Design of Sustainable Business Management from aspect of Environmental Protection: Green Sustainable Business Management through CO_2 emission reduction

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Research Report Presented to the Faculty of the

Graduate School of Asia Pacific Studies, Ritsumeikan Asia Pacific University,

in Partial Fulfillment of the Requirements for the Degree of

Master of Science in International Cooperation Policy

Abstract

The global warming seems to have become the serious problem for worldwide to cause natural disasters. One of the chemicals that are believed to cause such global warming is CO_2. The nations and industries have a responsibility to take care about the global warming by focusing on reduction of CO_2 emissions.

The government is executing some measures or policies for CO_2 emission reduction to industries in their individual countries. Thus, CO_2 emission reduction has been the obligation for each company. However, companies have been reluctant to accept the imposition which hampers company's business achievement due to the constraints from the imposition. More recently however there seems to be moves among some companies to accommodate the need for CO_2 emission reduction while pursuing the business profitability for the sustainability.

The current study looks at a Japanese subsidiary of a German automotive company. In particular their Narahsino Office was investigated in terms of CO_2 emissions made by three business processes which are parts importation process, car user monitoring process and the Narashino Office management.

The study showed that the key issues for this company in terms of reduction of CO_2 emission are technological improvement of the vehicles, more effective parts importation operation and employment of more renewable energy sources for the electricity requirement.

Once the current situation is grasped the future intention of the author is to propose a set of environmental technologies further to decrease their CO_2 emission without sacrificing their operational efficiency.

Acknowledgement

This dissertation would not have been possible without helps and supports of several kind people who takes time to valuable assist in preparation and completion of this study.

First of all, my at most gratitude to Dr. Masanori Kato, Professor of the Department of International Business Management in Ritsumenkan Asia Pacific University whose sincerity and encouragement I will never forget. Dr. Kato has been my inspiration I hurdle all the obstacles in the completion of this thesis.

This thesis would not have been possible to complete without Dr. Klaus Helling, Dean of the Department of Environmental Business Management in University of Applied Science, Trier. He also my most great advisor and has been invaluable on an academic level, for which I am extremely grateful.

Dr. Peter Heck, Head of International Material Flow Management in University of Applied Science Trier, who kindly gave me advice regarding master thesis.

Dr. Michael Kanus, Professor of International Material Flow Management in University of Applied Science Trier, who had consideration regarding my academic requirement.

Members in the Department of Business Development in a German Automotive industry where I executed an internship, who supported and had kind concern and consideration regarding my completion of master thesis.

My colleagues in International Material Flow Management Dual Degree program 2010 who in one way or another were assistance when I had problems regarding completion of master thesis.

The staffs of Ritsumenkan Asia Pacific University and IfaS for managing IMAT program and all helps regarding master thesis management.

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1. Introduction

Economic growth tends to entail into gas emission, waste disposal, use of energy, and waste disposals from the industrial activity. It has been viewed that business growth is contradicting to the environmental protection. Recently, however, the corporate managers have been driven to see if there are suitable environmental solutions in managing businesses without diluting the profitability. Such a situation stems out of the historical evidences of environmental deteriorations. The social mood has changed recently in such a way that corporate managers can no longer disregard the environmental protection. Indeed they must consider three elements in harmony with each other: community, society and profitability as the objective of sustainable business strategies.

The most highlighted achievement for companies is CO_2 reduction since 1997 Kyoto protocol when CO_2 emission reduction became one of the most important objectives. The reduction targets are fixed for each of the participating countries through the protocol. In order to achieve the targets each of the nations has been enforcing rules for the companies operating in that country to reduce their CO_2 emissions by setting percentage reduction targets.

Under such circumstances, the current research will investigate the best sustainable solutions in each of the business processes in an automobile company to reduce CO_2 emissions without sacrificing the corporate growth and profitability.

2. Background

2.1 Global Warming

Global Warming has become a serious problem causing Environmental, Social and Economical effects. It is not configured when and how much environmental damages are caused by the warming. The underlining drivers are the population growth, economic growth and choices of energy, technology and agriculture[1].

The Global Warming is the temperature rise on the Earth's surface including ocean surfaces started from the industrial revolutions since 19th century. The global average surface temperature has risen by about 0.8℃ over the past 100 years[2], which has been driven mainly by increased greenhouse gas concentration in the atmosphere. The cause for this increase is due to human activities such as deforestation, air pollution and burning fossil fuels. It is predicted that the global average temperature will further increase by 1 to 6.4 ℃ by the end of the current century. The increase is higher than that in the period of 1980-1999 (Figure1). The cause of these temperature rises is from Greenhouse gas, in particular Carbon dioxide which is produced mainly by human activities. It is easier said than done that the one of ways to stop warming is reduction of CO_2. Scientists Richard Wetherald, Ronald Stouffer and Keith Dixon reports that even if greenhouse gas level in atmospheric is stabilized at the current level, the temperature would increase by 1℃[3].

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[1] Bert Metz (2010). Controlling Climate Change, P9

[2] Washington, D.C.: The National Academies Press. 2011. p. 15.

[3] NOAA(2001), http://www.gfdl.noaa.gov/cms-filesystem-action?file=/user_files/kd/pdf/onepageb01.pdf

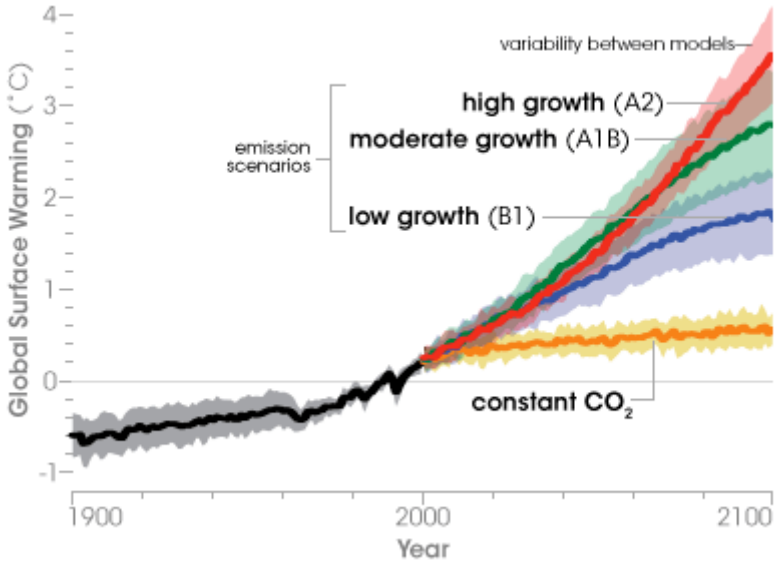


Figure1:Temperature projections to the year 2100, based on a range of emission scenarios and global climate models. Scenarios that assume the highest growth in greenhouse gas emissions provide the estimates in the top end of the temperature range.

(Source: EPA, *NASA Earth Observatory, based on IPCC Fourth Assessment Report (2007)*)

Furthermore, the characteristic of Warming is such that the temperature increase will vary from the region to region. (see Figure2).

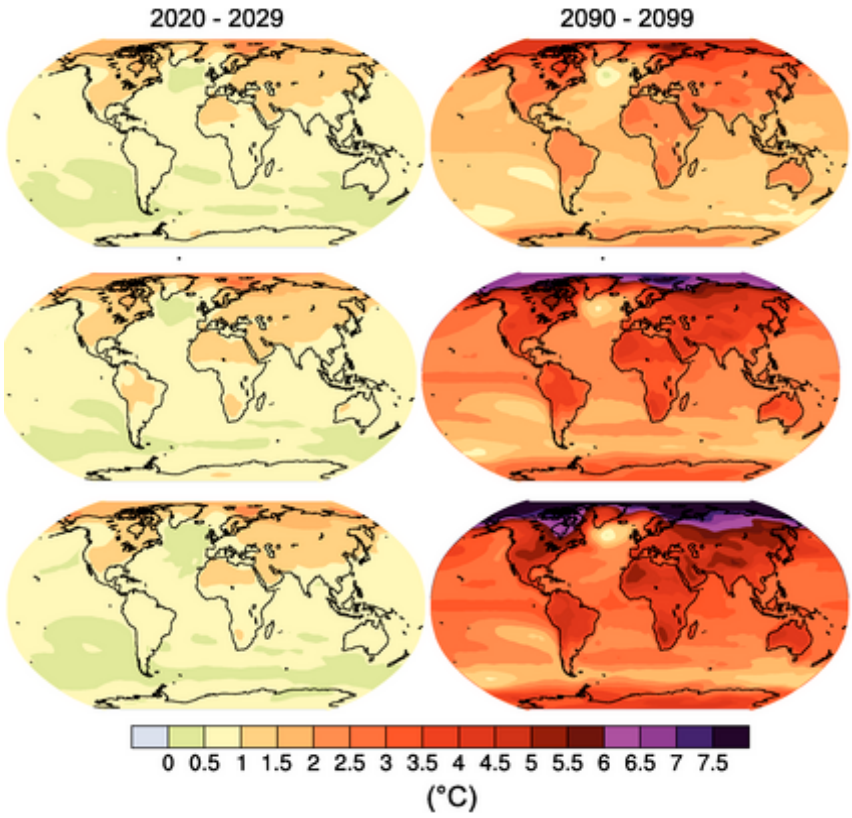


Figure 2: *Projected future regional patterns of warming based on three emissions scenarios (low, medium, and high growth).*

Source: NASA Earth Observatory, based on IPCC Fourth Assessment Report (2007)

As seen in Figure 2, the pole areas show higher warming and the equator part less warming. This is caused by the atmospheric circulation patterns that transport heat towards the pole[4]. The temperature in the North Pole is expected to be more than 7.5 ℃ higher by the end of century than in 1990, which is more than twice as higher as the global average temperature.

[4] Bert Metz (2010). Controlling Climate Change, P10

2.2 Effect of Carbon Dioxide on Global Warming

The Global Warming has a correlation with man-made Green House Gases (GHG). GHG causes temperature increase and it is required to control the emission of these gases.

The earth is warmed by the solar radiation. Some of the radiation is reflected back to the space by the earth's surface and atmosphere including water vapor, methane and CO_2. About a half of the remaining solar radiation is used to warm the earth's surface and the heated Earth then radiates infrared light which is then absorbed by GHGs and warm the atmosphere. This mechanism is called Greenhouse Effect that causes temperature increases. In addition, human activities have added the greenhouse gases to the atmosphere, and led to enhance the Greenhouse Effect. IPCC concluded that the main cause of increasing Greenhouse Effect is human activities and not the natural mechanism.

CO_2 concentrations in the atmosphere are a balance between the input and the escape of the gas. The speed at which the gas (CO_2) escapes from the atmosphere is very slow. The half life of the CO_2 gas disappearance is estimated at 100 years and the 20% of it can survive as long as 1000 years. Therefore, concentration of CO_2 is the most important anthropogenic GHG[5] to contribute to Global Warming because it has been rising at a high speed but disappearing slowly from the atmosphere. Its annual emission increased by about 80% from 1970 till 2004. The increase of CO_2 emission in 2004 for

[5] IPCC Fourth Assessment Report (AR4), Climate Change 2007: Synthesis Report; Summary for Policy makers

example was much larger compared with other gasses such as CH_4 which increased by 15% and N_2O by 8%[6].

CO_2 produced by human activities such as from burning oil, coal and gas, accounts for 75% of total CO_2 generated. A smaller amount of CO_2 produced from turning oil and gas into plastics and other compounds is within 3%[7] (Figure 3).

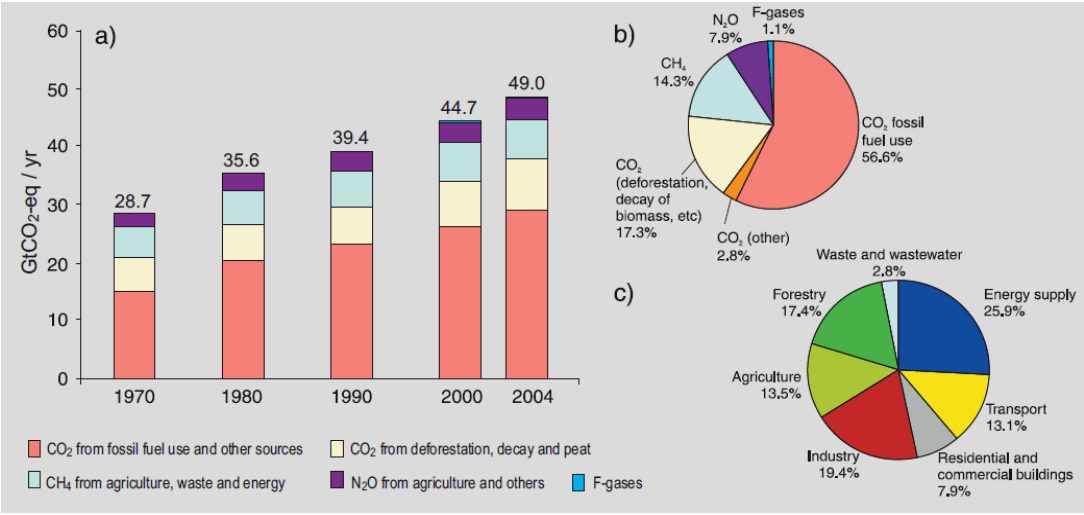


Figure3: (a) Global annual man-made emission of greenhouse gases from 1970 to 2004. (b) Share of different gases in total emissions in 2004. (c) Share of different sectors in total emissions in 2004. Gases are weighted according to their GWP (Global Warming Potential) and expressed in terms of CO_2-eq.

Source: IPCC Fourth Assessment Report, Synthesis Report, figure SPM.3.

Recent CO_2 emission by country in 2009 was announced by IEA. The country that emits the most CO_2 is China producing 7,710 million tonnes which is higher than 2008 by 13.3%. The second largest country in producing CO_2 is United State and the third is India and the fourth is Russia (Figure 4). Although CO_2 emission reduction has been a focal issue in the world, it actually is increasing rather than decreasing. On the other

[6] Bert Metz (2010). Controlling Climate Change, P30.

