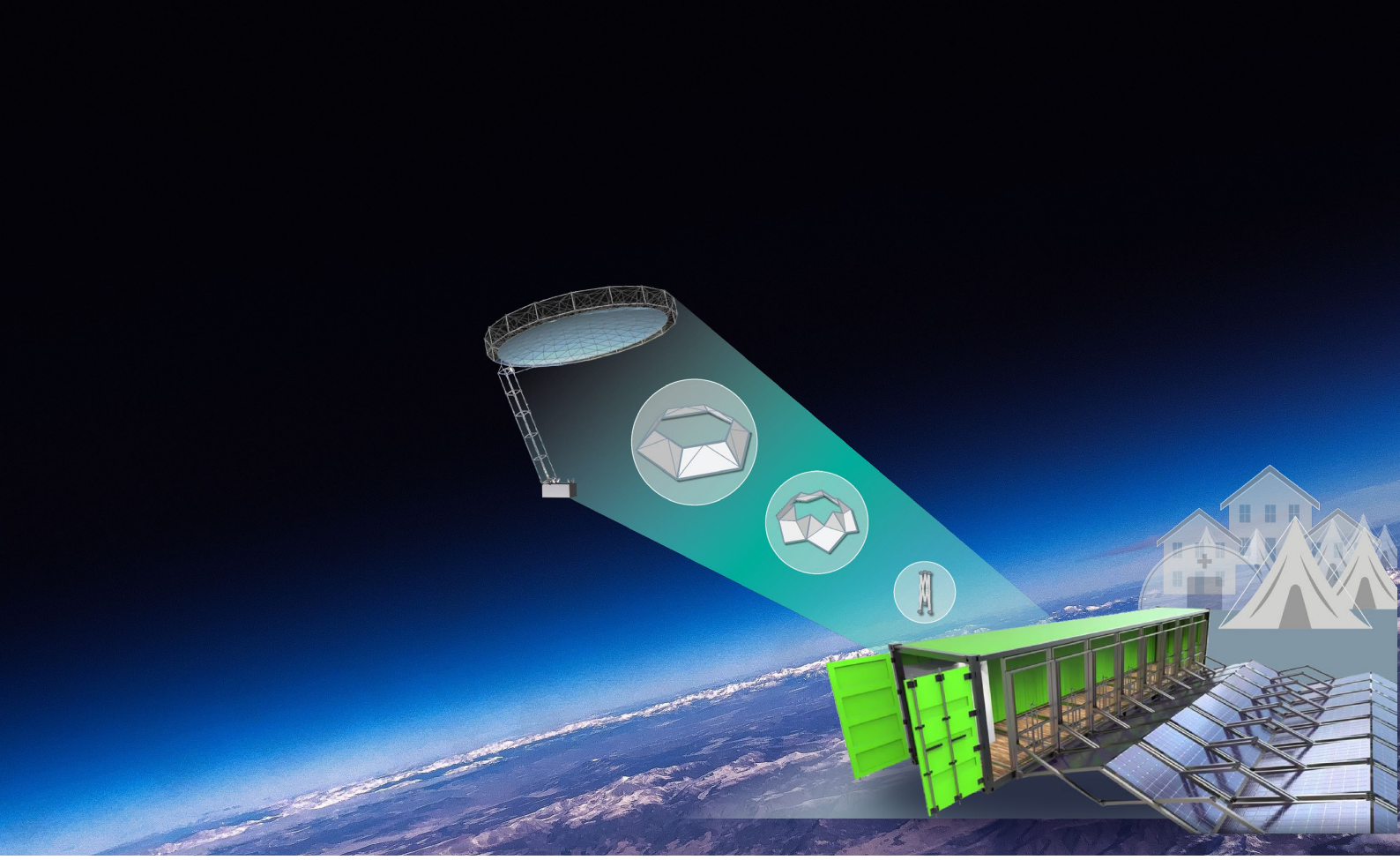


Socio-economic benefits from ESA Technology Transfers

A report for esa

CASE STUDY: POLAR GREEN CONTAINER

know.space

July 2022

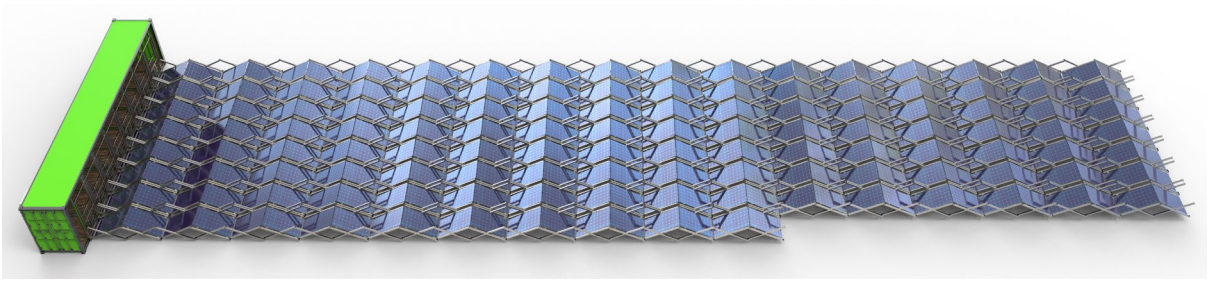
Powering a village from a shipping container: space structures to transform portable energy generation

ESA's 2023 Biomass mission will launch on the Vega rocket[1], designed for small-medium payloads. The rocket measures just over 3m in diameter at its widest point, and its payload fairing is only 2.6m in diameter and 7.9m long[2]. Meanwhile, the Biomass mission will require a 12m elliptical reflector[3]. This disparity has created the need for compact, lightweight, rigid structures that can be used for the reflector, allowing it to be stowed in a rocket and then reliably deployed once in orbit. Comet used the Biomass mission as the starting point to develop a terrestrial solution.

Under ESA contract, Comet Ingeniería, in consortium with Airbus SSE and Prosix Engineering, are developing a deployable ring and mast system, capable of compacting to less than 10% of its final size to fit within medium and large launchers[4]. This technology is currently at TRL4 and capable of deploying a 6m dish.

The structure is comprised of unit cells, which concertina, allowing the entire structure to flatten when not deployed. **These unit cells can be arranged into virtually any arbitrary shape or size structure, creating the opportunity for many possible applications.**

Comet recognised the potential for modular deployable structures in the portable generators market. In emergency situations, communities often require energy infrastructure that is transportable, and quick and easy to set up. Polar Developments, a spin-off from Comet, has developed several portable solar panel solutions, including the Polar