WIND POWER AS AN ALTERNATIVE TO NUCLEAR POWER FROM HINKLEY POINT C: A COST COMPARISON

A short analysis commissioned by Greenpeace Energy in Germany
Berlin, 6 January 2016

Authors: Marie-Louise Heddrich, Thorsten Lenck and Carlos Perez Linkenheil

WIND POWER CAN REPLACE NUCLEAR POWER FROM HINKLEY POINT C AT A LOWER COST

At EUR 110.51$_{2012}$/MWh, the cost for a combined system of wind power and windgas [hydrogen or methane produced by temporary surplus wind power], as a renewable alternative to Hinkley Point C, is 8.2 percent lower than the subsidy cost of EUR 120.30$_{2012}$/MWh that the nuclear power plant is expected to receive for a period of 35 years. This is the major finding of the study.

The study examined what it would cost to replace the Hinkley Point C (HPC) nuclear power plant with renewable energy technology, namely wind power and windgas facilities. The renewable alternative investigated in this study uses wind power directly as far as possible, commensurate with the supply of wind. Natural fluctuations in power generation from wind are balanced by windgas (also known as power-to-gas) so that, overall, the same volume of electricity within the same production structure is generated as would be by the base-load power plant[1] Hinkley Point C with an installed capacity of 3.2 gigawatts (see Illustration 1).

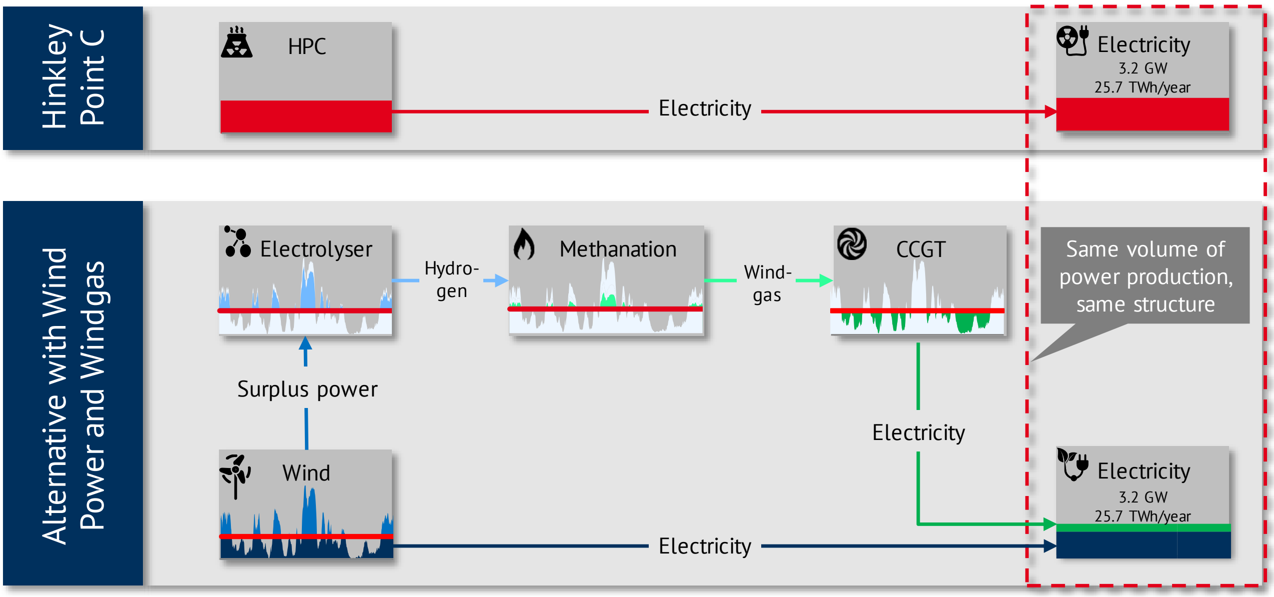

Illustration 1: Power generation from Hinkley Point C compared to power generation from wind and windgas

[1] Energy Brainpool (2015a).

A portion of this electricity is generated directly by wind turbines. In order to make a direct comparison with Hinkley Point C's expected constant power output, natural fluctuations in wind power in the renewable alternative have to be balanced. This balance is achieved by relying on windgas.

