

# Eco Product Innovation In Search Of Meaning: Incremental and Radical Practice for Sustainability Development

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## Abstract

**Purpose:** The purpose of this paper is to discuss the role of eco innovation in order to achieve sustainable development in manufacturing industries. The outcomes of this paper attempts to describe the main drivers of eco innovation among companies, core categories of eco innovation practices in manufacturing industry and framework of radical and incremental eco product innovation. The last part of the paper provides the insight of the new paradigm for eco innovation research in new millennium particularly in developing countries.

**Design/methodology/Approach:** The selected papers that have been reviewed were retrieved from Google scholar database with high citation index.

**Findings:** Manufacturing acknowledges eco innovation as a pivotal role to attain sustainability development in ecology, economy and society. There are three main drivers that able to boost the manufacturing sustainability namely regulation, responsibility and competition. Four types of eco innovation practices are product, process, marketing and organizations. However, among of them, eco product innovation is highly discussed among scholars in new millennium. Most of high cited literature describes the dimension of radical and incremental literature in four dimensions: modes of changes, economy values, design changes and eco innovation practices. The new research paradigm should discuss on eco innovation management in manufacturing industry.

**Originality/value:** Most of scholars are confused with the correct concept of eco innovation and its relationship towards sustainability development. Therefore, this paper attempts to provide a clear direction on difference between the incremental and radical eco product innovation implementation in manufacturing industry en route for building the sustainable development echoes to economy, ecology and society.

**Keywords:** Eco product innovation, radical and incremental, sustainability development

## 1. Introduction

Manufacturing recognized as a core business for many companies and plays a significant role for economic and social development. In the early 1980, manufacturing competition lies on the practice of improving production efficiency in terms of quality, cost and time. Common manufacturing practice as Total quality management (TQM), Lean management (LM), Kaizen and Six Sigma ( $6\sigma$ ) approved as a pivotal role to dramatically improved production efficiency, but insignificant used as a weapon for the sustainable competitive advantage (Hayes, Pisano, Upton, & Wheelwright, 2005). Therefore, in order to sustain, companies are required to be a frontier in their activities (Porter, 1991) and provide a superior and unique product to maintain market positioning (Cooper & Edgett, 2006). Thus, innovation is crucial as a driving engine in sustaining both the economic growth and nation development (Soliman, 2013; Bogliacino, Perani, Pianta, & Supino, 2012; Revilla Diez, & Kiese, 2006).

Furthermore, in new millennium, due to rapid changing of customer demand and national regulation, companies acknowledge an innovation in the form of environmental technology as the heart of the competitive advantage (Rennings, 2000). Most manufacturers believe by implementing environmental activities, effect on the company profit as incur in cost of operation in waste treatment and management. Limited companies involved in integrating environmental practices in manufacturing process or developing a green product because of the unstable demand and high investment to explore new technology. Recently, more studies conducted in profiling eco innovation dimension, implementation, driver and barriers. Most of the extensive research in the innovation

49 studies has been conducted by the Organization of Economic Cooperation Development (OECD). The eco  
50 innovation practice as reported by OECD manual ranged from the introduction of new product, process, method  
51 and organization (Manufacturing, 2009). Therefore, this paper provides an insight on several questions  
52 embedded between the literature and manufacturer in attempts to justify the dimension and benefits of effective  
53 implementation of environmental practice in the manufacturing industry. This paper provides a meaningful  
54 review to clarify several questions listed as below:

- 55 a) What are the drivers of sustainability building between the global manufacturing industries?  
56 b) What are the types of eco innovation practices implement in manufacturing activities?  
57 c) What are the dimensions of radical and incremental eco product innovation towards sustainability  
58 development?

