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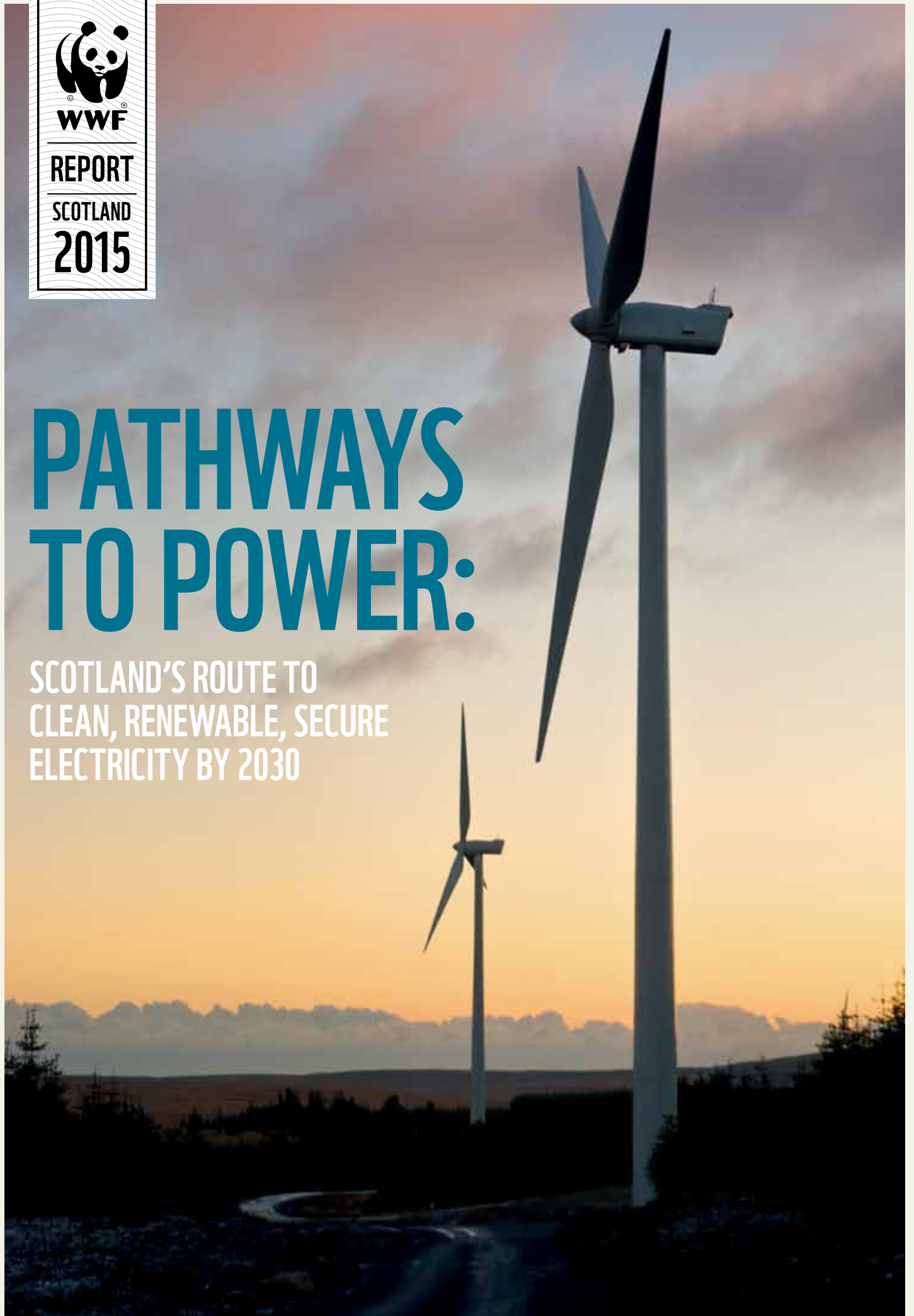
REPORT

SCOTLAND

2015

PATHWAYS TO POWER:

SCOTLAND'S ROUTE TO
CLEAN, RENEWABLE, SECURE
ELECTRICITY BY 2030



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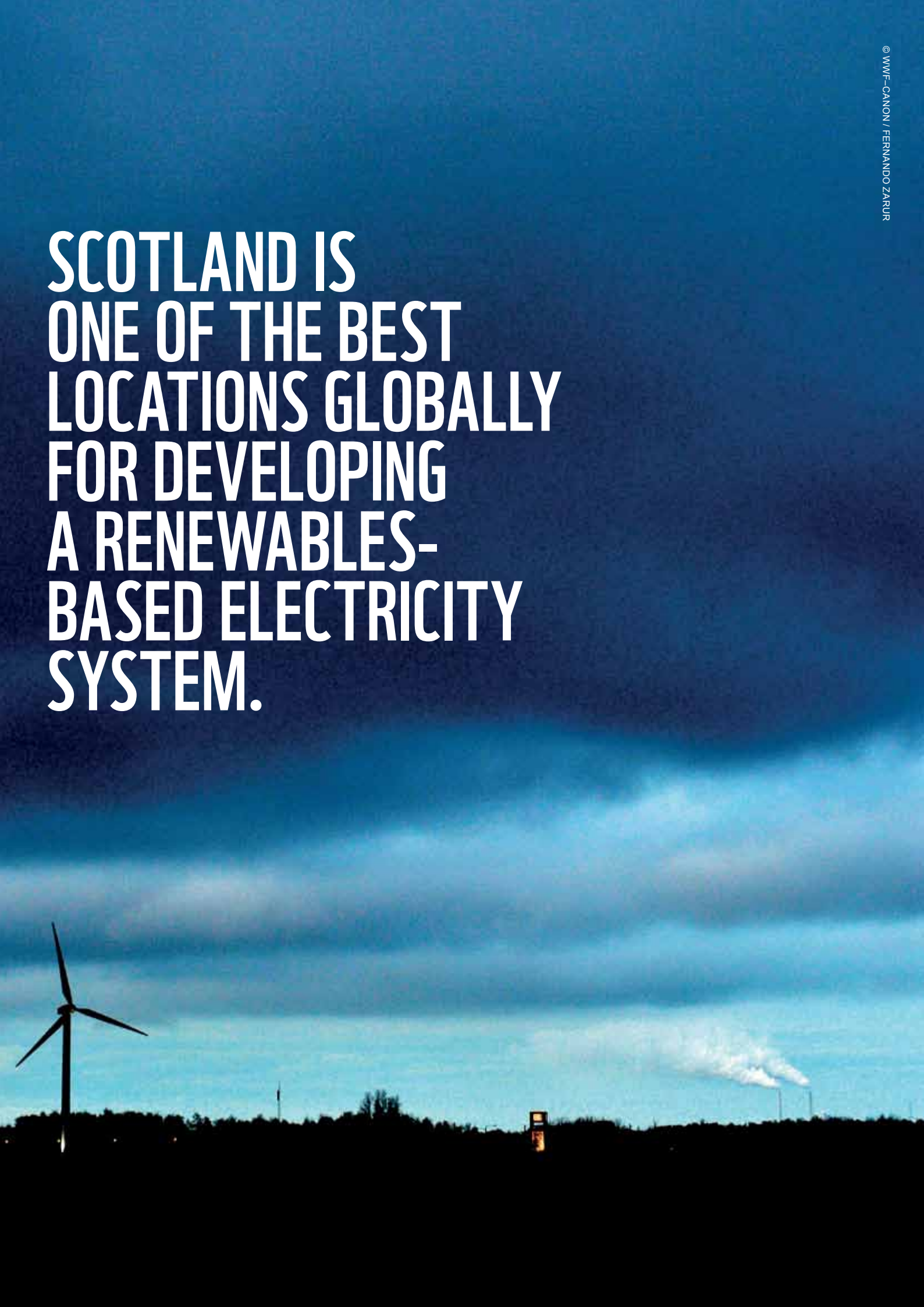
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**SCOTLAND IS
ONE OF THE BEST
LOCATIONS GLOBALLY
FOR DEVELOPING
A RENEWABLES-
BASED ELECTRICITY
SYSTEM.**