Illustration 2 demonstrates this principle using the simulated example of electricity production during August 2025, a month well-suited to depicting strong fluctuations in wind power yield due to weather conditions during that period of time. The illustration shows how steady power production by Hinkley Point C (straight red line above A + B areas, or 3.2 gigawatts) can be replaced by wind power and windgas (A + C areas).

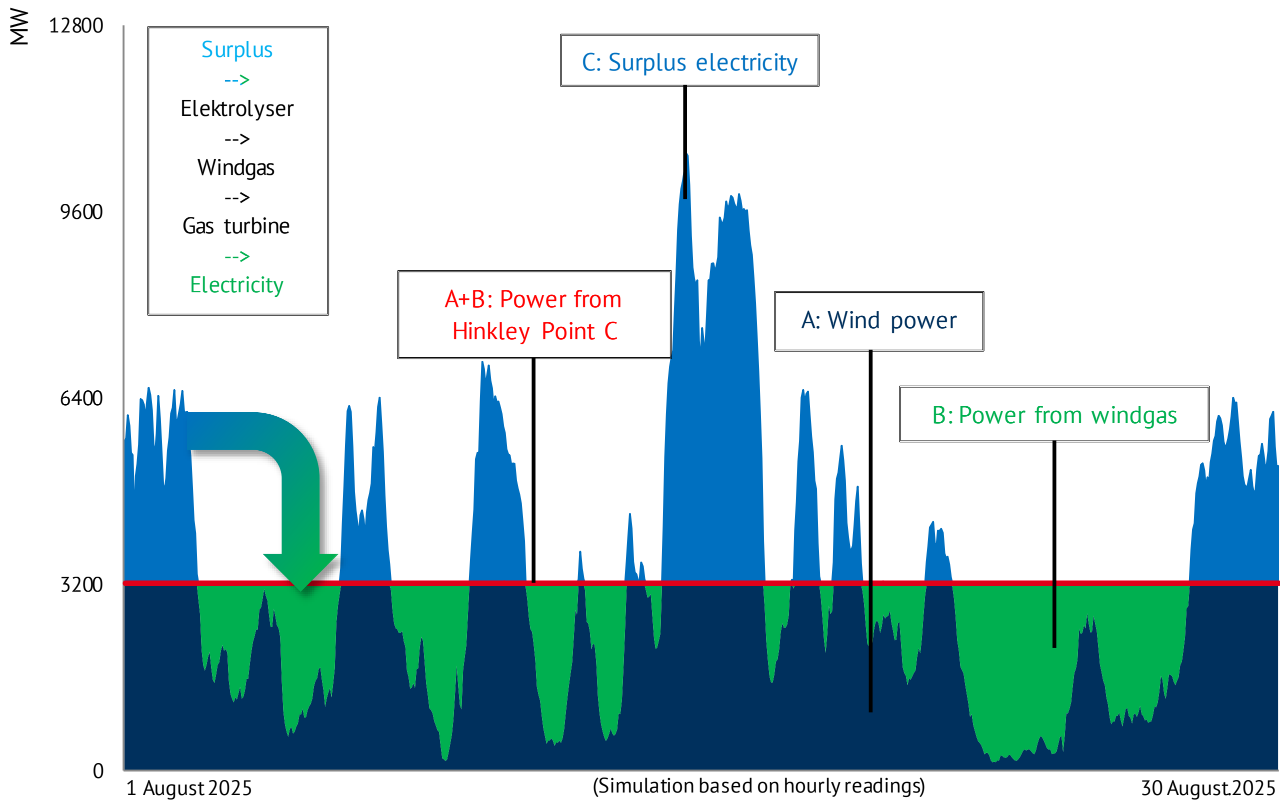

Illustration 2: Balancing intermittent wind power production by generating power from windgas during the sample month of August 2025

The illustration shows that surplus wind power in excess of the amount of power generated by the Hinkley Point C nuclear power plant (3.2 gigawatts) is used in windgas facilities to convert hydrogen (H_2) to methane gas (CH_4) which is then fed into the conventional gas distribution system or stored in already existing gas storage facilities and later reconverted into electricity in combined-cycle gas turbine (CCGT) power plants when the need arises (B in green). For the study, the installed capacities of windgas facilities and CCGT plants needed to balance fluctuations were calculated at their optimal cost based on an annual quantitative balance. Hydrogen produced by electrolysis can often be used directly without needing methanation. However, the study took a conservative approach and based calculations on a complete methanation of surplus stocks because windgas can then be fed into the existing gas network.

