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Closing The Carbon Gap: The UK's Progress In Climate Change Mitigation And Increasing Need For Strategic Policy

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CLOSING THE CARBON GAP: THE UK'S PROGRESS IN CLIMATE CHANGE MITIGATION AND INCREASING NEED FOR STRATEGIC POLICY

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The UK has reduced emissions substantially, aiming for an 80% decrease in emissions by 2050. However, a changing energy generation portfolio, growing electricity demand, and wavering political support are forcing the country away from its desired emissions trajectory. By focusing on renewables and nuclear power, efficiency in sectors such as building and transportation, and balance of electricity supply inconsistencies, the UK can meet its ambitious targets.

Introduction

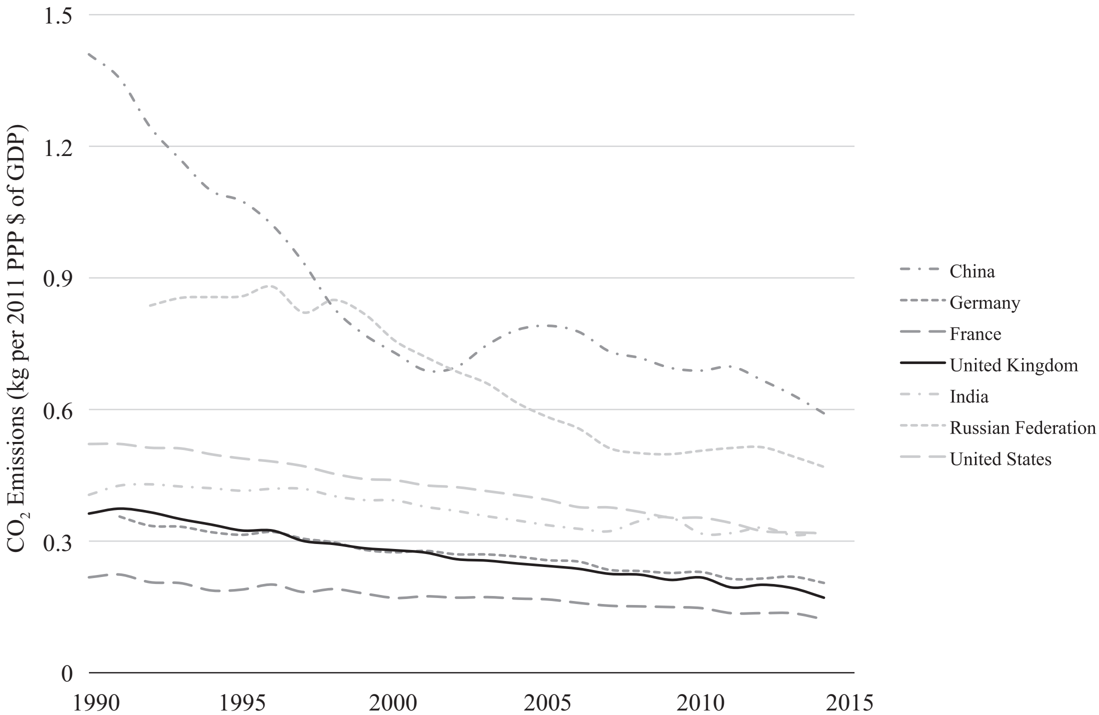
As evidence builds that climate change poses a threat to human safety and quality of life, many countries have begun addressing this problem. Wealthy EU countries, in particular the UK, have spearheaded programs and treaties that attempt to mitigate or adapt to climate change. The numerous climate change programs the UK has tried, with varying success, can serve as a learning tool for countries that have been slower to act and help the UK hone environmental policy going forward.

The UK is a world leader in reducing carbon emissions, yet there is a growing gap between the UK's legislated goals and its projected emissions due to a combination of technical and political challenges. The UK needs to concentrate on improving efficiency in sectors beyond electricity generation, using electricity rather than less efficient fuels to power these sectors, increasing renewable and nuclear generation capacity to meet rising demand, and implementing a mixture of technologies, from pumped hydroelectrical energy storage to smart grids, to balance the fluctuations in supply brought on by renewables. Upgrading regulations and government programs to focus on these targets should provide the necessary support to close the gap.

