Fatimah et al. Journal of Remanufacturing 2013, 3:6
http://www.journalofremanufacturing.com/content/3/1/6

Journal of Remanufacturing
a SpringerOpen Journal

CASE STUDY Open Access

Sustainable manufacturing for Indonesian small- and medium-sized enterprises (SMEs): the case of remanufactured alternators

Yun Arifatul Fatimah[1*], Wahidul Biswas[1], Ilyas Mazhar[2] and Mohammad Nazrul Islam[2]

* Correspondence: yun.arifatul@postgrad.curtin.edu.au
[1]Sustainable Engineering Group, Curtin University, Perth, Australia
Full list of author information is available at the end of the article

Abstract

Achieving sustainability is a great challenge for most of the Indonesian manufacturing small- and medium-sized enterprises (SMEs). Remanufacturing has been considered to be a key strategy to attain sustainable manufacturing by maximising the use of old components and minimising landfill size and energy usage. However, SMEs, which are undoubtedly the engine of the Indonesian manufacturing industry, do not have adequate experience, skill, resource, technology and financial support in the remanufacturing area. This paper proposes a new concept for sustainable manufacturing assessment framework through remanufacturing strategies in Indonesian SMEs. In this sustainable manufacturing assessment framework, the existing remanufactured products are assessed using sustainable manufacturing criterion (e.g. reliability, life cycle cost, employment opportunity and greenhouse gases). This framework identifies improvement opportunities, including eco-efficiency, cleaner production and green technology to make existing remanufactured products technically, economically, environmentally and socially sustainable. The sustainability of remanufactured alternators produced by Indonesian SMEs has been assessed to validate the aforementioned sustainable manufacturing assessment framework.

Keywords: Remanufacturing; SMEs; Sustainable manufacturing

Introduction

The manufacturing industry is a wealth-producing sector of the Indonesian economy accounting for 24% of gross domestic product (GDP) followed by agriculture (15%) and other economic sectors [1]. Large enterprises and small- and medium-sized enterprises (SMEs) accounted for 43.28% and 56.72% of the total GDP in the manufacturing sector, respectively, while SMEs alone represent 99.96% of total number of manufacturing industries (3.27 million companies) and also absorb employment for 87.47% of the total industry workers [2].

However, the proportion of SMEs for total manufacturing export and GDP is still low compared to the large number of enterprises due to a lack of innovative technology, inefficient production processes, limited skilled workers, insufficient capital investments and unqualified and unclassified standardisation products [3]. Most of SME exports are dependent on large enterprises, and their contributions are usually unrecorded and undermined. As a result, SMEs cannot expand their market independently

Springer

© 2013 Fatimah et al.; licensee Springer. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/2.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

[4]. Furthermore, many Indonesian manufacturing SMEs are not environmentally conscious and contribute a large amount of pollution and resource depletion due to inefficient equipment usage [5].

Thus, Indonesian manufacturing SMEs do not comply with the economic, social and environmental objectives of sustainable development. This is because the objective of sustainable manufacturing is to develop and improve human life continually over time through the optimization of production and consumption activities by conducting efficiency on material and energy consumptions, focusing on poverty reduction and maintaining the resources for human beneficial reasons [6].

The main strategies for attaining sustainable manufacturing are remanufacturing, reuse, recondition and recycling [7]. Remanufacturing which is defined as a series of manufacturing steps acting on an end-of-life part or product in order to return it to like-new or better performance, with warranty to match [8], appears to be the most appropriate strategy to attain sustainable manufacturing in Indonesia due to the following reasons.

Firstly, it fulfils three objectives of sustainable manufacturing. Remanufacturing is economically viable by maximising the use of old components or product, and it is environmentally friendly by reducing the size of landfill, minimising the energy usage, and it is socially viable by providing employment opportunities and developing prosperity flows [9-11]. For example, an automotive engine remanufacturing company reduced metal consumption by 7,650 tonnes, conserved energy of 16 million kW h and decreased emission of about 11,300 to 15,300 tonnes CO_2 equivalent (CO_2eq) [12]. In the UK, remanufacturing contributes to the workforce around 50,000 employees and provides £2.4 billion GDP in 2009 [13], while in the USA, 73,000 remanufacturing industries employed about 480,000 people [14]. In addition, the increased employment opportunity, job satisfaction, income and clean environment will improve the quality of human life. These advantages significantly place remanufacturing as the main contributor to the sustainability of prosperity [10].

