Submission ID: 27098

This comment offers a detailed critique of the Applicant's response (REP1-018 ) to the Issue Specific Hearing 1 (ISH1) question the Examination Authority (ExA) posed regarding “the level of wind resources in the Channel”. Question 2.
We believe the Applicant's response lacks merit and misleads the conversation on the quality of the wind resource in the Channel, in particular the Sussex Bay inshore.
This comment has a summary highlighting information that indicates the actual level of the wind resource in the Sussex Bay inshore where up to 90 Rampion 2 turbines would go, including wind power density, and actual load factors and load duration curves for Rampion 1 as compared to similar windfarms in other UK offshore locations. The Main Section of this comment and annexes elaborate the indicators offered with evidence. We believe that evidence suggests the Applicant’s response to the ExA on this vital question seeks to present Rampion 2 in a favourable light, without offering the full picture, or the consequences if Rampion 2 were consented. Those consequences include the opportunity costs that flow from committing £3-4 billion to installing expensive large wind turbines in a less favourable wind resource area. That would result in recurrent costs for UK society over the 20-25 years of Rampion 2 operation from 2030 or so, before the Rampion 2 infrastructure is decommissioned and taken out, or replaced around 2050. Incrementally more public investment would be needed in national grid infrastructure (e.g., for the additional low-emission backup generation (dispatchable power) and more power system ancillary services to ensure system reliability). Relative to other critical national priority investments in low emission generation, Rampion 2 also means incrementally greater need for the UK to import LNG from volatile international markets (e.g. from Qatar through the Suez canal and the US mainly at the moment) and/or power from Europe at a high costs, with balance of payments impacts, greater emissions than otherwise outside UK territory in LNG and technology supply chains, and overall less UK energy-self reliance.
This comment thus sets out some of the considerations that Protect Coastal Sussex and the affiliation of community organisations on the south coast and affected inland areas, who would be required to “host” Rampion 2 infrastructure, see as important and relevant in any informed discussion of the wind resource in the Sussex Bay inshore in this Examination, and what it actually means NPS policy-wise and materially.

PROTECT COASTAL SUSSEX

Examination Deadline 2 for EN010117 – Rampion 2 Offshore Wind Farm

## Comment on the Applicant Response in REP1-018 to the ExA Action Points Arising from Issue Specific Hearing 1 (ISH1)

# Item 2: Applicant to make a response in detail as to the level of wind resources in the Channel (Sussex Bay Inshore)

### PCS Comment to the Rampion 2 Examination Authority (ExA) Deadline 2

**Submitted by Protect Coastal Sussex (PCS) in affiliation with community groups and civil society organisations on the Sussex Coast and affected inland areas**

| | |
|---|---|
| **PCS: IP Registration Number:** | **20044835** |
| **Submission Date:** | **20 March 2024** |

**Submitted By:**


The Secretary
Protect Coastal Sussex
Member of the Rampion 2 Community Project Liaison Group

On behalf of PCS Co-Chairs

Chris Lee, Aldwick
Melanie Jones, Middleton on Sea
Lawrence Haas, Littlehampton
Meera Smethurst, Cowfold

# SUMMARY

This comment offers a detailed critique of the Applicant's response to the Issue Specific Hearing 1 (ISH1) question the Examination Authority (ExA) posed regarding *"the level of wind resources in the Channel*". We believe the Applicant's response lacks merit and misleads the conversation on the quality of the wind resource in the Channel, in particular the Sussex Bay inshore.

Contrary to the Applicant's assertions that the Sussex Bay inshore is a productive wind area demonstrated by Rampion 1 "exceeding targets", the Sussex Bay inshore as we understand has a moderate <u>wind power density</u> (WPD, watts/m2) rating. WPD is an accepted quantitative measure of the energy available in the wind at different locations that is published by the Government.

All wind turbines have variable and intermittent output; how productive they are depends on the WPD of the location and intermittency of wind there, among other key factors. A higher wind power density indicates a more favourable location for windpower generation.

The Sussex Bay inshore presents a WPD of around **200-300 W/m2**, which varies year-to-year. The Dogger Bank area in the North Sea known for its excellent wind resource has a WPD normally in excess of **1,000 W/m2**. The Applicant's claim that Rampion 1 is **"<u>exceeding its target</u>"** fails to reveal the full situation, also recognising Rampion 1 targets are set by the Applicant itself.

Rather, in response to the ExA request, "***to detail the level of wind resource in the Channel***", we offer seven sets of information, indicators and evidence as follows.

1. **<u>The UK Wind Power Density (WPD) data</u>**: this indicator for wind power density (WPD) shows the Sussex Bay inshore is at the lower end of the scale comparing wind resources in UK offshore areas. More generally, inshore areas close to shore where Rampion 2 turbines would be located exhibit considerably less wind energy generation potential and less steady winds than locations beyond 12 nautical miles offshore, as seen in the published WPD maps herein.
2. **<u>The Royal Society Report (2023)[1] critique of using single-year data</u>**: this indicator points to an emerging present-day controversy on the very real problem of relying on a single year, or limited years of wind data to develop renewable energy policy. That concern extends to offering limited data to infer the lifetime performance of wind turbines in a given location, or in this case, the quality of the wind energy resources in the Sussex Bay inshore, as the Applicant does.
3. **<u>The Observed Capacity Factor of Rampion 1</u>**: this indicator shows that Rampion 1 has consistently performed at the lower end of the range of windfarms in UK waters with respect to capacity factors (i.e., the ratio of the energy produced by the turbines to the nameplate capacity (MW) over a given period of time). As detailed herein, Rampion 1 has a 36.7% capacity factor since commissioning in 2017. In the 12-months to May 2022 Rampion 1's capacity factor was 38.1%. In contrast, Hornsea 1B, a roughly similar size windfarm in the North Sea, performed at a 46.6% capacity factor in the 12-months to May 2022 (47.3%, lifetime) with steadier output.
4. **<u>The Load Duration Curve (LDC) of Rampion 1</u>**: this indicator graphically shows the capacity factor of a windfarm potted against the percent of time it has generated power at that output. It indicates the variability and intermittency of wind in that location, such as the percentage of time the windfarm had little or no output versus the time it produced at maximum nameplate capacity (MW). The LDC helps get beyond the problem of using averages for variable RE power output, which the Royal Society critiques as dangerously misinforming.

[1] The Royal Society Report critique in Sept 2023 of the Parliamentary Committee on Climate Change (CCC) and exchanges https://www.telegraph.co.uk/news/2024/03/09/climate-change-committee-chris-stark-net-zero/

- The Rampion 1 LDC shows that since commissioning, turbines in the Sussex Bay inshore produced no output at all 15% of the time.[2] While anecdotal and only to illustrate the variability, at the time of drafting this comment 10 March 2024 and submitting it 20 March 2024 , Rampion 1 was producing 2.0 MW or 0.5% of its nameplate capacity of 400MW (Figures 5 and 6, herein in the Main Comment).
- Otherwise, for 60% of the time, Rampion 1 output was 40% or less of its 400 MW installed capacity. In the main comment, we also compare the LDC for Honsea 1B on Dogger Bank with Rampion 1 to highlight the difference in the wind resource in the two locations.
- The Applicant may argue that Rampion 2 turbines may perform slightly better than Rampion 1 turbines, being taller with more swept area, but they are still in the same lower WPD inshore area. Moreover, the "wake effect" that occurs with many turbines in the same area, may offset part, or all of that efficiency gain depending on wind conditions or direction. [3]

5. **<u>The effect of locating turbines in lower wind resource areas on the Power System</u>**: this indicator illustrates there are real consequences of choosing to install wind turbines in lower wind resource areas (either inshore, or onshore). To name a few, in this case it means for the 20-25 year life of Rampion 2, the National Grid will must incrementally import additional and costly LNG to run abated gas turbine generation, or arrange costly power imports from Europe (if available) to balance demand-supply and maintain grid system stability and reliability.
    - That has numerous policy consequences and real world costs (opportunity costs) that converge to place upward pressure on power system costs.
    - That in turn means upward pressure on consumer electricity bills, at least for the near and mid-term, this given the UK supply mix, and until such time in future decades when the renewable energy storage nexus is solved.
    - This reality will bite hard as the Royal Society argues and as expressed by international energy agencies including the World Bank argue in advising countries on the integration of higher levels of variable renewables in national grid systems.[4]
    - Meanwhile, in the transition to low-emission generation only by 2035 there are for example, additional costs for grid infrastructure incurred by recommending and choosing to spend £3-4 billion installing wind turbines in moderate wind regimes in the Sussex Bay inshore at this time for Rampion 2 to operate between 2030 and 2050 or so.
    - These include the cost of incrementally needing more low-emission backup generation with associated transmission, as well as other power system investments needed to provide ancillary services to maintain reliability, the quality of supply (voltage and frequency control, stability, etc) and load balancing.
    - The full opportunity cost (I.e. reliance on additional energy imports of some mix of costly LNG imports from international markets or interconnection power imports from Europe, and additional grid infrastructure investment to provide ancillary power system services [5] can be

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[2] 15% of the time is equivalent on average to 1 day a week with no power. 40% is equivalent to nearly 5 months (4.86 months) that Rampion 1 output is less than 40% its installed capacity. Crown Estates rolling 30-day output, in Figures 4 and 5 show periods of low output actually vary up to several days at a time or longer.
[3] Rampion 2 adds up to 90 very large turbines to an existing field of 116 turbines, as explained in the main Comment citing research the wake effect reduces the efficiency of turbines downwind. It is not presented as the main problem in this comment as it is very dynamic and complex to model.
[4] Strategic advice to developing and richer countries the UK Government co-financed. See PCS WR #3 Consideration of Alternatives references, including Annex 4 in the Deadline 1 PINs Examination Library as REP1-145 as the third standalone WR with its own preface and summary in a compilation of three PCS WRs
[5] See Annex 1 of this Comment for a definition of ancillary power system services.

quantified with power system value analysis modelling, which power sector bodies such as Ofgem could provide to inform the Rampion 2 Examination, if asked.

6. **The Interpretation of National Policy Statements**: this indicator notes there are risks and various consequences of investing in windfarm in lower efficiency areas, including incrementally more reliance on energy and power imports and what that means for the UK's energy self-reliance and balance of payments over the 20-25 year life of Rampion 2, if consented.

   - Rampion 2 effectively means more reliance on other countries not only for UK energy supply (LNG from international markets and/or power imports from Europe), but also the ongoing reliance on imported proprietary RE technology and international finance also at the cost of jobs and export opportunities (as opportunity costs).
   - All things considered, national energy security risks are increased given the higher and longer reliance on price-volatile LNG transported from Qatar through the Suez Canal and dependence on USA policy. The opportunity costs are significant over 20-25 years.
   - In the case of incrementally more power imports, that increases the UK's vulnerability to reliance on trade policies of European States. It can have unintended and unforeseen cross-sector consequences, such as witnessed in the forced tradeoffs between awarding fishing rights in UK waters and maintaining French power supply to Jersey.
   - While interdependence (interconnection of grids) is important, the UK needs to be on the best footing (less in need of power imports) and in the strongest possible negotiating position to secure favourable power trade arrangements and prices, in the national interest.

