



WIND POWER SYSTEM

For a village in North Wales

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Abstract

This project assesses the feasibility of supplying a Welsh village with electricity using a small-scale off-grid wind energy system. The village consumes 1,081,571.65 kWh annually, costing £2.27 million over 10 years via the National Grid at 2021 prices. Due to an average wind speed of 5.84 m/s, wind turbines outperform solar for consistent year-round generation. Two LTW42 250 kW turbines were selected, generating 1.31 GWh annually, with surplus stored in a 696 kWh lithium-ion battery system. The total system cost—including turbines, switchgear, protection, battery storage, and 10 years of maintenance—is £1.51 million. With a £53 monthly household fee, the investment is recoverable within 10 years, reducing long-term electricity costs and greenhouse gas emissions, offering a sustainable, cost-effective solution.

Table of Contents

Abstract.....	1
Lisf of figures.....	3
Introduction.....	4
Wind energy power system	5
1. The cost of the electricity supply by the National Grid Electric Power for a period of 10 years	5
2. Why Wind Energy Power System?	6
3. The design of the wind power system.....	7
4. The cost of the small off-grid wind system	15
5. Monthly fee.....	16
6. Comparison of the cost of electricity tariff generated by National Grid Power the wind power system	17
7. Environmental impact	17
8. Conclusion	18
Appendix 1.....	22
Appendix 2.....	24

Lisf of figures

Figure 1. Shows the increase of electricity price over 12 years with the greatest peak in 2022	5
Figure 2 Showing the Hummer H25.0-200kW wind turbine	8
Figure 3 Shows the Leitwind LTW42 250kW wind turbine	9
Figure 4 Shows the average wind speeds in Bethesda, Wales	11
Figure 5 The diagram showing the parts of low voltage switchgear	13
Figure 6 Showing daily wind fluctuation periods	14
Figure 7 Shows the power curve	Error! Bookmark not defined.
Figure 8 Shows the power curve	26

Introduction

The objective of this project is to design and evaluate an off-grid wind energy power system capable of supplying a rural village with a total annual electrical energy demand of 1,081,571.65 kWh and an average daily demand of 2,963.21 kWh. The existing solution—electricity supplied by the National Grid—presents a long-term economic constraint, with projected costs of approximately £2.27 million over a 10-year period based on 2021 tariff rates.

To meet this demand sustainably, a wind energy power system a great option. Unlike solar power, which is heavily affected by seasonal changes and limited daylight during winter months, wind energy is more reliable in regions like Wales, which experiences consistently strong winds. Modern wind turbines have improved efficiency and output, allowing fewer turbines to generate sufficient energy, reducing long-term costs and maintenance requirements.

The report includes an assessment of village energy consumption, a wind viability survey, selection and performance analysis of appropriate wind turbine models, and calculation of energy production. The system design incorporates wind turbines, low-voltage switchgear, protection systems, and battery energy storage to manage supply variability. A detailed economic analysis compares the capital, maintenance, and operational costs of the proposed wind power system with National Grid electricity tariffs over a 10-year period. Environmental impacts and long-term sustainability considerations are also evaluated to determine the overall feasibility of the proposed solution.

Wind energy power system

1. The cost of the electricity supply by the National Grid Electric Power for a period of 10 years

Annual average electricity bill in the UK in 2021 was £769¹. This is because the average UK household consumption of electrical energy is 3600kWh. With the help of this information, I have calculated that the 1 kWh of electrical energy in the UK in 2021 costed £0.21 (21pence).

The chart² below shows the increase of electricity price over 12 years with the greatest peak in 2022.

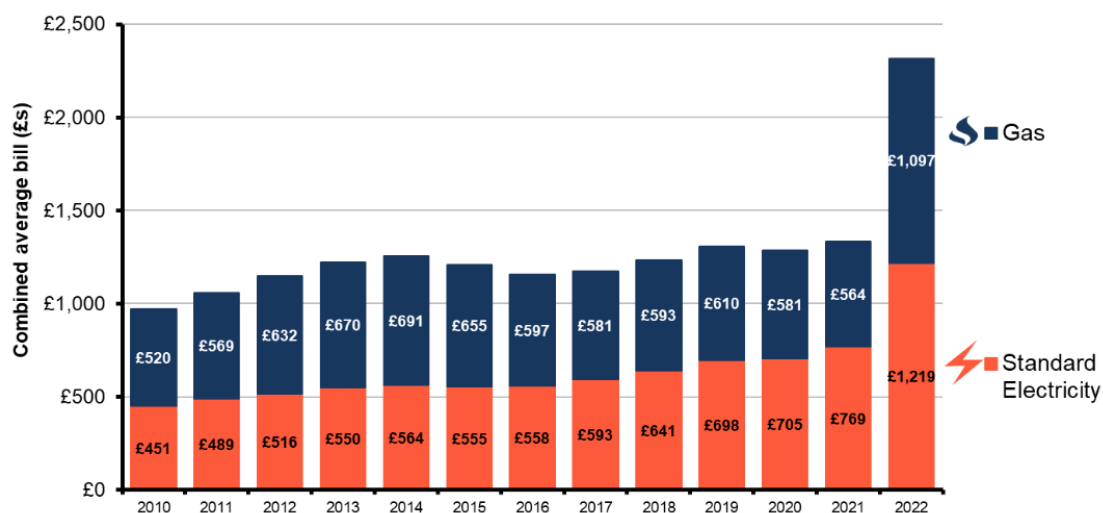


Figure 1. Shows the increase of electricity price over 12 years with the greatest peak in 2022.