Secondly, since 1997 - when the economic crisis took place Indonesia - the new products became unaffordable and expensive for majority of the Indonesian people. Consequently, refurbished, reconditioned, cannibalised, reused and remanufactured products such as electronic, household appliances, automotive components and office furniture have become the usual products in the Indonesian market [15].

Unfortunately, the development of the remanufacturing industry which is mainly held by SMEs is still undercover, neglected and environmentally unfriendly. Many SMEs feel doubtful that their remanufacturing business will continue to grow due to high competency in the global market. Only few giant companies (e.g. PT Sanggar Sarana Jaya, PT Komatsu Remanufacturing Asia) have recognised the value of remanufacturing strategies in Indonesia as they can offer economic, social and environmental benefits to the manufacturing sector of Indonesia [16,17].

State of the art of Indonesian-remanufactured auto parts

The automotive industry sector is growing alarmingly in Indonesia in the recent years. The production growth was about 35.21% from 2009 to 2011, while the market growth was 37.54% [18]. The total number of automotive industries was around 445 which are mainly held by SMEs absorbing around 185,000 to 204,596 employees [19]. In the case of motor vehicle industries, sales were 894,164 units in the last 2011, and the prediction shows that the percentage will be increased to 50% in the next 5 years [18,20]. As a result, the use of auto parts such as engine, transmission, steering gear, starter and alternator will increase.

Alternator is part of the automotive components which can potentially be remanufactured. The remanufactured alternator dominates the remanufacturing market around 22% [21]. The remanufactured alternator offers 50% cheaper costs than the new ones and consumes 60% less energy and 70% less material compared to the new product. Also about 80% of the alternator parts can potentially be reused [22,23].

The legislations (e.g. End-of-Life Vehicle Directive and Energy-Using-Product Directive), which are crucial drivers for a successful implementation of the remanufactured products in developed countries (e.g. UK, Japan) [10], have been found absent in Indonesia. The next important driver is market demand. The Indonesian automotive component market is divided into original equipment market and market for low-cost and minimum standard product which are manufactured mainly by SMEs. Due to the affordable price of remanufactured products [24], the remanufactured alternators are expected to dominate the market.

Except for a few (e.g. Galeri alternator), most SMEs are not effectively producing remanufactured alternators. The Indonesian SMEs producing remanufactured alternators experienced a number of challenges. Firstly, the lack of financial mechanism has been perceived to be an obstacle to expand SMEs. Although the Indonesian government offers business credit programme (KUR-Kredit Usaha Kecil) for SMEs, it is mostly applied to few specific locations in Indonesia (e.g. Java, Bali) [25]. Secondly, the lack of knowledge and skilled worker has led to ineffective and inefficient production activities. Thirdly, the orientation of product standardisation based on the domestic market generates low quality, less reliability and short warranty period which reduce the attractiveness of the remanufactured alternators in the market. Fourthly, most of the SMEs are not environmentally efficient and produce more pollution due to lack of advanced technology and waste management.

Thus, this paper provides a remanufactured alternator as a case study to test the sustainable manufacturing framework for both assessing and improving the SMEs' remanufacturing auto parts in Indonesia and seeks to come up with the best solutions and strategies to overcome the aforementioned problems.

The model for sustainable manufacturing

Based on Figure 1, the steps for assessing the sustainability of remanufactured products are stated.

