HydroGlyn Renewable Energy Hydrogen Powered Farm

A Non-Technical Summary of the HydroGlyn Project Feasibility Roadmap

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Innovate UK

Sero Net Diwydiant Cymru Net Zero Industry Wales

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Executive summary

Farmers in Wales and across the UK are facing unprecedented pressures on their profit margins. Rising costs for electricity, diesel and heating fuels are pushing many into energy poverty, forcing difficult decisions about day-to-day operations. At the same time, farms must reduce greenhouse gas emissions to meet national, regional and supply-chain climate targets. The most obvious solution — full electrification — is simply not feasible for most farms due to grid constraints, connection delays and high upgrade costs.

A practical alternative is needed, and Water to Water's HydroGlyn project at the Gelli Aur farm offers a viable, future-proof route.

HydroGlyn has provided Water to Water with a first-of-its-kind opportunity to test its renewable microgrid model in a real Welsh farming context. The system is designed to supply a site with more than 100% of its annual energy needs using a fully independent, renewably powered microgrid (Figure 1).

Figure 1: Water to Water Microgrid Solution

Water to Water solutions allow farms to generate and use their own clean energy on site. Solar power and anaerobic digestion meet the Gelli Aur farm's day-to-day electricity and heating needs, while excess energy is stored in batteries or converted into hydrogen. This hydrogen can replace diesel and petrol in vehicles or be converted back into electricity during periods of low generation. Any surplus hydrogen — and fertiliser produced through anaerobic digestion as a solid by-product — can create additional revenue streams for the farm, as can be seen in our hypothetical farmer profile (Appendix I).

This roadmap summarises the feasibility work carried out by Water to Water and Coleg Sir Gâr's Agricultural Research Centre, and a consortium including Thornton Tomasetti, Stopford, MDMC and CamNesa Consulting. The project followed the same process of any rural energy project undertaken by Water to Water:

1. **Assess technology options** to identify the mix of technologies needed to supply 100% of a farm's annual energy demand.

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2. **Assess constrains** to ensure the project can be delivered responsibly and compliantly.
3. **Asses carbon impact and financial returns** to quantify the environmental benefits and evaluate the financial viability.

This process has been simplified and visualised in Appendix II.

The combined analysis shows that a HydroGlyn-style system can dramatically improve energy stability, reduce carbon emissions and strengthen farm profitability. The results for Gelli Aur are shown in Table 1.

Table 1: Comparison of before and after the HydroGlyn development

Item	Before HydroGlyn	After HydroGlyn
Energy bills	Over £100,000 per year, all paid to external suppliers	Free onsite energy and hydrogen; equipment repayments less than previous bills.
Resilience	Dependent on grid failures and rising prices	100% self-reliant for electricity, heating, cooling and transport fuel
Farm profitability	Margins squeezed by rising energy costs	New revenue options while saving money
Carbon emissions	More than 1000 tonnes of CO2e per year	Net-negative emissions

HydroGlyn demonstrates that it is not only possible to supply over 100% of a farm's electricity, heating and transport fuel from on-site renewables — it is also a financially and environmentally viable model for farms across Wales, the UK and beyond. The project provides clear evidence that rural energy independence is achievable today, using proven technologies, while strengthening farm resilience for the decades ahead.

Introduction & Overview

The HydroGlyn project has been supported by Innovate UK and Net Zero Industry Wales to explore how farms across Wales could produce all, or more than all, of their own energy on site. This document provides a clear, easy-to-read overview of the work completed at Coleg Sir Gâr's Gelli Aur farm and sets out a practical roadmap for other farms interested in following a similar path.

Water to Water's core belief is simple: rural communities should have access to affordable, reliable and locally-produced clean energy. For many farms, rising energy prices and grid limitations make it increasingly difficult to run daily operations. At the same time, farming is expected to reduce its greenhouse gas emissions. HydroGlyn was designed to show how a farm can meet both challenges by producing its own clean electricity, heating and transport fuel from resources already available on site.

The work was carried out by Water to Water in partnership with Coleg Sir Gâr and a specialist team including Thornton Tomasetti, Stopford, MDMC and CamNesa Consulting.

The aim of this roadmap is not only to report on the findings from Gelli Aur, but to provide farmers across Wales with a realistic, non-technical guide to what is involved in building an on-farm microgrid. While every farm is

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different, many of the lessons from HydroGlyn — especially around energy modelling, planning and technology choices — are widely applicable across the sector.