INTRODUCTION:

With its powerful winds and waves and its strong tradition of engineering and innovation, Scotland is one of the best locations globally for developing a low-carbon, renewables-based electricity system.

Decarbonising the power sector by 2030 is the cheapest, most effective pathway to hitting legally-binding climate targets, as the UK Committee on Climate Change has repeatedly shown. Not only does it tackle direct emissions from electricity, it also acts as a building block for developing low-carbon heat and transport options. The Scottish Government has rightly adopted this approach and is committed to largely decarbonising Scotland's electricity sector by 2030 – with a target of 50g CO₂/kwh.

However, current policy to meet the 2030 decarbonisation target is high risk. Despite the slow pace of carbon capture and storage (CCS) development globally,¹ the Scottish Government's Electricity Generation Policy Statement 2013 (EGPS) assumes that CCS will be operating at scale in the next decade, fitted progressively across 2.5GW of gas plant. The Government has already risked high-carbon lock-in by granting consent to a major gas plant at Cockerzie as 'CCS-ready.' But with no guarantee that the technology will be commercialised in time, WWF Scotland commissioned international energy consultancy DNV GL to test whether current policy is fit for purpose, and to examine whether a future based almost exclusively on proven renewable technologies is possible.

The good news is that we don't have to rely on a high-risk strategy based on unproven CCS technology. In fact, a renewables-based, efficient, flexible, electricity system is perfectly feasible by 2030. Not only that – it is less dependent on imports from the rest of Great Britain at peak demand, is cheaper, and has lower emissions than current Scottish Government scenarios in the Electricity Generation Policy Statement. And critically, it makes more of Scotland's abundant renewable resources and flourishing green energy industry, triggering economic, social and environmental benefits.

...a renewables-based electricity system is perfectly feasible by 2030.



KEY FINDINGS:

A FOSSIL FUEL AND NUCLEAR FREE SYSTEM IS ACHIEVABLE AND CREDIBLE

Scotland can achieve a secure, decarbonised power sector by 2030 with only renewables and minimal CCS-fitted gas power². An almost entirely renewables-based Scottish system is possible with moderate efforts to reduce demand for electricity and ongoing work to reinforce the grid. The current pipeline of renewables will be more than adequate to hit the decarbonisation target and allow for substantial export of electricity to the rest of Great Britain, particularly if Scotland makes perfectly feasible progress on energy efficiency. There is also an economic opportunity for further exports.

A FOSSIL FUEL AND NUCLEAR FREE SYSTEM IS SECURE

A system based almost entirely on renewables would be more secure than the current Scottish Government scenario at peak demand, as long as the overall Great Britain (GB) system itself is secure.³ Great Britain-wide security will be delivered by a combination of interconnection, storage, demand management and flexible back-up generation. Overall, Scotland can maintain and expand on its position as a net exporter of power with an almost entirely renewable electricity system. During infrequent periods of high demand and low renewables production, electricity will need to be imported from the rest of Great Britain, but ongoing and planned grid upgrades will be more than enough to accommodate this. During periods of high renewable production and lower demand, Scotland will export to the rest of Great Britain and beyond. This is increasingly the norm as European markets move towards greater interconnection.

Scotland can achieve a secure, decarbonised power sector by 2030 with only renewables and minimal thermal power.

A FOSSIL FUEL AND NUCLEAR FREE SYSTEM IS CHEAPER

The cost of the additional generation capacity needed to hit the 2030 target in a renewables-based system is smaller (£663m/yr) than the cost of a system with CCS-fitted thermal plant (£1.85bn/yr), because the cost of new wind power is lower than the cost of CCS.⁴

The cost of a renewables-based system is broadly similar to the cost of generating the same amount of unabated gas-fired electricity.

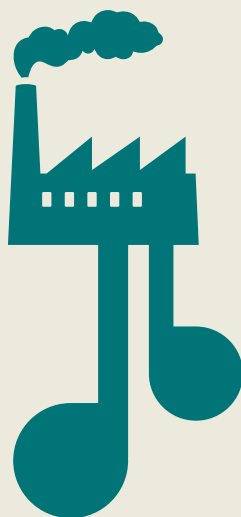
A FOSSIL FUEL AND NUCLEAR FREE SYSTEM MEANS LOWER CLIMATE RISK

While all scenarios considered achieve the decarbonisation target, it could easily be breached if the Scottish Government's CCS gamble does not pay off and unabated gas plants are operating in 2030. Unabated gas power would generate 6.6 million more tonnes of carbon dioxide annually than if CCS is operating at scale,⁵ radically undermining Scotland's ability to hit its climate targets. The climate risks are lower in a scenario that relies on proven renewables, already under construction or consented.

Box 1. Scotland's 2020 and 2030 targets – what's the difference?