7. **The Carbon footprint of Rampion 2**: This indicator concerns the embedded co2 emissions in the "cradle to grave" life-cycle of Rampion 2. In this comment on the wind resource, it relates to the lower operational efficiency of wind turbines in the Sussex Bay inshore, which leads to the need to transport and import more LNG, all things considered, and the carbon implications.

   - The context is that from 2035, the UK aims to achieve full decarbonisation of bulk power supply to the National Grid. Thus from 2035, Rampion 2 will compete only with other low-emission generation sources now classified as critical national priorities (CNP) in the National Energy Policy Statement (Nov, 2023).[6, 7]
   - Rampion 2, in effect, has no comparative CO2 benefit after 2035, as the UK must choose to draw power from other low-emission sources and seeking to optimise power system reliability, ability to meet growing demand, and the affordability of supply. For the short term there may be capacity constraint payments to companies, where periods of excess wind generation attract payment to curtail output that would otherwise destabilise the grid.
   - Yet, until renewable energy storage is available (meaning until utility-scale battery, or green hydrogen production and storage systems are developed, affordable and deployed),

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[6] It means while terrestrial emissions within the UK borders from generation sources supplying the National Grid will be NetZero by 2035, significant co2 emissions will still be "off-shored" to other countries. Those emissions are in the UK RE technology supply chains, in particular wind turbines, and to a lesser extent for other CNP technology systems. Consenting Rampion 2 adds to the commitment to import more LNG longer, in relative terms, compared to investing in wind turbines in locations with better wind regimes and SMRs.

[7] That will include (1) renewable generation from wind turbines sensibly located in better wind resource areas (2) co2 emission abated gas-fired power stations (fitted with carbon capture and with multi-fuel capability – hydrogen ready) close to load centres to minimise transmission and other grid investments and to provide dispatchable power on demand when wind and RE output drops away, and (3) dependable firm power supply from small modular reactors (SMRs) driving steam turbines to meet load growth, such as from mandated electrification for transport and heating expected to double grid demand between 2035-2050.

consenting Rampion 2 means the UK on top of incurring significant opportunity costs (for more backup and ancillary system costs) commits to incrementally more LNG imports.

- The carbon footprint of Rampion 2 thus grows over time especially as imported LNG has 3 to 10 times the Co2 emissions in processing and transport than pipeline gas from the North Sea, depending on where in the world the LNG is sourced.
- The desirability of a £3-4 billion investment Rampion 2, at this time, thus needs to be weighed against the full consideration of its carbon footprint, as well as its impact in terms of national-to-local affordability in terms of upward pressure on power system operating costs, the national balance of payments and especially the affordability of consumer electricity tariffs in the near to medium term (again until the renewable energy storage nexus is resolved and those renewable storage systems are actually in place).
- It is not at all clear that will be before Rampion 2 itself would be decommissioned around 2050. Rampion 1 will certainly be decommissioned by then (or replaced with larger turbines following a Rampion 2 precedent which we argue against.

Those are some of the considerations that PCS and community organisation affiliates see as being important and relevant in the discussion of the wind resource in the Sussex Bay inshore in this Examination.

The Main Section of this comment and annexes elaborate the above arguments with evidence. We thus believe the Applicant's response to the ExA on this vital question seeks to present Rampion 2 in a favourable light, without offering the full picture of the wind resource here on the Sussex Bay inshore and the policy and material consequences if Rampion 2 were consented.

**On Top of these Sussex Bay Inshore Wind Resource concerns**

In written representations, PCS offers comprehensive and reasoned argument with evidence that suggests:[8]

1. **The Examination needs to clearly establish whether Rampion 2 is actually in breach of the European Landscape Convention (ELC) and the closely aligned and reinforcing UK Marine Policy Statement (MPS, 2021), and the recent Levelling up and Regeneration Act (LURA, 2023).**
   - Specifically, in terms of interpretation of an ECL breach in the Rampion 2 case, the Government's own Offshore Energy SEA programme in its latest OESEA-4 (2022) states its very objective is, "*To accord with, and contribute to the delivery of the aims and articles of the European Landscape Convention and minimise significant adverse impact on seascape/landscapes including designated and non-designated areas.*"
   - As we understand, the strategic visual buffer advice offered by the OESEA programme is exactly what it sees is required for the UK to accord with the aims and articles of the European Landscape Convention (ELC) to which the UK is a signatory. We look forward to argument to the contrary.
   - That OESEA advice means that wind turbines the size and scale of Rampion 2 should be greater than 25 miles from UK designated landscapes and highly sensitive visual receptors.

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[8] Including a Local Impact Assessment (PCS WR#1, provided in the Deadline 1 Examination Library as REP1-145); and Due Diligence on the Applicant's Claims about the performance, benefits and impacts, submitted as PCS WR#2, also in REP1-145 as the second standalone document with a summary. The latter points to the "chilling effect" that local communities witnessed throughout the Applicant-led consultations on responses such as the Applicant now provides on the wind resource.

- That generally conforms to the interpretations of the ELC in other EU jurisdictions, which includes the German Offshore Wind Law in effect from 2017, which would not permit a scheme of the scale and proximity to the German coast on the Baltic or North Sea as the Applicant proposes in the Sussex Bay inshore.
- Even if the Rampion 2 ExA were to recommend setting aside the OESEA's interpretation of the ELC, which a recommendation to consent would imply, Rampion 2 challenges any reasonable interpretation of the ELC aims and aligned UK policy and law for the protection and management of designated landscapes and their statutory functions.
- The impact on designated landscapes is addressed in the Local Impact Report of the Southdown National Park, other Representations and PAD Statements.
- The Levelling up and Regeneration Act (2023) specifically imposes a new active duty for such developments (as Rampion 2) to enhance the designated functions of National Parks and the protection of Designated Landscapes (i.e., SDNP) and has been interpreted also by Natural England for DCO Examinations (as cited in REP1-145, the LIA).

2. **That consenting Rampion 2 poses an unacceptably high risk of undermining the achievement of sustainable development on the south coast and affected inland areas, as opposed to advancing sustainable development.**
   - This is due to the sheer scale, expanse and proximity to the shore, and consequent location-specific significance of its adverse ecological, social and socio-economic effects.
   - The offshore infrastructure being in a bio-productive and sensitive inshore marine ecosystem and the onshore infrastructure physically and visibly disrupting protected designated landscapes and a National Park (SDNP), which arguably challenges the relevant legal safeguards in place, as we note in 1 above.
   - The PCS Local Impact Assessment provides evidence, perspective, and local knowledge that concluded there are no net positive gains across either the social, economic or environment objectives of sustainable development – which is how sustainable development is defined in law and policy terms.[9]
   - We believe this is corroborated by other Relevant and Written Representations and by the Principal Areas of Disagreement Statements (PADS) as we have elaborated in the PCS Local Impact Assessment.
3. **That consenting Rampion 2 means that UK authorities would accept comparatively inefficient infrastructure (or rather a comparatively inefficient location for wind turbines, in terms of wind energy density and the consequences).**
   - That has serious opportunity costs, including the requirement as noted previously in the Summary and detailed in the three PCS Deadline 1 Written Representations.
   - Contrary to the Applicant's narrative, consenting Rampion 2 offers limited help for the UK's ambition of energy-self reliance and Energy Security, and it means upward pressure on power system infrastructure and operating cost at least for the foreseeable future, as noted.
4. **At the same time, there are practical and viable alternatives for low emission generation to feed the National Grid that are identified as Critical National Priorities in the NPS (Nov, 2023), which can do more for less money than Rampion 2 across all NPS policy metrics, among which alternatives the UK Government calls "game changers".**
   - The consideration of alternatives in the Rampion 2 Examination is a case-specific policy requirement in the NPS (2011), EN-1 Section 4.4 "Alternatives" and, para 5.9.10 under

[9] In PCS WR#1 Local Impact Assessment, Chapter 2 (REP1-145)

"Developments within Designated Landscapes". The requirement to consider Alternatives in cases such as Rampion 2 is carried forward to the NPS (Nov, 2023).

- That Alternative analysis can be taken into account by the Secretary of State when taking the final Rampion 2 decision in 2025, in particular, considering the alternatives for low-emission generation now designated as critical national priorities (CNP) in the National Policy Statements that do more to meet the ambition of decarbonisation of the UK power sector by 2035 than Rampion 2, as well as outperform Rampion 2 over most if not all other NPS policy objectives.
- With reference to the Applicant's response about locating power generation close to demand in the south of England, two three CNP Alternatives will do more to relieve pressure on north-south power transfers while the requisite transmission infrastructure is put in place for the longer term to build out of variable RE, as set out in the PCS WR#3, REP1-145, "Consideration of Alternatives in the Rampion 2 Examination" on Deadline one submission REP1-145 in the PINs Examination Library PDF. [10]

[10] The three standalone PCS WRs are compiled as a single PDF file, as of 20 March 2024, though we have requested PINs these be given separate file identity numbers. The Alternatives WR is the third.

# CONTENTS OF THIS COMMENT

# MAIN COMMENT AND EVIDENCE

## 1. General

The following is from REP1-018, the Applicant's response to the ExA's Action Point 2 arising from the Initial Issue Specific Hearing (ISH1) ***… as to the level of the wind resource in the Channel.***

| ExA Request | Applicant Response (EN010117-000998) |
|---|---|
| ***Action Point 2.***<br><br>***Applicant to make response in detail as to level of wind resource in the Channel.***<br><br>*Applicant's Response to Action Points Arising from Issue Specific Hearing 1 Date: February 2024*<br><br>*EN010117-000998* | *The developer for Rampion 2, RWE, has over 20 years of experience in constructing and operating offshore wind farms, and has determined that Rampion 2 is a viable site and productive location for wind energy generation, with a predicted wind speed of ~ 9.3 m/s. The latest figures show that the operating Rampion Wind Farm exceeded target generation by 15% in 2023. Rampion has exceeded its target for three of the four complete years of operation from 2020-23 and in terms of total generation across this period; Rampion has exceeded the target by 8%.*<br><br>*It is not only the wind resource that makes Rampion 2 a good location for an offshore wind farm. With the southeast of England being one of the most densely populated regions in Europe, it is a huge demand centre for electricity. Rampion 2 can therefore create a greater contribution to electricity generation close to where the demand centre is located, which reduces transmission losses and requires no transmission grid upgrades.*<br><br>*1. Target generation is 1,367GWh per year. Assumed capacity factors for offshore wind, The Contracts for Difference (Standard Terms) Regulations August 2014, DECC. Generation: 400MW x 0.39 x 8760 x 1,000 = 1,366,560,000KWh / 1,367GWh pa)*<br>*2. Total target for 2020 – 2023 = 5,468GWh (4 x 1,367GWh). Total actual generation for 2020 – 2023 = 5,919GWh (2020 = 1,600GWh, 2021 = 1,363GWh, 2022 = 1,376, 2023 = 1,580GWh.* |

This Main Comment and Evidence section focuses on the Sussex Bay inshore wind resource where Rampion 2 turbines would sit visibly 6 nautical miles from shore stretching along the Sussex Bay. We also offer comment important and relevant NPS policy interpretations.

