Interreg North-West Europe
TRANSFORM-CE
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Business support – case study Badger Energy Ltd

Redesigning products with recycled plastic feedstock

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As part of the TRANSFORM-CE project, several case studies will be done to assess the conditions that foster the uptake of recycled plastic feedstock in (new) products. This document covers the results of the case study at Badger Energy Ltd, based in Manchester, UK. A total of 20 case studies will be done, each representing one product to be (re)designed with recycled plastic. In depth support will be given to five cases per country (The Netherlands, Germany, Belgium, and the United Kingdom).

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Deliverable WPT3 D3.4 Redesigned products with AM
WPT3 D3.5 Redesigned products with IEM
WPT3 D3.7 Redefining Circular Economy business models

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1. Introduction and method

1.1 Goal of case study

TRANSFORM-CE is an international research project about the uptake of recycled single use plastic (SUP) feedstock. A core part of this project is to provide in-depth business support to businesses willing to use recycled plastic materials in (new) products. The uptake of SUPs implies that companies in the plastic industry must make a major transformation. In order to gain a better understanding of the support required for the wider uptake of recycled plastics (such as SUP) by companies, 20 different case studies will be completed, documenting the conditions that foster the uptake of recycled feedstock. In line with the technologies of the pilot plants from the TRANSFORM-CE project, cases will represent either IEM[1] technology or AM[2] technology.

Thus, the aim of these case studies is twofold; 1) to support the case study company with their specific request to help foster the uptake of recycled plastic feedstock into one of the company's products, and 2) to gather insights into the conditions necessary to support the wider uptake of recycled plastics by using IEM and AM technologies. The case studies also present a unique opportunity to study the technical requirements for (re)designing products with IEM and AM. The learnings of the various cases and (re)designed products could serve as a proof of concept that provides the entire value chain with the insight and confidence to uptake recycled feedstock, creating circular economy opportunities for all stakeholders.

1.2 Case study process

The case studies are being carried out between September 2021 and December 2022. The case study process is structured in four steps[3], with an iterative approach at the end of each step. The first step (*initial diagnostic*) aims to establish a starting point and describes the challenge to be addressed. The second step (*circular product development*) captures basic information about the product (re)design and describes prototyping and testing leveraging IEM and/or AM technologies. The third step (*circular product management*) covers how to commercialise the new (or redesigned) product and describes the product's relevance for business and environment, creating a successful circular business model. The last step involves a wrap-up of the results and concludes with strengths of the redefined business model, an overview of the barriers and enablers for circularity, and learned lessons from the case study. The final result is a case study report, covering the previously established information.

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[1] IEM: Intrusion-Extrusion Moulding (for low(er) value recycled material), a combination of two techniques to produce plastic products/components. With extrusion the polymer is being melted, thereafter the polymer is being forced into a shape (by using a mould).

[2] AM: Additive Manufacturing (for high(er) value recycled material), method of creating objects layer by layer according to a digital design.

[3] This work uses insights derived from other activities of TRANSFORM-CE, in particular the case study method of WPT3 D2.1: *Case study methodology - Researching good practices of circular economy business models.*

The total case study can be seen as a package of business support (all steps). Yet, a specific type of 'in-depth support', chosen from the menu-card[4], will be done for each case study. This support differs from company to company and will be selected based on a first analysis of the case. Examples of in-depth support include: material testing, prototyping and production trials, implementation of technology and use of recycled filament.

An overview of the case study analysis process is shown in figure 1 on the next page. In order to obtain the results, a 'collaborative/participative' assessment is used to collect further information, which gives insights in the overall innovation process. At the end of the case study, an iteration will be done to validate the results. The reported results will be sent to the contact person by email, so this person can validate the results and check if something is still missing or if information has been misinterpreted. Any comments will be processed, and the results will be adjusted accordingly. Table 1 gives an overview of the people that have been interviewed during the case study.