Scotland's 2020 target is to meet 100% of its electricity demand from renewables. It is well on track to hitting this, at 46% in 2013. It's estimated that 14-16GW of renewables capacity will be needed to hit the target and there is more than enough in the pipeline to do so (see Box 5). However, the renewables capacity needed may be lower if the current trend of declining electricity demand continues. The 2020 target is not a carbon intensity target and places no restrictions on the amount of fossil fuel generation on the system. In fact, the Scottish Government has clearly stated that it envisages thermal power continuing 'to play an important role' in Scotland's energy future.

Scotland's 2030 target is to achieve power sector carbon intensity of 50g CO₂/kWh or lower. The latest available figures (2011) show that Scotland's grid intensity is approximately 271gCO₂/kWh,⁶ considerably less than the rest of the UK due to Scotland's thriving renewables sector. The target could be theoretically be achieved using a variety of low carbon technologies, including renewables, nuclear, and fossil fuel plants fitted with carbon capture and storage, although the Scottish Government rightly sees no role for nuclear in its vision of the future electricity sector.



Box 2: What role for Carbon Capture and Storage?

While Scotland's abundant renewable resources mean it can enjoy a clean, renewable electricity supply, carbon capture and storage (CCS) has the potential to play a role in cutting emissions globally from existing (fossil fuel) power plants while we transition to a 100% renewable energy future, as well as in decarbonising heavy industry, which currently has few alternatives for reducing emissions other than CCS and biomass. Scotland has the opportunity to demonstrate CCS technology at Peterhead and WWF's support for CCS is limited to the demonstration programme. For this reason we have included a minimum of 340mw of CCS at Peterhead in all scenarios studied.

KEY POLICY

RECOMMENDATIONS:



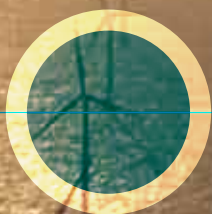
SCOTLAND DOES NOT NEED ANY FOSSIL FUEL POWER STATIONS OPERATING BY 2030 SO THE SCOTTISH GOVERNMENT SHOULD NOT CONSENT NEW PLANTS AS CCS-READY

THE SCOTTISH GOVERNMENT DOES NOT NEED TO GRANT LIFE EXTENSIONS FOR NUCLEAR PLANTS INTO THE 2030S



THE UK GOVERNMENT NEEDS TO STOP INCENTIVISING COAL

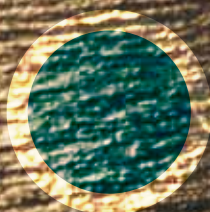
THE UK GOVERNMENT NEEDS TO MAKE ELECTRICITY MARKET REFORM WORK BETTER FOR OFFSHORE WIND



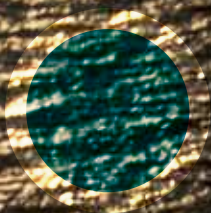
THE UK GOVERNMENT MUST SHOW STRONG AMBITION FOR RENEWABLES GROWTH AND CLARITY ABOUT THE FUTURE MARKET FOR RENEWABLES POST-2020 AS SOON AS POSSIBLE IN ORDER TO DRIVE INVESTMENT



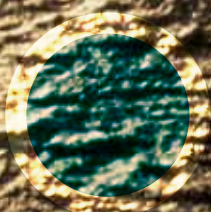
THE UK AND SCOTTISH GOVERNMENTS MUST WORK WITH INDUSTRY TO ENSURE THAT THE WAVE AND TIDAL SECTORS ARE ADEQUATELY SUPPORTED



THE UK AND SCOTTISH GOVERNMENTS MUST CONTINUE WORKING WITH INDUSTRY TOWARDS A SOLUTION TO THE PROBLEM OF AFFORDABLE AND TIMELY GRID CONNECTION FOR THE WESTERN ISLES, ORKNEY AND SHETLAND



GREATER EFFORT IS NEEDED FROM THE UK AND SCOTTISH GOVERNMENTS ON ELECTRICITY DEMAND REDUCTION AS IT REQUIRES LESS NEW GENERATION CAPACITY TO ACHIEVE POWER SECTOR DECARBONISATION



THE UK AND SCOTTISH GOVERNMENTS NEED TO WORK WITH INDUSTRY TO INCENTIVISE INVESTMENT IN PUMPED STORAGE

KEY POLICY RECOMMENDATIONS:



1 Scotland does not need any fossil fuel power stations operating by 2030 so the Scottish Government should not consent new plants as CCS-ready

A system based almost entirely on renewables is feasible and desirable and therefore life-extending coal plants or building new gas plants is unnecessary. However, should new gas plants be built in Scotland they must have operational CCS from the outset. Consenting plants as 'CCS-ready' risks breaching the decarbonisation target and locking Scotland into a high-carbon future. Operating a gas plant like the one consented at Cockenzie at more than 50% capacity factor would, for instance, exceed the target in most credible scenarios.⁷

2 The Scottish Government does not need to grant life extensions for nuclear plants into the 2030s

The Scottish Government has stated that, while it does not support new nuclear in Scotland, it is open to life extensions for Scotland's existing

nuclear stations to help maintain security of supply once safety standards are met.⁸ DNV GL's analysis shows that there is no need for nuclear to still be operating in 2030 to maintain security of supply.

3 The UK Government needs to stop incentivising coal

Efforts to decarbonise power supply are being undermined by policies that are incentivising life extensions to coal, including the failure to apply an Emissions Performance Standard to existing coal plants; the freezing of the carbon floor price; and the fact that revenues from the capacity market may well exceed the cost of compliance with the Industrial Emissions Directive.⁹ The UK Government should provide a clear regulatory signal through a progressively tightening Emissions Performance Standard for existing coal from 2023 to give lower carbon generation clear incentives to invest and the Scottish Government should champion this approach, including in the five year review of the UK Energy Act.



4 The UK Government needs to make Electricity Market Reform work better for offshore wind

Clear volume signals and foresight about available funding are needed to create the conditions for long-term, sustainable investment in offshore wind, boost the domestic supply chain and accelerate cost reductions. The enduring regime under Electricity Market Reform is currently constraining growth to around 8-900MW equivalent to around one project under the first allocation round across the whole of the UK, which could severely restrict growth in Scotland.

5 The UK Government must show strong ambition for renewables growth and clarity about the future market for renewables post-2020 as soon as possible in order to drive investment

A future UK framework needs a 2030 power sector decarbonisation target of 50g CO₂/kwh, clarity about the post-2020 Levy Control Framework, and a prompt and firm decision on the Fifth Carbon Budget in 2016, all based on the advice of the UK Committee on Climate Change. The current lack of ambition and certainty risks stymying investment in an industry with long-lead in times and a need for deployment at scale to drive learning and cost-reductions.

