

<b>Institution:</b> Brunel University London		
<b>Unit of Assessment:</b> 12 Engineering		
<b>Title of case study:</b> Driving a Carbon Negative Market in Europe		
<b>Period when the underpinning research was undertaken:</b> 2013-2020		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b> 1) Prof Mizi Fan 2) Dr Yonghui Zhou	<b>Role(s) (e.g. job title):</b> 1) Professor 2) Research Fellow	<b>Period(s) employed by submitting HEI:</b> 1) 07/2007-present 2) 02/2015-present
<b>Period when the claimed impact occurred:</b> 2014 – Dec 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> N		

### 1. Summary of the impact (indicative maximum 100 words)

Brunel research has supported the growth of a green technology business that produces decking from wood polymer composite incorporating waste products. Having started as a small importation business, by 2017 Brunel research had helped Ecodek develop into a company worth GBP8,500,000 manufacturing durable, recyclable decking in the UK and selling its products across the UK and worldwide.

It now employs over 50 staff, manufacturing 1,000,000 linear metres of decking per annum, consuming 3,600t of sustainably sourced wood and recycled plastic (including the equivalent of over 100,000,000 4-pint milk bottles) whilst locking up 600,000 kgCO<sub>2</sub> each year. The decking has now been used in over 6,000 projects, including a number of high-profile prestige projects, such as the Jumeirah Residence Beach Walkway in Dubai, the London Olympic Stadium and Prime Place Greenwich.

### 2. Underpinning research (indicative maximum 500 words)

Professor Mizi Fan's long-standing collaboration with Vannplastic and Ecodek has enabled the company to develop the technology to produce decking from wood polymer composite (WPC) and hence become the UK's leading decking manufacturer and supplier.

A key focus of the research has been the use of waste products to create the composite as well as ensuring that the decking is recyclable [Ref 1]. To enhance the sustainability of WPCs and alleviate the resource competition with other industrial sectors, Prof Fan developed a research programme which explored the use of waste tyre rubber as a potential source material to create Rubber-Wood-Plastic Composites (RubWPC). In 2013 Brunel led an EU FP7 R&D project, RubWPC, collaborating with Ecodek and other partners [Ref 2].

In this research the Brunel team developed new mixture designs, determined the structure and bonding mechanism, and established the complex structure-property relationship of RubWPC. These were then transferred to the Ecodek research facility for further testing on the test production line before being scaled up for commercial production.

Further research continued into other potential materials. In 2016 Brunel and Ecodek collaborated in the EU funded SMART-Plant and GelClad research projects which sought to create new generations of WPC using both biopolymer and bio/renewable fibres with minimal environmental impacts. These projects aimed at replacing the extensively used oil-based thermoplastics in WPC by using bioplastics, such as Polyhydroxyalkanoates (PHA) and Poly(lactic acid) (PLA). A highly novel cost-effective, durable industrialised and easy to install composite insulation cladding system was developed and implemented (GELCLAD cladding, <https://www.gelclad.eu/>) [Ref 3].

## Impact case study (REF3)

The Brunel research group has also sought to address the major challenges of fire and other properties of cellulosic-bioplastics materials [Ref 4], intrinsic incompatibility and insufficient interfacial bonding between the raw material constituents [Ref 2,5], and processing difficulties of bioplastics on existing compounding/extrusion line [Ref 3,6].

### 3. References to the research (indicative maximum of six references)

- 1) Zhou Y., Stanchev P., Katsou E., Awad S. and Fan M. (2019). A circular economy use of recovered sludge cellulose in wood plastic composite production: Recycling and eco-efficiency assessment. *Waste Management* 99, 42-48.  
<https://doi.org/10.1016/j.wasman.2019.08.037>
- 2) Zhou Y., Wang Y. and Fan M. (2019). Incorporation of tyre rubber into wood plastic composites to develop novel multifunctional composites: Interface and bonding mechanisms. *Industrial Crops and Products* 141, 111788.
- 3) Rao J., Zhou Y., & Fan M. (2018). Revealing the interface structure and bonding mechanism of coupling agent treated WPC. *Polymers* 10(3), 266.  
<https://doi.org/10.3390/polym10030266>
- 4) Naughton A., Fan M., & Bregulla J. (2014). Fire resistance characterisation of hemp fibre reinforced polyester composites for use in the construction industry. *Composites Part B: Engineering* 60, 546-554. <https://doi.org/10.1016/j.compositesb.2013.12.014>
- 5) Zhou Y., Fan M. and Lin L. (2017). Investigation of bulk and in situ mechanical properties of coupling agents treated wood plastic composites. *Polymer Testing* 58, 292-299.  
<https://doi.org/10.1016/j.polymertesting.2016.12.026>
- 6) Madyan O. A., Wang Y., Corker J., Zhou Y., Du G. and Fan M. (2020). Classification of wood fibre geometry and its behaviour in wood poly(lactic acid) composites. *Composites Part A: Applied Science and Manufacturing* 133, 105871.  
<https://doi.org/10.1016/j.compositesa.2020.105871>

