between potential winners and losers from a potential intervention, and the way in which these different groups try and are able to influence the final policy outcome. Finally, 'structural challenges' include difficulties in integrating scientific advice into the policy-making process and the difficulties of taking an integrated approach when objectives are managed across different government departments and institutions (Workman et al, 2018).

Moving from health to a general co-benefits perspective, the scoping review of co-benefits evidence undertaken for the UK government in 2016 by consultancy Aether, and described in the previous section, identified a range of barriers that make it difficult to achieve co-benefits in practice, despite the existence of 'many well-established win-win options'. The barriers include failure by government departments to co-ordinate their objectives and activities across policy areas or levels (compounded by time and resource constraints); use of cost-benefit approaches that do not incorporate co-benefits; short-term political cycles and a focus on short-term economic growth; and lobbying by vested interests from high-carbon sectors. Most of these echo observations from the other papers referenced above. An underlying issue relating to the distribution of costs and benefits between individuals and organisations is also noted (for example the costs of mitigation may fall narrowly on specific industrial sectors and firms, while the benefits accrue broadly across society).

The Aether report also made recommendations for a number of priority research areas for co-benefits evidence including development of simplified models; improved networking between researchers and modellers; compilation of case studies (to improve policymakers' knowledge and understanding); real world demonstration projects (to provide empirical rather than purely theoretical evidence); and improved ability to characterize economic impacts (which are not as robustly modelled as e.g. air quality benefits) 'to overcome commonly held myths about the potential adverse impacts of climate mitigation action on the economy' (Aether, 2016).

**In conclusion:**

- While the literature on the use of co-benefits is not extensive, several papers note that co-benefits are often not included in cost-benefit assessment exercises

- A small body of work focusses on health benefits in particular, noting that they have had limited policy impact despite the large scale of potential benefits
- Challenges identified in the literature include:
    - Lack of data and large effort required for / complexity of assessments
    - Lack of consistency in modelling approaches, assumptions, scenarios and evaluation metrics, and uncertainty in avoided damage estimates (health) and lack of standard valuation approaches
    - Climate policy usually considered in a cost-minimisation mindset that does not easily incorporate benefits
    - Lack of engagement from full range of disciplines needed, and from policymakers early in process
    - Difficulty integrating results (especially qualitative) and lack of appropriate decision making frameworks
    - Institutional separation between policy communities such as air and climate
    - Governments typically have a preference for direct interventions that target each issue separately
    - Costs and benefits are unevenly distributed and costs may be valued more by the narrow group of firms that pay them vs the benefits which accrue in small amounts to many
    - Vested interests and lobbying (especially from incumbent potential 'losers')

The experts interviewed identified a number of challenges, echoing several above from the literature, and adding a few specific observations. One noted that climate change may be 'a victim of its own success' in that it has become the preeminent environmental problem that must be addressed, and somewhat detached from other environmental problems, which hinders achievement of multiple objectives. Regarding economic impacts such as 'green growth' (economic development opportunities stimulated by climate policy), there is a risk that it may seem 'too good to be true' and that the climate community is trying to 'sweeten the pill', so the economic evidence needs to be very robust. Adding to the point above about distribution of costs, one expert noted that not only are the benefits and costs unevenly distributed, but that people tend to value losses more than gains, and actually the benefits, though very large in aggregate, may be quite small per person (a matter of months of lifetime) and possibly heavily discounted when considering the other health risks that people face (and often ignore). There is also a potential misalignment with short term (c. 5 year) political cycles, because while many of the costs will occur in the shorter term, the benefits may accrue over a longer period and thus may be discounted by politicians as they will occur outside their period in office.

# 4. Exploring the drivers of climate policy – three case studies

***Have co-benefits played a role in shaping climate policy in specific countries and regions? What evidence has been available to these countries? How has it been used and which co-benefits are most prominent?***

This section examines three specific case studies – the EU, the UK, and China – and tries to establish whether co-benefits have been important in influencing climate policy, drawing on official documents, academic articles and other commentaries and reports, and interviews undertaken for this paper. Because this paper is interested in whether co-benefits are able to influence climate ambition at the highest national level, it focusses on headline climate targets (rather than specific policies) and the evidence that seems to have been important in agreeing them. In the case of the UK, the Climate Change Act of 2008 is a major part of the climate policy story (and incorporates headline targets) so is considered in detail.

The three case studies were selected because they all have clearly stated climate targets of reasonable ambition, along with serious implementation efforts that show they are taken seriously. Importantly, they all have substantial country (or region) specific co-benefits evidence bases available to them. Finally, as major emitters and leading economies they have all been studied extensively in the academic literature. Other potential case studies considered for the paper included India (which has, unusually, framed climate mitigation as a co-benefit of its chosen development pathway) and the USA.

Needless to say, even with the relatively transparent policy procedures of the EU and UK, it is not possible to identify exactly which considerations were really important in deciding to adopt a certain level of GHG reduction ambition. As interviews with a broad range of people directly involved at the time were not possible for this paper, it has been necessary to draw on a mix of published sources, complemented by a few interviews with people who were involved (for the EU and UK cases).

Each case study starts with a summary of the evolution of relevant headline climate policy over the last 10-15 years, then provides a selective overview of the co-benefits evidence base available, before considering the apparent prominence of specific co-benefits in headline policy development, as represented in major policy documents and drawing on other sources.

## 4.1. The European Union

**Major developments in headline ambition**[5]

EU climate policy development began in the late 1990s and early 2000s, partly stimulated and given purpose by the signing (and eventual ratification) of the Kyoto Protocol (although it is noteworthy that as early as 1996, the EU's Environment Council[6] agreed the importance of keeping global warming to within 2 degrees of pre-industrialised levels). In 2004 the European Commission (hereinafter 'the Commission') was

[5] *For a comprehensive and insightful summary of the development of EU climate policy up to 2015, see Delbeke and Vis, 2015.*

[6] *Among the environment ministers at the time were Gerrmany's Angela Merkel, and from the UK, John Gummer, since 2012 Chairman of the UK Committee on Climate Change (the independent advisory body established by the 2008 UK Climate Change Act).*

asked by the European Council[7] to consider new climate targets for the EU, based on analysis of the costs and benefits.

In 2007 the Commission proposed a set of targets for 2020 (the 20-20-20 package: a 20% reduction in GHG emissions; 20% renewable share; and 20% improvement in energy efficiency), which were adopted that year by the European Council as the EU's headline climate targets in advance of the Copenhagen COP in 2009.

By 2011 the focus was extended to include the longer-term, through the development and publication of '*A Roadmap for moving to a competitive low carbon economy in 2050*'. This document showed how it was possible for the EU to achieve an 80% reduction in emissions by 2050, while achieving substantial co-benefits in the form of improved energy security, air pollution and health, and development of new low-carbon markets.

Attention then turned to 2030, with the adoption in late 2014 of the climate and energy framework for 2030 (40% GHG reduction; 27% renewable share; and 27% ('indicative') improvement in energy efficiency), and subsequent development and adoption of the package of measures to achieve it. Most recently, in November 2018, the Commission published 'A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy', which sets out how the EU could reduce its emissions to net-zero by 2050, in light of the Paris Agreement.

**Box 2: Timeline of selected EU policy developments and key policy documents**

1996: EU Environment Council agrees importance of limiting global warming

2004: European Council asks European Commission to consider new EU climate targets

2005: European Commission publishes 'Winning the battle against global climate change' which makes clear reference to co-benefits of mitigation

2007: European Commission proposes 20% GHG reduction target for 2020;
adopted by European Council

2011: European Commission publishes 2050 low carbon roadmap

2014: European Commission proposes 40% GHG reduction target for 2030;
adopted by European Council

2018: European Commission publishes vision for net-zero emissions by 2050

**A considerable co-benefits evidence base**

Alongside these developments in headline EU climate policy, a considerable evidence base has been produced about the co-benefits of EU climate action. This includes evidence produced or procured by the

[7] *Several different EU institutions are relevant to this case study. The European Council is composed of the Heads of State of the Member States and sets the priorities and guidelines for the EU's development. The European Commission is essentially the civil service of the EU, and proposes legislation and policies to achieve the EU's goals. The EU's Environment Council is made up of environment ministers from Member States and is responsible for environmental policy.*

Commission or agencies such as the European Environment Agency, research projects funded by the EU through programmes such as Horizon2020, and studies undertaken by or for NGOs. Some notable examples, which give a flavor of the available evidence, include:

- Although it really pre-dates the serious climate action debate in the EU, the Extern-E project(s), which ran from 1990-2005 (funded by the EU), developed methodologies and results about the external costs of electricity generation, providing evidence for air pollution related benefits of renewable energy, and was used to inform various policies as well as developing methodologies that have been widely used since. A Commission press release from 2001 highlights some of the results and makes a clear statement that renewables have much lower external costs than fossil fuels (European Commission, 2001).
- Air pollution related co-benefits to human health were clearly linked to climate action in a 2006 report from the European Environment Agency, which stated that "Action to combat climate change will deliver considerable ancillary benefits in air pollution abatement by 2030… lower overall costs of controlling air pollutant emissions in the order of EUR 10 billion… and 20,000 fewer premature deaths per year" (EEA, 2006).
- From 2006 to 2009, the EmployRES project (funded by the EU) was "the first study to assess the economic effects of supporting renewable energy in this [high level of] detail" and estimated a net effect of 410,000 additional jobs and 0.24% increase in GDP from achieving the 2020 renewables share of 20% (EmployRES, 2009).
- From 2014-16, DG Energy[8] ran a two-year study aimed to improve understanding and modelling of the links between EU energy-related policies and macroeconomic dynamics. Ten reports were commissioned by the project, including a study on policy-induced energy innovation which aimed to improve the theoretical understanding and modelling of innovation impacts (European Commission, 2016).
- At the Commission's request, in 2014 the EU funded Towards2030 project investigated how renewable energy and energy efficiency could improve gas security in selected vulnerable Member States, using detailed gas market modelling to conclude that it is 'feasible to reduce Russian dependency on natural gas supply to a very low level without causing skyrocketing natural gas prices in any of the EU member countries' (Toth et al, 2014).
- Co-benefits from energy efficiency have been the focus of several substantial research projects, ranging from studies on "The Macroeconomic and Other Benefits of Energy Efficiency" (commissioned by the Commission and published in 2016), to Horizon2020 funded multi-partner research projects such as INBEE (Assessing the intangibles: the socio-economic benefits of energy efficiency, 2015-17) and COMBI (Calculating and Operationalising the Multiple Benefits of Energy Efficiency in Europe, 2015-18).
- In 2018, IRENA and the Commission together published "Renewable Energy Prospects for the European Union", a report presenting the results of analysis on renewable energy potential in the

[8] *DG Energy is the Directorate-General for Energy, the policy department of the European Commission responsible for energy. DG CLIMA is responsible for climate change.*

EU, including estimates of net energy system savings of USD 25bn per year and avoided health costs of USD 19-71 bn per year by 2030 (IRENA, 2018).

The above examples represent just a sample of the co-benefits evidence. The Commission and other EU agencies and research institutions undertake (and commission) a vast amount of modelling and research to inform policy development. Some of the important evidence – for example on energy security – may not appear as 'co-benefit' or external impacts evidence, but rather is naturally created as outputs from energy system planning and modelling activities that are undertaken for a range of purposes[9]. It is not possible to summarise it all here, and probably not valuable; as noted at the start of this section it is hard or impossible to know which evidence has been used, where and how. That said, the impression for the EU is clearly one of a comprehensive and continually evolving evidence base on the broader impacts of climate and energy policy.

**Prominence of co-benefits in policy documents**

Starting with the Commission's 2005 Communication[10] '*Winning the Battle against Global Climate Change'*, EU climate policy documents make clear references to co-benefits.

The 2005 Communication mentions energy security, improved air quality, job creation from energy efficiency, and development of low carbon industries. It anticipates likely variance in impacts from sector to sector, and – pre-empting the hypothesis of the Ambition to Action project – observes that co-benefits may be interesting to developing countries as a motivation to act on climate change. The discussion of the co-benefits is very brief however, and there is little quantification of the scale of any of the co-benefits. The document, which is less than 20 pages in total, contains in Annex 2 a 3 page, largely qualitative description of the co-benefits, that includes some quantitative references for GDP impact and the reduction level of certain air pollutants given a 15% reduction in EU power sector CO2 emissions (European Commission, 2005).

The 2007 Communication '*Limiting Global Climate Change to 2 degrees Celsius - The way ahead for 2020 and beyond'*, which proposed the 2020 targets, mentions only energy security and health benefits in the main (13 page) document, but with quantitative estimates for both (20% reduction in oil & gas imports; health benefits of €8-27bn) (European Commission, 2007). The impact assessment accompanying the document includes a 7 page section (out of 50 pages) just about the 'Benefits of Climate Action', which includes sub-sections on air quality, energy security, employment, and soil fertility. The employment section is just a few short paragraphs, containing a rather random set of references to external studies and estimates, suggesting that EC modelling of climate scenarios at this point did not extend to employment impacts and which may explain why employment is not referenced as a co-benefit in the main document (European Commission, 2007b).