6 The UK and Scottish Governments must work with industry to ensure that the wave and tidal sectors are adequately supported

The sectors are at risk of being ignored in the short-term. Given their long-term economic potential, both Governments need to support the wave and tidal industries to ensure that connection issues, transmission charging, and Electricity Market Reform do not impede progress in what could potentially be a major long-term contributor to power sector decarbonisation, with the potential to deliver up to 20% of UK electricity by 2050.¹⁰

7 The UK and Scottish Governments must continue working with industry towards a solution to the problem of affordable and timely grid connection for the Western Isles, Orkney and Shetland

Once connected, the islands would produce several hundreds of MW of onshore wind generation at costs significantly cheaper than offshore wind. This would also provide major economic and social benefits to remote and rural areas, and, critically, could enable the demonstration and long-term commercialisation of wave and tidal arrays at reasonable connection cost.



8 Greater effort is needed from the UK and Scottish Governments on electricity demand reduction as it requires less new generation capacity to achieve power sector decarbonisation

Moderate demand reduction (of 1% year) will allow Scotland to decarbonise the grid well within the current renewables pipeline. Making efforts on demand reduction would help to insulate Scotland from uncertainties about future electricity and renewable energy policy at UK and EU levels and enhance security. By reducing demand and in turn pressure on supply infrastructure, it could help protect households against rising energy bills while achieving decarbonisation more cost-effectively. While there has been progress in reducing electricity demand in recent years in Scotland, it is important that the downward trend continues and economic recovery does not lead to surging demand.

At a UK level, electricity demand reduction could be incentivised through improvements to the UK capacity market which would prioritise demand reduction, through the introduction of an energy efficiency feed in tariff,

and through constructive engagement with the EU on efficiency standards for electrical appliances. At a Scottish level, a clear electricity demand reduction strategy is required, using Scottish powers and policy levers to the full to ensure continued decoupling of economic growth and electricity demand, and to ensure that negawatts – electricity savings – receive greater policy attention.

9 The UK and Scottish Governments need to work with industry to incentivise investment in pumped storage

Despite its important role in storing energy generated from variable renewables and in providing balancing services to ensure security of supply, pumped storage is not recognised under the current UK Electricity Market Reform regime. Notwithstanding its clear benefits, and the fact that consent for a major project is already in place in Scotland with another included in the National Planning Framework, there is no mechanism to enable investment decisions to be taken. A solution must be found that unlocks the potential of pumped storage to contribute to a flexible decarbonised grid.

DEVELOPING THE SCENARIOS:




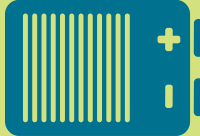
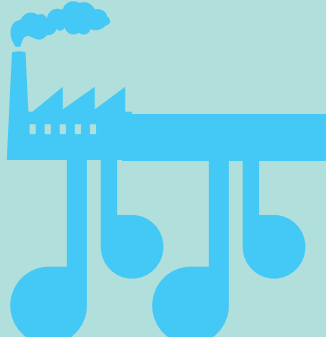
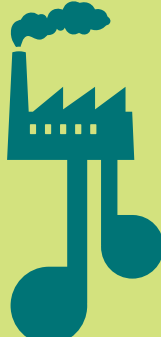
We commissioned a technical report by respected international energy and engineering consultancy DNV GL (incorporating Garrad Hassan) – the world’s largest renewables advisory – which was reviewed independently. DNV GL investigated a range of scenarios for power sector decarbonisation in Scotland which are technically and economically possible. Here we focus in depth on the two which represent current Scottish Government policy and WWF’s preferred scenario.

The first is termed the ‘**High Climate Risk**’ scenario. This generation scenario is based on current Government policy as set out in the Electricity Generation Policy Statement (which is in turn based on modelling conducted by SKM). CCS is commercialised and fitted across 2.5GW of thermal power. Elsewhere energy and climate issues, especially energy efficiency, have relatively low political priority. Regulatory, market and public acceptance barriers remain for pumped storage.

The second is termed the ‘**Low Climate Risk**’ scenario. CCS is not commercialised beyond a single demonstration plant at Peterhead and no other gas, coal or nuclear plant exists on the system. Elsewhere there is high political priority for energy and climate issues, a strong policy drive and public acceptance, with moderate, but sustained, efforts to reduce energy demand, high uptake of electric vehicles (EVs), and low barriers to building new pumped storage.


The axes on which the scenarios vary are:

- **Demand:** How much progress will be made on energy efficiency and the electrification of heat and transport?¹¹
- **Flexibility:** How much progress will be made on pumped storage and demand response?
- **Carbon Capture and Storage:** Will CCS be developed beyond a single demonstration plant at Peterhead?

	HIGH CLIMATE RISK SCENARIO, (WEAK POLICY DRIVE, HIGH CCS)	LOW CLIMATE RISK SCENARIO, (STRONG POLICY DRIVE, LOW CCS)
Electricity Demand	<p>Increased underlying demand, and some electrification of heat and transport outweigh energy efficiency improvements.</p> 	<p>Moderate efforts on energy efficiency outweigh increased electric heating and electrification of transport. Transport demand is stabilised</p> 
System Flexibility	<p>Some increase in pumped-storage capacity, limited demand response</p> 	<p>Substantial additional pumped-storage and some demand response</p> 
Fossil fuel generation fitted with CCS	<p>2500MW</p> 	<p>340MW (Peterhead)</p> 

ASSUMPTIONS

High Climate Risk Scenario

 **18%**
assumed electricity
demand increase

HIGHER DEMAND:

It assumes electricity demand increases by 18% to 43.1 TWh in 2030, in line with previous forecasting for the Scottish Government by SKM.¹² Efforts on energy efficiency are offset by increased electrification of heat and transport.




1340MW
pumped storage
capacity

LOWER FLEXIBILITY:

It assumes that deployment of non-hydro energy storage and demand response measures are hampered by technical and regulatory barriers and don't contribute to meaningful 'load shifting' before 2030. 600MW of new hydro pumped storage proceeds (there is already planning consent for this scale at Coire Glas), resulting in a total pumped storage capacity of 1340MW and 46GWh. At peak periods, demand response (e.g. deferred electric vehicle charging) is conservatively assessed at 100MW.

HIGHER CCS:

It assumes that there is 2.5 GW of existing or new gas plant fitted with CCS by 2030, building on the Scottish Government's Electricity Generation Policy Statement.