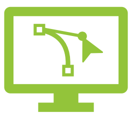
Table 1: *Overview of interviewed people*

	Interviewed person	Function
Step 1: Initial diagnostic	Llion Rowlands	Managing Director
Step 2: Circular product development	Llion Rowlands	Managing Director
Step 3: Circular product management	Llion Rowlands	Managing Director

[4] An extensive list of the support possibilities is presented in a separate document '*Transform-CE support Summary*', describing the menu-card.

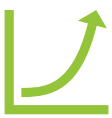
Step 1. Initial Diagnostic

- First assessment of company
- Establish starting point
- Describe challenge to be addressed
- State project goal



Step 2. Circular Product Development

- Describe product to be (re)designed
- Assess context in which product will be produced, used and marketed
- Design product
- Describe product's relevance for business and environment
- Create successful circular business model
- Prototyping and testing leveraging IEM and/or AM technologies



Step 3. Conclusion

- Wrap-up of results
- Strengths of redefined business model
- Summarise barriers and enablers for circularity
- Describe learned lessons

Report

- Succinct, yet informative case study report
- Excellent exposure opportunities for business

Figure 1: *Overview of case study process*

2. Step 1 – Initial diagnostic

The first step focusses on an initial diagnostic of the case study, which includes outlining the company profile, its wishes and the project goal.

2.1 Company profile

Badger Energy Ltd operates in the cleantech sector and is an Electric Vehicle (EV) infrastructure hardware and software solutions provider. A short overview of Badger Energy Ltd is given in table 2.**Error! Reference source not found.**

Table 2: *Overview of company*

Topic	Information
Company name	Badger Energy Ltd
Website	https://badger-ev.com/home-uk/
Country	UK
Size of company (0-10, 10-200, 200-500, 500+ employees)	0-10
Mission/vision	Badger Energy Ltd was established in 2020 together with a group of like-minded stakeholders and partners as a master distributor of existing, multi award-winning renewable energy products with a mission to stimulate business-led market interventions, that advance a low-carbon economy throughout the EMEAA region. The group commits to providing the best environmentally friendly technologies and to keep developing sustainable renewable energy solutions & products to cover the energy demand of communities, commerce & industry, and the public sector.
Value proposition	They service their customers' needs while exceeding expectations, differentiating themselves by providing innovative, best in class products, end-user & installer enquiries, training, competitive pricing, and excellent customer service to their exclusive distribution partners in each region.
Main activity	Badger Energy Ltd supplies and fits EV charging points to private/residential and business customers. The range of charging points supplied are designed to be cost-effective and aesthetically pleasing, with features that can include PV integration, RFID authorisation, smart charging, and dynamic load balancing. Badger Energy Ltd also partner with Eden Reforestation Projects to plant 5 trees for every EV charger purchased.

2.2 Current situation & challenge

Badger Energy Ltd supply and fit self-contained EV chargers, predominantly to residential clients. The EV chargers include an EV charging unit and a clip-on fascia. Currently the charger and fascia are both manufactured in China, using virgin plastics (assumed ABS). Badger Energy Ltd recognise that their customer base is currently very environmentally conscientious, but they are expecting that the EV market will expand to incorporate non-environmentally mind customers as late-stage adopters. In the future, Badger Energy Ltd would like to have the fascia's manufactured locally (Manchester or UK) using recycled plastic. While they believe that manufacturing the product from recycled plastic would create a key USP, they would also like to redesign the fascia so that can be retrofitted onto the existing charging point, is aesthetically pleasing, is at a suitable price point, and can enable the functionality of the charging point. Challenges are related to design for manufacture to incorporate more sustainable materials that can be mass manufactured, are technically suitable for the lifetime of the EV charger while retaining price competitiveness and the possibility to manufacture more locally in the UK (rather than the Far East) to allow reduced transport costs and carbon footprint, as well as shorter lead times greater flexibility to adapt in the future.

Description of support

The support provided has centred around the plastic fascia of their existing EV charging point, which was redesigned and optimised for mass manufacture. The plastic fascia was redesigned using CAD software and produced (as scale prototypes) through AM technologies using TRANSFORMS-CE recycled filaments. Guidance was provided on optimising the design for mass manufacture and assistance given to Badger Energy Ltd in identifying additional potential support mechanisms, both internal and external to the project, that could enable mass manufacture.

