Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 8 (2017) 284 – 291

Procedia MANUFACTURING

14th Global Conference on Sustainable Manufacturing, GCSM 3-5 October 2016, Stellenbosch, South Africa

Circular Economy Ownership Models: A view from South Africa Industry

Paul T Mativenga[a]*, John Agwa-Ejon[b], Charles Mbohwa[b], Al Amin Mohamed Sultan[a], Norshah Aizat Shuaib[a]

[a]*School of Mechanical, Aerospace and Civil Engineering, The University of Manchester, Manchester, M13 9PL, United Kingdom*
[b]*Quality and Operations Management, Faculty of Engineering and the Built Environment, University of Johannesburg, 1 Bunting Road, Auckland Park , 2092, Johannesburg, South Africa*

Abstract

The world is neither globally successful in remanufacturing and re-use of products nor recycling of waste materials. This requires a combination of circular economy management systems, business models and novel technologies. There are contrasting views in literature regarding models for a circular economy. The main views are built on extended producer responsibility and on the role of end users. This paper is based on a study of the South African industry's view of circular economy models, drivers and sustainers, with particular focus on composite waste. Cost reduction was found to be the strongest driver and sustainer for recycling of composites. Thus, maximizing opportunities to reduce cost is a key factor in encouraging South African companies to embrace the circular economy. This is important in developing appropriate national models for managing the transition to a circular economy.

Peer-review under responsibility of the organizing committee of the 14th Global Conference on Sustainable Manufacturing

Keywords: Circular economy ownership models; composites; recycling; South Africa; drivers and sustainers

* Corresponding author. Tel.: +44 161 306 3821; fax: +44 161 306 3803.
E-mail address: P.Mativenga@manchester.ac.uk

Peer-review under responsibility of the organizing committee of the 14th Global Conference on Sustainable Manufacturing
doi:10.1016/j.promfg.2017.02.036

1. Introduction

In a circular economy resources are kept in use for as long as possible, extracting the maximum value and then recovering and regenerating products and materials at the end of each service life. Unfortunately, the opportunities of such a green economy and the potential to develop low carbon products, remanufacture retired products and recover valuable materials, are not being fully utilized on a global level. For 2015, it was estimated that the European Union (EU) produced over 300,000 tonnes of composite waste, of which around 250,000 was end-of-life (EOL) waste [1]. It is estimated that 98% of the composite waste is disposed to landfill. These volumes illustrate the challenge faced by industry in tackling the waste problem. There are also major opportunities because carbon fibre reinforced composite materials are high value materials and re-using or recycling these would enable cascading of value within the supply chain. The high volume of glass-fiber reinforced plastic (GFRP), which is typically 98% of composites volume, imply that there is a bigger environmental challenge and advantage for re-using and recycling GFRP. The energy content of new carbon fibre and glass fibre are is relatively high and around 183 to 286 MJ/kg and 13 to 32 MJ/kg respectively [2]. It was also reported that the energy required to recycle carbon fibre is only about 5% to 10% of the production energy of virgin fibre [3]. In recent studies it was established that the energy demand for mechanical recycling of GFRP is only 0.17 MJ/kg at a recycling rate of 150 kg/hour [4]. Thus, the use of composites in a circular economy is also a good strategy to avoid or reduce the high energy demand associated with virgin material production. EU legislation is forcing companies to consider recycling of composites. It is therefore timely and proactive for the South African companies to consider end–of-life options for composite waste in line with international trends.

1.1. Ownership Models for a Circular Economy

There are examples of transition to circular economy for other products outside the composite industry. For end-of-life vehicles (ELVs), Sweden implemented the Extended Producer Responsibility (EPR) scheme, which incorporates environmental costs throughout the product lifecycle, into the market price of the product [5]. This additional money goes into the Car Scrapping Fund, funding the dismantling of the product. It makes the manufacturer responsible for the waste they produce, using financial incentives, either combined with a reuse, buy-back or recycling initiative. Third parties, also known as Producer Responsibility Organizations (PRO), can be paid by the producer to deal with the waste management. Proponents argue that EPR takes the financial burden of waste management from local government and gives incentive to manufacturers to reduce the amount of primary resources, to improve product design, to use secondary materials and reduce waste [6]. In Japan, the end-of-life vehicles (ELV) system includes a recycling fee collected by the Japan Automobile Recycling Promotion Centre [7]. Japan already achieves 95% recovery of automotive shredder residues. For the four streams targeted by specific EU Directives (packaging, batteries, ELVs and WEEE), an EPR scheme has been systematically implemented in EU Member States [8].