A DETAILED COST COMPARISON

For this process, the study calculated the cost of the windgas alternative using the Power2Sim energy market model, based on hourly simulation, and compared this with the subsidies that Hinkley Point C is expected to receive for the 35 years following the start of its operation.

The result: In a comparison using the figures from HPC's current subsidy programme and the present degression defined in Germany's Renewable Energies Act (EEG), wind power and windgas facilities can replace the Hinkley Point C nuclear power plant at a lower cost.

Illustration 3 shows the results of the cost analysis of the windgas alternative compared to the planned subsidy costs of EUR 108.6 billion (nominal) for Hinkley Point C. Cost developments for windgas are based on assumptions calculated by the Technical University of Regensburg's Research Centre for Energy Networks and Energy Storage (FENES) / Energy Brainpool in 2015.

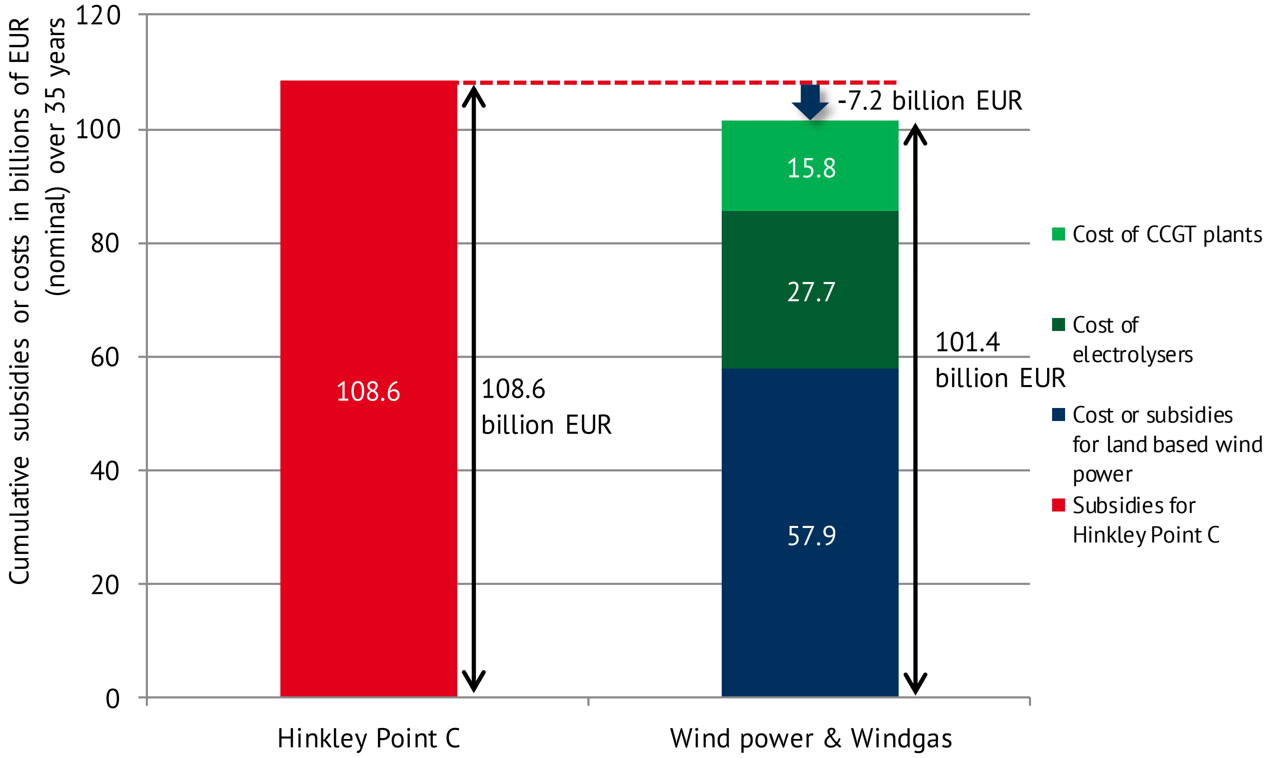

Illustration 3: Cost comparison between Hinkley Point C and the renewable alternative with wind power and windgas