## 59 **2. Drivers of Sustainability Development**

60 As the environmental issues arose dramatically almost 50 decades, a Buntland report 1987 and ECO 92 report in  
61 Brazil have shed a light on the environmental sustainability issues and accentuated an awareness among the  
62 NGOs, politician and business leader (Angelo, Jabbour, & Galina, 2012; Dyllick & Hockerts, 2002). The  
63 concept of sustainability development refers as 'the ability of current generation to meet their needs without  
64 compromising the ability of future generations to meet theirs'(WCED, 1987). The strong voice in both  
65 conferences has made tremendous changes in manufacturing perception in doing business. Manufacturing are  
66 driving to eco innovate based on three main factors; regulation, responsibility and competition (Dangelico &  
67 Pujari, 2010; Rennings, 2000). Porter in his report strongly recommended that nation development should  
68 emphasize on environmental regulation because it will increase on the innovation activities and good economic  
69 exchange (Porter & Linde, 1995; Porter, 1991). In Canada, the government has enforced the manufacturing  
70 process to innovate based on the environmental friendly technology. In Europe, eco innovation practices  
71 incorporate services sectors such as consulting services as one of the main factors to reduce environmental risk  
72 and increase economy exchange. In such, Japanese acknowledge eco innovation in a form of social development  
73 which integrated the environment and people to reduce environmental issues. As far as now, eco innovation  
74 implementation in the OECD countries, is not only central in government regulation, but has been wider to  
75 policies initiatives under the umbrella of supply side and demand side (Machiba, 2009). Supply side initiatives  
76 rest on the government programs to encourage eco innovation exploration through funding the eco project,  
77 encourage R&D, education and training, creating a network and partnership. Similarly, at the demand side relies  
78 at the adoption and diffusion stages to the business activities, where government emphasized on the regulation of  
79 producing product in green manner and increase the customer awareness to purchase eco product labelling  
80 scheme. Thus, through strong regulation from government to eco innovate between manufacturer and customer  
81 will regulate the awareness of sustainability development.

82 The second drivers of sustainability development depend on the responsibility of both top management and  
83 stakeholders. Manufacturing activities believe to be the major contributor for environmental pollution from the  
84 process of taking natural resources, making a product and producing waste and emission contributed on the 61%  
85 of world energy consumption and 36% of global C02 emission respectively (Manufacturing, 2009). Continuing  
86 exploitation of natural resources resulted in increasing of Green House effect (GHG), natural disaster such as  
87 water, air and soil contamination and indirectly effect on the human health and social life. In 21<sup>st</sup> century, the  
88 sustainable concept are accepted and adopted in a business strategy as the management mission. Companies are  
89 more responsible and aware on production activities especially generation of toxic waste and exploitation of  
90 natural resources. Therefore, environmental practice in manufacturing process is a reaction by top management  
91 which comply with the regulation in order to control the industry pollution namely; (i) Environmental  
92 management such as ISO 14001 audit series, (ii) Environmental regulation namely, restriction on  
93 Chlorofluorocarbon in product usage in 1987, C02 emission control in Kyoto Protocol, Restriction of Hazardous  
94 Substances (RoHS) in Electric and Electronic Equipment (iii) Environmental program such and Waste  
95 electronics and electrical equipment (WEEE) for collection end life electronic product. Furthermore, top  
96 management implies the environmental practices to improve their business model. Most of the environmental  
97 compliances related to the customer demands specifically in automotive industry. The automaker enforced their  
98 suppliers to increase the production efficiency through minimizing waste and energy used.

99 Lastly, the drivers of environmental implementation reflect on the competition strategy. A green practice at the  
100 firm's level at one hand reflects on the increasing of firm image and cost of operations through compliances  
101 towards environmental regulations. Indirectly they will nurture the environmental spirit to their customers by  
102 introducing a green product. Recently, demand on green product can be considered at early stage, but will grow

103 dramatically in future (Halila & Rundquist, 2011). Increasing awareness of green consumerism and introduction  
104 of eco friendly product represent that customers are willing to pay at premium price in attempt to protect the  
105 environment. Green product concept widely accepted by all kind of product from basic to luxury because of  
106 changes in customer purchasing behaviour (Sharma, Sonwalkar, & Maohr, 2013; Mei, Ling, & Piew, 2012; Tsen,  
107 Phang, Hasan, & Buncha, 2006). Borin and Lindsey-mullikin (2010) in analysis of purchase intention between  
108 green and non green product discover that, customers are willing to buy a green product in form of new green,  
109 recycle or refurbish product and company who practice green manufacturing in production process. Designing a  
110 new product in the 21<sup>st</sup> century shows tremendous challenge because the mission in doing business rely on  
111 sustainability performance in triple bottom line dimension; wealth creation, social development and pollution  
112 prevention (Dyllick & Hockerts, 2002).

### 113 3. Types of Eco Innovation Practices in Manufacturing Industry

114 Eco innovation terminology refers as an ecological, environmental, green and sustainable innovation initiate in  
115 most previous publications (Angelo et al., 2012; Schiederig, Tietze, & Herstatt, 2012) and the terms have  
116 resemblance in the objective to reduce the environmental impacts (Schiederig et al., 2012). Fussler and James  
117 (1996) was known as the pioneer in this field and they defined eco innovation as a creation of product, process  
118 and services which offers value creation and simultaneously reduced environmental effect. On the other hand, a  
119 mass findings from previous research since the late 1990s until the 21st century have shown that, eco innovation  
120 is best described as innovations activities performed at every levels of society or community that related in  
121 reducing environmental risk, pollution, waste and resource used (Arundel & Kemp, 2009; Machiba, 2009; Kemp  
122 & Pearson, 2008; Rennings, 2000). Apart from it, manufacturing is accepted by many scholars as the heart of eco  
123 innovation practices towards building the sustainable society.