Sachs [9], in his paper “Planning the Funeral at the Birth..”, argues that the end-of-life responsibility should be borne by the end user who turned the product into waste and not the manufacturers who are creating beneficial products. While, Scheijgrond [10], suggests that that government should take charge entirely. Thus, there is no consensus on a universal ownership system for dealing with end-of life waste. It is timely to consider the views of industry across different countries and understand the drivers and sustainers for transition to a circular economy.

1.2. Drivers and Sustainers for Sustainable Manufacturing

Bey et al [11], in a study of international companies, reported that the main barriers for implementation of environmental strategies in companies were a lack of information on environmental impacts, a lack of expert knowledge and a lack of allocated resources (manpower and time). In terms of sustainers, they reported two main factors, namely customer demand and competitive edge.

2. Research Methods

This study was based on questionnaires administered to a total of 50 companies in South Africa, and todate, 22 companies returned the questionnaires, a response rate of 44%. This response rate is fairly high compared to many questionnaire based studies. Most of the questionnaire was administered by hand to improve the response rate. For the study, the composites manufacturers list for South Africa was not readily available. The companies were identified by searching the Kompass Business directory and the information was supplemented by internet searches. Kompass enables searching for detailed information about a company such as Business sector, Company Name and Contact information.

The target group for the questionnaires was company Directors and Senior Managers. The time they would have to fill the questionnaire was limited, thus most of the questions were designed to be closed i.e. forced choice format and to fit on a 2 page length. The response options were provided on a scale to make it easy to code and analyse results quantitatively. The questions were developed to assess drivers and sustainers for transition to a circular economy. These were inspired by Bey et al [11], who published a CIRP Annals paper on barriers for implementation of environmental strategies in manufacturing companies. Bey et al [11], administered their questionnaire to international companies. Unlike their work, this paper was focused on composite materials/waste and on the South African industry. The motivation was to develop country specific information that can be directly relevant to the region and ultimately to enable future comparison to other countries and jurisdictions. A new addition is also that one of the questions was to ascertain circular economy ownerships models, to enable exploring alternative views in literature, with regards to extended producer responsibility and the role of end users. Considering the local governance, other options of stakeholders were added. Additional information was sought to ascertain volumes of composite material and production waste for the associated companies.

3. Results and Discussions

Fig. 1 shows the responses to the questionnaire for the drivers that triggered or may trigger companies to reuse/recycle production waste. The response options available on the questionnaire design were, (1) Strongly disagree, (2) disagree, (3) Neither agree or disagree, (4) Agree, and (5) Strongly agree. These where converted to a scale of 1, 2, 3, 4, 5 which translates to 20, 40, 60, 80 and 100% respectively. As shown in Fig. 1, the industrial respondents generally agreed that cost reduction was a major driver for them to consider reuse/recycling of production waste. Additionally, they acknowledged the role of management and being proactive as drivers for sustainable materials usage. The respondents disagreed on all the other factors such as legislation, customer demand, pressure from stakeholders and avoiding bad publicity (i.e. these did not score up to 80%). This is interesting as it was expected that legislation would come up as a major driver. It could be that the use of legislation to drive up change is not as prominent in South Africa as it is in the EU, possibly because the companies are business and bottom-line driven. This international difference needs further investigation to understand the business environment and local conditions.

