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2050 Pathways Call for Evidence Coordinator
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Date: 05/10/2010

Dear 2050 Pathways Team,

RenewableUK response: 2050 Pathways: Call for Evidence

RenewableUK (formerly the British Wind Energy Association (BWEA)) is the trade and professional body for the UK wind and marine renewables industries. Formed in 1978, and with over 650 corporate members, RenewableUK is the leading renewable energy trade association in the UK, representing the large majority of the UK's wind, wave, and tidal energy companies.

Questions:

Q1a. Are there any low carbon technologies or processes or major demand-side options which are not currently included within the scope of the model but that you consider should be in future?

RenewableUK welcomes efforts made by the 2050 pathways team to assess in detail how a future UK electricity system can securely operate at times of peak demand and in the context of real time variation in both demand and generation.

We note the work undertaken by National Grid on electricity balancing; however we are very concerned about the methodology of translating meteorological data, which is not from wind generation sites, into wind power output figures especially when considering extreme conditions (e.g. low winds and peak demands). We would like to see a thorough assessment of this issue, primarily using real output data from windfarms and system demand figures (e.g. triads – peak demands). We would like to see the impact of embedded wind generation included and considered in relevant generation and demand figures. Without carrying out such a piece of work, it should be noted that DECC 2050 pathways modelling will remain un-validated, and potentially inaccurate in its understanding of a fundamental system operational characteristic.

To support further analysis on the basis of real, rather than modelled, data we would like to see a immediate comprehensive literature review so that DECC can have full benefit of both industry and academic experience[1].

We note one demand side option not absorbed within the 2050 pathways modelling includes the evolution of significant volumes of demand switching within large demand sites (e.g. medium-heavy industry). As more wind connects to the UK electricity system, we expect demand to take advantage of low carbon power[2] with the lower market prices expected in these periods. Such behaviour could improve the competitiveness of UK industry owing to reduced energy costs, but could also substantially reduce peak demand at times of low supply from wind generation. We would encourage 2050 pathways modelling to factor in such behavioural change with large demand sites.

We would also support the case that there is a lack of detail around future developments concerning Batteries, Fly Wheels, Pumped Storage, Compressed Air (CAES), Heat Pumps and other types of storage. We believe this to be an area that could benefit from additional work.

[1] As a starting point we reference two reports by David Milborrow: firstly for DTI “Capacity Credits for Renewable Energy Sources in the UK”, and secondly for WWF “Managing Variability” June 2009. These documents contain references to a body of other work in UK and overseas and reference real data such as output during Triads.
[2] Wind Energy and Electricity Prices: Exploring the “Merit Order Effect” - A report by Poyry for EWEA.

Q2a. Does the range of alternative levels of ambition presented for each sector cover the full range of credible futures? If not, what evidence suggests that the range of scenarios should be broader than those presented?

Onshore wind

We present further comparative analysis of European countries to assess UK onshore wind potential.

	Current Wind Capacity MW	Population Millions	Land area sq Km	Population density 1000s / sq Km	Power density W / Capita	Equivalent UK capacity (Population) MW	Power density W / sq Km	Equivalent UK capacity (Land area) MW
Denmark[3]	2851	5.3	43075	0.12	538	31796	0.0662	16200
Germany[4]	26302	82	356840	0.23	321	18971	0.0737	18040
Netherlands[5]	1999	15.8	33940	0.47	127	7506	0.0589	14416
Spain[6]	19450	39.4	504880	0.08	494	29195	0.0385	9429
Portugal[7]	3357	10	91630	0.11	336	19858	0.0366	8967
Italy	5133	57.6	301245	0.19	89	5260	0.0170	4170
Ireland	1381	3.7	68895	0.05	373	22044	0.0200	4906
UK	3580	59.1	244755	0.24	61	NA	0.0146	NA
Greece	1185	10.5	131985	0.08	113	6678	0.0090	2197
Austria[8]	1001	8	83855	0.10	125	7388	0.0119	2922
France[9]	4690	60.8	543965	0.11	77	4551	0.0086	2110
Sweden	1560	8.9	449790	0.02	175	10343	0.0035	849

Table 1: Deployment density data: Onshore wind energy

Regarding practical resource, we note the 2050 pathways work highlighted Denmark's wind deployment on the basis of power density (land area). We would suggest Germany provides a better example for demonstrated land-area density feasibility, on the basis the UK and Germany share a similar population density, almost double that of Denmark. If the density of onshore wind farms in the UK (MW/per 1000km2) was similar to the current density in Germany then it is estimated that the total capacity would be around 18 GW (see Table 1).