Knowing the price of electricity in 2021 and knowing that the annual energy demand of the village is 1081571.65 kWh I can calculate the cost of the electricity supply by the National Grid Electric Power for a period of a decade.

$$1\,081\,571.65 \times 0.21 \times 10 = 2\,271\,300.5$$

¹ Department for Business, Energy & Industrial Strategy, Quarterly Energy Prices: UK July to September 2022 and estimates for 2022, pg 5, (20.01.2026)

² Department for Business, Energy & Industrial Strategy, Quarterly Energy Prices: UK July to September 2022 and estimates for 2022, pg 5, (20.01.2026)

The cost of the electricity supply by the National Grid Electric Power for a period of 10 years is £2 271 300.5.

2. Why Wind Energy Power System?

To cover the electricity demand of the village, I have chosen to use wind turbines as opposite to solar panels. Solar power generation is greatly impacted by the weather and geographic location, and to generate electricity efficiently, solar panels need a large surface area. They should also be placed in locations where sufficient sunlight can make power generation effective. The winters bring short daylight, many clouds and rain which is not a great environment for solar power generation, however the same weather can bring strong winds which is more optimal for wind turbine power generation.

Although, the initial cost of wind power system can be greater than solar power system, in the long run the cost effective, particularly if the power generation exceeds the demand – it can turn into profit. Modern generations of wind turbines can generate over 375% more electricity than the ones built two decades ago. “Wind customers can potentially get more energy with fewer turbines, decreasing the upfront cost of installation.”³ This then naturally leads to lower electricity cost over a certain period. The wind is an unlimited source, and Wales is one of the “windier parts of the UK”⁴ it is understandable to use it to generate power.

³ Solar energy vs. wind energy. Pros and cons, (26.01.2026)

⁴ Met Office, Wales: Climate, (05.02.2026)

3. The design of the wind power system

3.1 Wind machines property and number

User	Number of users	Daily energy consumption per 1 user (kWh)	Daily energy consumption per number of users (kWh)	Annual energy consumption (kWh)	10 yearly energy consumption (kWh)
Cottage	120	12	1440	525600	5256000
Primary school	1	130	130	47450	474500
Health clinic	1	220	220	80300	803000
Library	1	150	150	54750	547500
Community centre	1	180	180	65700	657000
Place of worship	1	10.71	10.71	3909.15	39091.5
Local shop	4	180	720	262800	2628000
Street and traffic light	45	2.5	112.5	41062.5	410625
Total:	174	885.21	2963.21	1081571.65	10815716.5

	Daily consumption per 1 user	Daily consumption per number of users	Annual consumption	10 yearly consumption
Power (kW)	36.88	123.47	45065.49	450654.85

The values from the table are important as they give an insight of how much electrical energy and power is the village using per day, per year and per decade. These are a valuable information to help to determine what power system would be most suitable to cover the power demand of the village.

The electrical energy demand of the village is 1081571.5 kWh. To determine the number of wind turbines needed to cover the demand, I will consider the 200kW and 250kW wind turbines.

a) Hummer H25.0-200KW



Figure 2 Shows the Hummer H25.0-200kW wind turbine.

According to the power curve⁵, electrical power generated at 5m/s is 25kW and 35kW at the speed of 6m/s. To determine the power output at 5.84m/s I have considered $P \propto v^n$.

$$\left(\frac{34}{25}\right) = \left(\frac{6}{5}\right)^n$$

$$n = \frac{\ln\left(\frac{34}{25}\right)}{\ln\left(\frac{6}{5}\right)} = 1.686$$

$$P = 25 * \left(\frac{5.84}{5}\right)^{1.686}$$

$$P = 32.48 \text{ kW}$$

At the wind speed of 5.84m/s this wind turbine will generate **32.48 kW**.

Using the formula $E_{\text{Turbine}} = 32.48 * 24 * 365 = \mathbf{284542.8 \text{ kWh}}$ helps to determine how many turbines are needed for this project. So therefore, as the annual electrical power demand of the

⁵ Appendix 1

village is **1081571.65 kWh**, then, the number of wind turbines needed can be calculated by the formula: $\frac{\text{annual energy demand of the village}}{\text{annual output power of the turbine}}$.

$$= \frac{1081571.65}{284542.8} = 3.80$$

To cover the energy demand of the village, **four Hummer H25.0-200kW** wind turbines would be needed, and they would generate **1138099.2 kWh**, which exceeds the demand by 56577.55 kWh.

b) Leitwind LTW42 250kW



Figure 3 Shows the Leitwind LTW42 250kW wind turbine

The data from the table and the power curve⁶ helped me to determine how much electrical power can this wind turbine produce at the wind speed of 5.84m/s. Considering that the wind speed of 5m/s, this wind turbine produces 47kW, and 81kW at the 6m/s. So, to determine how

⁶ Appendix 2

much electrical power the wind turbine produces at 5.84m/s, I have considered the following:

$P \propto v^n$.

$$\frac{81}{47} = \left(\frac{6}{5}\right)^n$$

$$n = \frac{\ln\left(\frac{81}{47}\right)}{\ln\left(\frac{6}{5}\right)} = 2.985$$

$$P = 47 * \left(\frac{5.84}{5}\right)^{2.985}$$

$$P = 74.72 \text{ kW}$$

At the wind speed of 5.84m/s this wind turbine will generate **74.72 kW**.