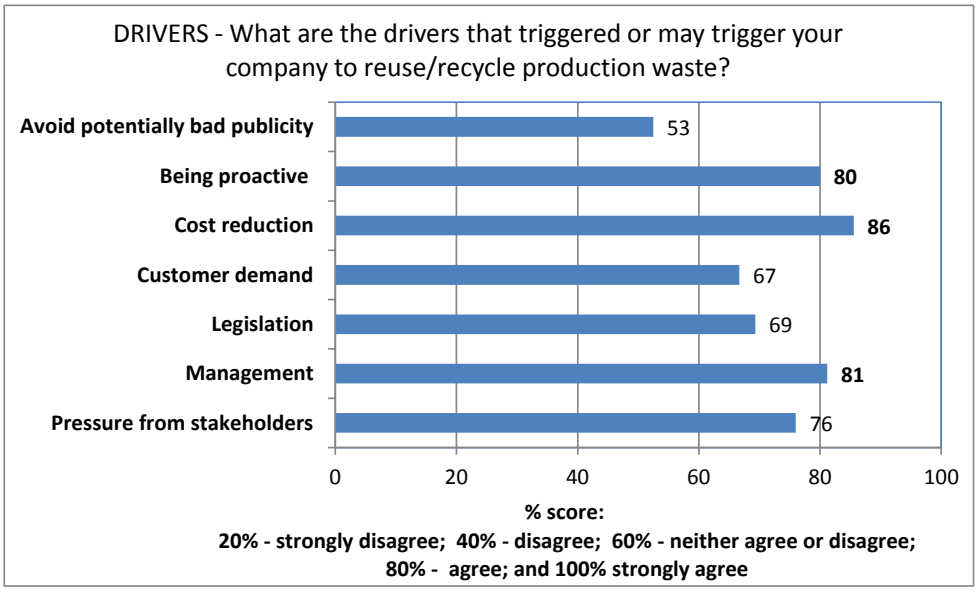

Fig. 1. DRIVERS - What are the drivers that triggered or may trigger your company to reuse/recycle production waste?

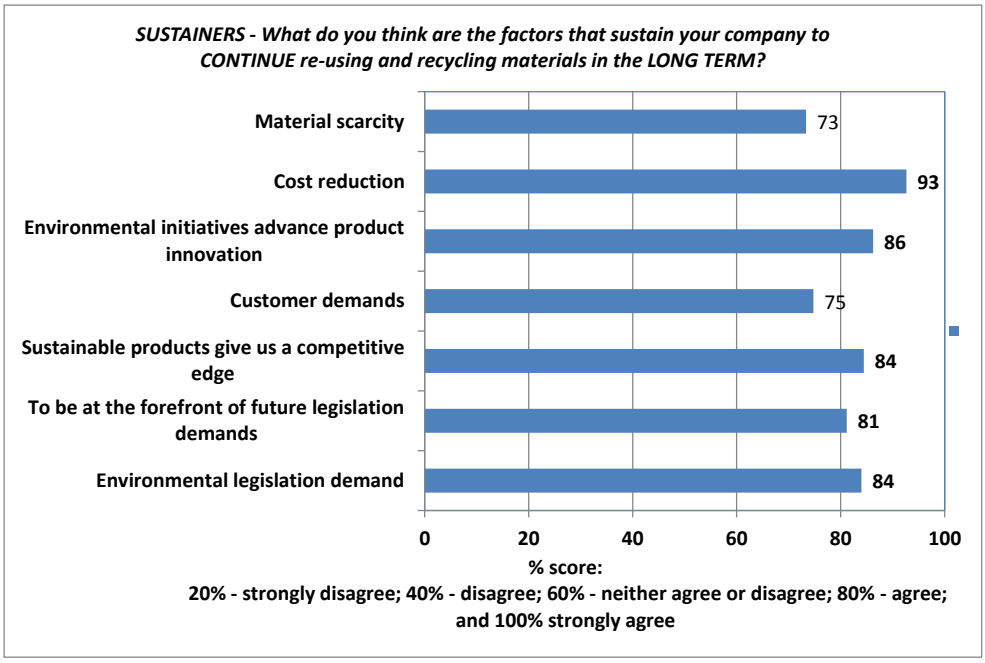

Fig. 2.SUSTAINERS - What do you think are the factors that sustain your company to CONTINUE re-using and recycling materials in the LONG TERM?

In this research drivers were differentiated from sustainers. The drivers help to kick start an activity and practice while the sustainers are those requirements that would enable companies to re-use and recycle production waste in the long term. Fig. 2, shows how the South African companies responded to the question of sustainers. The results

show that the strongest sustainer according to the respondents was the opportunity to reduce cost by re-using or recycling materials, this had a score of 93%. The Figure also demonstrates that the respondents assess that environmental initiatives that advance product innovation and sustainable products that give a competitive edge as significant sustainers. The need to be at the forefront of future legislation demands and environmental legislation were also strong factors that sustain reuse and recycling of production waste.