If the density of onshore wind farms in the UK (MW/per capita) was similar to the current density in Denmark, then it is estimated that the total capacity would be around 32 GW (see Table 1).

On the basis of research carried out to date, we would suggest 0 – 50 GW of operational onshore wind capacity represents a credible range for future ambition.

[3] Danish Energy Agency
[4] DEWI magazin, August 2010. Deutsches Windenergie-Institut
[5] Wind Service Holland
[6] Aeeolica
[7] http://www.centrodeinformacao.ren.pt/PT/publicacoes/EnergiaEolica
[8] http://www.connexionfrance.com/wind-turbines-planned-in-france-but-where-11833-view-article.html
[9] Austrian Wind Energy Association

On the basis of German and Spanish deployment over recent years, coupled with increasing annual onshore wind deployment in the UK, a maximum sustained annual deployment of 2.5GW seems sensible for inclusion within the context of Level 4 scenario.

Offshore wind

On the basis of research carried out to date, and subsequent to the formation of 2050 pathway assumptions for offshore wind, 0 – 140 GW of operational offshore wind capacity is an insufficient range for future ambition. We do not recognise 140 GW by 2050 as representing "a level of change that could be achieved with effort at the extreme upper end of what is thought to be physically plausible by the most optimistic observer".

In line with the pathway's stated ambition to model a level 4 deployment value in line with that which "pushes towards the physical or technical limits of what can be achieved", we refer to the work of the Offshore Valuation Report (OVR). The OVR calculates the maximum resource potential for offshore wind to be 466 GW of installed capacity by 2050. In light of such research, and related deployment scenarios, we recommend a 2050 pathways Level 4 deployment scenario to be reclassified in line with the OVR scenario 3, at 361 GW of offshore wind capacity by 2050.

We note that higher levels of offshore wind deployment will depend on the successful widespread deployment of floating turbine technology. Whilst this technology is new and currently under demonstration in various parts of Europe, its full development is more certain, and is further advanced than other technology heavily relied upon within 2050 pathways modelling (e.g. new nuclear, or CCS).

We recognise the modelled peak annual deployment rate of 7 GW broadly represents that reported for the Crown Estate. However, offshore wind is free from the constraints of onshore constraints, and at an early stage of market and supply chain development. By the 2020s, and certainly by the 2030s, we would expect the maximum annual rate of deployment to significantly exceed that experienced in delivering Round 3 sites. In the context of a 2050 pathway level 4 adopting 361 GW of offshore wind deployment by 2050, annual deployment rates consistent with the OVR i.e. ~ 10 GW per annum.

In the context of 2050, the consideration of offshore wind deployment requires UK energy market modelling to consider the adoption of a vastly increased EU-centric vision, and far less founded upon the demand for low carbon electricity from UK consumers alone. With the best wind resource in Europe, UK territorial waters represent an essential asset for supplying a significantly increased demand for electricity to a continental Europe that is less abundantly resourced.

Wave and Tidal Stream

On the basis of research carried out to date, we suggest 0 – 58 GW of operational capacity represents a credible range of future ambition.

Small wind systems

It is unclear how the 2050 pathways defines small wind systems. Although the document in part references 0-5 MW, much of the analysis only considers 0-100kW installations. RenewableUK recommends that small wind systems are defined as 0-100kW (in line with GB Feed In Tariff bands 1-3), and we reply to the call for evidence on such basis.

RenewableUK (as BWEA) modelled small wind system (SWS) deployment up to 2050 as part of our response to the Government's Renewable Energy Strategy in 2008[10]. This work was informed by industry on the basis of (a) Number of viable SWS sites in the UK (4 million), (b) Year of market saturation (2040), (c) average size of SWS (1.9 kW[11]), and (d) Applied capacity factors (0-1.5kW = 0.1, 1.5-100 kW = 0.17[12]). The deployment 2020 results were as follows:

(a) 600,000 units deployed;
(b) 1.3 GW of installed capacity;
(c) 1.7 TWh of energy production.

The 2050 results were as follows:

(a) 4,000,000 units deployed;
(b) 8.75 GW of installed capacity;
(c) 8.75 TWh of energy production.

