UNIVERSITY OF MALAYA

Greening Malaysian Industries

Prof. Ir. Dr. Abdul Aziz Abdul Raman
Department of Chemical Engineering
Faculty of Engineering
University of Malaya

Inaugural Lecture

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4 April 2016

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Abstract

Malaysia voluntarily committed itself to reducing its carbon intensity by 40% in 2020, compared to the level in 2005, during the United Nations Climate Change Conference in 2009. Since then, many strategies have been implemented, especially in the energy sector. Introduction of Renewable Energy Act in 2011 was a great milestone. The carbon intensity was significantly reduced to 0.72 $kgCO_2$ /USD in 2013 from 1.3 in 2005. However, this was still higher than the carbon intensity of the other developed countries like Australia, which only generated about 0.4 $kgCO_2$/ USD in the same year. Manufacturing is one of the sectors that contribute to about 20% of the total carbon emission in Malaysia. Prof. Abdul Aziz and his team have adopted Cleaner Production strategies to reduce the carbon intensity in many industrial premises including printing, food & beverage, chicken processing, plastic, pharmaceutical and chemical industries. A standard method for auditing and generating greening options has been developed. The generated options are mainly achieved through changes in materials, operational parameters, design and process modifications. Generally, around 30-40% of the implementation cost of those greening options can be recovered within six months in most premises.

Biography

Professor. Ir. Dr. Abdul Aziz Abdul Raman is currently the Deputy Dean (Academic) of the Faculty of Engineering, University of Malaya. He is a Chartered Engineer registered with the Engineering Council of the UK and a certified Professional Engineer with the Board of Engineers of Malaysia. He has been actively contributing to the development of engineering profession by participating in various professional organizations, which serve as platforms for knowledge and experience sharing. He is currently the Chairman for the Malaysian Branch of the Institution of Chemical Engineers (IChemE), UK. Apart from the above, Prof. Abdul Aziz is also a corporate member of the Institution of Engineers, Malaysia. He aspires to improve the environmental quality through his professional knowledge and he believes that the mother earth ought to be taken care of for the future generation. He is involved in a wide range of environmentally related research, including advanced water treatment, Cleaner Production, Green Technology and biofuel. Besides, he is also active in research in mixing in stirred vessels, focusing on efficient mixing strategies that boast optimized use of natural resources. To-date, Prof. Abdul Aziz has more than 200 publications in the form of books, book chapters, indexed journals and conference papers. More than 80 PhD and Master holders have been produced under his supervision. Besides, he has developed several patents on environmental friendly process, which are a joint effort between his research team and him.

Prof. Abdul Aziz's contributions are not only on papers or in the academic world. He has well utilized his expertise in improving the societal well being through a number of non-academic activities. For example, he has trained more than 120 officers from the Department of Environment on Cleaner Production (CP), equipping them with the relevant knowledge to promote CP at the industrial level. He has also developed a methodology on Cleaner Production Auditing, which is already in-use by the Department of Environment of Malaysia. Apart from the collaboration with the governmental bodies, Prof. Abdul Aziz also believes in engaging and helping the industrial players. He has helped more than 40 Small and Medium Enterprises (SMEs) to increase their productivities through implementation of Cleaner Production. He has developed a guideline for the Batik, Printing and Beverage Industry in Malaysia, which is the first of its kind to help these industries to comply with the environmental regulations.

In short, Prof. Abdul Aziz is a strong believer that engineering knowledge does not only contribute to technological advancement, but also serves as a tool to make our living environment healthier and cleaner. He hopes to improve the life of human kind and the environment through his expertise.

Acknowledgement

I would like to express my gratitude to all my team members, colleagues and students who have contributed to my progress in all professional and personal aspects. Special thanks go to the Faculty of Engineering Management Team and Chemical Engineering staff for making many of the achievements possible.

Thanks are given to Raja Shazrin Shah, Razuana and Kai Shing for their special contribution in assisting me in realizing greening initiatives for the last five years. I am also indebted to Prof. Nik Meriam Sulaiman, Prof. Kheireddine Aroua, Prof. Shaliza Ibrahim, Dr. Rozita Yusoff, Dr. Che Rosmani Che Hassan and En. Mohd. Iskandr Md. Nor for starting the pioneering work in promoting the greening efforts for the Malaysian industries.

This greening effort would not been possible without the contributions and support from En. Ramli Abd. Rahman and the team from the Green Industry Unit, Department of Environment, Malaysia.

I would like to take this opportunity to express my gratitude to Puan Maznolita Hamdan from the University of Malaya Consultancy Unit for behind-the-scene support and motivation to carry out many of the work undertaken by the team and myself.

Last but not least, I sincerely dedicate all the goodness I have achieved to my family, especially my wife Ramizah, without whom, I would not be a useful human being.

Greening Malaysian Industries

Introduction

Environmental conservation and sustainable development have become global efforts in the last two decades. A green and environmentally friendly business no longer adheres to being compliant legally but also being energy efficient, having minimal waste generation and processes. In order to remain competitive, industries have to be more creative in reducing resource consumption, increasing processes efficiency, preventing waste generation and ultimately reducing carbon footprint.