[7] Bert Metz (2010). Controlling Climate Change, P30.

hand, when looking at CO_2 emission by sector in the world, electricity and heat use accounts for about 40% of all. Transport sector is the second emitter of CO_2 at 22%, and Manufacturing industries and construction sector generates CO_2 at 20% (Figure 5).

Furthermore, when looking at energy consumption in public sector about energy consumption, corporate sector accounted for 20% and transport sector accounted for 23.6% in all[8]. Figure4 shows that Energy consumption has been increasing since 1989 until 2009.

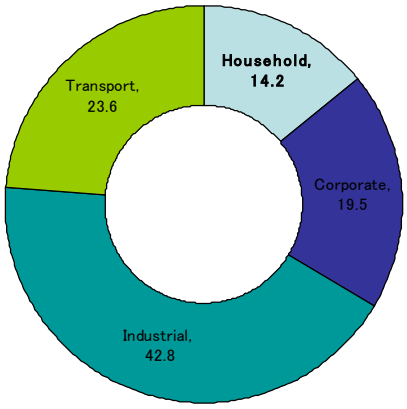


Figure 4: Energy consumption by sectors in 2009

Source; Energy report 2011

[8] Energy report (2011), http://www.enecho.meti.go.jp/topics/hakusho/2011energyhtml/2-1-2.html

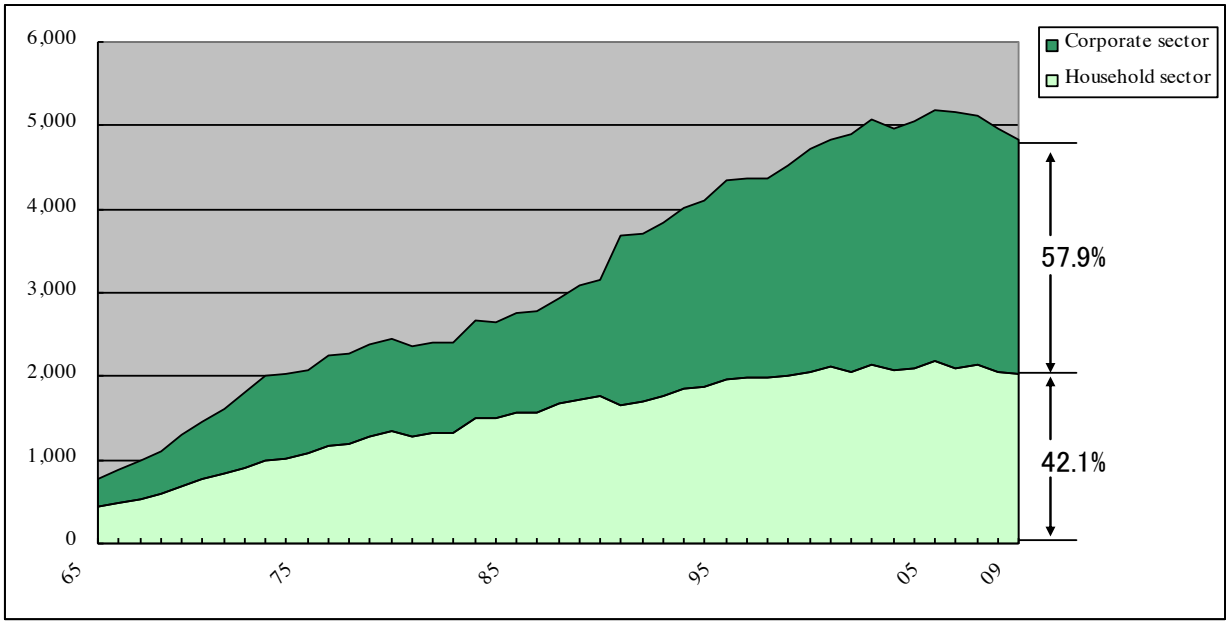


Figure5: Energy consumption by two sectors in public group

Source: Energy report 2011

2.3 Consequences of Global Warming

The global warming has influenced many fields in our human life. We human recently are getting to notice the effect of the global warming such as extreme weathers and natural disasters. The influence of the global warming on the earth seems to be getting bigger as human activities increase. The effect of the global warming can be categorized into three groups; Environmental, Social and Economical effects.

Environmental Effect (Ecosystem and Natural system)

Nature consists of all the ecosystems on the earth. They are functioning for the biosphere and delivering the tangible benefits to the human society. The global economy is also supported by them via clean water and food. Both are interconnected with each other and create a living system. However, unfortunately this system has been gradually destroyed by the global warming. The irony is that the global warming is man-made. The human activities for so-called development are threatening ecosystem which was created some billions of years ago and changing to adapt to the environmental changes.

The recent changes in physical and biological systems on the Earth seem to be serious and are proceeding rapidly. Those changes vary by region but representative changes are reported by IPCC.

Changes in physical system[9]

- **Sea ice**; Arctic sea-ice extent declined by about 10 to 15% since the 1950s.

  Glaciers and permafrost; Mountain glaciers were receding on all countries, and Northern Hemisphere permafrost was thawing.
- **Snow Cover**; Extent of snow cover in the Northern Hemisphere has decreased by about 10% since the late 1960 and 1970s.
- **Snow melt and runoff**; snowmelt and runoff has occurred increasingly earlier in Europe and western North America since the late 1940s.

[9] IPCC Fourth Assessment Report (AR4), Climate Change 2007: Impacts, Adaptation and Vulnerability, chapter1; Assessment of observed changes and responses in natural and managed systems

- **Lake and river ice**; annual duration of lake and river ice cover in Northern Hemisphere mid and high latitudes has been reduced by about 2 weeks and become more variable.

The changes in the physical system show us the clear evidence of rapid increase in temperature since around 1940s.

Changes in biological systems[10]

- **Range**; plant and animal ranges have shifted pole ward and higher in elevation
- **Abundance**; within the ranges of some plants and animals, population sizes has changed; increasing in some areas and declining in others.
- **Phenology**; timing of many life-cycle events, such as blooming, migration and insect emergence, has shifted earlier in the spring and often later in autumn.
- **Differential change**; species changed at different speeds and in different directions, causing a decoupling of species interactions.

The above changes are deeply related to ecosystem changes, the most familiar example is the range section mentioned in biological system. Pole bears are the one that was declared as a threatened species[11] due to the continuing loss of sea ice. Signs of decreasing number of the bears are already confirmed in the southern most ranges in Canada. Approximately 20 to 30% of plant and animal species are exposed to a high risk of extinction as the temperature exceeds by 2 to 3 ℃ compared to the

[10] IPCC Fourth Assessment Report (AR4), Climate Change 2007: Impacts, Adaptation and Vulnerability, chapter1; Assessment of observed changes and responses in natural and managed systems

[11] Bert Metz (2010). Controlling Climate Change, P17.

pre-industrial level[12]. Ecosystems in as many as 34 areas with high concentrations of unique species have been threatened. (Figure 3)

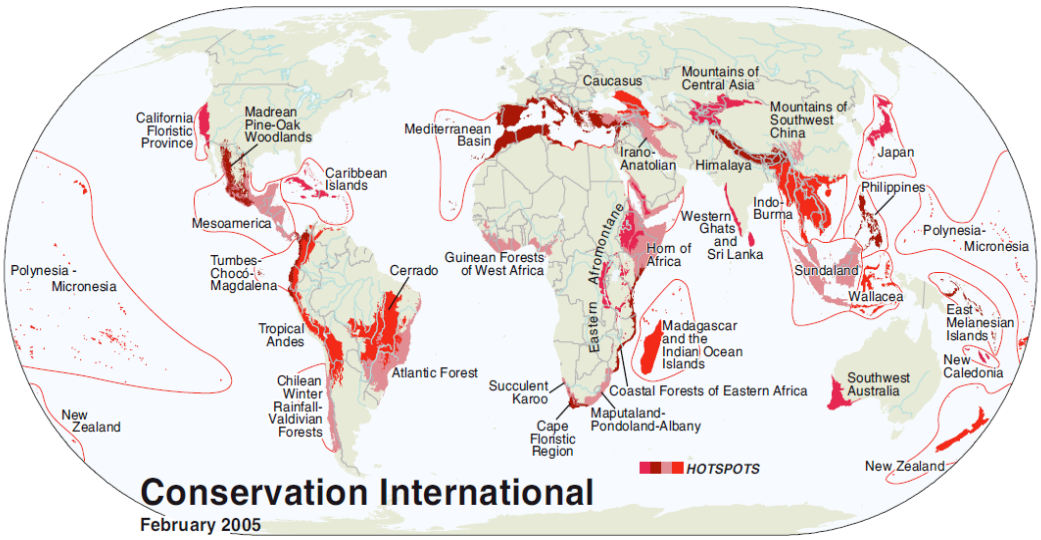


Figure3: *Biodiversity hotspots*

(Source: Conservation International, http://www.conservation.org/Documents/cihotspotmap.pdf)

Social system impacts

The term of social system has broad meaning but here it is focused on food security and human health.

Food production:

Food is essential for our life and related to agricultural situation and market economy. The productivity of some crops such as wheat which requires enough water would be increased due to the increasing temperature. However, crop productivity will decline if

[12] IPCC Fourth Assessment Report (AR4), Climate Change 2007: Impacts, Adaptation and Vulnerability, chapter1; Ecosystem, their properties, goods, andservices

temperature goes up by more than 3 degrees. Moreover, the moderate temperature increase up to 1 -2 degree in the tropical and subtropical area will reduce the productivity of the staple food for people such as rice and maize. These phenomena provide different impacts to each of countries. It means that total global food production could increase up to a warming by 3 degrees, but food scarcity in poor countries presents a real danger even at much lower temperature increases[13]. In recent years food prices are rising, thus food is exported to other countries, in particular from poor countries to rich countries for profit but unnecessary for the food requirement of the rich countries. The high prices and the local scarcity mean that poor people cannot obtain even the minimum necessary food. More than 3 degree temperature increase will bring a serious situation in these scarcity problems. The reason why this vulnerable situation takes place is due to the agricultural condition. The increasing temperature causes droughts and reducing soil moisture. IPCC mentioned that the subtropical farm land could be devastated by the drought by the end of century and its consequence could bring about huge stress on the agriculture sector.

Crops at low latitudes will have greater exposure to higher temperatures than crops at mid and high latitudes, thus yields for grain crops, which are sensitive to heat, are more likely to decrease at lower latitudes than others at higher latitudes[14]. (Figure 5)

[13] Bert Metz (2010). Controlling Climate Change, P15.

[14]Chapter 19: Assessing Key Vulnerabilities and the Risk from Climate Change, Section 19.3.2.5 Societal systems in IPCC AR4 WG2 2007

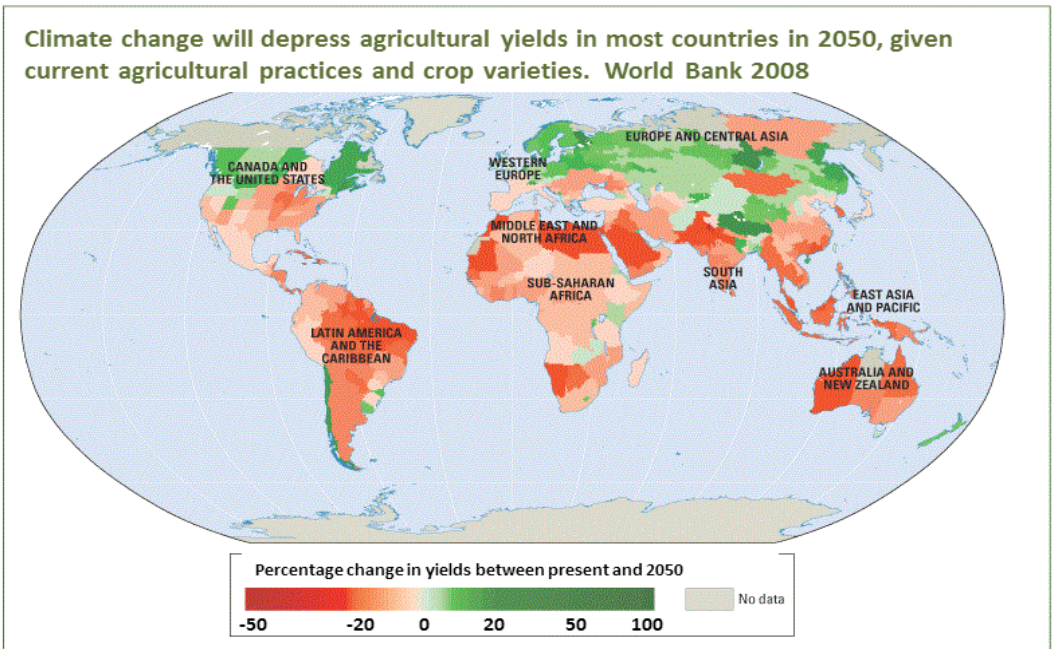


Figure5: Agriculture yields in most countries in 2050. Percentage of crop yield at lower latitude is higher than high latitude area. Source: http://www.climatechange-foodsecurity.org/intro.html

In a fact, Italy experienced a record drop in maize yields by 36% from a year earlier, whereas in France maize and fodder production fell by 30%, fruit harvests declined by 25%, and wheat harvests (which had nearly reached maturity by the time the heat set in) declined by 21%[15] . In addition, it is expected that in parts of Africa yields from rain-fed agriculture could be reduced by 50% in as early as 2020. These production shortfalls hurt the region's farmers economically, although global food trade, subsidies, and insurance compensation would help to avert serious price hikes or reductions in regional or global food security. The lack of food security could lead to social unrest.

[15] W. Easterling *et al*., in *Climate Change 2007: Impacts, Adaptation, and Vulnerability*, M. Parry *et al*., Eds. (Cambridge Univ. Press, New York, 2007), p. 976.