124 Manufacturing competitive advantage relies on producing innovative product. However, new trends of market  
125 embrace to the development of eco product compared to the product innovation because its contribution on  
126 lowering the environmental risk (Kemp & Person, 2007; Machiba, 2009). Eco innovation management in  
127 manufacturing depends on the degree of organization evolution and perception either in the form of reactive,  
128 preventive or pro active. The reactive and preventive are central on company compliances towards regulation  
129 and market demand, while the pro actives companies are significant in exploring new market opportunities and  
130 as an effort to minimize environmental problem (Angelo et al., 2012). In summary, eco product innovation  
131 development incorporate on reducing or eliminating usage of harmful materials, waste, and pollution (Arundel &  
132 Kemp, 2009; Ottman, Stafford, & Hartman, 2006). Recently, manufacturing companies are aware on new trends  
133 and looking for the best practice to manage their manufacturing process to produce product in green manner.

134 As reported in the (Manufacturing, 2009) eco-innovation practices outline its target or object (products,  
135 processes, marketing methods, organisational and institutions) as indicated in table 1; which contrary in report by  
136 Rennings (2000), eco target includes product, process, organizational, social and institutional. Meanwhile  
137 Arundel and Kemp (2009) defines eco target falls as the four categories such as environmental technologies,  
138 organizational innovation, product and service innovation and green system innovation. Broad definition of eco  
139 innovation can be found in Carrillo-Hermosilla, del Río, and Könnölä (2010), yet, eco innovation definition in  
140 OECD manual is a pertinent to organization as useful guidelines (Arundel & Kemp, 2009), because the  
141 innovation definition acceptance worldwide and the innovation information ahead compared to others institution.  
142 OECD report in eco innovation in industry promoted that eco innovation typology rest on *target*; technical  
143 (product and process) and non technical (marketing, organizational and institution) innovation, *mechanism* or  
144 methods of changes (modification, redesign, alternatives and creation); and level of *environmental impact*  
145 (product life cycle). The definition of eco innovation target describe as below:

146 Eco product innovation related on the designing product that is not harmed to the environment during either in  
147 the development process by minimizing the used of material, energy, resources or the product disposal is less  
148 polluted. The implementing of eco process innovation associated on the changing of production methods to be  
149 efficient in managing the flow of material input to output. Meanwhile, the organisational innovation is embedded  
150 to managerial level intention on controlling the impact of pollution via changes in companies' policy and  
151 auditing systems. In the institutional innovation initiatives, involves in both formal and informal approach. In  
152 one hand, formal change related to the companies openness in public to incorporate the environmental rules and  
153 regulations, while in non formal approach, related to the transformation of culture in organization or society to  
154 be tolerate to environmental concern. However, the broad concept of eco target only gives a rudimentary  
155 indication to differentiate the eco innovation practices. In line with this statement (Rogers E.M (2003) in his  
156 book diffusion of innovation, he argued that the distinction between product and process is not clear when a new  
157 product becomes a part of process in another location in the value chain. On top of that, Hellström, (2007) and

158 Rennings, (2000) defined product and process as one entity by means of integrated environmental technology  
 159 when the companies implementing both types of innovation to generate product that less harmful to  
 160 environment.

161

162 Table 1. Eco innovation target and description

	Target of Eco Innovation	Description of eco innovation
<b>Technology</b>	Product innovation	Designing or developing a product or service that is new or significantly improve in reducing environmental risk in terms of (i) materials of the product usage produce least pollution (ii) materials of the product consume least amount of energy and resources (iii) fewest amount of materials to comprise a product (iv) product is easy to recycle, re-use and decomposed.
	Process innovation	Implementation of a new or significantly improved production process or procedure to reduce environmental burden in terms of (i) manufacturing process reduce the emission of hazardous substances or waste (ii) manufacturing process implement recycles waste and emission that allow for re-used (iii) manufacturing process reduces the consumption of water, electricity, coal or oil (iv) manufacturing process reduces the use of raw materials
<b>Non Technology</b>	Marketing innovation	New ways of communication and marketing strategies (4Ps- Product, Price, Promotion, Place) such as e-marketing or Product-service system (PSS)
	Organizational innovation	New environmental management such as eco audit (EMS) and corporate environmental strategies Formal – New or improved decision, roles, and ways on legal enforcement (laws, rules and regulation) , international agreement or voluntary public participants to integrate in environmental concerns
	Institutional Innovation	Informal – change in social behaviour and cultural values towards perception on environmental awareness.