Industries play an irreplaceable role in the country's quest to become a developed nation by 2020. In spite of their indispensable financial contribution to the country's wellbeing, their impacts on the environment are significant, building on the augmenting figures and facts of global warming and climate change. Industrial activities are unquestionably the main causes of greenhouse gases emission that is the culprit of rising global temperature. Moreover, inefficient industrial processes that often over exploit natural resources and adopt direct disposal method without a second thought on waste reclamation or resources reduction exaggerate the already worsening environmental condition. Industries, which only take care of their backyards and profits are no longer acceptable at the global stage in the long run, if they are to sustain.

Green Industry (GI) is an important strategy for sustainable development. It focuses on process optimization, cost saving, high business return and compliance to environmental laws and regulations. GI is a preventive strategy aiming at minimizing the negative impacts of manufacturing process and products on the environment. As compared to the end-of-pipe treatment, GI based techniques and technologies use energy, raw materials and by-products more effectively, reducing waste and hazardous waste generation, encouraging reuse and recycling of natural resources and systematic management of wastes. Therefore, GI implementation plays a role in raising the legal compliance level of a premise, especially to the Environmental Quality Act 1974 (EQA 1974). Besides, GI strategies also significantly benefit a premise both financially and environmentally at a global level.

In short, GI strategies aim at reducing global greenhouse gases emission to mitigate climate change. It is in line with the statement made by the Malaysian Prime Minister at the United Nations Climate Change Conference at Copenhagen in 2009, which pledged that Malaysia would reduce its carbon intensity by 40% by 2020 compared to its carbon intensity in 2005.

Current Malaysia's Environmental Status

Global warming and climate change have become global concerns since the last decade. The greenhouse gases (GHG) in Malaysia are increasing due to economic growth and huge developmental activities. Malaysia, with a population of 29.9 million (The World Bank, 2013), has an emission per capita of approximately 7.8 million. The total GHG emissions increased by 13% in 2013 compared to 2009. The GHG emission intensity increased by 28.7% between 2009 to 2013 as shown in Table 1. Figure 1 shows the trend of the carbon intensity in Malaysia between 1990 to 2013.

Table 1: GHG Emissions for Malaysia (Source: Trading Economics)

	Unit	2013	2009	% Increase
GDP	USD billion	323.34	202.26	37.4
Population	Million	29.95	27.8	0.07
CO_2 equivalent	Mil ton	234.66	204.05	13.0
CO_2 equivalent per GDP	Ton/ thousand USD	0.72	1.01	28.7
CO_2 equivalent per GDP	Ton/ capita	7.8	7.34	5.9

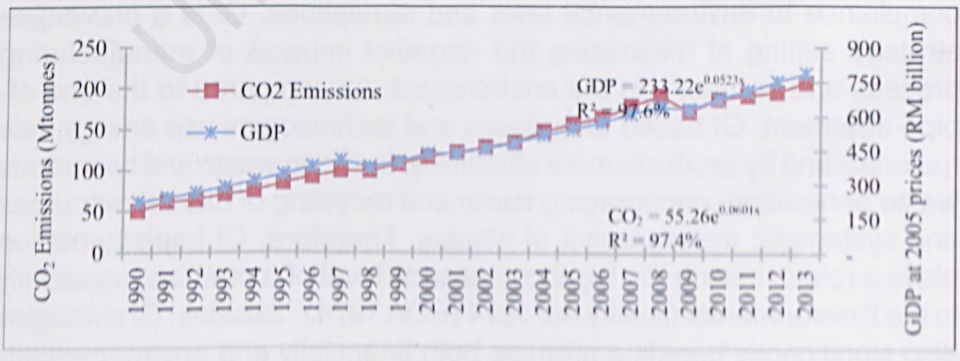

Fig. 1: CO_2 emissions and GDP trends in Malaysia (1990 – 2013) (Source: DOSM (2013) and IEA (2014b))

In 2013, a total of 235 million ton of CO_2 was emitted, where a total of 208 million ton of CO_2 emissions were emitted from the energy sector (IEA, 2014b). Electricity generation, transportation, manufacturing and other sectors contributed to 46%, 22%, 19% and 13% of the total CO_2 emission with an annual growth rate of 6.4%, 4.4%, 3.6% and 13.9%, respectively. The industrial sector is among the largest emitters after the transport sector. This indicates the significant impact of this sector on the country's overall emission and more effort should be taken to mitigate and reduce GHG emission.

Malaysia's Commitment

Malaysia is undergoing rapid development in order to achieve the status of Developed Nation by year 2020. The aspiration towards economic competitiveness has led to rapid urbanization and industrial development, which increase the generation of CO_2 emissions. Figure 2 shows the comparative CO_2 emissions between Malaysia and a few developed and developing countries. Although developed countries such as Sweden, Switzerland and France are traditionally the main emitters of CO_2 emissions, developing countries like Malaysia and China have now surpassed their emissions (den Elzen et al., 2009; World Bank, 2014).