 **17%**
assumed electricity
demand decrease

Low Climate Risk Scenario

LOWER DEMAND:

It assumes lower electricity demand of 30.5 TWh in 2030. This equates to a 17% reduction on current levels and a 1% annual reduction (broadly in line with National Grid's Slow Progression Scenario).¹³ Energy efficiency improves rapidly, by 2030 half of all new car sales will be electric (750,000 electric vehicles overall), and transport demand stabilises. While there is a relatively high uptake of air and ground source heat pumps, electricity demand from heat is reduced overall due to uptake of energy efficiency and low-carbon options.



2540MW
pumped storage
capacity

HIGHER FLEXIBILITY:

It assumes that there is significant growth in storage and demand response, with hydro pumped storage remaining the dominant technology in Scotland. Three new 600MW pumped storage schemes are built by 2030, resulting in total capacity of 2540MW and 106GWh. At peak periods, demand response (e.g. deferred EV charging or heat pump use) is conservatively assessed at 500MW.

LOWER CCS:

It assumes that CCS fails to reach commercialisation beyond a single demonstration gas plant at Peterhead of 340MW by 2030.

Box 3: Scottish Government Assumptions for Thermal Power

The Scottish Government's assumptions for electricity generation are as follows:



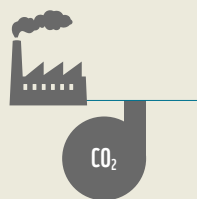
Coal:

Longannet (2.4GW) will close in 2020



Gas:

2GW of new gas plant will be operating by 2020



CCS:

500MW of CCS-fitted gas plant will be operating by 2020, with 1.6GW in operation by 2027



Nuclear:

Torness and Hunterston will be closed by 2030

Overall: 2.5 GW of thermal plant will be operating by 2030, progressively fitted with CCS. While the closure dates for coal and nuclear plant are not certain, currently there are no indications that they will be running in 2030. However, their closure depends on a range of regulatory and commercial considerations, including the signals provided by the capacity market, the carbon price, fuel costs and other factors. Recently, Scottish Power decided not to progress Longannet in the UK capacity market auction, increasing the likelihood of its closure by 2020.

Box 4: Hydro Power

Both scenarios assume 2.5GW of hydro (of which 1.5GW is already in place).

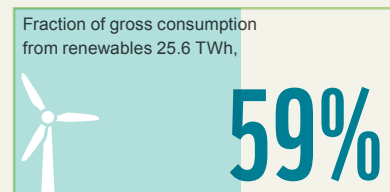
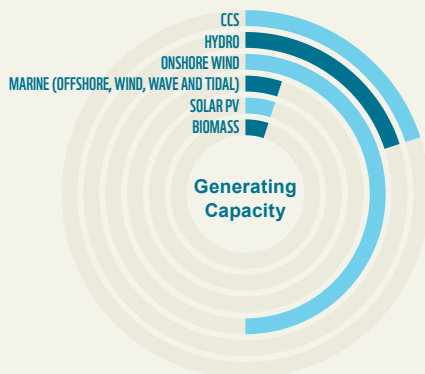
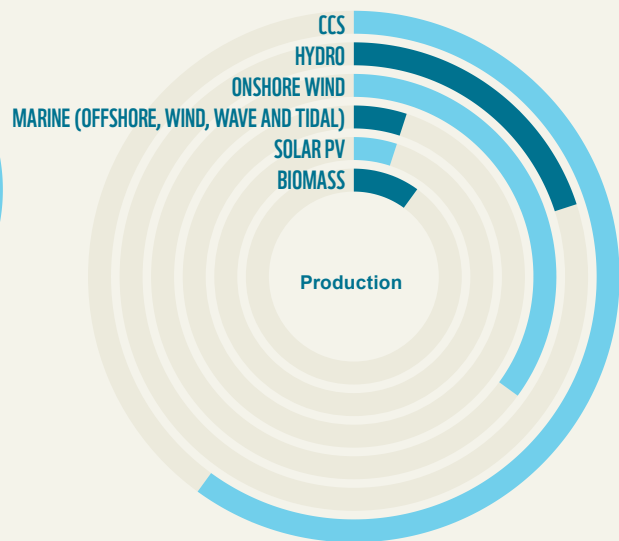
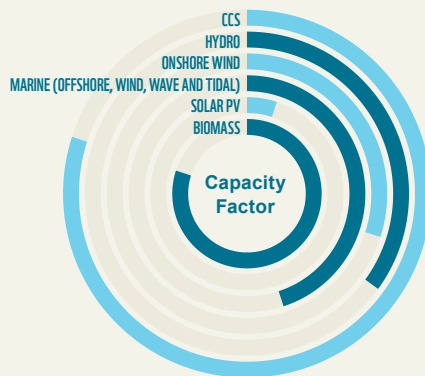
There is approximately 1.2 GW of run of the river hydro technically and financially available in Scotland, the bulk of which is assumed to be developed by 2030, although some uncertainties around support for hydro are currently impeding developers. Should this level of hydro fail to be developed, the shortfall could easily be met by other renewables such as onshore wind or solar photovoltaics.