The UK as a Global Leader in Reducing Greenhouse Gas Emissions

Although other countries have also lowered greenhouse gas (GHG) emissions in the past decade, the UK became a leader by reducing them to a comparatively low level. GHG emissions, the de facto measure of climate-related pollution, are often simplified as carbon dioxide (CO_2) emissions, as this gas dominates GHG footprints (US Environmental Protection Agency, "Greenhouse…"). Since 1990, when GHG emissions from all sectors weighed in at 799 equivalent metric tons of

Figure 1
CO_2 Emissions per Dollar of GDP for Selected Nations



Note: The World Bank has adjusted GDP dollars in this data set using purchasing power parity (PPP) in 2011 values to control for differences between countries and inflation.
Source: World Bank.

CO_2 ($MtCO_2e$), the country has lowered GHG emissions by more than 40% to 466 $MtCO_2e$ in 2016 ("Provisional…").

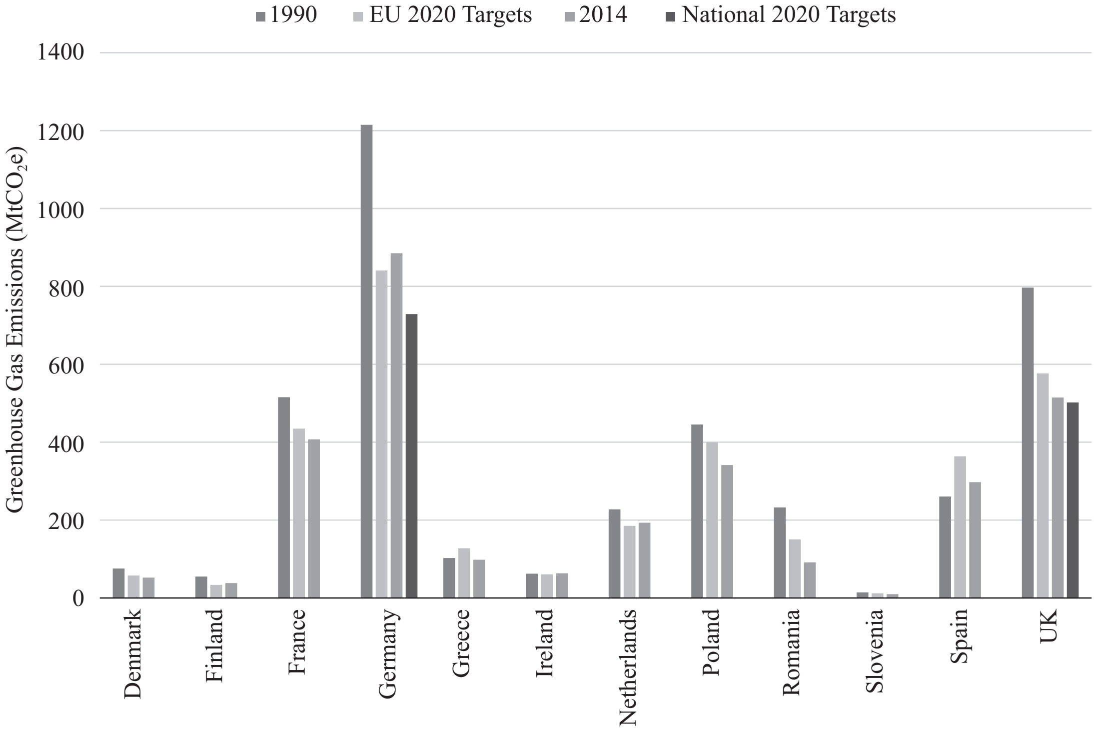
Figure 1 shows the UK's relative success through CO_2 emissions, adjusted for economic output, compared to countries of varying wealth and size. Some countries, such as China, have greatly reduced emissions but remain large polluters. Others, like France, are the lowest emitters but have improved minimally. The UK resembles France far more than China in its emission history, but in cutting 0.192 kg CO_2 per dollar of GDP versus France's 0.096 reduction, the UK is also improving faster than many of its fellow low emitters. Overall, the UK emerges as a leader when considering both emissions reductions and absolute emissions relative to GDP.