Recently published UK market intelligence has shown that the average size of SWS deployed has increased from 1.9kW in 2007 to 2.1kW in 2008, to 2.6kW in 2009, to 3.2kW in 2010. We expect this trend to continue, with owners of their second turbine likely to increase their capacity from that originally installed. Together with this trend, reduced technology cost, improved technology performance, increased customer awareness, increased retail price of electricity will dramatically increase the number of viable SWS sites across the UK. In the

[10] BWEA RES Response: http://www.bwea.com/pdf/080926%20BWEA%20RES%20Consultation%20response.pdf
[11] BWEA SWS UK Market Report 2008, Note average size has increased since 2008
[12] Consistent with Energy Saving Trust recommendation as of 2008

context of such trends the minimum annual average windspeed at which a site becomes financially viable or attractive will reduce expanding the viable UK market place.

Industry has previously highlighted the following sectors for SWS deployment: (a) domestic, (b) commercial, (c) agricultural, (d) industrial, (e) leisure, and (f) public sector. Beyond the referenced work of EST, and the Carbon Trust, we recommend the 2050 pathways team to also consider the following studies:

(a) Renewable Advisory Board - 2020 vision;
(b) BERR (2008) - The growth potential for Microgeneration in England, Wales and Scotland;
(c) BERR (2008) - The growth potential for on-site renewable electricity generation in the non-domestic sector in England, Scotland and Wales;
(d) DTI (2005) – Potential for microgeneration – Study and analysis[13]
(e) EST (2008) – Generating the Future: An analysis of policy interventions to achieve widespread microgeneration penetration
(f) RenewableUK SWS UK market report 2010

RenewableUK recommends 0 – 9TWh should represent the credible range of ambition, but does not represent a high level of ambition which stretches the bounds of optimism as demanded for a level 4 pathway. The BWEA's work carried out in response to the Renewable Energy Strategy broadly co-aligns with 2050 pathways level 4 analysis. Industry maintains that such deployment is a credible, likely path, and more suitable for application within a level 2-3 scenario.

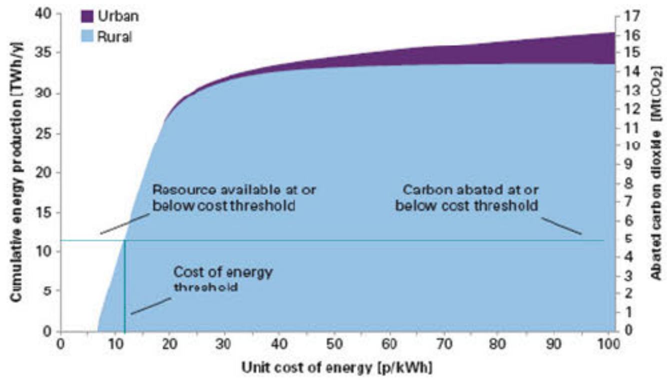
We recommend that the SWS level 4 pathway should not use the EST report as a basis, as this work only examines a third of the UK market segments for SWSs (i.e. not commercial, leisure, public or industrial sectors). The EST report models site viability on the basis of current technology costs, as opposed to considering significant technology cost reduction expected as a result of high volume manufacturing. The EST methodology for assessing site suitability was crude and inferior to that adopted by the Carbon Trust. Lastly, EST quoted size of market was dependent upon sites possessing a minimum average annual wind speed of 5.0 m/s, ignoring all market potential below such resource availability. In reality, if technology cost reductions were fully taken into account, the minimum average annual wind speed at which any given site would become commercially attractive to the site owner would decrease below 5.0 m/s over time. By accounting for sub 5.0 m/s sites at the 2050 timescale, the actual market size potential for deployment of small wind systems would potentially be far in excess of that estimate to be available in 2009 by the EST on the basis of 2009 technology costs .

[13] EST Report: http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file27559.pdf

We recommend the use of the Carbon Trust reporting as a basis for level 4 analysis (See "Small-scale wind energy - Policy insights and practical guidance" – Carbon Trust 2008), which highlights "In theory, small-scale wind energy has the potential to generate 41.3 TWh of electricity and save 17.8 MtCO2 in the UK annually".

a) Cost-resource curve

The chart is based on 100% market penetration. In the table, the 100% market penetration bracket means 'if every turbine at or below a given cost of energy were installed', while the 10% bracket means 'if 10% of turbines at or below a given cost of energy were installed'.



b) Selected data from cost-resource curve

Sources: Met Office and Entec

		Cost of energy	
		<12p/kWh	<100p/kWh
Market Penetration	100%	15 TWh/year 6.3 $MtCO_2$/year	37 TWh/year 16 $MtCO_2$/year
	10%	1.5 TWh/year 0.6 $MtCO_2$/year	3.7 TWh/year 1.6 $MtCO_2$/year

Figure 1: Carbon Trust small scale wind analysis

By applying cost reduction scenarios to overall capacity values, a value for 2050 SWS energy production can be arrived at in support of level 4 ambition.