163 Adapted from: (Machiba, 2009; Manufacturing, 2009; Chen, Lai, & Wen, 2006; Rennings, 2000)

164

165 The aforementioned findings, linkage on the eco innovation definition and new product development, echo the  
 166 establishment of green product innovation framework by (Dangelico & Pujari, 2010). The development of green  
 167 product innovation or new green product occupied in three key types of environmental focus which is material,  
 168 energy and pollution while its impacts occurred in different stages of product life cycle (PLC) including  
 169 manufacturing process, product use and disposal as describe in figure 1: In the manufacturing process, the  
 170 utilization of resource in material and energy required in terms of recycle, recyclable and biodegradable material  
 171 or packaging usage in process development. In sync, energy efficiency is requisite during the production process  
 172 by implementing or use of renewable energy source in manufacturing process. In the product use, eco product  
 173 will reduce the usage of energy or product operates by using the renewable energy sources. In the pollution focus,  
 174 firm implement cleaner pollution technology to reduce the pollution in the production process or the product  
 175 generate is less or no effects to the environment. In sum, Pujari as the pioneer in green product study, defines eco  
 176 product innovation as a developing of product with low input of material and energy to produce less pollution  
 177 along the product life cycles (PLC) either in the manufacturing process, product usage or disposal stage  
 178 (Dangelico & Pujari, 2010)

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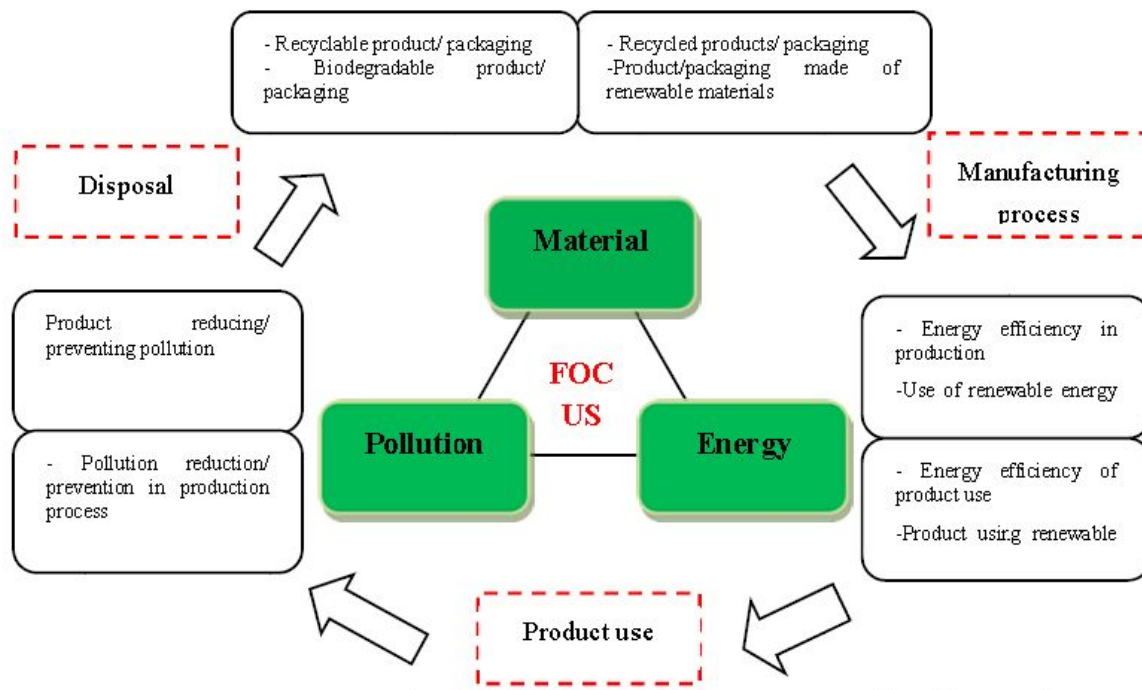


Figure 1. Framework for green product innovation

#### 4. Dimension of incremental and radical innovation

More authors have explained and explored about radical- incremental incident in eco innovation typology in differences views (Brezet, 1997; Carrillo-Hermosilla et al., 2010; Dangelico & Pujari, 2010; Hellström, 2007; OECD, 2005, 2012). Mass findings provide insight to different the innovation strategy as below:

- Modes of changes: Soft and hard elements.
- Economy values: value added or value creation
- Design changes: Component or architectural changes
- Eco innovation practices towards sustainability development

An incremental green product innovation is referring to the minor improvement of previous product versions using existing or low technologies and skill of employees. Changes performing based on value added activity to continuously improve product or process performance and respond based on customer demand. This type of innovation is straightforward as changes are based on the similar production and network while no marketing research evaluate a new needs of customer. On the other side, radical innovation required the transformation on soft elements such as social and skill while hard elements in terms of high technology and machinery (Hellström, 2007). The activities defines as a destructive activities because requisite to conduct research and development (R&D) in new marketing, technology, operation and management respectively. The activities renown as value creation in economist as the output of the activities creates a new system. Companies applying patent to guarantee product copyright as they have a right as a pioneer for the product development (Dangelico & Pujari, 2010). Both type of innovation brings different challenges to carry out as level of complexity increase from incremental to radical, however, performing radical innovation resulted on sustainability development in triple bottom line effect of social, economy and ecology.