Using the formula $E_{\text{Turbine}} = 74.72 * 24 * 365 = \mathbf{654547.2 \text{ kWh}}$ helps to determine how many turbines are needed for this project. So therefore, as the annual electrical power demand of the village is **1081571.65 kWh**, then, the number of wind turbines needed can be calculated by the formula: $\frac{\text{annual energy demand of the village}}{\text{annual output power of the turbine}}$.

$$= \frac{1081571.65}{654547.2} = 1.65$$

To cover the energy demand of the village, **two LTW42 250kW** wind turbines would be needed, and they would generate **1309094.4 kWh**, which exceeds the demand by 227522.75 kWh.

3.2 Wind viability survey

Wind viability survey essential to be able to predict the wind turbine energy production and select appropriate turbine models. Energy production estimates forecast the amount of electricity a wind turbine can generate over a specific period. “It’s important to account for factors such as downtime for maintenance and grid connection limitations when making estimates. Regularly updating these estimates with real operational data can improve accuracy.”⁷

⁷ <https://vals-ikev.com/wind-energy-potential-site-assessment-tools-and-metrics/>

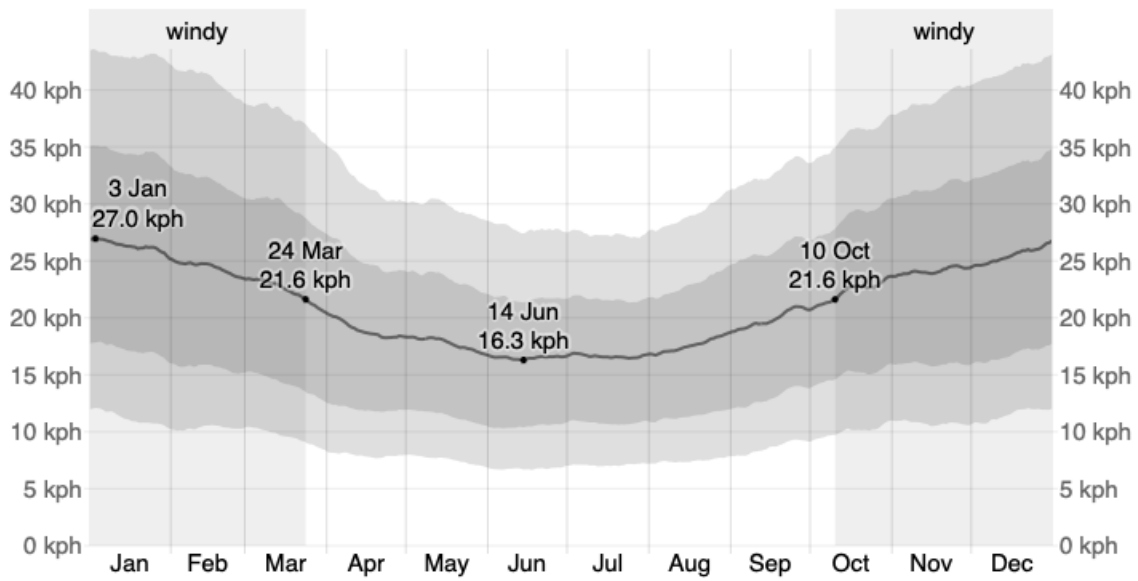


Figure 4 Shows the average wind speeds in Bethesda, Wales

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind speed (km/h)	26.3	24.4	22.2	18.9	17.7	16.5	16.6	17.7	20	22.4	24.1	25.6

The table below shows the average monthly wind speed (km/h) in Bethesda, Wales.

The average wind speed = 21.03 km/h. To convert this value into m/s I have considered:

$$\frac{\text{average wind speed in km/h}}{3600} = \frac{21.033}{3600} = \mathbf{5.84m/s}.$$

The average wind speed of 5.84m/s is crucial to determine what and how many wind turbines are needed for this project.

3.3 Turbine

Although both turbines I have considered have the same (2.5 m/s) cut in speeds and Hummer H25.0-200kW generates more energy at lower speeds. However, at the annual average wind speed of 5.84 m/s, LTW42 250kW performs significantly better. For this project, therefore, I

will use two LTW42 250kW wind turbines. It is because they generate more electrical energy than the other turbine I have considered. Two turbines also mean better efficiency, lower maintenance cost (there are less components maintain or fail), lower project costs, and better land utilisation (two bigger wind turbines require less space than four small ones).

3.4 Converter

The LTW42 250kW wind turbine that I have chosen for this project already have a converter implemented. It is a 4Q full power - 3 phase IGBT, as per datasheet. This means that the output is not 'raw' variable AC – it has already been converted via back-to-back IGBT converter.