(a) Number of viable SWS sites in the UK (4 million[14]),

(b) Year of market saturation (2050),

(c) Average size of SWS (3.2 kW[15]), and

(d) Applied capacity factor (0.19[16]).

The 2050 results were as follows:

(d) 12.8 GW of installed capacity;

(e) 21.3 TWh of energy production.

We note that if the current trend for the average size of UK deployed Small Wind System was to continue to increase beyond its current 3.2kW level. Level 4 pathway figures could be in theory extended further.

<u>Interconnection</u>

[14] Industry survey by BWEA

[15] 3.2kW = Average size of SWS deployed in the UK in 2010, according to RenewableUK 2010 market reporting

[16] Capacity factor is in line with latest Energy Saving Trust recommendations

4 – +50 GW of interconnection by 2050 seems reasonable, however the overall benefits accorded to significant volumes of variable renewable output (e.g. from higher than initially modelled offshore wind deployment – See response to Q2a and Q2b) may require even higher levels of interconnection. The level of ambition applied within level 2 and level 3 pathways is also too low.

Peak power

We acknowledge that 3.5 – 20 GW of peak power is reasonable in the context UK potential capacity. Beyond such levels, the development of interconnection capacity, and peak power operations outside the UK could potentially supply increased ambition thereafter.

We recommend that the provision of non UK peak power should be considered in further detail.

Q2b. Do the intermediate levels of ambition (levels 2 and 3) provided for each sector illustrate a useful set of choices, or should they be moved up or down?

Onshore wind

In the context of research carried out up to date, as well as latest market and industry intelligence, we recommend level 2 and 3 represent credible, intermediate levels of ambition and should remain unchanged.

Offshore wind

See response to Q2a.

Analysis carried out by Douglas Westwood (DW) on behalf of RenewableUK[17] suggests a healthy UK offshore wind industry could deploy at an annual rate of between 3.3-6 GW post 2017. We recommend such levels of annual activity are realistic and achievable, and should form the basis of level 2 and level 3 pathways.

The OVR suggests a fully developed indigenous UK industry and supply chain, supported by EU counterparts, could deliver annual deployment rates of up to a decadal average of 6.3GW/ annum in the 2020s, and up to 20GW/annum thereafter. We recommend such levels of deployment depend upon technology development of floating turbines to seamlessly provide new market opportunities within timescales of seabed mounted turbine market depletion. At this stage of industrial development we would recommend such levels of deployment more appropriately support a level 4 pathway.

If one applies the DW healthy industry scenarios to current deployment, 23GW of offshore wind would be operational by 2020. If one were to extend a steady state annual deployment of 3.3GW (*to be increased to account for replacement @ 25 year life*) until 2050, total offshore wind deployment would stand at 128GW by 2050. On the basis of the UK's abundant resource, large offshore territorial waters, and the anticipated provision of fully developed floating wind turbines, we recommend the continuation of such deployment rates are realistically feasible. On this basis we recommend 128GW should be applied to the level 2 pathway.

Similarly, if one accepts that annual deployment rates will match those expected by the Crown Estate, and related reports, 6GW could be annually deployed post 2020. On the basis that UK supply chain will ramp up until 2020 but then delivers 6GW annual thereafter, 203GW of operational offshore wind could be realised by 2050. We recommend 203GW of offshore wind by 2050 represents a "very ambitious level of effort" and will depend upon significant system changes (e.g. high levels of interconnection), and so should be applied to the level 3 pathway.

In summary RenewableUK recommends the following level of 2050 offshore wind deployment by 2050 pathway work modelling the following:
Level 1 – As is;
Level 2 – 122 GW, 374 TWh pa;
Level 3 – 203 GW, 623 TWh pa;
Level 4 – 361 GW, 1108 TWh pa.

Wave and tidal stream

In the context of research carried out up to date, as well as latest market and industry intelligence, we recommend level 2 and 3 represent credible intermediate levels of ambition, and should remain unchanged.