Human Health

Recently, the relationship between Global Warming and human health is getting to be a serious problem. In 1986, WMO convened a scientific meeting in Leningrad to review the relationship between climate and human health. This meeting focused on the health impacts of present natural multifariousness in climate. Thus, significant global climate changes have occurred during the twentieth century and the human health issues from Global warming must be considered since that time. Measuring the health impact by the global warming cannot be very accurate. However, WHO concluded that the modest warming that occurred since the 1970s was already causing over 140,000 excess deaths annually by the 2004[16].

All populations will be affected by global warming in many aspects, but some of them who live in certain areas are more vulnerable than others. People living in small islands and coastal regions, megacities and mountains and polar regions are especially at risk[17]. Human health is threatened by various consequences of global warming such as sea level rise, extreme weather, scarcity of water and heat wave as mentioned by WHO.

The more frequent the extreme weather events the more potential deaths and injuries caused by storms and floods. Flooding can be followed by outbreaks of diseases, such as cholera, especially when water and sanitation services are damaged or destroyed. Storms and floods are already among the most frequent and deadly forms of natural disasters.

Extremes of temperature both heat and cold, can cause physiological disturbances

[16]Global heath risks: mortality and burden of disease attributable to selected major risks.World Health Organization, Geneva, 2009.

[17] WHO Climate change and health, http://www.who.int/mediacentre/factsheets/fs266/en/

and organ damages, and leading to illness or death. One outcome of Global warming is an increase in heat related morbidity and mortality, particularly in response to episodes of stressful weather, such as heat weaves (WHO, 1990). Extravagant heat causes heat stress, illness and mortality. (Figure 4)

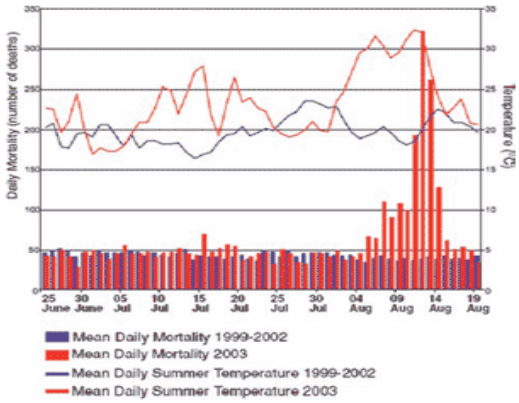


Figure4: Connection between temperature and daily mortality rate
Source: Climate institute, http://www.climate.org/topics/health.html

The elderly and very young persons are prone to the influence of heat. These persons could suffer from cardiovascular diseases caused by such weather extremes because the immune systems can be weakened. More than 70,000 excess deaths were recorded even in Europe because of the extreme heat in 2003. Moreover, pollen and other aeroallergen levels can also be higher in extreme heat. These can trigger asthma, which is currently affecting around 300 million people (WHO 2010). Global warming does not only influence environment but also our human health.

Economic Impacts

Economic impacts by Global warming are difficult to estimate but are linked to market transaction and affect GDP of each countries. These economic impacts in each country depend on the local situation. However, it is concluded by IPCC that the estimates of economic impacts for developing countries are twice as high as developed countries and also the poorest countries would suffer most. Again it is caused by doubling of

atmospheric CO_2 concentration (IPCC 2007). The estimate damage range is 0.25% to 2% of GDP[18] for industrialized countries. The prospective long-term damage in the world would be 20% of GDP.

For example, damages in the United State for 2.5 degree warming would be close to $ 60 billions annually at the 1992 U.S economic scale. The damage equals to 1% of the 1992 GDP. The corresponding range of damage would be from 2% to 4% of 1992 U.S. GDP with the warming of 4.5 degrees which arise from doubling the carbon dioxide equivalent[19]. The monetary impacts from Global Warming in the U.S. would be more at the present scale.

Some of Global warming events are considered to contribute to serious economic damages. Sea-level rise or higher sea surface temperature, extreme weather, heat stress should be taken into consideration as the most heathen causes.

Wetland and Dryland loss are caused by sea-level rise. It is estimated that some billions of dollars could incur for protections (Figure 5). World investments against a 50cm rise of the sea level amounts to $203.15 billions over 100 years, equaling to $2.03 billions on average per year[20]. The repair cost incurs to protect harbors, cities, beaches and densely populated coastline against the sea-level rise.

[18] Samuel Fankhauser, Global Warming Damage Cost : Some Monetary Estimates, P6.

[19] William R. Cline (1992). The Economics of Global Warming, P6

[20] Samuel Fankhauser, Global Warming Damage Cost : Some Monetary Estimates, P6.

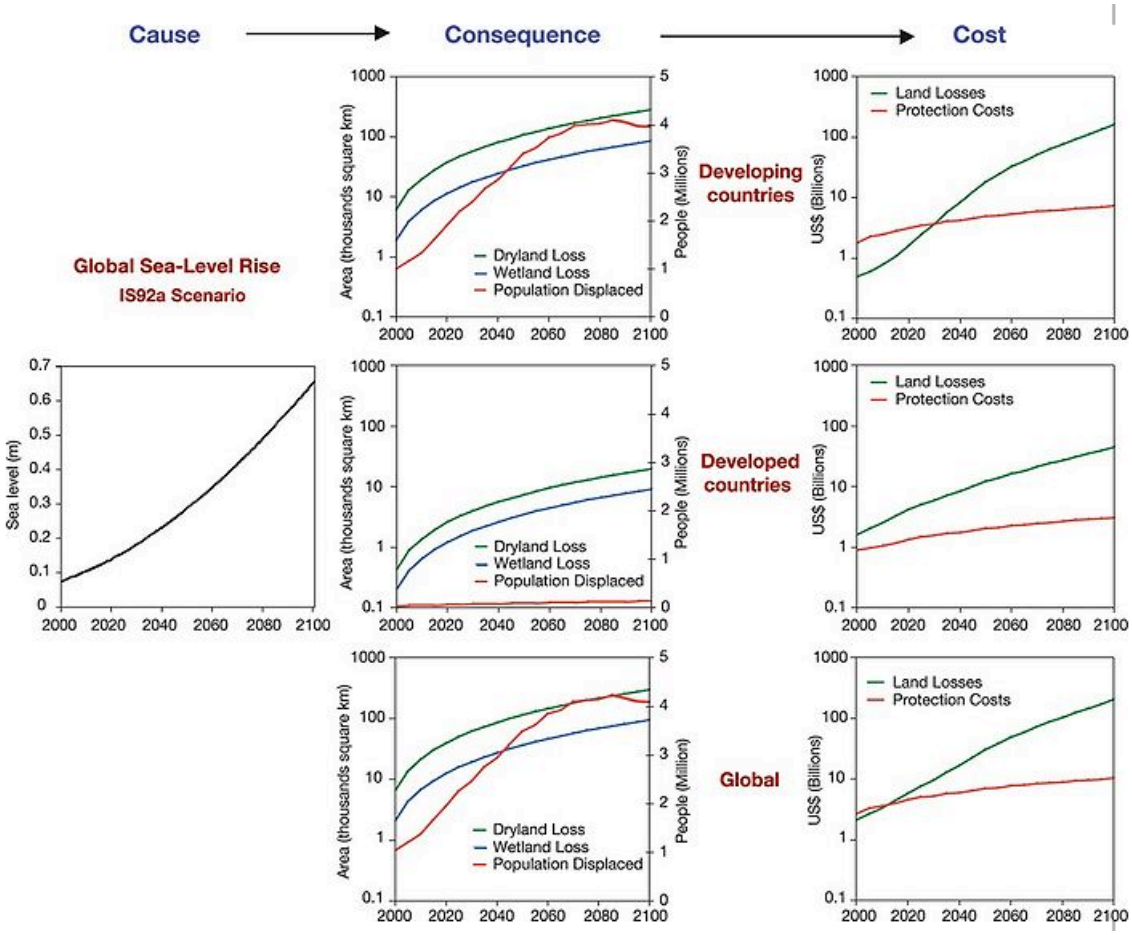


Figure5: Causes, selected consequences (dryland and wetland loss, people displaced) and the total costs of an assumed sea-level, for developing countries, and as a global total, Source; IPCC Fourth Assessment Report (2007)

Extreme weather is also estimated high monetary risk in the world. The extreme weather has already caused multibillion dollar losses in only the United State. According to NRDC (Natural Resources Defense Council), hurricane damages translated to economic losses is estimated about $ 422 billion by the increased intensity of Atlantic and Gulf coast storms in 2100[21]. In addition, less rainfalls as one of the extreme weather in the U.S make $950 billion loss in terms of the underwater supply in 2100[22].

[21] Frank Ackerman, Elizabeth A. Stanton (2008), The cost of Climate Change, P5.

[22] Frank Ackerman, Elizabeth A. Stanton (2008), The cost of Climate Change, P5.

Heat stress is linked to agricultural situation, which is in turn related to food production. Heat stress could cause a drastic reduction of food in one country and an excess food production in another. Consequently food has to be internationally traded.

The global agricultural loss from the heat stress and the droughts on average amounts to some $18 billion annually. Heat stress and drought damage both water and soil and change the yield of crops. As a consequence international trade of agricultural products is affected in terms of traded volumes, prices and import duties.

Increased atmospheric temperature also affects individual households and businesses. The demand of using air conditioners and refrigerators would go up rapidly by the increased temperature. The electricity prices must increase at the same time. The demand for air conditioner equipment also increases as people who do not have air conditioner would buy one. The atmospheric temperature increase could push the energy cost higher. In the case of the US it is estimated that an energy bill in 2100 could reach $141 billion.[23]

[23] Frank Ackerman, Elizabeth A. Stanton (2008), The cost of Climate Change, P5.

The Global Warming Price Tag in Four Impact Areas, 2025 through 2100

		In billions of 2006 dollars				As a percentage of GDP				U.S. Regions Most at Risk
		2025	2050	2075	2100	2025	2050	2075	2100	
	Hurricane Damages	$10	$43	$142	$422	0.05%	0.12%	0.24%	0.41%	Atlantic and Gulf Coast states
	Real Estate Losses	$34	$80	$173	$360	0.17%	0.23%	0.29%	0.35%	Atlantic and Gulf Coast states
	Energy-Sector Costs	$28	$47	$82	$141	0.14%	0.14%	0.14%	0.14%	Southeast and Southwest
	Water Costs	$200	$336	$565	$950	1.00%	0.98%	0.95%	0.93%	Western states
	SUBTOTAL FOR FOUR IMPACT*	**$271**	**$506**	**$961**	**$1,873**	**1.36%**	**1.47%**	**1.62%**	**1.84%**	

Figure6: Estimated costs due to Global Warming, 2025 throughout 2100

The amount of economic monetary damages will be increasing because of impacts of Global Warming in U.S.

Source: Frank Ackerman, Elizabeth A. Stanton (2008), The cost of Climate Change

Economic impacts by Global Warming are assumed to be in the range from 1 to 4 % of the national GDP of the country. It was also concluded that the financial damages of Global Warming is much higher than the investment for activities against Global Warming.

3. Literatures Reviewed

Correlation between Environment and Business management

Literatures related to my research are gradually published in recent years. Most of those discuss business management in production process and product design. This area has been already studied by many authors in detail for improving business management. On other hand, there are some other areas not well studied. The missing parts may call for the necessity of my research. In this paragraph, therefore, the studies already done are reviewed and the parts that those studies lacked are identified.

History of Environment and business management – ISO-

Environmental protection issue started to be considered by corporations as CSR since 1970. In the beginning pollution issues were the main problem for them. A wider awareness of the environmental problems started in 1992 when the earth summit (The United Conference on Environment and Development: UNCED) was held in Rio de Janeiro and 172 governments participated, with 108 sending their heads of state or government. Some 2,400 representatives of non-governmental organization (NGOs) attended, with 17,000 people at the parallel NGO "Global Forum" (a.k.a. Forum Global), who had Consultative Status. The key word in this summit was “Sustainable Development”. This “Sustainability” is linked with Triple Bottom Line (Putting profit and loss balance which collaborated with Economic, Social and Environment aspects into practice throughout Business Management) which was proposed by Sustainability Limited. Moreover, ISO was commissioned by International Standard of Environmental management in 1992 though BCSD declaration to create a work standard to mitigate the corporate activity that could result in environmental problems. After this, ISO issued

ISO14001 leading to an efficiency for production management system and resource productivity through reducing energy and reuse of resources in 1996 as an International Standard of Environmental Management System. ISO 14000 series consist of Environmental Inspection (ISO 14010~14012), Environmental Label (ISO 14020~14025), Environmental Performance (ISO 14031), Life Cycle Assessment (ISO14040 to 14049) and Design for Environment (ISO/TR 14062). The offices and factories accredited with ISO 14001 are 111,162 groups over 138 countries by 2005[24]. After 1997 Environmental Management System as defined by ISO 14001 was developed to cover a range of businesses from services, educational organizations and smaller companies. In particular, since 2003 ISO14000 has become essential in Business Management in terms of environmental business conduct and measures. Following this trend, sustainability report, recycle and LCA have been widely practiced as Environmental Management in Business.

Changing Concept opposite Environment in Business management

The concept of sustainable **d**evelopment comes from the report of "Our Common Future" by the World Commission on Environmental and Development in 1987. If sustainable development is to be pursued, it requires the pursuit of economic efficiency, social equity and environmental protection. Sustainable development is recently a focal point in business corporations as they learned from the historical incidents that damaged the environment. Corporate Sustainability Strategies consist of following four aspects:

[24] ISO

- Innovation & Technology

  The method of sustainable practices focuses on a company's ability to change its products and services toward less waste production and development of good practices for sustainability.

- Collaboration

  The formation of networks with similar or partner companies facilitates knowledge sharing and promotes innovation.

- Process Improvement

  Continuous survey of the business processes for improvement is essential to reduce waste. Employees' awareness of companywide sustainability plan further aids the integration of new improved processes.

- Sustainability Reporting

  This is periodic reporting of company performance in relation to goals. The goal is incorporated in the corporate mission.