Green Container. **This product utilises the folding unit cells to store enough solar panels to generate 108kW of power from a 40 feet shipping container**[5]. The solar panels deploy mechanically in just a few hours, without the need for trained specialists and can be stored again just as easily.



Mock-up of solar panels deployed from Polar Green Container solution

Image: Polar Developments.

[1] ESA, 2022. *Biomass: ESA's forest mission.* Available at: https://www.esa.int/Applications/Observing_the_Earth/FutureEO/Biomass
[2] Arianespace, 2022. *VEGA - the light launcher.* Available at: https://www.arianespace.com/vehicle/vega/
[3] Nieto et al. (2017) *Modular deployable structures*
[4] Comet Ingenieria, 2022. *MODAR.* Available at: https://comet-ingenieria.es/productos/modar/
[5] Polar Developments, 2022. *Polar Green Container.* Available at: https://polardv.es/container/

Space technology brought down to Earth ...

Comet Ingeniería is a Spanish mechanical engineering firm, working in a variety of industrial sectors, including the space sector. Comet developed the ring and mast deployable structure under an ESA contract, in consortium with Airbus and Prosix.

Polar Developments was founded in 2018 as a Comet spin-off. They are developing suitcase, tow and shipping container solar panel solutions, with support from the ESA business incubation centre.

Polar Developments is not the first firm to offer solar panels deployable from shipping containers, but the Polar Green Container is unique in its use of space technology and the benefits this brings to the product functionality and end user application. The modular deployable structures developed for satellite applications allow solar panels to be deployed more quickly, packed more densely and subsequently generate more power than other solutions.

