Trialling off-grid wind energy in Africa and the Pacific

R&D approaches, experiences and learnings from Aegis Energy's 'Project Zephattan' 2024-2025

aegis energy

Introducing Project Zephattan: Moving e-mobility beyond the grid

Moving e-mobility beyond the grid

With our creative, data-driven and adaptive R&D approach as our guide, in 2024 Aegis Energy set up three research pilots in remote regions of Côte d'Ivoire and Fiji.

Working with local and international innovation partners, we set out to field test different wind turbine technologies through community-based demonstrations, as part of a collaborative and global wind energy research project with ZE Gen and Innovate UK. With energy access inequalities still a major barrier to the decarbonisation of transport worldwide, our selection of these locations reflected Aegis Energy's commitment to improving access to clean energy and helping to prepare emerging markets for the green transition.

These projects to research and rigorously test clean energy alternatives to fossil fuel generators in off-grid locations were collectively called **Project Zephattan**. Named for the European westerly winds of Zephyr and the Harmattan winds of the Sahara, Zephattan represented our collaborative research connecting these regions.

Project partner overview

Small-scale wind R&D has arguably been under-researched compared to other energy solutions, such as solar. Yet wind has unique attributes, including the ability to generate power at all hours and reduce reliance on expensive energy storage and the efficient use of space, both of which give it the potential to be globally deployable, particularly in areas beyond the grid.

These attributes make wind power a highly attractive area of exploration for Aegis Energy's emerging market research project demonstrations.

In the course of this project, Aegis Energy surfaced key learnings about wind technology in particular and R&D processes in general. Those learnings centred on the idea of adaptability — namely that **there is no universal wind technology that works effectively in all contexts, making adaptability absolutely essential both in terms of the functionality of the technology itself and the project management of its R&D deployment.**

All three of the innovation partner technologies trialled for Project Zephattan generated sustainable, clean energy in their designated environments at a lower operational cost per kWh than fossil fuel generators, meaning that there is a financial incentive for their uptake in these markets.

However, their successful long-term operation within these environments required adaptation and creative problem-solving, making **project management agility and adaptability critical to success.**

Project Zephattan's learnings are already being actively applied by Aegis Energy, with the data collected during these project demonstrations, and collaboration with innovation partners from across the globe, contributing to the ongoing design and development of Aegis Energy's e-mobility EnergyHub.

The EnergyHub is a resilient, off-grid EV charging solution designed specifically for 2/3-wheeled EVs, which integrates different sources of clean-energy generation — namely solar, wind and biogas — with advanced energy storage. Conceptualised as part of Project Zephattan, the EnergyHub will demonstrate a complete end-to-end clean-energy off-grid EV-charging hub in Tanzania as part of our upcoming Ayrton Fund-backed Project PowerFarm in 2025-2026.

Meet the innovators: Aegis Energy's Project Zephattan partners

TECHNOLOGY NAME

Energy in a Box

A participatory approach to community built and owned wind energy.

Implementer	KOC Bridges to Peace
Pilot Location	Côte d'Ivoire
Number of Turbines Deployed	21
Cost of Product or Technology	£80-£2,500 (GBP)
Max kW Potential	0.015 – 10kW
Battery Size Tested	1.8 – 5.4kWh

Launched in April 2024, local Irovian consultancy KOC Bridges to Peace, with support from Aegis Energy, facilitated a fully community-led wind alternative to fossil fuel generators via their 'Energy in a Box' approach.

Across a number of remote Ivorian villages — where the majority of residents have no access to grid power and community power demand is urgently required for basic elements like lighting for midwives assisting with births or charging phones to stay in contact with relatives in high risk conflict areas, but remains costly — **'Energy in a Box' turned coastal Sahel winds into reliable community built and owned energy using turbines constructed from 100% local, recycled materials.**

In just five months, 21 off-grid villages were each trained to construct turbines capable of providing residents with power for batteries, phones and other day-to-day energy needs.

Over the course of the project, around 960 batteries were charged across these sites, providing energy access to over 1,700 people. In eight months of operation, the turbines installed collectively generated 0.19MWh of electricity with a rough total of 0.27 metric tons of CO_2 abated in total. Most of the 1.5kW turbines constructed with Energy in a Box produce 27 Volts at 400 RPM—enough current to charge a 12-volt battery every half-hour, even in moderately light (4 metres per second) winds.

The blueprint for Energy in a Box's turbine designs originated in Hugh Piggott's Small Wind Movement. Its inception was underpinned by the idea that small-scale energy independence can be achieved using homebuilt and DIY turbines that are both effective and simple to construct.