Following the adoption of the 2020 framework in 2007, the focus of work turned to how to achieve the targets. Considerable analysis and modelling was undertaken to assess different scenarios for the EU ETS,

[9] *For example using the PRIMES model. See https://ec.europa.eu/energy/en/data-analysis/energy-modelling for a description of the EU's energy modelling.*

[10] *The European Commission uses 'Communications' to set out its thinking on particular issues, summarising evidence and analysis undertaken and proposing or comparing different courses of action, and their costs and benefits. The Communications are usually addressed to EU lawmakers (e.g the European Council) but have no legal authority.*

differentiated Member State targets, as well as use of JI and CDM credits. The Commission's findings are set out in the 2008 documents relating to the '*Package of implementation measures for the EU's objectives on climate change and renewable energy for 2020*'. They show how the Commission used modelling of the broader benefits, as well as the costs of different scenarios, in order to choose between them. For each scenario, the impact assessment contains estimates of the value of reduced fuel imports (€41-49bn), the air pollution reduction (10-14%) and the employment impact vs BAU (-0.09%-0.05%) (European Commission, 2008).

Co-benefits are referenced, and quantified, in subsequent EU policy documents. The 2050 Roadmap, published in 2011, contains estimates of energy security benefits in the form of a reduction in average fuel costs of €175-320 bn per year, 1.5m extra jobs by 2020, reduced air pollution control costs of €46bn by 2050, and monetized health benefits of €17-38bn per year by 2050. Similarly, the suite of documents from 2014-16 relating to the targets and implementation measures for 2030 make qualitative references to the synergies between climate and energy policy and explicitly reference energy security, new jobs and growth, and reduced air pollution (European Commission, 2011; European Commission, 2014).

References to (and quantitative estimates for) energy security, human health job creation are all included in the very recent strategic-vision for a climate neutral economy, and unlike the preceding documents, this one actually states that the benefits are already being achieved: 'The EU's pursuit to achieve its 2020 energy and climate targets already delivered new industries, European jobs and increased technological innovation, driving down technology costs. The renewable energy revolution is the best example of this... EU leadership demonstrates to other parts of the world that this transition is both possible and beneficial beyond the fight against climate change' (European Commission, 2018).

Over this whole period – from 2004/05 up to 2018, there have been many more similar documents produced by the Commission (for example roadmaps, strategies, green papers, covering energy security, renewable energy, energy efficiency, green employment, etc.) as well as other official documents such as Conclusions from the European Council. Many or most of these documents reference the synergistic relationship between climate and energy policy (as well they should given the increasing strategic alignment of these policy areas in Commission thinking) and mention or contain estimates of the main co-benefits mentioned above. It is hard though to see any clear trends which reveal much about the real importance and influence of co-benefits in the EU's climate policy development. Between 2004 and 2008 the depth of consideration of co-benefits clearly increases, from mainly qualitative references in 2005, first to specific quantitative estimates and then by 2008 to more sophisticated and flexible modelling results for specific co-benefits indicators. This presumably reflects the ability of the Commission to develop (or procure) evidence about co-benefits, as well as a greater need for scrutiny of the proposals from various angles. But it remains hard to draw from this any firm conclusions about the relative importance of the co-benefits in the internal debates of the Commission and in negotiations with the Member States. There does not appear to be a particular pattern of increasing prominence for any one or more co-benefits, though the language about energy security is generally stronger in its description of the synergies with climate action.

Indeed analysis of the published documents is highly unlikely to tell the whole story. Despite the EU's commitment to transparency and evidence based policymaking, climate and energy policy are still the

product of political negotiations, in the case of the EU, with the added complexity of having to satisfy a majority of almost 30 Member States. The following sub-section draws on interviews and some specific literature to try to pin down the degree to which co-benefits really influenced EU climate policy, and if they did, which were more important and why.

**Assessing relative importance and influence**

There are three main co-benefit areas, judging from the policy documents mentioned above, that might conceivably have played a role in influencing EU climate policy: energy security; air pollution and health; and jobs and growth (especially through leadership in new low carbon markets). These are in fact the 'usual suspects' in most co-benefit analyses. But which, if any, made a difference?

A 2015 book, '*EU Climate Policy Explained*', edited by Jos Delbeke (Director-General of DG Clima from 2010-18 [and interviewed for this paper]) and Peter Vis (Head of Cabinet to the European Commissioner for Climate Action from 2010-14) provides some insights into the importance of energy security:

"One of the major developments – and achievements – of the past 10 years has been the alignment and coordination of energy and climate policies**. This arises from the strategic view that, for a region such as the EU that is largely dependent on imports of fossil fuels, the instruments and technologies to achieve a more competitive and secure energy system largely coincide with those needed to reduce greenhouse gas emissions**" (Delbeke and Vis, 2015).

This observation is strongly echoed in the European Energy Security Strategy, published by the Commission in 2014 (and accompanied by a 200 page 'In-depth Study of European Energy Security'), which clearly states the links between energy security and climate action for the EU: "In the long term, the Union's energy security is inseparable from and significantly fostered by its need to move to a competitive, low-carbon economy which reduces the use of imported fossil fuels" (European Commission, 2014b). While, as noted above, Commission documents consistently mention several co-benefits, seldom is the language so strong as to state that the issues are 'inseparable'.

The perceived importance of energy security and the value of reduced import dependency provided the Commission with a powerful argument in favour of deploying more expensive technologies:

"Some analysis suggests that the costs for the EU of meeting its 20% greenhouse gas reduction target in 2020 may have been some 10% higher than what was strictly necessary... **These extra costs can, however, be defended by the additional benefits renewables bring in terms of reducing dependency on oil and gas imports**, and in terms of the advantages gained by developing new technologies" (Delbeke and Vis, 2015).

According to interviews with Commission officials undertaken for this paper, this argument was not just important, but in fact instrumental in getting a sufficient number of Member States to support the EU's climate targets and associated implementation packages. It is no secret that certain eastern and central European Member States are less supportive of climate action than those from the north and west, but they were prepared to accept the higher costs of climate action (especially renewable energy) because of the energy security benefits it could offer. In contrast, northern and western Member States accepted the need to take action on climate change, and principally focused on the need for cost-optimisation to find the

lowest cost pathway (thus in a way confirming the stereotypical cost-minimisation approach observed in the literature referenced in Chapter 3 of this paper).

The energy security message was also given extra impetus by an external event, in the form of the 2005-6 dispute between Russia and Ukraine, which led to interruptions in gas supply to several MS and heightened awareness of the risks of being so reliant on imported energy (Skjærseth, 2016).

Energy security thus seems to have been the most influential co-benefit, and played a vital role in the development (and adoption across Member States) of the EU's climate policy.

Further evidence for the primacy of energy security comes from a recent paper by Annabelle Workman which specifically investigates the role that health co-benefits have played in the development of EU climate policy. Based on interviews and document analysis, she finds that while health benefits "are incorporated into integrated impact assessments for mitigation policy proposals through a suite of models that support their quantification and monetization… they are less relevant and influential in climate change mitigation policies. The economic costs associated with policy implementation and energy supply security remain more powerful influences on climate change mitigation policy outcomes", and "Interviewees advised that for the EU, energy supply security is paramount and is a central policy focus for both the EU and Member States" (Workman et al, 2018b).

Workman also found further evidence of the overwhelming focus on cost-minimisation discussed above, which in this case led to large estimates of health benefits being discounted from the decision-making process:

"Member States that have to implement these measures, they don't look at the positive side. They only look at the cost. They have a very conservative view on this….even if you show that there were billions saved and so on…if you look at value of statistical life or life years lost and so on, huge benefits. The Member States completely ignored that in the debate. They only looked at the cost figures" (Interviewee, quoted in Workman et al, 2018b).

The last of the three 'regular' co-benefits relates to jobs and economic growth. As noted above, employment seems to have lagged behind the other co-benefits in terms of quantitative references in Commission policy documents, and the economic opportunity from new low carbon markets is not specifically quantified (rather a high level GDP impact is given for scenarios in the impact assessments, which would aggregate numerous impacts). According to the interviews, the narrative around jobs and growth was not used as a leading argument by the Commission but was rather used 'defensively' to respond to Member States who were concerned about negative job impacts, by reassuring them that job losses should be balanced by new jobs in new industries and activities. Detailed work commissioned by the Commission to better understand the theoretical basis for policy-induced energy innovation in 2016 (see evidence base summary above) suggests a desire to improve the evidence base for this co-benefit, which could enable the low carbon innovation narrative to be used more widely.

## 4.2. The United Kingdom

**Early national targets and the Climate Change Act**

As it did in the EU, climate policy in the UK becomes interesting from around the year 2000 onwards – that being the period in which the government adopted meaningful, science-driven long term GHG reduction targets, and laid the foundations for a period of genuine global leadership on climate change that lasted for several years from 2007/8, its high-point being the introduction of the world's first national legal climate framework: the 2008 Climate Change Act (now widely replicated in various forms around the world).

In June 2000, the Royal Commission on Environmental Pollution submitted its 300-plus page report 'Energy - the Changing Climate' to Parliament, advocating based on the latest science a 60% reduction in UK GHG emissions by 2050, as a 'fair' contribution with the intention to show global leadership on the issue (RCEP, 2000).

The Labour government at the time had in fact already set itself, in its 1997 election manifesto, a GHG reduction target of a 20% reduction vs 1990 levels by 2010, which was considerably more ambitious than the UK's Kyoto target (12.5% by 2012, which the UK was expected to achieve easily because of the 'dash for gas' shift in electricity generation that took place during the 1990s).

The government responded positively to the Royal Commission's 60% target recommendation, and the Energy White Paper of February 2003, 'Our energy future – creating a low carbon economy', adopted the 60% target and set out how the government would respond to the three challenges of climate change, the UK's declining domestic energy supplies, and the need to replace much of the UK's energy infrastructure, as well as stating that economic benefits could be realized in the form of new markets and exports of low carbon goods and services, and environmental impacts such as improved air quality (UK Government, 2003). From this point on, the UK had a serious long-term science-based climate target, and UK energy policy now had an additional objective: to become low carbon. Much as they had within the thinking and approach of the European Commission, the two issues of energy security and climate change began to be presented together as the two key issues facing UK energy policy.

Policy implementation however took a few years to catch up with this new national ambition, and it became apparent around 2004-5 that the 2010 target was unlikely to be achieved (indeed, it was not achieved). Reviews of UK climate policy undertaken at the time revealed the need for a new and much more robust approach placing importance on pathways and interim milestones as well as long-term targets and which would give real top-down impetus to GHG reduction action across government. The recommendations from this process started the debate which was to lead to the development of the Climate Change Act (for a more comprehensive account, see Institute for Government, 2012).

Meanwhile, the wider political landscape around climate change in the UK was evolving, which further allowed climate change to attract more political attention and support, and created the space for a real step-change in the national approach to climate policy. The evolution of climate policy over this period has been discussed and analysed, including in the academic literature, with various factors generally considered to have coincided to create the conditions for change, including: the move by the Conservative Party to embrace climate change as part of its modernizing strategy, which created a high degree of cross-party

consensus – and even competition – on climate change; the publication of the Stern Review in 2006 which made the economic case for action on climate change (see the overview of co-benefits evidence below) and which was highly influential in government including in the previously disinterested Treasury; and new and energized leadership at the environment ministry, Defra, from David Miliband (who made climate change a priority, as he later did at the Foreign Office). Civil society, led by Friends of the Earth, seized this window of opportunity and effectively campaigned to build comprehensive cross-party political support for the Climate Change Bill[11], leading to the passing of the Climate Change Act in 2008 (Institute for Government, 2012; Friends of the Earth, 2017). Although it is hard to be sure, it appears that right from the beginning of this period, a real recognition of the importance of averting climate change (rather than more self-interested national concerns) was at the heart of the UK's embrace of climate policy.

The Climate Change Act contains a range of provisions in addition to the long term target, of which the most relevant to this case-study are: the 5 yearly carbon budgets, which set the near-term pathway towards the long-term target; the need for each government to submit a report to parliament how it will achieve those carbon budgets (there have now been three of these reports since 2008 and they are considered from a co-benefits perspective later in this case-study); and the establishment of the Committee on Climate Change (CCC), to provide independent advice and scrutiny.

The conditions which enabled the passing of the Act soon began to weaken. The financial crisis that began in 2008 and the new Conservative-Liberal Democrat coalition in 2010 created a much less supportive political (and fiscal) environment for tough action on climate change, and the UK began to pull back from its global climate leadership role. The continued support of large business and civil society, the clear case made by the CCC for continued action and ambition, and sufficient residual support in parliament helped

**Box 3: Timeline of selected UK policy developments and key policy documents**

1997: Labour party election manifesto contains 20% GHG reduction target by 2010

2000: Royal Commission on Environmental Pollution submitted its report 'Energy - the Changing Climate' to Parliament, advocating a 60% GHG reduction target by 2050

2003: UK Government energy white paper adopts the 60% GHG reduction target for 2050

2006: The Stern Review on the economics of climate change makes a powerful (and influential) economic case for mitigation, and also clearly highlights existence of co-benefits

2008: UK Climate Change Act adopted by Parliament, with strengthened and legally binding 80% GHG reduction target for 2050

2009: First national climate change plan (post Act) published (The Low Carbon Transition Plan)

2011: New Conservative/Liberal Democrat coalition government publishes its climate plan (The Carbon Plan)

2017: Conservative government publishes climate plan (The Clean Growth Strategy)

[11] *Major legislation in the UK is proposed to the Houses of Parliament in the form of a Bill, which if passed by Parliament, then becomes an Act of Parliament and thus a law to be enforced across the UK.*

ensured that occasional calls to weaken or repeal the Act never gathered serious momentum, and new carbon budgets were set in 2011 (though there was disagreement at Cabinet level, with the Chancellor and business secretary advocating weaker targets to protect the UK economy (see e.g. Guardian, 2011).