As to the Applicant's response concerning power demand in the southeast of England and north-south transmission capacity, we note that the consideration of alternatives for low-emission generation is a case specific policy requirement in the Rampion Examination. PCS offers input "Consideration of Alternatives in the Rampion 2 Examination". Two of the three alternatives identified as CNP would be located in the south. They address the Applicant's concerns and provide firm and dispatchable power to support the long-term build out of variable renewable energy. [11]

Otherwise, we do not believe that is justification to set aside lawful interpretations of environmental safeguards that Rampion 2 challenges, as noted in the Summary.

[11] IPCS WR#3, REP1-145, a simple benchmarking and rating analysis indicates three critical national priority alternatives that offer a better way forward in respect to local and national benefits, as compared to a £3-4 billion capital investment in Rampion 2. Extending a recent offshore wind licence on Dogger Bank instead of extending the existing Rampion installation would for example lead to 1.3 times the national benefit than granting consent to Rampion 2. For the assumptions set out for 11 NPS policy indicators (in PCS WR#3 ) carbon-capture on gas-fired power stations (hydrogen ready) could lead to 1.7 times the benefit; small modular reactors (SMRs) could lead to twice the national benefit over the economic life of Rampion 2 and likely much longer.

## 2. The Sussex Bay Inshore Wind Resource

This looks in turn at the seven indicators as noted in the Summary and offers the evidence.

### 2.1 The UK Wind Power Density (WPD) data

In wind power density terms (WPD) the Sussex Bay is low as compared to wind resources in other UK offshore areas. It has a WPD of **200-300 W/m2**, while Dogger Bank in the North Sea, known for its excellent wind resource, is in excess of **1,000 W/m2**. The Applicant's statement that Rampion 1, **"exceeds its target",** fails to reveal the quality of the wind resource for Rampion 2 or that those annual "targets" are set by the commercial developer itself.

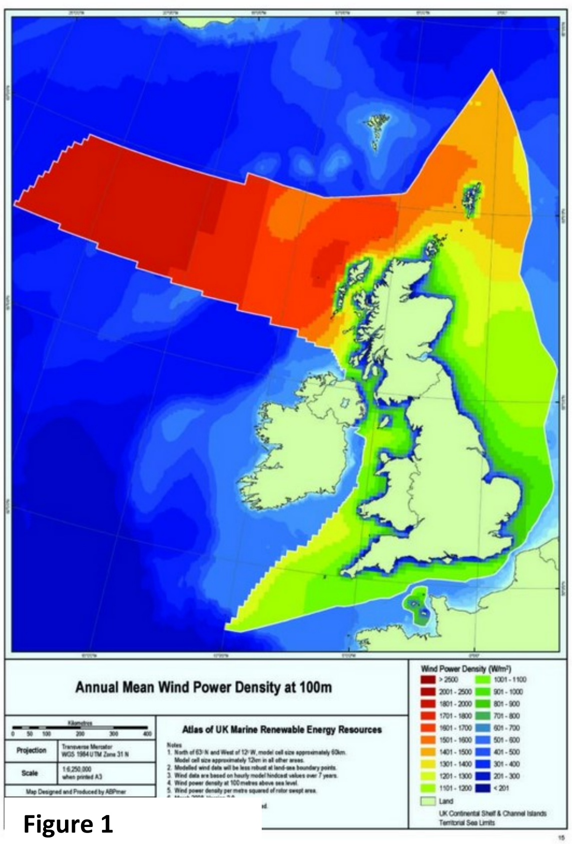


**Figure 1**

UK Annual Mean Wind Power Density

WPD calculations provided by the UK government are based on long time-series wind data.

That data shows, generally, inshore areas of UK coasts have considerably less wind energy generation potential and less steady winds than locations further out beyond 12 nautical miles offshore.

That is seen in WPD maps, as in Figure 1, from the Atlas of UK Marine Renewable Resources. [12] Annex 2 offers a larger version of this same WPD map.

The blue along the coast inshore show in Figure 1 (i.e., under 300 wattts/m2 in areas less than 12 nautical miles from shore) indicates the WPD is far less than it is beyond 12 nautical miles, where the officially designated renewable energy zone (REZ) starts and extends 1,000 km to the limit of economic zone.

WPD is one indicator to consider, where all indicators point to the same conclusion; the Sussex Bay inshore is not a high wind energy density area for the UK.

No annual averaging of wind speeds or policy interpretation can change the fact that large wind turbines perform far better in favourable wind regimes further offshore, genuinely beyond 12 nautical miles (respecting OESEA advice) not inshore, apart from the many adverse consequences of committing £3-4 billion to Rampion 2 that are noted in the Summary.

[12] "The UK marine renewable atlas is a new information resource designed to assist government strategic planning for large-scale offshore renewable energy development. The atlas provides a means to identify, quantify and spatially map the potential interest areas for wave, tidal and offshore wind resources at a regional scale across the limits of the UK continental shelf. The assembled database and technical reports generated by the study are publicly available, and have received great interest from potential developers, stakeholders and the general public. The project has been funded by the Department of Trade and Industry's strategic environmental assessment combined programme covering oil and gas and marine renewable agendas." (the predecessor to the OESEA)
https://www.researchgate.net/publication/245409609_An_introduction_to_the_UK_marine_renewable_atlas

## 2.2 The Royal Society critique on use of single-year data for variable RE

The present-day controversy emerging around the use of wind data highlights the very real problem of relying on single year wind data to develop renewable energy policy. That concern extends to offering limited data to infer the likely lifetime performance of wind turbines in a particular location, or in this case, the quality of the wind energy resources in the Sussex Bay inshore as the Applicant has done in response to the ExA request to detail the wind energy resources.

Specifically, a Royal Society study[13] published last year advising the UK Government on how to deliver "a reliable decarbonised power system" by 2035, in a way that is consistent with both the updated NPS (Nov, 2023) and NPS (2011) that argues: "*The UK's need for long-term energy storage has been seriously underestimated... **Studies that do not consider long sequences of years underestimate the need for long-term storage. Studies of single years cannot cast light directly on the need for storage lasting over 12 months and overestimate the need for other supplies***."

The Royal Society report published September 2023 concluded that a vast network of hydrogen-filled caves was needed to guard against the risk of blackouts under the shift to wind and solar generation, which the Royal Society described as "volatile". Apart from real concerns about having sufficient renewable energy storage to support the build out of variable offshore wind and RE with all the ramifications, the same principles apply to considering wind energy resources in the Sussex Bay inshore, and how NPS are interpreted in the Rampion 2 Examination.

Consenting to invest £3-4 billion locating wind turbines in low-efficiency areas makes the UK's energy supply problems incrementally worse, relative to other choices that are available to invest in low-emission critical national priority (CNP) generation, from all perspectives. As we argue, consenting Rampion 2 would not be a reasoned application of NPS EN-1 or EN-3.

The UK Prime Minister's recent statement on the need for urgently accelerate investment in more high efficiency gas turbines to back up variable renewable energy reinforces this concern,[14] where presumably those gas-turbines will be fitted with carbon capture and storage systems and multi-fuel capability to switch to hydrogen as some point in the future, as now indicated as a critical national priorities in the NPS.

Otherwise, this is another indication that the Applicant failed to respond to the essential question. It also indicates the policy requirement to consider alternatives in the Rampion 2 Examination really needs to be taken seriously and done in a holistic way that recognises the critical national priority and need for dispatchable and firm power as windpower is built out - systematically.

[13] Article and emails secured under FOI reported a claim by Sir Chris Llewellyn Smith, who led the recent Royal Society study on future energy supply, that the Climate Change Committees (CCC) had privately admitted that it made a "mistake" when it only "looked at a single year" of data showing the number of windy days in a year, when it made public pronouncements … on the Government's net zero targets. The Royal Society study looked at multiple decades of wind data with up to 70-day wind drought to arrive at different conclusions than the CCC on require energy storage. The CCC spokesman indicated it "modelled Britain's power system in 2035 using hourly energy demand across that year and real weather data from a low-wind year, stress-tested with a 30-day wind drought."

[14] https://www.bbc.co.uk/news/science-environment-68538951 New gas power plants needed to bolster energy supply, PM says.

## 2.3 The Observed Capacity Factor of Rampion 1

The capacity factor of any energy supply source is the ratio of energy produced (e.g., MWh) to the maximum potential output of that power station or windfarm (based on its install capacity in MW) over a given period of time. It is an averaging process that ignores the variability and intermittency of output from RE wind turbines.

For context, small modular reactors creating steam to drive steam turbines would have a 90-95 % capacity factor and are anticipated to have near twice the operating life of wind turbines. Gas turbine generators with carbon capture fitted, running on natural gas (later on hydrogen) can be turned on or off when needed to provide dispatchable power, where all things considered, is close to a 100% capacity factor.[15]

If providing back-up to wind generators, gas-turbines are turned on less if they back-up wind turbines in the best wind regimes with high wind power density.

| |
|---|
| This indicator shows that Rampion 1 turbines commissioned in 2017 has consistently performed at the lower end of the capacity factor range for large UK offshore windfarms (at between 36%-39%) |

Rampion 1 turbines starting 6 nautical miles from shore (or 13km) all within the inshore of Sussex Bay reportedly has a 36.7% life-capacity factor. In the 12-months to May 2022, Rampion 1's capacity factor was 38.1%. In contrast, the Hornsea 1B windfarm 65 nautical (120 kms) off the Yorkshire coast on Dogger Bank in the North Sea performed at a 46.6% capacity factor in the 12-months to May (47.3%, life time) with steadier power output. That latter point is seen in the load duration curves in the next section 2.4 of this comment.

Rampion 2 may perform slightly better than Rampion 1 and have a marginally higher capacity factor, as it is taller and has more swept area, but it still is located in the same lower WPD inshore area as Rampion 1. However, that is only achieved by setting aside OESEA environment safeguards on distance large turbines should be from designated landscapes as intended to respect the European Landscape Convention. Rampion 2 turbines cannot be pushed further out into the channel where the WPD is higher, due to the interference with marine traffic lanes.

In addition, in some situations the wake effect due to up to 90 very large Rampion 2 turbines in close proximity that may offset some or all the potential improvement in the Rampion 2 capacity factor over Rampion 1 as observed in the same Sussex Bay inshore wind regime.

The wake effect refers to wind turbine wakes lowering wind speeds which may reduce the performance of downstream turbines in the farm, depending in part on wind directions (as in the research cited in the footnote) [16] This is given the fact that up to 90 very large turbines (up to 325m tall) in arrays with significant increased swept areas may be added to the 116 existing turbines 140m tall.

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[15] Dispatchable low-emission power cannot be compared has a far higher value to a power system than variable and intermittent output from wind turbines and cannot be compared.

[16] These wind turbine wakes affect the performance of downstream turbines in the farm. In addition, large wind farms act as additional resistance to the atmospheric boundary layer (ABL). This reduces the wind speed upstream and inside the farm, which affects the power production of the wind farm compared with the ideal situation where the upstream wind speed is not affected. Understanding wind farm power densities Richard J.A.M. Stevens, Physics of Fluids Group, Max Planck Center Twente for Complex Fluid Dynamics; J. M. Burgers Centre for Fluid Dynamics, University of Twente, The Netherlands (Received 19 January 2023; accepted 6 February 2023)

Annex 4 provided a range of capacity factor for offshore wind farms of various turbine heights operating around the UK. Most are beyond 12 nautical miles from shore, hence in what is legally define as the Renewable Energy Zone (REZ), and wisely so under the UK Energy Law (2004).