Replace this paragraph with 'The Piggott Turbine has been extensively tried and tested in Europe, Africa and America. Now, Energy in a Box is applying it through a community-led approach using only locally available components, contributing to peacebuilding efforts in rural Côte D'Ivoire.

The initial project plan was to work with communities to build five 1.5kW wind turbines. However, **the project was so cost-effective that the budget allowed them to build an additional 10, smaller 0.2 kW wind turbines in San-Pedro, Man Tehini, Ouagadougou and Adiake provinces.** These smaller turbines produced enough power to charge 12 volt batteries that could be used to power up to 40 households in each of the villages where they were deployed.

While not deployed as part of Project Zephattan, the turbine models used in the Energy in a Box project can scale up to 10kW models. However, the specific research focus of this project was to explore the effectiveness of turbines that could be produced affordably and at relative scale using readily available materials from scrap yards. KOC Bridges to Peace identified the 0.2kW and 1.5kW models as best suited to this purpose, and aligned to local power consumption.

Another **fundamental part of the 'Energy in a Box' model is its participatory approach.** Right from inception, the project involves village residents and local tradespeople in the construction process, securing buy-in from those who benefit from and consume the energy generated by their turbine.

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An advantage of the 'Energy in a Box' model, demonstrated during Project Zephattan, was its focus on resourcefulness and adaptability to the local environment. Côte d'Ivoire receives vast volumes of global e-waste, which became a **readily available, large supply of electronic components for the turbines**. Metal, magnets, copper wiring, and resin were sourced from scrap yards and local markets — keeping the material costs for each small 1.5kW turbine and mast at around £2,200 GBP with the majority of the cost (between 80-90%) being the construction of the mast. 0.2kW turbine systems could be constructed for even cheaper, at around £80 GBP whilst a 15 watt turbine can be built for a little as £9 GBP.

KOC Bridges to Peace facilitated community wind workshops, where village residents learned how to install and manage their own turbines. Over the course of the project, 500 individuals took part in these workshops. Each village was also involved in the consultation and design of local action plans, and helped source materials and build the turbines, giving them connection to and ownership of the energy they produced and consumed.

Once the turbines were operational and successfully generating power, **adjustments were made in January 2025 to the turbine design to address wind speed issues** - increasing the number of blades from 3 to 5 in order to better generate power in consistent winds. These adaptations were highly successful, with the **turbines recording an increase in power production of 2,144%.**

Four turbines were also retrofitted with Energy Management Systems (EMS) to remotely monitor and record real-time performance data and optimise their efficiency. However, the large volume of data captured led to data management issues, curtailing some of the optimisation efforts. Further improvements to the Energy in a Box EMS are planned to build on Zephattan's pilot systems.

Zephattan's largely successful deployment of Energy In A Box has encouraged further investment in the project and ongoing energy access for the various communities involved. In 2025, Energy In A Box was nominated for the Earthshot Prize, receiving international recognition for their contribution to community-led climate solutions.

In the majority of the communities involved, Energy Management Committees were established which continue to oversee the usage of the turbines, ensuring the community-led approach with representation divided equitably according to gender and ethnicity. **650 community members in total were trained in community governance as part of KOC's involvement in Project Zephattan, with 72 of those participating in these Energy Management Committees.**

TECHNOLOGY NAME

EnergyPod/MonoPod

Highly engineered and transportable multi-energy technology designed for tough environments.

Implementer	Amphibious Energy
Pilot Location	Abidjan, Côte d'Ivoire
Number of Turbines Deployed	1
Cost of Product or Technology	£100,000 (GBP)
Max kW Potential	5kW (10kW with solar pack)
Battery Size Tested	86kWh

Netherlands-based company Amphibious Energy specialise in combined renewable energy innovations, specifically for off-grid and harsh outdoor environments. For Project Zephattan, they partnered with Aegis Energy to **install one of their combined solar and wind energy MonoPods** at Côte d'Ivoire's Félix Houphouët-Boigny University in Abidjan.

All MonoPods are designed as off-grid ready, multi-energy generation units, heavily engineered to withstand harsh conditions and arduous long-haul transportation in a single shipping container. The modular design includes solar PV panels mounted on its exterior, a highly specialised pressure wind turbine and integrated battery energy storage systems (BESS). Its amphibious design utilises **all available energy resources to support a maximum battery capacity of 86kWh, and a rated power output capacity of 10kW.**

Originally designed (and currently used) as **a zero-emission alternative to diesel generators** on off-shore oil rigs, the EnergyPod was built to be fully transportable with a single lift placement. It can be moved by crane or helicopter, and placed directly on site where it can start to generate power immediately. Its off-shore use also necessitated it withstand the harshest outdoor conditions including exposure to saltwater corrosion and hurricane strength winds.