The above generic corporate sustainability strategies have been introduced in many companies for implementation. Regulations, policies and laws have influenced corporate activity for constructing sustainable operations.

The decade between 1960 and 1970 is called Industrial Environmentalism, which is the starting point to attempt to mitigate the environmental damages. Chemical pesticide leaks (in particular "endrin") became the main problem during this period. The leakage affects environment and even human health through polluted waterways[25]. Chemical

[25] Richrd R. Johnson. (1999), AN OVERVIEW OF THE HISTORICAL CONTEXT FOR SUSTAINABLE BUSINESS IN THE UNITED STATES, 1960-2000.

pesticides have deteriorated conditions of rivers, lakes and streams. The problem was caused mainly by industries, but laundry detergents from the households also contributed to this problem. People did not have sense for environment protection. People did not know which products we use incur environmental damages.

The period from 1970 to 1982 is called Regulatory Environmentalism. During this period, air pollution was the main issue due to the smoke discharged from the factories and households causing so called smog. Then the oil shock happened in 1972/3. The incident brought a harsh reality that the energy may not always available. The incident contributed to making people aware of the finite nature of the energy and in turn of the need of environmental conservation. Governments introduced laws forcing corporations to use specific pollution control technologies, despite vehement industry opposition. The environmental issues in business started through focusing on compliance with the regulations.

Following the above decade as background, Environmentalism as Social Responsibility prevailed from 1982 to 1988. During this period companies sought a cooperative relationship with government and environmental management and integrated into corporate operations. Until this period, environmental disasters had been perceived confined to geographically limited locations, and people rarely feared contamination from their local chemical and power plants. However, Chernobyl accident in which inside of a reactor at the nuclear plant was exposed changed their notion. People then realized that an environmental disaster could extend to international scale as water system, agricultural land and forest were contaminated due to radioactivity. The impact

of this accident was not limited to the environmental problems. It also caused ill effects to human health. Some 21,000 people in Western European countries were expected to die of cancer and even more to contract the disease due to this accident. In addition, in 1980's, sulfur dioxide, nitrogen oxides from smokestacks and car tailpipes were found to be carried over 600 miles by prevailing winds, causing acid rains.

In the Strategic Environmentalism period from 1988 till 1993, industry became more proactive in environmental matters, looking specific environmental management strategy.

The latest period is called Environmentalism by Design since 1994 till present. Environmental issues became a core business strategy and are integrated directly into the operation of each corporate firm. Therefore, recent companies have a duty to consider sustainable business design derived from the historical background. After Kyoto protocol companies turned their views from that compliance to environment rules is one of the cost for them to that environmental investment could lead to profitability. Porter et.al (1995) mentioned that positive management for environment can support companies' competitiveness and innovation. In other words, factors from the process of implementing environmental measures and initiatives are connected to competitiveness and effective result.

Sustainable Business Development

Sustainable Business Development has a root in the environmental management encompassing the concept of pollution prevention and waste minimization[26]. The traditional environmental management is not considered as an essential part of the business strategy[27]. The enactment and environmental laws and regulations contributed most companies to focus on environmental concerns leading to sustainable business management. They considered that environmental strategies are opportunity to be competitiveness. Actually, reducing air emissions, improving water effluents, reducing hazardous waste and managing disposal waste require investments. However such investment is now carried out with no fears that it turns into just cost. Such consciousness toward environmental strategies among companies is comprehended through sustainability report. Recent core strategy for companies has shifted from the position of product/market leadership in the late twentieth century to innovations in the early twenty first century[28]. Thus, environmental strategies should be corroborated by innovation along with customer satisfaction and financial feasibility. Nonetheless, the profitable growth still remains to be very difficult when a company wishes to be successful in Sustainable business development.

Pollution Controls

Pollution control and resource productivity have been discussed since 1995 under the Environmental management. Eliminating pollution is following the same basic principles: Use inputs more efficiently, eliminate the need for hazardous or hard to

[26] David L. Rainey (200). Sustainable Business Development

[27] David L. Rainey (200). Sustainable Business Development, P21

[28] David L. Rainey (200). Sustainable Business Development, P677

handle materials, and eliminate unneeded activities. Reducing pollution leads to improvement in productivity, innovation and cost reduction.

Pollution control was the first initiative since 1970s as sustainable business management. Pollution often is a form of financial waste because it means that resources have been used incompletely, inefficiently, or ineffectively[29]. Environmental improvement efforts have overlooked the system incurring cost by inefficient use of resource. It was considered as the way of how to manage pollution as a result of production process. In around 1995, this view shifted to the resource productivity or source reduction. The concept uses material substitutions, closed loop process and the like to limit pollution before occurring. Pollution control was the right direction as the first step. However, companies started to pay attention to the opportunity cost of pollution.

Resource productivity

Resource productivity is the initiative in the process of using resources as effectively as possible when producing goods and services in order to reduce or avoid waste. Namely, pollution often reveals flaws in the product design and production process. The concept of resource productivity is a new way of looking at the full systems cost and the value linked with any product[28]. Resources are lost when the products including usable materials are discarded and customers pay for the product disposal too. Resource productivity encourages innovation and improvement of production processes. Dow chemical's California is one of successful examples with resource productivity. The

[29] Michael E. Porter and Claas van der Linde. (1995), Green and Competitive: Ending the Stalemate, P122

company used to store the wastewater in evaporation pounds. They redesigned the production process. The new process reduced the use of caustic soda, hence decreasing caustic waste by 6000 tons per year and hydrochloric acid waste by 80 tons per year. Moreover, they gained a part of the waste stream to be reused as a raw material in another plant. It took $ 250,000 to implement as a once off cost. However, they obtained annual savings of $ 2.4 million instead.

4. Environmental Technology Audit

Some initiatives to solve the environmental problem for business management are already discussed. Initiatives regarding pollution reduction have been focused to protect human health and environment. This was the important and right first step to lead to solving environmental problems. Many companies rechecked their business process especially at waste stage and tried to implement measures following regulations or laws enacted by Government. The current pollution problem by companies has been dramatically reduced compared to 1960s. Instead the energy problem is becoming the most important problem for the world. This problem has attracted a great deal of public attention after the Fukushima nuclear accident happened in Japan. Japanese Government is trying to introduce renewable energy instead of nuclear energy because credibility of nuclear power in Japan is near zero. Japanese people fear nuclear power generation even it can support about 30% energy used in Japan. Moreover, electricity fee is being raised in mega cities by average of 10.28% for household and 17% for corporate sector. Under these situations it is the time to consider seriously about solutions to protect our life and environment.

Environmental technology pervade all economic activities and sectors, where they often cut costs and improve competitiveness by reducing energy and resource consumption, and so creating fewer emissions and less waste (ETAP, 2004). They support solving environmental problems and produce benefits in the market. Environmental technologies are basically consisted of Recycling, Renewable energy, Water Purification, Sewage treatment, Air purification, Environmental remediation, Solid waste management and Energy conservation. In order to reduce CO_2 in business

management, all environmental technologies are required. In the current work however use of renewable energy and recycling are focused as they have more effect.

4.1 Environmental Technologies Available

Renewable energy is the energy coming from natural sources such as sunlight, wind, rain, tides, and geothermal heat, which can be replenished. Renewable source of energy has received a great deal of attention since the World Summit on Sustainable Development in 2002. Energy from the renewable source is increasing fast in recent years among household and corporations. According to IEA statistics, in 2009, World relied on renewable source for around 13.1% of primary energy supply. Moreover, renewable source accounted for 19.5% of global electricity generation and 3% of global energy consumption for road transport. The most important reason considered is production of minimal carbon emissions. Renewable energy is supporting energy supply not only in developed countries but also in developing and poor countries. Today developed countries are using the carbon trading system for reduction CO_2 emissions in their countries. The renewable energy must be the most attractive and prospective energy for all countries. Therefore, it is expected that renewable energy would provide effective business management to reduce CO_2 emissions.

Solar power

Solar energy is the radiant light and heat from the sun. Solar technologies include solar heating, solar photovoltaic, solar thermal electricity. They may contribute to solving some of urgent environmental problems the world faces. The characteristics of solar

technologies are clean with no production of CO_2 emission and renewable in that it is an abundant natural resource with no virtual limitation.

Solar technologies are divided into two categories which are passive solar and active solar depending on the way they capture, convert and distribute.

i) Passive solar technology

Passive solar technology is the use of solar energy by appropriate choice of site, and /or by using appropriate design and building materials for the building and take advantages of the sun's position and availability of sun beam to provide the direct heating. Passive solar technology is considered from the demand side as a part of energy saving potential rather than from the supply side. This technology is used often for new building or when old buildings and offices are refurbished. Passive solar heating includes extensive sun-facing glazing, double-walled structure, air-flow windows, thermally massive walls behind glazing, or air ventilation through buried pipes. A full exploitation of the opportunities for passive solar energy through a combination of a high performance thermal envelope, efficient systems and devices, can either eliminate or satisfy 50 to 75% of the energy needs of new buildings as constructed under normal practice.[30] Unfortunately, the single market for passive solar technologies does not exist yet as they have components counted for both architecture side and energy efficiency improvement side. The solar energy consumed in building sector is accounted for about 40% of total solar energy output according to the EU commission. However, this passive solar energy is not counted for in this statics.

[30] IEA (2006), Barriers to Technology Diffusion: The case of Solar Thermal Technologies, P 9.

ii) Active Solar technology

Active Solar Technologies reduce requirements from fossil fuels as well as CO_2 emission and associated fuels cost. Energy from active solar system is used as a source of electricity and heat. Active solar system includes the photovoltaic panels and solar thermal collector.

-Solar heating-

Solar energy collectors for domestic hot water can be used for heating houses, offices, schools, hotels, warehouses and other types of buildings. Most systems are in fact "Combisystems" that provide space and water heating altogether. Currently solar collectors have capacity limitation of 0.7 kW/m^2. The annual thermal energy production from the collector depends on the solar radiation available, the outside temperature and the solar thermal technology used.

-Photovoltaic (PV)-

Direct conversion of sunlight into electricity in PV cells is the one of three main solar active technologies, the two others being concentrating solar power (CSP) and solar thermal collectors for heating and cooling (SHC). Today, PV provides 0.1% of total global electricity generation[31]. PV is expanding rapidly in the world with supporting policies and laws. Moreover, it is available in commercial sector, and the reliable technology that allows the use in a long term and in any places. Consequently, the rate of usage of PV is increasing and PV is expected to account for around 5 % in 2030 and

[31] IEA (2010). Technology Road Map Solar Photovoltaic Energy.

11% in 2050 for the global electricity use. In fact the estimated installed capacity of PV cells would reach roughly 40 GW at the end of 2010 compared to 15GW in 2000 (Figure 8).

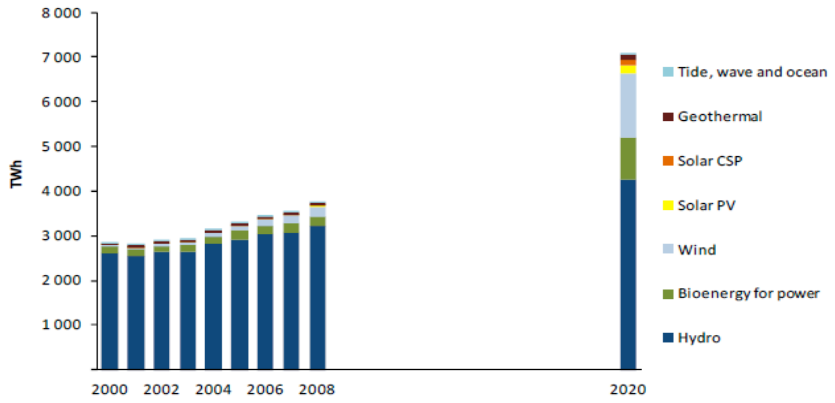


Figure 8. Global power generation from renewable sources, Source from IEA Clean Energy Progress Report 2011

The basic block of a PV system is PV cell, which is a semiconductor device that converts solar energy into the direct current (DC) electricity. PV cells are interconnected to form a PV module, typically up to 50 to 200W[32]. These are produced by semiconductor such as silicon, which works to generate power being in proportion with the strength of solar radiation. The most popular PV currently representing 85 to 90 % of the global annual market is crystalline silicon (c-Si) module consists of two semiconductor; p-type and n-type having different electrical property.

PV is expected to contribute the reduction of CO_2. The development of PV will contribute significantly to the reduction of CO_2 emission of electricity generation[33].

[32] IEA (2010). Technology Road Map Solar Photovoltaic Energy.

[33] IEA (2010). Technology Road Map Solar Photovoltaic Energy.

According to IEA, 4500TWh generated by PV in 2050 will save 2.3 Giga tons (Gt) of CO_2 emissions on an annual basis worldwide. Over the period of 2008 to 2050, estimated saving will be 100 Gt of CO_2 (Figure 9).

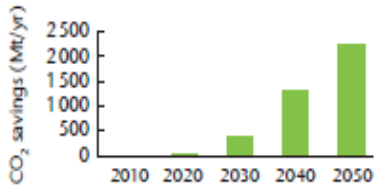


Figure 9, Annual Co2 emissions avoided by PV

Wind Power

Wind power is used by converting the wind energy into electricity, mechanical power and water pumping and drainage. The unequal heating of earth's surface produces wind. Wind turbines are the basic devices to produce electricity by converting the kinetic energy of wind into mechanical power that runs a generator to produce electricity. Today's turbines are versatile modular sources of electricity[34]. Wind power has an image that it is installed as power generation, however, it is useful and possible to use in households and corporate offices as one of means to obtain electricity. Installing the wind power in the world is increasing and IEA expects that the growth of the global wind power capacity will increase to 5100TWh representing 12% of the total power generation by 2030.

[34] U.S department of energy (), Small Wind Electronic System.

