Netherlands Enterprise Agency

Government's response to the study 'A theoretical upper limit for offshore wind energy extraction'

Commissioned by the ministry of Climate Policy and Green Growth

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Attachment(s)
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Date 20 January 2026
Subject Government's response to the study '*A theoretical upper limit for offshore wind energy extraction*'

Dear Chairman,

The Government has taken note of the study '*A theoretical upper limit for offshore wind energy extraction*' by Simão Ferreira et al., that was published on 24 November 2025 in Cell Reports Sustainability.[1] In this letter, at the request of the House of Representatives, the Government provides an assessment of this research and gives permission for officials from the Ministry of Climate and Green Growth to provide a technical briefing on this subject.[2] The Government proposes to expand this briefing with experts from Whiffle, TNO and TU Delft.

The Government welcomes the fact that research is being carried out into offshore wind energy and associated energy yields. If research provides new insights, this will help to make the best possible choices for the design of wind farms to maximise energy yield.

Following the recent study by Simão Ferreira et al., the Government does not see any major consequences for the design of the energy system, including the roll-out of offshore wind farms. Further study shows that some important assumptions in this study do not correspond to the Dutch roll-out scenario for offshore wind energy. An example of this is the size of the wind farms. The scenario in the article is based on a large hypothetical future wind farm (10 GW). In contrast, the scenario the Government uses to calculate energy yields is based on planned wind farms (about 1 GW or smaller). This means the results cannot be compared with each other.

This letter first outlines the context for the roll-out of offshore wind energy. Then research into energy yields of offshore wind farms will be discussed. The Government will then discuss the role of wind energy and its contribution to the energy system, and how the capacity factor is taken into account. The Government then draws conclusions from the various studies. Finally, the

[1] https://www.sciencedirect.com/science/article/pii/S2949790625002691
[2] Letter from the Committee on Climate and Green Growth of 10 December 2025, regarding the Government's response to the study by Simão Ferreira et al., on the yield of offshore wind farms and approval for technical briefing (reference: 2025Z21673/2025D51205).

Government outlines how it will maintain contact with the scientific community to learn from the latest insights in this field and how it will incorporate these insights into policy for the energy system.

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Context of the roll-out of offshore wind energy
In the transition to a climate-neutral and more import-independent energy system, technologies are used that are continuously subject to innovation and there are large leaps in scale. The energy transition is not a linear process; there is constantly evolving insight and many variables are still uncertain. Therefore, the Government is taking the latest insights and uncertainties into account and, if necessary, adjusting climate and energy policy. This applies to offshore wind energy, but also to other energy sources. To this end, the Government is using the best available knowledge from knowledge institutions, network operators and research agencies.

In developing the energy system, including the roll-out of offshore wind energy, the Government is not only aiming for the highest energy yield, but for the highest social value. In doing so, the Government takes into account various public interests, such as affordability, safety, space (also for other national interests) and the environment.[3]

Wind farms can be optimised in various ways, such as for energy yields and costs. The Government provides frameworks that wind farm developers must adhere to developing wind farms. For example, there is a minimum for installed capacity (in GW) per site to ensure that sufficient energy is converted in the wind farms. This optimisation takes place within the space made available for offshore wind energy. In determining this space, in addition to energy revenues and costs, the Government also takes into account space for other national interests in the North Sea, such as fisheries, nature, shipping, defence and mining. The 'capacity factor' is the result of this optimisation and balancing of interests. The capacity factor is a measure that represents the ratio between actual converted energy and the theoretical maximum energy that can be converted if the wind farm were to operate continuously at full capacity.

Research into energy yields from offshore wind farms
It has been known since the start of the roll-out of offshore wind that wind turbines have lower energy yields the closer they are to each other due to wake effects. As more offshore wind farms are built, even more knowledge is gained about the mechanisms behind this. The Government is monitoring these developments, actively contributes to them and continuously incorporates new insights into policy developments.

In 2024, Whiffle was commissioned by the Government to calculate the impact of wake effects on annual energy yields for the Offshore Wind Energy Roadmap (hereinafter: Roadmap). Assuming a total installed capacity of 21 GW, divided between sites of about 1 GW or smaller, these yields are estimated at 84 TWh measured at the rotor (blades) of the wind turbines. This corresponds to a capacity factor of about 46% at the rotor. These results were published in July 2025 and discussed with the wind energy sector.[4] A similar capacity factor at the rotor (46%) has been calculated for a Dutch scenario by

[3] The public interests that form the basis of the choices made in the design of the energy system are elaborated in the National Energy System Plan under "Public interests" from p. 11.
[4] anc_20250811_wakestudy_whiffle_report_f.pdf

Fraunhofer IWES in September 2025 on behalf of the German Government.[5] This study also shows that the Netherlands will have a higher capacity factor than Germany and Belgium, but lower than that of Denmark, Norway and Great Britain. This is partly due to the available space for wind farms and local wind conditions.