The 4-quadrant drive means that the motor can operate in all 4 quadrants of the speed-torque plane. It can operate in forward and reverse motion as well as monitor and perform regenerative braking. These inverters convert the fluctuating DC power generated by wind turbines into AC power. "These frequency converters are able to manage reactive power, in accordance with the power grid, and can also support weak or unstable grids."⁸

3.5 Low Voltage Switchgear

Low voltage switchgear are the electrical components and devices designed to isolate, protect and regulate electrical circuits in systems operating at voltages up to 1000V. It consists of circuit breakers, fuses, contactors, and control devices which are essential for safe and efficient electricity distribution and management.

I have the following: 250 kW wind turbines with the output of 690V each, 3-phase. As per the datasheet, the reactive capability: 0.95 ind – 1 – 0.95 cap.

Considering the power factor of 0.95, I can calculate the apparent power (per wind turbine):

$$S = \frac{P}{PF} = \frac{250}{0.95} \approx \mathbf{263 \text{ kVA}}$$

The reactive power for per turbine is:

$$Q = P * \tan(\cos^{-1}(0.95)) = 250 * \tan(\cos^{-1}(0.95)) \approx \mathbf{82 \text{ kVAr}}$$

With this information, I can calculate the current:

⁸ Leitwind, Technology, (04.02.2026)

$$I = \frac{250000}{\sqrt{3} * 690 * 0.95} = \mathbf{220A}$$

Knowing this, the switchgear and protection devices must be rated accordingly: ~263 kVA at 690 V, ≥ 220 A continuous, and appropriate short-circuit levels.

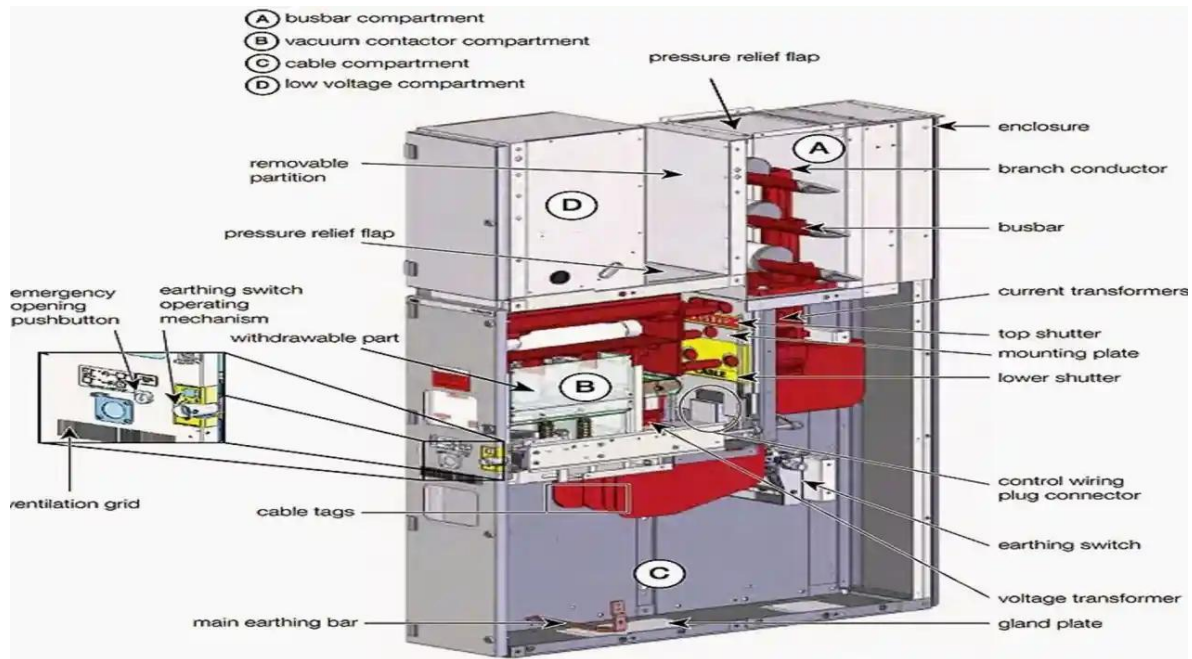


Figure 5 The diagram showing the parts of low voltage switchgear.

The ABB catalogue⁹ of low voltage product has a full range of wind turbine low voltage switchgear components. The switchgear is usually custom made, however, as a guiding price I will consider that the price of the complete switchgear per wind turbine is **£30 000**.

3.6 Battery property and number

Excess energy (annually): 227522.75kWh (623.35kWh daily).

Daily energy demand of the village: 2963.21kWh

The electrical energy that exceeds the demand can be stored and then used as needed. The stored energy is mostly going to be used on daily wind fluctuations periods.