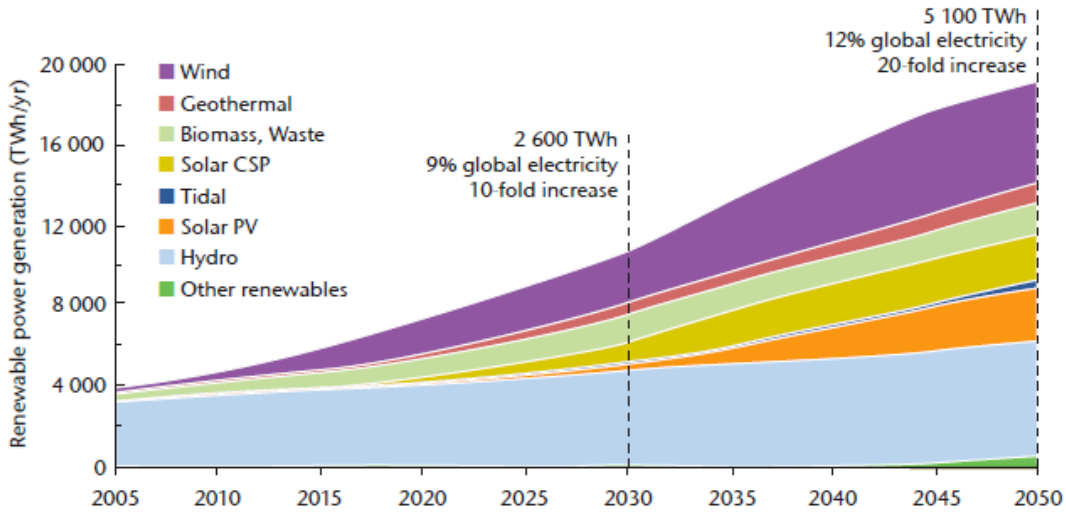


Figure9: Electricity from renewable energy sources up to 2050 Source: IEA 2008

The global wind power capacity was 238GW accounting for 27% among renewable energy at the end of 2011. It dramatically increased from 18GW at the end of 2000. The average growth rate of wind power capacity has been over 25% pa over the past five years. The growth of wind power has recently shifted from European and North American countries to Asian countries. In particularly, China has been growing very fast (17GW increased in 2010) in building new wind capacity. Wind power only provides for 1 % of total electricity output in China.

From the view of investment, the overall cost per unit of energy produced is similar to the cost for new coal and natural gas power generations installed. The installation cost for wind power plant has decreased by 23% over the 2008.

Wind power is plentiful, renewable and can be distributed widely. It does not produce CO_2 emissions during the operating and its plant uses only a small space. Any effects on environment are generally less than other conventional power sources. Under these situations, producing electricity by wind power is utilized not only by the dedicated

power generation farms in a large scale but also by individual companies in a smaller scale. Wind energy system for business is considered as one of most effective renewable systems. Although depending on wind source, it is estimated that electricity bills after installing small wind energy system could be reduced by 50% to 90%. In addition companies can reduce CO_2 emissions. According to IEA, Wind power will contribute to reduction of CO_2 by 12% of the power sector in 2050 and CO_2 abatement from wind energy under the BLUE MAP SCENARIO[35] reaches a total of 2100 Mt per year in 2050.

Geothermal

Geothermal energy emits little CO_2 and regarded as one of effective means to deal with global warming issues. Geothermal energy resources for power generation are concentrated in a small number of countries. The technology is considered relatively risky. Therefore, growth is slower than other renewable energy and geothermal technology are not spread over the last decades. Figure 10 shows the global leader about geothermal energy; US, Philippines, Mexico and Italy. Global installed power capacity is approximately 11 GW, generating over 67 TWh of electricity.

[35] IEA (2010)

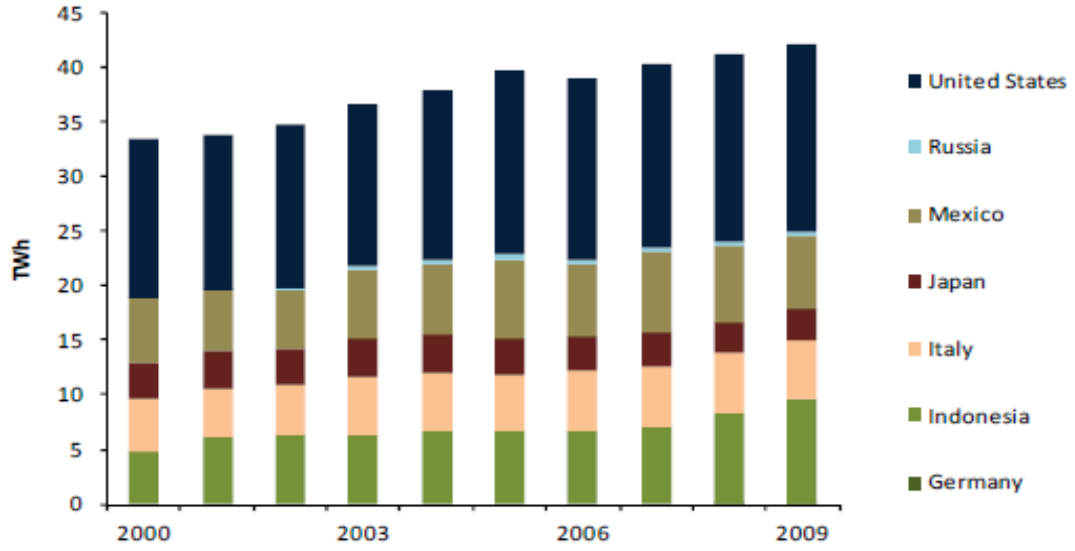


Figure10: Geothermal electricity production (TWh)

Source: IEA (2010)

Japan has potential to grow geothermal electricity production because Japan is the most one of distinguished volcanic countries. However, it is not dramatically growth because geothermal energy resources have some difficulties such as huge initial cost. In Japan the studies have started since 1950 and the first geothermal power plant operated in 1966. After 35 years 16 geothermal power plants in the 14 geothermal power stations sites are operating. The total authorized rated output reaches 530GW and it is account for 0.2% of the whole Japanese power capacity of 250GW. Actual power output for 1999 was 340GWh accounted for 0.3% of 1000TWh[36].

[36] New energy foundation

Water Management

Rain water and grey water harvesting

Growth of world population increases water demand and there are some people who cannot reach water reservoir easily. Global warming is accelerating this situation such as in Africa, Southeast Asia and East Asia with drought. On the other hand, developed countries can take water as much as they want and they use it as if water is never-ending resource. They do not even consider recycling the used water. Instead, they are wasting comparative clean water for flushing toilet and washing cars. They do not use water which is still usable such as grey water for toilet flush or rainwater after cleaning for drinking.

Here two water technologies: Rain water harvesting and grey water recycling are explained. They have huge opportunity to reuse and contribute to environment protection. The society should move to efficient and appropriate water use.

Rainwater harvesting

The use of rainwater has 4000 years of history. Ancient people used rainwater especially for irrigation. The most common way to utilize the rainwater may be the rooftop collecting system for providing drinking water, domestic water, for livestock and for small irrigation.

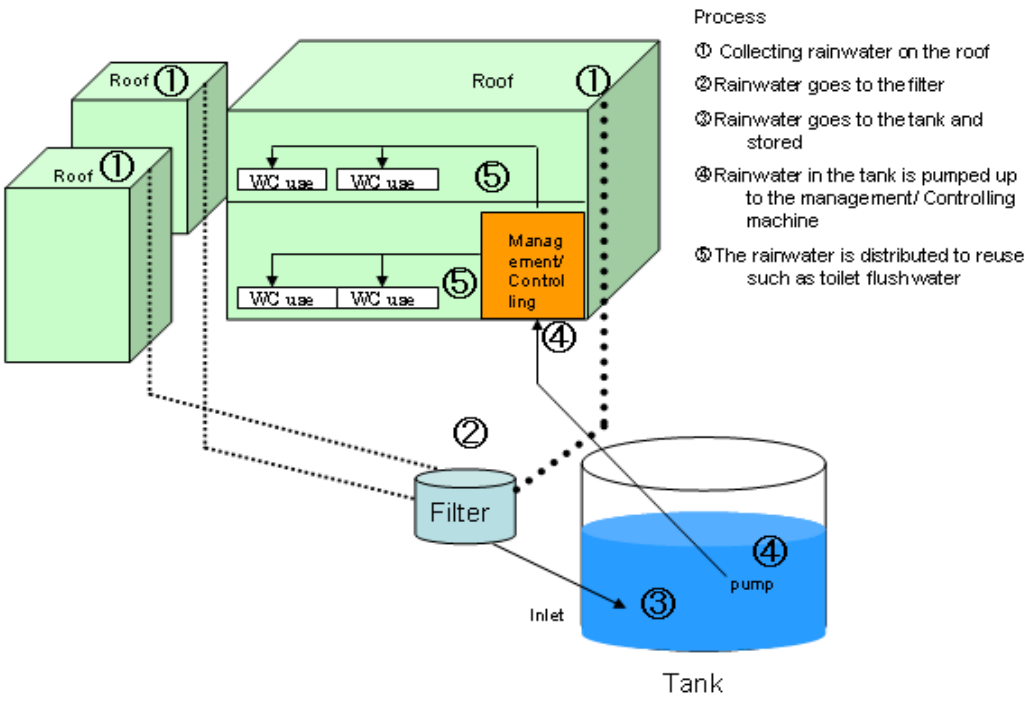
Rainwater harvesting is the process of capturing storm-water runoff and putting it to efficient and beneficial use. Rainwater is usually collected from rooftops, concrete

patios, driveways and other impervious surfaces[37]. Increasing rainwater harvesting is possible due to a better design of rainwater harvesting system, and the roof formation. The system in companies or commercial sector is usually larger, more sophisticated version than those used for domestic situations. The economics of rainwater harvesting in industrial and commercial situation can be significantly larger than household due to the higher demand for non potable water. Installation cost is very different depending on the size, type of the system and its construction. The type of rainwater harvesting is roughly divided into two group; Roof water collection system and Land surface catchment.

-Roof water collection system-

The main components in roof water collection system are cistern itself, the piping that leads to the cistern and the appurtenances within the cistern. In some cases, the collected rain water is filtered and in other cases it is disinfected. The process of rainwater harvesting in roof collection is consisted of simple following steps.

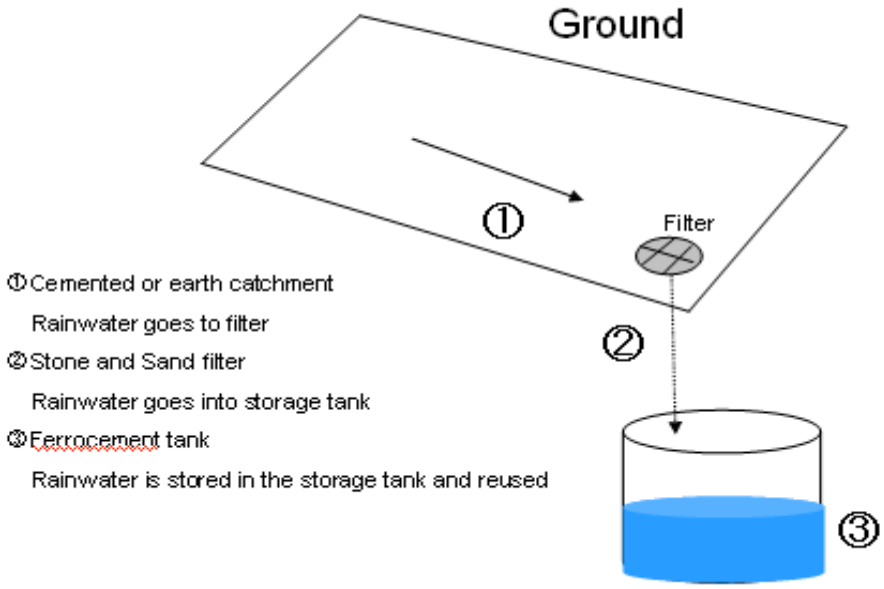
[37] R.Waskom and J.Kallenberger (2012), Graywater Reuse and Rainwater Harvesting



Picture1: The simple process of roof water collection system

-Land surface catchment-

Rainwater harvesting using ground or surface is the simplest way. Land surface catchment has a more opportunity to collect rainwater than roof water collection system due to the expanded area. However, there is also possibility to lose the high rate of water due to infiltration into the ground. This technique is suitable for storing water for agricultural purposes because of the marginal quality of water collected.



Picture2: Land surface catchment Source: Rainwater Harvesting and Utilization

5. Research Methodology

The research methodology is to calculate carbon footprint of a company by business process and to see if there is opportunity for cost reduction while cutting down CO_2 emission.

The investigation was conducted in a German automotive company located in Japan. The company is essentially importing German made cars and car parts to the Japanese market. The method of investigation is a combination of obtaining the relevant data from the company followed by interviews with the personnel associated with the each business processes in the company.

6. Result and Discussion

The company the researcher investigated is a Japanese subsidiary of a German Automobile company.

The German parent company is a large automotive manufacturing company in Germany. They use their brand image in full for cars, buses, coaches and trucks. Their business is to manufacture vehicles and provide financial services and after-market services. Their entire sales are 97.8billion Euros in 2010. They were founded in 1886 and currently provide area services worldwide. The number of employee is about 260,100 worldwide.

The Japanese subsidiary is one of those global service offices. The Japanese company was founded in 1986. They currently have 5 offices in Japan; Roppongi, Narashino, Hitachi, Shin-Kawasaki, and Osaka. Their main business in Japan is import sales of automobiles and their parts. They also provide services. The supplier is the Headquarters located in Germany. They import automobiles and parts from them and sell customers. However, they do not sell these directly to customers. They have the authorized 204 dealers in Japan. Some dealers are directly linked to them but others have different linkages. They gained annual sales in 195,158million yen in 2010 through such dealers. The number of automobile sale was 32,027 in 2010. Now the Japanese office has the second biggest sales in Asia following China.