3. Step 2 – Circular product development

After creating a first analysis of the company and project, a more detailed assessment of the (re)designed product is made. This includes basic information about the product and an assessment of the context in which the product will be produced and used, as well as an analysis of the circularity of the product. Moreover, a more detailed design of the product is created, which goes hand in hand with prototyping & testing.

3.1 Circular product canvas

The new (or redesigned) product is investigated by using a circular product canvas (CPC). This model is created for the purpose of this study and covers the main aspects to consider in circular product design. The CPC of Badger Energy Ltd is visible in Figure 2 and a description of each element is given below.

RESOURCES & MATERIALS

- Final product will be mass manufactured in UK.
- Made with recycled plastic.
- Prototypes printed using AM technologies and Transforms-CE filament.

CIRCULARITY OF PRODUCT

- Use of recycled plastics.
- Increase material efficiency.
- Manufacture locally (reduce transportation emissions and impacts).

PRODUCT

- Redesign fascia using recycled plastic.
- Retrofit onto existing EV charging unit
- Should conceal the charging unit / cables
- Include a cut out to enable lights to indicate operational settings and error codes.
- Egg-shape is desired
- Matte black or metallic silver

BUSINESS & PRODUCT VALUE

- Product provides the outer surface of the charging unit.
- Reshoring manufacture from China to the UK.
- Using recycled plastic, utilising waste materials.
- USP – use of recycled content
- Must appeal to non-environmentally minded late adopters
- Reduce unit cost price.

TOOLS & TECHNOLOGY

- Final product will be mass manufactured using injection moulding.
- Prototype designed and produced using CAD and AM technologies.

REQUIREMENTS

- Needs to retrofit on to existing charging unit.
- Should be made from recycled plastic.
- To be made in UK / locally

REGULATIONS & COMPLIANCE

- Adhere with requirements to achieve CE / UKCA marking
- Adhere to applicable standards such as EN IEC 61851-21-2018 and EN IEC 61851-1:2019 (general requirements for EV conductive charging systems)
- EU Fit for 55 deal

Figure 2: *CPC of EV Charger fascia for Badger Energy Ltd*

Product

The redesigned product is a fascia that fits onto the outside of an existing EV charging point unit, which are fitted in residential settings, usually attached to a garage or outside wall. The fascia provides the outer surface of the charging unit, concealing the charging unit and associated cables when not in use. The fascia design includes a cut out which enables the light of the charging units to be seen and enables operational settings and error codes to be indicated using different colours and patterns. In line with their existing range, the redesigned fascia will be made available in matte black and metallic grey, but the company name/logo will be designed to be more inconspicuous. In terms of shape, Badger Energy Ltd preferred an egg-shaped design. The design of the new fascia has been optimised for mass manufacturing, where it will be made using recycled plastic. The prototypes created by MMU were printed using AM technologies and TRANSFORMS-CE recycled filament.

Resources & materials

It is intended that the final product will be mass manufactured using recycled plastic. Assistance has been given to Badger Energy Ltd to identify additional potential support mechanisms, both internal and external to the project, that could enable mass manufacture locally with in Manchester or the UK. The prototypes created by MMU were printed using AM technologies and TRANSFORMS-CE recycled filament.

Tools & technology

It is expected that the final product will be produced through mass manufacturing, where the product will be made through injection moulding. The final product will also be made using recycled plastic, rather than virgin ABS, thus adhering to circular design principles. To further improve the circularity of the final product, manufacture will be located in the UK (preferably the north-west / Manchester), thus saving the carbon emissions (and other impacts) associated with the existing production contracts in Asia. During the product design and prototyping phases, CAD and AM technologies were used.