The UK's climate change goals are ambitious. Most countries have minimal climate change policies, such as participation in the Kyoto Protocol or Paris Agreement. Although ratified by an overwhelming number of nations, these international agreements fall short of obligating the entire globe to binding emissions goals (United Nations). The EU goes a step further, with binding short-term targets and a broad goal of reducing emissions by 80% to 95% by 2050 from 1990 levels (European Parliament).

Some ambitious EU countries, notably Germany and the UK, have set even more demanding 2020 targets than those required by the EU. Figure 2 displays various EU countries' 1990 emissions levels, their EU 2020 targets, their 2014 GHG emissions, and, for the UK and Germany, their tighter national 2020 targets.

The UK and Germany, with more stringent 2020 goals, appear most successful at lowering emissions. These two countries have

Figure 2
2020 Targets, and 1990 and 2014
Absolute Greenhouse Gas Emissions of Select EU Countries



Source: United Nations.

seen the largest reductions both in absolute numbers and compared to 1990 levels. The UK's upfront goals and precursive dedication to climate change efforts are closely connected to emissions reductions to date.

Germany provides an interesting comparison when trying to understand the relationship between self-established goals and the UK's emissions reductions. Both countries owe much of their reductions to reducing coal-powered electricity. Beyond coal, Germany and the UK vary greatly in how they have improved. Like the UK, Germany relied on reductions from the power sector but through a uniquely decentralized energy generation structure with high municipal and residential ownership. This model depends on local banking institutions to finance the small-scale renewables that abound in Germany. The UK has far less small-scale generation (Chilvers et al.). Germany also decommissioned nearly all nuclear power plants prematurely in response to the 2011 Fukushima accident in Japan. In contrast, nuclear power remains important in the UK (Renn and Marshall).

On the surface the UK and Germany have similar emissions histories—both set ambitious short-term goals, reduced coal, and became two of the lowest GHG emitters in the world. However, given their distinct approaches, multiple paths are apparently feasible. Even so, both cases suggest that clear goals and a commitment to low emissions are prerequisites.

Successful UK Climate Change Policy and Ongoing Challenges

The Climate Change Act of 2008 is integral to the UK's progressive climate change policy. This act legally committed the UK to reducing carbon emissions by 80% of the 1990 levels by 2050 (Committee on Climate Change, "Carbon…") and set budgets for five-year periods in the interim to ensure the UK could meet its goal. The act also established the Committee on Climate Change (CCC) to monitor the UK's progress. The CCC holds power as a reliable, data-driven source on cost-effective routes to reducing emissions. The CCC proposed the carbon budgets for ratification by Parliament, and the agency provides expertise on developing issues, such as Brexit's impact on UK climate change goals (UK Parliament). Annually, they report progress and quantify the expected impact of policies on emissions and the economy. For example, the CCC estimates the quantity of CO_2 a program can remove from UK output and the cost to both government and consumers. These publications also suggest key actions which, with government support, could yield large reductions. These suggestions often highlight funding for research and efficiency improvements (Committee on Climate Change, "2017…"). Backed by extensive data, the CCC is an influential voice on UK climate change policy.

CCC recommendations often lead to the government approving subsidies, funded competitions, carbon trading programs, and various other policies. UK climate change programs aim to correct environmental externalities. In other words, the government tries to associate environmental degradation with costs polluters pay immediately and directly so that protecting the environment makes economic sense. This concept appears in countless ways, from payments to households generating renewable energy to a vehicle emissions cap with enforceable fines.