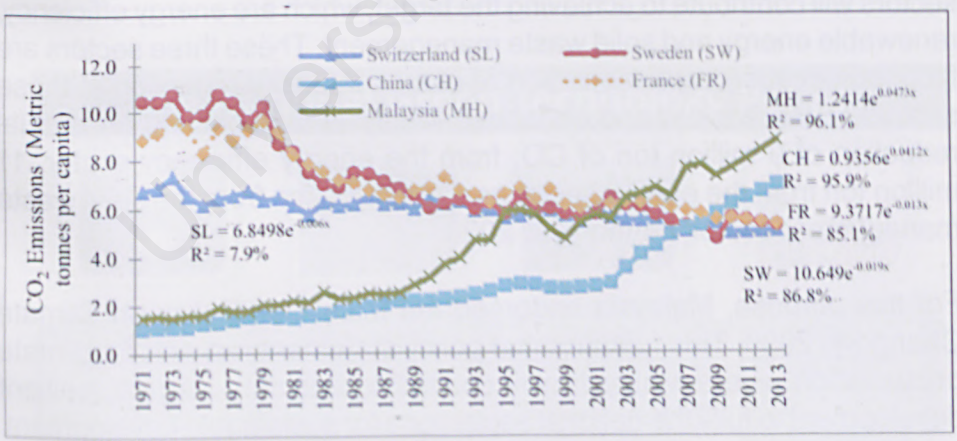

Fig. 2: CO_2 emissions per capita in countries (1971 – 2013)
(Source: World Bank 2014)

Malaysia has taken several mitigation measures in view of the alarming domestic and international pressures in reducing the emissions.

Consequently, many developing countries including Malaysia have declared their commitment to reduce CO_2 emissions. Malaysia is a signatory of many international accords for CO_2 emission reduction, which include Montreal protocol of 1987, Kyoto protocol of 1992, Copenhagen accord of 2009 and Cancun agreements of 2010. In 2009, Malaysia stated a voluntary target of reducing its CO_2 emissions intensity by 40% (based on its 2005 levels) by 2020 (NRE, 2011) to implement the Cancun agreements and the Bali declaration of joint efforts of emission reduction by both developed and developing countries at the 15th Conference of Parties in Copenhagen. This translates into emitting about 60% of the 2005 emissions in the production of each unit of GDP while the targeted reduction of the emission intensity for 2020 is 0.37 t CO_2/thousand RM. On the assumption that Malaysia successfully progresses on the path of the projected development, the GDP in 2020 is expected to be RM 906.6 billion. Therefore, the total emission would have to be limited to about 335 million ton of CO_2.

The voluntary 40% reduction is seen as a major step by the Malaysian government to achieve continuous economic growth and development without ignoring the environment. In order to achieve the target, various government link policies have been developed. The government has introduced a short-term roadmap to guide the CO_2 emission intensity reduction. This roadmap has identified that activities from three different sectors will contribute to achieving the target, which are energy efficiency, renewable energy and solid waste management. These three sectors are focused because implementation of carbon intensity reduction in these sectors is the easiest and cheapest. Malaysia is expecting an annual reduction of 9 million ton of CO_2 from the energy efficiency sector, 11 million ton from the energy sector and 25 million ton from the solid waste management sector, by the year 2020.

For this purpose, Malaysia endorsed the Malaysian Policy on Climate Change in 2009. This fundamental policy statement focuses on climate preservation where Malaysia will commit to ensuring climate resilient development to fulfil the national aspirations for sustainable development. Additionally, it is highlighted in the national policy that collective responsibility is needed in order to mitigate climate change to ensure national sustainability. Malaysia is aware that climate change will have an adverse impact on human by threatening the sustainability of natural resources. Therefore, 3 major objectives and 5 major principles have been underlined in the climate change policy, as shown in Figure 3.

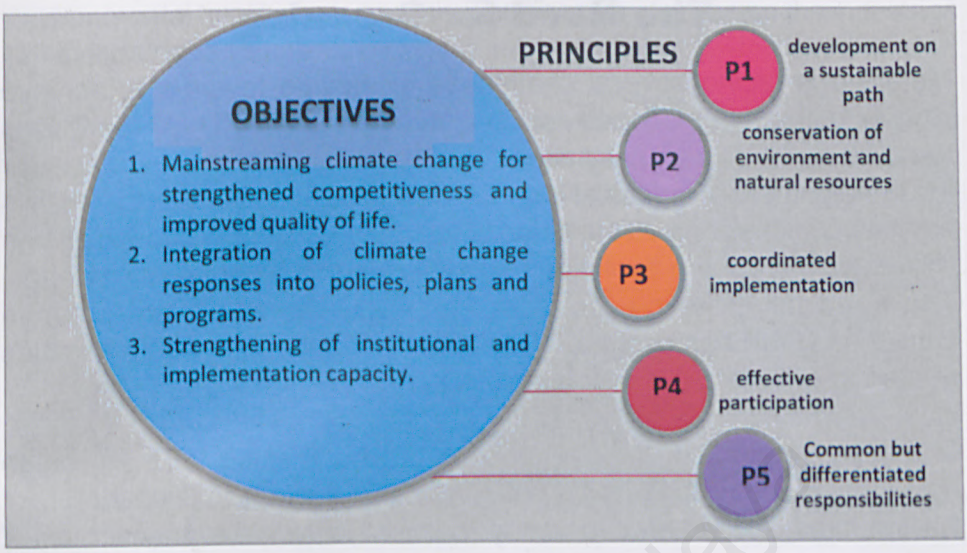

Fig. 3: National Policy on Climate Change

Besides, Malaysia has also launched the National Green Technology Policy in the 10th Malaysian plan focusing on 4 main aspects, which are energy, environment, economy and society. The policy emphasizes the initiatives to implement green technologies in Malaysia, which target at achieving zero or low emission, as shown in Figure 4.