**Evidence base on co-benefits**

Like the EU, the UK has been able to draw on an increasing volume of co-benefits evidence in the form of major reviews commissioned by the Government (e.g. the Stern Review) as well as studies and syntheses procured by the government and the CCC (the UK also had the second highest number of total academic co-benefits publications after the US, and four of the 11 most productive institutes according to Deng et al, 2018) . Some notable examples are detailed here:

- The Royal Commission's report on energy and climate in 2000, which recommended the first 2050 GHG reduction target for the UK, contained, as noted above, some references to co-benefits, including on page 2 of the summary, which says "Major benefits, unrelated to reducing climate change, would flow from policies to reduce our use of fossil fuels. Among the benefits are a reduction in the air pollution which harms human health…", though there is not much detail (in terms of quantitative estimates of the scale of such impacts) in the main 200 plus page report (RCEP, 2000).
- The Stern Review on the Economics of Climate Change, requested by the UK Chancellor and published in 2006, was one of the most influential reports produced during the key 2000-2010 period of UK climate policy development. Its message – that the costs of action on climate change are greatly outweighed by the costs of inaction – was highly influential within the higher levels of the UK government and also internationally. Unsurprisingly, the 600 page report also discusses co-benefits:
    - The 3 page summary of conclusions states that "Costs could be even lower… if there are major gains in efficiency, or if the strong co-benefits, for example from reduced air pollution, are measured". It also discusses the economic growth co-benefit: "Action on climate change will also create significant business opportunities, as new markets are created in low-carbon energy technologies and other low-carbon goods and services. These markets could grow to be worth hundreds of billions of dollars each year, and employment in these sectors will expand accordingly".
    - Chapter 12 of the report is called 'Opportunities and Wider Benefits from Climate Policies' and over 12 pages discusses the opportunities from new low carbon markets ("Individual companies and countries should position themselves to take advantage of these opportunities"); the opportunity for energy efficiency savings and reduced fossil fuel subsidies; energy security; and health and environmental protection benefits (referencing the European Environment Agency study mentioned in the EU case study).
    - The report advises that "Thinking about these issues in an integrated way is important in understanding the costs and benefits of action on climate change. Policymakers can then design policy in a way that avoids conflicts, and takes full advantage of the significant co-benefits that are available." and makes the neat point that "Tackling climate change is the

pro-growth strategy for the longer term" (a message that Lord Nicholas Stern continued to make in his advocacy work for several years afterwards) (Stern, 2006).

- During 2008, the UK environment ministry (Defra) commissioned work "to assess the impact of future carbon reduction targets on air quality emissions" which was undertaken by AEA Energy & Environment based on MARKAL modelling, and which found significant synergies between air quality and climate policy (AEA, 2008). This work is referenced in the 2009 Impact Assessment relating to implementation of the CC Act.
- In 2009 and 2010 DECC commissioned work on the 'Future Value of Carbon Abatement Technologies in Coal and Gas Power Generation to UK Industry', which estimated the potential market share that the UK could gain in global CCS markets, to inform DECC's strategy development for CCS (AEA, 2010). Similar work was later undertaken for a range of low carbon technologies as part of the 'Technology Innovation Needs Assessment' (TINA) programme, which included assessment of the future export value of successful UK innovation activity (LCICG, 2011-17).
- A 2010 report from Defra, 'Air Pollution: Action in a changing climate', stated that "Air pollution causes annual health costs of roughly 15 billion to UK citizens" and that "Factoring air quality into decisions about how to reach climate change targets results in policy solutions with even greater benefits to society. Optimising climate change policies for air pollution can yield additional benefits of some £24 billion (net present value) by 2050", as well as identifying some trade-offs of air and climate policy (such as increased PM pollution from biomass) (Defra, 2010).
- In 2013, the CCC published a 'Review of the impacts of carbon budget measures on human health and the environment' which it had commissioned from consultants Ricardo-AEA to provide inputs to its advice to government on the target levels of the 4th carbon budget (2023-27). Among the overall conclusions was that "For those impacts that have been quantified in monetary terms, the net benefits out weight the net costs by a significant amount (over £85bn). Whilst the totals presented exclude important unquantified costs and benefits, such as certain impacts on landscape and ecosystem services, the inclusion of these impacts is not expected to change the overall conclusion. Therefore, including these impacts in the cost-benefit analysis of climate policy would strengthen the case for setting ambitious climate targets" (Ricardo-AEA, 2013).
- In 2014, Defra launched the 'Sustainable Pathways to Low Carbon Energy (SPLiCE)' programme, which was designed to be a collaborative multi-phase research programme to identify and fill gaps in knowledge about the environmental, social and economic impacts of different energy technologies, and to develop a comprehensive and accessible evidence base to support decision making. The programme's ultimate objectives included identifying "how energy production and demand reduction options can be balanced to achieve optimum economic, social and environmental outcomes" and to "improve public acceptability to the low carbon agenda by increasing confidence that the transition will be made in an acceptable way" (Defra, 2013; Defra, 2015). Defra's own research plan from 2013 stated that these were very ambitious aims, and the SPLiCE programme was in fact not continued beyond phase 1 (scoping and planning), following a programme review in 2015, due apparently to overlaps with other work across government

(although no evidence base as comprehensive and accessible as the one envisaged by the SPLiCE programme has been developed).

- In 2016 the UK climate and energy ministry (DECC) commissioned a study of co-benefits evidence, undertaken by consultancy Aether (as discussed in section 2), which was based on a review of over 400 co-benefits papers, and like the SPLiCE programme above, was designed to summarise current understand, identify gaps and inform future research priorities. The report is published on the UK government with summary text that states that 'co-benefits can provide additional support for the need for mitigation; the evidence suggests that benefits outweigh risks; and adverse side effects do occur but these can be managed by well-designed climate policy' (Aether, 2016; UK Government, 2018).
- In 2016 the CCC commissioned a study on the 'UK business opportunities of moving to a low carbon economy' which analysed the potential export opportunities for UK industries from the development of low carbon markets around the world (Ricardo, 2017).
- Most recently, there has been a revived focus on communicating the health co-benefits of mitigation action, spearheaded by the medical community. An example is a letter sent to the Prime Minister in November 2018 from the UK Health Alliance on Climate Change (representing 16 major health organisations and 600,000 health professionals) which called on the government to set a net zero emissions target in light of the health impacts of climate change. The letter also highlighted the health co-benefits, stating that 'acting on climate change presents a profound opportunity to improve health as many of the drivers of climate change – fossil fuels, over-consumption, and poorly designed cities – also cause ill health themselves, through air pollution, unhealthy diets, and physical inactivity' (UKHACC, 2018).

As with examples given for the EU in the previous case study, this is not a comprehensive overview but clearly indicates the impressive depth of co-benefits evidence available, especially over the last 10 years. Human health is well covered and there is clearly an effort to produce evidence on the business opportunities. Energy security evidence is less clearly published as a co-benefit, but is likely available direct from various energy system modelling activities that would be undertaken anyway.

Analyses in official government policy documents (such as the Impact Assessments considered in the following sub-sections) are informed by the Green Book, whose 2018 edition foreword notes that "For nearly half a century the Treasury's Green Book has provided guidance to help officials develop transparent, objective, evidence-based appraisal and evaluation of proposals to inform decision making". The foreword also notes that "Many of the changes in this edition reflect important advances in appraisal and evaluation that government departments and agencies have made since 2003. This is especially notable in environmental appraisal, where scientific advances have transformed our understanding of environmental impacts and improved our ability to understand and value them" (HM Treasury, 2018).

**The 'official' case for the Climate Change Act**

Despite the highlighting of likely co-benefits in at least two key reports preceding the main phase of development of the Climate Change Act, (the Royal Commission in 2000 and the Stern Review in 2006), the main official arguments for the Act – at least judging from the Impact Assessment for it and some of the

discussions about the Act in, for example, the House of Commons Environmental Audit Committee, and indeed in the debates about the Act in Parliament, seem to have been very focused on climate science and the avoidance of damaging climate change (including through a global deal), rather than arguments about co-benefits that would accrue to the UK (Environmental Audit Committee, 2007; UK Parliament, 2008[12]).

The Impact Assessment for the Act, signed off by the environment minister in November 2007, describes (on the front page) the objective of the policy as "To avoid the impacts of dangerous climate change in an economically sound way", and "in particular by: demonstrating the UK's leadership in tackling climate change" to increase the chances of securing an international climate agreement, and "by providing clarity and predictability for UK industry" to help them plan and invest effectively (UK Government, 2007).

The Impact Assessment notes that the level of the target – i.e. how ambitious to be – "will be the most important factor" impacting the costs and benefits. It states that ambition would also require more aggressive policies more quickly, which would help firms and households increase energy efficiency and spur innovation, providing "greater opportunities for the UK to benefit from the development of a low carbon economy". However, it also noted that "Reducing emissions further is likely to increase the level and range of potential economic and social costs of mitigation". Beyond these references, little evidence is referenced for, for example, the potential gains from innovation and resulting economic opportunities, beyond pointing to the example of Denmark's wind industry and referencing a 1995 paper by well-known business consultant Michael Porter on how stringent environmental policy induces increased competitiveness (the 'Porter hypothesis' – as discussed briefly in Section 2 with reference to Hamilton et al, 2017). Potential benefits relating to energy security or air pollution are barely mentioned at all (indeed the document clearly states that no assessment of ancillary benefits from energy security[13] or public health were made)[14] (UK Government, 2007).

The only benefit actually included in the cost-benefit analysis and resulting 'Net Benefit' calculation (which is clearly displayed on the second page of all such UK government impact assessments) is the benefit from avoided GHG emissions, calculated using the 'Shadow Price of Carbon' which "captures the damage cost of climate change caused by each additional tonne of greenhouse gas emitted", using standard UK government guidance at the time and resulting in a benefit range "in the order of £82 to £110 billion"

[12] *An exchange between Peter Lilley (one of the very few MPs who voted against the Climate Change Bill) and John Gummer, Conservative MP and former environment secretary (and now Chair of the CCC), exemplifies the focus on 'doing the right thing' in responding to climate change:*
*Mr. Lilley: Do I understand from my right hon. Friend's logic that, while there is a case for being ahead, if others do not follow us we should cease to give leadership, and that therefore a Bill that binds us unilaterally, by law, to targets 42 years ahead goes too far?*
*Mr. Gummer: No, I do not agree with that. If I may say so, I think that my right hon. Friend is entirely wrong. The world is faced with the biggest threat that we have ever known about in advance, and for us not to take these measures would constitute a deep dereliction of our duty to this generation, the next generation and the generation after that.I must tell my right hon. Friend that I deeply disagree with the approach that if no one else helps as we go over the precipice, we had better run with them. That is a totally unacceptable position. We must stand up. That is why the Bill is so important, why the Conservative party supported it from the beginning, why it is a triumph of cross-party agreement that we have secured it, and why it is so important to tighten it up in the areas that it does not currently cover.*

[13] *The record of oral evidence given to the Environmental Audit Committee shows that the absence of such benefits was noticed at the time: EEF, an organisation recognising the UK manufacturing industry, commented that 'One aspect of the benefits of everything we are doing in renewable energy is energy supply security and at the moment, that seems to have no value in the documents that are before us. Energy supply security may be the one thing that can kick the market into the investments that are necessary for, yes, 80% or whatever, but it is certainly not given adequate consideration today' (Environmental Audit Committee, 2007).*

[14] *In a later Impact Assessment about the Act, published March 2009, air pollution benefits of 32 billion GBP are included in the net cost-benefit calculation, referencing work commissioned by Defra in 2008. The Act had already passed into law in November 2008, this Impact Assessment is focussed on the measures under the Act.*

although this is caveated as being “For indicative purposes only” (despite its presentation on the second page) (UK Government, 2007).

The main argumentation of the Impact Assessment thus appears to be based on the benefits of avoided climate change (largely excluding ancillary benefits), the contribution to secure a global climate deal, and the benefits a long term framework provides to help business planning and investment. This seems consistent with the wider debate around the Act as evidenced by various documents and the parliamentary record. Furthermore, this impact assessment was for a Climate Change Act with a 2050 target of “at least 60%”, rather than the 80% that was eventually adopted. Again, the argumentation, and especially the interim advice from the newly-formed CCC, given in October 2008, for a more stringent target was entirely based on updated understanding of the climate science and a fair contribution from the UK, rather than any argumentation about the potential co-benefits contributing to nearer-term goals (Environmental Audit Committee, 2007; CCC, 2008).

**The politics: concerns over unilateral leadership**

The Institute for Government’s 2012 case study about the Act, based on inputs from key people involved at the time, reveals some concern among ministers about unilateral leadership and whether the Act should have a conditionality clause in case other countries did not take similar action. The concern from e.g. the Treasury was that if that was to happen, the UK would bear all of the costs but receive none of the benefits, and that energy intensive industries would relocate out of the UK (Institute for Government, 2012). This logic is actually also visible in the Impact Assessment from 2009, which says that “The economic case for the UK continuing to act alone where global action cannot be achieved would be weak” (though as this document’s net benefit calculations include £32 billion of air quality benefits which would occur even if the UK acted alone, this suggests a rather narrow interpretation of ‘economic case’).

This high-level concern suggests that potential co-benefits – which *would* accrue even under unilateral action – such as improved energy security, energy efficiency savings in business and households, and air quality and other environmental benefits were heavily discounted. Arguably the potential economic opportunity from low carbon innovation would indeed be greatly reduced if other countries did not take action and thus create market and export opportunities (although energy efficiency technologies would surely be attractive anyway).