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Taking into account system losses (e.g. cable losses), it is estimated that the annual energy yield from 21 GW of installed capacity is 76 TWh at the TenneT platform, the so-called offshore socket. This is about two-thirds of current net electricity consumption in the Netherlands and amounts to an average capacity factor of about 42% at the TenneT platform. This figure should not be taken as a given, as certain factors such as the choice of wind turbine and wind farm layout can influence it.

The Government welcomes new studies that provide more insight into the uncertainties and development of offshore wind farms. The article by Simão Ferreira et al., which is the reason for this letter, is startling because it comes to different conclusions than the studies mentioned above. Further study of the article and discussions that Ministry for Climate and Green Growth (KGG) staff had with Simão Ferreira, as promised in the question time on Tuesday 9 December 2025, indicate that the results cannot be compared with each other. For example, Simão Ferreira et al. did not look at wind farms included in the Roadmap, but at a large hypothetical future wind farm.

A scientific memo dated 19 December 2025 (appendix to this letter) addressed to the Ministry of Climate and Green Growth on behalf of two professors from Delft University of Technology (TU Delft) provides context for the findings of Simão Ferreira et al.[6] Following this memo, and the commitment made in the question time on Tuesday 9 December 2025, KGG staff, in addition to Simão Ferreira, also had a discussions with these two professors. The professors indicate, among other things, that the capacity factor of 35%, which Simão Ferreira et al. arrived at, is based on a "*pessimistic scenario".* The professors conclude that the calculated capacity factor of a wind farm is very sensitive to assumptions and that results of simplified models, as used in the study by Simão Ferreira et al., should be interpreted with caution.

Role of offshore wind energy in the energy system
When drawing up the Wind Energy Infrastructure Plan (WIN), the Government concluded that existing system studies did not take sufficient account of wake effects. For this reason, the Government has had additional scenarios calculated. The Netherlands Organisation for Applied Scientific Research (TNO) has investigated the potential impact of a lower energy yield on the Dutch energy system, in line with a capacity factor of 42% at the TenneT platform. The analysis shows that, even in additional scenarios, offshore wind energy remains by far the largest source of electricity, and the 30-40 GW stated in the WIN is needed.[7]

Conclusion
The Government therefore concludes that the capacity factor estimate in the article by Simão Ferreira et al. is too conservative an estimate for the Dutch roll-

[5] https://www.bsh.de/DE/THEMEN/Offshore/Meeresfachplanung/_Anlagen/Downloads/IWES_Bericht.pdf?__blob=publicationFile&v=1
[6] Watson, S., & von Terzi, D. (2025). Context for scientific publication. TU Delft. Appendix to this letter.
[7] The North Sea Wind Energy Infrastructure Plan, p. 83.

out scenario for offshore wind energy. The Government draws this conclusion based on recent studies by Whiffle and the Fraunhofer Institute for Wind Energy Systems, and a scientific memo from TU Delft, which confirms that Simao Ferreira et al. are basing their findings on a "pessimistic" scenario that is not in line with the Dutch roll-out scenario. The results of the various studies described above show that determining the energy yield requires accurate and careful research with assumptions that are as realistic as possible.

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Follow-up

The Government will continue to actively engage with various experts in the field of offshore wind energy to better understand the assumptions, models, objectives, variables and preconditions involved. The Government is also consulting with TenneT, the Netherlands Environmental Assessment Agency (PBL), TNO and the Royal Netherlands Meteorological Institute (KNMI) to explore the assumptions and models used for various studies. In consultation with TNO, the Government will also include the most recent insights into the energy yields of wind energy in an update of the nuclear energy system cost study published in October 2025, as promised in the Nuclear Energy Commission Debate on 17 December 2025.[8]

If these discussions and analyses lead to new insights, the Government will integrate them into climate and energy policy and inform the House about this. The update of the National Energy System Plan (NPE) offers the next opportunity for this. This is expected to be presented on Budget Day.

Sophie Hermans
Minister for Climate and Green Growth

[8] Nuclear System Cost Analysis | Report | Rijksoverheid.nl and TZ202512-060

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