Some aspects of UK climate change strategy are EU-wide. Most notable is the EU Emissions Trading System (ETS), arguably the most effective cap-and-trade system worldwide. The ETS sets a limit on total emissions and allocates allowances to companies. Companies can keep allowances to cover their own emissions or sell to others with excess emissions. Companies emitting more than allowed face steep fines. Over time, the cap is lowered, decreasing total emissions (European Commission). The UK supplements the ETS by removing surplus allowances from the market and forcing the price of carbon to stay above a specified level, thereby enhancing incentives to reduce emissions (Ares and Delebarre). Because the ETS is a substantial piece of UK climate change policy, Brexit could have consequences on emissions progress unless the UK can maintain participation in the program or successfully replace it with a national version.

Many UK programs rely on positive incentives and aim to reduce risk. Consider the power sector where the government encourages large-scale investment in renewables through Contracts for Difference. These contracts guarantee low carbon generators a consistent "strike price" when selling electricity to the grid rather than variable market prices. A government-owned company pays or receives the difference between these prices, making renewables a stable, secure investment for companies (UK Government). Similarly, the former Feed-in Tariffs program supported small generators of solar, hydro, anaerobic, micro-heat, and wind energies through monthly payments based on the technology and quantity of energy (Ofgem). This class of policy incentives aims to make renewables generation economically viable for companies and households.

With so many positive incentives, the UK's environmental programs are costly. The government tries to maximize value, but there are limits on spending. Two prematurely closed power sector programs exemplify this conflict. In 2015, a carbon capture and storage competition with a £1 billion funding promise was abandoned. The competition was in progress for more than four years, when the Treasury decided it could not afford the offered £1 billion (Carrington). The Renewables Obligation program also ended before its promised deadline. This program required generators to source a percentage of energy from renewables, either by generating their own or buying Renewables Obligation Certificates from an accredited generator. Generators who failed to meet their quota were charged a fee proportional to their unmet obligation. After nearly 15 years, the UK ended the program early to eliminate the operating cost (Ofgem). As these examples show, the UK has had varying success balancing costs and environmental goals.

Considering the cost to the UK of meeting environmental goals, it is natural to wonder what compels the country to meet these targets. Unlike the EU emissions targets, which carry fines, the "legally binding" UK carbon budgets lack overt consequences. Nevertheless, political and economic implications could be substantial. Failure to meet the targets may prompt political backlash and impede outside investment by disrupting the UK's image as a powerful, innovative nation on climate change mitigation.

Consider the early 2010s, when Parliament wavered over approving the fourth carbon budget. Seven global electricity technology firms responded by writing the Energy Secretary to note that "the UK was in danger of undermining its reputation as a country with low political risk for energy investments" (Lockwood). This same period of political uncertainty increased interest rates on energy project investment by 15% (Harper). When the UK environmental technology market appears uncertain, borrowing to fund investment becomes more expensive, raising the effective price of reducing emissions. The UK depends on a green image to limit uncertainty and win investors. If the image is tarnished, outside funding will decrease, so reducing emissions will require additional government funding. To maintain private investment and keep the cost of climate change mitigation low for taxpayers, the UK must continue meeting its carbon budgets.

The Developing Landscape of UK Climate Change Mitigation

Despite recent advances, progress has slowed. A gap is widening between the UK's trajectory and its ambitious five-year budgets. Figure 3 shows legislated carbon budgets, past emissions, and anticipated emissions over the next 15 years. The two projections indicate the range of emissions that could be expected given the policies either in place or strongly expected to be implemented. It also shows a cost-effective route to the 2050 goal of 80% reduction advised by the CCC.

Although on track to meet and even outperform budgets through 2022, by the 2028–2032 period, projected emissions exceed the budget. The gap is small, but the targets should be comfortably achievable. Meanwhile, the cost-efficient pathway is even lower than the budgets themselves. Considering the CCC's desired trajectory, the minor deviation becomes the ever larger and concerning policy gap highlighted in Figure 3. To close this swelling gap and adhere to goals beyond 2022, policy and market changes are needed in the UK.