The EnergyPod has effectively completed its R&D process through extensive off-shore and near-shore testing with the results leading to modifications to improve its adaptability to different environments and applications. **With Project Zephattan, Amphibious Energy saw an opportunity to trial their technology in an inland setting for the first time, where wind currents and patterns are typically lower and more variable.**

The MonoPod was deployed on the Félix Houphouët-Boigny University (FHB) campus in the Ivorian capital of Abidjan. Since September 2024, it has been providing power to the University's FabLab — a space for learning, innovation and technology development.

Once installed, the MonoPod began not only generating energy, but also **provided students with technical, hands-on learning and a real-world example of a resilient, off-grid, renewable energy source.** FHB students and staff were engaged in the redesign process when the turbine was retrofitted to maximise power generation and Amphibious Energy engineers provided training to students on the assembly and disassembly of the MonoPod.

The high level of student interaction with the MonoPod was facilitated by its simple construction and human-computer interface, designed as a 'plug-and-play' intuitive software. Designed for ease of use and minimal maintenance — enabling local workers without specialised technical knowledge to keep the MonoPod operating effectively — these features clearly had a strong community engagement function for on-shore use as well, and contributed to the adaptability of the technology during its redesign phase.

However, the MonoPod's first inland testing experience also yielded some environmental challenges.

The solar and battery systems performed well over the course of the project, generating a daily average of 20.4kWh, and totaling 3.06MWh over the course of the demonstration. **However, suboptimal conditions meant the wind turbine was not able to demonstrate its technical performance capabilities and was unable to generate wind power. This was due to its placement in a built-up area surrounded by buildings, leading to both site obstruction and consistent low-wind speeds of less than 1 metre per second.** Most modern turbines — the EnergyPod included — begin to generate power in continuous

wind speeds of around 4 metres per second. Whilst a second, windier site on a nearby hilltop was identified as a good placement for the MonoPod, there were no cranes available that were capable of transporting it to the top of a steep incline, rendering the relocation of the MonoPod unviable and reinforcing the 'picky' nature of on-shore wind environments.

Faced with this new development, project partner KOC Bridges to Peace stepped in to **provide input and knowledge sharing** that enhanced the MonoPod's power generation capability.

The unit was **retrofitted — with help from FHB students and consulting support from KOC Bridges to Peace — with a 1.5kW 'Energy in a Box' turbine, increasing its height to access stronger wind currents.** This new turbine functioned well, producing over 4000Wh in the two months it was operational, as recorded by its onboard energy management system.

During the demonstration the Amphibious Energy team used the **real-time data monitoring tools built into their technology to remotely track and optimise power generation**, helping them to better understand the MonoPod's solar energy storage capacity.

Practical learnings, community partnership and knowledge sharing were fundamental throughout Amphibious Energy's work on Project Zephattan. Now, as a result of this practical adaptability, the MonoPod continues to provide further teaching opportunities on the FHB campus.

TECHNOLOGY NAME

Mobile Power Station (MPS)

Meeting island energy demand with the world's first commercial-power-rated portable wind turbine.

Implementer	Uprise Energy
Pilot Location	Viti Levu, Fiji
Number of Turbines Deployed	1
Cost of Product or Technology	$250,000 (USD)
Max kW Potential	14kW
Battery Size Tested	100kWh

> "You need to be able to make power where the people are."

Jonathan Knight, Uprise CEO, on the thinking behind the mobile wind turbine.

Alongside Project Zephattan's Côte d'Ivoire projects, Aegis Energy partnered with Californian company Uprise Energy in Fiji, to **field test their world-first portable commercial-power-rated 14kW wind turbine** in the South Pacific island nation.

Around two-thirds of the planet has the potential for wind energy generation, but variable wind direction and consistent low-wind speeds remain a challenge. Uprise set out to develop a turbine capable of generating energy from these variable low winds, effectively redefining the possibilities of globally transportable and rapidly deployable wind power.