Firstly, the existing remanufactured products are assessed using the sustainable manufacturing criterion, including technical (i.e. reliability), economic (i.e. life cycle cost, sales) environmental (i.e. solid waste, GHG emission) and social aspects (i.e. employment opportunity, warranty). Secondly, the calculated values of these criterions are compared with the threshold values of the sustainability criterion. These threshold values are derived from the standard Indonesian and international literature discussing Indonesian and global remanufacturing issues. Examples of the threshold values of technical, economic, social and environmental aspects are reliability (99%), life cycle cost (50% cost of new product), warranty period (2 to 3 years) and greenhouse gas

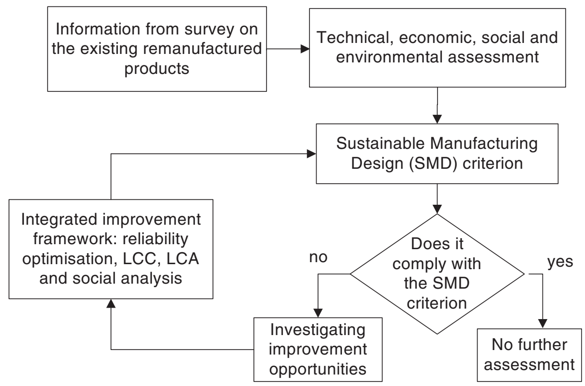

Figure 1 Model for sustainable manufacturing assessment.

emission (2.58 kg CO_2eq) which appeared in the remanufacturing sectors [23,24]. Remanufactured products not complying with any of these sustainability criteria are considered as unsustainable remanufactured product and are then redefined by investigating improvement opportunities through an integrated improvement framework involving reliability optimization, life cycle cost (LCC), life cycle assessment (LCA) and social assessment. The objective of this integrated improvement is to determine technically feasible solutions which are economically, socially and environmentally feasible and meet the sustainable manufacturing criterion. Figure 2 shows the detailed version of the integrated improvement framework.

Firstly, technical criterion involving reliability of the remanufactured products is assessed. Using this criterion, the material, method, man, machine, energy and information are analysed, and appropriate technical feasible solutions involving the best available technologies, processes, technical skills and energy and material consumption are proposed. Along with technical feasibility studies, LCA analysis of the technically feasible solutions is carried out following the ISO 14040–43 guideline [26] to determine environmental criteria including greenhouse gas (GHG) emissions and solid waste. If technically feasible solutions are not environmentally viable, 'hotspot' or the process producing the most pollution is identified to apply mitigation strategies (e.g. cleaner production, eco-efficiency, green technology and industrial symbiosis).

These two analyses are carried out simultaneously until both technically feasible and environmentally friendly solutions are obtained. Once technically and environmentally feasible solutions are obtained, the socio-economic viabilities of these options are

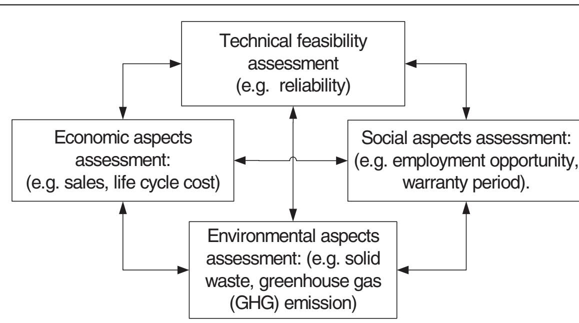

Figure 2 An integrated improvement framework.

assessed involving sales and life cycle cost assessments. The economic viability is attained when sales and life cycle cost are equal or greater than the threshold values. Similarly, social criteria such as employment opportunity and warranty period are required to meet the threshold value. If the revised version of technical option is not socio-economically viable, different socio-economic policies including rebate, subsidy and education are considered to attain socio-economic feasibilities.

Once technically, economically, socially and environmentally feasible solutions are determined, some appropriate institutional framework, including policy instruments, stakeholder responsibilities, key actions, targets and key performance indicator, are developed to implement sustainable manufacturing in SMEs. The institutional framework takes into account the constitution of direct (e.g. remanufacturer, supplier and consumer) and indirect (e.g. government, research institution and bank) stakeholders who participate in the decision-making process for sustainable remanufacturing.

The case study of remanufactured alternators

The existing situation of SME remanufactured alternators

A survey has been conducted in an SME producing remanufactured alternators in Central Java, Indonesia to test the proposed model and the framework. Remanufacturing operations have begun with a recovery process where alternators were collected directly from used alternator collection centres (e.g. service centre and auto junkyard). It should be notable that this research is limited to factory gate, and therefore, downstream activities such as customer satisfaction have been excluded.