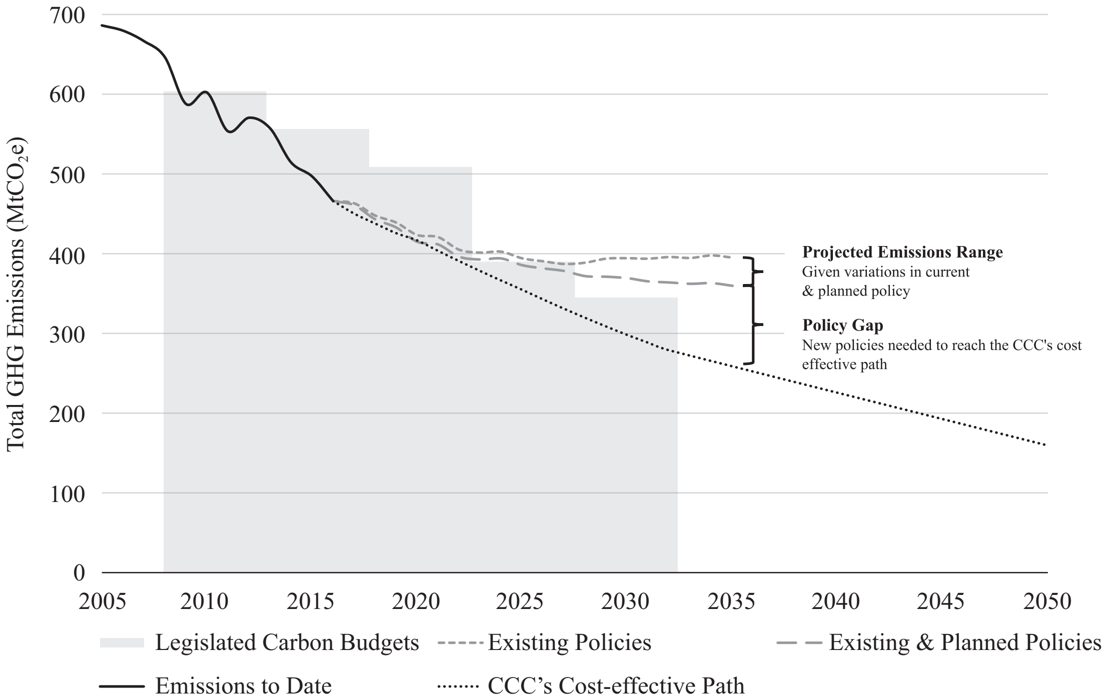
Technical Challenges Decelerating UK Emissions Reductions

The changing makeup of the energy sector and a push to substitute electricity for higher carbon sources in other sectors, topped with the political climate and Brexit-related changes to policy, are the main causes of the slowdown in reductions.

Since the Climate Change Act of 2008, emissions due to electricity generation have dropped dramatically. The energy sector is responsible for 50% of emissions reductions between 1990 and 2016, even though it accounted for only 30% of the 1990 GHG emissions ("Provisional…"). Renewables and other technologies provided attainable, cost-effective means of decreasing carbon output, making this outside decrease possible. Coal played a key role. The switch from coal to greener electricity accounts for 75% of UK emissions reductions since 2012. Limiting coal has allowed the UK to quickly lower emissions; but now, even eliminating coal completely would provide less than two years' worth of the emissions reductions needed to stay on target (Committee on Climate Change, "2017…"). Electricity generation has a new composition: natural gas (45%); limited coal (10%); nuclear (21%); and growing renewable generation, including onshore and offshore wind (12%), biomass (9%), hydro (2%), and solar (2%) (Committee on Climate Change, "2017…"). The new makeup means decreasing coal dependence is no longer enough.