Due to frequent outages across the Fijian grid — especially in remote areas — most Fijians are reliant on fossil fuel generators for backup power. Aegis Energy set out to harness the trade winds on the island of Viti Levu to meet energy demand using the Uprise portable wind turbine design, the **Mobile Power Station (MPS).**

During this partnership, Uprise and Aegis Energy faced some of **Project Zephattan's toughest challenges in the difficult island terrain** where forested mountains rise from the middle of the world's largest ocean. This topography makes Fiji largely unsuitable for ground- or roof-mounted solar — which requires large tracts of sunny, unshaded flat land — but ideal for much more compact wind turbines.

After initial testing in the strong California desert wind, the MPS was reinforced for improved stability and shipped to Fiji in August 2024.

The MPS is unique in three key aspects:

1. A compact transportable design intended for deployment to remote islands in 20ft containers;
2. An expedited set-up time that delivers immediate clean energy;
3. A blade and rotor technology optimised to generate energy from even low and variable wind speeds.

A portable Jungle Power 80kWh battery energy storage system was also dispatched from Australia to help capture and store the energy generated by the turbine.

The MPS was designed to be fully transportable by ¾ tonne truck towing. However, this is dependent on the availability of suitable trucks which are ubiquitous in the US, where the MPS was created. In Fiji, these vehicles are not available, and in their absence, the MPS had to be transported by a flatbed truck. This restricted where the MPS could go, and ultimately limited the MPS' transportability. **This learning —demonstrated throughout Project Zephattan —underscores the importance of prioritising local environmental considerations in designing wind technologies.**

In early November 2024, the MPS was installed on the island of Viti Levu, on a hilltop within the holiday accommodation Crusoe's Retreat.

Set-up and construction of the MPS at the hilltop site took just 30 minutes to complete. During a three-day demonstration, it successfully generated significant power of **3.4kWh in typical and consistent Fijian trade winds of less than 5 metres per second wind speeds, achieving a peak power output of 9kW in wind speeds of 10 metres per second.** During this time, Uprise engineers successfully calibrated the wind tables of the MPS to ensure optimal adaptation to local wind conditions and behaviour, further highlighting the versatility of the technology.

Given this data, Aegis Energy's projected 6-month performance of the MPS estimates that, if operating continuously at this rate, it would have generated 4.2MWh.

However, a combination of technical complexities and human error caused the unexpected structural failure of the MPS mast after 3 days of operation.

The critical incident occurred when the MPS' overspeed prevention system—which regulates and stabilises the turbine's load when it reaches maximum rated wind speeds — required a manual restart whilst in a period of operation. During this restart, the energy management system's programmable logic controller — which instructs the mechanical movements of the turbine — did not have the critical 'PowerMax' system safety function engaged. In high (10-metre-per-second) winds, this caused the turbine's blades to spin uncontrollably and strike the mast with 29,000 pound-per-foot of torque, rendering the MPS inoperable.

Though this failure presented a significant setback, **it was also a valuable learning opportunity that facilitated a comprehensive technical redesign of the mast, the introduction of new features and software improvements within the human-computer user interface, an in-country repair assessment to identify and demonstrate local damage inspection and repair capabilities, and the redeployment of the J80 BESS for e-mobility purposes to become Fiji's first mobile EV charging station.**

Project Zephtattan's demonstration directly informed comprehensive structural changes to the mast to significantly improve its strength and durability in extreme conditions.

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The original mast design used two asymmetrical aluminum pieces per mast section. While lightweight, this limited its structural rigidity, which contributed to the failure.

The new design incorporates features to enhance rigidity, including:

- 4 flat aluminum sides, connected with square tubes in every interior corner for enhanced rigidity
- Angle reinforcements on exterior corners to resist torsional and bending loads
- Lattice structure connecting angle pieces to enhance load distribution and wind resistance.

With these elements, the MPS has been **re-engineered to 4x the strength and stiffness of the previous design for improved safety and performance in high-wind and high-load conditions.**

One of the key R&D objectives motivating Uprise's involvement with Project Zephattan was the chance to test the MPS as an intuitive, mobile and self-contained energy generation and storage system in the target market it was designed for. Full commercialisation of the technology would see it deployed to regions where local workforces would be able to set up, install and operate the system with minimal training.

The initial set-up of the MPS was achieved in just 30 minutes with minimal direction from Uprise needed and no issues, proving the success of the design concept for installation and activation.

However, the events leading to the power failure and mast strike highlighted two areas where greater design input was required: the human-machine interface (HMI) and the programmable logic controller (PLC). As a result of this incident, both of these elements were refined to ensure that operator errors could be minimised in future deployments.

To improve the HMI design, **Uprise introduced an icon-based intuitive design for the user interface (UI),** replacing similar-looking toggle switches. In addition, refined hardware and software changes created a streamlined UI to ensure that the MPS is as "simple to operate as an electric vehicle".