In the factory line, disassembly is the first step where housing, stator, rotor, regulator, rectifier, brush and bearings are dismantled using simple tools and manual methods, and then all parts have been cleaned and dried by gas heating. Following this, testing including inspection and sorting of parts has been done for reconditioning on the basis of the reusability of parts. The reconditioned and new parts have been reassembled to make the remanufactured alternator. The alternator was tested before they were packed and ready to be delivered to the customer. The assessments of the existing remanufactured alternators have been done in the following ways.

Technical assessment

In this case study, the number of alternators that failed in 3 years (2008 to 2010) was 3,838. Failure of alternator components happened mainly due to failure of regulator (63.68%), followed by rectifier (13.25%), brush (11.97%) and other components such as stator and rotor (11.11%).

The reliability of the remanufactured alternator was calculated using the Weibull ++8 software. Intensive data including failure identification of the alternator, time of failure of the alternator and sales of the alternator were identified. The purchasing date, failure date and failed parts were collected to determine the time to failure. Data related to the number of failed alternators, suspended alternators and status (e.g. failure/F or suspended/S) were also involved to get the valid reliability result of the remanufactured alternator. Based on the calculation using Weibull distribution, the Weibull reliability plot in Figure 3 presents the shape parameter (β) which was 2.4 and the scale parameter (η) which was 1,288 days.

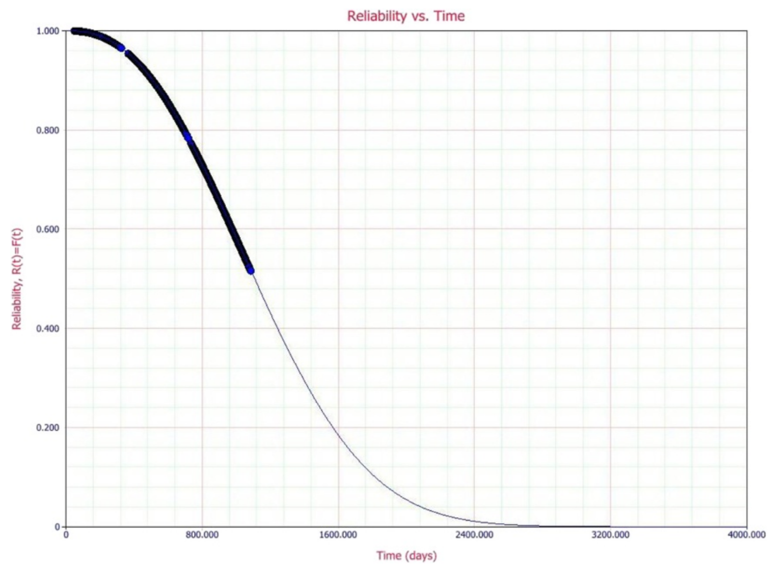

Figure 3 The reliability vs. time of the remanufactured alternators.

However, the reliability of new product is 100% in the early part of its life and gradually declines during its lifetime [8]. The mean time to failure of the alternator was 1,142 days, and the reliability model of the remanufactured alternator is presented in the following equation:

$$R(t) = exp\left[-\left(\frac{t}{1288}\right)^{2.4}\right] \tag{1}$$

The threshold value of the remanufactured alternator reliability is estimated to be about 99% which is close to 194 days (6.5 months), while the reliability of the remanufactured product in 1 year is 95%.

Economic assessment

The lack of investment on SMEs, inefficiency and ineffective production and the lack of quality and reliability made difficult situations for the SMEs to compete in the global market. This can be seen in the sales performance of the SMEs which showed that the number of sales decreased gradually from 2008 to 2010. In 2009, the sales decreased by 7.20% and dropped again in 2010 by 21.7% which led to a financial crisis in the SMEs.

The life cycle cost analysis of the remanufacturing process that includes the cost of product recovery, disassembly, cleaning and washing, inspection and sorting, reconditioning, replacement, reassembling, final testing, packaging and warranty have been performed. The acquisition cost was not considered in this LCC because the remanufacturing process used old infrastructure and machinery.