There are several authors discussing on the changes in product design to differences the incremental and radical changes (Hellström, 2007; Halila & Horte, 2006; Ehrenfeld, 2001; Brezet, 1997). The most influences design change definition in eco innovation initiate by Brezet and it is widely discusses in literature (Halila, 2007). Brezet (1997), developed four types of eco design model which comprised of (i) product improvement, (ii) redesign product, (iii) function innovation and (iv) system innovation. The model is purely related to changes in product innovation which incremental defines as product made base on environmental compliances or added a substances with the attention to reduce the environmental impact in product life cycle. Radical innovation

214 engaged on development of new product that functions as a replacement of the existing product or introducing a  
215 new product that changes the entire system of usage. Brezet model encourages Ehrenfeld (2001) to develop the  
216 eco innovation categories and level of changes dimensions. He agreed that eco innovation design changes can be  
217 both products and services which embedded in four types of category; process and product redesign (category 1),  
218 functional innovation (category 2), institutional innovation (category 3) and system innovation (category 4). The  
219 former categories reflect on the incremental innovation as the changes are minor or none in device concept,  
220 infrastructure and changes in users learning. The later categories rest on radical innovation as reflect on minor to  
221 significant changes in three categories (Smith, 2008). Halila and Horte (2006) in their research which extending  
222 Brezet model because they argued that product improvement, redesign product and function innovation are  
223 improperly described and uneasily understood. However, eco innovation model developed by Halila and Horte  
224 (2006) is a holistic in describing the changes of product innovation and are not specifically discussing the  
225 changes in eco product innovation. In summary, there are three most influence journal describing the radical  
226 incremental changes in eco innovation practices in Product life cycle are belong to (Carrillo-Hermosilla et al.,  
227 2010; Dangelico & Pujari, 2010; Hellström, 2007). Pujari proposal in eco product innovation framework is  
228 highly cited while Hermosilla and Hellstrom model is widely acceptance in describing changes in radical  
229 incremental eco innovation practices.