Fig. 4: Four pillars of National Green Technology Policy
(Source: GreenTech Malaysia)

The Need for Greening

Malaysia is facing several challenges in moving towards to achieve high-income and developed-nation status by 2020 (EPU, 2015). This is because as the country progresses, the requirement for energy, mainly for the development of industrial activities, will increase and directly result in higher CO_2 emissions. At the same time, unsustainable economic growth will result in resource depletion and severe environmental degradation. The need for greening the industry, especially small and medium industries (SMI) has become an important agenda to tackle the issues related to climate change and emission.

End-of-pipe approach, which has been practiced since 1975, is able to help SMIs in complying with the environmental regulations (Department of Environment, 2013). However, it does not contribute to the improvement of environmental quality because there is no effort to reduce the consumption of input resources such as raw materials, utilities and the generation of various types of waste. Figure 1 shows that the CO_2 emissions in Malaysia increases with the GDP growth. Since the CO_2 emissions intensity is measured as CO_2 emissions per unit GDP, the strategy for CO_2 intensity reduction can be done by increasing the GDP sufficiently, while maintaining the total CO_2 emission or constraining the increase of total CO_2 emission. Malaysia needs to take effective measures to encourage industrial sectors to adapt environmental friendly development. There must be greening initiatives among the industries. The greening strategies should be implemented to help the industries improve their environmental compliance and increase the overall efficiency of the premise.

Green Industry (GI) promotes sustainable production and consumption. It covers various initiatives and efforts in greening of industries, where industries continuously improve their productivity and environmental performance. It aims at helping the industries produce environmental friendly products and services with lower CO_2 emission generation with proper waste management and recycling services and renewable energy technologies. Greening of industries has become the main determinant of economic competitiveness and sustainable growth since resource input is the main cost factor for the industries. Therefore, improved production efficiency benefits the industry.

Greening of industries can also promote health and safety aspects, create job opportunities, reduce overall operating costs and improve

environmental quality performance. The benefits of greening the industries are illustrated in Figure 5.

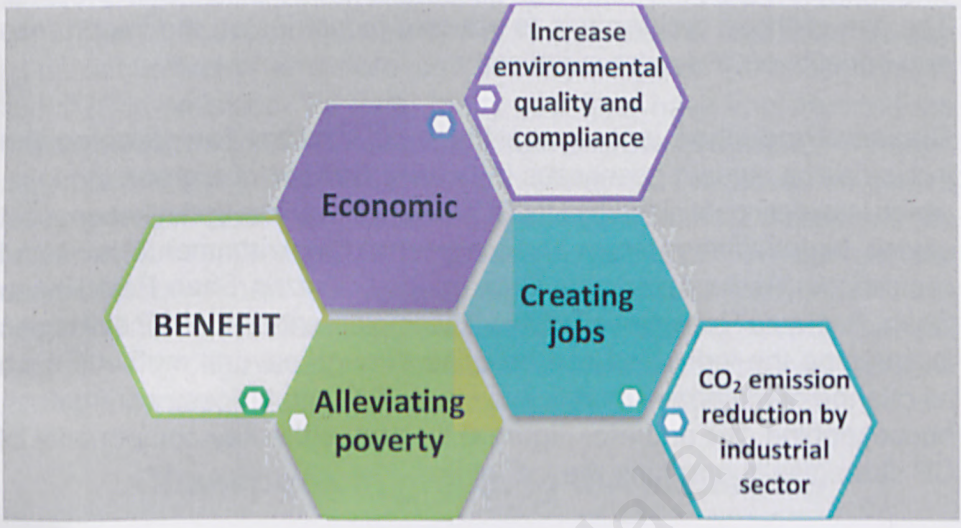

Fig. 5: Benefits of greening the industries

Greening Strategies

In 2009, the United Nations Industrial Development Organization (UNIDO) launched the Green Industry Initiative, emanated from a Ministerial declaration signed by over 30 representatives of the Asian governments. The Green Industry Initiative helps decouple growth from resource use and pollution by greening existing industries and creating new green industries. Currently, there are no specific laws and regulations in Malaysia that compel the industries to implement green industry initiatives in their premises. Currently, Green industry initiatives or a Cleaner Production (CP) strategies are implemented by the industry on a voluntarily basis. For example, a survey conducted in 2009 showed there were 369 out of 619 respondents that had implemented CP or part of CP in their premises. This showed that the industries had embarked on the CP programs on their own to optimize the processes and productivity of their premises (Department of Environment, 2011). The Department of Environment Malaysia has been promoting the Cleaner Production programme to the industries since 1990s. The department put in more aggressive efforts in promoting CP in 2007 during the 9th Malaysian Plan and the efforts continue with the 10th Malaysia Plan. The activities or programmes that have been conducted include capacity developments to create the skills

required to implement resource-efficiency initiatives and dissemination of knowledge and information through road shows, workshops, CP audit assistance program, CP training website and CP demonstration projects. The aim of these programs is to educate industries on the importance and benefits of CP implementation.

Cleaner Production is seen as the best strategy for greening the industries because it possesses the characteristics of a green industry, which is widely publicized by UNIDO, such as process optimization, cost saving, high business return and compliance to environmental laws and regulations (Abdul Aziz Abdul Raman, Raja Shazrin Shah Raja Ehsan Shah, Razuana Rahim, et al. 2014). The implementation of CP strategies in greening the industries can be done through several methods such as change of materials, modification in design and process parameters, housekeeping, 3R and etc. Figure 6 illustrates the key components of CP strategies in greening the industries.