### Funded projects

- 1) EU FP7 project RubWPC 'Rubber fusion of wood plastic composite to make functional composites for building applications' (Project Number: 333083). Start date: 01 October 2013, End date: 30 September 2016, Overall budget: GBP1,444,071.
- 2) EU Horizon 2020 project SMART-Plant 'Scale-up of low-carbon footprint material recovery techniques in existing wastewater treatment plants' (Project Number: 690323). Start date: 1 June 2016, End date: 31 May 2020, Overall budget: GBP8,658,874.
- 3) EU Horizon 2020 project GelClad 'Highly efficient cladding eco-panels with improved Nano-insulation properties' (Project Number: 723425). Start date: 1 September 2016, End date: 31 August 2019, Overall budget: GBP4,909,523.

### 4. Details of the impact (indicative maximum 750 words)

Ecodek is now the leading company for extruded wood polymer composite (WPC) decking in the UK and the only one which manufactures its products in the UK. A carbon negative organisation, Ecodek was founded in 2002 and was purchased by the Epwin Group for GBP8,500,000 in 2015 [S1]. By 2017 they were manufacturing around 1,000,000 linear metres of decking per year consuming 3,600t of sustainably sourced wood and recycled plastic [S2, S3]. The Founder and Former Managing Director of Ecodek stated [S1], that Professor Fan's research

*"was fundamental to the company's technical development and growth and underpinned development of the Ecodek product range".*

The composite material which is used for all of Ecodek's products, would not have been achievable without the initial research and subsequent development work of Prof Fan and his team [S1, S3]. This longstanding relationship between Professor Fan and the company has been key to the success of the products that it has developed.

Each year the Ecodek manufacturing process locks up 600,000kgCO<sub>2</sub>, the equivalent of 300,000 trees per year.

### **Developing products with a sustainable lifecycle**

Ecodek manufactures its products from recycled waste materials (98%) – primarily plastic (HDPE) with sustainably sourced or waste wood- and its products are 100% recyclable and will be bought back by the company for reuse. The company only sends 2% of its waste to landfill and aiming to reduce this to 0%.

The company prides itself on creating a product that is sustainable. In 2016 the company used the equivalent of 100,000,000 recycled (4 pint) milk bottles in its decking, ensuring that the plastic did not get sent to landfill, and will be recycled again at the end of its life as decking [S3]. The Ecodek product range has been assessed by Bangor University to be carbon negative due to the net effect of removing carbon from the atmosphere.

Professor Fan's expertise in materials and composites enabled the company to develop its own algorithms for agile additive solutions allowing them to adapt to variable qualities of HDPE feedstock. Ecodek was able to accept a wider range of waste materials from recycling companies, which allowed them to move away from using virgin HDPE in its formulas.

In addition, Ecodek is able to offer a waste buyback scheme: returned waste, off-cut, old-stock or unused Ecodek decking are bought back, recycled and used again.

### **Building in-house research and development capabilities**

The EU funded RubWPC project was the catalyst for Ecodek to develop their own in-house capabilities. Prior to this, technical development was the responsibility of one of the founding partners. The project *"enabled the company to invest in technical staff as well as create a dedicated in-house laboratory as well as a small test production line. The lab was equipped with DSE, FTIR and a UTM in order to test tensile strength, all of which enabled us to develop our product range and factory quality control."* [S1]

The company was able to recruit a technical manager and a lab technician in 2014 and 2015 to conduct the research with Brunel and they remained following the project. The ongoing relationship between Professor Fan and his team and the Ecodek team has meant that the staff based at Ecodek have been able to increase the capabilities of their in-house research and development laboratory. In particular, the company now has facilities and capabilities to test their product durability to more formal, industrial standards. The Technical Manager said (in a private communication) that "working with Prof Fan had forced changes, in a good way", leading to an expansion of the skill sets employed at Ecodek and growing the technical department.

Ongoing research and development on the consistency of the polymer has been a necessary part of the Ecodek story as the availability and composition of the feedstock varies. In 2016, Ecodek used over 100,000,000 recycled 4-pint milk bottles in their product [S3]. As a result of Prof Fan's research, the company has developed an ability to respond to changing source materials, such as variations in the thickness of the bottles, which can vary between 0.3-0.66mm. Additional research on the consistency of the product material has expanded to testing of other recyclable materials, including gypsum, glass, hemp, agricultural waste, film waste and HDPE waste.

### **Growing the Company**

From its formation in 2002, Ecodek has grown from a small operation that imported its product to a local manufacturer of environmentally-friendly decking that was sold across the UK and the world.

## Impact case study (REF3)

In 2014 Vannplastic Ltd (trading as Ecodek) made an operating profit of GBP600,000. Ecodek was acquired by Epwin Group plc in November 2015 for GBP8,500,000. Epwin Group's operational profit for the year to 31 December 2016 was GBP24,000,000 up from GBP19,100,000 in 2015. The increased material input costs as a result of continuing weakness of sterling against both the US Dollar and the Euro resulted in an operating profit of GBP22,300,000 in 2017 [S3, S4].

