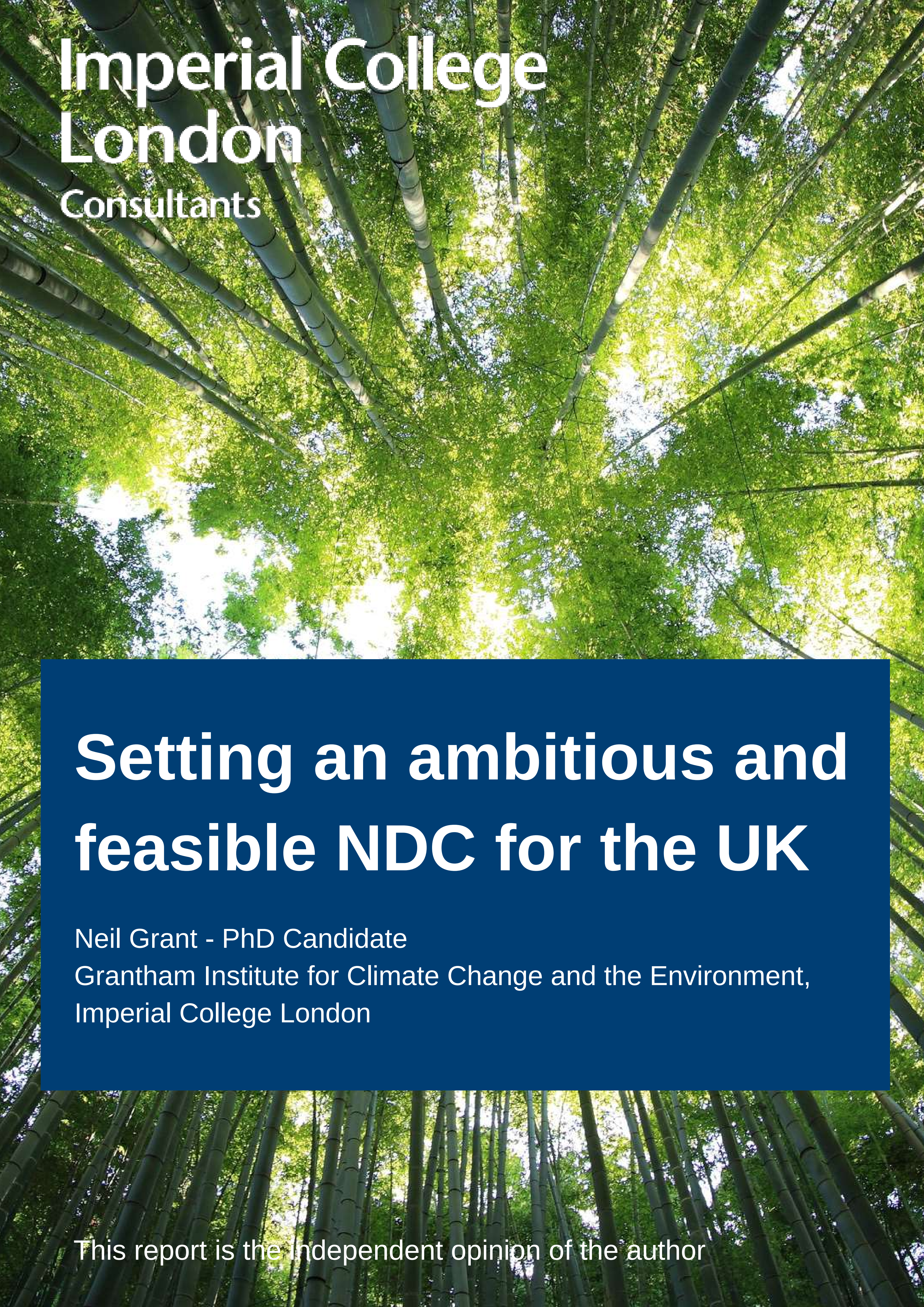

Imperial College London
Consultants

Setting an ambitious and feasible NDC for the UK

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This report is the independent opinion of the author

Contents

1. Summary

Now that the UK is leaving the EU, it must submit its own NDC to the Paris Agreement. This represents a key opportunity for the UK to demonstrate global leadership in the run up to COP26, which will be a critical element of building diplomatic momentum for a successful summit in Glasgow in 2021. It is therefore essential that the UK's NDC represents a high level of ambition.

WWF commissioned Neil Grant from Imperial College London, working independently via Imperial Consultants, to provide analysis on an appropriate level of ambition for the UK's NDC. Three key work packages were identified:

- WP1: A literature review of existing analysis, to suggest the range within which domestic emission reductions in the UK's NDC should fall.
- WP2: A brief feasibility analysis, to identify a level of domestic emissions reduction which is evidence-based while also representing a high level of ambition.
- A consideration of the UK's 'fair share' of global mitigation (written by WWF).

The report recommends that WWF campaign for an NDC that aims for **at least 71.5% emissions reduction domestically relative to 1990 levels,** including international aviation and shipping emissions, and accounting for incoming changes to the land-use, land-use change and forestry (LULUCF) inventory for peatland emissions. The UK can reduce its domestic emissions to 239MtCO_2e in 2030. This is in line with **halving the UK's emissions in the next 10 years.** In order to ensure that the UK is contributing it's fair share to the global effort, this domestic target should be accompanied with **specific and ambitious efforts to support emissions reductions overseas** for countries with much lower historical carbon footprints and lower capacity to transition quickly to a zero carbon economy. These support measures should include capacity building, technology transfer and climate finance, among other actions. This report is the independent expert opinion of the author, and any views expressed herein cannot be attributed to Imperial College itself.