HydroGlyn ultimately demonstrates that Welsh farms have the resources, space and day-to-day energy demand profiles that make energy independence possible. With the right combination of solar power, anaerobic digestion, hydrogen storage, batteries and other renewable technologies, farms can generate all the heat, power and transport fuel they need while reducing carbon emissions and improving long-term financial resilience.

Overall concept

The HydroGlyn-Wales project was created to show how a working Welsh farm can move from rising energy bills and fuel uncertainty to becoming a fully self-reliant producer of clean, affordable energy. By building a small on-farm microgrid powered by solar, anaerobic digestion, hydrogen production and batteries, HydroGlyn demonstrates that farms can generate all the electricity, heat and transport fuel they need on site.

The purpose of the project is simple: to give farmers a way to break free from unstable energy prices and unreliable grid infrastructure. Many rural areas face long delays, expensive upgrades or limited capacity when trying to electrify buildings or machinery. HydroGlyn takes a different approach — instead of relying on the grid, the farm becomes its own power station, using its existing resources such as sunlight, slurry, roof space and daily operations to generate clean energy year-round.

This model matters for Wales because farming communities have a crucial role to play in both rural resilience and climate action. Agriculture currently contributes around 12% of Welsh greenhouse gas emissions, and farmers are under growing pressure from government, supply chains and consumers to reduce their environmental impact. HydroGlyn offers a practical, farm-led solution by showing that energy independence and emission reduction can happen at the same time — and in a way that strengthens long-term farm profitability.

By developing this roadmap, the project team has created a clear, real-world guide to how on-farm microgrids can be planned, assessed and delivered. Although the work was carried out at Gelli Aur, the same principles apply widely across Welsh agriculture. Many farms have similar energy profiles, similar renewable resources and similar challenges — meaning the HydroGlyn approach can be replicated across the region, offering farmers a viable path to lower costs, lower emissions and greater control over their future.

HydroGlyn system model

The HydroGlyn farm (Gelli Aur) has energy demands from farm activities and an on-site college campus. The farm is predominantly dairy with 500 milking cows, as well as smaller herds of beef cows. Electricity use is dominated by the farm, and dairy operations makes up a large part of this – particularly through vacuum milk pumping, milk cooling and water heating. As well as electricity for heating on the farm, the college uses LPG for space heating and cooking, and red diesel for farm vehicles.

For HydroGlyn, technologies considered included panels, wind turbines, ground source heat pumps, air source heat pumps, hydroelectricity, combined heat and power (CHP), micro anaerobic digestion. For further detail on the listed technologies see this helpful article from our friends at Farm Carbon Toolkit. It is worth noting that AD systems can be utilised to produce baseline energy for farms as well as fertiliser for farm use.

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Energy storage technologies incorporated include battery energy storage systems (BESS) and hydrogen. BESS systems are utilised for short term energy storage to balance the system's capacity during day-to-day operations. Whereas hydrogen can provide fuel and long-term energy storage for the farm.

Hydrogen storage is a critical form of long-term storage for these projects - if electricity can be described as a river, hydrogen can be described as a reservoir. Electricity can be stored in battery systems for short-term storage to keep the microgrid performance optimised, whereas hydrogen can be used for longer form storage similar to a reservoir utilised only when there is a limited supply of energy. Hydrogen can also be used as a fuel source for agricultural vehicles.

To offset this energy demand requires renewable energy production systems which can complement each other. There is a high area of roof space available and large quantities of slurry produced from livestock, so a combination of solar panels, and a micro anaerobic digestion (AD) feeding a combined heat and power (CHP) unit was the preferred option. Because slurry is collected in greater quantities in winter, electricity and heat produced by the CHP units can offset the drop in solar energy production. Surplus energy is used to keep batteries charged and produce hydrogen which can be used for space heating, cooking, or powering farm vehicles.

Wind energy was considered for the site, but wind recordings showed relatively low average wind speeds, due to its relatively sheltered valley location. This, combined with potential permitting issues due to low flying aircraft in the region, ruled out the use of wind for HydroGlyn.