Based in Wrexham, North Wales, Ecodek has grown from a small company in 2002 with only one production line to a company with 4 full production lines staffed by 50 staff 24 hours a day. The research and development team has grown from just the founding partner to a team of 6 staff with relevant technical knowledge and skill. Both the Founder and the Technical Manager of Ecodek attribute this growth to the work with Prof Fan [S1,S3].

New products and innovative solutions have been developed as a result of Fan's research findings which address the difficulties of mixing recyclable materials and maintaining consistency, thereby sustaining the business in the market. In addition to decking, Ecodek's product range has expanded to facades, sub-structure support beams for decks, and motorway sound barriers. All of these products use the composite materials developed in collaboration with Prof. Fan [S3,S4].

### Ecodek products in use

The weather resilience of Ecodek products means that they have an international appeal and are in use by clients across the globe, whether direct to consumers or through builders' merchants such as Travis Perkins, including:

Dubai, UAE – Ecodek designed and developed a specific substructure for the Jumeirah Beach Walkway which would withstand the rigors of the climate. The walkway runs 14km along the UAE's Persian Gulf coastline. At 1.7km "JBR The Walk" was designed as part of the Jumeirah Beach Residence, a hotel and shopping area with 15,000 residents in one of the most developed areas of Dubai. The final delivery of substructure was made in 2017. The Walk is one of Dubai's most famous tourist attractions. Brunel's research on wood polymer composite was used in this construction [S1, S3].

London, UK – Ecodek decking was installed around the outside of the London 2012 Olympic stadium. As part of the legacy of the London Olympic Games, the park, stadium and other facilities have been converted and have been in continuous use since 2012. With over 5,700,000 visitors [S5] to the stadium since 2013 and its rebranding as the permanent home of British Athletics and West Ham United, the unique design benefits of Ecodek decking, including sustainability and durability, continue to be effectively demonstrated in this high traffic area. West Ham reported total attendance of 1,238,318 for the 22 games of the 2018/19 season [S6]. Following the end of the 2018/19 football season, the stadium hosted over 242,000 visitors at concerts, athletics meetings and baseball matches [S3, S7]. Again, this product had been developed with research from Brunel [S1, S3].

Other prestige projects that have used decking manufactured by Ecodek include the Old Bailey London, Royal Wharf Docklands, Mann Island Liverpool and RSPB Weymouth [S8]. In total, Ecodek products have been used on over 6,000 projects.

### Sustainability in UK Housing Developments

A key market for Ecodek products has been high rise housing developments with balconies across the UK as the decking can be manufactured to the exact size of the outdoor spaces. This reduces wastage in terms of having to re-cut standard lengths and also saves time in the installation of the product. By 2015, approximately 65% of Ecodek's sales were to housing developers, such as Barratt Homes and Taylor Wimpey. An example of such a development is Prime Place Greenwich which utilised 6 tonnes of decking [S9]. The bespoke nature of the manufacturing meant that at 360 Barking, another London development, Ecodek was able to supply lengths of decking at very specific lengths e.g. 7m, 5.73m, 4.9m, 3.75m and 1.9m,

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leading to minimal waste for the developer [S10]. Owners of the properties in these developments value the weather-proofing and durability of the decking, which come with a 25-year guarantee.

**5. Sources to corroborate the impact** (indicative maximum of 10 references)

[S1] Letter from the Founder and Former Managing Director of Ecodek

[S2] Ecodek website: <https://ecodek.co.uk/about-us/>

[S3] Letter from the Technical Manager of Ecodek

[S4] 2017 Epwin Group Investment Case:  
<https://beta.companieshouse.gov.uk/company/07742256/filing-history?page=1>

[S5] Queen Elizabeth Olympic Park – Key Facts Summary:  
[www.queenelizabetholympicpark.co.uk/-/media/key-facts-summary-july-2019-v1.ashx?la=en](http://www.queenelizabetholympicpark.co.uk/-/media/key-facts-summary-july-2019-v1.ashx?la=en)

[S6] West Ham Attendances 2018-19 season | Olympic Stadium London Crowd Figures & Stats:  
<https://westhamunitedblog.co.uk/2018/10/19/west-ham-attendance-figures-18-19-season-olympic-stadium-crowds-premier-league-2018-2019-whufc-stats/>

[S7] London Stadium Transforms Through Summer 2019 (18 July 2019) [www.london-stadium.com/top-stories/london-stadium-transforms-through-summer-2019](http://www.london-stadium.com/top-stories/london-stadium-transforms-through-summer-2019)

[S8] Ecodek Case studies: <https://www.ecodek.co.uk/case-studies/>

[S9] Ecodek Case Study: Prime Place, Greenwich: <https://ecodek.co.uk/case-studies/prime-place-greenwich/>

[S10] Ecodek Case Study: NU Living, 360 Barking, London - Composite Balcony Decking:  
<https://www.ecodek.co.uk/case-studies/nu-living-360-barking-london/>