Based on the calculation done, the unit cost of the remanufactured alternator product was 183,000.00 IDR (USD = 9,700 Indonesian Rupiah (IDR) in 2010). The threshold value of LCC that was used to evaluate the economic criterion of the remanufactured product was 50% of the new product [25]. The breakdown of the remanufacturing operation costs of the alternator is shown in Figure 4. The product recovery cost contributed the largest portion (34.84%) of total unit cost, followed by replenishment cost

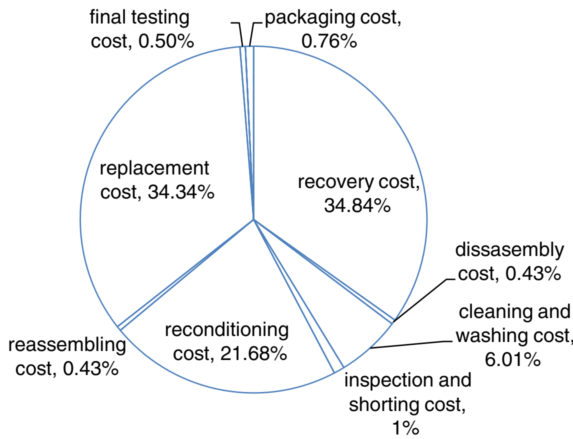

Figure 4 The life cycle cost of the remanufactured alternator.

(34.34%), reconditioning cost (21.68%), cleaning and washing cost (6.01%), inspection and shorting cost (1%), packaging cost (0.76%), final testing cost (0.50%), reassembling cost (0.43%) and disassembling cost (0.43%).

Social assessment

Warranty is one of the key social indicators of remanufactured product which represents an industry for its corporate social responsibilities [27]. The warranty of remanufactured product is proposed to maintain the performance of the product to be as good as new, which offers a social benefit to the customer. However, the remanufactured alternator SMEs could only provide a 1-year warranty against a 2- to 3-year warranty for new alternators. The next social indicator is employment opportunity because a higher employment opportunity could alleviate poverty and enhance social equity by reducing the gap between the rich and the poor [28]. The survey conducted in the SMEs' remanufacturing alternators found that they could hire nine to ten employees per year. However, the financial crisis faced by the SME has decreased the number of employee to about 24% per year in 2008 to 2010.

Environmental assessment

Environmental assessment includes the determination of solid waste and GHG emissions. After the disassembling, washing and testing processes, 59% of components are reused, 22% of components are replaced with used component and 19% of components are replaced with new components. Therefore, the remaining parts have been categorised as solid waste. About 41% (0.83 kg) of the parts have been replaced with used and new parts consisting of steel (24%), cast iron (26%), copper (33%), plastic (11%) and carbon (1%). The threshold value used to evaluate the solid waste contributed from the remanufactured alternator was 21% [24].

The GHG emission was calculated using an LCA software known as Simapro 7.3 [29]. As the remanufacturing processes were conducted in Indonesian SMEs, Indonesia's emission factors for electricity generation were used to determine the CO_2 equivalent emission from the remanufacturing process. The emission from the production of new components which replaced the worn-out components had also been

Table 1 The existing situation and the threshold value

Assessment	KPI	Threshold value	Existing situation	Yes/No
Technical	Reliability	99%	95%	No
Economic	LCC	172,500 IDR	183,000 IDR	No
	Sales	Increase	Decrease 21.70%	No
Social	Employment opportunity	Increase	Decrease 24%	No
	Warranty	2 to 3 years	1 year	No
Environment	Solid waste	0.43 kg	0.83 kg	No
	GHG emission	2.58 kg CO_2eq	5.98 kg CO_2eq	No

considered. GHG emissions associated with transportation for product recovery and shipment of new components from China to Indonesia were estimated using emission factors obtained from the Simapro 7.3 software database. The results show that the remanufactured alternator contributed 5.98 kg CO_2eq of GHG emissions, while the threshold value of the GHG emissions was 2.58 kg CO_2eq for a remanufactured alternator [24]. Table 1 represents the existing scenario of the remanufactured alternator in comparison with the threshold values.

The result indicates that the remanufactured alternator industry does not comply with the SMD criterion as all key performance indicators do not satisfy the threshold value.

The integrated improvement framework

The processes, material, labour and machinery from the existing situation were assessed using the sustainable manufacturing framework to determine the best possible technical solution meeting the sustainability criteria (or threshold values).