A key component in the UK's electricity portfolio is nuclear power. Nuclear power can produce an invariable electricity supply with

Figure 3
Past and Projected UK Greenhouse Gas Emissions Compared to Legislated Carbon Budget



Note: Existing Policies: based on central estimates of economic growth and fossil fuel prices, including only policies that were in place by 2016. Existing & Planned Policies: existing policies plus policies "where decisions on policy design are sufficiently advanced to allow robust estimates of impact" ("Provisional…").
Sources: Committee on Climate Change, "2017…"; Committee on Climate Change, "Carbon…"; "Provisional…".

relatively low carbon emissions, helping make the UK's energy sector dependable and robust. But by 2025, half of the nuclear capacity will be decommissioned while only a sixth of the capacity will be replaced by new plants by 2030 (World Nuclear Association), leaving the UK with a diminished capacity for low carbon power generation. Government action is necessary to encourage replacement of this capacity with more nuclear or renewable generation.

Beyond the capacity needed to replace decommissioned nuclear power, additional generation will be required to meet the increasing demand from other sectors. With coal nearly eliminated, natural gas is the dirtiest of common electricity sources. Because natural gas emits fewer tons of CO_2 per unit, switching to renewables today reduces fewer emissions per unit of electricity.

Consequently, the cost of subsidizing each ton of reduced emissions through onshore wind in 2016 was nearly double the 2009 cost (Renewable Energy Foundation). Even considering the US EPA's maximum estimate of the impact to society of each emitted ton of CO_2, the cost of subsidizing emissions via onshore wind would be 50% more than the cost to society of not reducing those emissions (US Environmental Protection Agency, "The Social…"). Other renewable technologies are even more expensive; therefore, desired reductions likely cannot come from electricity generation alone. Decoupling carbon from growth in other sectors, such as transportation, buildings, and industry, may be more effective.

The UK's next steps involve efficiency, from superior insulation that conserves heat to efficiency requirements for new cars

(Committee on Climate Change, "2017…"). Next steps also likely involve raising electricity demand. Electricity *can* be produced with limited emissions, so employing electricity rather than oil in technologies, such as electric vehicles or heat pumps, can lower emissions even while increasing electricity demand. Combining the impacts of changes in efficiency and demand, the CCC estimates electricity demand will rise by 7% between 2016 and 2030. If supplied by renewables, the transition would reduce emissions by 62% (Committee on Climate Change, "2017…").

Political Challenges Compounding Deceleration in UK Emissions Reductions

The technical challenges of climate change in the UK are compounded by waning political support. Political disinterest was particularly evident from 2010 to 2015, when the government needed to approve the fourth carbon budget for 2023–2027. With extensive research to justify their suggestion, the CCC proposes each target 12 years before the budget's period. However, before the budgets become law, Parliament must approve them (Committee on Climate Change, "Carbon…"). During this process, the fourth budget met substantial resistance from conservative lawmakers. They raised concerns for a variety of reasons: the UK was recovering from a financial crisis, lawmakers were satisfied by the 2008 Climate Change Act, and the fourth budget was the first to extend beyond the UK's obligations to the EU, making it the first commitment stricter than those of neighboring countries (Lockwood). Additionally, the cost to eliminate emissions was rising as coal generation dropped. These circumstances prompted Parliament to dispute the CCC's recommendations for more than two years before finally approving the budget. Sound supporting evidence for the CCC's proposal ultimately convinced Parliament to approve the fourth carbon budget, but the politics surrounding climate change remain lackluster in comparison to the enthusiastic commitment of 2008. Parliament's discordance on climate change will likely continue impeding progress toward the UK's emission targets.

Objectives for the UK Going Forward

Combating climate change in the UK is more challenging today compared to a decade ago, when the 2008 Climate Change Act was enacted. Coal-powered generation no longer presents an easy target, governmental support of environmental measures has waned, and electricity demand is predicted to increase while generation capacity decreases. The CCC presented a reasonable path to continued reductions while accounting for these pressures. The following advised objectives incorporate the CCC's suggestions together with the opinions of other experts.