Circularity of the product

Throughout the design phases the circularity of the end product has been improved. As a start, Badger Energy Ltd were keen to incorporate recycled plastics into the final design. This would be an improvement in circularity compared with the original which uses virgin ABS. Furthermore, during the different design iterations, the decision was made to reduce the overall size of the fascia. By reducing the size, greater material efficiency can be achieved. Finally, the approach used in the design phase, specifically the use of CAD and AM technologies to create prototypes, enabled more the product to be redesign (and prototyped) with greater agility and at greater speed reducing the resources (human, material, and time) needed to complete this task.

Another request made by Badger Energy Ltd was for the final product to be mass manufactured locally (in the UK, ideally Manchester or the Northwest). Guidance has been provided to the company to explore potential avenues that would realise this ambition. By manufacturing the part locally, this would adhere to the proximity principle, and provide local green jobs. Furthermore, by reshoring the production phases, the carbons emissions and other impacts associated with transporting parts from the Far East could be avoided.

The product itself (fascia) will be retrofitted onto existing charging units. Badger Energy Ltd are expecting to produce between 2,000-5,000 units per month. It is expected that the fascia will have a lifespan of numerous years with Badger Energy Ltd currently offering a 3-year warranty on their existing charging units. As the fascia clips onto the charging unit, it can be easily removed and replaced/upgraded when necessary.

Requirements

The redesigned fascia should be able to be retrofitted onto the existing EV charging unit. Designs for the fascia were first hand drawn, then reproduced in CAD, where the design could be edited and refined within an existing file. Prototypes for two iterations were produced using AM technology. Where the prototypes were 3D printed using TRANSFORMS-CE recycled filament. The use of IEM was also explored through project partner Save Plastics. However, this was deemed unfeasible due to the technical requirements needed – i.e., the fascia requires a thickness of approx. 2mm, whereas the minimum thickness achievable using IEM is 20mm.

Business and product value

The redesigned fascia fits onto the outside of an existing EV charging point unit, which are fitted in residential settings, usually attached to a garage or outside wall. The fascia provides the outer surface of the charging unit, concealing the charging unit and associated cables when not in use.

Currently the facias used by Badger Energy Ltd are produced and transported from China for use in European and American markets, where the current cost is USD$15 per unit. It is expected that the redesigned fascia will be manufactured locally in the UK (preferably Manchester or the Northwest) using recycled plastic, where Badger Energy Ltd are hoping to achieve a unit cost somewhere in the region of GBP£10-12.

The fascia is an integral part of the EV charging unit, which provide concealment for the actual charger and cables as well as a mechanism to provide information (a cut out enables the light of the charging unit to be seen where operational settings and error codes can be indicated using different colours and patterns).

Badger Energy Ltd have acknowledge that to-date their consumer base has focused on the environmentally conscious – i.e., those that have chosen to purchase an electric car, and thus need a home charging point, due to their awareness concerning environmental issues. It is thought that in the future, the consumer base will expand to include non-environmental conscientious consumer who will take up the technology as late adopter. Thus, it is important that the look of the charger (specifically the fascia) is aesthetically pleasing for both types of customers.

Badger Energy Ltd also believe that using recycled material to manufacture the fascia will provide a unique USP and link into the environmental credentials of the wider EV sector.

Regulations and compliance

Once at the production stage, the fascia will have to adhere with conformity requirements – UKCA in the UK and CE for access to the European Single market. Conformity requirements ensure that any product placed on the market conform with relevant health, safety, and environmental protection standards. The fascia (within the charging unit set-up) will also need to adhere with any requirements detailed by standards specifically developed for EV charging systems such as IEC 61851-21-2018 and IEC 61851-1:2019 (general requirements for EV conductive charging systems).

The recently agreed "Fit for 55" deal published by the EU will seek to end the sale of new CO_2 emitting cars by 2035. This presents a clear signal to manufacturers and citizens to accelerate the production and sale of low- and zero-emission vehicles. As a consequence, the uptake of EV by consumers has the potential to increase in the next few years. As such the demand for residential EV charging points may also increase.