Fig. 6: CP components

The introduction of carbon tax can also be the driving force in greening the industries by urging the industries to take serious actions in reducing the

CO_2 emissions generated from their production activities. Carbon tax is a form of explicit carbon pricing, which refers to a tax directly linked to the level of CO_2 emission, often expressed as a value per t CO_2e (WorldBank.org). The objective of this strategy is to recover the cost incurred due to harmful effect of emissions and thereby influence the consumers to reduce the emission. Till date, many countries have implemented the initiative such as Sweden, Australia, Japan and Switzerland. Even though the initiative has yet to be enforced in Malaysia, the industries should be prepared for the implementation. In addition, financial institutions are important for supporting new business opportunities, development and dissemination of new technologies among the industries. Malaysia has taken initiatives in promoting green industry by offering several financial incentives through financial institutions or independent funds, such as Green Technology Funds Scheme by Green Tech Malaysia.

Challenges in greening the industries

Many countries face severe environmental degradation and resource depletion, which threaten opportunities for sustainable economic growth and industrial development. The manufacturing sector alone accounts for a significant part of the world's consumption of resources and generation of waste. In recent years, countries that are facing environmental pressures have been increasingly aware of these environmental problems and making some improvements to their environmental management and industrial development regimes. However, many continue to face formidable political, institutional and resource-based constraints in trying to foster the greening of industries and promote sustainable economic growth. The Malaysian industries, especially Small and Medium Industries (SMIs) can exert considerable pressure on the environment. This is true for both developed and developing countries. For example, it is estimated that there are more than 600,000 of companies, which contribute significantly to the environmental problems in Malaysia.

There are several reasons why SMIs may be reluctant to adopt improved environmental practices. Firstly, they are often unaware of the environmental impact or the environmental legislation affecting them. Further, many SMIs lack the in-house expertise to identify and properly implement environmental technologies. SMIs usually do not carry substantial assets and therefore have difficulty accessing conventional loans. This lack of resources often leads to SMIs being risk-averse and less willing to invest in new environmental technologies, partly because

of the long payback period of the investment. SMIs also tend to have a short-term economic perspective, which often results in the perception that environmental management is peripheral to core business. The way they are organized and their operating procedures are significantly different from those in larger companies. They are unlikely to have an environmental division or a designated specialist responsible for environmental compliance and management in the company. The key challenges and limitations of implementing GI are illustrated in Figure 7.

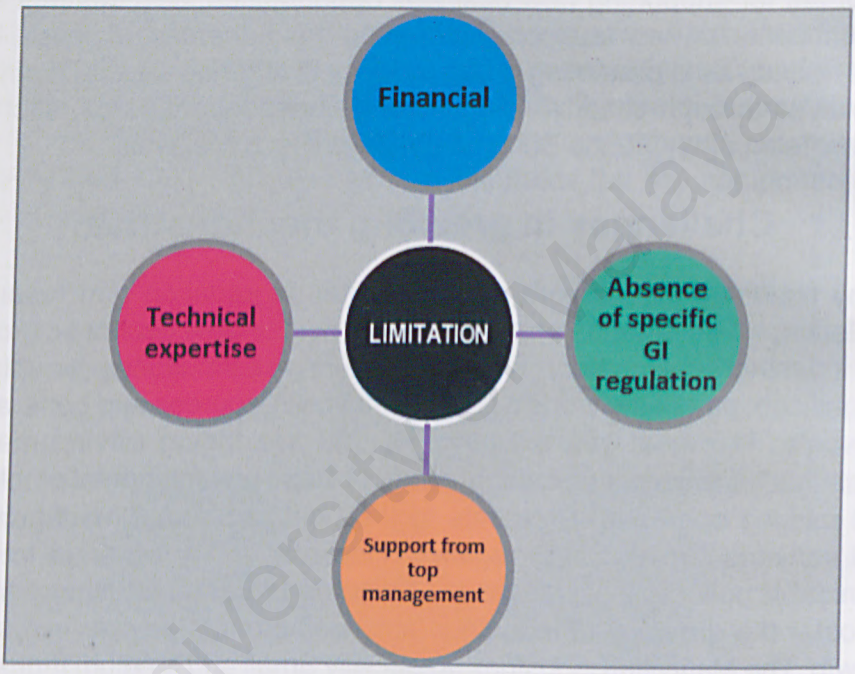

Fig. 7: Challenges in implementing GI

Role of Universities

Science and technology play a vital role in encouraging manufacturing industries towards using sustainable patterns of production and economic growth. Since most developing countries make technological advancement by adapting and adopting pre-existing technologies, the government's assistance programmes should facilitate both the absorption and diffusion of new technologies. Capacity development and technology transfer can be achieved through the provision of information, demonstration projects, technical assistance programmes, workforce training and the support

of technical institutions (e.g. Cleaner Production Centres, Centres of excellence).

Educational institutions can facilitate knowledge transfer and diffusion of environmental technologies through infrastructures such as science centres, research clusters, incubators, global networks etc. In addition, financial support, such as Research & Development (R&D) grants and venture capital funds are important for supporting the development and widespread use of environmental technologies. Therefore, the government should support strategic R&D programmes linked to industry, as a means of providing scientific platforms to leverage new environmental technologies.