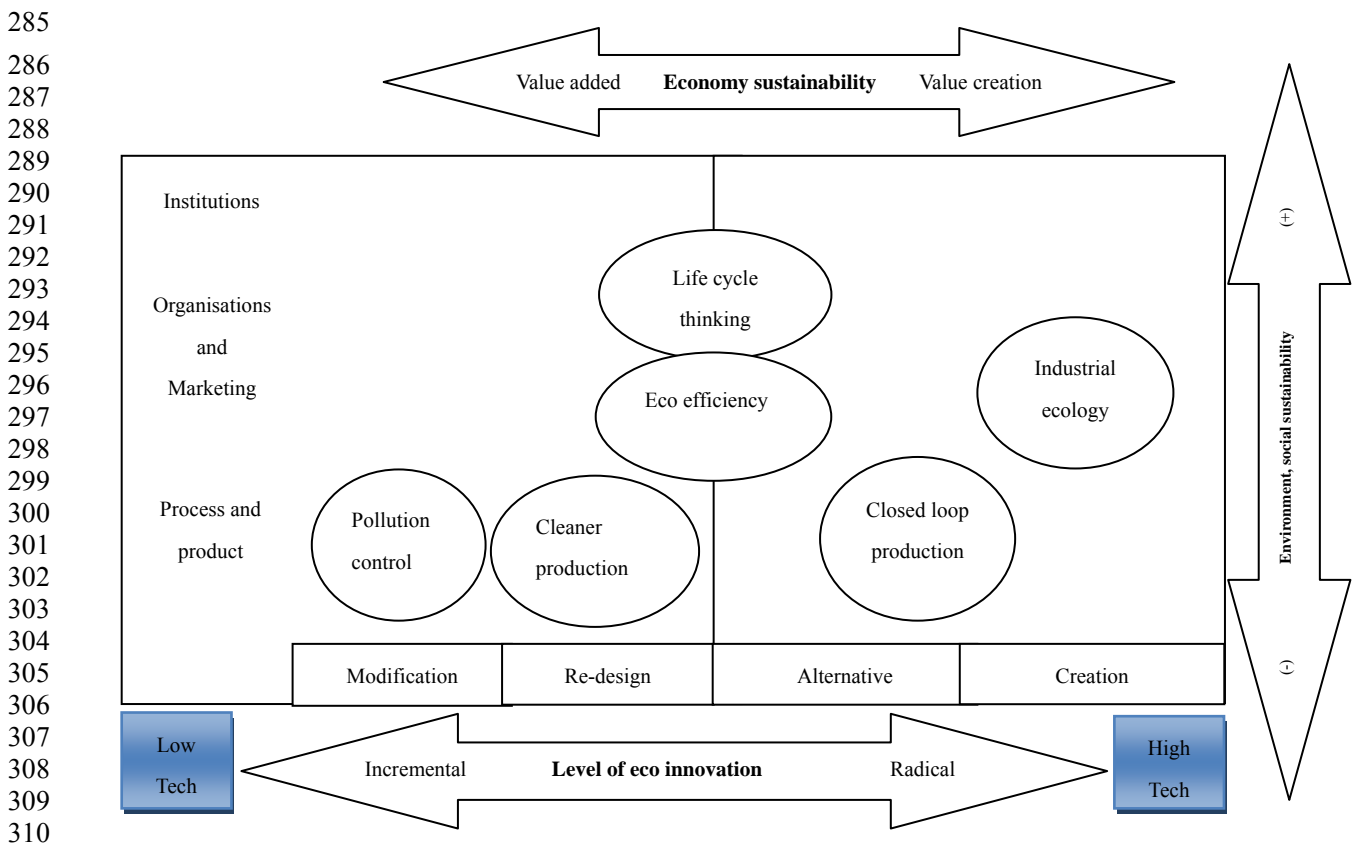
230 Hellström (2007) as the founder of incremental–radical in eco innovation describes type of changes in both  
231 innovations can be either in form of component or architecture. A component change is related on the  
232 replacement of one element within a larger system while the architecture relate on changes in altering the overall  
233 system design and mode of connection within the system. Under the umbrella of eco innovation typology,  
234 pollution prevention and cleaner production, obviously lies on the incremental innovation because it is related on  
235 the minor improvement such as component addition and sub-system change (Carrillo-Hermosilla et al., 2010).  
236 Changes made in the production system or curative action has limited impact to the environment and most  
237 probably the impact is unknown. Pollution control or end of pipe technology is a classical approach related on  
238 the additional component or devices (scrubber, filter, catalytic converters) and waste treatment at the end of  
239 production process to control air and water quality. Even though this technology has impact to environment,  
240 however this technology seems to be as burden to the companies as the treatment require investment and reflect  
241 on diverging company profit and economy growth Porter & Linde (1995) and the implementation based on  
242 regulatory push (Rennings, 2000). Other approach is the cleaner production which focusing on the preventive  
243 solution at the earlier stages in production lines to treat the source of pollution. (Machiba, 2009) reported four  
244 applicable approaches by companies in reducing environmental risk namely; (i) housekeeping in production  
245 process and work practice (ii) Process optimisation and low toxic materials used (iii) new technologies (iv) new  
246 design. Greening the production is much cheaper than curative technology as the impact indirectly increased on  
247 the manufacturing efficiency (reduced defect, maximized quality),reduced cost of operations and non  
248 compliances punishment of effluent or emission ( Arundel & Kemp, 2009; Hart, Ahuja, & Arbor, 1996)

249 The World Business Council for Sustainable Development (WBCSD) initiates the notion of eco efficiency in  
250 business level to leverage sustainable development with the objective is to “produce more goods or services with  
251 less waste and pollution”. MEI measures companies performance in seven eco efficiency such as; energy, water  
252 and material consumption, Greenhouse gas, other gas emission and total waste output and total waste mass  
253 balance (Kemp & Person, 2007) . Companies are advised to monitor, audit and plan strategies for their  
254 production process which align the eco efficiency objective. Performing environmental management system  
255 (EMS) benefits the companies in designing their activities based on environmental thinking, increase corporate  
256 images and better economic performance. Life cycle thinking linked to the green supply chain methodology.  
257 Companies performing environmental assessment in every stage of product life cycles and measure suppliers’  
258 performance based on quality, cost, and delivery and environmental to ensure non hazardous product supplied.  
259 Further, product and packaging used back in the production line to reduce cost of operation.