Three designs were proposed. The base case concept, Case 1, comprises the following main components:

System	Capacity	Footprint
Roof-mounted solar panels on existing south facing roofs	239 kWp	1148 m^2
Carport-mounted solar panels built over existing car park	292 kWp	1400 m^2
Micro-AD / CHP system with digester(s), raw gas conditioning equipment and biogas engine	35-50 kW	370-450 m^2
Hydrogen production unit and compression	264 kWp	90 m^2
Hydrogen storage cylinders / tube in racks	150 kg	10-35 m^2
Hydrogen vehicle refuelling unit	350 bar	30 m^2
Battery: free-standing battery cabinets	512 kWh	10 m^2

Table 2: Base Case 1 key components

The overall layout of the Case 1 concept is shown in Figure 2.

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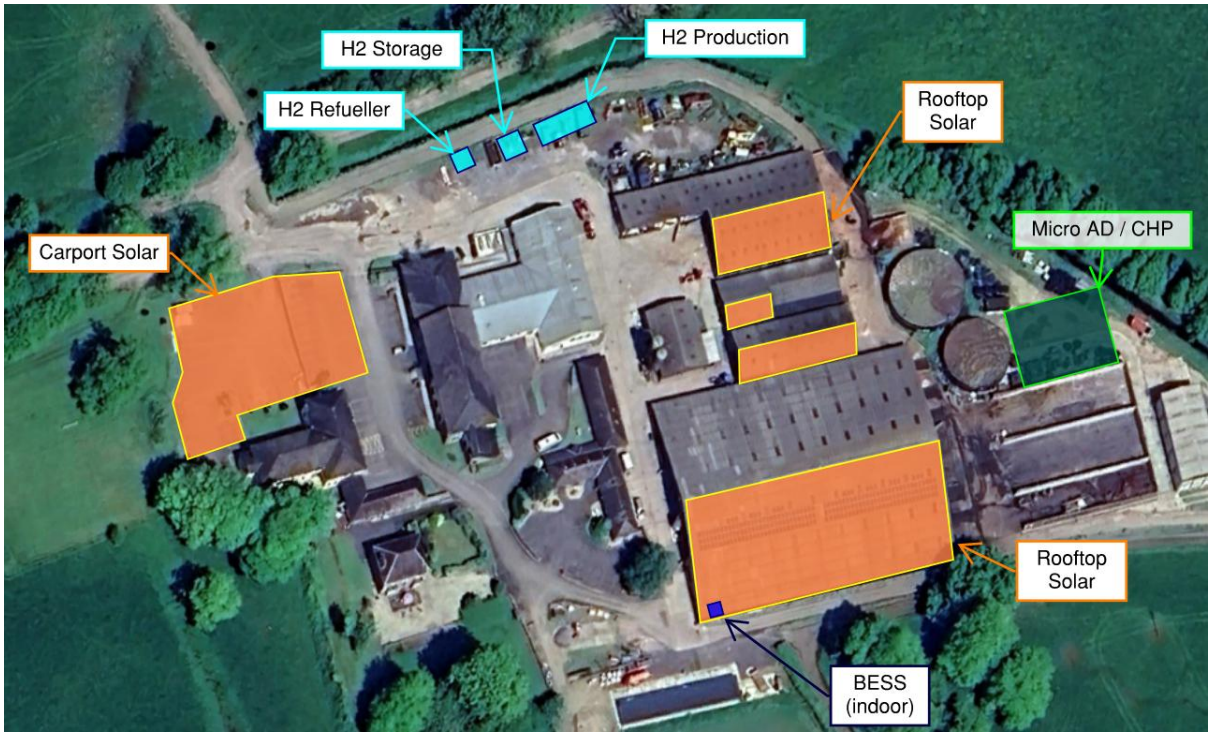

Figure 2: Concept Layout of Main System Components – Case 1

As well as new equipment, modifications or upgrades to existing equipment would be required, such as converting existing boilers and cooking equipment to run on hydrogen or use heat from CHP (taken into account in all calculations). Alternatively, as the design progresses, the expected balance of electrical vs. heat energy produced may make it preferable to electrify some of this equipment. These considerations are explored in cases 2 and 3:

- Case 2 assumes anaerobic digestion is not available, requiring expansion of solar to a ground-mounted system in field. All heating is converted to electric power to compensate for loss of heat from the micro–AD CHP system. It is noted that ground-mounted solar may not be an option for all farms, particularly dairy farms where grazing land is more valuable.
- Case 3 has the same systems components as Case 1, but all heating is converted to electric power. This maximises the available hydrogen to use as fuel for vehicles.