That comparison of load factors (life time and 12 months to May 2022) and also the column on power per unit area spanned (watts/m2) in Annex 4 also illustrates the Sussex Bay inshore does not offer the most favourable wind regimes as also seen in the WPD data.

## 2.4 The Observed Load Duration Curve for Rampion 1

Standard load duration curves (LDC) are a graphical plot of the capacity factor versus the percentage of time the windfarm has generated at that level of power output, in a given wind resource, over a selected period. Hence LDCs help provide an indication of the variability and intermittency the wind resource in the Sussex Bay inshore and compared to other UK areas.

While all wind farms are variable and intermittent sources of energy, some locations offer more intermittent and less steady power than others. Locating wind turbines in areas of high wind power density make them more efficient and value for money, and with less opportunity cost as noted in the Summary, all things considered.

Power output from Rampion 1 varies day-to-day, seasonally and year-to-year as seen in the output data on The Crown Estate website. Exceeding its, "target" as set by the Applicant has little meaning as a response to the important question the ExA raised. [17]

An illustration of the relative performance of wind turbines in the Sussex Bay as compared to similar turbines placed offshore North Sea is seen in the in Figure 2 that shows the load duration curve for Rampion 1 and Honesea 1b.[18]

That graphical data tells us:

- 15% of the time the existing Rampion windfarm turbines produce no output at all. [19]
- That compares with 7% of the time the Hornsea 1b windfarm in the North Sea produces no output. Rampion thus has no output twice as often.
- 60 % of the time Rampion 1 output is 40% or less of its installed capacity; or conversely, Rampion only produces above 40% of installed capacity 40% of the time.
- In contrast, the Hornsea 1b windfarm spends 55% of the time generating above 40% of its installed capacity (compared to 40% for Rampion).
- Honsea 1b produces above the UK average capacity factor 65% of the time.

The point being that Rampion 2 turbines would have the same relative lower performance noted above (being adjacent to Rampion 1 in the same wind regime) as compared to investing the same £3-4 billion to install those turbines in the North Sea area.

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[17] This is seen on The Crown Estates website tracking the combine power output from all UK offshore wind on a rolling monthly basis and every 40 minutes for individual installations such as Rampion 1 and Hornsea One.

[18] Rampion 1 has 116 x 140m turbines in arrays starting 6 nautical miles (13 km from shore) , with a installed capacity of 400MW that began supplying power to the grid in 2017. Hornsea 1b is a 600 MW phase of the Hornsea One project (spit in two areas or phases), 120 kms off the Yorkshire coast on Dogger Bank with 174 x 190m turbines that started supplying power to the grid in 2019.

[19] 15% of the time is equivalent on average to 1 day a week with no power. 40% is equivalent to nearly 5 months (4.86 months) that Rampion 1 output is less than 40% of its installed capacity. Figures 3 and 4 with the rolling 30-day output show that periods of low output actually vary up to several days at a time.

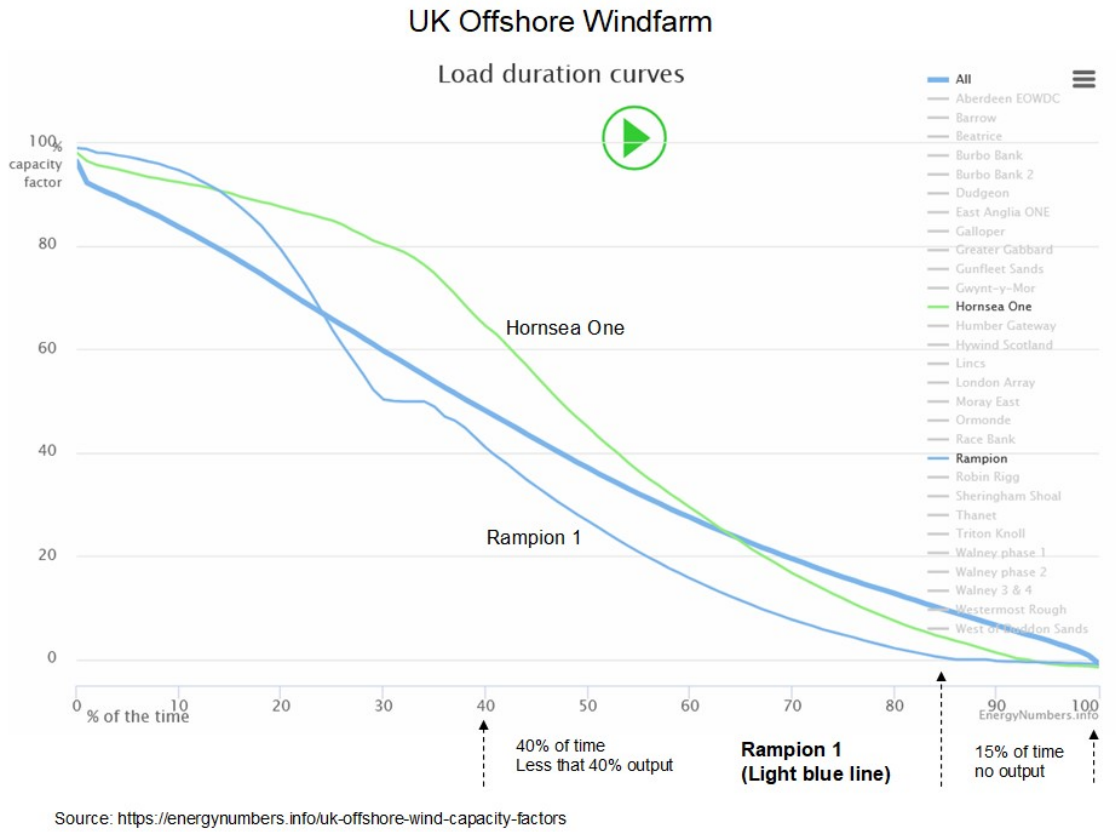


**Figure 2: Comparison of Loads Duration Curves (capacity factor versus % of time) for Rampion 1 on the South Coast (light blue line), Hornsea One in the North Sea (green line) and, the average for all UK Offshore windfarms (thicker blue line).**

The intrinsic variability of UK wind resources is illustrated by the rolling 30-day graphs on the Crown Estates website of total offshore wind output, as in Figure 3 for Jan-Feb 2023 and Figure 4 for Aug 2022 recognizing it varies daily, seasonally and year-to-year.

Clearly there are expended periods of low or no wind power output.

Again only for illustrative purposes and anecdotal evidence, Figure 5 and 6 indicates there was little to no output from Rampion 2 in the Sussex Bay at the time of drafting this comment on the Applicant's response to the quality of the wind resource on 10 March 2024 and again 20 March 2024 this comment was submitted. Those images are from The Crown Estates website as indicated.

The problem is with windpower is sometime there is lots of power and sometimes there is little or no power. One immediate challenge of course is to appreciate and deal with the RE resource variability issue, as wind and solar resources will form a large share of renewable supply, and to thus optimally sequence complementary low-emission generation investments optimally.