⁹ ABB, ABB in wind industry Low voltage products portfolio, (04.02.2026)

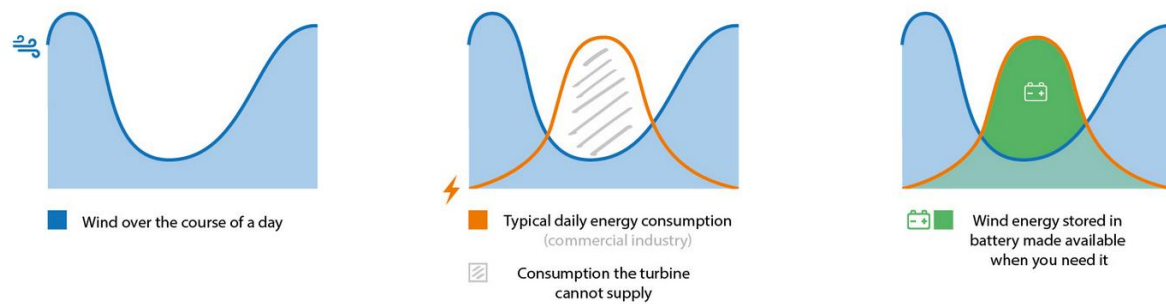


Figure 6 Showing daily wind fluctuation periods (Ampowr, Battery Energy Storage Systems for Wind Turbines, (04.02.2026), <https://ampowr.com/energy-storage-systems-wind-turbines/>)

$$\text{Battery power} = \frac{2963.21}{24} = 123.47\text{kW}$$

To determine the capacity of the battery, I will consider:

For 6 hours: $123.47 \times 6 \approx 740\text{kWh}$

For 8 hours: $123.47 \times 8 \approx 988\text{kWh}$

Since daily excess energy is 623.35kWh, I will consider the battery storage of up to 800kWh. Choosing a larger capacity battery (e.g. 1000kWh) would be a waste of resources as it mostly would not be fully used. I will use Lithium-ion Battery Energy Storage System (BESS). More accurately, it is AMPWR's Ampitowertm (AT-HVLC-100/232) liquid cooled battery storage system. As per the datasheet¹⁰, this battery system has the nominal capacity of 232kWh and a nominal power output of up to 232kW. This project requires three AT-HVLC-100/232 battery storage units which then equals to the storage capacity of 696kWh (daily energy demand is 623.35kWh).

The price of the battery storage system varies from the manufacturers, capacity and type. However, as a guide on the pricing I will refer to the “£200-£450 per kWh for a commercial setup”¹¹, but rather consider £300/kWh as a price. Therefore, BESS for this project will approximately cost £210 000.

¹⁰Ampowr, Ampitowertm datasheet, (04.02.20260)

¹¹ Heatable, Commercial Battery Storage in the UK: Costs, Installation & Payback Periods, (04.02.2026).

3.7 Protection devices and settings

The wind turbine protection are devices that lightning and surge protection¹².

The table below shows the essential components of wind turbine protection system/settings.

There are no concrete prices online for a full system, so I will assume that the price for protection devices and settings is £15 000.

Therefore, for two turbines, it is £30 000.

Category	Device
Generator protection	Overcurrent, earth-fault, temperature sensors, negative sequence
Converter protection	IGBT overcurrent, DC-link, under/overvoltage, short-circuit, thermal protection
Grid protection	Under/over voltage and frequency relays, earth-fault, loss of mains
Lightning and surge protection	Blade receptors, surge arresters, grounding system
Mechanical safety protection	Mechanical brake, overspeed sensors, vibration sensors, pitch system
Control and emergency protection	Emergency stop circuits, safety relays, SCADA shutdown and PLC protection logic

4. The cost of the small off-grid wind system

4.1 Capital cost of the hardware of the system

“Onshore wind turbines intended for wind farms typically cost roughly €1 to €1.5 million per megawatt (MW) of capacity. For instance, wind turbine manufacturer Vestas reported an

¹²Dehn, Lightning Protection Solutions for Wind Turbines, (0502.2026)

average selling price of about €1.21 million per MW in 2024.”¹³ When converted to GBP (£1 053 002.50), and divided by 4, ≈£263 651. For two turbines the price would be **£526 502**.

Low voltage switchgear and protection devices for two wind turbines is priced to £90 000, and the battery storage system is priced to **£210 000**.

4.2 Maintenance cost

Assuming that the cost of the spare components of the wind system per year is 3% (turbine, switchgear, protection parts and battery storage system), the cost comes to £28 000 per year.

The two part-time wind turbine technicians cost on average £21/hour¹⁴, and if they work 20 hours/week it comes to approximately £1680/per month. Therefore, annually the two technicians would cost £40 320.

Annually, the maintenance would cost £68 320.

For a 10 years period, maintenance cost is £683 200.

The initial cost of the turbines, switchgear, protection devices and battery storage system with the 10 yearly maintenance cost comes up to **£1 509 702**.

5. Monthly fee

Considering the price of electrical energy to be £0.21¹⁵ (as at the end of 2021).

Therefore, 10 years of village’s electricity demand (10.8157165 GWh) costs **£2 271 300**, and the 10-yearly wind power system costs **£1 509 702**. The difference of £761 598 needs to be covered by a fee that each cottage will pay for 10 years.

The amount of monthly fee is determined by: $\frac{761\,598}{120 \times 12 \times 10} = 52.88 \approx \textbf{£53}$

¹³ Delfos, Cost of Wind Energy in Europe: Investment and Financial Returns, (04.02.2026)

¹⁴ Glassdoor, RWE Wind Turbine Technician Hourly Pay, (04.02.2026)

¹⁵ Energy Switching, UK Electricity Prices per kWh 2021, (21.01.2026)

Assuming no interest on the initial cost, with the fee, the project will be paid off in 10 years.