2. WP1: Literature Review

a) Summary

Since the publication of 'Keeping it Cool' by WWF in 2018, a range of analysis has explored how the UK could reduce its territorial emissions to contribute to the Paris Agreement. None of these analyses have focused specifically on the appropriate level of ambition for a UK NDC, but they provide some context on what UK greenhouse gas emissions could look like in 2030.

These analyses often have different focuses and use different methods to explore how the UK can reduce emissions. Making comparisons between them is therefore not simple. However, we can broadly categorise them into analyses that account (to some extent) for differences in responsibility and capacity between nations, and those that do not. Analyses that make this distinction consider the UK's cumulative emissions on the path to net-zero and limit this based on some consideration of differentiated national circumstances – e.g. the fact that the UK has a large historical responsibility for climate change, and has a greater capacity than many nations to reduce emissions. We term these analyses 'budget-constrained' scenarios. Analyses that don't make this distinction are not concerned with cumulative emissions from the

UK on the path to net-zero and don't consider whether the remaining carbon budget for the rest of the world might be fair or feasible.

The reports assessed in this literature review are summarised in Table 1. Overall, publications assessed in the literature give a range of possible NDCs from a 56% reduction relative to 1990 levels (below the existing 5th Carbon Budget), to reaching net-zero by 2030 with a 100% reduction in emissions. Accounting for differences in responsibility/capacity between nations suggests that the UK's NDC should generally target emissions reductions in the higher range of 75+% (emissions reduction from 1990 levels). Ignoring these differences leads to a lower NDC, between a 56% and 69% reduction in emissions below 1990 levels.

This literature review does not focus on the UK's 'fair share' contribution to the global mitigation effort based on formal effort-sharing mechanisms. These approaches use various applications of principles of fairness to allocate a global carbon budget or emissions pathway between countries. For example, the [Civil Society Equity Review] applies the globally agreed principles of **common but differentiated responsibility** and **respective capability to** demonstrate that developed economies need to support developing countries to attain better standards of living through pursuing low-carbon development pathways.

These studies were not considered here as they focus on an equitable distribution of mitigation, without considering pathways to achieving this goal. The UK is the fifth largest historical contributor to greenhouse gas emissions and has the 23rd highest GDP per capita in the world. As such, it has a 'fair' share of global mitigation greater than what is feasible domestically. These 'fair share' analyses highlight a central issue, that the UK's role in global climate action cannot be confined to domestic action alone, but do not provide actionable information on the level of domestic emissions reduction which would be appropriate (beyond a general principle of ambition maximisation). In the literature review only Pye et al (2017) consider effort-sharing mechanisms within their analysis, and only apply one equity-based allocation scheme.

The UK's NDC must include not only the greatest domestic emissions reduction that is feasible, but a credible and coherent set of initiatives that will support emissions reduction in in the Global South. By providing resources for developing nations to reduce their emissions the total UK contribution would be greater than 100% of its own emissions and in line with an equitable response to the climate change challenge. See Section 4 from WWF for more detail on the UK's 'fair share'.

b) Existing literature on domestic emissions in a possible UK NDC

The UK's 5th Carbon Budget legislates for a 57% reduction in emissions by 2030, relative to 1990 levels. This is measured by the net carbon account, a particular accounting methodology that estimates the UK's share of the EU ETS, and so does not correspond exactly to the UK's territorial emissions. Converting to consider UK emissions, the 5th Carbon Budget requires a 61% reduction in territorial emissions by 2030. If international aviation and shipping are included in this target, then it is reduced to ~58%. The 5th Carbon Budget was set before the UK legislated for net zero emissions by 2050, and as such an NDC which is compatible with net-zero will have to be greater than 58%. Reports which assume that the UK will reduce emissions in line with the 5th Carbon Budget on the way to net zero emissions, such as Innovating to Net Zero (Energy Systems Catapult, 2020), are therefore not included in this analysis.

The National Grid's Future Energy Scenarios (FES) provided three different pathways to net-zero: System Transformation, Consumer Transformation and Leading the Way. These scenarios are all compatible with net-zero emissions by 2050, but do not consider the UK's cumulative emissions on the path to net-zero. Emissions in 2030 are 56-63% below 1990 levels (including international aviation and shipping). WP3 takes the FES scenario 'Leading the Way' as the basis for further analysis.

Pye et al (2017) explore how the UK could reach net-zero emissions using an energy system model, UKTM. Taking a global carbon budget of 590GtCO_2 from 2015 (which is commensurate with limiting warming to 1.5°C with >50% likelihood (Rogelj *et al.*, 2018)), they distribute this to the UK either based on current emission shares (590Inertia), or by ensuring that all nations converge to an equal cumulative emissions per capita across the century (590Equity)[1]. The first scenario does not account for the UK's historical responsibility for climate change, and thereby gives the UK a larger share of the global carbon budget than the second scenario, 590Equity. This more constrained scenario leads to emissions reductions of 82% relative to 1990 levels in 2030 but is on the boundary of feasibility in the model, with 70% of model simulations failing to solve. This analysis considered only energy-sector CO_2, and so assumptions had to be made around non-CO_2 emissions to calculate an NDC (see methodology).