Areas for Research

Green research and technology offer opportunities in research areas in environmental studies and new technologies to help industries be more sustainable. Generally, the relevant research examines topics such as alternative fuels, renewable energy, advanced materials and technology used to reduce emissions. Figure 8 illustrates the potential research areas in greening the industries.

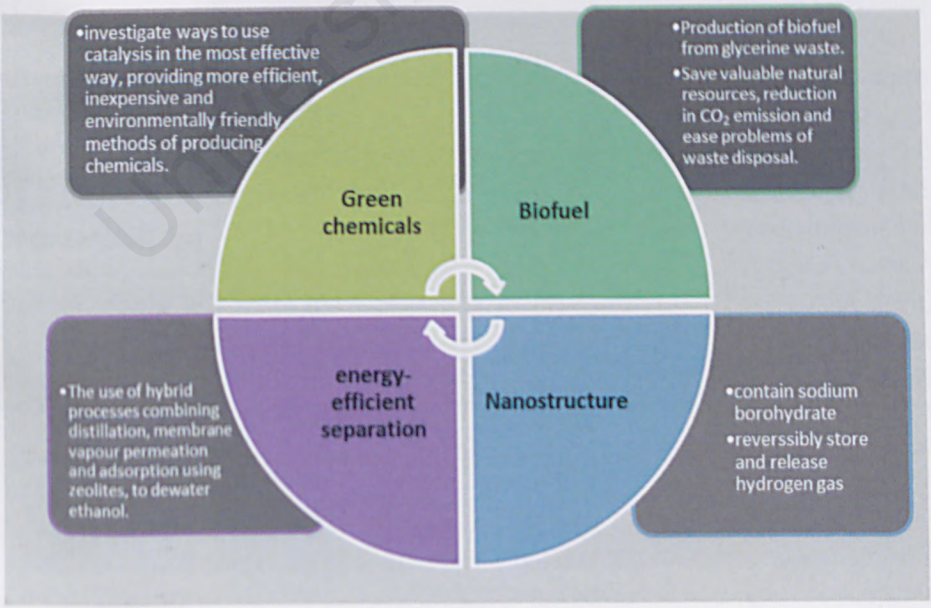

Fig. 8: Research area

Business Opportunities in Greening the Industries

Green business strives to reduce its negative impact on the local environment, community, society or economy while maintaining the profit. Today, green business is an extremely profitable branch of businesses and it hosts a range of companies from prestigious multinational companies to small, locally based companies. There are opportunities for sustainability in every aspect of the business, mainly focusing on eliminating or reducing harmful chemicals, excess materials, and waste by-products. Greening a business saves money and reduce environmental regulatory requirements. There are various degrees of going green, such as large factories may install solar panels to reduce energy costs while a local restaurant may deliver food by bicycles to reduce carbon emission. It has become a norm that companies generally recognize the potential cost saving and profitability of going green. More and more are taking steps, small and large, towards greater sustainability.

Greening Initiatives By The Author

Books

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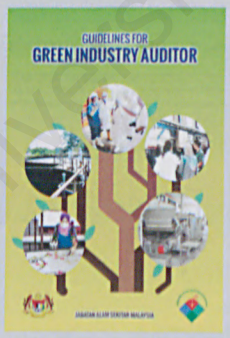

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Abdul Aziz Abdul Raman. April-June 2008. Case Study on Simple CP Implementation Through Design and Operational Modifications. ENSEARCH Bulletin. 4-5.

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Seminar on Cleaner Production: Towards Cleaner Malaysian Industries, Speaker, 2011, Department of Environment, Malaysia

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Cleaner Production for the Minimization of Chemical Usage and Waste Generation in Glove Manufacturing, Consultant, 2013-2014, TOP GLOVE Sdn. Bhd.

Consultant & Trainer and External Auditor for (1) Capacity Building Programme for Department of Environment Officer and External Auditors

for Small and Medium Enterprises (SME) (2) Training Programme for Small and Medium Enterprises (SME) Towards Developing a Demonstration Premise for Green Industry by Department of Environment Malaysia, Consultant, 2013-2013, Dasar-Data Sdn. Bhd.

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Technical Expert and Consultant for Cleaner Production Audit Competency Training (Level 2) for Officers of Department of Environment, Malaysia for Dasar-Data Sdn. Bhd., Consultant, 2010-2010, Dasar-Data Sdn. Bhd.

Demonstration of Cleaner Production through Cleaner Production Virtual Centre (CPVC), Project Leader, 2010, Department of Environment, Malaysia

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Module Development for Cleaner Production Audit, Expert Advisor, 2009-2009, Dasar Data Sdn. Bhd.