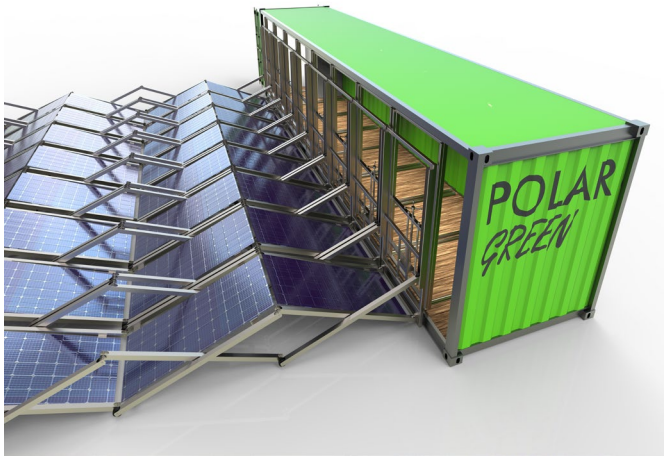


Image: Polar Developments

Each unit cell is comprised of 6 simple aluminium bars connected with hinged joints, which lock into position when deployed. After use, the cells to fold inwards and pack flat for storage in the container. These cells can be arranged into virtually any configuration, creating large, foldable structures, which are strong and rigid once deployed. To adapt the space technology to provide renewable energy on Earth, Polar Developments changed the configuration of these cells, added wheels and changed materials to lower costs and make the product suitable for harsh weather conditions on Earth.

Potential for significant socio-economic benefits

Whilst the technology transfer of the deployable structures for solar panels is still in the late development stage, some initial socio-economic benefits have begun to emerge, with the promise of many larger, global benefits to come through its successful commercialisation, for the business involved, their customers, and for broader society and the environment.

Developing a mobile, autonomously deployable solar power generator

Commercial opportunities

Polar Developments is confident that through the use of its space technology heritage providing innovative ways to deploy portable photovoltaic generators, it will present a great opportunity for the company to commercialise and grow. Indeed, the company is originally a **spin-out** from Comet Ingeniería, established for the express purpose of exploring the downstream applications of the modular deployable structure in the renewable energy domain. Their revenues will come from

product sales tackling a **wide range of end users**, from energy providers and distributers to solar panel developers and large governmental/non-governmental organizations.

The company is in the process of finalizing purchase orders for its smaller sized products, whilst its larger products (Tow and Container) will be available in their commercial forms by spring 2022. They are actively making steps towards commercialisation.

Polar Developments hopes to expand and reach sales of more than **€6 million by 2026**[6].

Job creation

The creation of Polar Developments brought a **new SME to the market** that currently employs 6 people and aims to expand to **20 people by 2026**.

For Polar Developments, future success of the concept would create **more jobs** and act as a **source of employment** within the Spanish economy, as it aims to more than triple its number of employees.

Wide range of products for different end users

The company offers a suite of products utilizing the philosophy of easy deployment, that can address a variety of end users and needs. Their Polar Green Tow product for example can be transported by a car/truck and **deployed within 5 minutes** for scenarios where there is a need to generate energy autonomously in a very fast period of time, such as during emergency situations or natural disaster relief. The Polar Green Container meanwhile can be transported by helicopter or by sea, to provide energy to communities requiring emergency energy production, but also for small populations in remote areas that are experiencing energy poverty or have no electrical grids.

End users of the products will include companies distributing equipment for adventures or small-scale professional activities, companies selling solar panels or providing energy generator solutions, and construction companies building in remote areas. Non-governmental and governmental organisations are also key clients for the larger products, where they are aiming to solve the challenge of a lack of energy for people in difficult to reach or non-permanent locations, such as **refugee camps, emergency hospitals, or isolated rural communities**.

New Markets

Comet Ingeniería spun-out a company that has **entered into the new portable photovoltaic generator market**

The **portable photovoltaic generator sector is a nascent market**, seeking to provide a solution that is more easily transportable, in contrast with current solar energy, which predominantly comes from fixed infrastructure, and yet is more sustainable than fuel generators, which require fuel being delivered for ongoing use.

Through the Technology Transfer program, Comet Ingeniería has been able to spin-out Polar Developments, which is now **offering products within this new and growing market**.