Pye et al (2019) use a global integrated assessment model to explore how the UK, along with a number of other countries, could take a lead on early decarbonisation as part of an 'early movers' group. This would release more of the remaining carbon budget to allow nations in the Global South the space needed to transition to a zero-carbon future without compromising developmental aspirations in the short term. This was done by taking the cost-optimal allocation of a global carbon budget[2], and then rebalancing it so that the budget assigned to the 'early movers' is reduced by a certain %. Without any budget rebalancing, the UK reduces emissions by 69% relative to 1990 levels for a global scenario that limits warming to 1.75°C. With the budget of the 'early movers' reduced by 40%, the UK reduces emissions even faster, with the 2030 implied NDC rising to 82%. Again, the feasibility of such a rate of emissions reduction was highlighted as a challenge by the modelling.

Anderson et al (2020) explore how the rate of emissions reduction from 'climate progressive' nations need to be urgently increased. Focusing only on energy sector CO_2 emissions, they allocate a global carbon budget of 716GtCO_2 between different nations. They assume that developing countries will be able to, at most, reach peak emissions in 2025, and thereafter reduce emissions at an increasing rate towards a maximum of 10%/year. This is already a highly ambitious pathway but leaves only 94-135GtCO_2 for all developed nations. Translating this into a UK emissions reduction pathway suggests that the UK should be reducing CO_2

[1] Note that this approach is only a limited application of principles of fairness as it considers historical responsibility for climate change (cumulative emissions converge over the time horizon), but does not consider the capacity to reduce emissions, as other allocation schemes such as greenhouse gas development rights (van den Berg *et al.*, 2019) would do.

[2] It is important to note that cost-optimising models, as a general rule, do not incorporate principles of fairness as they fail to recognise that while many of the economically cheapest mitigation options are in developing nations, these are exactly the countries that do not have the resource to access them, nor the historical responsibility to take action first. Hence the need in Pye et al (2019) to further constrain the regional distribution of mitigation in a cost-optimising model to account for regional differences to some extent.

emissions by 10-13%/year from 2020 onwards. Making assumptions around the rate of non-CO_2 emissions reduction converts this into an NDC of *at least* 75% reduction relative to 1990 levels in 2030 (which could be increased, depending on the rate of non-CO_2 emissions reductions). Anderson et al. do not conduct detailed analysis into how such an emissions reduction could be achieved, however.

Author	Scenario	Budget constrained?	Implied NDC
National Grid (2020)	System Transformation	No	56%
National Grid (2020)	Consumer Transformation	No	60%
Pye et al (2017)	590Inertia	No	61%
National Grid (2020)	Leading the Way	No	63%
Pye et al (2019)	1.75°C Scenario – No Rebalancing	No	69%
Anderson et al (2020)	10%/y emissions reduction rate	Yes	75%
Anderson et al (2020)	13%/y emissions reduction rate	Yes	80%
Pye et al (2017)	590Equity	Yes	82%
Pye et al (2019)	1.75°C Scenario – Rebalancing Budget by 40%	Yes	82%
CAT (2019)	Zero Carbon Britain	Yes	100%

Table 1
This shows a range of reports which were considered by the author to help inform the appropriate level of an NDC.

Finally, the Centre for Alternative Technology's report, *Zero Carbon Britain: Rising to the Climate Emergency*, suggests that the UK should reach net-zero emissions by 2030 (Centre for Alternative Technology, 2019). Residual emissions in 2030 are 47MtCO_2e, which are balanced by LULUCF sinks to reach net-zero. To reach this level of emissions in 2030 requires a pace of action which will likely cross the boundary of feasibility in many areas, e.g. requiring 140GW of offshore wind by 2030, more than triple the current target.

In summary, the sources assessed above indicates that a UK NDC should target domestic emission reductions at least in the region of 70%, as even scenarios which don't consider the UK's unique responsibility for and capacity to reduce GHG emissions can suggest emissions reductions approaching this level. However, the sources also demonstrate the challenges of reducing emissions by 75+%, with scenarios either being at the bounds of modelling feasibility(Pye *et al.*, 2017, 2019), or requiring highly ambitious assumptions that could be challenged (Centre for Alternative Technology, 2019). This suggests that a detailed bottom-up analysis is required to further establish an ambitious, but feasible, rate of emissions reduction, which WP3 performs. This also suggests that the UK needs to contribute to emissions reductions elsewhere to contribute its fair share of the global effort to keep warming well below 2°C, aiming for 1.5°C.

c) Methodology

Following the CCC's advice that international aviation and shipping should be including in formal carbon budgets (CCC, 2019a), we include international aviation and shipping emissions in all NDCs.

Some of the reports assessed did not consider all the UK's greenhouse gas emissions but focused on CO_2 emissions from the energy sector (Pye et al., 2017; Anderson, Broderick and Stoddard, 2019). For these scenarios, emissions from agriculture and land-use, as well as non-CO_2 emissions, had to be added to determine an NDC. In the absence of other information, we assumed a linear trajectory between emissions in 2018 (BEIS, 2020), and emissions in 2050 as contained in the CCC's Further Ambition scenario, which achieves a 96% reduction in emissions relative to 1990 levels (CCC, 2019b). In reality the rate of emissions reduction for non-CO_2 greenhouse gases could be greater than this, which would increase the ambition of the calculated NDC. However, this approach is in keeping with the approach used by other recent reports (National Grid, 2020). For further detail on the individual scenarios, and any calculations performed to understand the NDC implications of the scenario, see the accompanying spreadsheet for WP1.

3. WP2: A technically feasible rate of domestic emissions reduction for the 2020s

a) Summary

The literature review conducted in WP1 found a range of proposed domestic emission reductions for 2030 in the literature, with the majority in the range of 60-80%. Analyses that constrain the UK's future carbon budget on the basis of the differentiated responsibilities/capabilities of nations suggest that the NDC should be to the higher end of this range, but highlight the substantial challenges involved with reducing emissions at this rate.