In addition, to the drivers and sustainers, the respondents were asked about ownership models for circular economy and the results are shown in Fig. 3. Respondents could select from: the Government, local authority (e.g. city council, Manufacturer), product retailers /distributers, end users or third parties, as being responsible for managing end–of-life product waste. It is clear from Fig. 3, that there was no consensus (no factor scored more than 80%), on a preferred stakeholder to drive forward the management of end-of-life product waste. The industry survey appears to mirror the different and opposing views advanced in the academic literature. There seems to be a slight preference for the local authority or council, which had the highest score of 75%.

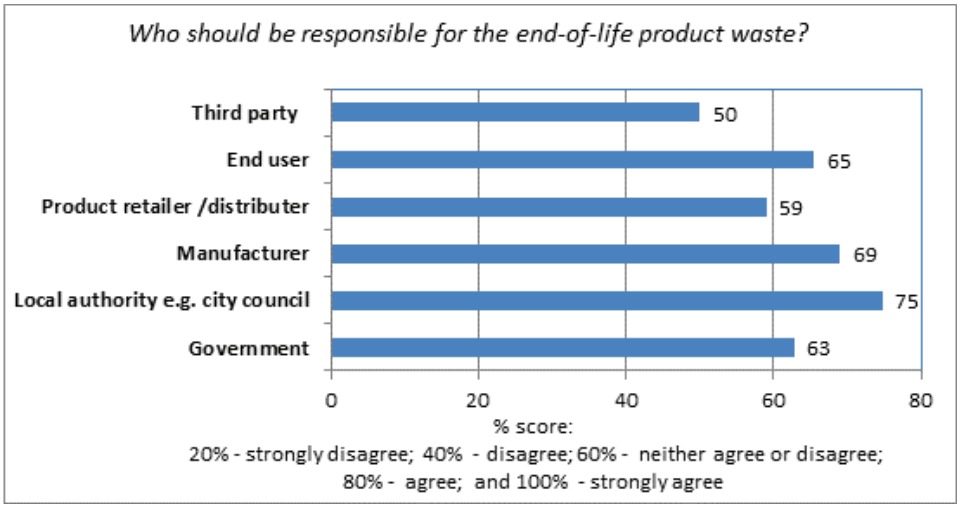

Fig. 3. Who should be responsible for the end-of-life product waste?

Specifically, in relation to composite waste, the companies were asked to assess the barriers to the reuse of recycled composite materials. The response is summarized in Fig. 4. The findings suggest that quality assurance of recycled composite materials was the main barrier to the reuse of composites waste in industry. Indeed, one manufacturer highlighted that products were part of a system that required airworthiness certification.

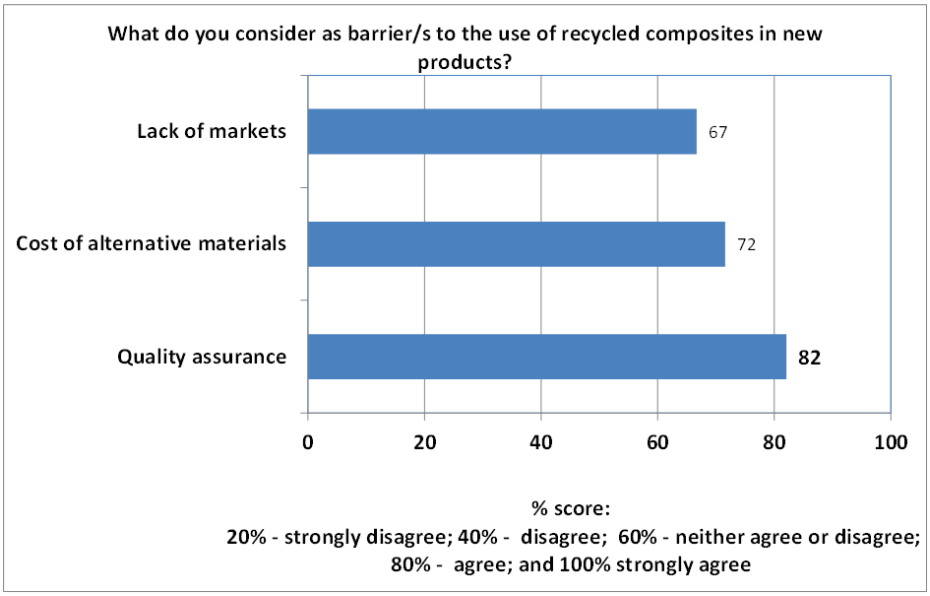

Fig. 4. What do you consider as barrier/s to the use of recycled composites in new products?