Policy and planning context

An early planning and permitting review was completed for the proposed HydroGlyn development. This stage focuses on identifying any significant planning or regulatory constraints that could act as showstoppers as well as shaping how the HydroGlyn system will be implemented.

The review guaranteed that technology options were assessed to ensure the project aligns with local planning policy, permitting requirements, and site sensitivities.

Ground-mounted solar was not considered a viable option for HydroGlyn, due to restrictions related to using land that is valuable to agricultural uses. However, this review established that for some farms it may be a suitable option and should be explored on a case-by-case basis.

Welsh national and local planning policy strongly supports renewable energy development in rural locations. Planning Policy Wales (Edition 12) recognises the urgent need to reduce carbon emissions and confirms that

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Wales must increase low carbon power generation. Policy also encourages local authorities to support renewable proposals that fit well with local land use and community needs, these principles have guided the development approach from the outset.

This review focuses on how the proposals can integrate with the agricultural setting, taking into account existing land use, farm operations and access arrangements. The review highlighted possible constraints including grid capacity, environmental sensitivities, or land designations. This early review ensured any project constraints could be understood and addressed within subsequent planning applications and supporting assessments.

The next phase of the project will involve a detailed feasibility assessment for the site as well as providing a comprehensive roadmap for securing planning and permitting approval. Operational arrangements, including energy storage, hydrogen use, and potential by-product management, will also be defined during this stage.

Further environmental assessments such as ecological surveys, landscape and visual impact assessments will be carried out to support any future planning application. This ensures continued alignment with planning policy and environmental requirements while remaining sensitive to local agricultural operations.

Cost benefit of HydroGlyn

Over the next 35 years, the campus is expected to spend an average of 23.69p per kWh of energy used across electricity, heating and transport, based on UK government projections[1].

As well as the crucial benefit in protecting the college from spikes in the price of energy, and providing resilience against blackouts, all HydroGlyn cases are expected to enable lower energy costs for Gelli Aur campus and protect the college against long-term rises in conventional energy costs. Case 2 in particular has a far lower cost than the campus' current energy expenditure over the equivalent period, however Case 2 is unlikely to be a feasible development at the Gelli Aur campus due to planning constraints around ground mounted solar.

Around 90-95% of the lifetime spend is associated with the construction phase, with minimal costs incurred over the operating life. In addition to power generation for the site, two additional revenue streams are generated: sale of excess hydrogen and sale of solid fraction fertiliser.

Table 3: Cost comparison of HydroGlyn cases

	Case 1	Case 2	Case 3	Baseline
Total construction cost	£3.2m	£3.6m	£2.7m	N/A
Annual operating cost	£36,000	£22,000	£34,000	£119,000
Annual energy production	1,274,000kWh	1,983,000kWh	1,235,000kWh	560,000kWh
Annual hydrogen production	3,860 kg	1,230 kg	2,640 kg	N/A
Levelised Cost of Energy	22.58p/kWh	15.92p/kWh	22.05p/kWh	23.69p/kWh

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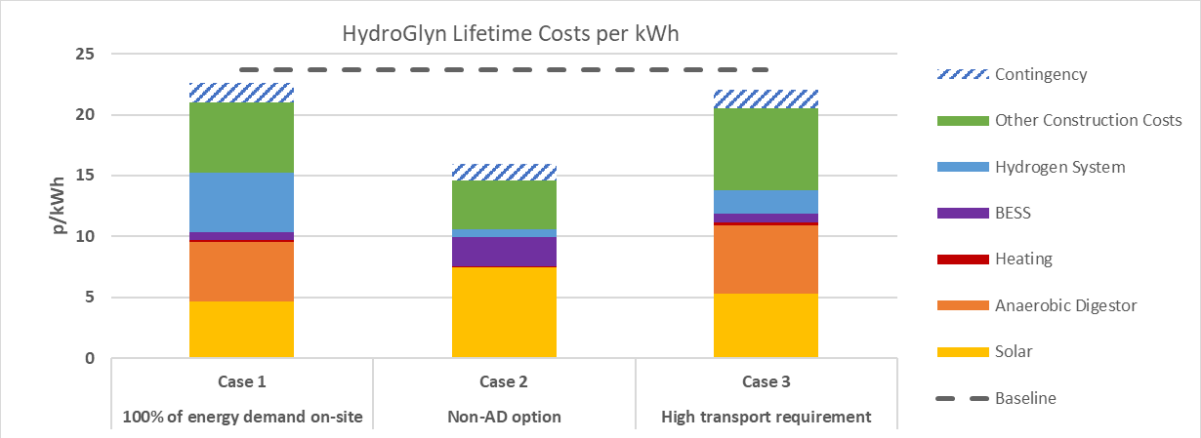