Scenario I

In this scenario, the technical feasibility of the replacement of all worn-out components (41%), including voltage regulator, rectifier, insulator, brush, bearings, pulley and rotor, with original equipment components was assessed in order to increase the reliability of the alternator. This means that 22% of the components, which were previously replaced with the used components, have now been replaced with new components.

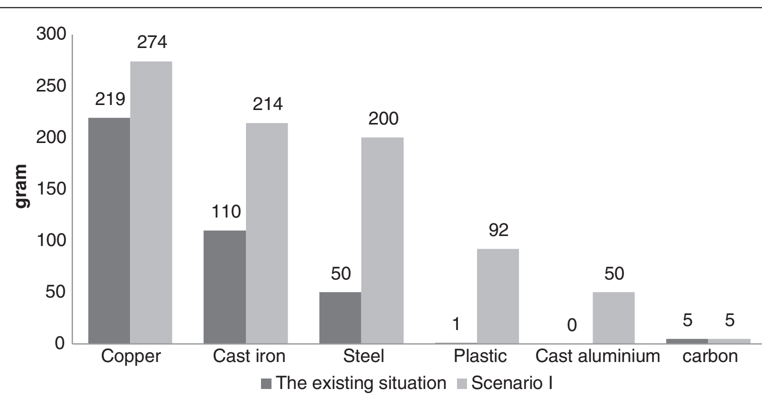

Figure 5 The materials used in the existing situation and scenario I.

Table 2 The environmental impacts of scenario I

	GHG emission (kg CO_2eq)	Solid waste (kg)
Existing situation	5.98	0.83
Threshold values	2.58	0.43
Scenario I: replacement with new components	14.6	0.83

The reliability of the alternator in scenario I was assumed to be the same as a new alternator because this scenario had considered the use of new parts instead of reconditioned parts. However, some key information such as time to failure, failure data and suspension data associated with the use of new components could have been considered in order to calculate the exact value of reliability of the improved version, but this was beyond the scope of this paper. Figure 5 shows the comparison of material intensities between the existing situation and scenario I.

The environmental impact assessment for scenario I in Table 2 shows that the replacements of worn-out components with new ones do not satisfy the threshold value of the environmental indicators, so an alternative scenario (scenario II) was conducted.

Scenario II

This scenario involves the use of recycled components. The following assumptions and considerations were applied to this scenario:

- The components including housing and pulleys have been reconditioned. The only recycled item considered was the coil of stator and rotor.
- The use of recycled components could reduce the GHG emission to about 83% and waste to about 88% [24].
- Since the brush and plastic cannot be recycled in an economically viable way, they were assumed to be sent to a landfill.
- The electricity consumption for reconditioning, recycling and transportation was considered for assessing environmental aspects of this mitigation strategy [24,30].
- It was assumed that there is a collaboration between the remanufacturing SMEs and the recycling industry to exchange worn-out and recycled components.

Table 3 shows that the technical and environmental criteria have been met by applying scenario II. The next step was to assess the socio-economic viabilities of the remanufactured alternator.

Table 4 shows that the LCC (170,600 IDR) of scenario II had met the threshold value (172,500 IDR). Following Cook and Ali [31], the reliability of the remanufactured alternator was assumed to increase the customer's satisfaction by 0.2%. This means that the increase in market response was predicted to increase the sales of the remanufactured

Table 3 The technical aspect and environmental impact assessment of scenario II

	Reliability (%)	GHG emission (kg CO_2eq)	Solid waste (kg)
Existing situation	95	5.98	0.83
Threshold values	99	2.58	0.43
Scenario II: replacement with recycled components	99	2.48	0.10

Table 4 The socio-economic analysis of scenario II

Indicator	Existing situation	Scenario II	Threshold value
LCC[a]	183,000 IDR	170,600 IDR	172,500 IDR
Sales	Decrease by 21.7%	Increase by 0.2%	Increase
Warranty	1 year	2 years	2 to 3 years
Employment opportunity	Decrease 24%	Increase 0.3%	Increase

[a]LCC analysis was calculated based on the additional variable cost for replacement (15,000 IDR), sustaining cost (237,000 IDR) and cost saving (61,000 IDR).

alternator by about 0.2%, which had in turn increased the employment opportunity by around 0.3%. The warranty period of a remanufactured alternator was considered to be the same as that of a new alternator. The increase in reliability was expected to extend the warranty period and to reduce warranty cost. Nominal customer's risk analysis was used to assess the warranty of the remanufactured alternator. Based on this analysis, the warranty of the proposed scenario was about 2 years which is the same as the threshold values.