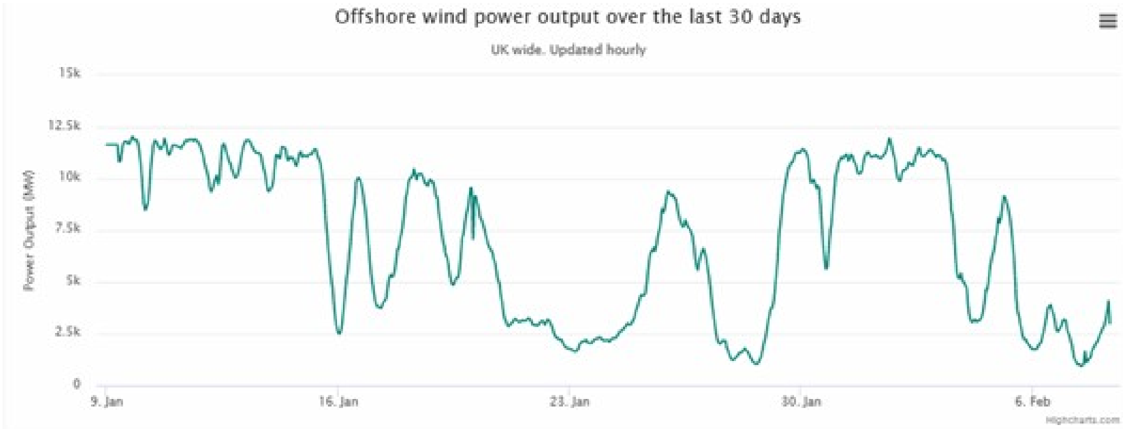


**Figure 3: Total UK offshore wind rolling Output 30-day Jan-Feb 2023 (Crown Estate website on 08 Feb 2023)**

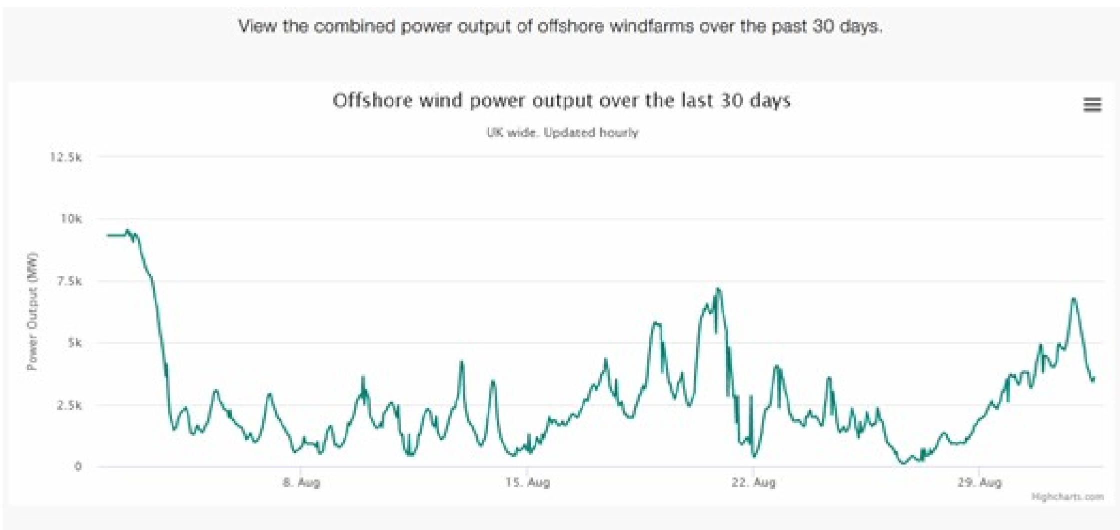


**Figure 4: Total UK offshore wind rolling Output 30-day August 2022**

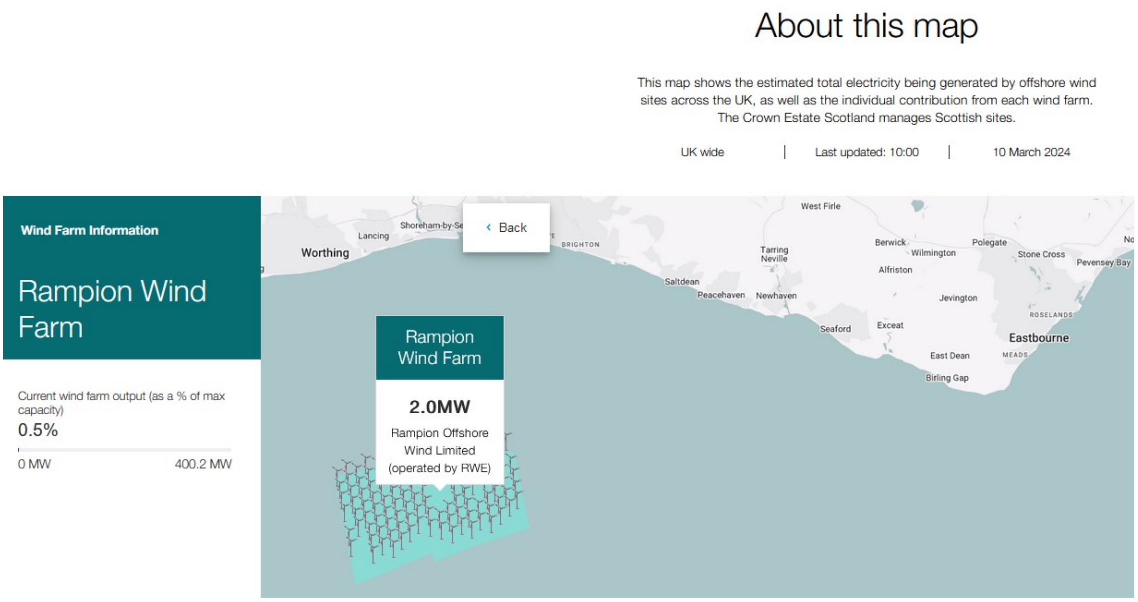


**Figure 5: Illustration of a low power day for Rampion in the Sussex Bay inshore 10 March 2024**

(Source, the Crown Estates website 10 March 2024 at the time note in the figure) [https://www.thecrownestate.co.uk/en-gb/what-we-do/asset-map/#tab-2](https://www.thecrownestate.co.uk/en-gb/what-we-do/asset-map/#tab-2) )

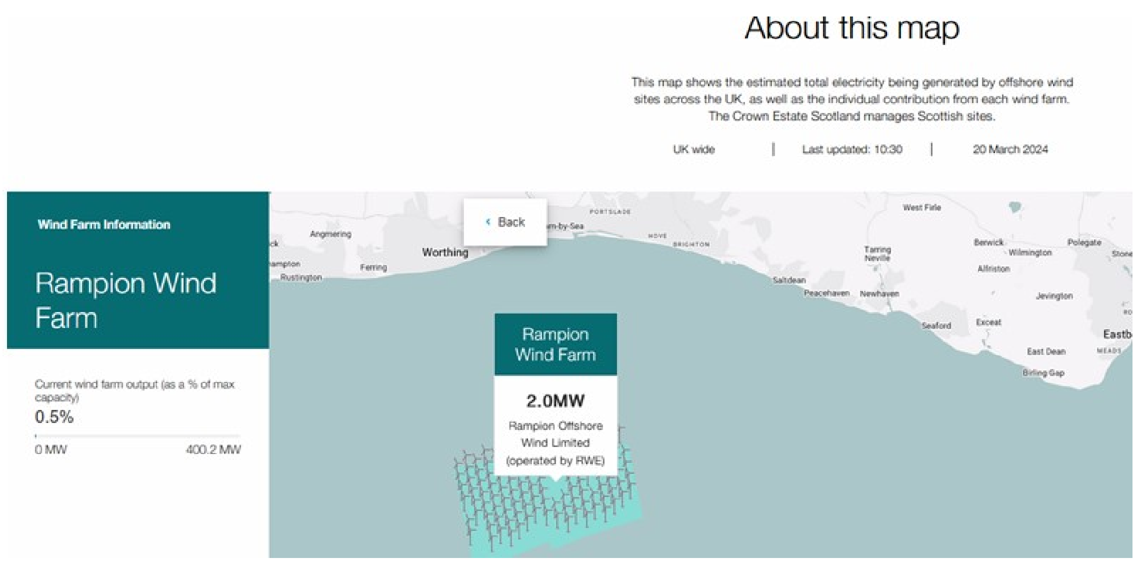


**Figure 6: Illustration of a low power day for Rampion in the Sussex Bay inshore 20 March 2024**

## 2.5 The effect of locating turbines in lower wind resource areas on the Power System

Choosing to install wind turbines in a low or lower wind resource area (either inshore or onshore) means for the foreseeable future well beyond 2035, there will be incremental or additional LNG imports from around the world from international energy markets either at spot prices or on long term contracts or interconnection imports from Europe for which a large premium is paid.

There are also additional costs for power infrastructure including the cost of incrementally more low-emission back up capacity (low emission generation from abated gas-fired turbines with carbon capture and/or for power imports from Europe, if available), and in the longer term renewable energy storage systems) as well as other investments needed for the grid to provide what are call ancillary services which renewable sources do not provide.

The more the share of renewable energy sources in mix the greater the need to invest in ancillary services and related grid infrastructure.

These ancillary services are a required for a range of support functions and capabilities within a power system to ensure reliable operation, particularly in systems with a significant presence of intermittent and variable renewable generation like wind and solar as planned. These services help to maintain grid stability, voltage and frequency control, reactive power and power factor correction and balance supply and demand, and otherwise manage variability and uncertainty that is inherent with whether dependent renewable energy sources. [20]

The issue is that Rampion 2 will require incrementally more ancillary services investments than the other critical national priority alternatives, that due to lower efficiency of wind turbines in the Sussex Bay inshore. Hence Rampion 2 will have higher opportunity costs.

The net effect is upward pressure on average power system costs, which in turn translates to upward pressure on consumer electricity bills (as noted in the Summary until the renewable energy storage nexus is resolve and at what cost for that energy storage and use).

The full opportunity cost (energy imports and additional infrastructure) can be readily quantified with power system value analysis modelling to inform the Rampion 2 Examination, and as we argue should be made available routinely on £3-4 billion investment decisions.

## 2.6 The consequent interpretation of relevant National Policy Statements

The National Policy Statements (NPS, Energy) on which decisions about Rampion 2 are based are complex, interwoven and comprehensive. However, there are tradeoffs in the interpretation of specific policy statements that conflict. Judgements on what overrides or to give weight to arr th role of the ExA.

Our understanding is, for example, overriding considerations in the NPS include NPS (2011) EN-1 policy 1.1.4 which covers the application of the European Convention on Landscapes (ECL) as interpreted by the Offshore Energy SEA process and aligned UK policy and law. [21]

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[20] PCS WR#3, "Consideration of Alternatives in the Rampion 2 Examination", Annex 8, offers a list and description of power system ancillary power system services.

[21] In Chapter 2 para 2-57 of the PCS local impact assessment on Rampion 2 noted that "As a point of reference, the White Report (2000) on visual buffers commissioned by BEIS for the OESEA in its International Review of visual buffers in the case of Germany indicated that:
- "6.29. The German market regulation changed with the introduction of the WindSeeG (Offshore Wind Act) which became law on 1 January 2017. The WindSeeG introduces a centralised planning approach, which involves an Area Development Plan. This outlines the location and construction schedule of future transmission assets, currently out to 2025.
-"6.30. The majority of new areas coming forward (for wind) are 115km or more offshore in the North Sea. In the Baltic, the areas defined are extensions of existing wind farms at the outer edge of the German exclusive economic zone (above 25 km from the coast). The draft environmental report of the draft Site Development Plan for the North Sea (BSH (1), 2019) indicates that there is a limit of a height of 125m wind turbines within sight of the coast and islands (2.15, page 148)."
"2-58. The BEIS updated advice on visual buffers is adopted in the in the OESEA-4 (2022) where it also discusses the application of visual buffers for offshore wind in European jurisdictions that conform to the European Convention on Landscapes (ECL)."

When talking about the quality of the wind resource in the Sussex Bay inshore several NPS policy-relevant aspects come into play.

While there is an opportunity cost in terms of incrementally more energy import (either LNG or power interconnection imports from Europe) it has implications for energy self-reliance over the 20-25 life of Rampion 2, from around 2030-2050. There are corresponding national energy security considerations. These including greater and longer reliance on price-volatile international energy markets for imported LNG from Qatar through the Suez Canal and dependence on the USA, as well as reliance on European States for fair power trade terms.

As PCS argues in Written Representations for Deadline 1, at this time in the UK's energy transition, on top of all the other concerns, investing £3-4 billion to add up to 90 more wind turbines to the Sussex Bay inshore needs to take full account of these NPS relevant policy considerations explicitly and transparently.

There is clear inherent geopolitical risk of over dependence, or even incrementally increasing dependence on imported natural gas by LNG since 2022. The aftershocks are ongoing and long-term. Adding turbines in low WPD area whether onshore or in the Sussex Bay inshore incrementally increases that risk, until such time as renewable energy storage is viable to replace dispatchable power from abated gas-fired power stations. That is likely well beyond the economic life of Rampion 2 that will be ready for decommissioning around 2050.

In terms of interconnection with EU States, for example, it still leaves the UK dependent on the power demand-supply situation in France. It also incrementally adds to the UK's political vulnerability and security of energy supply threats, as recently witnessed with France threatening to cut Jersey power supply via undersea cable unless there were concessions for fishing in UK waters.

The other dependence noted previously the ongoing and deepening UK dependence on imported and proprietary RE technology, where value added in terms growing industrial capacity and jobs is an opportunity afforded to international suppliers, not the UK. For wind power that is mainly Continental interests, where the UK now effectively off-shores high value jobs, profits and innovation along with the opportunity to create a domestic Green energy industrial capacity.

There is little local content in Rampion 2 as discussed in PCS Representation on the Local impact Assessment Chapter 5, and in the PCS Representation 3 on the "consideration of alternatives in the Rampion 2 Examination, where the EU commission sued the UK in the World Trade system when the UK tried to introduce local content rules from UK offshore wind enjoying UK the Contract for Difference (Cfd) subsidy . The EU Commission claimed that was not permitted under retained EU law and the Brexit Agreement. The UK has since abandoned that ambition.

Otherwise PCS Representation 3 looks at 11 NPS-relevant policy Indicators to benchmark Rampion 2 against three viable low emission alternatives as noted in Annex 5 of this Comment.

## 2.7 The Carbon footprint of Rampion 2

This issue concerns both the imbedded co2 emissions in the "cradle to grave" or life-cycle of the Rampion 2 proposal, and more directly here to focus on the implications relating to the quality of the wind resource in the Sussex Bay inshore.

The latter relates to operational efficiency of wind turbines here, which in turn leads to the requirement to import incrementally more LNG (carbon), all things considered, due to the lower efficiency of turbines located in the Sussex Bay inshore.