To help inform WWF on an appropriate level of ambition for domestic emission reductions in a UK NDC, a brief analysis was carried out. This took the National Grid's FES scenarios as a basis, to make use of the very detailed outputs from this modelling. Using the 'Leading the Way' scenario, which reduces emissions 63% in 2030 relative to 1990 levels, the analysis identified a credible and feasible set of 'ambition increments' which can further reduce emissions in 2030, and quantified their impact. This new scenario is termed the Higher Ambition scenario.

This analysis suggests that the UK can reduce its territorial emissions **by at least 71.5% relative to 1990 levels in 2030,** including international aviation and shipping emissions, and accounting for incoming changes to the LULUCF inventory for peatlands. UK emissions in 2030 in this Higher Ambition scenario are 239MtCO_2e. For comparison, this is **less than half of 2019 emissions levels** (which were 502MtCO_2e when aviation, shipping and peatland emissions are included), and is 28.5% of 1990 emissions, which were 839MtCO_2e on the same basis**.** The list of ambition increments covered was non-exhaustive, and so further emissions reductions by 2030 could be achieved. As such, this report recommends that WWF campaign for a target of *at least* 71.5% domestic emissions reduction relative to 1990 levels, leaving open the possibility of increased action should the evidence base improve.

The analysis shows that the UK can reduce domestic emissions by 50% across this decade while ensuring sufficient electricity supply to meet demand. This could occur while also reducing demand for bioenergy by at least 10% across the decade, allowing the UK to meet almost all bioenergy demand via domestic production (although there is uncertainty in the exact extent of bioenergy reduction, which could be greater than 10% in some circumstances). The UK can also reduce its reliance on BECCS compared to the National Grid scenarios, with 25% less capacity in 2030 than in the *Leading the Way* scenario. Further action in other sectors could further reduce reliance on BECCS, which has a range of possible risks and negative side-effects.

b) The ambition increments used in the Higher Ambition scenario

A range of ambition increments are considered to further reduce emissions in 2030 relative to the National Grid's *Leading the Way* scenario. While historically, emissions reduction has been driven predominantly by power sector decarbonisation, in the 2020s, greater action must be taken in the end use sectors. The majority of emissions reduction in the Higher Ambition scenario come from:

- Greater behavioural change to reduce demand, particularly in the agricultural sector and transport sector.
- Greater use of resource efficiency measures to reduce overall demand for products.
- Greater electrification of the end use sectors, driven by faster deployment of electric vehicles and heat-pumps.

These are briefly summarised below.

1. Agriculture and land-use

Enhancing LULUCF sinks and increasing the rate of dietary change could save an additional **23MtCO_2e in 2030**, compared to the National Grid's Future Energy Scenarios.

In *Leading the Way,* AFOLU emissions are assumed to decline on a linear trajectory between 2019 emissions (34MtCO_2e) and a 2050 emissions level of 15MtCO_2e. This 2050 ambition level was taken from published CCC scenarios. In the CCC's Further Ambition scenario, 2050 emissions from agriculture are 26.3MtCO_2e, with a small LULUCF sink of 2.3MtCO_2. Emissions can be further reduced by increased rates of afforestation, or increased rate of dietary change, each of which can reduce emissions down to ~15MtCO_2e. The National Grid must be using *one* of these assumptions to further reduce AFOLU emissions in 2050 – however, it was not clear which assumption is used, as they have equivalent impacts on 2050 emissions (CCC, 2019).

In this analysis, we assume that the National Grid scenarios include the increased rates of afforestation (to 50,000ha/y), but no increased rate of dietary change, forecasting a 20% reduction in per capita meat and dairy consumption by 2050. This assumption affects the breakdown of the 23MtCO_2e into enhanced sinks vs increased dietary change, but it does not affect the overall level of ambition increase, as the two options have an equivalent impact on 2030 emissions for the National Grid scenario.

We then calculated the impact of increased action to enhance LULUCF sinks, as well as a 50% reduction in meat and dairy consumption per capita by 2030. The data used to perform these calculations comes from an existing roadmap for reducing agriculture and land-use emissions by 40% in 2030 (Green Alliance, 2019). The 2030 data from National Grid was corrected to be comparing emissions on a consistent land-use inventory basis (including the incoming updates to peatland emissions), and was then compared to data from the Green Alliance report, altering to include emissions from settlements and increasing the rate of dietary change to a 50% reduction in 2030, beyond that modelled by Green Alliance.

The transition towards a more sustainable food system will provide many opportunities and benefits, but there will also be challenges, particularly for those working in the meat and dairy industry. While the environmental and health benefits of transitioning towards healthy and sustainable diets are well documented, the consequences for food producers, processors, and other workers are less known. It is important to ensure that everyone can access affordable, healthy and sustainable food, while securing a just transition for sectors which could be negatively impacted by dietary change.

2. Transport sector

Greater action to electrify road transport, and to replace car/plane demand with active and public transport could save an additional **19MtCO_2e in 2030**, compared to the National Grid's Future Energy Scenarios.