Another limitation the Uprise team encountered was the system's third-party inverter capacity capping how much power the turbine could generate. Since the data from its 72-hour operation period showed a strong energy generation profile, and the need to convert more electricity from DC to AC, Uprise is actively working with its inverter supplier to increase the size of the system in order to avoid the peak power being capped at 9kW.

As with the EnergyPod in Côte d'Ivoire, the challenges Uprise faced during their technology demonstration led to collaboration between Uprise, Aegis Energy, local partners and funding partner Innovate UK to explore the best path to redeploy the MPS.

However, due to logistical challenges, long-lead times required for shipping components to Fiji, and the 12-month time constraints of the project demonstration, it was not possible to redeploy the MPS during Project Zephattan's initial timeline. **Instead, an in-country repair assessment, damage inspection and nacelle repair was conducted in February 2025** in the Fijian capital, Suva, in close collaboration with local engineering firm Vatuwaqa Engineering.

TECHNOLOGY NAME

J80 Mobile Battery Energy Storage System

Exploring portable, right-sized storage solutions for distributed island energy.

Implementer	Jungle Power
Pilot Location	Viti Levu, Fiji
Number of Turbines Deployed	1
Cost of Product or Technology	$80,000 (USD)
Max kW Potential	N/A
Battery Size Tested	80kWh

Australian company Jungle Power specialises in portable, clean energy solutions. For Project Zephattan, they supplied Aegis Energy with a J80 — a highly mobile 80kWh Battery Energy Storage System (BESS), to complement the MPS wind turbine.

Alongside the MPS's own integrated 20kWh BESS system, the J80 provided an additional unit sufficient in capacity to store the significant energy generated by the MPS whilst also being equally mobile, preserving the portability of the turbine and energy system. Alongside the MPS's own integrated 20kWh BESS system, the J80 provided an additional unit sufficient in capacity to store the significant energy generated by the MPS whilst also being equally mobile, preserving the portability of the turbine and energy system.

The J80 is a high-capacity battery, designed to provide dispatchable-on-demand renewable energy in the remote and rugged settings of the Australian outback. It was created to reduce reliance on diesel generators in applications such as film sets, off-grid homes, outdoor events, and as an emergencyback-uppowersystem. With advanced lithium battery technology, fast-charging capabilities and a highly transportable design it was deemed a good fit for the MPS' Project Zephattan deployment.

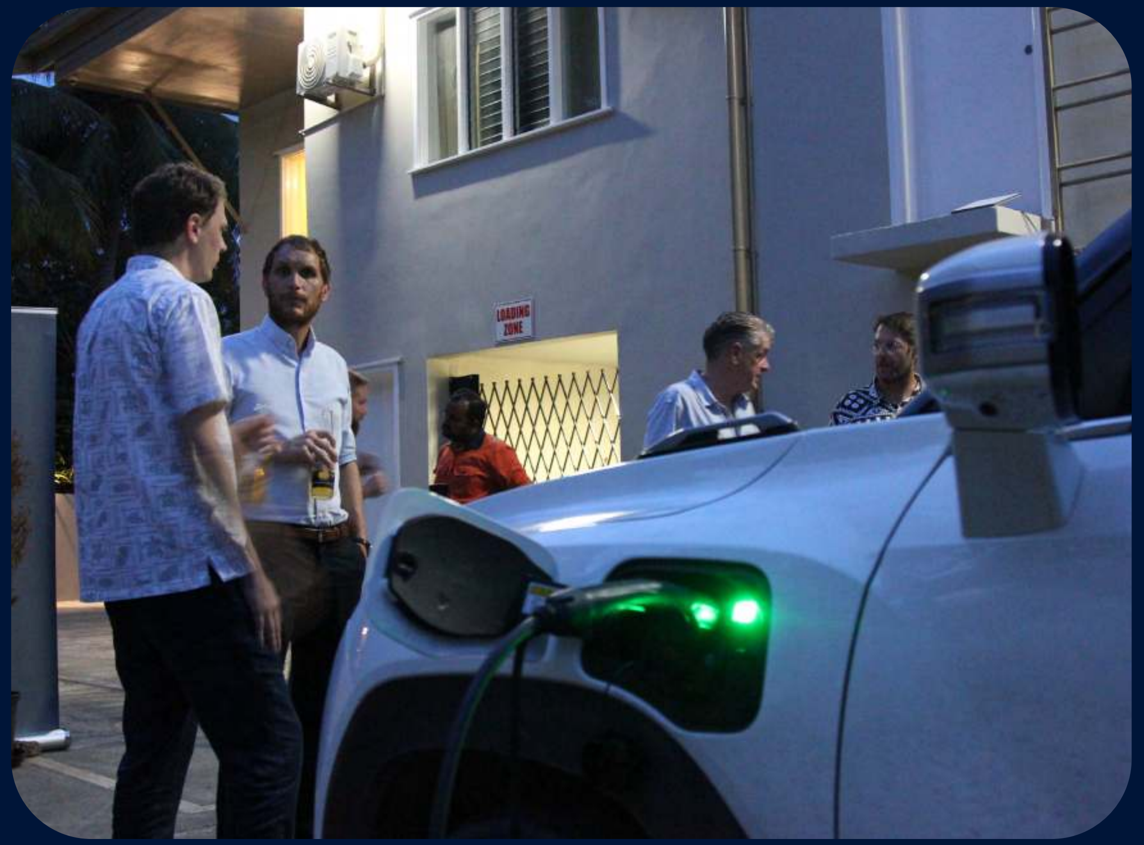
In the aftermath of the MPS incident, the J80 was disconnected and redeployed to Fijian partners, island EV charging pioneers Leaf Capital/Switch who incorporated a 60kW charger to the unit. In February 2025, the J80 became Fiji's first mobile EV charging station, trialled in two locations within the capital city, Suva - Mana Coffee and Kundan Singh Service Station. **During its month-long demonstration, the J80 delivered 590kWh to 25 EV users, which equates to approximately 295kg of CO_2 emissions abated.** Suva has a very nascent market of 12 electric vehicles, so this represents a significant initial uptake, highlighting the promising potential for expanded adoption as infrastructure and awareness improve.