- We note the Applicant claims that Rampion 2 will reduce UK carbon emissions in the power sector by around 1.8 million tonnes per year, implying that is over its economic life of 20-25 years from 2030 to about 2050 (or 40-45 million tonnes Co2 total).
- Though in fact, the carbon benefit from Rampion 2 would only be for 5 years, 2030 to 2035, if consented. That is because the UK power sector is to be fully decarbonised by 2035 (as in the NPS). There will only be low emission generation on the national grid from 2035 on. That generation mix will include renewables and NetZero ready gas-fired power stations with full carbon capture (and hydrogen ready) and nuclear, such as small modular reactors SMRs in the bulk generation mix).
- Thus from 2035 Rampion 2 will compete only with other low-emission generation sources for bulk power supply to the national grid all now classified as critical national priorities (CNP) in the National Energy Policy Statement (Nov, 2023). [22]
- Until renewable energy storage systems are available, meaning until utility-scale battery, or green hydrogen production /storage systems are technically developed, commercially-ready, scalable, affordable and deployed) Rampion 2 will be complemented by and compete with other CNP generation sources from 2035 to form the generation mix. [23]
- Thus while terrestrial emissions within the UK borders from generation sources that supply the National Grid will/must be NetZero generators by 2035, significant co2 emissions will still be "off-shored" to other countries.
- Those emissions are in the UK Renewable technology supply chains, in particular wind power related to its consumption of rare earths and critical minerals and other to a lesser extent for other CNP technology systems that need to back up intermittent RE supply until renewable energy storage is available and deployed at scale.
- Specifically in the context of the Sussex Bay wind resource conversation, and the desirability of the £3-4 billion Rampion 2 Application, it means again incrementally more carbon in LNG imports to provide more backup generation over the 20-25 year life of Rampion 2 to about 2050, when it is decommissioned (or replaced). Rampion 1 will be long retired by 2050.
- It also begs the question as the claims about CO2 reduction over its life. Due diligence would suggests that, as Rampion 2 only offers 5 years of carbon emission reduction benefit (2030 to 2035), the calculation of all the imbedded co2 in Rampion 2 in the mining, processing, smelting, manufacture, construction, operation and maintenance would be helpful.
- That would help understand if greater or lesser CO2 emissions are imbedded than the 5 years savings (10 million tonnes at the assumed 2 million tonnes Co2 a year to 2035 (i.e., considering the quantum of rare earth and critical minerals mined and steel and concrete involved in turbines and the offshore and onshore works).

[22] Rampion 2 thus will not displace carbon after 2035; only compete with other low emission generation sources on a price and power system impact basis – i.e. what may be needed to keep the lights on, keep the grid from collapsing and supply the demand growth due to mandated electrification, and at what cost to society and the environment.

[23] That will include renewable generation from wind turbines sensibly located in better wind resource areas, as well as co2 abated gas-fired power stations (fitted with carbon capture, and multi-fuel) close to load centres to minimise transmission and other investment and to provide dispatchable power on demand when RE output drops away; and dependable firm power supply from small modular reactors driving steam turbines to meet load growth such as from mandated electrification expected to double grid demand between 2035-2050.

Otherwise, the carbon footprint of Rampion 2 thus grows over time especially as imported LNG, has 3 to 10 times the co2 emissions in processing and transport than pipeline gas from the North Sea depending on what source of information one prefers and where it comes from in the world.

Rampion 2 will simply be part of a complementary low-emission generation mix, as a comparatively lower efficiency location for wind turbines as compared to truly offshore locations, the questing being at what cost to society and the environment.

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## Annex 1: Some Definitions

| Item/terminology | Definition / Explanation |
|---|---|
| Wind Power Density | Is a quantitative measure of the energy in the wind available at any location that may be captured for wind power generation. Wind power density refers to the amount of wind energy available at a particular location, typically measured in watts per square meter (W/m²) or kilowatts per square meter (kW/m²). It represents the mean annual power available per square meter of the swept area of a turbine. The calculation of wind power density takes into account the effect of wind velocity and air density. A higher wind power density indicates a more favourable location for wind power generation. |
| Capacity Factor (wind turbines) | Also called load factor is the observed ratio of the amount of energy produced by wind turbines (MWh or GWh) to its total potential based on the nameplate capacity (or installed capacity, in MW or GW) over a period of time, usually the past year or since it began operating, to account for seasonal variability. |
| Load duration curve: | A load duration curve for an offshore wind farm represents the cumulative distribution of electricity generation over a specified period, typically a year, arranged in descending order of magnitude. The plot is capacity factor on a vertical axis and the percentage of time the wind turbine or windfarm generates at that level on the horizontal axis. It helps visualize the contribution of a particular wind farm to meeting electricity demand as a percentage of time, as all wind turbines generate different levels of output depending on the wind, weather and other factors. |
| Opportunity Cost | Opportunity cost refers to the potential benefits that are forgone when one alternative is chosen over another. In this context it refers to the economic and environment cost associated with choosing Rampion 2 over an Alternative such as additional LNG or power imports or savings on upfront capital costs |
| Variable renewable energy generation | Electricity generated from renewable sources supplied to the grid. In this case wind which exhibit fluctuations in output due to natural variability in weather conditions on an hourly, daily, seasonal basis and year-to-year. |
| Intermittent generation | Electricity generation that occurs sporadically or irregularly in this case offshore wind, which are subject to changes in weather patterns and location specific factors. |
| Dispatchable power | Electricity generation that can be controlled and dispatched according to demand, allowing grid operators to adjust output levels as needed. In this |

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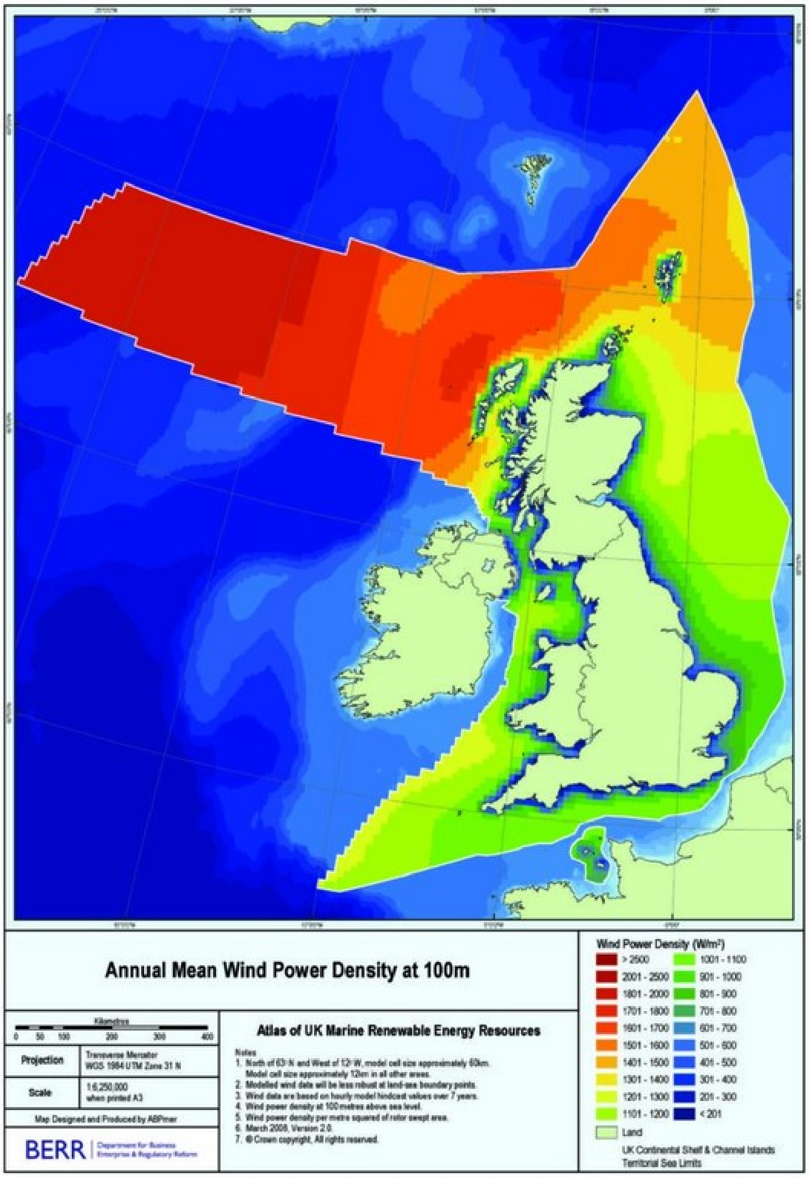
|---|---|
| | context it mainly means gas-fired turbines with carbon capture fitted. In the longer term it includes utility-scale energy storage. |
| Dependable Power | Electricity generation that can be relied upon to provide a consistent and predictable supply of energy, in this case mainly meaning SMRs but include natural gas with carbon capture used for peaking and backing up variable offshore wind when the wind drops |
| Power system reliability: | The ability of a power system to deliver electricity to UK consumers consistently and without interruptions, while meeting certain performance standards for voltage and frequency. |
| Ancillary services in a power system | Additional services provided by power system operators to maintain the stability, reliability, and efficiency of the grid. These services may include frequency regulation, voltage control, and reserves for managing sudden changes in supply or demand.: See Annex |
| Abated Gas-fired Power Stations | Abated means no carbon emissions. Gas-fired power stations that are fitted with a carbon capture system so that they have no carbon emissions or little. All UK gas-fired power stations will have to be fitted with carbon capture by 2035 in the UK. Up to 10 percent of the power from the turbines will be needed to operate the carbon capture system. The carbon then needs to be processed and transported by pipeline or barge to a carbon storage depot. |
| Grid Collapse | A catastrophic failure of the electrical grid resulting in widespread blackouts and loss of power to large areas or regions. Grid collapses can be caused by various factors such as equipment failures, extreme weather events, operator errors or insufficient dependable and dispatchable power to balance demand and supply. At present the most risk is in coldest weather in high pressure which are typically low wind periods, cost and electricity demand is highest. |
| Unserviced energy cost | The economic and social cost associated with energy that is not delivered to consumers due to transmission or distribution losses, equipment failures, or other factors that prevent electricity from reaching its intended destination and use. |
| Power system "brown out" and "black out" | A "brownout" in the context of a power system refers to a temporary decrease in voltage levels supplied to consumers. Unlike a blackout, where power is completely cut off, a brownout typically involves a reduction in voltage levels that can lead to dimming of lights, slower operation of electrical appliances, and potential damage to sensitive electronic equipment.<br><br>Brownouts can occur for various reasons, such as high demand for electricity exceeding the supply capacity, faults in the power grid, or intentional voltage reductions by utility companies to prevent a total blackout during periods of high demand or system stress. While brownouts are less severe than blackouts, they can still disrupt daily activities and cause inconvenience or damage to electrical devices. |
| Load Shedding | Load shedding is a deliberate action taken by a utility company to reduce the demand for electricity on the power system by temporarily cutting off power to certain areas or consumers. This is typically done during periods of high demand or when the power system is under stress, such as during heat waves or in cold periods when the wind drops when there is a high proportion of RE capacity on the grid of or when there is insufficient generation capacity to meet demand.<br><br>Load shedding is implemented to prevent a widespread blackout, which could occur if the demand for electricity exceeds the available supply. By shedding |

| | |
|---|---|
| | load, the utility company can balance the supply and demand of electricity, thus maintaining the stability and reliability of the power grid.<br><br>During load shedding, certain areas or consumers may experience power outages for a predetermined amount of time, usually rotating among different areas to distribute the impact fairly. Utilities often prioritize critical services such as hospitals, emergency services, and essential infrastructure to minimize the impact of load shedding on public safety and essential services. |
| | |
| Carbon Capture on gas-fired power stations | The process of capturing carbon dioxide emissions produced by gas-fired power stations and storing them in the UK’s offshore carbon storage depots initially in the North Sea to be read by 2030. In this context, initially transport from the southern power stations to storage would be by barge. Reference the Net Zero Teesside Power (NZT Power) project consented in Feb 2024 to be the UK's first fully integrated gas-fired power and carbon capture project with an 860 MW combined cycle gas turbine which, in that case will use a dedicated CO2 pipeline to offshore storage depot. |

## Annex 2: Larger WPD Map




UK Annual Mean Wind Power Density


Abstract

The UK marine renewable atlas is a new information resource designed to assist government strategic planning for large-scale offshore renewable energy development. The atlas provides a means to identify, quantify and spatially map the potential interest areas for wave, tidal and offshore wind resources at a regional scale across the limits of the UK continental shelf. The assembled database and technical reports generated by the study are publicly available, and have received great interest from potential developers, stakeholders and the general public. The project has been funded by the Department of Trade and Industry's strategic environmental assessment combined programme covering oil and gas and marine renewable agendas.