The ambition increments considered are:

- Bringing forward the ban on internal combustion engines to 2030, from 2032 in *Leading the Way.* The ban applies to PHEVs as well as ICEs. This could save an additional 4.9MtCO_2e in 2030, based on analysis conducted for Greenpeace and Green Alliance. Additional electricity demand was estimated to ensure the scenario was internally consistent.
- Reducing demand for cars by 15% through a combination of a switch to active transport (replacing 6% of car miles through short-distance trips) and public transport (replacing 9% of car miles through a range of short and medium-distance trips) could save an additional 3.25MtCO_2e in 2030. For further details on the exact assumptions made, please refer to the accompanying spreadsheet for WP3.
- Resource efficiency in the production and use of vehicles could save an additional 3.4MtCO_2e in 2030. This includes measures such as the light weighting of vehicles to reduce demand for steel/aluminium and reducing waste in the manufacturing of vehicles.
- Increased deployment of battery electric HGVs in 2030. Although electric HGVs have a lower level of technological readiness than electric cars, the rapid stock turnover in the HGV fleet (a typical HGV might run through its mileage in ~5y, rather than a car

which could last ~15y) can facilitate a faster transition to low-carbon technology. Here we assume that 10% of the fleet can be electrified by 2030, which corresponds to 50,000 electric HGVs on the roads by 2030. This could save an additional 1MtCO_2e compared to *Leading the Way.*

- Finally, we consider a reduction in aviation demand beyond that considered in *Leading the Way*. In the National Grid scenarios, aviation demand in 2050 is limited to 20% growth from 2005 levels, which is equivalent to an 8% decline from pre-Covid levels. This would equate to demand reduction in 2030 of only ~2.5%. We instead assume that demand for international aviation in 2030 is reduced 20% compared to pre-Covid levels and replaced by videoconferencing. Demand for domestic aviation is reduced 75% compared to pre-Covid levels and replaced by rail travel. This saves an additional 6.5MtCO_2e in 2030. Every 10% reduction in international aviation demand saves an additional ~3MtCO_2e in 2030, demonstrating the scope to further reduce the UK's emissions if more ambitious action was taken on demand reduction.

3. Buildings sector

Greater action to transition away from fossil gas to electricity in heating buildings, as well as resource efficiency measures in construction, could save **23MtCO_2e in 2030**, compared to the National Grid's Future Energy Scenarios.

The ambition increments considered are:

- An increased deployment of air-source heat pumps (ASHPs) to decarbonise residential heat. In *Leading the Way*, there are 5m ASHPs in 2030. We increase this to 10m ASHPs, which could save 10.5MtCO_2e in 2030. Achieving 10m ASHPs in 2030 will require a substantial increase in installation rates, as only 27,000 were installed in 2018 (Rosenow *et al.*, 2020). Of these 10m heat pumps, around 2m would go into new-builds by 2030, requiring around 8m homes to be retrofitted with ASHPs by 2030. Although this is a large amount, a plausible diffusion curve could require installation rates in existing homes to reach 500,000/y by 2025, and then ramp up further beyond this.
- There is also increased deployment of air-source heat pumps (ASHPs) to decarbonise commercial heat. In *Leading the Way,* demand for gas heating in commercial buildings only falls 15% across the 2020s. We increase this to a 20% reduction in demand, which requires an additional 1.5m heat-pumps to be installed by 2030, saving 3.2MtCO_2e.
- Finally, we consider a range of resource efficiency in construction measures, which are estimated to save 9.3MtCO_2e in 2030 (Green Alliance, 2018). These include greater use of low-carbon building materials such as timber, and an increase in the reuse of construction materials.

We did not consider the potential for greater levels of energy efficiency in buildings to further reduce emissions in 2030, as it was not clear from the National Grid scenarios what level of action around energy efficiency had been assumed in 2030. Therefore, it would have been difficult to determine what level of emissions reduction would be additional in 2030. However, this again suggests that the 71.5% emissions reduction achieved in the Higher Ambition scenario could plausibly be increased if greater action on energy efficiency measures were possible.

4. Industrial sector

Greater deployment of industrial CCS could save an additional **10MtCO_2e in 2030**, relative to the *Leading the Way* scenario from National Grid.

In *Leading the Way*, there is minimal deployment of CCS in industry by 2030, with only 0.05MtCO_2e being captured in 2030. This is to prevent double investment, as industry is decarbonised entirely using electricity and hydrogen. This however, contravenes existing Government plans to deploy CCS at industrial clusters, and the recommendations of the CCC, who suggest that at least 10MtCO_2e should be being stored by 2030 (CCC, 2018).

In the Higher Ambition scenario, we simply assume that the CCC's recommendations are carried out, and that 10MtCO_2 is captured and stored from industrial clusters by 2030. This does not preclude a future in which industry is still predominantly decarbonised via electricity and hydrogen (10MtCO_2 is only ~15% of current UK manufacturing emissions), but acknowledges that CCS will likely be required to play some role in industrial decarbonisation, and should therefore be deployed by 2030 to reduce emissions from fossil fuel use.

5. Consumer action

In the Higher Ambition scenario, we include greater action on resource efficiency in the consumption of electronics and clothing/textiles. This has been estimated to save an additional **2.6MtCO_2e** in 2030 (Green Alliance, 2018).