As a versatile piece of equipment, several possibilities were considered for the J80 going forward:

1. Continuing to demonstrate the J80 as a **mobile EV charging station** in Suva. Over time, this would help assess the feasibility of establishing new charging locations, particularly in remote areas, bypassing the long lead-in times required for Fiji's national power company (EFL) to install the necessary infrastructure.

2. **A highly mobile, clean energy source for events** in locations where power demands might outstrip the existing supply, or where the grid is unreliable — as is the case in much of Fiji. The J80 can be fully charged in advance using Leaf's existing solar farms and then transported to a site, providing a reliable and clean alternative to traditional backup generators. This use case can become increasingly relevant for clean construction, including the charging of electric non-road mobile machinery (NRMM) such as electric forklifts.

3. **Deployment as a battery system for a solar array,** particularly in remote areas lacking permanent infrastructure. This would allow solar energy to be stored and utilised efficiently while awaiting necessary upgrades from EFL to support long-term solutions. In these cases, the J80 would act as a temporary energy storage solution to help showcase the potential of hybrid solar and battery storage solutions, enabling renewable energy use without requiring immediate dependence on the national grid.



Project Zephattan's demonstration has shown that battery innovations such as the J80 could be particularly beneficial to Fiji, where most of the population live in off-grid and weak-grid areas with intermittent power. The sustained deployment of the BESS could challenge the prevalence of fossil fuel generators across Fiji and provide a clear path to increase the capacity and reliability of renewable energy systems. The potential applications of high-capacity and portable batteries are numerous, and could incentivise the uptake of renewable energy sources among some of Fiji's many remote communities and businesses including island resorts like Crusoe's Retreat where the MPS was originally located.

Key learnings for the future of wind energy R&D

Wind turbine design, optimisation, and deployment is highly context-dependent

Project Zephattan's wind energy projects presented many challenges and, as a result, a number of lessons learned.

Wind turbines vary widely, with different types suited to different environments. The most effective turbines *in their contexts* were those that met — or could be adapted to meet — **climatic factors** (such as local wind patterns and behaviour), **technical factors** (such as the strength of local supply chains, technical expertise and maintenance requirements) and **human factors** (such as community need and buy-in, and communication/collaboration between implementers and local partners).

In the table on the right, we can see how the three demonstrated technologies compared across these factors.