Company	German Automobile
Business	Import and sales of German automobile,

	parts and services Supplier: German headquarter Sales channel: Authorized dealers
Location	Japan Roppongi: Headquarter in Japan Narashino: Training, parts center and Service & Parts department Hitachi, Shin-kawasaki, Osaka
Foundation Year	1984
Sales	195,158 millions yen (2010)
The number of sales automobiles	32,027 (2010)
The number of Employees	481
The number of Dealers	204

Chart 1: Company's Profile chart

The main office I investigated is the Narashino office. Their business is linked directly with import of parts and sends used parts back to German headquarters. Despite their business content CO_2 emissions are related to this business. Their mainstay of the business process is import and export. CO_2 emissions occur in this process. The Narashino office uses a dedicated building for their own. Therefore, the information about CO_2 emissions from the use of the electricity regarding the building of Narashino office can be comprehensible. The office building information is shown in Figure 11.

Location	Narashino
Objective of building	Stock room, Office
Site area	67,102.84m^2
Building area	30,511.66m^2
Floor space	38,066.34m^2
Floor area ratio	56.73%
Parking space	Large automobile: 22 Passenger car: 136

Figure11: Building information

Floor space ・Stock space ・Office	37,432.65m^2 32,376.32m^2 5,056.33m^2
Scale	2nd stories
Structure ・Roof ・Outside wall	 Heat insulation board (Stock) Asphalt water proofing exterior thermal insulation (Office) Sandwich panels

Figure12: Stock space and Office

6.1 Business flow

The Narashino office is closely in contact with the German headquarters because they import automobile parts. The business in Narashino Office is divided into 5 divisions; Business development, After-sales, Technical, Training and Parts. Work in Business development is to manage new business suggested from the German side, thus, Green Environmental technologies into Automobile and remanufactured parts are managed by this department. After-sales manages dealers and takes care of service for customers after purchasing automobiles. Technical responds the problems in technical parts regarding automobiles from the dealers and supply suitable information about technical parts. Training department manages the training system for dealers in the aspects of sales and mechanics. Parts department receives orders from the dealers and order these to German headquarters.

Chart2: Work flow chart

Business Development
Managing new business in Japan after receiving request from German side. ・CO_2 emission management in the process of operation of automobiles ・Customer segmentation ・Electric car management ・Remanufactured management ・After-sales event management

After-sales
Managing the services for dealers and for customers. ・Managing the dealers. ・Service product management ・Customer satisfaction management

Technical
Corresponding to technical parts for dealers.

Training
Managing training system for dealers and mechanic

Parts
Managing orders from dealers and receiving orders from German side regarding parts

The target division for the current investigation is Business development department because they are related to manage new businesses such as Environment automobiles and remanufactured parts. These businesses have more linkages with CO_2 emissions in Japanese offices especially if the operation of automobiles by the customers is included. Remanufactured parts are directly linked with CO_2 emissions due to transportations and production cycle.

In Narashino office most of the employees work at the desk. Therefore, they are using electricity and water for all days expect for weekends. The stock room for parts is

working almost of everyday. In this situation building management regarding electricity and water is one of key issues for them if one considers CO_2 emitted from this office.

6.2 CO_2 emission from workflow

i) Automobile Operation

Japanese offices don not manage the production of automobiles. However, operation process (driving) is implemented in Japan and environmental automobile technologies are related to manage CO_2 emission. Business Development department has managed automobiles introducing environmental technologies and their CO_2 emissions in operation have been much reduced. This section mentions about the effect of technology for two types of vehicles toward CO_2 emissions on the basis of Life cycle assessment.

One type of vehicle is called as A-type and the other type of vehicle is called as B-type here.

a) The New A-type

The new A-type was released recently. It introduced environmental consideration into new A-type. New A type is a compact car among their products. The target of this type is younger generation.

Specifications	
Length・Width・Height	4270×1780×1605mm
Wheel base	2780mm

Weight	1390kg
Engine displacement	2034cc
Maximum output	136ps/5500rpm
Maximum torque	18.9kgm/3500rpm
Fuel tank capacity	54 liter
Fuel efficiency	16km/liter

Chart13: Measurement and Weight

The engine of this new A-type is the new 1.6 liter linear 4 valves direct injection type which is developed by the HQ company. The A-type introduced the Idling stop function with consideration for engine and environment. The fuel efficiency is about 16 km/l which increased up by about 19% compared to the conventional model. This car was accredited 「平成 17 年排出ガス基準 75%低減レベル（☆☆☆☆）」(2005 emission standard at 75% reduction level) and achieved「平成 27 年燃費基準+10%」(2015 fuel standard+10%). Therefore it qualified Eco-car tax reduction (75% reduction on Weight tax and acquisition tax), Green Tax Benefit (50% car tax reduction in the following year of purchase) and the eco-car subsidy.

The following is the technical data for the variants of the newly released A-type.

Characteristic	**A-type: 1**	**A-type: 2**	**A-type: 3**	**A-type: 4**
Engine type	Petrol	Petrol	Diesel	Diesel
Displacement(cc)	1595	1595	1796	1796
Power output(kW	90	115	80	100
Exhaust Emission (g/km)				

CO2	137-144 137-145*	137-144 137-145*	115-121 115-122*	116-122 116-122*
NOx	0.013 0.012*	0.013 0.012*	0.150 0.160*	0.150 0.160*
CO	0.101 0.177*	0.101 0.177*	0.348 0.227*	0.348 0.227*
PM	0.0001 0.0003*	0.0001 0.0003*	0.0001 0.0005*	0.0001 0.0005*

*: Values with dual clutch transmission

Figure14: Exhaust gas regarding New A type model

Over the entire life cycle of the new A-type, the life cycle inventory analysis yields for example a primary energy consumption of 468 gigajoules (corresponding to the energy content of around 14,300 liters of petrol), the environmental input of approx. 33 tonnes of carbon dioxide (CO_2), around 15 kilograms of non-methane volatile organic compounds (NMVOC), around 18 kilograms of nitrogen oxides (NOx) and 29 kilograms of sulphur dioxide (SO_2)[38]. In addition to the analysis of overall result the company investigated the individual environmental factor for life cycle of new A-type vehicle. For CO_2 emissions, and likewise for primary energy consumption, the use phase dominates with a share of 80 and 77 percent respectively[39].

[38] [41]The company's new A-type report

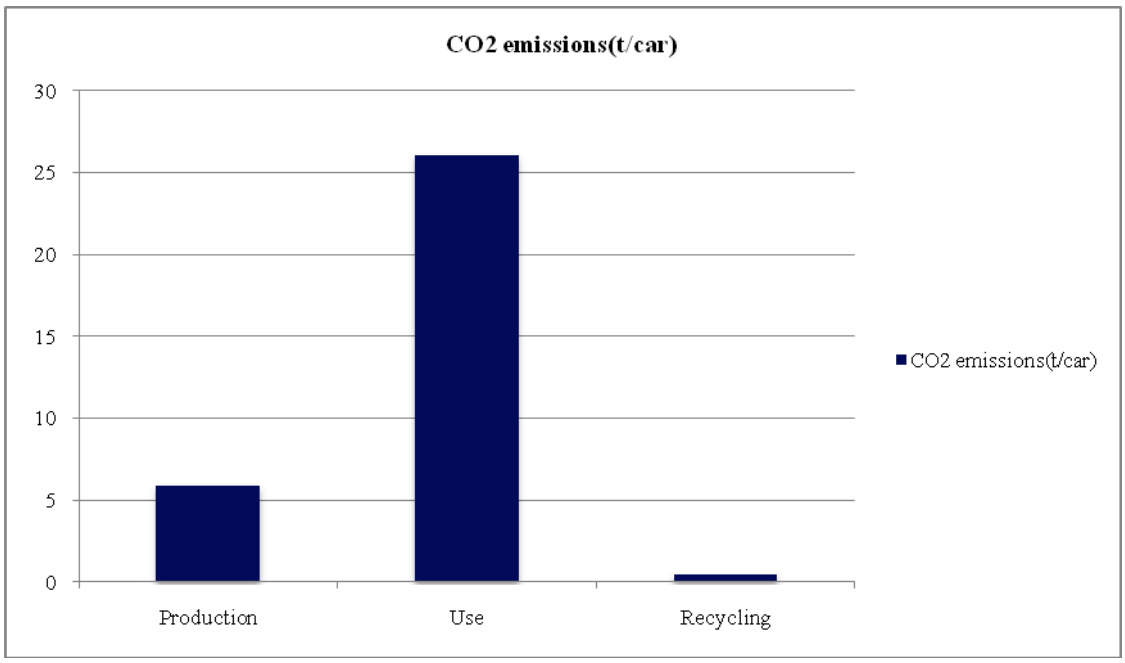


Figure15: Overall CO_2 emissions in tonnes Source: The company's report about new A-type

In the subsequent usage phase, the new A-type emits around 26 tonnes of CO_2; the total emissions during production, use, and recycling thus amount to 33 tonnes of CO_2.

CO_2 emissions are decreased if looking at overall stage, however, the production process got a different result. In the production process 0.4 tonnes are increased. Over its entire life cycle, comprising production, use over 160,000 kilometres, and recovery, the new model gives rise to 16 percent (6 tonnes) less CO_2 emissions than its predecessor[40].

[40] The company report for new A-type

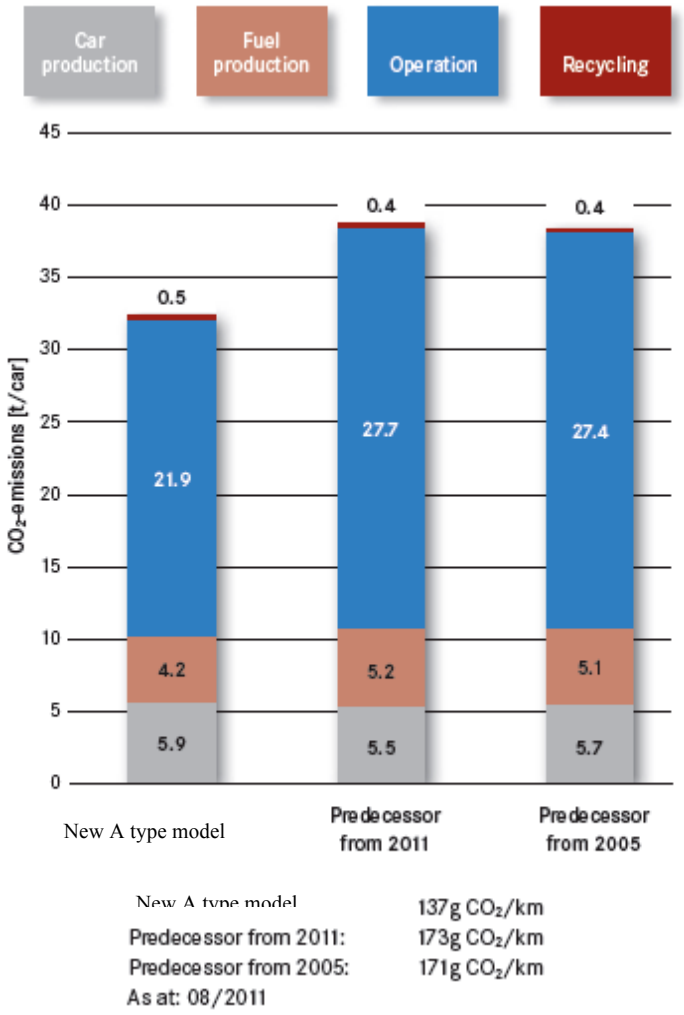


Figure16: Selected result parameter of A-type

For comprehensive and sustainable improvement of the environmental impacts associated with a vehicle, the end-of-life phase must also be considered. The use or initiation of recycling systems is worthwhile from an energetic point of view. For a comprehensive assessment, all environmental inputs are taken into consideration within their each phase of the life cycle.

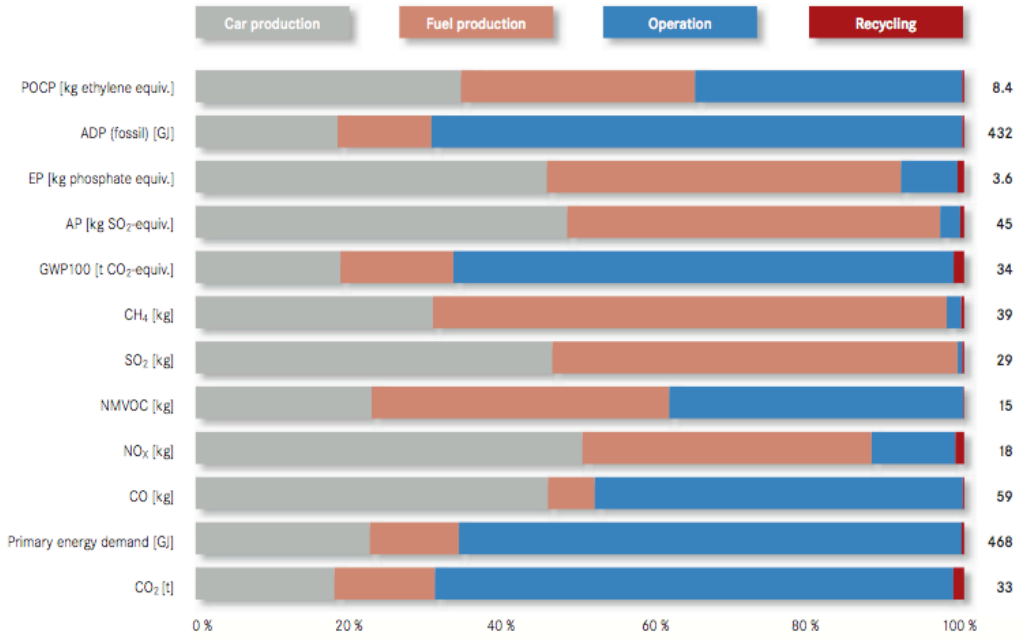


Figure17: Life cycle stages for selected parameters Source: The company's report for A-type

From above data, municipal waste and stockpile goods (especially ore processing residues and tailings) largely arise in the manufacturing phase, while special waste is created mainly through the production of petrol in the usage phase.