[6] Polar Developments competitive analysis

Delivering a competitive product to the market

Fast deployment

Polar Green products are **fast to install**, and designed for **deployment** that can be undertaken by **unskilled personnel** without specialised tools

A unique aspect of the Polar Green products is its compact and easily-deployable structure. Many of the current structures required to set up solar panels are heavy and need a robotic arm to complete installation. Most of the larger products, competitors for the Polar Green Container especially, require 2 or more operators for set up, whilst for both the Polar Green Container and Tow, only **1 non-specialized operator is necessary**. This simplicity of deployment was highlighted as a key point of interest for potential buyers in conversation with end users.

This simplicity also enables a fast installation time, with the Tow product **deployed within 5 minutes**, and the Container within a few hours by means of an automated system.

Cost savings

The markets for **stationary solar energy products** and **fuel generators** are both very **mature** in comparison with portable photovoltaic generators, and are also both **heavily price-driven,** given many of the remote areas requiring portable generators are in poorer countries. This price-driven approach has been more difficult to achieve within the portable photovoltaic generator market.

A unique selling point for Polar Green is the performance it provides in terms of pricing per kilowatt-peak. A kilowatt peak (kWp) is a standard unit of measurement indicating the amount of power each solar panel can deliver under optimal conditions, showing that the higher a panel's kWp, the better it performs – its nominal power. A competitive analysis of Polar Green products against its closest competitors indicated that its **price per kilowatt peak (€/kWp) was 28% cheaper for the Polar Green Container**, and **42% cheaper for its Polar Green Tow product.**[7]

Furthermore, the portability of the Polar Green solutions mean that unlike stationary solar energy products, they can be **packed up and redeployed** to a new area, therefore being a reusable product for an end user such as the emergency services or non-governmental organisations.

Its easy-to-use deployment structure and lightweight solar panels also remove the need to have a robotic arm to deploy the product, which generates an **additional cost reduction** in comparison to some other solutions.

Autonomous and near-instantaneous power

Deployable solar generator solutions can provide **near-instantaneous power** to regions affected by **natural disasters**, whose power grids face **recovery times anywhere from 1 day to 3-5 weeks**

The existence of a reliable supply of electrical power is a foundation of the European economy – the critical infrastructure sector upon which all others rely. Therefore, in the event of an emergency causing damage to power grids, it is essential to bring power back to the affected communities as quickly as possible. A study by the Joint Research Centre outlined the impact on power grids during natural disasters in Europe, highlighting a recovery time of around **1-4 days for earthquakes** and up to **3 weeks following major floods**. Even longer recovery times – of up to 5

[7] Polar Developments competitive analysis

weeks – were identified for floods caused by hurricanes or storms.[8] A **'plug-and-play'** solution such as Polar Green can **provide energy quickly** to some of these communities as well as to the **emergency services** carrying out operations in the area.

Increased Capacity

Thanks to Polar Green's deployable structure, it remains **lightweight yet highly compact**, with a **greater number of solar panels per product** compared to its nearest competitors whilst still at a low weight. Thanks to this, a competitive analysis of Polar Green products against its closest competitors indicated that its **capacity** – the volume needed to stow a kilowatt peak – is **176% more for the Polar Green Container** and **37% more for the Polar Green Tow**.[9]

Providing energy to at-risk populations

Tackling energy poverty

Portable photovoltaic generators can help tackle the global challenge of '**energy poverty**' around the world, where there are still **759 million people without electricity**, and **2.6 billion** without access to clean cooking

Electricity is a crucial means for communities to alleviate poverty, enjoy economic growth, and improve living standards, and yet today, the concept of 'energy poverty' is still an ongoing challenge. Whilst there has been overall growth in the number of people connected to electricity globally, there has actually been an increase in the number of people without electricity in Sub-Saharan Africa, especially when **the financial impact of the COVID-19 crisis has made it unaffordable for around 30 million people to access basic electricity services**.

Globally, there were still **759 million people without electricity** in 2019, and some **2.6 billion** people without access to clean, modern energy for cooking – one third of the global population.[10] Polar Development's portable photovoltaic generators would be simple solution to deploy in some of these communities, to **start providing energy until more permanent facilities can be built**. They are especially useful as sustainable sources of energy, which do not require additional fuel to be shipped to the community, in comparison to traditional fuel generators.