6. Power sector

Many of the actions summarised above lead to an increase in electricity demand in 2030. Electricity demand in 2030 is up by 33TWh compared to the *Leading the Way scenario.* Achieving ambitious emissions reductions in the 2020s relies heavily on expanding the supply of clean electricity. The Higher Ambition scenario produced for WWF achieves this by a range of measures:

- There is increased deployment of variable renewable energy (VRE), with 45GW of offshore wind, 35GW of onshore wind and 45GW of solar PV deployed by 2030. This leads to an additional 50TWh of generation in 2030.
- The Higher Ambition scenario relies less on fossil fuels to provide electricity. While there is still some unabated gas in the power sector, the capacity factor for these plants is very low, and they operate for around 4% of the year, providing 2% of generation. While this is low, they provide critical generation at times of high electricity demand and low VRE supply. In the 2030s, these could be entirely replaced by hydrogen turbines, enabling a fossil-free power sector. However, it is unlikely that by 2030 gas could be entirely replaced by hydrogen turbines, and as such there is some small remaining generation in 2030.
- The Higher Ambition scenario requires no unabated biomass in the power sector at all.
- This scenario has a greater proportion of electricity from variable sources, with 78% of all generation coming from wind and solar, up from 71% in the *Leading the Way* scenario from National Grid. To ensure reliability of supply, a range of measures can be taken including short-term/long-term storage, interconnection to other power systems and demand-side response. In this scenario, there is 21GW of interconnection capacity, 13.5GW of battery storage (which provides storage on the timescale of hours), 2.25GW of compressed air storage, 4.25GW of pumped hydro, and 1GW of hydrogen

turbines, which can all provide long-term storage for electricity, ensuring that demand is reliably met by supply.

- Detailed power sector modelling has not been carried out here, and so the exact levels of additional storage and interconnection capacity, along with demand-side response, might need to be further updated to accommodate 78% variable generation in 2030. However, this is a relatively modest increase from the National Grid scenario of 71% VRE in 2030, and as such the author is confident that this could be achieved, should there be sufficient political will to achieve this goal.

Reducing the reliance on unabated gas in the power sector saves **3.7MtCO_2e in 2030** relative to the *Leading the Way* scenario.

7. Removals sector

Removal of CO_2 from the atmosphere will likely be a key part of achieving global climate goals. Carbon dioxide removal (CDR) should be in *addition* to substantial emissions reductions, rather than as a supplement for emissions reductions. There are many diverse CDR methods, from enhancing natural carbon sinks such as forests, to technological removal methods such as bioenergy with carbon capture and storage (BECCS) and direct air capture (DAC).

The National Grid FES scenarios have been criticised for their large-scale reliance on BECCS, which has a range of risks in terms of increased competition for land and water, impact on vulnerable ecosystems, and uncertainty around the true extent of carbon sequestration from the entire BECCS value chain. In the Higher Ambition scenario, BECCS capacity in 2030 is reduced by 25%, to 2.7GW of BECCS. For illustration, this is less than the capacity of Drax's current biomass facility (3.6GW). Greater action in other areas can help limit reliance on BECCS in achieving an ambitious NDC. The UK could also reach net-zero emissions with limited reliance on BECCS, through a combination of other measures such as demand reduction (Grubler *et al.*, 2018), greater behavioural change (Van Vuuren *et al.*, 2018) or the use of other removal options such as direct air capture (Breyer *et al.*, 2019). The deployment of BECCS in the Higher Ambition scenario should not be seen as a requirement for large-scale and long-term use of BECCS to achieve the UK's climate goals, therefore.

c) Reducing domestic emissions by more than 71.5%

This analysis did not consider all possible means by which UK domestic emissions could be reduced, and as such, the ambition of the UK's NDC could be pushed further if additional action was taken elsewhere.

The most obvious action would be increased action on energy efficiency in both homes and the industrial sector, which is often a neglected component of climate action. Without sufficient information on the assumptions made around energy efficiency in the National Grid scenarios, it was not possible to determine what actions could be taken here which would be *additional* to existing measures in the scenario. To avoid double-counting, these actions were therefore neglected in the analysis. Energy efficiency should be a central plank of any decarbonisation agenda, and it is likely that greater action in this area could further reduce emissions in 2030.

This analysis also did not consider increased use of hydrogen in the end-use sectors prior to 2030, with increased hydrogen deployment confined to the power sector to ensure reliability of supply. Greater use of hydrogen, particularly in industry, could further reduce emissions. However, a central finding of this analysis was that in the 2020s, the availability of low-carbon electricity is a limiting factor on the rate of decarbonisation. Therefore, the energetic cost of decarbonisation, in kWh of additional electricity demand per kgCO_2 saved, is an important metric. Using electricity to produce hydrogen to displace fossil fuels in industry, while an important long-term decarbonisation strategy, ranks poorly on this metric due to the efficiency losses in converting electricity to hydrogen. Large-scale electrolytic hydrogen deployment is likely to be delayed until the 2030s, when sufficient renewable generation is available to drive production.

Other possible levers could include greater levels of demand reduction for aviation and agriculture and a greater modal shift from cars to active/public transport than assumed in this analysis. Most notably, this analysis only considered a modal shift from cars to buses when analysing public transport. Further car use could be shifted onto other modes, particularly trains, which could further reduce road transport emissions and increase the level of ambition in the UK's NDC.

While these measures could enable further reduce emissions, they have not been quantified in this analysis. This suggests that the level of ambition for domestic emissions in the UK NDC *could* be pushed further than the 71.5% emissions reduction produced here. At the same time, the rate of emissions reductions here are already very ambitious, and are limited by the availability of low-carbon electricity generation. Further research would be needed to explore the feasibility of a higher domestic emissions target in the NDC. As such, this report recommends that a UK NDC of *at least* 71.5% domestic emissions reduction below 1990 levels would be appropriate, ensuring a minimum level of ambition while leaving the door open to increased levels of emissions reduction as the evidence base for such actions improves.

4. WWF: Contributing a fair share of the global effort

This final section of the report was written by WWF-UK, and is not the work of Neil Grant, Imperial Consultants or Imperial College London. It is included here for ease of access to the reader, and to provide a complete picture of the analysis conducted for and by WWF-UK.