	CLIMATIC FACTORS	HUMAN FACTORS	TECHNICAL FACTORS
Energy in a Box turbines	Adaptable turbines were built specifically to suit their climate or environment, with a fully iterative design a fundamental part of the technology.	The owners/stewards of the turbines constructed them with support of local communities and tradespeople, addressing direct need, incentivising local maintenance and prioritising simple functionality.	Turbines were built affordably, quickly and using a readily available (and readily replaceable) supply of recycled materials, providing a robust supply chain of parts, skills and personnel.
Amphibious Energy EnergyPod	The MonoPod turbine is designed to maximise all available resources for power generation. As such, its blades are designed to perform as both a hydroelectric and wind turbine. This novel innovation was not able to demonstrate its full capability during this project, as it was in an environment with insufficient wind speeds.	MonoPod's plug-and-play design, straightforward instalment and minimal maintenance made it easy to engage with as a learning tool and allowed for mid-project adaptation. However, its optimisation for off-shore environments where factors like weight and manoeuvrability are less important made it hard to find the resources for its relocation.	MonoPod's low-maintenance design and optimisation for extreme environments served it well. It performed well in hot environments and the battery system in particular was not impacted by high heats.
Uprise Mobile Power Station	The MPS performed impressively in Fiji's high-wind conditions. The technology's specific, and groundbreaking, focus on variable wind conditions shows immense promise for similar environments.	The MPS setup was fast and simple. However it proved less mobile than originally intended as the unit was designed to be towed by a pick-up truck of a size not available within the local market. Issues with Uprise's user interface led to a human error. The highly sophisticated nature of the design and the remoteness of the demonstration site made this early error unfixable within the project timeframe.	There was a lack of readily accessible expertise available locally to easily fix the MPS, compounded by significant lead times for delivery of replacement components due to the remoteness of the demonstration site.

This primary, overall learning can be summarised thus:

There is no universal wind technology that works effectively in all contexts. Significant upfront research is required to determine the right turbine for each setting, with adaptability proving absolutely essential to the success of any technology.

Across Project Zephattan, "off-the-shelf" turbines optimised for specific environments often struggled in the realities of geography and the nuances of emerging markets, even when the technology itself was highly sophisticated.

In future R&D processes, rather than finding the environment for the product, Aegis Energy must work to identify and prepare the product for the environment.

The limitations of current frameworks for R&D projects

There are several frameworks used to assess technologies' suitability for deployment; MATCH (Market, Architecture, Technology, Context and Human Capabilities), Context Readiness Models and Technology Readiness Models among them.

Our learnings from Project Zephattan indicate that these frameworks — designed for market-ready, commercialised technologies — are often inadequate in the case of R&D projects.

All of the wind turbines demonstrated in Project Zephattan **fulfill the objective of producing sustainable zero-carbon energy in their designed environment**, but none are capable of working optimally or reliably in every location. Rather, their successful long-term operation depends on a thorough needs analysis and research prior to their deployment — **both of the environments in which the technology will be demonstrated, *and* of the innovation partners themselves.**

Project Zephattan's Innovation Partners were not solely participating to demonstrate their respective technologies. Each partner equally contributed to the project as both a grantee and an R&D innovator, meaning that **project management agility and adaptability was critical to the performance of technologies.**

For Aegis Energy, optimal outcomes from Project Zephattan were dependent on our partners' ability and willingness to adapt, make changes, refine their technology and test iteratively — a behaviour that can be better understood through the 'COM-B' matrix.

Applying the COM-B framework to understand grantees

The COM-B (Capability, Opportunity, Motivation — Behaviour) matrix provides a comprehensive lens to analyse and encourage behavioural decision-making and can be applied usefully to both Project Zephattan and future R&D projects.

In the context of Project Zephattan, where the outcomes of the project are heavily influenced by the decision-making and behaviour of innovation partners and other stakeholders, the COM-B model offers a breakdown of factors that could help identify the ideal combination of grantees and environments to engage on a project, and then predict and drive their behaviours throughout.

With this view, Aegis Energy can assess the factors that led to the different outcomes from Innovation Partners through the COM-B matrix, as laid out below. The desired behaviour from innovation-focused grantees is the ability to refine, adapt and trial new thinking and approaches.

These partner-specific learnings can be distilled into a series of **generalisable lessons which can inform Aegis Energy's R&D approach going forward** in terms of project partner selection, project management and the essential role of adaptability within the project process.

Capability

The psychological and physical ability to engage in a behaviour.

The level of sophistication of a technology, whilst in some instances improving performance metrics, can also create major challenges in addressing technical issues and adapting iteratively to an environment. Lower sophistication technologies minimised the need for deep technical expertise and specialised components/tools, thus allowing local communities or partners to assemble, maintain and adapt the technology without extensive training or supervision, or reliance on the slow and/or costly import of specialised equipment.