RESULTS OF THE SCENARIOS

The Generation Mix in a Decarbonised Power Sector

GENERATION MIX, HIGH CLIMATE RISK SCENARIO

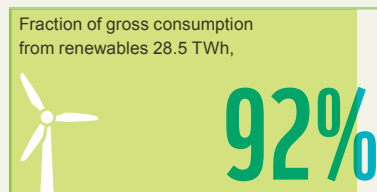
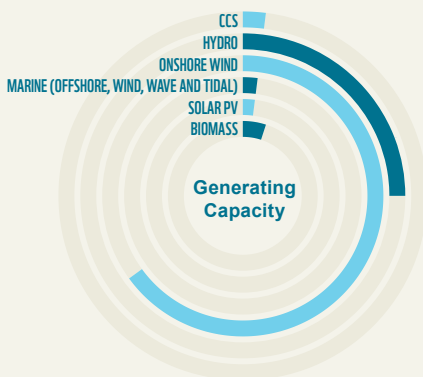
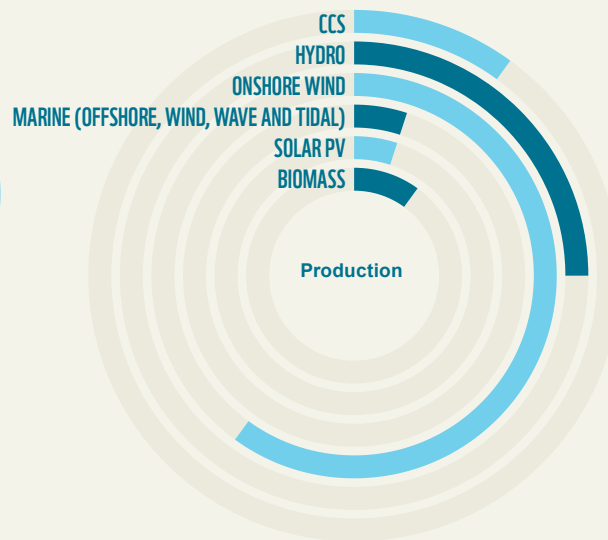
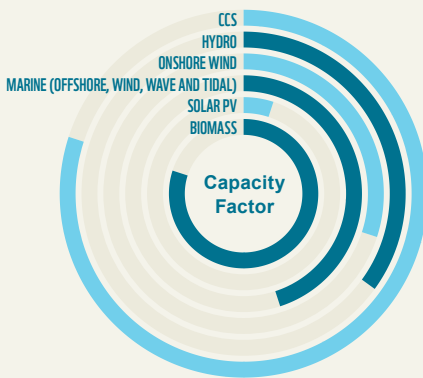


DNV GL developed a generation mix for each scenario, shown here, building on the assumptions outlined on page 16. It's important to stress that the scenarios have been conservatively designed to consider only the minimum level of renewables required to decarbonise and should not be seen as a cap on overall renewables ambition. In practice, there is likely to be more renewables built than assumed below (see Box 5 on Scotland's Renewable Power Pipeline).

Source	Capacity Factor	Generating Capacity	Production
CCS	0.8	2500 MW (defined by scenario)	17.5TWh
Hydro	0.34	1500 MW existing 1000 MW extra assumed	7.4 TWh total
Onshore wind	0.29	4500 MW existing capacity (2013). 1000 MW extra assumed.	11.4 TWh from existing capacity. 2.5 TWh from assumed additional capacity
Marine (offshore wind, wave and tidal)	0.45	190 MW existing offshore wind capacity.	0.7 TWh from existing capacity.
Solar PV	0.08	116 MW existing.	0.1 TWh from existing capacity.
Biomass	0.8	140 MW existing 360 MW extra assumed	3.5 TWh total
Total			43.1 TWh
Fraction of gross consumption from renewables			25.6 TWh, 59%

The scenarios have been conservatively designed to consider only the minimum level of renewables required to decarbonise, and should not be seen as a cap on overall renewables ambition.

GENERATION MIX, LOW CLIMATE RISK SCENARIO



Box 5: Scotland's Renewable Power Pipeline

The latest figures¹⁴ show that Scotland has 7.1 GW of installed renewable electricity generation capacity, with an additional 6.2 GW either under construction or consented, the majority of which is expected from onshore wind. Including projects in planning, this figure totals 20.4 GW – nearly three times the level of renewables currently deployed. While a certain amount of attrition is inevitable, there is more than enough renewable capacity in the pipeline to hit future targets.

Source	Capacity Factor	Generating Capacity	Production
CCS	0.8	340 MW defined by scenario	2.4 TWh
Hydro	0.34	1500 MW existing 1000 MW extra assumed	7.4 TWh total
Onshore wind	0.29	4500 MW existing capacity (2013). 2100 MW extra assumed to be constructed.	11.4 TWh from existing capacity. 5.4 TWh from assumed additional capacity
Marine (offshore wind, wave and tidal)	0.45	190 MW existing offshore wind capacity.	0.7 TWh from existing capacity.
Solar PV	0.08	116 MW existing.	0.1 TWh from existing capacity.
Biomass	0.8	140 MW existing 360 MW extra assumed	3.5 TWh total
Total			30.9 TWh
Fraction of gross consumption from renewables			28.5 TWh, 92%

Results of the Scenarios

Both scenarios show that the current renewables pipeline will easily allow Scotland to meet the decarbonisation target. The High Climate Risk Scenario requires an additional 1 GW of onshore wind (which is already under construction), while the Low Climate Risk Scenario relies on an additional 2.1 GW of onshore wind (which is already consented).

The mix within the scenarios should not be seen as the only way to hit the target. Other renewable technologies, such as well-sited offshore wind or solar PV, could easily form a larger part of the mix. For instance, solar PV units have dropped in price by two-thirds between 2009 and 2013¹⁵, leading to growing uptake on domestic and commercial buildings in the UK. Solar PV output was up 67% in Q2 2014 against the same period in 2013, reaching over 4GW of installed capacity across the UK, though less than 200MW are currently installed in Scotland.¹⁶ However, the scenarios crucially don't depend on future solar growth – only on wind capacity already consented.¹⁷


Box 6: Reducing Electricity Demand

How successful Scotland is in reducing electricity demand will determine how easily it hits its decarbonisation target. After all, the cheapest, cleanest and most secure energy is the energy that is never used and reducing demand is cheaper and less technically challenging than building new generation capacity. In fact, the scenarios show that a perfectly feasible demand reduction of 1% annually will allow Scotland to hit the 2030 target well within the current renewables pipeline, even allowing for the electrification of heat and transport. Electricity demand has reduced in Scotland in recent years (about 3% per year between 2008 and 2012, though this is affected by a weak economy).

The Scottish Government assumes increasing demand long-term as a result of increased electrification of heat and transport,¹⁸ supported by analysis for the Scottish Government by SKM, which forecast demand rising by 18% to 2030. This assumption is based on rising demand from heat and transport electrification. DNV GL analysis shows that, despite growing electrification of heat, heat demand falls due to insulation and a switch from resistive heating to heat pumps. This nearly offsets the growth in demand from Electric Vehicles.¹⁹

Analysis by National Grid for the Future Energy Scenarios²⁰ report supports more conservative assumptions about demand growth to 2030 than the Scottish Government. In the Slow Progression Scenario, demand falls by 6% between 2013 and 2035 (driven by energy efficiency, improved lighting and lower industrial output), while in the Gone Green Scenario, it rises by 6% by 2035 (driven by heat and transport electrification and greater industrial output, after falling initially). Ofgem recently highlighted, however, that “structural changes might be taking place” in the relationship between the economy and electricity demand, as a drop in demand in 2013/14 happened “against a backdrop of the strongest economic growth in GB since the economic crisis”.²¹