## Annex 3: Capacity Factors for UK offshore windfarms and Rampion 1

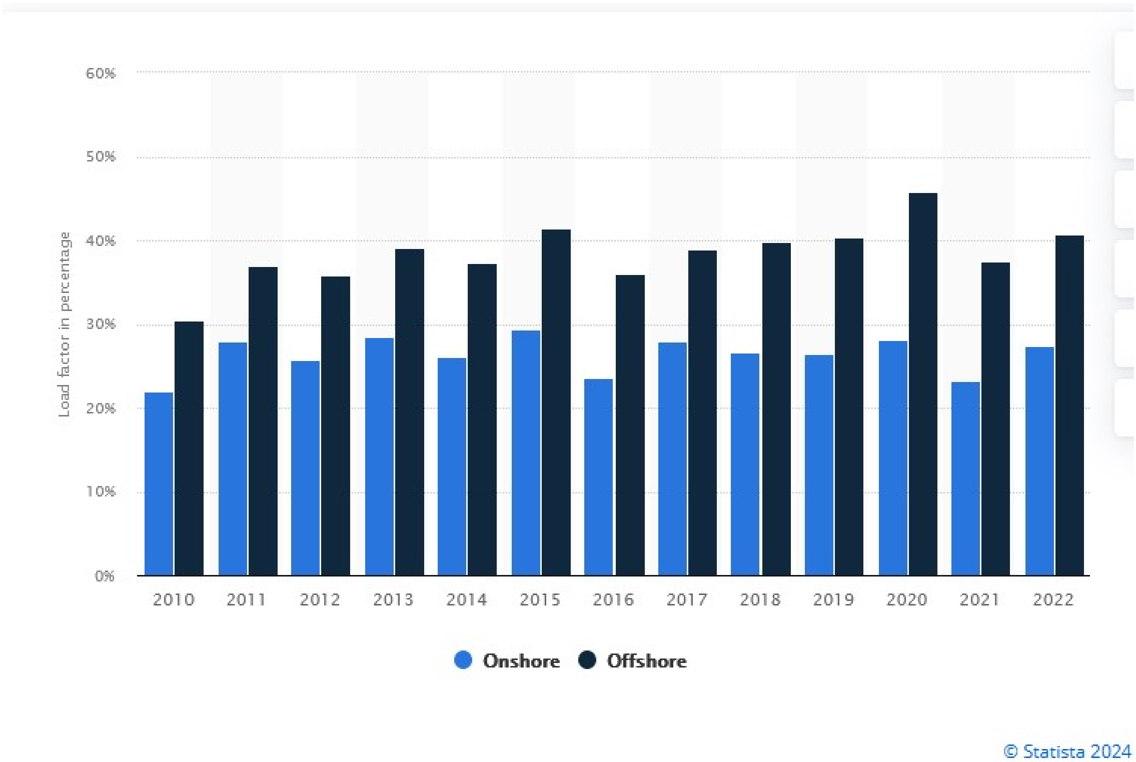
| All numbers are to the end of May 2022. Analysis by EnergyNumbers.info. Raw data from Ofgem and Elexon | Latest rolling 12-month capacity factor | Life capacity factor | Age (y) | Installed capacity (MWp) | Total elec. gen. (GWh) | Power per unit area spanned (W/m2) | Rolling annual capacity factors (click to enlarge) |
|---|---|---|---|---|---|---|---|
| Total | 42.2% | 39.6% | . | 12,233 | 235,690 | 1.4 | |
| Aberdeen EOWDC | 35.3% | 37.4% | 3.9 | 93 | 1,294 | 1.7 | |
| Barrow | 30.8% | 35.4% | 15.7 | 90 | 4,378 | 3.2 | |
| Beatrice | 32.1% | 41.8% | 3.0 | 588 | 6,438 | 1.9 | |
| Burbo Bank | 26.2% | 33.4% | 14.6 | 90 | 3,859 | 3.0 | |
| Burbo Bank 2 | 36.9% | 40.3% | 5.2 | 254 | 4,628 | 2.6 | |
| Dudgeon | 45.3% | 47.5% | 4.6 | 402 | 7,784 | 3.5 | |
| East Anglia ONE | 43.4% | 46.8% | 1.8 | 714 | 5,392 | 2.1 | |
| Galloper | 45.8% | 47.2% | 4.1 | 353 | 6,039 | 1.5 | |
| Greater Gabbard | 37.3% | 40.6% | 8.8 | 504 | 15,929 | 1.4 | |
| Gunfleet Sands | 33.2% | 36.8% | 11.9 | 173 | 6,689 | 4.0 | |
| Gwynt-y-Mor | 31.4% | 34.3% | 6.9 | 576 | 12,101 | 2.9 | |
| Hornsea One | 46.6% | 47.3% | 2.4 | 1,218 | 12,128 | 0.5 | |
| Humber Gateway | 41.7% | 43.4% | 7.0 | 219 | 5,830 | 3.5 | |
| Hywind Scotland | 49.5% | 52.6% | 4.6 | 30 | 642 | 1.0 | |
| Lincs | 41.3% | 42.4% | 8.7 | 270 | 8,749 | 2.8 | |
| London Array | 38.3% | 40.2% | 9.1 | 630 | 20,444 | 2.1 | |
| Moray East | 26.3% | 13.2% | 0.1 | 950 | 162 | 0.4 | |
| Ormonde | 25.1% | 36.5% | 10.3 | 150 | 4,932 | 5.5 | |
| Race Bank | 42.8% | 43.4% | 4.3 | 573 | 9,421 | 4.0 | |
| Rampion | 38.1% | 36.7% | 4.1 | 400 | 5,337 | 2.0 | |
| Robin Rigg | 33.4% | 35.5% | 11.7 | 174 | 6,371 | 3.4 | |
| Sheringham Shoal | 35.9% | 39.7% | 8.7 | 317 | 9,642 | 3.6 | |
| Thanet | 31.7% | 33.5% | 11.7 | 300 | 10,317 | 2.9 | |
| Triton Knoll | 25.0% | 23.2% | 0.2 | 857 | 424 | 1.3 | |
| Walney phase 1 | 33.8% | 39.5% | 10.9 | 184 | 6,959 | 2.6 | |
| Walney phase 2 | 41.4% | 45.3% | 9.9 | 184 | 7,258 | 1.8 | |
| Walney 3 & 4 | 40.5% | 46.0% | 3.7 | 659 | 10,062 | 2.0 | |
| Westermost Rough | 45.2% | 47.3% | 7.0 | 210 | 6,122 | 2.8 | |
| West of Duddon Sands | 41.3% | 45.2% | 7.6 | 389 | 11,676 | 2.6 | |
| Beatrice Demo (closed) | 14.6% | 18.9% | 8.3 | 10 | 123 | | |
| Blyth Demo (closed) | 18.0% | 9.2% | 11.8 | 4 | 39 | | |
| Blyth Demo Array 2 | 36.5% | 42.7% | 3.9 | 42 | 586 | | |
| Fife Demo | 12.7% | 13.6% | 8.1 | 7 | 72 | | |
| Gunfleet Sands Demo | 13.3% | 29.0% | 8.7 | 12 | 273 | 1.4 | |
| Inner Dowsing | 33.3% | 35.2% | 13.2 | 97 | 3,948 | 3.9 | |
| Kentish Flats | 28.3% | 30.8% | 16.5 | 90 | 3,926 | 2.8 | |
| Kentish Flats Extension | 37.6% | 41.9% | 6.5 | 50 | 1,151 | 2.5 | |
| Kincardine demo (closed) | | 7.5% | 1.9 | 2 | 115 | 0.0 | |
| Lynn | 33.4% | 35.2% | 13.2 | 97 | 3,943 | 4.3 | |
| North Hoyle | 27.3% | 32.3% | 17.9 | 60 | 3,015 | 2.0 | |
| Rhyl Flats | 34.0% | 34.4% | 12.5 | 90 | 3,342 | 3.2 | |
| Scroby Sands | 32.1% | 31.4% | 17.5 | 60 | 2,879 | 4.5 | |
| Teesside | 31.7% | 36.0% | 7.1 | 62 | 1,373 | 5.2 | |

https://energynumbers.info/uk-offshore-wind-capacity-factors

Andrew ZP Smith, ORCID: 0000-0003-3289-2237; "UK offshore wind capacity factors". Retrieved from https://energynumbers.info/uk-offshore-wind-capacity-factors on 2024-03-12 15:41 GMT

## Annex 4: Capacity factors of offshore and onshore wind

Load factor (capacity factor) of electricity from onshore and offshore wind in the United Kingdom (UK) from 2010 to 2022 (in percentage)



# Annex 5: Alternatives to more wind turbines in Sussex Bay

**Consideration of Alternatives in the Rampion 2 Examination**

These alternatives also conform to what Ofgem calls "least regret" choices, as they are wholly consistent with technology specific NPS. They include:

**Alternative 1**

**Rather than extending the Rampion 1 installation, extend a recent licence award for an offshore windfarm in the North Sea area.**

Specifically, facilitate incremental investment in an equivalent number of wind turbines (as proposed for Rampion 2) in southern Dogger Bank area where the Rampion 2 developer RWE has recently acquired two licences under the Crown Estate's fourth offshore wind bid round in Jan 2023. RWE only confirmed in Sept 2023 that it would proceed, when the UK increased the Contract for Differences (CfD subsidy) for offshore wind developers by up to 66%.

That reasonably re-directs £3-4nb of foreign capital investment to an area of higher wind power density, where the same Rampion 2 turbines would be more efficient; generating higher and more constant output. That affords the opportunity to take advantage of economies of scale with shared facilities like offshore substations, power evacuation cables and National Grid transmission connection to reduce costs. That reduces opportunity cost in the system (less costly LNG import) and can free up UK borrowing capacity for other strategic infrastructure. That also offers greater scope for 2-way power exchange with the continent and access to an offshore ring grid.