Figure 3: LCOE comparison of HydroGlyn cases versus baseline

In all scenarios, HydroGlyn reduces long-term energy costs compared with today — and provides insulation against future energy price shocks.

HydroGlyn Energy Carbon Footprint

An assessment of HydroGlyn's carbon footprint has been completed, which considers the total greenhouse gas emissions associated with the use of materials, vehicles and construction processes throughout the system's lifecycle.

The Gelli Aur campus currently relies on grid electricity, propane and conventional transport fuels. Electricity in South Wales has a carbon intensity of 352gCO_2e per kWh in 2025 - double the national average due to the dominance of gas power plants as an electricity source in South Wales[1]. Propane and transport fuels also have a high carbon footprint – Gelli Aur's total carbon footprint is estimated to be **394gCO_2e per kWh**[2], though this figure is likely to reduce as Wales continues to work towards the target to meet 100% electricity consumption from renewables by 2035.

Table 4: Carbon footprint comparison of HydroGlyn cases kilograms of carbon emissions (CO_2 equivalent)

	Units	Case 1	Case 2	Case 3
Construction footprint	**kgCO_2e**	**898,173**	**2,106,023**	**856,119**
Annual operating footprint	**kgCO_2e**	**8,835**	**27,173**	**8,710**
Annual anaerobic digestor emissions offset	**kgCO_2e**	**-170,043**	**N/A**	**-170,043**
Recycling & Reuse of equipment	**kgCO_2e**	**-238,471**	**-675,664**	**-225,226**
Total carbon footprint	**gCO_2e/kWh**	**-107.20**	**53.15**	**-107.20**

The HydroGlyn micro grid system designs are expected to enable significantly lower, or even negative, carbon footprint for the Gelli Aur campus versus the current baseline. The anaerobic digestor plays the most important role in the farm's emission reduction – as well as generating heat and power, the digestor reduces emissions, primarily methane, from dairy slurry by 50% or more.

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Closing statement

Use of materials drives the carbon footprint, with some additional impact from vehicle usage during the construction and operating life. Due to the less efficient use of materials for Case 2 (reliance on solar during winter requires a large amount of installed capacity, plus large batteries), Case 2 has the highest carbon footprint, which is still 85% lower than Gelli Aur's current carbon footprint.

Case 1 and Case 3 both have a net-negative lifetime GHG impact of -107gCO_2e per kWh, driven by the emission avoidance enabled by the AD.

The HydroGlyn project shows that farms can take real control of their energy future by producing their own heat, electricity and transport fuel on site. This roadmap has demonstrated that a well-designed microgrid, using technologies available today, can reliably meet the energy needs of a working dairy farm like Gelli Aur while cutting carbon emissions and reducing long-term energy costs.

This study highlights the growing pressures on farms: rising diesel/electricity prices, grid connection challenges, and increasing expectations to reduce emissions. HydroGlyn was developed as a practical response to these challenges. It brings together engineering, planning, financial modelling and carbon analysis to show what is technically possible, financially realistic and suited to rural Wales.

The concept behind HydroGlyn is simple: use the natural resources already present on farms — sunlight, slurry, roof space and existing infrastructure — to generate clean energy locally. By combining solar panels, anaerobic digestion, hydrogen production and battery storage, farms can operate their own 'farm power station' that supplies energy when it is needed, even in winter or during power cuts. This decentralised approach aligns strongly with Wales's ambitions for both rural resilience and climate action.

The system model demonstrated the best combination of technologies for Gelli Aur. The recommended Case 1 design includes rooftop and car-park-mounted solar, a small anaerobic digester and combined heat and power unit, a hydrogen system, and a battery bank. Together, these components supply heat, electricity and hydrogen for vehicles throughout the year. The alternative cases showed that other farm layouts — even those without slurry or without ground-mounted solar — can still achieve high levels of self-sufficiency.