Improve Beyond the Power Sector and Raise Low Carbon Generation Capacity

In the past decade, the ETS has fostered reductions in the UK by raising the cost of emitting carbon. With Brexit looming, the UK may want to negotiate continued participation in the international program or implement a national version of the ETS. Without a cap-and-trade system to encourage emissions reductions economy-wide, the UK may encounter heightened difficulty in reducing emissions through the more specific areas, discussed as follows.

Efficiency improvements, primarily in buildings, transport, and industry sectors, could play an integral role in the UK's plan going forward. Specific, targeted policies, for example, the "insulation of all practicable lofts by 2022" or a "32% improvement in efficiency of conventional cars by 2030" advised by the CCC (Committee on Climate Change, "2017…"), would drive these changes. The benefits are clear: higher efficiency means less energy and correspondingly fewer emissions to fulfill needs. Although investment is required, efficiency is one of the most cost-effective avenues to lower emissions. Policies that support individuals improving efficiency in their homes and vehicles or that raise efficiency standards in new buildings and transport would be a valuable step. Even so, efficiency represents only a fraction of the changes needed to meet targets.

Changing the composition of energy

sources in sectors such as building, transport, and industry may also prove important with the power sector holding less potential for reductions. Changes will likely include using biomethane in the gas grid, increasing the proportion of electric vehicles, and transitioning home heating from gas to heat pumps. These changes would raise electrical demand and emissions reductions only realized if the new electricity were generated through low carbon methods.

The UK will likely find renewable technologies and nuclear power the most effective additional low carbon generation sources. Onshore and offshore wind generation; medium-scale to small-scale hydropower, particularly in some areas of Scotland; and small-scale solar power are especially promising technologies. The CCC has already advised the government to expand contracts for renewables so supply can meet demand from sectors transitioning toward electricity (Committee on Climate Change, "2017…").

Simultaneously, nuclear power can provide a stable baseload. To maintain a nuclear base, the UK would need to invest in nuclear projects promptly to enable new plants to be operational before aging plants are retired. Nuclear is the lowest emitter among reliable sources, emitting far less CO_2 per unit of electricity generated than either coal or natural gas (Allen) and making it a reasonable choice to supplement renewables and the various sources needed to balance renewables. The Scottish government and some environmental organizations argue that nuclear generation carries inherent safety risks and that the UK should focus support on cleaner technologies, such as offshore wind (Mason and Goodley). Even so, nuclear power will likely prove worthwhile because, unlike renewables, it can provide consistent electricity.

Secure Power with Nuclear, Natural Gas, Batteries, and Flexible Demand

The significant flaw in renewable generation is that the technologies are sporadic and unreliable. Weather causes frequent, substantial fluctuations in the quantity of renewably generated energy. Consider the efficiency of onshore wind: a 2012 study demonstrated that in the best cases, on average wind farms produce 25% of their maximum energy capacity. This efficiency also decreases with age to as low as 10% after 16 years (Hughes). Inadequate electricity supply causes power outages, which are aggravating and dangerous in cold months, so balancing fluctuations in electricity supply is essential.

Effective balancing of fluctuations is also critical to keeping costs down, as Germany's experience shows. The country rapidly increased renewables to provide nearly 27% of electricity in 2014, decreasing CO_2 emissions while lowering the cost of generating and transmitting electricity. Yet the direct cost of electricity for German households rose due to surcharges resulting from the fluctuation of renewables (Pollitt and Anaya). Renewables would need to be complemented efficiently to ensure adequate electricity and minimize costs to customers.

The UK may find a varied generation portfolio effective. Diverse renewable technologies and a nuclear baseline could be part of a balancing portfolio as well as natural gas and batteries that can meet fluctuations with a rapid release of electricity to the grid. Despite a higher carbon footprint, natural gas could complement renewable generation's quick, unexpected dips. Natural gas plants can respond quickly to these variations. They can be started and reach full load capacity in as little as ten minutes. In contrast, lower-emitting nuclear plants require up to two days to reach full capacity (Atlinta Energy). Quick adjustment to intermittent renewable output is crucial; consequently, a moderate capacity of natural gas would be useful.