However, these strategies can only be applied through the implementation of appropriate policies by the Government of Indonesia and stakeholders' involvement. Socio-economic policies, including rebate, subsidy and education, are some possible policy instruments. In addition, the stakeholder responsibilities, key actions, targets and key performance indicators can be developed to implement the mitigation scenario for attaining sustainable manufacturing.

Conclusions

The development of sustainable manufacturing is a great challenge for Indonesian SMEs. Remanufacturing has the potential to achieve sustainable manufacturing in Indonesian SMEs. This research proposes a sustainable manufacturing assessment model and integrated improvement framework to address socio-economic and environmental objectives of remanufacturing SMEs. Following the integrated sustainable framework, it was found that the existing remanufacturing operation in Indonesian SMEs is unsustainable. The use of recycled components in the remanufactured alternator could help attain the threshold values for sustainable manufacturing, including reliability (99%), GHG emission (2.48 kg CO_2eq), solid waste (0.10 kg), LCC (170,600.00 IDR), sales (increase 0.2%), warranty period (2 years) and employment opportunity (increase 0.3%). Last but not least, an institutional framework, including remanufacturers, suppliers, consumers, government, research institutions and financial institutions, needs to be established in order to promote sustainable manufacturing strategies in Indonesian SMEs.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

YAF collected data, carried out literature review, conducted technical, environmental, economic and social analyses and finally completed this manuscript. WB reviewed the environmental, economic and social analyses. IM and MNI reviewed the technical analysis and participated in the consultation process. All authors read and approved the final manuscript.

Acknowledgements

Yun Arifatul Fatimah sincerely appreciates the Indonesian Directorate General of Higher Education (DIKTI) for the financial support granted through her doctoral scholarship, and Muhammadiyah University of Magelang for the support and encouragement with regard to her doctoral study.

Author details
[1]Sustainable Engineering Group, Curtin University, Perth, Australia. [2]Department of Mechanical Engineering, Curtin University, Perth, Australia.