6. Comparison of the cost of electricity tariff generated by National Grid Power the wind power system

Assuming the electricity tariff price in 2021 National Grid's Power (delivered by suppliers) per kWh is £ 0.21. Considering that the 1 cottage uses 4 380kWh of electrical energy¹⁶ the, the National Grid (suppliers) would charge £919.8 per year (£76.76/month),

The wind power system is paid off after 10 years. So, from now on, to keep it going only the maintenance cost needs to be covered, which annually costs £68 320. The monthly fee per each cottage would, therefore, cost £47.44/month. Comparing the two fees, after being paid off, the wind power system would be more cost effective for the households in the village.

7. Environmental impact

Construction disrupts habitats, with foundations and roads risking groundwater pollution, soil erosion, and sediment changes in coastal areas. Wildlife faces collision risks for birds and bats, plus noise and visual disturbance to marine mammals and fish from offshore site.¹⁷ Onshore substations for farms like Mona (107 turbines off Llanddulas/Abergele) threaten agricultural

¹⁶ As per table in Wind machines property and number subtitle.

¹⁷ National Resources Wales, Offshore wind developments, (05.02.2026), <https://naturalresources.wales/guidance-and-advice/business-sectors/marine/offshore-wind-developments/?lang=en>

land loss and rural industrialization in areas like Cefn Meiriadog. Cumulative projects increase construction traffic, waste, and visual impacts near scenic villages.¹⁸

There are some advantages of using wind to generate power:

- a) do not use fossil fuels
- b) do not emit CO₂ or air pollutants¹⁹, therefore reducing greenhouse gas emissions
- c) use unlimited resource (wind)

Outweighing the environmental downsides, the wind power system in an overall perspective makes the village dependant only to the National Grid's infrastructure which often brings problems such as unstable or inadequate power supply. Therefore, generating the power locally, even to cover the demand of a small village can ensure self-sufficiency and lower the energy transmission losses.

8. Conclusion

The village's electricity demand of 1,081,571.65 kWh per year can be met using two LTW42 250 kW wind turbines, with excess energy stored in a battery system to handle daily fluctuations. Over a 10-year period, the wind power system costs approximately £1,509,702, compared to £2,271,300 if supplied by the National Grid, resulting in savings of £761,598. Monthly household fees during the payoff period would be £53, decreasing to £47.44 once the system is fully paid off, making it more cost-effective than conventional electricity.

Environmentally, wind power produces zero greenhouse gas emissions, relies on a renewable resource, and reduces dependence on external grid infrastructure, despite some localized impacts during construction. Overall, the proposed wind energy system offers a technically feasible, economically advantageous, and sustainable solution, ensuring reliable, low-cost, and green electricity for the village.

¹⁸ BBC News, Climate change: Opposing wind farms morally unacceptable, (05.02.2026), <https://www.bbc.co.uk/news/uk-wales-65026300>

¹⁹ Mann+Hummel, The invisible danger: key air pollutants and their impact, (30.01.2026), <https://www.mann-hummel.com/en/leadership/expertise/air-pollutants-types-sources-impact.html>

9. References

In order as they appear in the report:

¹ Department for Business, Energy & Industrial Strategy, Quarterly Energy Prices: UK July to September 2022 and estimates for 2022, pg 5, (20.01.2026),
<https://assets.publishing.service.gov.uk/media/63a2e8c78fa8f53911cfd2c/quarterly-energy-prices-december-2022.pdf>

² Department for Business, Energy & Industrial Strategy, Quarterly Energy Prices: UK July to September 2022 and estimates for 2022, pg 5, (20.01.2026),
<https://assets.publishing.service.gov.uk/media/63a2e8c78fa8f53911cfd2c/quarterly-energy-prices-december-2022.pdf>

³ Solar energy vs. wind energy. Pros and cons, (26.01.2026) <https://pvcase.com/blog/solar-vs-wind-energy-which-is-better>

³ Met Office, Wales: Climate, (05.02.2026),
https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/weather/regional-climates/wales_-_climate-met-office.pdf

⁶ <https://vals-ikev.com/wind-energy-potential-site-assessment-tools-and-metrics/>

⁷ Leitwind, Technology, (04.02.2026), <https://www.leitwind.com/en/technology/>

⁸ ABB, ABB in wind industry Low voltage products portfolio, (04.02.2026),
<https://new.abb.com/docs/default-source/ewea-doc/abb-lp-wind-portfolio-brochure-external-rev140226.pdf?sfvrsn=2>

⁹ Ampowr, Ampitowertm datasheet, (04.02.2026), https://ampowr.com/wp-content/uploads/2025/01/AmpiTOWER-100kW-_232kWh-Liquid-Cooled-Datasheet-1.pdf

¹⁰ Heatable, Commercial Battery Storage in the UK: Costs, Installation & Payback Periods, (04.02.2026), <https://heatable.co.uk/battery-storage/advice/commercial-battery-storage?utm>