Intermittent renewables can be smoothed further by batteries, such as hydro-batteries, that store energy in high supply/low demand times and quickly regenerate the energy at low supply/peak demand times. Scottish Power's Cruachan Power Station, a pumped storage hydropower station, is one such battery. Built into a hollowed mountain, it pumps water from the lake at its base to a reservoir partway up the mountain when excess electricity is available. When electricity supply is insufficient to meet demand, water from the elevated reservoir is then released, flowing through generators within minutes. The overall process generates minimal emissions (Scottish Power). Similar batteries could be implemented where possible to provide swift response to dips in renewable generation or peaks in demand. In short, a combination of natural gas and batteries can promptly accommodate deviations.

Further stabilization can be found in flexible demand. Flexible demand is effective because actions, such as running a washer, charging batteries overnight, and heating a home, do not need to occur immediately. With smarter homes and electrical grids, these activities could occur automatically when electricity demand is low or when supply is in excess. A smart grid is a long-term method of matching supply and demand because it does not require modifications, such as changes in capacity, and it produces fewer emissions than natural gas, the predominant method of balancing fluctuations today. Incorporating this flexibility on the consumer side of the electricity market would accommodate a higher percentage of renewables in the UK's generating portfolio.

Unfortunately, converting to a smart grid is an enormous infrastructure change that calls for investment now. The UK's electrical infrastructure was built primarily during the 1950s and 1960s during a rapid expansion of electricity. It is aging and operating near full capacity (Jenkins et al., p. 415). Upgrading the electrical grid will be necessary whether through conventional expansion or modification to a smart grid, and researchers estimated in 2012 that the UK could save £19 billion in the long run by choosing a smart grid (Easton and Byars). The UK began progressing toward a smart grid with a requirement that smart meters, a necessary first step to overhauling the grid, replace conventional meters by 2020. However, concerns about privacy and inaccurate billing caused pushback until the government downgraded the requirement to a suggestion (Meadows and Brodbeck). Stricter smart meter quality standards may be needed to address citizens' concerns before the government can strengthen policies supporting investment in the smart grid.

Conclusion

The UK has made significant environmental strides, setting ambitious goals, reducing emissions drastically, and becoming a leader in the arena of climate change mitigation. Part of this success can be attributed to the effectiveness of the CCC, a data-driven organization that gives the government updates on climate change concerns and suggests programs and regulations to help keep the UK on track toward an 80% decrease in emissions by 2050. Various programs, many of which focus on correcting externalities, like the EU ETS, or reducing uncertainty to encourage investment, such as Contracts for Difference and Feed-in Tariffs, have also helped the UK to effectively encourage emissions reductions.

Despite the success, the country's climate change efforts face mounting challenges. With coal successfully reduced, more difficult methods of reducing emissions are necessary. Many nuclear power plants are scheduled to be decommissioned over the next decade without adequate replacements planned, leaving the country with a lower capacity for low carbon generation. Simultaneously, the UK will need to meet growing demand, growth partially caused by sectors beyond power moving toward electricity. Meanwhile, government support of strong climate change policy has wavered over the past five years. Through these rising concerns, it is important that the UK continue meeting self-set targets to keep uncertainty low and encourage outside investment.

To successfully lower emissions amid these challenges, prompt decisive policy with the following objectives would be helpful. In sectors beyond power, efficiency improvements and movement toward electrical power are key first steps. The consequent rising demand could be met primarily by nuclear power and a composite of renewables, including onshore and offshore wind, solar, and hydro generation. Finally, to balance the inconsistencies introduced by a higher ratio of renewables, the UK could look to natural gas power to address demand when renewables lull for hours to days, innovative batteries to provide extremely fast response to fluctuations, and a smart grid to offset discrepancies from the consumer side of the market in the long term.

The UK can meet its ambitious emission targets. However, maintaining its position as a world leader in combating climate change cannot wait five or ten years—it requires governmental action today.

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