The cost of the wind power and windgas alternative amounts to EUR 101.4 billion; this figure is EUR 7.2 billion lower than the subsidy cost of EUR 108.6 billion[2] that would accrue during the 35 years following the start of operations at Hinkley Point C in 2023.

The cost calculation for the wind power and windgas alternative includes the construction and operation of all wind turbines as well as all electrolysers and CCGT (combined cycle) power plants.

[2] Energy Brainpool (2015b).

If we also take into consideration that Hinkley Point C will not begin operating in 2023 but later due to delays in construction, we can assume that cost savings from using the windgas alternative will be even greater due to improved efficiency and lower costs in windgas technology, and possibly due to gas-fired power plants becoming less expensive. Operations are currently expected to begin in 2025 and not in 2017 as originally planned.[3]

In assessing these results, we must also take into account that the two variants in this study were compared with each other in ideal and typical settings (same volume of power production, same power production structure). In the renewable alternative, the installed capacity of gas-fired power plants is therefore calculated in dimensions large enough to ensure that these plants produce as much electricity as Hinkley Point C would even during a complete lull in wind. If there is wind supply, the gas-fired power plants are not used in the direct comparison with Hinkley Point C. If these plants are nevertheless kept in operation, additional revenue from their power generation would contribute further to the cost advantages of the renewable alternative.

In a real situation, each technology would be integrated into the UK's overall electricity market. This would allow electricity surpluses and shortages, already taken into account in the windgas alternative, to be balanced more efficiently with other flexible options throughout the entire power market, thereby further reducing the cost of the renewable alternative.

With the help of windgas, the wind power and windgas alternative is able to generate the same amount of electricity at the same level of availability as Hinkley Point C would, even if wind power were not available. In addition to windgas facilities, there are other technical flexibility options for balancing wind power such as photovoltaic facilities, hydropower plants, highly efficient cogeneration (CHP) plants, storage batteries, pumped storage hydropower plants, and shifts in demand or consumption. Although these options generally have a lower balancing effect than windgas does, they can be utilised more efficiently and cheaply in most cases. As an alternative to Hinkley Point C, a renewable energy system that makes use of flexibility options therefore has further cost-cutting potential.

[3] The Guardian (2015).

METHODOLOGY

Basic principles

- To guarantee the UK's future supply of electricity, the British government is planning the new build of a nuclear power plant (NPP) at the site of the already existing Hinkley Point NPP. Construction of this plant is to be subsidised with State Aid reflecting the strike price of EUR 120.30_{2012}/MWh. This adds up to a total subsidy volume of EUR 55.18 billion_{2012} over the subsidy's 35-year period of validity. Taking into consideration the figure used for the subsidy calculation, an annual inflation rate of 2.43 percent[4], the total subsidy costs amount to EUR 108.6 billion (nominal).

- Accordingly, Hinkley Point C will generate electricity steadily except during annual periods of maintenance (presumably in September each year). This is due mainly to its high level of subsidisation, which is based on the volume of electricity it feeds into the grid. For this reason, Hinkley Point C will tend to force other power plants out of the market rather than shut itself down and relinquish these subsidies.

- Modelling was done with the Power2Sim energy market model software based on hourly simulation.[5]

Power-to-gas

- Because the processes of electrolysis and methanation as well as the reconversion of windgas to electricity in combined-cycle gas turbine (CCGT) power plants have losses, there must be correspondingly more surplus electricity available to compensate for these shortages. Surplus electricity constitutes the amount of wind power that is generated above the 3.2-gigawatt level foreseen for Hinkley Point C. Shortages constitute the amount of wind power that is lacking below this 3.2-gigawatt level. Calculations for the power production of wind turbines are based on wind data for the UK published on the ELEXON portal.