This report focuses primarily on proposed and feasible domestic emissions reduction pathways for the United Kingdom. However, a discussion of the UK's contribution to tackling climate change cannot be complete without a consideration of the UK's 'fair share' of global mitigation – the level of ambition which could be compatible with different concepts of climate justice.

The Civil Society Equity Review (see Figure 1) illustrates the massive "Ambition Gap" between the level of emissions reductions required to meet the goals of the Paris Agreement, and current NDCs that countries have been submitted to the UNFCCC.

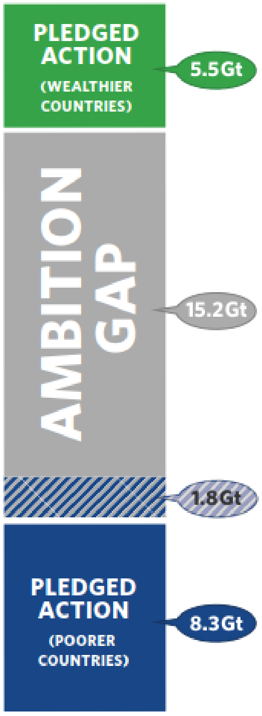

Figure 1 [(Civil Society Equity Review, 2014)](#) Pledged action below baseline projections (mitigation in 2030 below baseline in Gt CO2eq) vs required reductions

This gap in ambition can only be addressed through significantly scaled up cooperation among countries, especially between developed and developing countries. Wealthy countries have much higher capacity to act than others, due to their higher income and wealth, level of development and access to technologies. Most of these same countries have already emitted a great deal for a long time and thrive from the infrastructure and institutions they have been able to set up because of this.

Conversely, 'poorer countries' have domestic mitigation potential far larger than their fair share. By pursuing alternative low-carbon development pathways these countries can realise large emission reductions that help to fill the ambition gap, but they do not have the means to do so on their own. Countries like the UK have to recognise that their own carbon intensive development pathways have removed the opportunity for developing countries to attain higher standards of living using the same approach.

If we are to keep warming to safe levels, while recognising the right to sustainable development for everyone, those countries that have benefited most from carbon intensive development need to help pay for, and deliver, the emissions reduction potential in countries that have used a far smaller share of the global carbon budget to date.

The UK, as the fifth largest historical contributor to greenhouse gas emissions, and with the 23rd highest GDP per capita in the world, has a fair share of the global effort that far exceeds the emission reductions it can deliver domestically. Reducing domestic emissions to zero over the next 30 years cannot balance out more than 170 years of historical emissions.

Therefore, targets for domestic emission reductions in the UK NDC must be accompanied by pledges of climate finance for developing countries and/or commitments to help deliver additional emission reductions in other countries. Christian Aid and other NGOs have provided indicative assessments here for how large the UK's contribution to non-domestic emission reductions could be.

It is important to recognise that these UK contributions to emission reductions in other countries should not become "offsets" misused to justify slower decarbonisation in the UK. These are *additional* emission reductions required over and above the domestic emissions reduction, for the UK to deliver its fair share of the global effort.

The government should also consider how it can maximise the co-benefits of support to developing countries by considering where there are triple wins across climate, social and environmental dimensions. In addition to energy sector transformation nature-based solutions that sequester carbon, protect natural ecosystems and local communities' rights should be considered in this regard.

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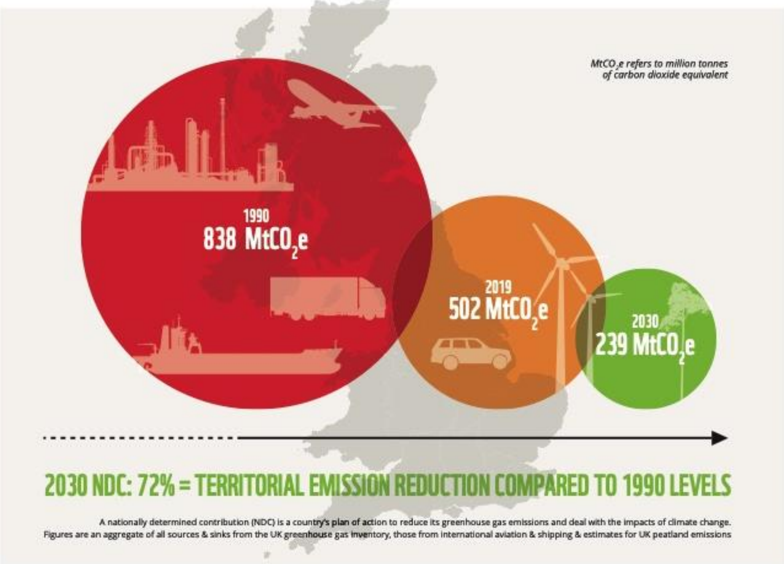
Appendix A1: WWF Infographic

This infographic was produced by WWF to summarise the analysis conducted by Neil Grant and WWF-UK on an ambitious and feasible NDC for the UK.