The feasibility of deploying technology is also dependent on this adaptability. Even high sophistication technologies specifically designed for simple operation and mobility can find themselves at the whim of local complications or limitations (such as the absence of relevant equipment, inaccessibility of roads, complexities of local bureaucracies) if they are unable to adapt iteratively.

Proximity to the technology and essential support structures is critical. If project partners are based remotely from the deployment of their technology, resolving issues becomes more challenging, unless there is a local partner or community with the necessary expertise. Where these types of local partners or communities are actively engaged in the project, reliance on external expertise is reduced, enhancing long-term sustainability.

Opportunity

External factors — physical and social — that enable behaviour.

Strong local buy-in facilitated smoother implementation and project success. Early community involvement in the design and hosting of projects played a significant role in fostering engagement and support. Where communities were actively involved in the build-out and installation, acceptance and support for adaptation were higher.

This buy-in was facilitated by projects directly benefiting the local community. Adaptations to increase performance, for example, were carried out more successfully and efficiently where energy solutions met a pressing local need, with engagement and participation in troubleshooting and maintenance stronger and less demanding on remote management from partners.

This kind of innovative behaviour was prevalent where mechanisms were in place to recognise and support adaptation. In some cases, locally available materials and skills for modifications encouraged iterative problem-solving and knowledge-sharing within communities.

The short project duration posed a significant challenge in terms of opportunity, particularly in remote locations with long lead times for deliveries and shipments. These time constraints were less of a hindrance when all components were sourced and assembled locally.

Motivation

Internal processes — both reflective and automatic — that drive behaviour.

Project partners who considered their technology to be 'late-stage' or 'near commercialisation' were often less inclined to make adaptations. In cases where local conditions diverged from the idealised settings in which more sophisticated, centrally designed and manufactured technologies were developed, partners tended to seek out environments that matched those expectations, rather than adapting the product. This dynamic reflects a tension between environment and product. The most effective R&D adaptations emerged when there was a recognition that the product needed to respond to the environment, rather than the environment being tailored to suit a pre-existing product.

Teams accustomed to iterative development, on the other hand, were more likely to modify their technology. Innovators and grantees with prior experience in emerging markets were generally more receptive to adaptation and iteration, understanding that, in these environments, idealised conditions can rarely be found in reality even if they exist on paper.

Partners' motivations for engaging in the project varied significantly, and these motivations mattered as much as the technical aspects of the technology. Partners with a stronger technology focus tended to be more deliberate and risk-averse when considering modifications and adaptations, whereas those with more holistic motivations such as peacebuilding or development goals tended to be more open to adaptation. In future R&D projects, an assessment of motivations, as well as technologies, can and should act as a useful aspect of the project partner selection criteria.

Conclusion

Project Zephattan was successful not only in further demonstrating the underexplored potential for wind energy in off-grid environments, **but in informing an increasingly dynamic and adaptive approach to Aegis Energy R&D projects moving forwards.**

The project aimed to demonstrate the possibilities and limitations afforded by wind energy as a replacement for reliance on fossil fuel generators in off-grid environments. In the year for which it ran, Project Zephattan provided Aegis Energy and project partners with applicable learnings about the deployment and management of wind energy generation across multiple off-grid and emerging market environments. It also furnished us with a toolkit of important learnings and considerations for undertaking future R&D processes in both emerging and established renewable energy markets.

The project actively demonstrated the importance of agility and adaptability at all stages of the R&D process — from selection of project partners, to the monitoring and management of technologies to reflect circumstances on the ground, to the rescoping and redeployment of project elements in the case of unexpected developments.

Further work can and should be undertaken to develop on these learnings. For example, in future R&D projects, standardised data collection for a **Levelized Cost of Energy (LCOE) analysis will form a valuable and quantifiable metric** on which to assess the performance of various technologies. Through the application of a COM-B framework, future project partners can and should be assessed for their suitability, perhaps via a more formalised set of criteria and questions.

The learnings from Project Zephattan — both in terms of specific technologies and an approach to R&D — have already had an invaluable impact on Aegis Energy's upcoming Ayrton Fund-backed Project Powerfarm, informing both aspects of the technical design of the EnergyHub and influencing the overall design of the project itself.

True to the key learnings from Project Zephattan, however, this process of adaptation is ongoing. Aegis Energy, in our pursuit of ambitious solutions for the green energy transition, will continue to adapt, iterate and prepare our technologies and systems for each environment as we find it, setting a course for the e-mobility revolution that's sustainable in every sense.

> **"There is no universal wind technology that works effectively in all contexts. Significant upfront research is required to determine the right turbine for each setting, with adaptability proving absolutely essential to the success of any technology."**

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