3.2 Design, prototyping & testing

Badger Energy Ltd met with representatives from MMU PrintCity to discuss the re-design of a fascia. The resultant re-design brief is presented below (Figure 3). During this initial meeting, the team also explored manufacturing from low-grade mixed waste using IEM with project partner: Save Plastics. However, this route to manufacture was deemed unfeasible due to minimum thickness requirements (i.e., a part produced using IEM could achieved a minimum thickness of 20mm, while the fascia being redesigned will have a thickness of appropriately 2mm). As a result, guidance was given to Badger Energy Ltd to explore other support mechanisms that could help them identify suitable manufacturers within the UK. After the meeting, the EV charging point unit and an example of the existing fascia was provided by Badger Energy Ltd and made available for 3D scanning.

Original design of fascia

(available in metallic grey and matte black)

Re-design brief:

- Retrofit existing charging unit.
- To use recycled plastic.
- To be manufactured locally.
- To have a curved or domed design (egg shaped preferred).
- To be streamlined.
- To enable functionality of charger (e.g., keep cut out for light).
- To incorporate the company name, leaf and/or lightening logo.
- To keep same colours, but may be open to other suggestions.
- To be optimised for mass manufacture

Figure 3: *The agreed re-design brief of an EV Charger fascia for Badger Energy Ltd.*

Using the 3D scans as a starting point, two new design options were developed for the fascia. The first design option (#1) followed a basis egg-shaped design, illustrated using a plain black and grey finish. The second design option (#2) followed a more creative design, utilising wood veneer. The designs were first hand drawn as initial sketches, then re-created as a CAD file, before prototypes were printed using AM technology and TRANSFORM-CE recycled filament. Following on from the first design meeting, initial sketches of potential designs (Figure 4) were sent to Badger Energy Ltd for review and a second design meeting set up.

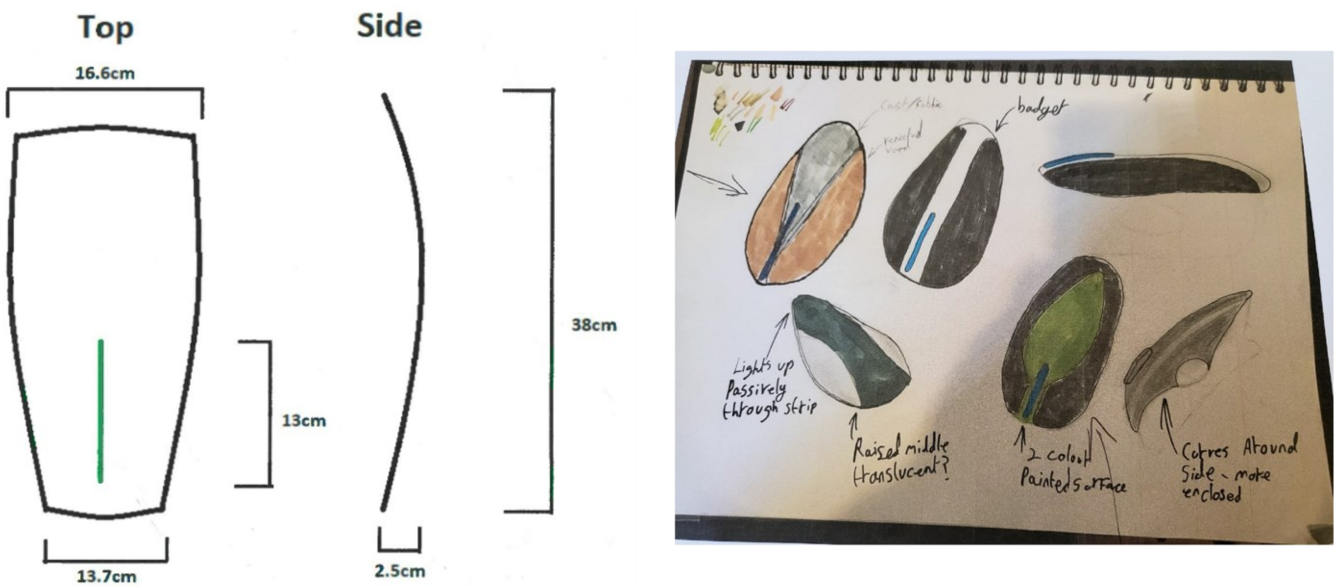


Figure 4: *Measurements from the original fascia, and sketches of potential designs.*