WWF

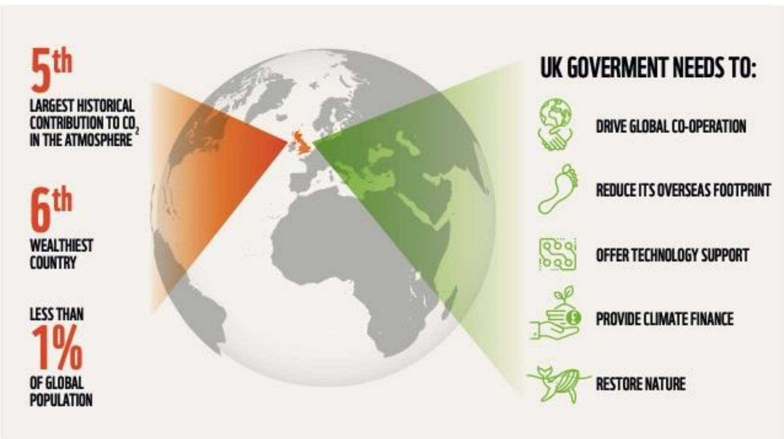
THE UK'S 2030 CLIMATE TARGET TO CUT EMISSIONS AT HOME

The global climate summit in Glasgow 2021 is a unique opportunity for the UK to show bold leadership and set us on the path to the greener, fairer future that we all want. To be credible hosts, it's essential that our government shows world-leading ambition by committing to cutting our emissions by at least 72% by 2030 (including international aviation and shipping) and contributing our fair share to global emission reductions by supporting developing countries to green their economies too.



THE UK'S FAIR SHARE CONTRIBUTION TO CLIMATE ACTION

The UK is historically the fifth-largest contributor to carbon emissions in the atmosphere, despite having less than 1% of the global population. Beyond reducing territorial emissions by 72% by 2030 (including international aviation and shipping), the UK must also recognise its 'fair share' of the global effort needed to achieve the Paris Agreement. As COP26 President, the UK must lead efforts to close the gap between NDCs and what is required to limit global temperature rise to 1.5°C.



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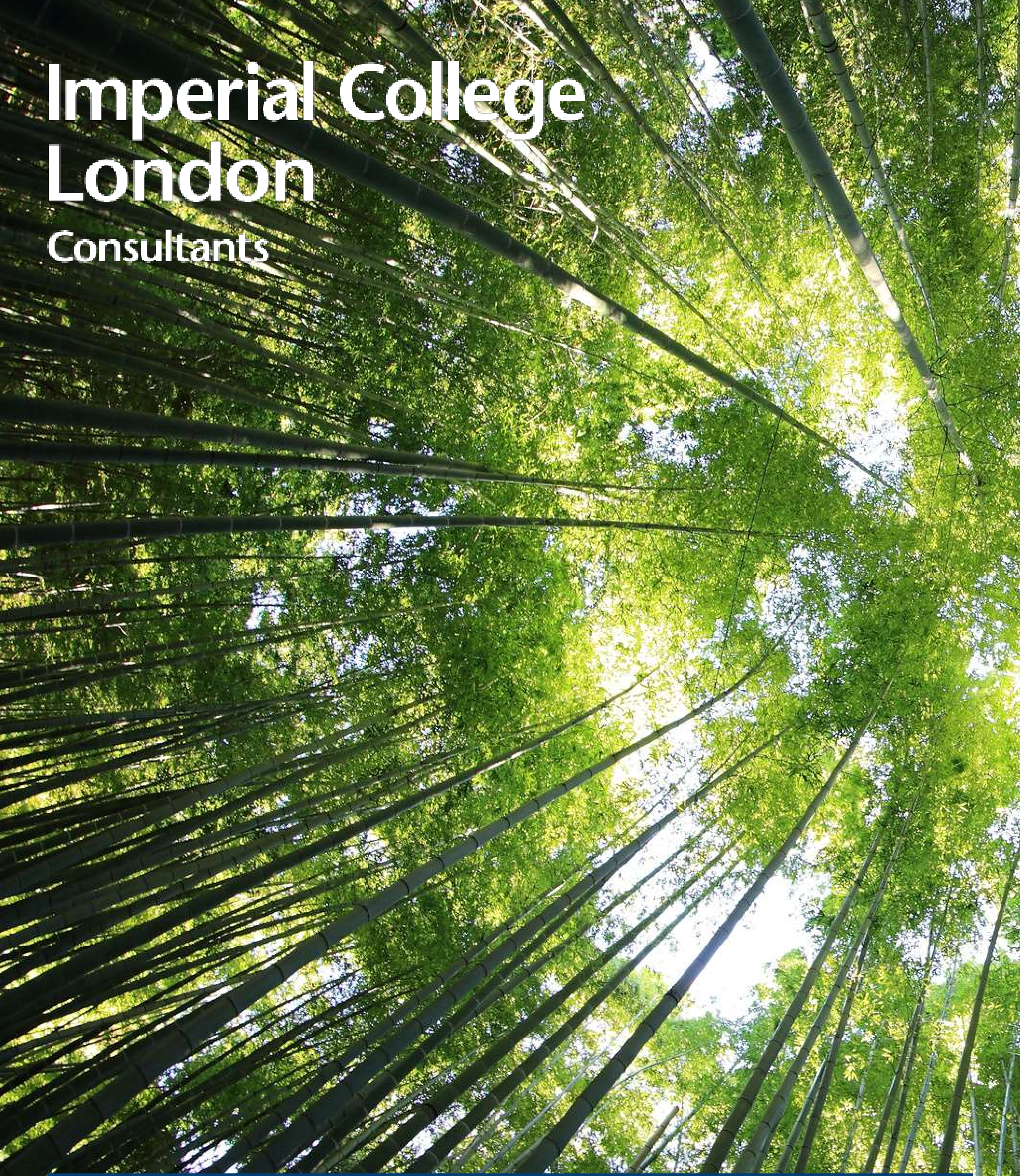

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