Those new North Sea projects are due to be completed around 2030 (about the same as Rampion 2). They are still in very preliminary stages of project preparation and design. It is a situation where good-faith negotiations can take place between the relevant parties (i.e., Crown Estates and RWE) with outcomes that are mutually beneficial for RWE and UK society.

**Alternative 2:**

**Retrofit existing and new high efficiency combined cycle gas-fired turbines (CCGT) with carbon capture (CC) on the south coast near load centres in a sensible phased manner.**

Putting carbon capture (CC) on existing and new gas-fired power stations to make them net-Zero ready as they will have no carbon emissions. New combustion turbines alongside existing turbines in power stations to extend their capacity, or a new gas power station fitted with carbon capture on the same site or new site can also be multi-fuel (i.e., and hydrogen ready).

This makes them NetZero as point source emitters for the 2035 decarbonisation drive. Locating that dependable and flexible abated gas generation capacity in the south of England minimises costs where grid connection and gas supply infrastructure are available. That reduces pressure on the need for infrastructure for north south power transfers. $CO_2$ storage would initially be handled by barge transport to one of three offshore carbon storage "clusters" the UK is to have ready by 2030, and thereafter flexibly phasing in CCUS (carbon capture, use and storage) as appropriate.

The approach is based the Net Zero Teesside Power (NZT Power)) 850 MW abated gas-fired project consented by the Secretary of State in February 2024. It is all existing and proven technology. The final investment decision will be taken by the owners in Sept 2023. The project is expected to be online in the 2026-2028 timeframe.[24]

The south has many efficient combined cycle gas turbine (CCGT) power stations where it is likely additional CCGT capacity can be added to existing power stations with carbon abatement, or building a new power station on the same site with carbon capture that will provide essential firm power to help meet mandated load growth and back-up variable RE generation. It will take time pressure off the costly north-south transmission expansion, and improve system flexibility for load balancing to reduce the risks of societal disruption from costly power shortages and blackouts across the south. The point is all UK gas-fired power stations must have carbon capture by 2035.

**Alternative 3:**

**Deployment of factory built, flexible Small Modular Reactors (SMRs) that use enriched uranium or thorium to raise steam to drive steam turbines. SMRs have a small footprint. They are to be co-located appropriately at decommissioned large nuclear sites, existing or under construction large nuclear power stations, or decommissioned coal or gas power stations.**

While the new UK entity Great British Nuclear (GBN) opted for a competition between UK and international/ national supplies and expects to announce winning bids by April 2023, Rolls-Royce has a 470 MW modular, factory-built commercial power SMR that up-scales its military reactors that it has been manufacturing and maintaining for over 60 years.

In February 2024 Rolls Royce announced it aims to have its civilian SMR operational by 2029 in Eastern Europe based on memorandum of understanding with a number of Governments, after previously announcing it has provisional orders and financing.

The UK Government' Great British Nuclear (GBN) was established in 2023 with the following mandate: [25]

- Great British Nuclear to drive rapid expansion of nuclear power at an unprecedented scale and pace
- government kickstarts competition for game-changing small modular reactor (SMR) technology, which could result in billions of pounds of public and private sector investment in SMR projects
- plans will boost energy security, create cheaper power and grow the economy - creating better-paid jobs and opportunity right across the country

**Comparison of National Benefits and Disbenefits**

Table 1 at the end of this Summary is a check list and simple benchmarking and ranking exercise as a way to help break down and compare national benefits and disbenefits of Rampion 2 and weigh those against the three alternatives.

[24] https://www.bp.com/en_gb/united-kingdom/home/news/press-releases/net-zero-teesside-power-and-northern-endurance-partnership-award.html
[25] https://www.gov.uk/government/news/british-nuclear-revival-to-move-towards-energy-independence

Table 1 shows the raw aggregate score for **12 NPS Policy-Relevant National Benefit Indicators** where the score shown is simply the sum of the scores for each criteria under each indicator. There are a different number of criteria under each indicator (criteria are scored 1 to 4).

This is elaborated and explained in the main representation in Section 4 Conclusions. In Table 6 on Section 4 all the detailed criteria and the scores are shown.

In the absence of systems value modelling ( we argue this should be undertaken to inform the Examinations) this is a fall-back technique that uses Rampion 2 as a baseline to rank order the four options, thus qualitatively benchmarking Rampion 2 against the three alternatives.[26]

Obviously, there are limitations and complexities. These indicators aim to help make the determination of essential NPS policy interpretations less subjective, more transparent and clearer. In applying this technique people or groups may wish to chose different indicators and criteria and apply weights them. We simply assume using the same weight on each Indicator and criteria.

It informs the Section 4.4, EN-1 policy requirement as well as how national benefits may be weighed in the Examination "on adverse impacts of Rampion 2 outweighing its benefits".

**Summary Conclusions:**

Considering Alternatives under NPS EN-1 Section 4.4 is helpful to break down and benchmark the national benefits of Rampion 2 to inform Examination decisions about Rampion 2, for the three purposes set out in the Preface of this Representation.

Rampion 2 has national benefits.

Our simple benchmarking and rating analysis results shown in Table 1 indicates that all three alternatives offer a better way forward than Rampion 2, in respect to national benefits overall. It suggests they are in the local, national and wider public interest as compared to a £3-4 billion capital investment in Rampion 2. The alternatives do not have the same high economic and environmental opportunity costs and risk as Rampion 2.

Extending an existing offshore wind licence on Dogger Bank would for example lead to 1.3 times the national benefit than granting consent to a £3-4 billion Rampion 2. That would be at less cost. The economic opportunity cost of Rampion 2 could be quantified via power system value modelling. For these assumptions as set out in the main submission in Part 4 Alternative 3, and SMRs could lead to twice the national benefit.

The method and assumptions used for the benchmarking, the 12 national policy indicators used to break down National Benefits, and the detailed criteria and scoring is elaborated in Part 4 of the main representation. That includes the detail matrix presented as Table 6 of Part 4.

In summary:

[26] This weighting, rating and ranking technique is recommended in the World Commission on Dams for the consideration of Alternatives as a Strategic Priority which the UK government co-funded (WCD, 2000).

| **Rampion 2 and three NPS Section 4.4 Alternatives** | **Benchmarking Indicator score (high being better)** | **Relative to Rampion 2** |
|---|---|---|
| <u>Rampion 2 – the Baseline</u><br>Extending the installation of turbines in the Sussex Bay with up to 90 WTGs up to 325m tall and transmission through designated landscapes | 115 | 1.0 |
| <u>Alternative 1:</u><br>Extending an existing Dogger Bank windfarm licence with equivalent capacity (up to 90 WTGs up to 325m tall) where they are more efficient, economies of scale and potentially link to an offshore ring grid to minimise onshore transmission and better facilitate connection to EU grids. | 156 | 1.4 |
| <u>Alternative 2:</u><br>Retrofitting an existing natural gas-fired power station with carbon capture (CCGT/CC) and adding a Rampion 2 equivalent new capacity at that site (or replacement power starting with CC, or a new power station with carbon capture in the south with multi-fuel capability to switch hydrogen when ready. | 201 | 1.7 |
| <u>Alternative 3:</u><br>A Small Modular Reactor (SMR)<br>(located in decommissioned large nuclear site (or existing / under construction site) or decommissioned coal-fired or gas-fired power station sites) | 236 | 2.1 |
| For assumptions noted and policy relevant criteria indicated in Part 4 and Table 6 in Part 4 | | |

It also raises a simple question: at least to 2035, when decarbonisation of the power sector is hopefully achieved and until energy storage systems are viable, affordable and deployed at scale some decades later: which is more environmental friendly and helpful for National Energy Security and UK energy-self reliance: (a) if the UK sources natural gas domestically from the North Sea fields, or (b) imports liquefied natural gas (LNG) transported over great distance from Qatar or the USA in the form of price vulnerable LNG.

That choice of (a) or (b) has real carbon emission implications, and whether those emissions appear in the UK's national carbon accounts or not.

An optimal "least regret" strategy can be highlighted when Alternatives are brought into Rampion 2 Examination. That may be for the UK to move in parallel with all three alternatives as complementary additions to the UK generation mix to achieve decarbonisation of the power sector by 2035 – rather than committing to an upfront £3-4 bn Rampion 2 capital investment at this time - is suggested by this analysis.[27]

[27] Ofgem 2021 strategic review of power system endorses a “least regrets” strategy.

**Table 1: Benchmarking National Benefits of Rampion 2 against realistic Alternatives**

| | | **Baseline** | **Three NPS EN-1 Section 4.4 Alternatives** | | |
|---|---|---|---|---|---|
| | **Criteria and National Benefit / Disbenefit Indicators** | **Rampion 2 (Sussex Bay inshore & transmission via a SDNP route)** | **Wind Turbines extending Dogger Bank Licence** | **Abated Gas Turbines with carbon capture (CCGT/CC) In South UK** | **Small Modular Reactors (SMR) (in decommissioned Large nuclear sites or decommissioned coal or gas sites)** |
| | Date Ready to deliver power | ~2030 | Possible Before 2030 | Possible Before 2030 | Possible Before 2030 Policy Dependent |
| | Average annual plant factor | 37-40% | 60-65% | 100% on demand | 95% always on expected |
| | | Both weather dependent | | | |
| | Estimate build time (years) | 4-5 yrs | 4-5 yrs | 1-4 yrs for CCGT/CC | 2-3 yrs is claimed |
| | Economic Life | 20-25 yrs | | Longer than Rampion 2 | 60+ yrs Expected |
| | Capital Cost (per project) | £3-4 bn | Depends on infrastructure sharing | Location specific CCGT has low capital costs | £2-2.5 bn claims |
| | **12 NPS Policy-Relevant Indicators** | | | | |
| 1 | Likely contribution to decarbonisation of the UK Power Sector by 2035: | 5 | 9 | 13 | 16 |
| 2 | Likely contribution to UK Energy Security and Energy Self-reliance: | 10 | 13 | 14 | 22 |
| 3 | Effects on National Grid operation, quality and reliability of power supply: | **9** | **15** | **28** | **34** |
| 4 | Affordability Effects (National to Local): | **8** | **11** | **20** | **24** |
| 5 | Project Financability, Investability and Market Risk: | **16** | **16** | **16** | **17** |
| 6 | Job Creation Opportunity and Benefits (Local to National): | **7** | **7** | **16** | **22** |
| 7 | UK Industry Strategy, UK export and UK developing country assistance: Opportunity and Benefits | **4** | **4** | **12** | **16** |
| 8 | Adverse Environmental Footprint and Impacts: | **24** | **28** | **26** | **27** |
| 9 | Environmental Externalities: | **12** | **12** | **9** | **10** |
| 10 | Avoidance of compromising the achievement of sustainable development in coastal and inland areas | **8** | **19** | **20** | **20** |
| 11 | Distribution and Equity Effects (national to local) | **4** | **9** | **8** | **8** |
| 12 | Lowering Opportunity Costs: Economic, social and environment opportunities forgone | **8** | **13** | **19** | **20** |
| | **Total Count (Un weighted)** | **115** | **156** | **201** | **236** |