Nineteen companies responded to the question "what percentage of composite materials end up as scrap within your operations". Fig. 5 shows that the percentage of scrap produced by the organizations could be as high as 25% down to less than 1%. The mean, median and mode percentage of composite production scrap was 5.7, 3.5 and 2 respectively. While the standard deviation was 6.0. The level of production scrap is generally lower than that reported for the UK [12]. It would appear, at face value, that South African companies are relatively resource efficient in terms of using production waste composites. Two companies reported that they do not have waste because it is reused and collected by a third party respectively.

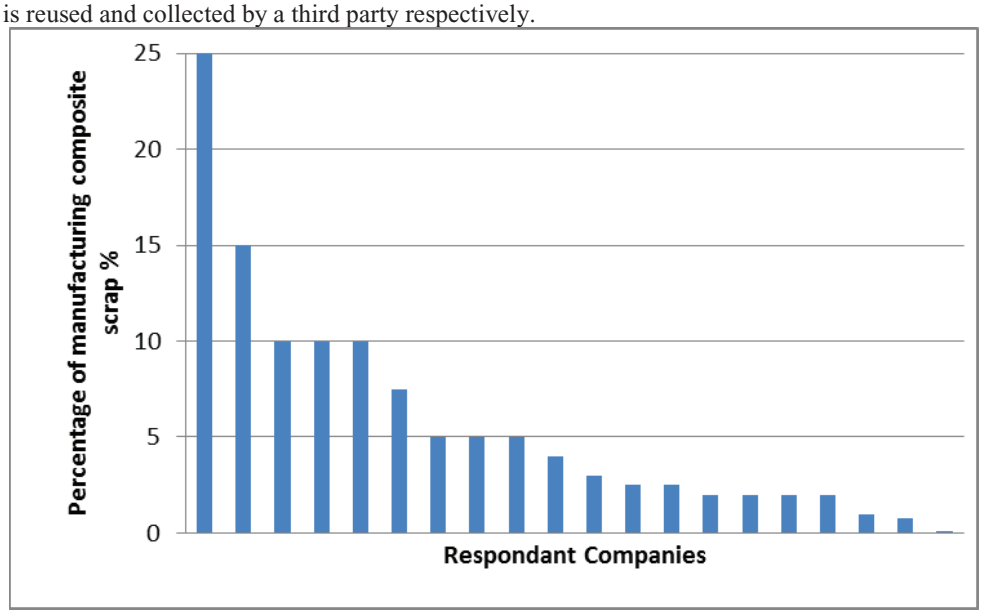

Fig. 5. What percentage of composite materials end up as scrap or waste within your operations?

Table 1 summarizes the end-of-life options selected by the companies for their production waste. The responses suggest that the landfill (53%) was the most common option for end-of-life composite waste. Interestingly, 34% of the options selected were for combined re-use and recycling. This suggests that the industry is already engaged in sustainable use of composite materials. The South African industry appears to be cost conscious and hence the reuse and recycling of composite materials is relatively practiced.

Table 1. How do you currently manage your **composite waste**?

	Landfill	Re-use	Recycling	Incineration	I do not know
Carbon fibre composite	8	1	2	1	1
Glass fibre composite	10	3	3	1	
Resins	8	3	3	2	
Dry fibres	8	4	3	2	1
Total	34	11	11	6	2
%	**53**	**17**	**17**	**9**	**3**

Conclusions

This study was based on the view of senior managers in South African companies that were identified as composite materials users.