Received: 22 January 2013 Accepted: 13 June 2013
Published: 21 June 2013

References

1. Bureau of East Asian and Pacific Affairs: Background note: Indonesia. http://www.state.gov/r/pa/ei/bgn/2748.htm. Accessed 20 March 2012
2. Indonesian Bureau of Statistics: Trends of the Selected Socio-economic Indicators of Indonesia. Indonesian Bureau of Statistic, Jakarta (2009)
3. Tambunan, T: SME Capacity Building Indonesia. Kadin Indonesia-JETRO, Jakarta (2006)
4. Tambunan, T, Xiangfeng, L: SME Development in Indonesia and China. Kadin Indonesia-JETRO, Jakarta (2006)
5. Dhewanthi, L: Addressing Financial Obstacles of Micro, Small, Medium Enterprises (MSMEs) for Environmental Investment in Indonesia, in Greening the Business and Making Environment a Business Opportunity. United Nation, ESCAP, Bangkok (2007)
6. Azapagic, A, Perdan, S: Indicator of sustainable development for industry: a general framework. Process. Saf. Environ. Prot. **78**, 243–261 (2000)
7. Anityasari, M, Kaebernick, H: A concept of reliability evaluation for reuse and remanufacturing. Int. J. Sustain. Man. **1**, 3–17 (2008)
8. Centre for Remanufacturing and Reuse: Remanufacturing and reuse. http://www.remanufacturing.org.uk. Accessed 20 May 2010
9. Gupta, SM, Kamarthi, SV: LRM-Engineering Solutions for Evolving Customer and Environmental Need. Research Publications Related to Environmentally Conscious Manufacturing. Northeastern University, Boston (2002)
10. Gray, C, Charter, M: Remanufacturing and Product Design: Designing for the 7th Generation. University College for Creative Arts, Farnham (2007)
11. Bernard, S: Remanufacturing. J. Environ. Econ. Manag. **62**, 337–351 (2011)
12. Shi-can, L: Benefit analysis and contribution prediction of engine remanufacturing to cycle economy. J. CSUT **12**, 25–29 (2005)
13. Chapman, A, Barlett, C, McGill, I, Parker, D, Walsh, B: Remanufacturing in the UK: a snapshot of the remanufacturing industry in the UK in 2009. Center for Remanufacturing and Reuse, Aylesbury (2009)
14. Smith, VM, Keoleian, GA: The value of remanufactured engines: life-cycle environmental and economic perspective. J. Ind. Ecol. **8**, 193–221 (2004)
15. Ramdansyah: Komputer Layak Pakai Senjata Melawan Kebodohan - Gerakan Pemberantasan Buta Komputer di Masyarakat Bawah. Rumah Demokrasi, Jakarta (2011)
16. Komatsu Reman Indonesia: Reuse and recycling activities. http://www.Komatsu.com. Accessed 20 July 2012
17. Statistics Indonesia: Statistics Indonesia. http://www.datastatistik-Indonesia.com. Accessed 20 November 2010
18. GAIKINDO: Statistic Data. GAIKINDO, Jakarta (2012)
19. Layton, C, Rustandie, J: Gambaran rantai nilai komponent otomotif, Justifikasi pasar dan strategi peningkatan pasar komponen dalam negeri. SENADA, Indonesia Competitiveness Program, Jakarta (2007)
20. Aftermarket Australian Automotive Association: Indonesian Automotive Aftermarket Opportunities. www.aaaa.com.au.files/IndonesiaReport12.pdf. Accessed 2 July 2013.
21. Jung, D, Seo, Y, Chung, W, Song, H, Jang, J: The quality stability improvement for remanufactured alternator. In: The Global Conference on Sustainable Product Development and Life Cycle Engineering: Sustainability and Remanufacturing VI, Busan, 29 September-1 October 2008. (2008)
22. Asif, FMA, Simere, DT, Nicolesu, CM, Hauman, M: Methods analysis of remanufacturing option for repeated lifecycle of starters and alternators. In: 7th International DAAAM Baltic Conference Industrial Engineering, Tallinn, 22–24 April 2010. (2010)
23. Zhang, T, Chu, J, Wang, X, Lie, X, Cui, P: Development pattern in enhancing system of automotive components remanufacturing in China. Resour. Conserv. Recycl. **5**, 613–622 (2012)
24. Kim, H, Severengiz, S, Skertos, SJ, Selinger, G: Economic and environmental assessment of remanufacturing in the automotive industry. 15th CIRP International Conference on Life Cycle Engineering, Applying Life Cycle Knowledge to Engineering Solution, pp. 195–200. CIRP, New South Wales, Sydney (2008)
25. Maurougane, A: Promoting SME Development in Indonesia. OECD Economics Department Working Papers no. 995. Organisation for Economic Co-operation and Development, Paris (2012)
26. ISO 14040: Environmental Management - Life Cycle Assessment - Principles and Framework (ISO 14040). International Organization for Standardization, Geneva (1997)
27. Anityasari, M: Reuse of industrial product - a technical and economic model for decision support. Thesis. The University of New South Wales, Sydney (2008)
28. Biswas, W, Bryce, P, Diesendorf, M: Model for empowering rural poor through renewable energy technologies in Bangladesh. J. Environ. Sci. Policy **4**, 333–344 (2001)
29. PRe Consultants: Simapro 7.2. PRe Consultants, Amersfoort (2010)
30. Jolly, JL, Maryland, D: The U.S. Copper - base Scrap Industry and Its By-Products - An Overview. Copper Development Association Inc, New York (2012)
31. Cook, VGC, Ali, A: Using net present value methods to evaluate quality improvement projects. Int. J. Quality and Reliability **27**, 333–350 (2010)

doi:10.1186/2210-4690-3-6
Cite this article as: Fatimah *et al.*: **Sustainable manufacturing for Indonesian small- and medium-sized enterprises (SMEs): the case of remanufactured alternators.** *Journal of Remanufacturing* 2013 **3**:6.