As the result, the new A-type vehicle give rise to 16% CO_2 reduction less throughout lifecycle including engine technology than previous A-type models.

b) The B-type vehicle

The new B-type also introduced environmental consideration into the model.

Specifications	
Length・Width・Height	4633×1877×1300mm
Wheel base	2585mm
Weight	1845kg
Engine displacement	3498-4663cc
Maximum output	395kW(537ps)/5500rpm
Maximum torque	81.6kgm/2000-4500rpm
Fuel tank capacity	75 liter

Figure18: Information about the new-B type model

The data of exhaust gas for the new B-type is following:

Exhaust emissions (g/km)	
CO2	159-176
NOx	0.005
CO	0.079
PM	0.0030

Figure19: Exhaust emissions regarding New B type model

The new B-type significantly improved fuel efficiency. In the case of one model, consumption has decreased from the previous levels of 11.7 l/100km (at the time of

market launch in 2001) and 9.7 l/100km (at the time of market exit in 2012) respectively down to 6.8 to 7.5 l/100km. [41] This improved fuel efficiency contributes to the environmental protection in the aspect of CO_2 emissions and fuel consumption.

Over the entire life cycle of the new B-type model, the life cycle inventory analysis yields for example a primary energy consumption of 989 gigajoules (corresponding to the energy content of around 30,000 liters of petrol), an environmental input of approx. CO_2 emissions for the life of the new B-type model is 69 tonnes.

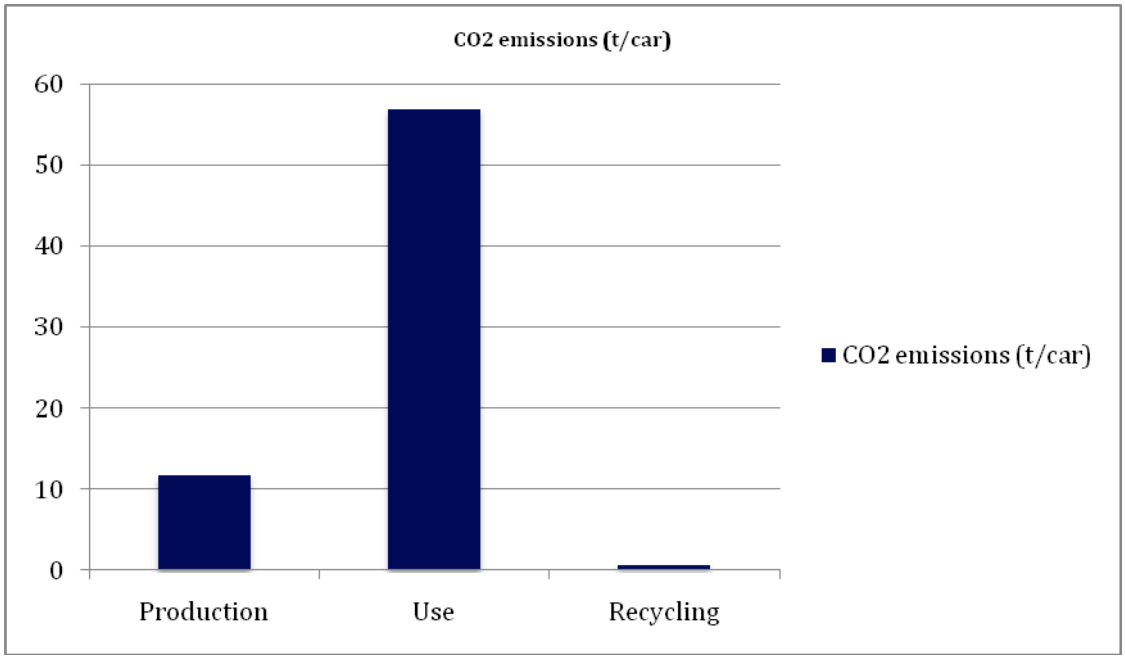


Figure20: Overall CO2 emissions in tonnes Source: The company's report about new B-type

The CO_2 emissions is 11.6 tonnes in production, 56.8 tonnes in use and 0.6 tonnes in recycling.

[41] The company's report for B-type

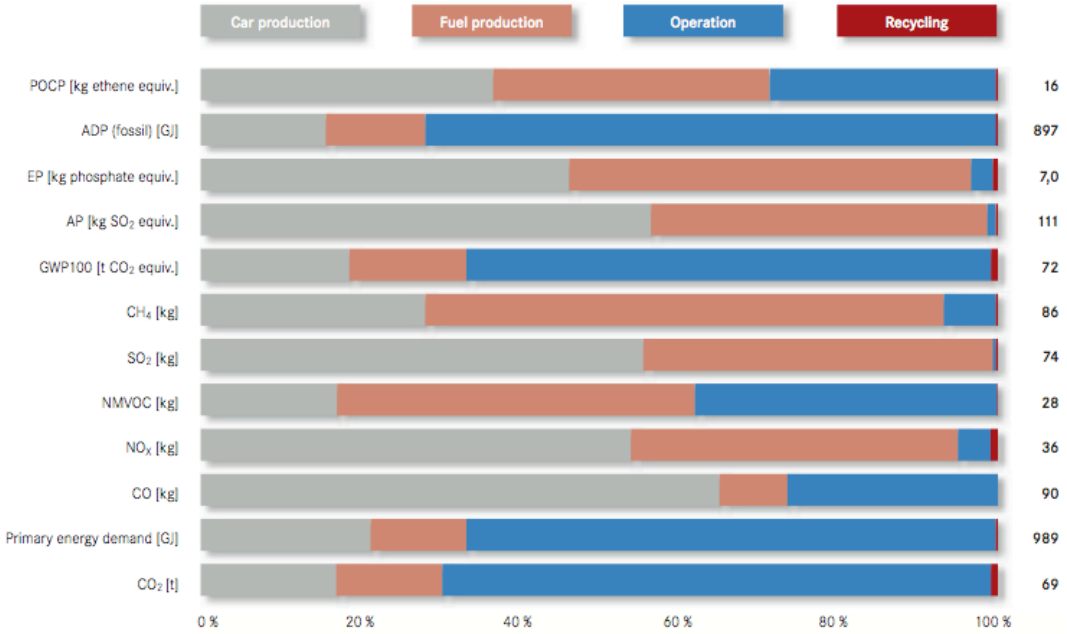


Figure21: Life cycle stages for selected parameters Source: The company's report for B-type

From above data CO_2 emissions in operation process and recycling is bigger than other gases. CO_2 emission in operation accounted for about 70% in the entire process. This figure is almost same with the new A-type.

When looking at lifecycle, production of the new B-type model gives rise to a quantity of CO_2 emissions which is greater than that of the predecessor (11.6 tonnes of CO_2 overall). In the subsequent usage phase, the figure 22 shows that the new B-style model emits around 56.8 tonnes of CO_2; the total emissions during production, use, and recycling thus amount to 69 tonnes of CO_2. Production of the previous model at the time of market exit (= predecessor from 2012) gives rise to 10.2 tonnes of CO_2. The figure for the predecessor from 2001 is lower at 9 tonnes. Due to the higher fuel consumption, the predecessor models emit 80.8 tonnes (2012) and 100 tonnes (2001) of CO_2 during use. The overall life cycle figures for both predecessor models are therefore around 92 tonnes and 109 tonnes respectively of CO_2 emissions. Aside from this, new B-type

model has been less 25 % (22.5 tonnes) CO_2 emissions than the previous models.

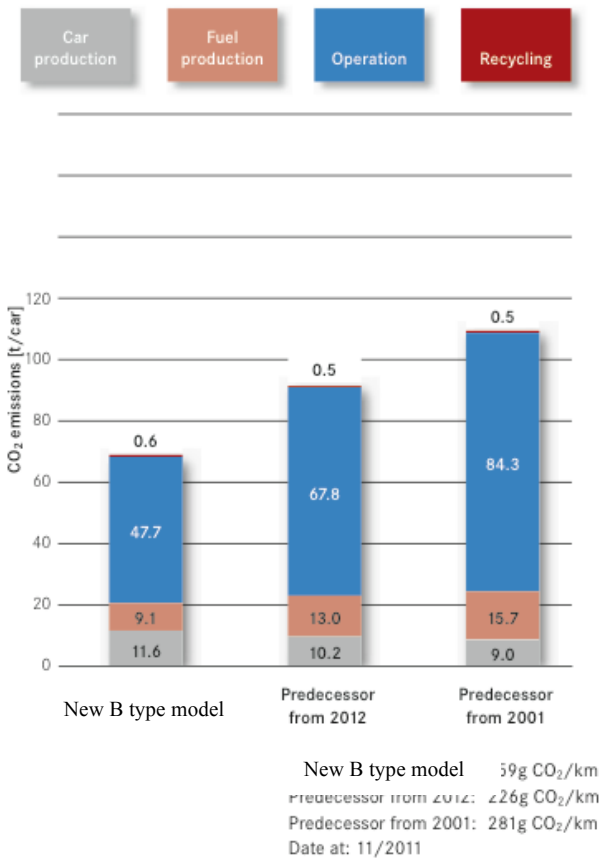


Figure22: Selected result parameter of B-type model

The one decisive factor to reduce CO_2 emissions in the new B-style model is the usage of aluminum body frame which is lighter than previous models. This effect is also contributing to fuel efficiency. Over the entire life cycle the usage of aluminum body results in 15% fewer CO_2 emissions. In other hand, the lifecycle assessment report does not mention about the CO_2 emission in the process of raw materials. CO_2 emissions for material resources are important factor in life cycle assessment because it is contribute to comprehend the efficient material use. Data of raw materials used for one car is

following to figure 23. In the fact, it is estimated that CO_2 emission in the process of raw materials increased up to 48% due to shifting the usage of steel into aluminum. However, figure 24 shows that there is a potential to reduce more 10% CO_2 emissions if the new model introduce aluminum into their entire frame.

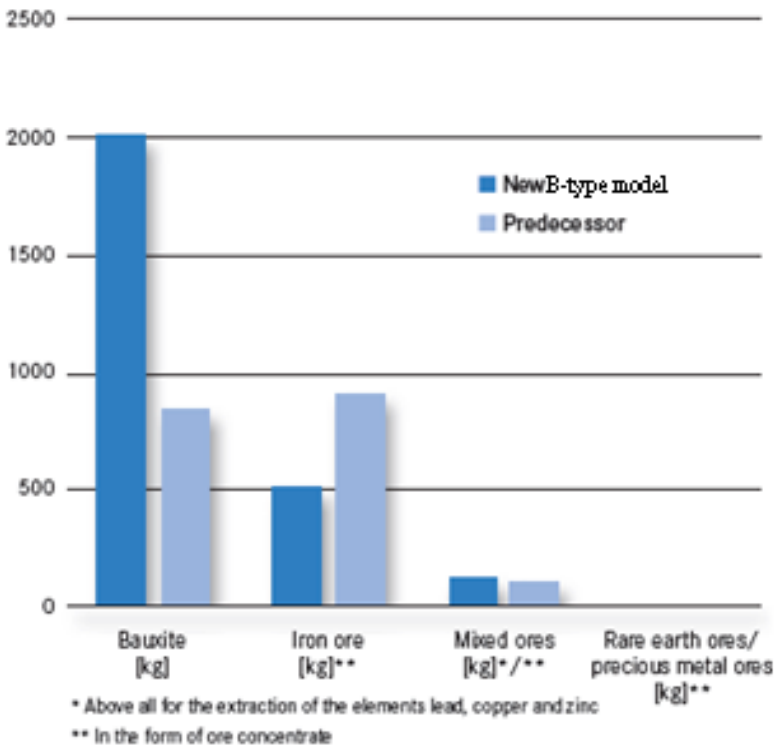


Figure23: Material resources per one car

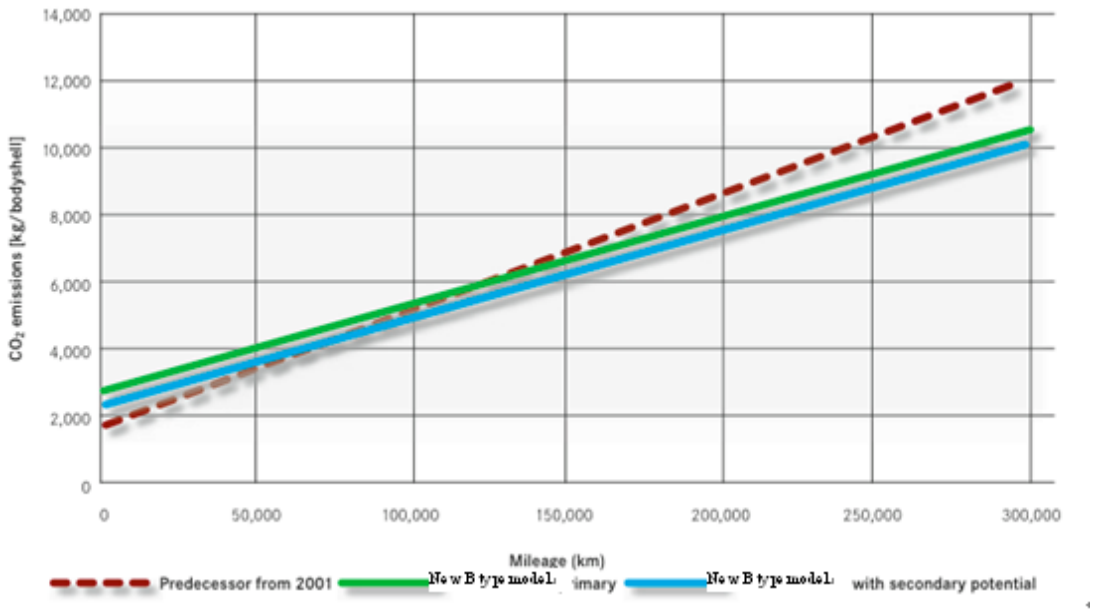


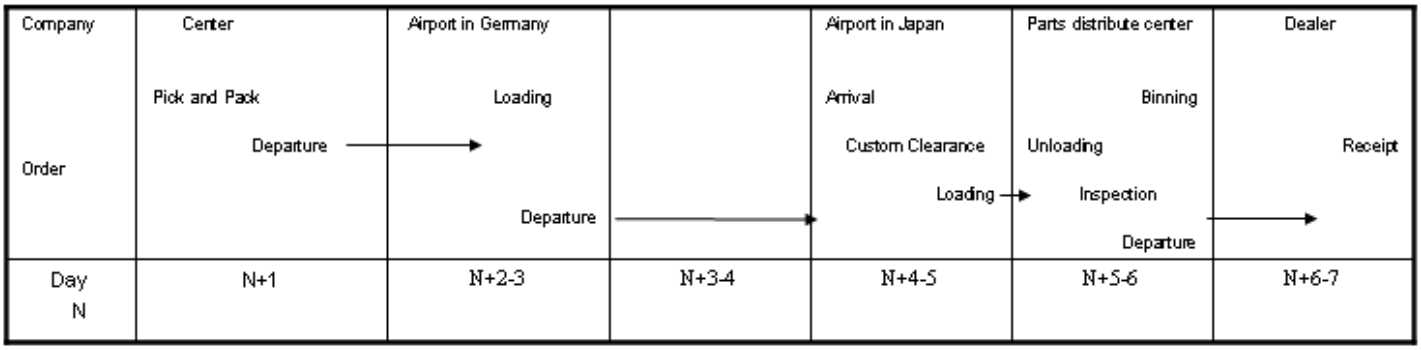
Figure24: Component concept Source: The company report for the new B-style model