Concerns about climate leadership’s effects on competitiveness were to resurface in the austerity years of the 2010 Coalition Government, for example in Chancellor George Osborne’s statements that the UK would not reduce emissions any faster than the rest of Europe (Guardian, 2011), because "We're not going to save the planet by putting our country out of business”, and which also suggest that the costs and benefits of climate action were understood principally in relation to avoiding climate change, rather than benefitting from potential synergies.

**A question of framing: co-benefits in the major UK climate plans since the Climate Change Act**

The Climate Change Act requires that the government presents a report to Parliament explaining how it will achieve the carbon budget targets, with a new report due each time a new carbon budget is set (which happens every 5 years). Since the Act was passed, three such reports have now been produced by the UK Government. They are in effect the headline climate policy statement of the government, in which it communicates its approach to reducing the UK's GHG emissions and how it sees the associated opportunities and challenges.

As is the case in the major climate policy documents from the EU (discussed in the previous case study), synergies with other national objectives are used to explain and justify the government's approach, but whereas the articulation of these synergies has been relatively constant in EU documents, the framing of the UK's climate plans has evolved significantly over the last decade.

This is apparent just from looking at the titles of the three plans. The first plan, published in 2009 by the same Labour government who oversaw the passing of the CC Act, was 'The UK Low Carbon Transition Plan'. This was followed in 2011 by the (Conservative and Liberal Democrat) Coalition Government's 'The Carbon Plan', and most recently in 2017 the (current) Conservative Government published 'The Clean Growth Strategy'. Each of these plans, and the way that different potential synergies are emphasized, is described below.

2009's 'The UK Low Carbon Transition Plan: national strategy for climate and energy' describes the Government's plan for reducing emissions while "maintaining secure energy supplies, maximising economic opportunities and protecting the most vulnerable". This phrasing, and these three objectives, appear throughout the document. Figure 4 shows the number of times the different co-benefit areas of 'energy security', 'economic growth', 'jobs' and 'air quality and health' are mentioned in the 2009 plan, and in the following two plans. Energy security and economic opportunities received the most attention in 2009, with impacts on air quality and health barely mentioned. In terms of detail (rather than just statements of aspiration, of which there are many), for economic growth, brief estimates of the scale of future markets or potential job creation are referenced, along with some figures about the current size of UK low carbon industries. While there are many references to energy security and how the plan will improve it, there is no substantive discussion of the impact (in volume or value terms) on energy security beyond a few references to the projected reduction in energy consumption vs BAU[15] (UK Government, 2009).

[15] *However there are several references to the separate review commissoned by the Government on energy security, undertaken by Malcom Wicks and published a few months later in 2009 in the form of the 120 page Wicks Review.*

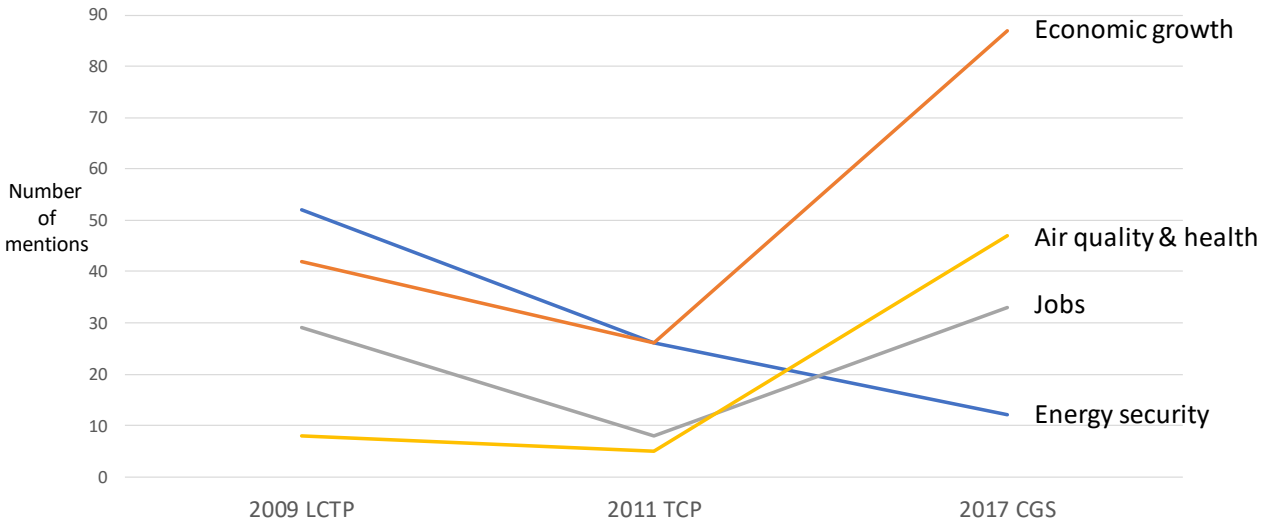



*Figure 4: Number of mentions of keywords or phrases[16] relating to 4 main co-benefit areas in UK climate plans (in main documents only, references in Annexes are not included). Source: Author's analysis*

2011's 'The Carbon Plan: Delivering our low carbon future' was published by the Coalition Government following the setting of the fourth carbon budget (which covers the years 2023-27), and is a more technical document than its predecessor, focusing mainly on the mitigation options (and pathways) that might be necessary to achieve the carbon budget targets. As a result, in the main document, there are considerably fewer references to any of the co-benefit areas than in either of the 2009 or 2017 plans, as shown in Figure 4. In terms of overall framing, the 2011 plan is fairly consistent with its predecessor, with broadly equal prominence given to energy security and economic opportunity, and also continuing concern about minimising the costs of the transition. The Annexes (100 pages in total) contain more detailed discussion of the potential co-benefits. For four different scenarios to achieve the 2050 GHG target (varying the contributions of energy efficiency, nuclear, renewables, etc.), the implications for security of energy supply and wider environmental impacts are briefly discussed, including quantitative (albeit high level ranges) estimates of improvements in air pollution impacts and of changes in UK energy imports. A second analytical annex focusses on the 'Wider impacts', briefly discussing the impacts on economic growth (including some quantitative references from UK government CGE modelling of the carbon budgets), fiscal impacts, security of electricity supply (including modelling of capacity margins), and environmental impacts. This last section covers air quality, water impacts, biodiversity, sustainability of bioenergy supply, and marine and landscape impacts. One striking reference included is that "one major study found that optimising climate change policies to improve air quality could yield benefits of £24 billion by 2050" – yet this very large number is not mentioned at all in the main document (in which there are just a handful of qualitative references to air quality or human health) (UK Government, 2011).

In late 2017, the Conservative government published 'The Clean Growth Strategy: Leading the way to a low carbon future'. Beginning with its title, this third national climate plan has quite a different framing to the two that preceded it. Seizing economic opportunity is the key theme (along with GHG reduction) of this plan, which spends as much time describing the potential commercial opportunities for UK firms and how

[16] *E.g. for energy security, 'energy security', 'security of supply, 'secure energy' etc were counted. For economic growth, variations of 'economic growth', 'economic opportunities', 'green growth', 'clean growth' etc were counted.*

the government will support them in developing new technologies as it does on GHG reduction opportunities and policy options. The synergy with energy security is far less prominently articulated. As can be seen in Figure 4, this issue is mentioned even less often than in the 2011 plan, and does not even get a mention until the seventh page of the executive summary (compared to the 2009 plan in which it is mentioned in the first paragraph and then a further ten times in the executive summary). Along with the many references to 'growth', there is also a marked increase in the number of references to air quality and health: the 'clean' part of clean growth; however the level of detail, especially in the Annexes, is considerably lower than in the 2011 plan and there are no quantitative estimates of the potential scale of environmental co-benefits (UK Government, 2017). The 'clean' part seems very much the junior partner to 'growth' in the actual content of the document.

**The growing emphasis on 'Clean Growth' as a framing**

This reframing around economic growth was noted (and welcomed) by the CCC in its 'Independent Assessment of the Clean Growth Strategy' published in January 2018. In the foreword, CCC Chairman Lord Deben (aka John Gummer, UK environment secretary during the 1990s) states that 'The first thing to say is that the Clean Growth Strategy, whilst much delayed, has changed the tone surrounding consideration of emissions reduction in the UK. Alongside the Industrial Strategy, it has recognised the essential contribution of the low-carbon transition to the economy as a whole'. The main report goes onto note in the Executive Summary that 'It [the Government] has placed the low-carbon economy at the heart of the UK's industrial strategy, framing the Clean Growth Strategy as a positive contribution to the economy (rather than a burden to be minimised)' (CCC, 2018).

This focus on economic opportunities arising from the low carbon transition is certainly not new, even if it has become the dominant framing recently. As noted above, economic opportunities were highlighted in the 2009 Low Carbon Transition Plan, there were efforts to develop a Low Carbon Industrial Strategy in 2009 (a brief 'Vision' document was published in March 2009, but it does not seem that the final Strategy was actually published), and a 'Low Carbon Business Opportunities' unit was set up within government in 2009[17].

To support and inform this focus on economic opportunity, an evidence base on the scale and nature of the opportunities, especially regarding potential exports, was developed (and continues to be developed). As noted above in the section detailing the UK's co-benefits evidence base, this included the reports commissioned by DECC and the CCC, the TINA evidence base developed collaboratively by the public bodies involved in low carbon innovation in the UK, and the regular surveying of the performance of the 'Low Carbon and Environmental Goods and Services' market in the UK.

External circumstances also seem likely to have played a role in increasing the focus on commercial opportunity. The passing of the Climate Change Act in 2008 was shortly followed by the global financial crisis; as noted above, this led to questioning of the UK's commitment to climate action as well as a need to get as much value for money as possible from mitigation action. This is highlighted in 2011's Carbon Plan: 'Current economic circumstances highlight the need for climate policy to be cost effective, to maximise the

[17] *https://webarchive.nationalarchives.gov.uk/20090609005254/http://www.berr.gov.uk/whatwedo/sectors/lowcarbon/index.html*

economic benefits and growth opportunities and minimise negative impacts' (UK Government, 2011). The UK's decision to leave the EU in 2016, and widespread concern over the potential impact on trade and the economy, has increased the pressure on the government to cast the UK's climate actions as part of a wider industrial and growth strategy. Thus 'Clean growth' is positioned as one of four 'Grand Challenges' in the UK's new industrial strategy (alongside Artificial Intelligence and data; ageing society; and the future of mobility). The importance of clean growth as a framing idea is shown in supporting communications activity: public attitude tracking undertaken for the government in 2018 asked the public about awareness of 'Clean Growth' because 'The Government has recently begun to promote the concept' (awareness is low: seven in ten people had not heard of clean growth) (UK Government, 2018b).

Institutional changes within government have mirrored the evolving positioning of low carbon development as part of a wider growth narrative. In 2008, responsibility for climate action was joined up with responsibility for energy in the newly created 'Department for Energy and Climate Change' (DECC); in 2016, DECC's climate and energy responsibilities were moved to the new Department for Business, Energy and Industrial Strategy' (BEIS), and DECC ceased to exist.

The waning of energy security as a key framing message over the last decade and the three climate plans perhaps also reflects the UK's evolving energy security (at least as far as import dependency goes, which is not equivalent to energy (in)security). The UK became a net energy importer in 2004, after a decade of being a net exporter due to the exploitation of North Sea gas and oil, and energy import dependency rose steeply to just over 20% by 2006, and 26% by 2008 (See Figure 5 below). So during the few years preceding the CC Act and the first climate plan (the 2009 Low Carbon Transition Plan), energy security presumably became increasingly relevant politically. Then in the three years leading up to the publication of the Clean Growth Strategy in 2017, the UK's reliance on imported energy has actually fallen by a quarter (in percentage terms), as a result of increases in domestic oil and gas production and the contribution of renewables (UK Government, 2018c). This may be to read too much into the statistics; the prominence (or not) of energy security messaging may simply be a reflection of what seemed most expedient from a framing point of view at the moment, rather than a reflection of the actual level of importance of the issue and the degree of synergy between the objectives (i.e. energy security has been trumped by Brexit-induced trade and growth worries); indeed a recent paper from the UK Energy Research Centre analyzing the energy security implications of different scenarios to hit the UK's climate targets found that energy security risks will not necessarily decrease as the energy system is decarbonized, with some scenarios showing higher energy security risks (UKERC, 2018).