E3G analysis points to clear evidence that with the right incentives electricity demand reductions of 2% per year are achievable Great Britain-wide.²² There is approximately 32TWh/year of electricity demand reduction technical potential available GB-wide according to analysis for DECC.²³



1%
DEMAND
REDUCTION
PER YEAR
WILL ALLOW
SCOTLAND TO
HIT THE TARGET
WELL WITHIN
THE CURRENT
RENEWABLES
PIPELINE

Fulfilling Renewables Ambition



Scotland has the potential to be a renewable powerhouse within the UK and Europe, with over 25% of Europe’s offshore wind and tidal power and 10% of its wave power.²⁴ It has a strong track record on renewable electricity and is making steady progress towards its target of meeting 100% of demand from renewables by 2020. Renewables are already the largest source of power generation in Scotland, outstripping nuclear, coal and gas.²⁵

The Low Climate Risk Scenario allows Scotland to have an almost wholly renewable generation system (with only 340MW of gas plant fitted with CCS) and to meet almost all of its needs from renewables – 92%. This contrasts with the High Climate Risk Scenario, where only 59% of Scotland’s needs are met from renewables. Given that Scotland has a 100% target by 2020, and a magnificent resource base, it would send a confusing signal to dilute Scotland’s renewables ambition to less than two-thirds of what it currently is.

Indeed, the Low Climate Risk Scenario would easily allow Scotland to meet 100%, 125% or potentially even more of Scotland’s needs from renewables.²⁶

This would not only allow Scotland to maintain its status as a net power exporter, it would actually allow Scotland to become a net exporter of green power. Reaching 125% could be done with only a portion of the level of onshore and offshore wind already consented (for instance around half the currently consented offshore wind capacity in Scotland) and ongoing grid upgrades will easily accommodate this level of export.²⁷

By contrast, meeting 125% of Scottish demand from renewables in the High Climate Risk scenario, though possible, would be more technically and economically challenging, requiring a large amount of new renewables capacity and related transmission infrastructure to be built, beyond what’s currently under discussion.

The graph below sets out how much additional capacity would be required to hit the 2030 decarbonisation target and what capacity over and above this will be needed to hit more ambitious renewables goals.

BY 2030, FURTHER ONSHORE WIND CAPACITY (OR EQUIVALENT) REQUIRED TO HIT DECARBONISATION TARGET AND...	MEET 100% OF DEMAND	MEET 100% OF DEMAND FROM RENEWABLES	MEET 125% OF DEMAND FROM RENEWABLES	TOTAL INSTALLED CAPACITY ²⁸ AT 125% OF DEMAND FROM RENEWABLES
High Climate Risk Scenario (4.5GW existing)	1GW	+7GW	+4GW	16.5GW
Low Climate Risk Scenario (4.5GW existing)	2.1GW	+0.9GW	+3.1GW	10.6GW

The 125% figure should not be seen as a cap on renewables growth, however. There is a huge amount of further renewable energy capacity available in Scotland, especially in the offshore sectors, which could be exported as an economic opportunity and to assist in meeting wider UK or EU climate and renewables goals.

**SYSTEM
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PROVIDED THAT
THE GB SYSTEM
ITSELF IS SECURE**

Maintaining System Security

Maintaining system security during periods of high electricity demand and low renewable production is critical, even though this will be a relatively infrequent occurrence as high demand for electricity in winter often coincides with high wind output. Where there is any shortfall between demand and supply, this can safely and securely be met by imports from the rest of Great Britain or Europe through interconnection, more efforts to manage Scottish demand, or back-up gas plants based in Scotland, depending on the economic case for each.

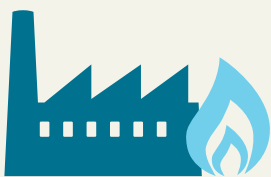
For all scenarios, DNV GL stress tested system security in a worst case scenario - with peak demand for electricity (e.g. winter evenings), low renewables generation and assuming that the largest power plant on the system wasn't working. The results show a much smaller gap between demand and supply in the Low Climate Risk scenario than the High Climate Risk Scenario as demand is lower and there is substantially more pumped storage.

The Low Climate Risk Scenario is less vulnerable from a security of supply perspective, requiring Scotland to import less electricity to meet peak demand.

Box 7: Securing the GB system

Studies have shown that a secure GB system is perfectly feasible with high levels of renewables. The Committee on Climate Change, National Grid and others have published long-term decarbonisation scenarios that maintain system security.²⁹ While the GB capacity margin is expected to tighten over the next two years before rising again, Ofgem's 2014 capacity assessment stresses that the new balancing tools available to National Grid and the forthcoming capacity market will lessen the risks of supply disruptions.³⁰ A suite of new interconnection projects will also boost security of supply for GB as a whole.

Most decarbonisation scenarios show significant amounts of new build gas-fired generation providing peaking and balancing services to complement renewables, operating ultimately at low capacity factors though working initially at high loads to recoup capital costs.³¹ While it is feasible that some of this generation could be based in Scotland, given the transmission regime, it is likely to be cheaper to locate it closer to major demand centres further south. DNV GL's analysis shows that while, in principle, a major gas plant could be located in Scotland, it would have to operate at a relatively low capacity factor (<50%) to avoid breaching the decarbonisation target. However, far less back-up generation will be required overall to complement renewables if progress is made on storage, demand side response and interconnection at a UK level.



50% CAPACITY

analysis shows that while, in principle, a major gas plant could be located in Scotland, it would have to operate at a relatively low capacity factor (<50%) to avoid breaching the decarbonisation target

Security of Supply with Peak Demand and Low Renewables

SCENARIO	POTENTIAL SHORTFALL AT PEAK DEMAND	PLUS: LOSS OF LARGEST UNIT IN SCOTLAND	LESS: DEMAND RESPONSE AVAILABLE AT PEAK DEMAND	NET SHORTFALL
High Climate Risk	2200 MW	1250 MW (CCS unit)	100 MW	3350 MW
Low Climate Risk	900 MW	600 MW (pumped-storage unit)	500 MW	1000 MW

It is important to stress that ongoing grid upgrades, including a subsea bootstrap on the west coast, will be enough to cover any shortfall between supply and demand well before 2020 in both scenarios. So system security can be achieved without any conventional coal, gas or nuclear capacity in Scotland, provided that the GB system itself is secure. Ultimately, as Scotland is part of the GB electricity system, which is operated and regulated as one system, security of supply is most effectively and cheaply delivered at GB level.³²