¹¹ Dehn, Lightning Protection Solutions for Wind Turbines, (0502.2026), https://www.dehn-international.com/sites/default/files/media/files/DS191_EN_0325.pdf

¹² Delfos, Cost of Wind Energy in Europe: Investment and Financial Returns, (04.02.2026) [https://www.delfos.energy/blog-posts/cost-of-wind-energy-in-europe-investment-and-financial-returns#:~:text=Commercial%2Dscale%20wind%20turbines:%20Utility%2Dscale%20wind%20turbines%20\(the,in%20absolute%20terms%2C%20but%20measured%20per%20kW](https://www.delfos.energy/blog-posts/cost-of-wind-energy-in-europe-investment-and-financial-returns#:~:text=Commercial%2Dscale%20wind%20turbines:%20Utility%2Dscale%20wind%20turbines%20(the,in%20absolute%20terms%2C%20but%20measured%20per%20kW)

¹³ Glassdoor, RWE Wind Turbine Technician Hourly Pay, (04.02.2026), https://www.glassdoor.co.uk/Hourly-Pay/RWE-Wind-Turbine-Technician-Hourly-Pay-E3769_D_KO4%2C27.htm?utm

¹⁴ Energy Switching, UK Electricity Prices per kWh 2021, (21.01.2026), <https://www.energyswitching.co.uk/uk-electricity-prices-per-kwh-2021/?utm>

¹⁶ National Resources Wales, Offshore wind developments, (05.02.2026), <https://naturalresources.wales/guidance-and-advice/business-sectors/marine/offshore-wind-developments/?lang=en>

¹⁷ BBC News, Climate change: Opposing wind farms morally unacceptable, (05.02.2026), <https://www.bbc.co.uk/news/uk-wales-65026300>

¹⁸ Mann+Hummel, The inviible danger: key air pollutants and their impact, (30.01.2026), <https://www.mann-hummel.com/en/leadership/expertise/air-pollutants-types-sources-impact.html>

¹⁹ Hummer H25.0 200kW, (21.01.2026), <https://en.wind-turbine-models.com/turbines/1681-hummer-h25-0->

10. Tables and figures

Figure 1: Department for Business, Energy & Industrial Strategy, Quarterly Energy Prices:

UK July to September 2022 and estimates for 2022, pg 5, (20.01.2026),

<https://assets.publishing.service.gov.uk/media/63a2e8c78fa8f53911cfc2c/quarterly-energy-prices-december-2022.pdf>

Figure 2: https://en.wind-turbine-models.com/getfoto-3Pq5tOvghgP-turbine-hummer_h25.0-200kw-17876.jpg

Figure 3: https://en.wind-turbine-models.com/getfoto-wVz1txd9in2-turbine-leitwind_ltw42-250-wVz1txd9in2.JPG

Figure 4: <https://weatherspark.com/s/36338/0/Average-Spring-Weather-in-Bethesda-United-Kingdom#Figures WindSpeed>

Figure 5: <https://www.linkedin.com/pulse/12kv-630a-25ka-lv-switchgear-panel-introduction-types-khan-fx2wf>

Figure 6: Ampowr, Battery Energy Storage Systems for Wind Turbines, (04.02.2026),

<https://ampowr.com/energy-storage-systems-wind-turbines/>

Figure 7: <https://en.wind-turbine-models.com/turbines/1681-hummer-h25-0-200kw#datasheet>

Figure 8: power curve.

Appendix 1

Hummer H25.0-200KW

The datasheet²⁰:

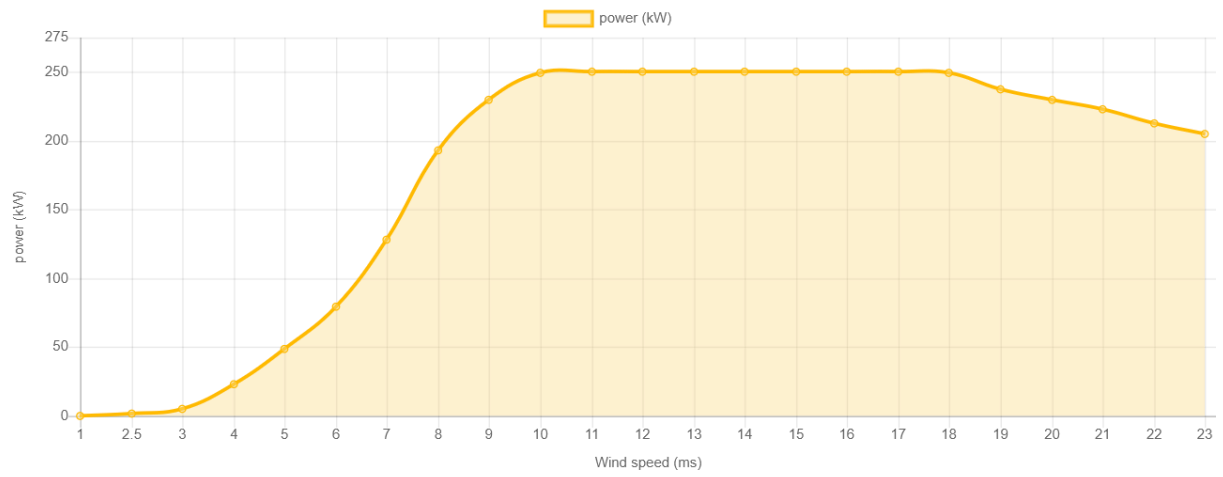
Power	
Rated power	200kW
Cut-in wind speed	2.5 m/s
Rated wind speed	11.5 m/s
Cut-out wind speed	20.0 m/s
Survival wind speed	50.0 m/s