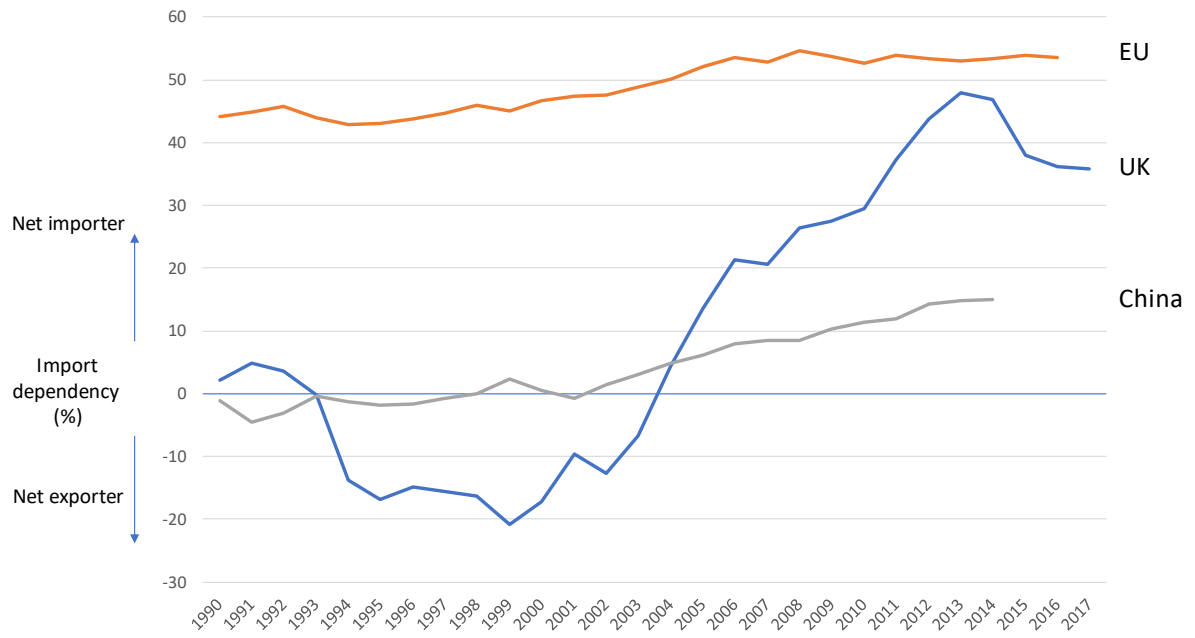



*Figure 5: Energy import dependency (all fuels) for the EU, UK and China from 1990 onwards. (Source: Eurostat; Digest of UK Energy Statistics; World Bank)*

## 4.3. China

The third and final case study in this paper focusses on China. It takes a slightly different approach to the previous two: because most official Chinese policy documents (such as impact assessments) are not published, or at least not in English, review of government documents has not been a major input. And because of difficulties in accessing Chinese government officials, no interviews were undertaken specifically for China. Notwithstanding these limitations, China was selected for one of the three case studies because of the widely held view, as discussed in the rest of this Chapter, that co-benefits have been instrumental in motivating China's climate action. The key sources used are: reports about Chinese climate policy, academic papers, and the author's experience of two years' work as a UK climate diplomat in China (2008-10).

**Summary of policy developments**

China engaged in the early international responses to climate change, as a participant and signatory to the UNFCCC and Kyoto Protocol, however as a developing country (and staunch defender of the 'common but differentiated responsibility' principle), China did not have to take on emissions reduction commitments under the Kyoto Protocol. As with the case studies for the EU and UK, climate policy becomes interesting in China for the purposes of this paper when meaningful national targets were adopted.

In China's case, this happened around 2005-6, with the passing of a Renewable Energy Law, establishing renewable energy targets and feed-in tariffs, and most notably with the inclusion of an energy efficiency target in the 11th Five Year Plan (FYP), which required a reduction in energy consumption per unit of GDP of 20% below 2005 levels by 2010 (the FYP period was 2006-10); although the 11$^{th}$ FYP did not actually mention emissions reduction or low carbon (Zhang, 2015). Over this period, the degree of engagement with

climate change as a topic deepened greatly, and a number of overarching plans and policy documents were produced (though some of these may have been intended more for an international audience than genuine domestic use). Having overtaken the US as the largest global GHG emitter some time around 2006, international scrutiny of China's emissions and actions began to increase, and, as the international climate negotiations began to turn towards a new global deal following the Bali COP in 2007, it was clear that China would ultimately have to take on emissions reduction commitments under a new global deal (indeed for the US, this was a crucial requirement for their own participation). In the months leading up to the Copenhagen COP in 2009, China announced its first GHG reduction goal: a reduction in carbon intensity of GDP by 40-45% by 2020 (based on 2005 levels).

During 2010 it became clear to Chinese officials that the energy intensity target of the 11$^{th}$ FYP was unlikely to be achieved, not least because part of China's response to the global economic crisis of 2008-9 involved massive stimulus packages and new infrastructure, which greatly increased energy consumption from heavy industry (especially steel and cement). Provincial officials attempted a range of last-minute interventions to achieve the target, including closure of factories and electricity rationing, which demonstrates the increased importance of energy efficiency targets to provincial governments during this period, but was also a costly and inefficient way to try to reduce energy consumption. This experience is thought to have encouraged the national government to consider a wider range of policy measures, including market mechanisms such as carbon trading, which China began to consider seriously from 2010 onwards (Lo, 2015).

The 12$^{th}$ FYP (2011-15) included a climate change target (a 17% reduction in carbon intensity over the plan period), the first time a dedicated climate target had been included in an FYP. The plan also contained a continuation of the energy intensity target, with increased efforts to improve energy efficiency in energy intensive sectors, and included a target to increase the proportion of non-fossil energy in the mix. It also identified a number of low carbon industries as 'strategic emerging industries', including energy saving, new energy technologies, and new energy automobiles. These were industries with strategic growth potential and which would benefit from industrial policy interventions to support domestic innovation and incubate local champions – an approach that has enabled Chinese firms to establish dominant positions in global renewable energy markets for example.

In the run up to the Paris COP in 2015, further significant developments took place. A carbon trading scheme was formally announced and subsequently launched in a number of pilot provinces. In late 2014, President Xi and President Obama (of the United States of America) issued a joint announcement in which China stated its intention to peak emissions by 2030 'and to make best efforts to peak early', as well as to increase the share of non-fossil energy to 20% (The White House, 2014). This joint agreement was widely seen to be a critical step in enabling the Paris Agreement to be reached in late 2015. China's INDC, submitted in June 2015, built on its previous GHG targets with a pledge to reduce its GHG intensity by 60-65% by 2030, also from 2005 levels. Since the ratification of the Paris Agreement, and in response to President Trump's stated intention to withdraw from the Agreement, China has been clear and vocal in its support for the Agreement and the multi-lateral climate process.

The 13th FYP, anounced shortly after the Paris COP, in March 2016, continued with carbon intensity targets (18% reduction over the plan period), and included a target to limit coal consumption by 2020. This was accompanied by various measures to reduce coal consumption including the closure of existing mines and a moratorium on new coal mine approvals (Averchenkova et al, 2016). The significant efforts made to diversify away from coal during this period were also motivated by growing concern about air pollution, and the increased cost of domestic coal supply, as is discussed later in this case study.

These high level developments have been complemented by the development of a range of supporting policy documents and policy measures, creation of new bodies, and rearrangement of institutional responsibilities (for a good overview of Chinese climate policy see Sandalow, 2018).

**Box 4: Timeline of selected Chinese policy developments and key policy documents**

2006: energy intensity target included in 11th Five Year Plan

2009: China announces first climate target, a reduction in carbon intensity of GDP by 40-45% by 2020

2011: carbon intensity target included in 12th Five Year Plan

2014: President Obama and President Xi issue joint announcement including Chinese commitment to peak emissions by 2030

2015: China's INDC contains target to reduce GHG intensity by 60-65% by 2030

2016: 13th Five Year Plan contains target to limit coal consumption by 2020

**China's co-benefits evidence base and the prominence of co-benefits in policy documents**

Given the language barrier, the somewhat lower commitment to transparency in policy making and policy documents and the related fact that the Chinese government may well procure studies that it does not publish, it is hard to assess the state of the co-benefits evidence base upon which Chinese policymakers are able to draw, and similarly hard to assess from published policy documents how important co-benefits have been in policy development. Indeed, given the importance placed by China on being seen as a responsible global actor, it may be in its interests to downplay the importance of co-benefits and suggest that it is motivated principally by a desire to play a meaningful role in a global effort to avoid dangerous climate change, although China's INDC (see below) does recognize the role of co-benefits as drivers for Chinese climate action.

Nevertheless, there are a few examples in English which show that at least some co-benefits evidence is available to the Chinese government and that recognition of co-benefits has been made in important documents:

- In a widely referenced (in Western reports and papers) paper published in 2007, Aunan et al assessed the cost and benefit to China of taking on climate commitments. They found 'significant ancillary benefits to China since associated particle and NOx-reductions improve public health and increase agricultural yields' and 'that China may reduce its $CO_2$-emissions by 17.5 per cent without suffering a welfare loss' (Aunan et al, 2007).

- In 2009, the China Council for International Cooperation on Environment and Development, a high profile and influential group of Chinese and international experts, published 'China's Pathway Towards a Low Carbon Economy', which stated that 'There are also very significant positive benefits to be gained for China as it moves to tackle its own internal energy resource and environmental constraints. It will alleviate resource and energy pressures; improve the structure of energy consumption; and safe-guard energy security… positioning itself as a global leader and provider of low carbon technology' (CCICED, 2009).
- China's 2015 INDC recognizes the broader benefits of sustainable development: 'China is making efforts to embark on a sustainable development path that is in line with its national circumstances and leads to multiple wins in terms of economic development, social progress and combating climate change'; it specifically references economic security, energy security, food security and improving people's health as drivers of climate action (Government of China, 2015).
- The Aether scoping study on co-benefits undertaken for the UK Government in 2016 assessed the geographical distribution of papers and found that 'the large number of papers from China is particularly striking … with good coverage across the power, industry, buildings and transport sectors'. Air quality was the most studied co-benefit in the China specific literature: 'Of the 54 papers reviewed, 45 focus on air quality co-benefits, driven by the severe pollution in Chinese cities'; energy security was mentioned in 7 papers and employment in just 4 papers. Tsinghua University in Beijing was also the second most prolific institution globally in terms of the number of co-benefits papers produced (out of the c. 400 reviewed in detail) (Aether, 2016).
- One 2015 paper highlighted in the Aether study by academics from institutions including China's influential Energy Research Institute, and the China National Renewable Energy Centre, used economic modelling to assess the economic impacts of large scale renewable energy deployment in China. They found that their highest deployment scenario would 'stimulate output worth $1.18 trillion from other RE related upstream industries and create 4.12 million jobs in 2050' (Aether, 2016; Dai et al, 2015).
- A 2018 paper by Markyanda et al (mentioned in the introduction of this paper) estimated the health co-benefits of meeting the Paris Agreement goals and found that 'the costs of reducing greenhouse gas emissions could be compensated with the health co-benefits alone for China and India' (Markyanda et al, 2018). A similar study by Chinese researchers, focusing purely on China, found similar results, with the health benefits covering 18-62% of NDC implementation costs by 2030, and 3-9 times the costs by 2050 (Cai et al, 2018).

**Commentary on the importance of co-benefits**

Whether or not there is a robust and comprehensive evidence base on co-benefits available to Chinese policymakers (in English or Chinese; in the public domain or not), and whether or not they make use of it, China is one of the few countries where external (and some internal) commentators state quite clearly their view that co-benefits have been a major part of the motivation for climate action.

As an example: in a 2016 Grantham Institute study assessing the factors affecting the development and implementation of climate policy in China, Averchenkova et al observe that 'the co-benefits of fostering a

growing green industry and reducing air pollution are so palpable that they have persuaded China to move strongly toward a low carbon path for economic growth' and that 'China is strengthening its actions on climate change based on a new political narrative focusing on the opportunity and ancillary benefits of low-carbon development' (Averchenkova et al, 2016). As noted in previous sections of this paper, rarely does the academic literature so clearly ascribe the (meaningful) climate policy developments of a nation to its recognition of the potential co-benefits.

In addition to green industrial growth and reduced air pollution, improved energy security is often identified as a third key driver motivating Chinese climate policy, for example Stern and Green observe that 'Continued strong expansions of non-fossil energy supply are rendered more likely by the three drivers identified […]: reducing air pollution; improving energy security; and promoting growth in strategic clean-technology industries' (Green and Stern, 2016). This set of three is observed in other papers (e.g. Harrison and Kostka, 2012; Teng and Jotzo, 2014).

Some observers suggest that these goals are the real drivers of climate action: 'Although China's low-carbon changes are widely recognized in the literature, most authors agree that they do not come as a direct outcome of responses to the climate challenge but rather as outcomes of three domestic challenges unrelated to global climate change' (Engels, 2018). In this perspective, GHG reductions in China are a co-benefit of actions to address these other pressing issues, rather than the other way round[18].

Whether or not it 'matters' which was the initial driver (climate concern vs other national interests), the point really is that China has identified – and acted upon – a convenient alignment between its priority strategic interests and the actions needed to reduce its emissions, particularly in the energy sector. That it might choose to present these actions as strongly (or principally) motivated by climate change is an understandable reaction to the international pressure it feels. No doubt other countries would do the same – e.g. had the UK's 'dash for gas' shift to gas-fired power generation taken place during a period of intense international focus on national GHG emissions reduction performance, it would probably have been presented in part as a climate mitigation measure.

The remainder of this sub-section briefly considers the three drivers generally acknowledged to be important in China – reducing air pollution, improving energy security, and promoting sustainable (in the economic sense) growth through creation of competitive new industries – in particular considering why they are so powerful in China.

**Three pressing domestic issues**

**Air pollution**

With China's air pollution occasionally attracting mainstream media attention in Western countries, especially during the 'airpocalypse' pollution events of the last c. 5 years, air pollution is perhaps the most intuitively obvious co-benefit driver for climate action in China.