During the second design meeting, the two design options were discussed. Badger Energy Ltd agreed to continue the development of the first design option (#1: simple egg-shaped design). With regards to the second design option (#2 creative wood veneer), Badger Energy Ltd were keen to explore this option. The challenges associated with a curved design in wood were explained, however the possibility of recreating the egg shape in 2D from a cut/milled sheet of wood was identified. As wood is outside the scope of TRANSFORM-CE, the team did not explore this option any further.

Over several stages, the design for the fascia was developed (Figure 5). Notes provided by Badger Energy Ltd during the design stage included that aesthetically, they were keen to steer away from the original badger design, and if using a leaf motif, it would need to match the leaf that features in the company's logo. Options for embossing and surface pattern design were also explored as a way to integrate further features and visual interest, at minimal cost. From the first iteration, it was agreed that the width and length of the cut out should be altered (thinner / shorter). All iterations were optimised for mass manufacturing. The first prototype was printed using TRANSFORM-CE recycled filament.

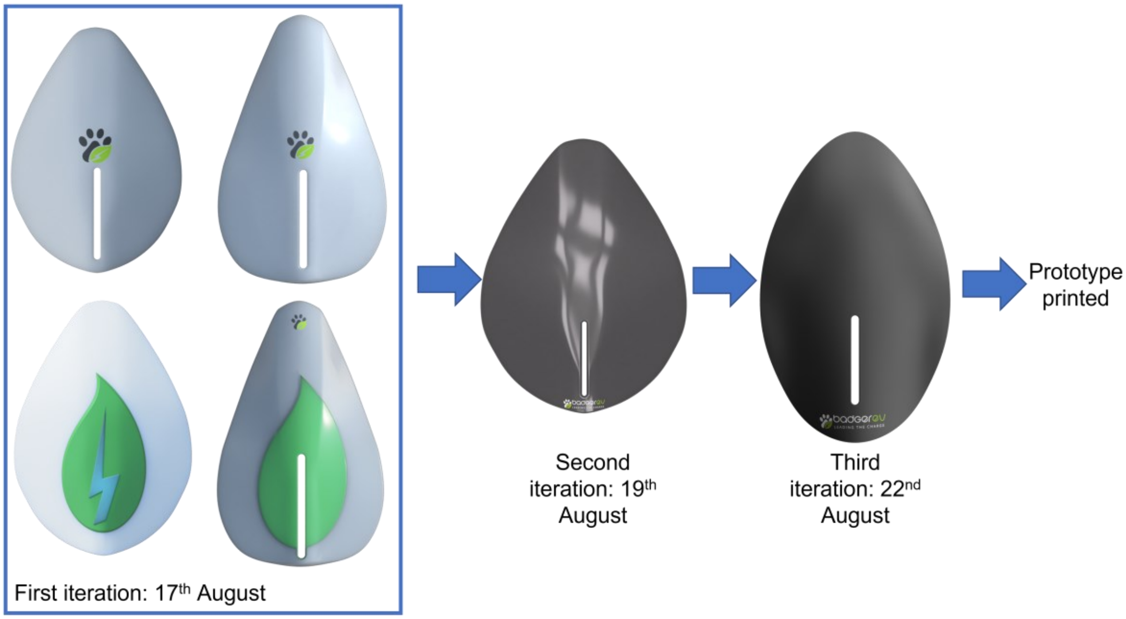


Figure 5: *Development of design iterations*

While satisfied with the design presented, feedback from Badger Energy Ltd highlighted concerns regarding the overall size of the fascia. As this was related to the size of the charging unit, Badger Energy Ltd agreed to explore the possibility of rearranging the components of the charging unit (in-house) to reduce the overall surface area that the fascia would be required to cover. During this time, Badger Energy Ltd presented the concept of the re-designed fascia at a soft launch during a trade show in Spain. Feedback from potential end-users were overall positive. A third design meeting took place in December 2022, where the dimensions of the adapted charging unit was provided to the design team. The CAD file of the initial prototype was then amended to fit the new dimension and a second prototype was printed using PLA. The prototype was vapour smoothed to enhance the final appearance.