The planning and policy review found that Wales is generally supportive of on-farm renewable energy projects, provided they are well designed and sensitive to their surroundings. No major planning barriers were identified for HydroGlyn, and the lessons from this site apply directly to many other Welsh farms.

The cost analysis showed a clear financial benefit. All HydroGlyn cases reduce long-term energy costs compared to today's baseline, with Case 1 and Case 3 offering particularly strong savings. Most of the investment happens upfront, but ongoing running costs are low and predictable. Additional income can be earned from surplus hydrogen and fertiliser.

The carbon footprint assessment showed that HydroGlyn can significantly reduce emissions, with Case 1 and Case 3 delivering net-negative carbon performance. Capturing methane from slurry through anaerobic digestion proved to be one of the biggest contributors to emission reductions.

Taken together, these findings show that HydroGlyn is more than a single pilot project — it is a replicable model for farms across Wales. Many farms already have the resources needed to adopt a similar system, improving resilience, reducing bills and contributing to Wales's net-zero targets.

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The next step is simple: Water to Water will continue developing HydroGlyn toward full feasibility, planning and construction between 2026 and 2028. Farmers interested in exploring whether a HydroGlyn-style system could work on their land are encouraged to get in touch for an initial, no-obligation assessment. By acting now, Welsh agriculture can lead the UK in building cleaner, more resilient and more profitable farms for the future.

Water to Water intend to take the learnings from the HydroGlyn and HydroGlen projects to develop and build 120 projects by 2040.

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Useful References

[1] https://www.gov.uk/government/publications/energy-and-emissions-projections-2023-to-2050
[2]Based on data reported by National Energy System Operator (NESO) on the regional carbon intensity of Great Britain's (GB) electricity system in the period from October 2024 to September 2025[1]
[3] Uses data from UK Government GHG Conversion Factors for Company Reporting (2025) https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2025

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Appendix I

HYPOTHETICAL CUSTOMER PROFILE:

Nye & Gwen Jones

Tŷ Gwyn, Powys

Context:

Tŷ Gwyn is a family-owned dairy farm run by Nye and Gwen, eighth-generation members of the Jones family.

There are currently 120 cows on site which are housed in sheds during the winter and turned out during the summer. Slurry is stored in a slurry pit and underground tanks; much of this is used on the land as fertiliser.

The farm generated power for the grid through solar panels on the silage silo, earning 7p per kWh, an income of approximately £3,000 per annum.

The farm is within 5 miles of a MOD facility so has no option for wind generation.

The farm experienced frequent power cuts and disruptions to the milking process. The price of electricity has just increased again.

Water to Water Solution:

WTW identified the potential for a renewable microgrid on site. Following an initial (free) consultation and an on-site assessment. The following modules were selected based on the site's needs and constraints:

Roof mounted solar: additional panels on 2 sheds and the farmhouse for domestic use and **EV car chargers**

Micro-AD: to collect the slurry during the winter months

Battery: to store power generated through solar

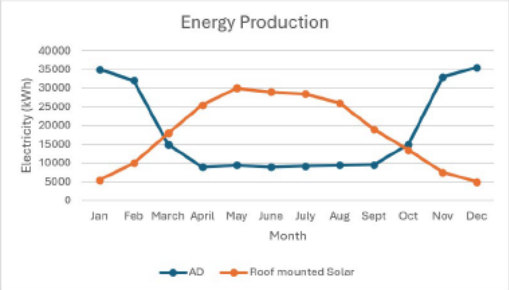
Hydrogen electrolyser & storage: to store excess power for farm use and potential additional income.

Water to Water identified a funding solution that supported the construction of the microgrid.

Outcome:

Tŷ Gwyn now **operates off grid**. The solar and AD work in synergy to produce more than enough power for the whole site throughout the year. Once the micro-grid was 'calibrated' there have been no power disruptions. As the Joneses are producing more power than they need, they have installed an EV charger for their car and are now looking into hydrogen vehicles for the farm.

The Jones family are also speaking to **WTW** about selling their surplus hydrogen to **increase the farms income**.