  The efficiency factor for electrolysis and methanation was calculated together at 71 percent and for CCGT power plants at 60 percent, with the resulting formula:[6]

  $$\text{Surplus energy} \times 60\,\% \times 71\,\% = \text{shortage}$$

  Therefore, when conversion losses are taken into account, 33.3 TWh of wind power must be generated each year.
  Assuming that sufficient gas storage capacity is available, the combination of wind power and windgas technologies can provide the same power output as Hinkley Point C at any time.

---

[4] European Commission (2014).
[5] Energy Brainpool (2015c).
[6] Energy Brainpool (2015d).

BASIC ASSUMPTIONS

	HINKLEY POINT C	LAND-BASED WIND POWER	CCGT PLANTS	WINDGAS FACILITIES
Installed capacity in GW	3.2	11.2	3.2	8
Power production per year in TWh	25.7	33.3	5.7	13.3
Annual full-load hours	8,040	2,700	1,773	1,288
Level of subsidies (based on real 2012 figures) in EUR/MWh	120.3	74.4		
Costs (based on real 2014 figures) in EUR/kW			803[7]	850[8]
Average annualized cost (nominal) EUR/kW			69.5	82.5
Subsidy period in years	35	15		
Lifetime in years	60	25	22,5	20
Inflation rate in %	0.02	0.02	0.02	0.02

- These **basic assumptions** were used for calculations in this study[8].
- **Subsidy for Hinkley Point C**: GBP 92.5/MWh.

  Hinkley Point C (HPC) will be subsidised by the same CfD mechanism used for wind turbines. However, in contrast to wind turbine subsidies, the strike price for HPC subsidies will remain constant at GBP 92.5/MWh and also be adjusted for inflation. This means that Hinkley Point C will always receive the difference between the market price for electricity and the strike price. The subsidy costs for HPC have been calculated using this principle (strike price minus the market price for power).[9]
- **Subsidy for wind turbines**: The CfD strike price at the last auction (GBP 79.23/MW[10]) formed the basis of calculations for 2023 and 2048, using the quarterly degression rate (0.04 percent) laid out in Germany's Renewable Energies Act (EEG). This resulted in a new average subsidy price of EUR 74.41 /MWh.

  This approach proved to be the most likely regarding the cost calculation of wind turbines in the UK. The Contract for Difference (CfD) mechanism is meant to replace the current subsidy mechanism for wind power in the UK by 2018[11]. The first CfD auction was held in January 2015. Subsidy prices for the years from 2023 to 2058 were

[7] Own research (various sources).
[8] Energy Brainpool (2015d).
[9] Energy Brainpool (2015b).
[10] UK Department of Energy & Climate Change (2015).
[11] UK Department of Energy & Climate Change (2013a).

determined on the basis of this price multiplied by the EEG degression. The inflation rate of 2.43 percent was used in these calculations as well.

- The **duration of CfD subsidisation for wind turbines** is 15 years[12], after which time the turbines continue to operate for 10 years without funding.

  Subsidisation with the CfD mechanism provides a funding period of 15 years. Considering that the average life span of a land-based wind turbine is 25 years, a period of 10 years remains during which the turbine is not subsidised.

- The **electricity prices used for the revenue accounting** of Hinkley Point C and of wind turbines were determined on a precise hourly basis with the Power2Sim energy market simulation programme.

  The method used for the revenue accounting of wind turbines was the same as for Hinkley Point C since both technologies are subsidised through the CfD mechanism. Calculations took into account that wind turbines usually generate lower revenue than base-load power plants do because at times of high wind power feed-in, prices fall due to the merit order principle.

- **Wind data** for the UK was based on information posted on the ELEXON portal[13].

  The ELEXON portal posts wind data for the UK; this information was used to extrapolate the amount of installed wind turbine capacity needed (11.2 GW) for the renewable alternative.

- **Wind power generation** per year is 33.28 TWh.

  This sum is the outcome of a cost-optimised quantitative balance calculation based on the assumption that enough surplus electricity or windgas is provided at any time to sustain power output at 3.2 GW.