Small wind system

We recommend the current level 4 pathway should be replaced with that outlined within our response to Q2a.

Level 3 pathway should apply that currently proposed under level 4, and broadly in line with that proposed by BWEA and industry at in their response to the Renewable Energy Strategy.

[17] UK Offshore Wind: Building an Industry: Analysis and scenarios for industrial development

Level 2 pathway should apply to that currently proposed under level 3.

In summary, RenewableUK recommends the following level of 2050 small wind system deployment by 2050 pathway work modelling the following:
Level 1 – As is;
Level 2 – 3.5 TWh pa (Current level 3 pathway);
Level 3 – 8.6 TWh pa (Current level 4 pathway);
Level 4 – 21.3 TWh pa (Methodology in line with our response to Q2a).

Interconnection

According to the ENTSO-E Ten Year Plan, currently approximately 10GW of UK interconnection is either operational, under construction or under consideration. To this extent we recommend level 2 pathway of 10GW of UK interconnection 40 years from now is overly pessimistic, and unlikely to satisfy demand for interconnection driven by increased deployment of variable renewable generation.

We recognise the extent to which the UK interconnection is developed will link closely to the extent to which the UK harnesses the power of its renewable energy resources, on the development of energy storage technology (both within the UK, and within continental Europe), and on the development of energy demand shifting.

Should the UK succeed in once more becoming a net exporter of electricity, or indeed energy, the significant development of offshore renewables (e.g. wind, wave and tidal) will be essential. In the context of UK resource opportunities being realised as not just as an UK asset, but relied upon by energy consumers in continental Europe, we recognise significant levels of interconnection will be required so to service the export of energy by UK generator. To this end we would recommend over 50GW of UK interconnection would be required to service levels of offshore wind deployment as highlighted in the recent Offshore Valuation Report, and recommend by RenewableUK for inclusion within revised level 4 pathways.

We recognise more work is required when considering the interaction of national markets across interconnection boundaries. Additionally, more work is required for examining the structure of related trading arrangement that will be necessary to fully facilitate interconnection use by variable generators.

We recommend UK interconnection pathways should apply as follows:
Level 1 – 4 GW;
Level 2 – 20 GW;
Level 3 – 35 GW;

Level 4 – +50 GW.

Q2c. The 2050 Pathways Calculator currently describes alternative directions of travel rather than different levels for some sectors where changes reflect a choice rather than a scale. Is this a suitable approach and clear to users?

This appears a sensible approach to take.

Q3a. For each sector, are the input assumptions and the methodologies applied to those input assumptions reasonable?

<u>Onshore wind</u>

See our response to Q2a and Q2b – annual deployment rates.

<u>Offshore wind</u>

See our response to Q2a and Q2b – annual deployment rates and maximum resource availability.

<u>Wave and tidal stream</u>

This appears a sensible approach to take.

<u>Small wind system</u>

See our response to Q2a and Q2b – annual deployment rates and maximum resource availability.

Q3b. As regards specific sectors: Are the bioenergy conversion routes used in the model accurate, or are there more efficient routes for converting raw biomass into fuels?

N/A

Q3c. As regards specific sectors: Can the model's assumptions on wave resource be improved, for example regarding the length of wave farms, their distance from shore, the efficiency of devices, constraints from other ocean users, and other assumptions?

RenewableUK overall supports the approach taken by the 2050 pathways team, but would add the following comments on the wave and tidal stream sections:

(a) We would highlight the publication of the Marine Energy Technology State of the Industry 2010 report by RenewableUK, as complimentary to that published by BWEA in 2009;
(b) We would recommend Strangford Lough does not represent a site of large overall resource. It is a very small site, but capable of providing robust conditions within in which a small number of units can be successfully tested or operated;
(c) Regarding notes on international competitions, we note that the USA are now substantially investing in wave and tidal stream technology on a regular basis.

Q3d. As regards specific sectors: Can the model's assumptions on tidal stream resource be improved, for example regarding the method for assessing the resource at specific locations, and the scaling up of individual devices into an array?

See our response to Q3c.

Q3e. As regards specific sectors: Is there any evidence that would help build an understanding of the potential impact of long term spatial development on transport demand, and how could this be accounted for in the model?

N/A

Q3f. Due to uncertainties in the evidence base on energy demand and associated emissions, the model currently sets out only one level of ambition for the future UK share of international shipping. Is there any evidence you could contribute to help build a greater understanding of the potential shipping trajectories?