260 Incremental eco product innovation related on replacement of conventional materials with recycles components,  
261 eco efficiency production and design for recyclable product. However, eco efficiency and life cycle thinking can  
262 be both incremental and radical changes depending on their impact to environmental. Radical eco product is  
263 much significant on replacement of critical components that resulted on high impact to environment, creation a  
264 valuable new product from recycle components or creation a new product that superior in technology and new to  
265 the market. Closed loop production, and industrial ecology lies on the radial innovation related on usage of  
266 alternative components and creation of new system that have a significant impact to reduce environmental  
267 burden.

268 In the radical green product implementation, two alternative design followed; close loop and open loop  
 269 production system. Close loop production promotes reuse, recovery and remanufacturer where companies collect  
 270 an end used product from a customer, disassemble and process them into valuable new product or rebirth the end  
 271 life product while maintaining the identity and functionality of the original product. In the industrial ecology or  
 272 called the open loop design, are which the materials can be both recycled on industrial production system or  
 273 biodegradable by the natural environment. The product is designed to be biodegradable and has zero risk impact  
 274 to environment during disposal. Radical product innovation can also be referred to as the development a new  
 275 product based on efficiency approach which react as substitute to the existing product but advance in technology,  
 276 for examples the introduction of hybrid and hydrogen alternatives for energy efficient vehicles (EEV) in terms of  
 277 lowering fuel consumption and carbon emission.

278 To conclude, the eco product innovation in manufacturing can be best understood as producing product that less  
 279 pollutant to environment through efficient usage of material, energy and resource (incremental). In a radical  
 280 change, the production process is known as complex because the environmental impact is higher. The  
 281 implementation consist of developing a green product that behave as creation a superior product to eliminate the  
 282 environmental pollution or using a substitute material such as recycle material or biodegradable components in  
 283 product design. Figure 2 shows a holistic diagram level of eco innovation implementation between  
 284 radical-incremental dimensions towards achieving sustainable development.



311 Figure 2. Conceptual diagram of radical-incremental eco innovation towards sustainability development adapted  
 312 from (Carrillo-Hermosilla et al., 2010; Machiba, 2009; Hellström, 2007)

313

### 314 5. Paradigm for Eco Innovation Research in New Millennium

315 Eco innovation approved as a bridge to achieve sustainability (Kijek & Kasztelan, 2013; Angelo et al., 2012;  
 316 Carrillo-Hermosilla et al., 2010) and manufacturing industries are the perfect medium to achieve the mission  
 317 (Sezen & Çankaya, 2013). The growing attention of global concerned on sustainability and green practices  
 318 acquire attention of both institutes and academic to discover the phenomenon. In one hand, more insight into best  
 319 practices in manufacturing activities developed by OECD as guidance to leverage sustainability development  
 320 (Machiba, 2009). Schiederig et al., (2012) reported that, a total of 8516 publications related to green, ecology,  
 321 environment and sustainability domain released from 1990 to 2010, which 62.6% of the scholar dominated in

322 Business, administrations, finance and economics (BAFE) relatives to other fields. However, the central topics  
323 under the umbrella of eco innovation is unbalance as widen knowledge determine at macro level in marketing  
324 and economic research ( Rennings & Rammer, 2010;Porter, 1991) compared to meso and micro level explicitly  
325 in green innovation management (Driessen, Hillebrand, Kok, & Verhallen, 2013; Schiederig et al., 2012; Halila,  
326 2007) and new product development (Dangelico & Pujari, 2010; Pujari, 2006).

327 Although recent publication shows an increasing trends of literature found in eco innovation and new product  
328 development domain; (i) resource base view in corporate environmental performance (Hart, 1995; Russo &  
329 Fouts, 1997) (ii) best practices of green product innovation activities (Pujari, 2006;Pujari, Peattie, & Wright,  
330 2004) (iii) dimension of eco innovation (Carrillo-Hermosilla et al., 2010; Dangelico & Pujari, 2010; Hellström,  
331 2007) (iv) market performance of green product (Halila & Rundquist, 2011; Sharma et al., 2013) and (v)  
332 measurement of eco innovation (Arundel & Kemp, 2009), however, academician and managers are keen to learn  
333 “how companies performing environmental innovation into manufacturing process particularly in developing a  
334 new product at the different level of innovation (radical versus incremental) and types of environmental focus  
335 (material driven, energy based or pollution prevention)” as limited knowledge and empirical study found in  
336 literature regarding on capabilities needed to manage green product innovation at micro and meso level  
337 specifically in developing countries ( Schiederig et al., 2012; Carrillo-Hermosilla et al., 2010; Dangelico &  
338 Pujari, 2010; Hellström, 2007)