A recent overview of the air pollution situation in China by Aunan et al makes clear the scale of the situation in China. Exposure levels to PM2.5 are 2-7 times greater in China than in developed countries and

[18] *India has been open about a similar 'reversal' of the co-benefits logic, stating in their National Action Plan on Climate Change of 2008 that they will pursue development objectives that offer co-benefits for mitigation (Government of India, 2008)*

during extreme pollution episodes, urban concentrations can be 'one or two orders of magnitude higher than urban levels in the US and Western Europe', making China 'among the top most polluted countries'. As a result, there were about 1.5m premature deaths attributable to PM2.5 pollution in China, with air pollution-related deaths accounting for 17% of total deaths in 2015 – among the highest levels in the world (Aunan et al, 2018).

The Chinese people are increasingly aware of the health damage caused by such levels of air pollution. Sales of air purifiers have been booming since 2013, and some private schools in Beijing have even erected fabric domes over their outside areas in order to purify the air for students. A 2015 documentary film about Chinese air pollution ('Under the Dome') was watched several hundred million times online before it was banned by the Government.

Surveys have shown that Chinese people in both urban and rural areas now rate environmental quality as more important than economic development and more closely linked to quality of life than jobs or income (Aunan et al, 2018; Sandalow, 2018). A study undertaken in Beijing in 2015 even explored how pollution levels influence the level of support for the government based on daily survey sampling and daily air quality records, finding (negative) correlation between the level of pollution and level of support (Alkon and Wang, 2017).

The Chinese public are not only expressing their views on air pollution through surveys; they are taking to the streets as well. Environmental pollution is the cause of numerous protests each year across China (media censorship about such events makes it hard to access accurate figures). The Chinese Academy of Social Sciences estimated that half of the 'mass incidents' attracting 10,000 or more participants between 2000 and 2013 were about environmental pollution (Steinhardt and Wu, 2015)[19].

Public concern and protests of this scale and number naturally attract the attention of the Chinese leadership, and have made dealing with air pollution a priority. President Xi Jinping has spoken about a 'war on pollution' and declared that addressing China's air pollution is one of three 'tough battles' for the years ahead (along with poverty reduction and reducing financial risks) (Sandalow, 2018).

This level of priority has led to new air quality policies and a greater focus on implementation. Although Chinese air pollution policies date back as far as the 1980s, implementation was poor because local government had limited incentives to enforce the policies. In late 2013, after the especially bad air pollution experienced that year, the government released the 'Action Plan on Prevention and Control of Air Pollution', which targeted cuts in PM concentrations by 2017 (including specific targets of 15-25% for regions such as Beijing and the Yangtze River Delta) and outlined 10 key tasks to improve air quality. Interim evaluation of the progress of the plan reported that significant reductions in various pollutant concentrations were being achieved. Aunan et al concluded in 2018 that 'the worst air pollution era may belong to the past for most of the Chinese population', although they note that pollution levels will remain high, well above WHO guidelines, and unevenly distributed across China's regions and socio-demographic groups (Aunan et al, 2018).

[19] *Many of these protests were directed against specific proposed plants, rather than about levels of pollution more generally.*

**Energy security**

China has substantial reserves of coal, oil and gas, but its huge population and recent decades of very high economic growth led to it becoming a net importer of energy in the early 2000s (see Figure 5 above). Oil has historically been the focus of Chinese energy security concerns; recognition of the importance of oil for military and development purposes dates back to the 1950s. Domestic oil growth began to take off in the 1990s, and in 1993 China became a net importer of oil. Rapid growth in oil demand (9% per year from 2000-2009) pushed import dependence from 30% in 2009 up to around 60% by 2013 (Leung et al, 2014). The IEA's World Energy Outlook 2018 predicts that by 2030 China will overtake the US to become the world's largest oil consumer, with oil import dependence rising from 69% in 2017 up to 77% in 2025 and 79% by 2040 (the IEA predicts slow growth in oil demand after 2030 due to the rising share of electric vehicles) (IEA, 2018)[20]. Though China's oil import dependence is large and has risen rapidly, it is by no means out of line with other major regions: current dependence in the EU is 85%, India's is 74% and Japan and Korea import 95% (IEA, 2018), however the fact that most of China's oil imports are shipped through the strategically vulnerable Malacca straight may make China feel more exposed.

China has vast domestic coal reserves and is by a long way the world's largest coal producer (47% of world production in 2017), but its heavy reliance on coal in the power and industrial sectors and rapid economic growth led to demand outgrowing its domestic supply: it became a net importer of coal in 2009, with import dependency of 8% in 2017. In 2000, China's share of world coal demand was 29%, by 2017 it had reached 51% (IEA, 2018). In line with other assessments that China's coal consumption has peaked (or will soon have), the IEA predicts declining coal demand in China from 2025 through 2040, with import dependency reducing to 6% in 2025 and 3% in 2040 (IEA, 2018).

China is a substantial producer of natural gas, but became a net importer of gas in 2007. Its import dependency has risen from 5% in 2000 to 43% in 2017; the IEA predicts this to increase to just over 50% by 2025 and then to hold steady. The IEA predicts a very strong outlook for gas in China, with demand tripling by 2040, mainly at coal's expense as action on air pollution leads to gas displacing coal in the power sector, industry and buildings. As a result China will become the world's largest gas importer, overtaking the EU around 2040 (IEA, 2018). China has large shale gas resources, and investment to exploit these is already substantial at over 5bn USD. Industry analysts expect production to double over the coming few years, but a game-changing shale gas boom (as in the US) is not expected anytime soon, not least because the shale gas sites are harder to access and there is not an open market of small nimbler players as there was in the US. The government's 2020 shale gas production target is expected to be missed by some distance (Wood Mackenzie, 2018).

All countries prioritise energy security; the Chinese government's belief that continued economic growth and development are essential to its legitimacy and to maintaining stability give this priority extra weight. The sheer scale of the energy imports is also likely to concentrate the minds of China's leadership: the IEA predicts that China would be spending half a trillion dollars per year on energy imports by 2040 (IEA, 2018). Lastly, the US, its only great power rival, increasingly finds itself in an opposite position: already a net

[20] *IEA predictions are for the 'New Policies Scenario'*

exporter of coal and gas, the IEA expects that it will become a net exporter of oil as well by 2025 (IEA, 2018).

**Rebalancing the economy**

The third driver generally linked to Chinese climate action is the opportunity it presents for economic restructuring and for the development of leadership positions in important future global low carbon energy markets. As noted above, continued economic growth is seen as being linked to legitimacy and political stability in China.

The Chinese government recognized around five years ago that the economic model that had delivered the astonishing growth performance of the previous c. 15 years was no longer fit for purpose in economic terms (as well as directly contributing to the air pollution and energy import situation described above). The old model of growth was characterized by very high investment, especially in infrastructure and heavy industry, low levels of domestic consumption, and a growing dependence on exports of low value-added manufactured goods. With demand for industrial products such as cement and steel slowing within China, further investment in these sectors would lead to excess capacity and poor investment returns. China's competitive advantage in low value-add manufacturing was being reduced by wage growth and the emergence of other low-cost manufacturing locations around the world. In addition, major debt-fuelled investment in industrial sectors as part of the stimulus package put in place following the global financial crisis of 2007-2008 led to Chinese banks holding a growing portfolio of non-performing loans, creating credit-related risks of increasing urgency (Green and Stern, 2015).

**Well aligned solutions**

China is fortunate - and was quick to realise – that there is considerable alignment between the solutions to these three pressing issues.

The air pollution which blights Chinese cities and is leading to unrest (as well as substantial economic costs), is principally caused by the burning of coal in power stations, industry and buildings, along with other solid fuels. Fast-growing private vehicle ownership adds tailpipe emissions to the problem.

The most urgent action to improve air quality, burning less coal through diversification of fuel sources (especially towards gas and renewables) and supply and demand-side energy efficiency, helps reduce coal imports (though these are far less of a concern than oil imports), as well as making a major contribution to reducing GHG emissions. Expansion of electric vehicles (or other automotive technologies not reliant on oil, such as fuel cells) would address growing transport related air emissions while also addressing China's key energy security concern, its oil import dependency, which is large and growing (and concentrated via the hard to secure Malacca straight shipping route).

Domestic deployment of low carbon technologies (along with local content requirements and other supporting industrial policy interventions) to address air pollution, energy security (and GHG emissions) can develop and incubate national champions which can then support economic restructuring through a shift to high value-add industries and exports.

Thus, many of the key economic, energy and environmental policies all support the achievement of multiple objectives, of which climate change may well be the lowest priority. The various measures to cap

coal consumption, switch from coal to gas, and stimulate renewable energy (and energy efficiency and electric vehicles) all can be presented as climate mitigation measures but achieve multiple wins across key policy domains.

An indication of the relative priority of the underlying drivers may be inferred from the mismatch between what China is doing at home compared to its overseas activity: while China cracks down on domestic coal consumption, it has been busy financing a major expansion of coal power overseas, with involvement in 240 coal plants across Asia with a total capacity of 250 GW (GEI, 2017). Although China is not alone in financing coal infrastructure in developing countries, it is clearly inconsistent with its professed focus on climate change mitigation (but would make more sense if the main motivations for reduced coal consumption at home relate to improving air pollution and energy security, which are not affected by overseas coal plants).

# 5. Observations and Conclusions

This chapter draws on the preceding three chapters and attempts to make some observations and conclusions on the extent to which co-benefits have been used to determine or communicate headline climate ambition, on some of the underlying drivers and challenges, and on some lessons that could be drawn for the future.

**It is first important to repeat a perhaps obvious caveat: it is hard in practice to track the influence of co-benefits in the evolution of headline national climate policy**. Looking at, for example, the striking estimates of health co-benefits (described as 'robust synergies' with 'very high confidence' by the IPCC) together with the generally inadequate ambition levels of most countries might lead you to conclude that co-benefits are having little effect in increasing ambition; on the other hand co-benefits (or the SDGs) are frequently mentioned in NDCs and other major climate policy documents, and especially so in the cases of the EU and UK, as explored earlier in the paper. Ultimately it remains extremely difficult to know what has really influenced national climate policy ambition and what has not, without being a fly on the wall of the right rooms at the right times over a number of years. Just because co-benefits references or even quantitative estimates are included in key documents does not mean that they were important to the high-level decision makers. Conversely, given the international pressure to take action on climate change, it may be that countries have presented their actions as designed principally for mitigation purposes when in fact they were motivated by other (co-benefit) concerns, with mitigation itself being a happily coincidental co-benefit.

**Another caveat is that outside the EU, the number of potentially useful case studies to explore the successful *positive* influence of co-benefits on climate ambition is small**. To make a useful case study, a country needs a long enough track record of climate policy development and implementation, with meaningful ambition and real commitment to implement it. It also needs to have a credible and country-specific evidence base on co-benefits, and the ability to process and act on it. There also needs to be sufficient transparency and comprehensiveness in published policy documents, or a body of external analysis and commentary. Few countries would really meet all these conditions (though some sub-national regions might – e.g. progressive US states such as California). The ambition and commitment point is important. If countries are not having a serious debate about the higher levels of ambition - where abatement costs become high, implementation is difficult, and co-impacts and trade-offs start to become significant – and instead focus on incremental short term mitigation measures, or low ambition high-level targets, then they have probably not had the kind of debate where real consideration of the co-benefits evidence is necessary or could really make a difference. It may be that there are useful case studies where a (seemingly) compelling co-benefits evidence base has failed to support positive ambition, for example the US, where there is strong evidence on co-benefits and where President Obama made health benefits a core part of the communication around the Clean Power Plan, but where adopting ambitious national climate policy still seems very difficult.

**The systematic reviews of the co-benefits evidence base conducted in recent years suggest that overall, co-benefits should be included in climate policy decision making and would mainly support higher ambition, with health benefits especially clear and well established**. The evidence base is two decades old, growing, and covers many different co-benefits at many different geographical scales, though it predominantly focusses on developed countries and the major emerging economies. While there is consensus that there are large positive co-benefits for health (mainly from reduced air pollution), the evidence is more mixed for economic impacts, food security and water security. In particular there are concerns about the robustness of economic evidence.

**The degree to which co-benefits have been instrumental in setting climate ambition and how they have been used varies greatly across the three cases in this paper. But all three have made use of the existence of co-benefits to advance mitigation action.** The UK seems to have been mainly motivated to adopt – at the time world-leading – climate targets by the desire to avoid dangerous climate change and to show leadership to help secure a global climate deal, and then used co-benefits as a framing narrative and justification. Similarly the EU (at an institutional level) was first motivated by the importance of taking action on climate change for its own sake, and then used the energy security co-benefit in particular to get more reluctant Member States on board. The story in China is almost exactly the opposite: the synergies between mitigation actions and actions to address its key challenges of extreme air pollution, worsening energy security and slowing economic growth are so strong that climate action was likely motivated mainly by those synergies (although understandably China has taken the opportunity to present itself as a responsible global actor by suggesting mitigation was the key motivation). But one way or another, all three cases have taken advantage of the existence of substantial alignment between key goals to advance real mitigation action.