Rotor	
Diameter	25.0 m
Swept area	490.9 m ²
Number of blades	3
Rotor speed, max	50.0 U/min
Tip speed	65 m/s
Type	12m
Power density 1	407.4 W/m ²
Power density 2	2.5 m ² /kW
Material	Fiberglass reinforced composite

Gearbox	
Type	Direct drive

Generator	
Type	Permanent magnet alternator. SCF technology
Number	1
Speed, max	50.0 U/min
Voltage	690V

²⁰ Hummer H25.0 200kW, (21.01.2026)



Appendix 2

Leitwind LTW42 250kW

Datasheet²¹:

Design data	
Rated power	250kW
Cut-in wind speed	2.5 m/s
Cut-out wind speed	20.0 m/s
Survival wind speed	50.0 m/s
Wind class	S
Concept	Direct drive 3-bladed upwind turbine with horizontal axis, variable speed and automatic pitch and yaw regulation

Rotor	
Diameter	42m
Swept area	1416m ²
Rotor speed	29.7rpm
Tip speed	66 m/s
Type	12m
Blade material	GFRP-EP
Power and rotor speed control	Active pitch control

Generator

²¹ I have created the datasheet tables helped by Leitwind, Product portfolio, pg 9, (21.01.2026)

Type	Permanent magnetic direct drive synchronous machine
Stator winding	Modular coils with tooth concentrated winding, exchangeable
Rotor topology	Modular permanent magnets with flux concentration, exchangeable
Cooling	Air cooled rotor, air cooled stator
Speed range	Variable Low speed machine

Power Electronic LeitDrive	
Converter type	4Q full power - 3 phase IGBT
Arrangement	Single LeitDrive converter
Converter rated voltage and frequency (grid-side)	690V $\pm 10\%$ (MV grid connection on demand) 50-60Hz $\pm 5\%$
Converter power factor (grid side)	0.95 ind - 1 - 0.95 cap for reactive power compensation control, grid voltage control capacity
Power quality and Grid codes	High quality output power in accordance with major grid code requirements. Integration into various grid systems worldwide.

LTW42 250kW	
Wind speed (m/s)	Electrical power (kW)
2.5	3
3.0	7
4.0	22
5.0	47
6.0	81
7.0	128
8.0	190
9.0	234
10.0	249
11.0	250
12.0	250
13.0	250
14.0	250
15.0 - 20.0	250

Figure The table shows the data for the wind speed and electrical power output.

From the wind speed and electrical power data, I have created the power curve:

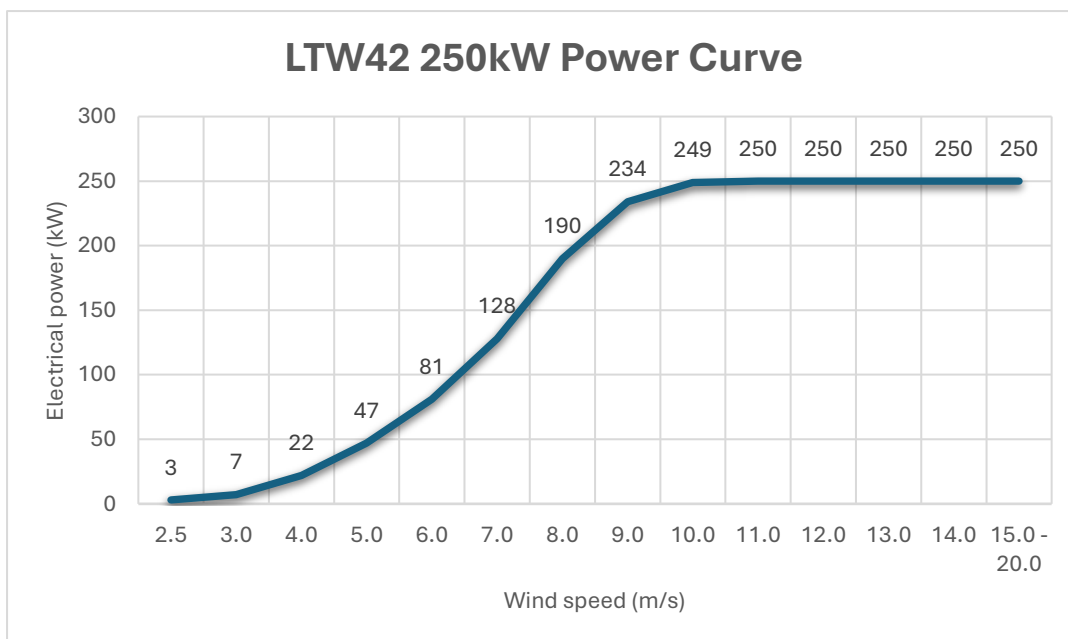


Figure 8 Shows the power curve.