339 Malaysia, as a part of developing countries grants the green awareness at their National level. The Prime  
340 Minister, Dato Seri Najib Tun Razak introduced National Green Technology Policy in 2009. Out of four areas;  
341 energy, transport, building and manufacturing as a bridge to sustainability, manufacturing initiatives are hotly  
342 debated in literature since this sector is predominant for nations and social development. The automotive  
343 industries have significant contribution in Malaysian employment (more than 550,000 employees before and  
344 after market) and economic growth (3%-4% GDP per year) via manufacturing and marketing activities  
345 (Nurulizwa, Yahya, & Samer, 2013; Samer, Majid, Rashid, & Fasasi, 2012). This industries steadily growth  
346 since 1985 in technology transfer and product development while highly protected by the government because  
347 the industries encompass increasing number of company (up to 570 manufacturer and 35,000 aftermarket  
348 business) and build up from numerous components and suppliers in different industries such as metal, plastic,  
349 rubber, Electric & Electronics and others. Ironically, in the recent years, automakers have faced a tremendous  
350 challenge since growing attention on sustainability development. Even though automotive industries relate on  
351 economic sustainability, however the impact on environmental and society are vice verse.

352 The automotives industry acknowledged as the main contributor for the 20% of CO2 emission (Machiba, 2009)  
353 and other source of air pollution such as particulates, sulphur dioxide, nitrogen dioxide, carbon monoxide and  
354 hydrocarbons mainly in urban areas (Nunes & Bennett, 2006). On top of that, the auto industry related on the  
355 increasing number of waste by 25,000 tons/day, exploitation of natural resources along the product life cycle  
356 (PLC) and indirectly effects to social life; noise pollution, losses from accident and traffic congestion (Ariffin,  
357 2012). Therefore, the current trends for the competitive advantage in global automotive industries rest on  
358 effective and efficient implementation of green manufacturing throughout introduction of cleaner technology,  
359 improves fuel efficiency, and developing green vehicles as the demand of green market increase globally mainly  
360 in Europe and United States (Kari & Rajah, 2008).

361 The increasing of attention and global competition in a sustainability development has forcing the local  
362 automakers and suppliers to shift their paradigm in green production strategy and activities. The pressure to eco  
363 innovate relies on worsen of air quality, response on Global trends of producing hybrid and electric vehicles  
364 originated from Japanese, Chinese, and Indian countries (MAI, 2013; Pujari, Wright, & Peattie, 2003) and  
365 compete with the traditional competitor which are Thailand and Indonesia (Yahya & Nurulizwa, 2012).  
366 Therefore, the priority in New Automotive Policy (NAP) released on 20th January 2014 emphasizes on the  
367 sustainability implementation in producing auto product; car and motorcycles driven by the alternatives energy  
368 resources and emphasizing of green automotive life cycle through 3R concept (Reuse, Reduce, Remanufacturer)  
369 (MAI, 2013). The new trends of sustainability development resulted on growing research attention of how to  
370 manage manufacturing sustainability and successfully develop product based green innovation practices.

371 Sustainability research in automotive industry is central for the manufacturing management in exploring its  
372 drivers and barriers (Amrina & Yusof, 2012), lean manufacturing implementation (Azlina, Salleh, Kasolang, &  
373 Jaffar, 2011), performance indication (E.Amrina & Yusof, 2011) and green practices (Condong, Mohd Zubir,  
374 Hashim, Sri Lanang, & Habidin, 2012). In contrast, literature found that, in the new product development areas  
375 is limited on the eco design implementation (Gonzales, Sakundarini, Ariffin, & Taha, 2010)(Taha, Sakundarini,  
376 Ariffin, Ghazila, & Gonzales, 2010) and increasing research demand on how companies successfully managed



377 eco product innovation development and its implementation (Eltayeb, 2009) while most of the companies in  
378 Malaysia are lacking on green information and not clear on capabilities needed to involve and performing green  
379 product development. In respect to the government regulations and market pull factors, for greener the product  
380 and value chain, a fruitful research needed as a platform for the companies to understand the effective way on  
381 managing eco product in two directions incremental or radical innovation. Incremental green practice is highly  
382 performed in end of pipe technology and Eco efficiency where 704 companies approved under Environmental  
383 Management System (653 companies) and Energy Management System (6 companies) respectively from SIRIM  
384 database. Yet, radical eco innovation practices is a new approach in manufacturing practices that reflect on new  
385 way of management and little companies invest in high technology by 314 green products registered under  
386 Green tech record and 57 products meet the requirements under eco label scheme in SIRIM certification since  
387 2010. Therefore, there is an urgent call by both academicians and industries to explore the paramount  
388 management practices on how companies incorporate environmental requirements during developing a product  
389 either in incremental or radical approach. This research is significant as many manufacturing industry in  
390 Malaysia are still struggling to improve their product performance in the global competition. By introducing eco  
391 product innovation will increase the rank of Malaysian product nationally and globally.

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