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A Self Help Tools for the Assessment and Deployment of Cleaner Production for SMI., Project Leader, 2003-2004, EIMAS

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Development of Cleaner Production Implementation Software for Small and Medium Industries, Consultant, 2003-2005, Department of Environment, Malaysia

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Study of Emission factors from Industries in Malaysia, 2002-2003, Consultant, 2002-2003, Department of Environment Malaysia

Brief Achievements and Contribution

Administrative Duties

Official appointments to date

No.	Position/Role	Date of Appointment
1.	Coordinator for UMCARES	2007 – 2009
2.	Deputy Dean (Postgraduate Studies) Faculty of Engineering	1 July 2011 – 15 May 2015
3.	Deputy Director University of Malaya Centre of Innovation & Commercialization (UMCIC)	16 May 2015 – 31 Jul7 2013
4.	Director University of Malaya Centre of Innovation & Commercialization (UMCIC)	1 Aug 2013 – 30 Sept 2013

No.	Position/Role	Date of Appointment
5.	Director Community and Industry Relations Center (CiTRA)	1 Oct 2013 – 1 May 2014
6.	Deputy Dean (Undergraduate Studies) Faculty of Engineering	1 Aug 2014 – 31 July 2016
7.	Senate Member for University of Malaya	1 Jan 2014 - present
8.	Member University of Malaya Consultancy Unit Council	8 Aug 2011 - present
9.	Director and Shareholder UPUM Sdn. Bhd.	8 Aug 2011 - present

Committees and other contribution to University administration

No.	Committee	Role
1.	UM ICT Users' Committee	Member
2.	Jawatankuasa Rayuan Universiti	Member
3.	Jawatankuasa SLAB/SLAI - Central Committee	Member
4.	Intellectual Property in UM Committee - UMCIC	Member
5.	Jawatankuasa Rundingan Terus A	Member
6.	Jawatankuasa Rundingan Terus B	Member
7.	Associate Professor Promotion Committee	Member
8.	Jawatankuasa Senat Mengenai Akreditasi (JSMA and JKSA)	Senate Representative
9.	Jawatankuasa Sistem Penilaian Prestasi PPT - 2012	Member
10.	Evaluation Panel for University of Malaya Excellence Award 2012	Member
11.	Pengurusan Penggantian untuk Kumpulan Pengurusan & Profesional (Bukan Akademik)	Assessor

No.	Committee	Role
12.	Jawatankuasa Pengadil Anugerah Cemerlang Universiti Malaya 2011 (Kategori Pengajaran)	Member
13.	University of Malaya (UM) Evaluation Panel – QMEC	Member
14.	Internal Auditor Panel	Member
15.	e-Learning Committee	Member
16.	Hazardous Waste Management Committee	Member

Committees and other contribution to Faculty of Engineering

No.	Committee	Role
1.	UM ICT Users' Committee	Member
2.	Jawatankuasa Rayuan Fakulti	Member
3.	Professional Development/Qualification Committee (PEng)	Chairman
4.	Jawatankuasa SLAB/SLAI	Member
5.	Postgraduate Committee	Member
6.	Undergraduate Committee	Member
7.	Quality Assurance Committee	Member

Committees and other contribution to Department of Chemical Engineering

No.	Committee	Role
1.	Workshop Services	Member
2.	Consultancy and Industrial Relations	Member
3.	Human Resource Committee	Member
4.	MQA Document Preparation Committee	Member
5.	Biodiesel Pilot Plant	Director
6.	Department of Chemical Engineering Bulletin	Editor
7.	Department Alumni	Coordinator

Other activities/contributions
National Level

No.	Description	Role
1.	Persatuan Kakitangan Akademik Universiti Malaya (PKAUM)	Setiausaha
2.	Ahli Giliran Majlis Kualiti Alam Sekeliling – Kementerian Sumber Asli dan Alam Sekitar	Member
3.	Chemical Engineering Technical Division Session 2013/2014 - Institution of Engineers Malaysia (IEM)	Council Member
4.	Visiting Professor – Universiti Malaysia Sarawak (UNIMAS)	Visiting Professor
5.	Committees of Green House Gases Inventory, Process Industry Sector - Malaysian Green Technology Corporation	Permanent Member

International Level

No.	Description	Role
1.	Institution of Chemical Engineers, UK (IChemE, UK) – Malaysian Branch	Chairman (2016 – present); Deputy Chairman (2014 – 2016); Hon. Treasurer (2013 – 2014)
2.	Institution of Engineers Malaysia (IEM)	Council Member (2014 – 2015)
3.	Global Awards Committee – Institution of Chemical Engineers, UK (IChemE, UK)	Member
4.	Promotion Exercise of an Academic to the Rank of Full Professor – Al-Balqa' Applied University, Jordan	Hon. Secretary
5.	Regional Staff/Student Development in Engineering in ASEAN – Southeast Asia Engineering Education Development Network (SEED-Net)	Member
6.	Asia-Oceania Top University League On Engineering (AOTULE)	Member

Consultancy & Expertise Offered

Client	:	Department of Environment Ministry of Natural Resources and Environment
Project title	:	Seminar on Cleaner Production: Towards Cleaner Malaysian Industries
Year	:	2011 - 2012
Roles/Services	:	Speaker and resource person for development of materials

Client	:	Department of Environment Ministry of Natural Resources and Environment
Project title	:	Implementation of Integrated Cleaner Production Strategies in Batik Premise
Year	:	2011 - 2012
Roles/Services	:	Project Leader

Client	:	Department of Environment, Ministry of Natural Resources and Environment & Dasar-Data Sdn. Bhd.
Project title	:	Consultant & Trainer and External Auditor for (1) Capacity Building Programme for Department of Environment Officer and External Auditors for Small and Medium Enterprises (SME) (2) Training Programme for Small and Medium Enterprises (SME) Towards Developing a Demonstration Premise for Green Industry by Department of Environment Malaysia
Year	:	2013
Roles/Services	:	Resource Person and Subject Matter Expert