Supporting isolated communities

There are as many as **7 million displaced people** in refugee camps that have **access to electricity for less than 4 hours a day**.[11] Globally, over **90% of refugees live in rural areas**[12] with very limited access to reliable and clean sources of energy.

Thanks to their transportability and ease of deployment, Polar Green products are well-placed to help provide sustainable energy solutions to people residing in **difficult to reach or non-permanent locations**, such as refugee camps, field hospitals or isolated rural communities.

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[8] Karagiannis, G., et al, 2017. *Power grid recovery after natural hazard impact.* Available at: https://publications.jrc.ec.europa.eu/repository/handle/JRC108842
[9] Polar Developments competitive analysis
[10] The World Bank, 2021. *Universal Access to Sustainable Energy Will Remain Elusive Without Addressing Inequalities.* Available at: https://www.worldbank.org/en/news/press-release/2021/06/07/report-universal-access-to-sustainable-energy-will-remain-elusive-without-addressing-inequalities
[11] Lehne, J. et al, 2016. *Energy services for refugees and displaced people.* Energy Strategy Review, Vol 13-14.
[12] UNHCR, 2021. *Solar cooperatives give refugees and locals in Ethiopia clean energy and livelihoods*. Available at: https://www.unhcr.org/uk/news/stories/2021/6/60b8c9874/solar-cooperatives-give-refugees-locals-ethiopia-clean-energy-livelihoods.html

Protecting the environment

Providing green energy solutions

Polar Green generator products are providing **sustainable** and **green** supplementary/alternative solutions to fuel generators

Traditionally, most generators have used fuel such as petrol, gas or diesel, and the portable photovoltaic generator market is an emerging one. While fuel generators can be reliable, they also have limitations such as **requiring refuelling** – which can be difficult for communities in remote locations. Furthermore, these types of generators can have **a sizeable impact on pollution;** they emit carbon dioxide as well as other pollutants, such as particulate matter and nitrogen oxides, and contribute to noise pollution also.

Polar Development meanwhile are offering a solution using **renewable energy**, that could **supplement or potentially replace** the use of fuel generators for certain end users. They also do not require refuelling, allowing for easier installation in hard-to-reach communities.

Environmental policies

The European Commission is seeking to **accelerate the take-up of renewables** in the EU, increasing the target of "at least 32%" of renewable energy sources in the overall energy mix to **"at least 40%"** by 2030, with the ultimate goal of becoming climate neutral by 2050.[13]

Polar Developments provides a solution that is helping to expand offerings within the renewable energy domain, especially with an **innovative product that could replace more polluting fuel generators**.

Would these benefits have been realised without ESA?

ESA has been highly involved in the project at every stage, providing continuous support. Nearly 20 years ago, ESA initiated work to find a solution for deploying large structures in space. This led to the development of the modular deployable structure technology and eventually the **ESA patent on modular deployable structures,** the technology key to the Container and Tow products. Comet was contracted under ESA to develop this technology and when Comet identified the potential for using these structures in a terrestrial application, the firm received further **ESA funding for the technology transfer**.

The spin-off company, **Polar Developments, has since been involved with the ESA Business Incubation Centre (BIC) in Madrid**. Polar Developments have graduated from the ESA BIC programme but remain a member of the ESA BIC family.

"**ESA was fundamental** for this product – we have had continuous support from them for its development."

Pepe Nieto, CEO & Program Manager for Comet Ingeniería

[13] European Commission, 2021. *Commission presents Renewable Energy Directive revision.* Available at: https://ec.europa.eu/info/news/commission-presents-renewable-energy-directive-revision-2021-jul-14_en

… with further development and benefits to come

Polar Developments are currently finalising purchase orders for their smaller case product and hope to commercialise the Tow and Container products by spring 2022. **The company has received considerable interest in its products and is engaged in early-stage discussions with a range of potential end-users for the container product**, including non-governmental organisations and private companies, reflecting the variety in the potential user base.

Though the focus will initially be on a European customer base, Polar Developments has global ambitions and sees strong potential for the container product in developing countries, particularly in remote areas and disaster response applications.