DNV GL also considered a range of technical issues relating to system stability and balancing (such as black start, inertia and frequency control).³³ While there are a number of challenges that will need to be addressed in the transition to a renewables-dominated system, DNV GL is confident that these can be managed in Scotland, and technologies such as pumped storage will have an important role to play in this respect. National Grid is currently working on a range of regulatory and technical options to mitigate any potential effects on the operation of the grid, which will ensure that system stability remains robust in the transition to a decarbonised electricity system across Great Britain.³⁴

Ultimately, the future electricity grid must move away from a system optimised around conventional 'baseload' power plants, which run all the time, towards a system where renewables become the new 'baseload', supplemented by flexible back-up generation, demand side response, storage (including heat storage) and interconnection. Many of the technologies that will underpin this system already exist. However, the current incentive structures in place do not adequately reward the electricity system services of the future.³⁵

**A GREEN
ELECTRICITY
GRID MUST
MOVE AWAY
FROM A SYSTEM
OPTIMISED
AROUND
CONVENTIONAL
'BASELOAD'
POWER PLANTS**



**THE LOW CLIMATE RISK SCENARIO
IS A CREDIBLE, PRAGMATIC
WAY OF MEETING SCOTLAND'S
DECARBONISATION TARGET.
PURSUING THIS PATHWAY WOULD
ALLOW SCOTLAND TO MAINTAIN
AND BUILD ON ITS REPUTATION AS**

**A RENEWABLE
POWERHOUSE.**

CONCLUSION:

The two scenarios outlined present alternative blueprints for decarbonising Scotland's power sector in 2030 – one where gas power fitted with CCS still has a big role to play, and one where Scotland moves beyond conventional generation and maintains strong renewables ambition.

First and foremost, the High Climate Risk Scenario is – as the name suggests – higher risk from a climate perspective because it relies on CCS rather than proven renewable technologies. Pursuing a future energy policy reliant on a technology that has not been commercialised is a high stakes game that could derail delivery of Scotland's Climate Act and distract from progress on renewables.

Furthermore, while the High Climate Risk Scenario achieves the decarbonisation target, it provides a weaker foundation for Scotland's renewables ambition (meeting less than two-thirds of demand from renewables in the decarbonisation scenario) and presents technical and economic challenges to delivering stretch renewables targets. It is also more expensive than the alternative, due to the relative cost of CCS compared to wind, and has higher import dependency on the rest of Great Britain at peak demand. With its reliance on fossil fuels, it continues to expose Scotland to gas price volatility, which has been the main driver of fuel poverty and rising energy bills, and continues the dependence on gas imports from overseas, including politically unstable regions, which undermines energy security.

The Low Climate Risk Scenario is a credible, pragmatic way of meeting Scotland's decarbonisation target. It means Scotland would have an efficient, flexible system based almost entirely on renewables which would meet almost all of Scottish demand and even allow for substantial exports of renewable power, all within the current renewable pipeline. Scotland could maintain and even expand on its position as an electricity exporting nation, maximising the economic opportunities presented by further renewables growth. The Low Climate Risk Scenario is cheaper to achieve than the Scottish Government's favoured alternative and has a lower import dependency at peak demand. Pursuing this pathway would allow Scotland to maintain and build on its reputation as a renewable powerhouse.

If there is enough political will to commit to a renewable powered future, it's clear that Scotland does not need to take a high stakes gamble on CCS.

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- 2 We've included 500MW of biomass and a minimum of 340MW of gas plant fitted with CCS in our scenarios. See Box 2 to explain the role of CCS and WWF's position on the technology. See Section 4 of the Technical Report where credible generation mixes are developed.
- 3 For full details of the security of supply implications of the report's scenarios, see Section 4.4. of the Technical Report.
- 4 While the two scenarios compared in this summary vary in terms of energy demand and system flexibility, even with the same assumptions about demand and flexibility, the scenarios with CCS have higher costs. See Section 5.7 of the technical report for a discussion of the cost implications. This considers the levelised cost of additional generation capacity. This per mwh price includes the costs of building, operating, and decommissioning, including the carbon costs, but not wider costs such as network costs or air pollution costs. In terms of transmission costs, no extra transmission capacity will be required between Scotland and the rest of Great Britain in the scenarios beyond what's already planned but grid reinforcement and new capacity will be needed at a GB level, with an estimated capital investment of £2bn between 2020 and 2030, according to the UK Committee on Climate Change. The costs represent only a fraction of the cost of generation.
- 5 See Technical Report Table 5.1
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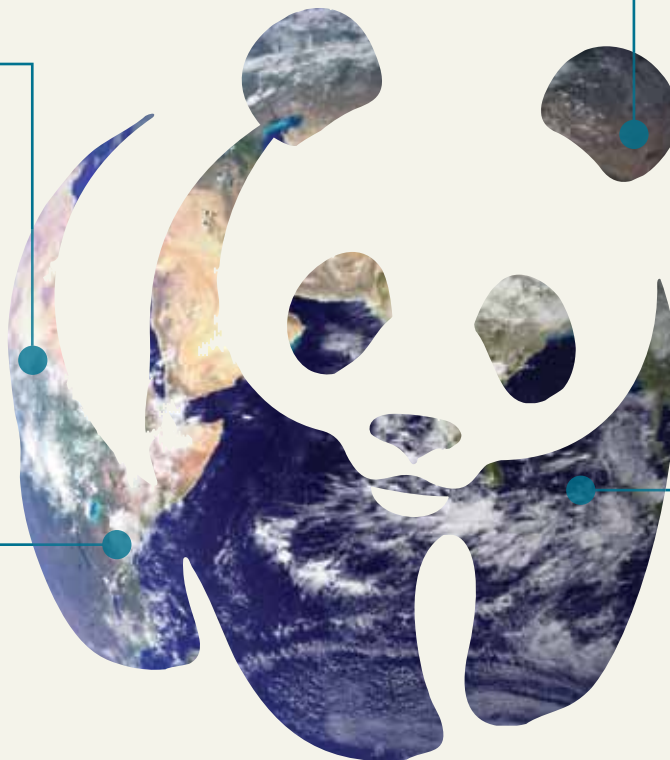
Renewable energy in numbers

50g CO₂/kWh

Scotland's 2030 power sector decarbonisation target.

32%

Renewables generated 32% more power than any other form of electricity generation in Scotland the first half of 2014.



11.9m TONNES CO₂

Emissions displaced by Scotland's renewables in 2013. That's more than the entire transport sector!

11,695

Renewables jobs in Scotland in 2013



Why we are here

To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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