**The cases raise the question of whether there are countries who will take substantial action on climate change because it is 'the right thing to do' from a global commons perspective, and whether there are others who will need more self-interested reasons for action – and for those in the latter category, will there always be sufficient co-benefits?** Even though the likely existence of substantial co-benefits had been suggested by such authoritative and influential reports as the Stern Review in the UK, co-benefits did not seem to feature in the debate around the ambition levels of the Climate Change Act, which centred on the benefit of avoiding climate change (which of course is also in any country's interest but can be achieved by free-riding). On the other hand, China has – thankfully – found a plethora of reasons to take action on climate. For the many countries that fall in between these examples (recognizing that many factors could determine where a country might sit on that spectrum – level of development; approach to global geopolitics; guilt over past emissions…), would the net position of positive and negative co-impacts be enough to motivate ambitious decarbonization? For countries with limited energy security concerns (due to large fossil reserves) and little realistic prospect of gaining major share in emerging markets for low carbon goods and services, can co-benefits make a low carbon development pathway seem sufficiently attractive? The MAPS programme, which worked with various Latin American countries to develop decarbonization scenarios, and devoted considerable effort and analysis to co-benefits, found "little evidence of co-impacts analysis motivating policy for a systematic decarbonization" among its partner countries (Cohen et al, 2016). There is also the unfortunate possibility that many of the countries who most need extra reasons to

take climate action, because they are (rightly) focused on economic development are probably least aware of the potential synergies and least able to undertake and absorb the necessary analysis.

**Given that co-benefits essentially manifest when there is an alignment between the actions required to achieve certain desired goals (such as renewables reducing both GHG emissions *and* fossil fuel imports), it may be that there are specific periods in a country's development when co-benefits are more likely to support climate ambition**. Take the case of China: while the stars are aligned at the moment such that actions to address some of its key challenges also reduce GHG emissions, this would have been far less the case c.20 years ago when its economic development was based on massive expansion of energy intensive industry and low value-add manufacturing, and when it was still a net exporter of coal and gas. It would have been hard to square mitigation action with its other priorities at that time. Fast forward to now, when the global mitigation effort is underway, creating pressure on China to reduce GHG emissions, and when it also faces real challenges from air pollution, energy security and a need to find new economic growth sectors. The stars are much better aligned to support climate ambition. For countries entering the industrialization phase of their development, supportive co-benefits may be much harder to find.

**The evolving prominence of different co-benefits in framing the UK's climate action shows how co-benefits can be used flexibly to suit the current situation.** The first major climate policy documents and plans emphasized the synergies with energy security, which was perhaps a priority at the time following a downturn in the UK's energy independence, with health and economic co-benefits far less prominently mentioned. By the time of 2017's 'Clean Growth Plan', this had reversed, with energy security hardly being mentioned and a much greater emphasis on economic growth and health, with the former especially important following the Brexit vote of 2016 and need for a positive national narrative about economic growth and industrial strategy. In particularly acute cases, a 'policy window' may open up where an alignment can be exploited to motivate climate action, such as in the case of interruptions in Russian gas supply in 2005-06 making some EU Member States even more receptive to the energy security benefits of increased renewable energy deployment. Thus, even where co-benefits are consistently net-positive over time, there may be periods when certain co-benefits are particularly relevant or compelling.

**Energy security has been more influential than the other co-benefits in influencing climate action (as opposed to just framing it)**. In the case of the EU various sources suggest that energy security has been the pre-eminent issue in motivating climate action, and was instrumental in getting otherwise unconvinced Member States to approve EU-level targets. In the UK it was the first issue that was presented along with climate change as the key challenges for the energy sector. China is perhaps unusual in that the other main co-benefit areas of air pollution/health and economic growth could make an equally pressing case, due to the severity of the air pollution and health impacts and the clear need to rebalance their economy. Looking further afield, a brief look at the country ratings from the Climate Action Tracker shows that those with major fossil fuel reserves (and thus limited energy security concerns) tend to be at the 'critically insufficient' and 'highly insufficient' end of the ambition spectrum, while countries like Morocco, which imports 95% of its energy are in the 'Paris Agreement Compatible' category (CAT, 2019). Energy security by no means explains all the distribution among the Climate Action Tracker rating categories (there are some notable exceptions, like Turkey and Singapore) but the alignment at the extremes seems fairly strong. Indeed perhaps the strongest evidence for the influence of co-benefits (or in this case, negative co-impacts)

comes not from those countries taking action on climate change, but those fossil fuel rich countries who are taking the least domestic action, and in some cases also being actively disruptive in the multilateral response to climate change. An important question for the future of this field is thus to investigate how energy security and climate ambition might play out in countries with and without different sorts of concerns about energy security.

**Energy security perhaps has certain advantages as an issue, compared to other co-benefits, which help explain its greater impact so far**. Some relate to nature of the evidence on the link between climate action and energy security, which is just more intuitive and easier to grasp than other co-benefits. Action on energy efficiency or increased renewables clearly and directly will reduce consumption of (potentially imported) fossil fuels. It's easier to value as well, as a tonne of oil has a well understood price. The issues of energy security and climate change were also institutionally closer from the outset, as most countries began thinking about decarbonization in the energy sector first (which for most countries produces the majority of GHG emissions). For example in the UK, government responsibilities were (for a number of years) merged in the form of the Department for Energy and Climate Change. Energy security was also already a directly modelled and managed issue, with projections for energy independence and energy balances already coming out of energy sector models that in many cases were then used to explore decarbonization options and pathways. Lastly, the consequences of getting energy security wrong are more immediate, and its impact more visible, such that it naturally commands greater political focus than longer term issues such as improving health. It also more clearly links to jobs and growth, which are basically impossible without energy, thus benefitting too from the importance of economic issues.

**Health, in contrast, has some particular disadvantages that may partially explain its lower impact on climate policy, despite the eye-catching scale of the estimated benefits**. Firstly, the link to mitigation actions, while probably more intuitive than, for example, the air pollution related impacts on crop yields, is not as obvious and clear as the energy security link. It is also harder to measure and prove objectively, given the overlapping causes and difficulty in attribution of health impacts to e.g. energy sector emissions. And even though public awareness in developed countries has risen greatly in the last few years, the absence of visible air pollution in most cities understandably reduces any public sense of urgency. Even if the health impacts were fully understood by people, it may be that they discount them quite heavily, and are not mobilized by them anymore than they are by medical advice not to smoke, eat red meat, drink alcohol, etc[21]. Lastly, the valuation of public health benefits is certainly not straight forward or intuitive, and is even a little controversial (in how it assigns a monetary value to human life), whereas the value of reduced energy imports is in comparison very easy to understand. Whereas a politician could easily explain the latter, explaining where a large public health benefit number comes from would be much harder, and potentially discourage them from engaging with it. These disadvantages are regrettable, because the failure to exploit the potentially vast synergy between climate action and public health surely represents a massive missed opportunity. As noted above, President Obama's 2015 Clean Power Plan is an example of a major climate plan in which public health benefits were placed front and centre, however the large health

[21] *The author admits a continuing enjoyment of at least the latter two of these while being fully cognisant of their health risks…*

benefits estimated were not enough to build widespread support for the plan which was challenged by a large number of states and has now effectively been repealed by President Trump.

**Beyond the specific challenges relating to health, there are more general challenges which make it harder for co-benefits to influence decision making**. These include the obvious difficulties in robustly working out which interactions between mitigation actions and co-benefit areas are important, and the scale (and positive / negative direction) of the interactions, as well as the difficulty in integrating this information into the already complex task of planning mitigation actions and setting ambition levels. This is compounded by structural challenges within government where related issues (like climate and health) are managed by separate institutions. Then there are difficulties in communicating these interactions effectively to different stakeholder groups (including the wider public). Difficulty in communication of co-benefits to the wider public could be unhelpfully self-reinforcing, in that failure to successfully communicate potential synergies makes it less likely they will become politically salient, which means they will attract less attention from government and thus be less well explored and again less well communicated. There is also often a mis-alignment between the short term political cycle and the longer time scale over which co-benefits such as health and economic growth are likely to materialize, which makes them less appealing to politicians seeking election. Vested interests who benefit from the status quo also may actively attempt to discredit co-benefits narratives or in other ways encourage that they are ignored, and because their potential losses are normally more concentrated than the broadly distributed potential gains, they are typically more vocal than the potential beneficiaries.

**The local level may be a 'sweet-spot' for co-benefits where the linkages are easier to see and exploit**. A number of the challenges mentioned above are less of an issue at the sub-national level, for example the same city government department may be tasked with delivering on multiple agendas (climate, energy, health, etc.) and thus can see and exploit synergies that siloed national institutions might miss or struggle to coordinate and implement. This has been seen in some Indian cities, where, for example, social housing has been built to higher standards of energy and water efficiency, so by investing more than they need to hit the housing targets, they can also deliver against other national and local goals. Hence it can be important to find a clear financial benefit to make the exploitation of such synergies valuable to local governments (who otherwise may not be strongly motivated by climate change).

**Furthermore, assessment of co-benefits at the sub-national level is essential to identify specific groups for whom the impacts are negative, even where there is a net positive national co-benefit**. For example, while a national level analysis may show that the economic and employment impacts of climate policies are positive, this might hide important differences at the regional or sector level. The new green economic activity and jobs that replace 'brown' (e.g. fossil fuel related) jobs may take place in a different sector or region, leaving substantial negative impacts to be managed locally (and thus nationally). To ensure a 'just transition' it will be necessary to identify the potential losers as energy and economic systems decarbonize, and provide them with the necessary support. Failure to do so will quickly create strong opposition to mitigation policy.

**Turning to the future, what lessons should we draw from the co-benefits experience so far? How can we maximise the chances that co-benefits play a stronger supporting role in stimulating climate ambition?**
As noted above, the interplay between climate ambition and energy security (or perhaps economic security that is reliant on fossil fuel resources) needs further study to understand how energy security can support climate ambition, or how its negative influence can be reduced or neutralized. The limited impact of the health co-benefit needs to be understood so that this potentially powerful driver of climate ambition can be harnessed. More broadly, there needs to be a deeper understanding of whether co-benefits really are a universal enabler of climate ambition (as sometimes seems to be claimed), or whether in fact this only happens in countries with specific conditions, at certain points in their development. If it seems probable in certain countries that the sum of important co-benefits and negative impacts is sufficiently net positive to encourage greater ambition, then the various challenges that have been observed to hinder policy impact need to be systematically addressed. Many of these – whether relating to policy coherence within governments, or political economy challenges more broadly – are relevant to the wider mitigation challenge as well. Some specific recommendations that draw on the experience of the case studies, and the wider literature reviewed in this paper, include:

- Include consideration of broader impacts (co-benefits and negative impacts) in policy assessments from as early as possible, at an appropriate and practical level of analytical rigour;
- Conduct a broad scan of potential impacts to help identify important co-benefits and negative impacts;
- Then focus on the key impacts to develop stronger evidence, also considering focusing more on those issues which attract greater political importance;
- Consider both national and sub-national scales and also sectoral effects to ensure the aggregate picture does not hide specific groups who might lose out (through negative impacts such as job losses);
- Make use of ‘policy windows’ and have analysis ready at key moments and to contribute to key policy development processes (such as the development of future NDC iterations);
- Maximise ease of communication of findings to help politicians use the results to engage broader political support and embrace flexible use of different co-benefits at different times;
- Provide proactive as well as reactive co-benefits evidence (e.g. evidence about employment impacts can be used to provide reassurance if stakeholders are concerned about potential job losses);
- Try to work across silos within government to avoiding missing important policy synergies between departmental objectives;
- Enlist support from credible messenger groups to build interest and engagement (e.g. the UK medical community emphasizing the importance of the links between climate change (mitigation and adaptation) and public health).

# 6. References

AEA, 2008 - Optimising delivery of carbon reduction targets: integrating air quality benefits using the UK MARKAL model, AEA Energy & Environment for Defra, November 2008

AEA, 2010 - Future Value of Carbon Abatement Technologies in Coal and Gas Power Generation to UK Industry, AEA for DECC, March 2010

Aether, 2016 - Scoping study on the co-benefits and possible adverse side effects of climate change mitigation: Final report, Aether for DECC/BEIS, June 2016 (not published until Nov 2018)

Alkon and Wang, 2017 – Pollution Lowers Support for China's Regime: Quasi-Experimental Evidence from Beijing, Alkon M and Wang E, Journal of Politics, August 2017

Ambition to Action, 2017 – NDC Update Report November 2017, ECN part of TNO and New Climate Institute, November 2017

Aunan et al, 2007 - Aunan K., Berntsen T., O'Connor D., Persson T.H., Vennemo H., Zhai F. Benefits and costs to China of a climate policy. Environment and Development Economics 12:471-497, 2007

Aunan et al, 2018 – Aunan K, Halskov Hansen M, Wang S, Introduction: Air Pollution in China, The China Quarterly Special section: Human Dimensions of Air Pollution in China, Volume 234, June 2018

Averchenkova et al, 2016 - Climate policy in China, the European Union and the United States: main drivers and prospects for the future – in depth country analyses, Alina Averchenkova, Samuela Bassi, Keith Benes, Fergus Green, Augustin Lagarde, Isabella Neuweg and Georg Zachmann. Policy paper, Centre for Climate Change Economics and Policy Grantham Research Institute on Climate Change and the Environment in collaboration with Bruegel and scholars at the Center on Global Energy Policy at Columbia University's School of International and Public Affairs, December 2016

Cai et al, 2018 - The Lancet Countdown on PM2·5 pollution-related health impacts of China's projected carbon dioxide mitigation in the electric power generation sector under the Paris Agreement: a modelling study, Cai W, Hui J, Wang C, Zheng Y, Zhang X, Zhang Q, Gong P, Lancet Planet Health 2018 2: e151–61, April 2018

CAT, 2019 – Climate Action Tracker, Country Rankings, as at June 2019. https://climateactiontracker.org/countries/

CCC, 2008. Letter from the Chair of the Committee on Climate change providing Interim advice by the Committee on Climate Change, October 2008 https://www.theccc.org.uk/wp-content/uploads/2013/03/Interim-report-letter-to-DECC-SofS-071008.pdf