Figure 6: *Final prototype before (Left) and after (right) vapor smoothing.*

4. Step 3 – Conclusion and recommendations

After going through the previously described steps, a wrap-up is presented in this chapter. This includes identifying the strengths of the redefined business model in regard to circularity, describing the learned lessons from the case study project and providing recommendations for the next steps.

4.1 Strengths of the redefined business model

Circularity of the product

By redesigning the fascia, Badger Energy Ltd can improve the circularity of their product by using recycled plastic from waste materials, improving material efficiency, and engaging with local manufacturing services to reduce carbon emissions and impact associated with long-distance transport.

Product (re)design, testing and/or prototyping

The plastic fascia was redesigned using CAD software and produced (as scale prototypes) through AM technologies, using TRANSFORM-CE recycled filaments. Guidance was provided on optimising the design for mass manufacture and assistance given to Badger Energy Ltd in identifying additional potential support mechanisms, both internal and external to the project, that could enable mass manufacture.

4.2 Lessons learned

This case study has highlighted the agility and speed at which AM technologies can be used to design, develop, and prototype products.

4.3 What's next

After a successful soft launch at a trade show in Spain in September 2022, Badger Energy Ltd hope to launch their new charging unit (including the redesigned fascia) first into the Spanish market over the next 12-18 months. They have been connected through an external contact (project: Eco-I NW) to the Growth Hub, who are working with Badger Energy Ltd to secure an appropriate supplier who would be able to mass manufacture the fascia in the UK using recycled plastic. They have also indicated an interest in redesigning the charging unit. However, this sits outside the support agreed through the TRANSFORMS-CE project, but guidance has been provided to find alternative means of providing similar support. They are also keen in the future to develop a mobile application for use with the charging unit.

About the project

The problems associated with plastic waste and in particular its adverse impacts on the environment are gaining importance and attention in politics, economics, science and the media. Although plastic is widely used and millions of plastic products are manufactured each year, only 30% of total plastic waste is collected for recycling. Since demand for plastic is expected to increase in the coming years, whilst resources are further depleted, it is important to utilise plastic waste in a resourceful way.

TRANSFORM-CE aims to convert single-use plastic waste into valuable new products. The project intends to divert an estimated 2,580 tonnes of plastic between 2020 and 2023. Two innovative technologies – intrusion-extrusion moulding (IEM) and additive manufacturing (AM) – will be used to turn plastic waste into recycled feedstock and new products. To support this, an R&D Centre (UK) and Prototyping Unit (BE) have been set up to develop and scale the production of recycled filaments for AM, whilst an Intrusion-Extrusion Moulding Facility, the Green Plastic Factory, has been established in the NL to expand the range of products manufactured using IEM.

Moreover, the project will help to increase the adoption of technology and uptake of recycled feedstock by businesses. This will be promoted through research into the current and future supply of single-use plastic waste from municipal sources, technical information on the materials and recycling processes, and circular business models. In-depth support will also be provided to a range of businesses across North-West Europe, whilst the insights generated through TRANSFORM-CE will be consolidated into an EU Plastic Circular Economy Roadmap to provide wider businesses with the 'know-how' necessary to replicate and up-scale the developed solutions.

Lead partner organisation
Manchester Metropolitan University

Partner organisations
Materia Nova
Social Environmental and Economic Solutions (SOENECS) Ltd
Gemeente Almere
Save Plastics
Technische Universiteit Delft
Hogeschool Utrecht
Hochschule Trier Umwelt-Campus Birkenfeld Institut für angewandtes Stoffstrommanagement (IfaS)
bCircular GmbH

Countries
UK | BE | NL | DE

Timeline
2019-2023

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