Client	:	Top Glove (M) Sdn. Bhd.
Project title	:	Seminar on Cleaner Production to Top Glove - Principles and Concepts
Year	:	2013
Roles/Services	:	Consultant

Client	:	Bank Negara Malaysia
Project title	:	Laboratory Testing for Malaysia New Version of 50 Cent and 20 Cent Coins
Year	:	2013
Roles/Services	:	Consultant

Client	:	Top Glove (M) Sdn. Bhd.
Project title	:	Cleaner Production for the Minimization of Chemical Usage and Waste Generation in Glove Manufacturing
Year	:	2013 - 2015
Roles/Services	:	Consultant

Client	:	Alam Sekitar Eco-Technology Sdn. Bhd.
Project title	:	Independent Third Party Assessor for Bi-Act SDO for SPAN's Approval
Year	:	2013
Roles/Services	:	Independent Third Party Assessor – Professional Engineer (PEng)

Client	:	Board of Engineers, Malaysia
Project title	:	Development of Curriculum and Question Bank for Professional Competency Examination (PCE) Programme for Environmental Engineering Discipline
Year	:	2013 - 2016
Roles/Services	:	Project Leader

Client	:	Department of Environment, Ministry of Natural Resources and Environment & Dasar-Data Sdn. Bhd.
Project title	:	Technical Expert and Consultant for Cleaner Production Audit Competency Training (Level 2) for Officers of Department of Environment, Malaysia
Year	:	2014
Roles/Services	:	Resource Person and Subject Matter Expert

Client	:	Department of Environment, Ministry of Natural Resources and Environment & Dasar-Data Sdn. Bhd.
Project title	:	Development of Guidelines for Green Industry Implementation for Malaysian SMEs
Year	:	2014
Roles/Services	:	Resource Person and Subject Matter Expert

Client	:	Department of Environment, Ministry of Natural Resources and Environment & Dasar-Data Sdn. Bhd.
Project title	:	External Auditor for Green Industry Course
Year	:	2014
Roles/Services	:	Lead Speaker and Subject Matter Expert Consultant

Client	:	Department of Environment, Ministry of Natural Resources and Environment & Dasar-Data Sdn. Bhd.
Project title	:	External Auditor for Green Industry Course
Year	:	2015
Roles/Services	:	Lead Speaker and Subject Matter Expert Consultant

Client	:	Greendex Sdn. Bhd.
Project title	:	Independent Third Party Assessor for HAUS – Three-phase Decanter for SPAN's Approval
Year	:	2015
Roles/Services	:	Independent Third Party Assessor – Professional Engineer (PEng)

Awards & Recognition
University/ National

	Description	Year
1.	Top Research Scientists Malaysia, Academy of Science Malaysia	2014
2.	Best Teaching Award, Faculty of Engineering, University of Malaya	2013

	Description	Year
3.	Excellence Award for outstanding achievement in the category of Excellent Lecturer, University of Malaya	2011
4.	Certificate of Excellence in Teaching, Faculty of Engineering, University of Malaya	2010
5.	Award for Invention/Innovation of "Production of High Quality Biodiesel from Malaysian Palm Oil Using Al_2O_3 Membrane Reactor" at the Malaysia Technology Expo 2009, Malaysian Association Research Scientists	2009
6.	Award for Excellence in Service, University of Malaya	2009
7.	Award for Invention/Innovation of "Non-Destructive Apparatus for Measuring Blocks Porosity" at the Malaysia Technology Expo 2009, Malaysian Association of Research Scientists	2009
8.	Universiti Malaya Excellence Award 2009 for teaching, University of Malaya	2009
9.	Award for Excellence in Service, University of Malaya	2008
10.	The Chancellor Award for Excellence in Invention, University of Malaya	2007
11.	Invention/Innovation Award for "Bricks and Tiles from Industrial Solid Wastes" at the Malaysia Technology Expo 2006, Ministry of Science, Technology and Innovation Malaysia	2006
12.	Invention and Innovation Category Award for "Nano Particles Coating Studies" at the Ekspo Penyelidikan, Rekacipta dan Inovasi 2006, University of Malaya	2006
13.	Invention and Innovation Category Award for "Bricks and Tiles from Industrial Waste" at the Ekspo Penyelidikan, Rekacipta dan Inovasi 2006, University of Malaya	2006
14.	Award for Excellence in Service, University of Malaya	2006
15.	Award for Excellence in Service, University of Malaya	2005
16.	Award for Excellence in Service, University of Malaya	2003
17.	Award for Excellence in Service, University of Malaya	2002
18.	Dean's Award for Service Excellence, Faculty of Engineering, University of Malaya	1999

International

No.	Description	Year
1.	ITEX Gold Medal for the invention Continuous Production of Super High Quality Biodiesel Using Al2O3/TiO3 Membrane Reactor at the 20th International Invention, Innovation & Technology Exhibition (ITEX 2009), Malaysia Invention and Design Society	2009
2.	Environmental Design Competition (EDC) 2006, United Arab Emirate University	2006

Publications

2016

Khaki, M. R. D., Sajjadi, B., **Raman, A. A. A.**, Daud, W. M. A. W., and Shmshirband, S. (2016) Sensitivity analysis of the photoactivity of Cu–TiO_2/ZnO during advanced oxidation reaction by Adaptive Neuro-Fuzzy Selection Technique, Measurement, 77(2016): 155-174.

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