CCC, 2018 - An independent assessment of the UK's Clean Growth Strategy: From ambition to action, Committee on Climate Change, January 2018

CCICED, 2009 - China Council for International Cooperation on Environment and Development, China's Pathway Towards a Low Carbon Economy, CCICED Policy Research Report 2009, November 2009 http://www.cciced.net/ccicedPhoneEN/Events/AGMeeting/2009_3973/meetingplace_3974/201609/P020160922381047979521.pdf

Chang et al, 2017 - Ancillary health effects of climate mitigation scenarios as drivers of policy uptake: a review of air quality, transportation and diet co-benefits modeling studies, Kelly M Chang, Jeremy J Hess, John M Balbus, Jonathan J Buonocore, David A Cleveland, Maggie L Grabow, Roni Neff, Rebecca K Saari, Christopher W Tessum, Paul Wilkinson, Alistair Woodward and Kristie L Ebi, Environmental Research Letters, October 2017

Cohen et al, 2016 - Lessons from co-impacts assessment under the Mitigation Action Plans and Scenarios (MAPS) Programme, Brett Cohen, Emily Tyler and Marta Torres Gunfaus, Climate Policy, November 2016

Dai et al, 2015 - Green growth: The economic impacts of large-scale renewable energy development in China, Applied Energy, January 2016

Defra, 2010 - Air Pollution: Action in a Changing Climate. Department for Environment, Food and Rural Affairs, March 2010

Defra, 2013 - Climate Change Evidence Plan 2013-18, March 2013
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/221074/pb13912-evidenceplan-climate-change.pdf

Defra, 2015 – Project Description - Sustainable Pathways to Low Carbon Energy (SPLiCE) Phase 1, 2015
http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=19040

Delbeke and Vis, 2015 – EU Climate Policy Explained, Edited by Jos Delbeke and Peter Vis, 2015
https://ec.europa.eu/clima/sites/clima/files/eu_climate_policy_explained_en.pdf

Deng et al, 2017 – Co-benefits of greenhouse gas mitigation: a review and classification by type, mitigation sector, and geography; Hong-Mei Deng, Qiao-Mei Liang, Li-Jing Liu and Laura Diaz Anadon. Environmental Research Letters, December 2017

European Commission, 2001 – European Commission, Research Directorate-General, Press Release 'New research reveals the real costs of electricity in Europe', July 2001

European Commission, 2005 – European Commission, Winning the Battle Against Global Climate Change, COM(2005) 35 final, February 2005

European Commission, 2007 – European Commission, Limiting Global Climate Change to 2 degrees Celsius - The way ahead for 2020 and beyond, COM(2007) 2 final, January 2007

European Commission, 2007b – European Commission, Impact Assessment accompanying communication on Limiting Global Climate Change to 2 degrees Celsius - The way ahead for 2020 and beyond, SEC(2007) 8, January 2007

European Commission, 2008 – European Commission, Impact Assessment accompanying Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020, SEC(2008) 85, Volume 1 and Volume 2 (Annex), February 2008

European Commission, 2011 – European Commission, A Roadmap for moving to a competitive low carbon economy in 2050, COM(2011) 112 final, March 2011

European Commission, 2014 – European Commission, A policy framework for climate and energy in the period from 2020 to 2030, COM(2014) 15 final, January 2014

European Commission, 2014b – European Commission, European Energy Security Strategy, COM(2014) 330 final, May 2014

European Commission, 2016 – European Commission, Policy-induced energy technological innovation and finance for low-carbon economic growth, prepared for DG Energy by Radboud University, Cambridge Econometrics, Trinomics and NTUA, July 2016

European Commission, 2018 – European Commission, A Clean Planet for - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, COM(2018) 773 final, November 2018

EEA 2006 – Air quality and ancillary benefits of climate change policies; European Environmental Agency Technical report, 2006

EmployRES, 2009 - The impact of renewable energy policy on economic growth and employment in the European Union; Summary of the results of the Employ-RES research project conducted on behalf of the European Commission DG Energy and Transport, April 2009

Engels, 2018 - Understanding how China is championing climate change mitigation, Engels, Anita. Palgrave Communications, 2018

Environmental Audit Committee, 2007. House of Commons Environmental Audit Committee 'Beyond Stern: From the Climate Change Programme Review to the Draft Climate Change Bill' Seventh Report of Session 2006–07, July 2007

Friends of the Earth, 2017 – Online account of the Big Ask Campaign. Published August 2017 https://friendsoftheearth.uk/climate-change/big-ask-how-you-helped-make-climate-change-history

GEI, 2017 – Global Environmental Institute, China's Involvement in Coal-Fired Power Projects along the Belt and Road, May 2017

Government of China, 2015 – China's Intended Nationally Determined Contribution, June 2015

Government of India, 2008 – National Action Plan on Climate Change, Prime Minister's Council on Climate Change, 2008

Green and Stern, 2016 - Green, Fergus and Stern, Nicholas. China's changing economy: implications for its carbon dioxide emissions. Climate Policy, 2016

Guardian, 2011a - Vince Cable and Chris Huhne clash over carbon emissions. May 2011. https://www.theguardian.com/politics/2011/may/09/vince-cable-chris-huhne-carbon-emissions

Guardian, 2011b - George Osborne vows UK carbon emissions cuts will not lead Europe. October 2011. https://www.theguardian.com/environment/2011/oct/03/osborne-uk-carbon-emissions-europe

Hamilton et al, 2017 – Multiple benefits from climate change mitigation: assessing the evidence, Kirk Hamilton, Milan Brahmbhatt, Jiemei Liu, Grantham Institute Policy Report, November 2017

Harrison and Kostka, 2012- Manoeuvres for a Low Carbon State: The Local Politics of Climate Change in China and India, Harrison T and Kostka G, June 2012

HM Treasury, 2018 – The Green Book: Central government guidance on appraisal and evaluation, HM Treasury, 2018

Institute for Government, 2012 - THE "S" FACTORS: Lessons from IFG's policy success reunions, Case Study on the Climate Change Act
https://www.instituteforgovernment.org.uk/sites/default/files/publications/The%20S%20Factors.pdf

IEA, 2018 – World Energy Outlook 2018, International Energy Agency

IPCC, 2018 - Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C, IPCC, October 2018

IRENA, 2018 - Renewable Energy Prospects for the European Union. Based on REmap analysis conducted by the International Renewable Energy Agency in co-operation with the European Commission. February 2018

Jack and Kinney 2010 - Health co-benefits of climate mitigation in urban areas, Darby W Jack and Patrick L Kinney, Current Opinion in Environmental Sustainability, June 2010

LCICG, 2011-17 – Technology Innovation Needs Assessment Programme, Low Carbon Innovation Coordination Group, 2011-17. https://www.gov.uk/guidance/energy-innovation-evidence-the-low-carbon-innovation-co-ordination-group

Leung et al, 2014 - Leung, G. CK., Cherp, A., Jewell, J., & Wei, Y-M. Securitization of energy supply chains in China. Applied Energy, 2014

Lo, 2015 – Challenges to the development of carbon markets in China, Alex Y. Low, Climate Policy, January 2015

Markyanda et al, 2018 - Health co-benefits from air pollution and mitigation costs of the Paris Agreement: a modelling study, Markandya A, Sampedro J, Smith SJ, Van Dingenen R, Pizarro-Irizar C, Arto I, González-Eguino M, The Lancet Planetary Health, March 2018

Mayrhofer and Gupta, 2015 – The science and politics of co-benefits in climate policy, Jan P. Mayrhofer, Joyeeta Gupta, Environmental Science and Policy, November 2015

Nemet et al, 2010 - Implications of incorporating air-quality co-benefits into climate change policymaking. G F Nemet, T Holloway and P Meier, Environmental Research Letters, January 2010

Remais et al, 2014 - Remais JV, Hess JJ, Ebi KL, Markandya A, Balbus JM, Wilkinson P, Haines A, Chalabi Z. Estimating the health effects of greenhouse gas mitigation strategies: addressing parametric, model, and valuation challenges. Environmental Health Perspectives, May 2014

Ricardo-AEA, 2013 - Review of the impacts of carbon budget measures on human health and the environment. Report for the Committee on Climate Change. July 2013

Ricardo, 2017 - UK business opportunities of moving to a low carbon economy, Ricardo Energy & Environment for the Committee on Climate Change, March 2017

RCEP, 2000 – 'Energy – The Changing Climate', Royal Commission on Environmental Pollution, Twenty-Second Report, June 2000

Sandalow, 2018 – Guide to Chinese Climate Policy 2018, Sandalow D, Columbia University Centre on Global Energy Policy, July 2018

Skjærseth, 2016 - Linking EU climate and energy policies: policy-making, implementation and reform, Jon Birger Skjærseth, International Environmental Agreements: Politics, Law and Economics, August 2016

Steinhardt and Wu, 2016 – Steinhardt HC and Wu F, In the Name of the Public: Environmental Protest and the Changing Landscape of Popular Contention in China, The China Journal, January 2016

Stern, 2006 - The Economics of Climate Change: The Stern Review, October 2006

Teng and Jotzo, 2014 – Reaping the Economic Benefits of Decarbonization for China, Teng F and Jotzo F, CCEP Working Paper 1413. Crawford School of Public Policy, The Australian National University, August 2014

Toth et al, 2014 - How can renewables and energy efficiency improve gas security in selected Member States? Issue Paper from the Towards2030-dialogue project, Borbála Tóth, Adrienn Selei, László Szabó, Péter Kaderják (REKK), Jaap Jansen, Piet Boonekamp, Bronia Jablonska (ECN), Gustav Resch, Lukas Liebmann (TU Wien / EEG), Mario Ragwitz, Sibylle Braungardt (Fraunhofer ISI), October 2014

The White House, 2014 - U.S.-China Joint Announcement on Climate Change, 12 November 2014 https://obamawhitehouse.archives.gov/the-press-office/2014/11/11/us-china-joint-announcement-climate-change

UKERC, 2018 – UK Energy Research Centre Research Report 'The Security of UK Energy Futures', Jim Watson, Ioanna Ketsopoulou, Paul Dodds, Modassar Chaudry, Simon Tindemans, Matt Woolf and Goran Strbac, March 2018

UK Government, 2003 – Energy White Paper 'Our energy future – creating a low carbon economy', Department for Trade and Industry, February 2003

UK Government, 2007 – Impact Assessment of the Climate Change Bill, Department for the Environment, Food and Rural Affairs, November 2007

UK Government, 2009 – The UK Low Carbon Transition Plan – National strategy for climate and energy, July 2009

UK Government, 2011 – The Carbon Plan: Delivering our low carbon future, December 2011

UK Government, 2017 – The Clean Growth Strategy – Leading the way to a low carbon future, October 2017

UK Government, 2018 – web page publishing Aether co-benefits study, November 2018 https://www.gov.uk/government/publications/climate-change-mitigation-the-co-benefits-and-possible-adverse-side-effects

UK Government, 2018b - BEIS PUBLIC ATTITUDES TRACKER Wave 26: Questions on Renewable Energy, Shale Gas, Clean Growth and Consumer Markets, August 2018

UK Government, 2018c – UK Energy In Brief 2018, July 2018 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/728374/UK_Energy_in_Brief_2018.pdf

UKHACC, 2018 – UK Health Alliance on Climate Change, letter to the UK Prime Minister calling for net zero emissions target, November 2018
http://www.ukhealthalliance.org/wp-content/uploads/2018/11/UKHACC-net-zero-letter-no-signatures-final-2.pdf

UK Parliament, 2008 – Record of House of Commons debate about aspects of the Climate Change Bill, 28 October 2008. https://publications.parliament.uk/pa/cm200708/cmhansrd/cm081028/debtext/81028-0008.htm

Ürge-Vorsatz et al, 2014 - Measuring the Co-Benefits of Climate Change Mitigation, Diana Ürge-Vorsatz, Sergio Tirado Herrero, Navroz K. Dubash, and Franck Lecocq; Annual Review of Environment and Resources, October 2014

von Stechow et al, 2015 – Integrating Global Climate Change Mitigation Goals with Other Sustainability Objectives: A Synthesis. Christoph von Stechow, David McCollum, Keywan Riahi, Jan C. Minx, Elmar Kriegler, Detlef P. van Vuuren, Jessica Jewell, Carmenza Robledo-Abad, Edgar Hertwich, Massimo Tavoni, Sevastianos Mirasgedis, Oliver Lah, Joyashree Roy, Yacob Mulugetta, Navroz K. Dubash, Johannes Bollen, Diana Urge-Vorsatz, Ottmar Edenhofer. Annual Review of Environment and Resources, September 2015

Wood Mackenzie, 2018 – 'Chinese shale gas production will almost double in two years', April 2018. https://www.woodmac.com/news/editorial/chinese-shale-gas-production-will-almost-double-in-two-years/

Workman et al, 2018a – The Political Economy of Health Co-Benefits: Embedding Health in the Climate Change Agenda, Annabelle Workman, Grant Blashki, Kathryn J. Bowen, David J. Karoly and John Wiseman, International Journal of Environmental Research and Public Health, April 2018

Workman et al, 2018b – Health co-benefits and the development of climate change mitigation policies in the European Union; Annabelle Workman, Grant Blashki, Kathryn J. Bowen, David J. Karoly & John Wiseman, Climate Policy, October 2018

Zhang, 2015 - Rethinking China's Low-Carbon Strategy, Le-Yin Zhang, January 2015