- ✓ Cost reduction was seen as the biggest driver and sustainer for the South African industry to consider reuse and recycling of production waste materials. Cost reduction was actually found to be much stronger as a sustainer than a driver. This suggests that there are striking synergies between cost reduction and the circular economy and that it is a key factor in encouraging companies to embrace the circular economy. These findings are in contrast to findings in Europe, where customer demands and competitive edge were the main sustainer factors.
- ✓ This study thus suggests that the sustainers for a circular economy cannot be assumed from a global perspective but have to consider the local environment. Cost is a major factor in South Africa. Development of composite recycling technologies for such a market has to consider opportunities for significantly reducing the cost of material reuse and recycling. This has to be balanced with the need to produce quality materials that if used in products will be acceptable for the product certification process.
- ✓ There was no consensus in the survey of composite manufacturing companies, of whether Government, local authority (e.g. city council, Manufacturer), product retailers /distributers, end users or third parties, should take responsibility for managing end-of-life product waste. In Europe, Extended Producer Responsibility has been accepted and is seen as key to driving a circular economy. More research is needed to establish ideal systems from South Africa, although industry appears to have a slight preference for the local authority as a key stakeholder. The different ownerships models could be assessed though detailed knowledge of the supply chain and composite volumes.
- ✓ In relation to composite materials, the need for quality assurance of recyclate and to certify products incorporating recyclate composites was a major barrier anticipated by the industry participants.
- ✓ The South African industry study shows that a large number of companies experience a relatively small percentage of composite production scrap material. It could be plausible that given the importance of cost as evidenced by the study, industries endeavour to use materials more efficiently in order to cut down manufacturing costs.
- ✓ This study was based on the South African industry, future work will compare the UK and South African industry with a view to unpack any differences in industry's perception of transition to a circular economy and to understand factors that need to be considered, given global markets and use of products across international

boundaries. The regulation governing waste disposal in South Africa will also be and compare to international cases.

Acknowledgements

The authors acknowledge the Royal Academy of Engineering, United Kingdom for grant under the Scheme: Newton Research Collaboration Programme (1), reference: NRCP/1415/167. Special thanks to all the participating companies in South African and the senior managers that dedicated their time to complete the questionnaire.

References

[1]. S. Halliwell, 2006. End of Life Options for Composite Waste Recycle, Reuse or Dispose, National Composite Network.
[2]. Y. S. Song, J.R. Young, and T.G. Gutowski, Life cycle energy analysis of fiber-reinforced composites. Composites Part A: Applied Science and Manufacturing, 2009. 40(8): p. 1257-1265.
[3]. R. A. Witika, R. Teuschera, V Michauda, C. Ludwigb, J. E. Månsona, Carbon fibre reinforced composite waste: An environmental assessment of recycling, energy recovery and landfilling. Composites Part A: Applied Science and Manufacturing, 2013. 49(0): p. 89-99.
[4]. N.A Shuaib, and P.T. Mativenga, Energy demand in mechanical recycling of glass fibre reinforced thermoset plastic composites. Journal of Cleaner Production, 2016. 120: p. 198-206.
[5]. K. H. Forslind, 2005. "Implementing extended producer responsibility: the case of Sweden's car scrapping scheme". Journal of Cleaner Production, 13(6), pp. 619-629.
[6]. R. Cahill, S. M. Grimes, D. C. Wilson, 2010. Extended Producer Responsibility for packaging wastes and WEEE - comparison of implementation and the role of local authorities across Europe. Waste Management and Research, 29(5), pp. 455-479.
[7]. M. Despeissea, Y. Kishitab, M. Nakanoc, M. Barwood, "Towards a circular economy for end-of-life vehicles: A comparative study UK – Japan", The 22nd CIRP conference on Life Cycle Engineering, Procedia CIRP 29 (2015), pp. 668 – 673.
[8]. European Commission - DG Environment, 2014. Development of Guidance on Extended Producer Responsibility (EPR), FINAL REPORT. http://ec.europa.eu/environment/waste/pdf/target_review/Guidance%20on%20EPR%20-%20Final%20Report.pdf.
[9]. N. M. Sachs, (2006). Planning the Funeral at the Birth : Extended Producer Responsibility in the European Union and the United States. Harvard Environmental Law Review, 30, pp. 51–98.
[10]. J. W. Scheijgrond, (2011). Extending producer responsibility up and down the supply chain, challenges and limitation. Waste Management & Research : The Journal of the International Solid Wastes and Public Cleansing Association, ISWA, 29(9), pp. 911–8.
[11]. N. Bey, M. Z. Hauschild, T. C. McAloone, Drivers and barriers for implementation of environmental strategies in manufacturing companies, CIRP Annals - Manufacturing Technology 62 (2013), pp. 43-46.
[12]. J. Rybicka., A. Tiwari, and G.A. Leeke, Technology readiness level assessment of composites recycling technologies. Journal of Cleaner Production, 2016. 112, Part 1: p. 1001-1012.