N/A

Q3g. Could the relative roles of coal and gas out to 2050 vary from the assumptions shown in this work, and if so, how?

N/A

Q4a. The introduction to the report sets out some of the implications and uncertainties common to the illustrative pathways. Does this list cover the key commonalities? If not, please identify other common implications and uncertainties and provide evidence as to why these are key conclusions from the analysis.

N/A

Q5a. What criteria should be taken into account in understanding the impact and relative attractiveness of pathways?

We recommend technology costs should be considered in their absolute terms, but also in terms of their uncertainty on the basis of current technology development. For example, offshore wind is currently ramping up to high volume deployment, and thus can currently provide firm evidence of related costs. Other technologies given high levels of focus within the 2050 pathways analysis have not been yet been deployed within the UK at either a demonstration stage or anything approaching high volume deployment, and are at an earlier stage of their development (e.g. New Nuclear, CCS). We therefore recommend the 2050 pathways team differentiate between those costs that are known through demonstration, and deployment, and those that are less evidenced both in UK and internationally.

We are surprised at the content of Figure 4 – “Average gross cost per megawatt-hour of the illustrative pathways in 2050” which illustrates the low renewable pathway to represent the least expansive modelled pathway. To this end we would recommend the 2050 pathways team refreshes their cost assumption by including latest research such as that conducted by UKERC in their “Great Expectations: Offshore wind costs” publication[18]. We would suggest Annex A costs are on the high side for offshore wind, and do not take sufficient account of innovation and related technology cost reductions that will be realised over the coming decade and beyond.

[18] UKERC report: http://www.ukerc.ac.uk/support/tiki-read_article.php?articleId=613

We note 2050 pathways cost assumptions currently only considers capital installation costs, and does not consider the full range of cost implications which will define the relative competitiveness and energy costs of particular technologies. We would recommend improved 2050 pathways cost modelling would account on the basis of all of the following:

(a) Capex costs;
(b) Devex costs;
(c) Extended operational life;
(d) Increased technology availability (reduced frequency and length of outage through breakdowns);
(e) Improved technology performance, via improved efficiency will increase energy production.

We note cost modelling assumption c, d, and e would not be accounted for by simply modelling installation cost on a per MW installation basis, as proposed by 2050 pathways work.

We acknowledge this modelling does not assess economic parameters, however we would recommend further assessment could usefully examine the following on a technology and pathway basis:

(a) Reliance on non-UK resource (supply chain, manufacturing, fuel) – How much revenue investment is channelled to UK centres of commerce, as opposed to those outside the UK;
(b) UK industrial benefit, and value added economic gain;
(c) Export potential from those UK industries created to supply related deployment pathways; and
(d) Supply chain constraints should be examined in more detail;
(e) Fuel cost risk should be examined in more detail;
(f) Waste cost risk should be examined in more detail;
(g) Global market priority status should be more closely considered. For example, the UK offshore wind market is prioritised by existing UK and EU supply chains. UK nuclear deployment has a limited supply chain, and may be reliant on an international supply chain focused elsewhere;
(h) The extent to which the technology cost has been demonstrated and proven, should be more closely considered. RenewableUK would strongly question the confidence that can be attributed to CCS and New Nuclear costing characteristics given their lack of deployment in the UK;
(i) Currency risk should be considered for those technologies not supported by a UK based supply chain;

(j) All technologies have a carbon cost of their own; from capital costs to operation e.g. fuel to service wind farms with boats & vehicles, mining and processing nuclear fuel, and managing waste. Some of these emissions will be made outside UK and some will be in the future.

Q6a. Can you suggest a methodology by which the wider cost implications of choosing one pathway over another could be accurately reflected, and any relevant findings from such an approach?

See above, response to Q5a.

Q7a. Do you have any further suggestions for refining the 2050 Pathways Calculator?

More detailed summary of assumptions would be helpful.

Q7b. Could the 2050 Pathways Calculator be improved to reflect the fact that the level of ambition for some sectors will depend on local preferences? Could the Pathways Calculator be improved such that the inherent degree of individual and local choice in a chosen pathway was clear?

NA

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If you would like to discuss the content of our reply in more detail, do please get in touch.

Yours faithfully,

[redacted]

[redacted], Head of Technical Affairs for RenewableUK

(Sent by email)

Tel: [redacted] | Tel: [redacted]