- **Shortages** are balanced during the entire period by means of electrolysis and methanation processes that consume surplus electricity and generate windgas which is later reconverted to electricity in combined-cycle gas turbine (CCGT) power plants. Taking conversion losses into account, 33.28 TWh of wind power must be generated each year. In comparison, the annual power production of Hinkley Point C is 25.7 TWh.

- It was assumed that the **efficiency factor** for converting electricity to methane was 71 percent on average (64 percent in 2023, up to 78 percent by 2043)[14].

  These figures, together with the efficiency factor for the CCGT plants (60 percent), formed the basis for calculating the quantitative balance because surplus electricity, multiplied by the efficiency factors, must equal the shortages.

- The **inflation rate** was taken from the information provided by the European Commission regarding the subsidisation of Hinkley Point C.

[12] UK Department of Energy & Climate Change (2013b).
[13] ELEXON website (2015).
[14] Energy Brainpool (2015d).

SOURCES

- Department of Energy & Climate Change (2013a): Electricity Market Reform Delivery Plan, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/268221/181213_2013_EMR_Delivery_Plan_FINAL.pdf, on 23 October 2015
- Department of Energy and Climate Change (2013b): Annex B: Strike Price Methodology, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/267610/Annex_B_-_Strike_Price_Methodology.pdf, on 20 October 2015
- Department of Energy & Climate Change (2015): CFD Auction Allocation Round One, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/407465/Breakdown_information_on_CFD_auctions.pdf, on 10 December 2015
- ELEXON Portal (2015): Wind Data for Great Britain, https://downloads.elexonportal.co.uk/file/download/LATESTFUELHHFILE?key=w81h6d6oi7bpala, on 23 October 2015
- Energy Brainpool (2015a): Auswirkungen von Hinkley Point C auf den deutschen Strommarkt [The Effect of Hinkley Point C on Germany's Electricity Market], http://www.greenpeaceenergy.de/fileadmin/docs/pressematerial/Hinkley_Point/Studie_EnergyBrainpool_Hinkley.pdf, on 25 October 2015
- Energy Brainpool (2015b): Kurzanalyse, Höhe der Staatlichen Förderung von HPC [A Brief Analysis: The Volume of State Aid for HPC], https://www.greenpeace.de/sites/www.greenpeace.de/files/publications/20150609_greenpeaceenergy_kurzanalyse-hinkleypoint.pdf, on 26 October 2015
- Energy Brainpool (2015c): Fundamentalmodell Power2Sim [Fundamental Model Power2Sim], http://www.energybrainpool.com/analyse/fundamentalmodell-power2sim.html., on 20 October 2015
- Energy Brainpool (2015d): Bedeutung und Notwendigkeit von Windgas für die Energiewende in Deutschland [Significant and Needed: Windgas in Germany's Energy Transition], http://www.energybrainpool.com/fileadmin/download/Studien/2015_08_EBP_GPE_Windgas-Studie.pdf, on 23 October 2015
- European Commission (2014): Official Journal of the European Union, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2014:069:0060:0098:EN:PDF, on 20 October 2015
- The Guardian (2015): Work to Begin on Hinkley Point Reactor within Weeks after China Deal Signed, http://www.theguardian.com/environment/2015/oct/21/hinkley-point-reactor-costs-rise-by-2bn-as-deal-confirmed, on 14 December 2015

ABOUT ENERGY BRAINPOOL

Energy Brainpool is an independent market specialist for the energy sector that focuses on electricity and energy trading in Europe. Our expertise encompasses the analysis, forecasting and simulation of electricity prices, individual consulting, the preparation of studies, and expert training in the energy sector. We combine knowledge and reliability with practical experience in conventional and renewable energy systems.

Energy Brainpool
Brandenburgische Str. 86/87
10713 Berlin, Germany
Tel.: +49 / (0)30 / 767654-10
Fax: + 49 / (0)30 / 767654-20
www.energybrainpool.com

Project Management:
Thorsten Lenck
Senior Manager
Tel.: +49 / (0)30 / 767654-10
Email: thorsten.lenck@energybrainpool.com