(power generated from solar and AD modules)

Farm Facts

Farm type:

Dairy Farm

Farm size:

190 acres

Region:

Mid Wales

No of livestock:

120 cows

Farm production:

1 million litres of milk

Water supply:

Bore hole, spring & mains

Energy uses

Electricity:

Heating water

Lighting

Fans

Automatic scrapers

Electric storage heaters

Vehicles:

2 private cars

Van

Farm pick-up

1 telehandler

1 UTV

4 tractors (70-110 HP)

1 large tractor (150-200 HP

Other:

Aga (domestic)

Energy supply

Electricity:

Grid connection

Renewables:

30kW solar - roof mounted. Feeding into the grid

Other:

Red diesel, kerosene (Aga)

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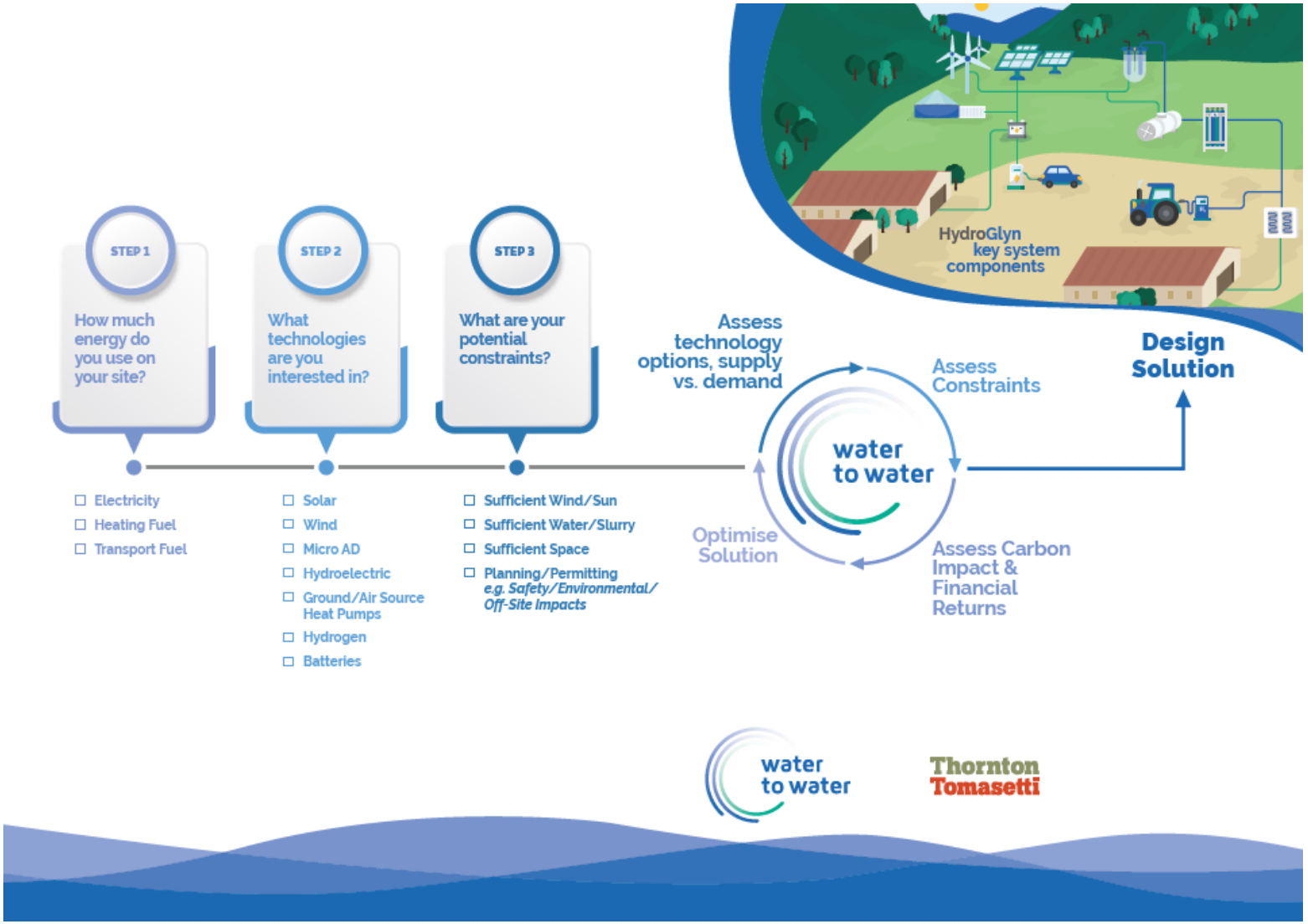
Appendix II



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