ii) Remanufactured parts

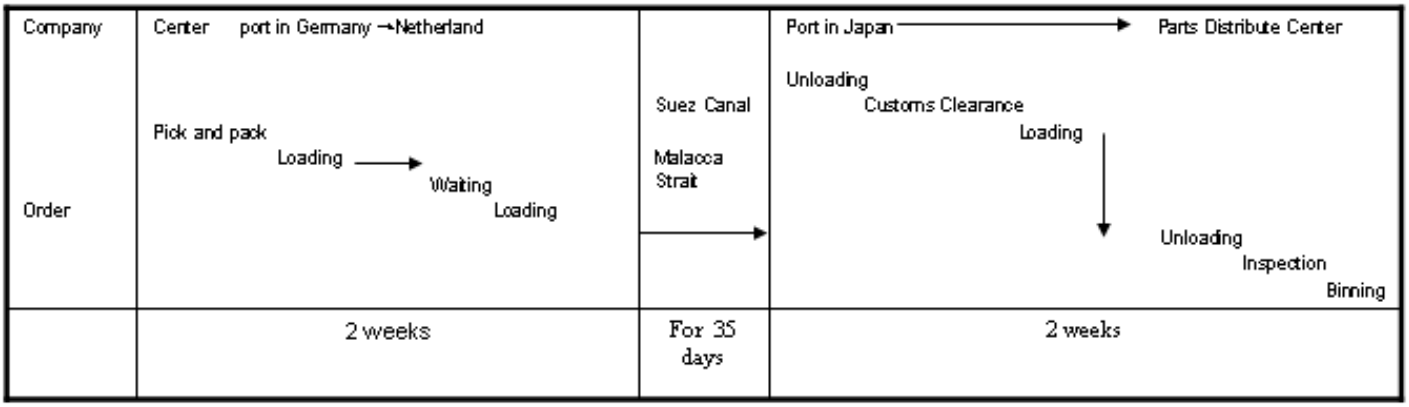
Japanese Narashino office's main work is to manage the import of parts, sell these, and take care of after-sale in Japan. One of important and new business is management of the remanufactured parts. Remanufactured genuine parts are reused and rebuilt products. Used parts collecting from customers through dealers are rebuilt in Germany and send these back to Japan. Every Remanufactured genuine parts are remanufactured to identical and exacting their company's standards as the new Genuine parts. This ensures the highest levels of quality and durability, a perfect fits first time every time and maximum performance for the life of the part. All these parts are rebuilt and fully tested to the latest specification standards of a new genuine part. Moreover, all components are fully inspected and all worn and compromised components are replaced with brand new company's genuine parts. The objective of this system is to reduce CO_2 emission and reuse the discarded products being possible to use. As environmentally

responsible, remanufactured parts supports their responsibility by significantly reducing the volume of raw materials and manufacture processes required in their production. Remanufactured parts have contributed to reduction more than 13,500 tonnes of raw materials every year, and saving more than 54,000MWkh of energy, which provides enough energy for around 17,000 households for a whole year.

This remanufactured parts system is introduced to almost all countries. The system process is following:



Picture3: Air Freight



Picture4: Ocean Freight

The first step is to collect used parts in Japan when customer order remanufactured parts throughout dealers. As second step, these are picked and packed to send to Germany by air plane or ship. Usually, considering CO_2 emission they select the way to carry these by ship. Arrived used parts are collected in factory located in Germany and parts being possible to reuse are remanufactured and rebuilt with other possible parts. Remanufactured parts are sent back by ship or air plane to Japan from Germany. The making process of remanufactured parts for engine in Germany plant is:

1. The used engine is disassembled into individual components
2. The oil and dirt are removed from all parts in this step during an intensive cleaning process. Hard soiled and corroded parts are subjected to cleaning using various blasting processes.
3. All the possible to uses component are re conditioned and comply with the manufacture's specification.
4. All of inspected parts are assemble in accordance with series production requirements to create a complete

In other hand, those above system emitted huge CO_2 emissions due to transportation to carry parts between Japan and Germany. The amount of consignment is 24.5TEU by air freight per month and 80.4TEU by ocean freight per month. Therefore, average weight of consignment is 0.81t/d by air freight and 2.68t/d by ocean freight.

CO_2 emissions by Air freight

First, CO_2 emissions in case parts are delivered by air plane are calculated. According to Picture3, parts are picked and packed in GLC and these are sent to Frankfurt air port. The distance between GLC to Frankfurt is about 200km. The carrying way is truck. Type of truck is delivery lorry light weighted 6 tonnes. Energy consumption per km by this truck is 0.43kWh/tkm (5.4 MJ/km) and CO_2 emissions 372g/km[42]. In here distance is 200km, therefore, clarified figure is following to figure 24.

Figure25: Information for CO_2 emission calculation by truck

Truck	Delivery driving lorry light 6tonnes
Distance	200km
Energy consumption*	2170kWh
CO2 emissions **	74.4kg

*Total energy consumption=distance*weight of products*energy

200km*24.5t*0.43kWh/tkm=2170kWh

**CO_2 emissions=CO_2 emission/km*distance

372g/km*200km=74,400g (74.4kg)

Second step is to calculate CO_2 emission between Frankfurt airport and Narita airport. The distance is 9370.8km and parts are delivered by aircraft. Energy consumption per tkm is 2.28kWh/tkm and CO_2 emission is 595g/tkm for long haul international flight[43].

[42] http://lipasto.vtt.fi/yksikkopaastot/tavaraliikennee/tieliikennee/kajakpienijakelue.htm

[43] http://lipasto.vtt.fi/yksikkopaastot/tavaraliikennee/ilmaliikennee/ilma_tavarae.htm

Figure26: Information for CO_2 emissions by Air plane

Air craft	Long haul International flight
Distance	9370.8km
Energy consumption*	523452.888kWh
CO2 emissions**	5575.626kg

*9370.8km*24.5t*2.28kWh=523452.888kWh

**9370.8km*595g/tkm=5575626g (5575.626kg)

Third Step is to calculate from Narita air port to Parts distribute center located in Narashino. The distance is about 30km and parts are distributed by truck being similar truck to the first step.

Figure27: Calculation about CO_2 emissions and energy consumption by truck

Truck	Delivery driving lorry light
Distance	30km
Energy consumption*	316.05kWh
CO2 emissions**	11.2kg

*30km*24.5t*0.43kWh=316.05kWh

**372g/km*30km=11,160g (11.2kg)

Actually, there is the forth step to deliver from Parts distribute center to dealers until remanufactured parts cycle complete. This calculation figure depends on location where dealers exist. Therefore, forth step calculations are abbreviated in here. The total CO_2 emissions except forth step is 5661.226kg (74.4 kg+ 5575.626kg + 11.2kg). However,

this figure is only one way that German side sends parts back to Japan after getting used parts from Japan. The period using air freight is about for 7.5days per months. As the result CO_2 emissions to deliver remanufactured parts between Germany and Japan per a month is 22,645kg (5661.226kg*4times) including sending back to Germany to Japan when all parts are delivered per month.

CO_2 emissions by ocean freight

Picture2 and 3 shows that delivery parts by Ocean freight takes long-term if it compares to air freight. However, company t mention that there are benefits from economical and environmental (CO_2 emission) aspects. Delivering parts by ship takes only 1/10 cost. In other hands, there is no environmental benefit comparison between using Air freight and Ocean freight. Therefore, in here environmental CO_2 emission figure are clarified.

First, CO_2 emission from German factory to Netherland port is calculated. During arriving to Netherland port there is 2 steps; delivery from factory to port in Germany and from port in Germany to port in Netherland through Rheine river. The distance from Factory to port is 20km and truck type is the same as figure used in calculation by Air freight.

Figure28: Information for CO_2 emission calculation by truck

truck	Delivery driving lorry light
Distance	20km
Energy consumption*	691.44kWh
CO_2 emission**	7.44kg

* 20km*80.4t*0.43kWh/tkm=210.7kWh

**372g/km*20km=7440g (7.44kg)

The energy consumption by ship is 0.094kWh/tkm and CO_2 emission is 47,221g/km[44].

Figure29: Information for CO_2 emission calculation by ship

Ship	General cargo ship
Distance	380km
Energy consumption*	2871.88kWh
CO_2 emission**	17.9tkg

*380km*80.4t*0.094kWh=2871.88kWh

**380km*47,221g/km=17943980g

The total CO_2 emission from Germany to Netherland is 1.80tkg.

The second step is to calculate CO_2 emission from nether land port to Tokyo port.

The distance between both is about 17,500km and same type of ship is use as the first step.

Figure30: Information for CO_2 emission calculation by ship

Ship	General cargo ship
Distance	17,500km
Energy consumption*	132,258kWh

[44] http://lipasto.vtt.fi/yksikkopaastot/tavaraliikennee/vesiliikennee/monikayttoe.htm

CO_2 emission**	826tkg

* 17,500km*80.4t*0.094kWh/tkm=132,258kWh

**17,500km*47,221g/km=826,367,500g

The third step to delivery parts to Japan is calculation from Tokyo port to Parts distribution center in Narashino. The distance between both is about 10km and parts are delivered by truck which is used in figure 25.

Figure31: Information for CO_2 emission calculation by truck

Truck	Delivery driving lorry light
Distance	10km
Energy consumption*	345.72kWh
CO_2 emissions**	3.72kg

*10km*80.4t*0.43kWh=345.72kWh

**10km*372g/km=3720g

The forth step to deliver parts to each dealers is abbreviated same as calculation of air freight. Therefore, the total net CO_2 emission is 844.3tkg (7.44kg + 17944kg + 826,367kg + 3.72kg). This CO_2 emissions figure is one way. The number of carrying should be considered. It is vaguely estimated that the number of carrying parts is 6times for a year including send it back to Japan and carry to China. Thus, total CO_2 emission for a year by Ocean freight is5065.8tkg (844.3tkg*6times).

iii) Building Management

All of offices are trying to reduce the usage of energy, papers, water, and some chemical substances. The office having biggest expansion installed solar panels to reduce CO_2 emission in 2010. This office has the huge warehouse to stock a lot of automobile parts. Employees in Narashino Office are basically doing desk work; therefore, energy is mostly consumed for air conditioning and electricity. The result of CO_2 emissions in Narashino Office is following to Figure 23. CO_2 emissions are calculated in basis of electric power. Calculation formula is;

CO_2 emissions = usage of electric power (kWh/d)*365.25days*CO_2 coefficient

CO_2 emissions are proportional to electric power usage.

Month	CO_2 emissions	Ratio of electricity toward objective
January	60t	127%
February	55t	122%
March	53t	118%
April	49t	115%
May	43t	110%
June	49t	109%
July	54t	109%
August	52t	110%
September	51t	109%
October	49t	109%
November	45t	107%

December	49t	107%
Total	609t	107%

Figure32: Monthly CO_2 emissions from electric power in 2011

Unfortunately, figure 31 shows that their usage of electric power and CO_2 emissions are over the objective. There is no month when go under 100% during one year, thought they are trying to save energy such as the temperature of air conditioner is set 26℃. The larger number of CO_2 emissions concentrated on summer and winter when rate of using air conditioners are growing. However, months at the high number don't have big difference. Therefore, electricity rate covered most of electric power usage and CO_2 emissions during one year in Narashino office.

Electric equipment

The total electric power is 1,646,298kW used for office and stock delivery area. Office is using electric power by electricity, air conditioner and computer. Unfortunately, there is no information of exact number about how much office or stock delivery area use electric power. According to a researcher's calculation, the usage of electric power by office is only accounted for less than 10%. However, researchers in Tokyo University come to conclusion that company use 30% electric power for air conditioner, 40% for electricity lighting and 32% for computers or consents. From this aspect, the solution to reduce electric power and CO_2 emissions should focus on the usage of electricity lighting.

The office having biggest expansion installed solar panels to reduce CO_2 emission in 2010. The energy produced from solar panel is used mostly for electricity in the

warehouse. The installed capacity is 480 kW and amount of generated solar energy per day is 1,382 kW/d. The detail of solar power generation is summarized in following:

	Efficiency	Notes
1. Installed capacity	480kW	
2. Electric power generation	1,382kWh/d	
3. Reduced electricity fee per year	8,114 thousand yen/a	Average of usage fee×yearly power generation
4. CO_2 emission reduction (t=CO_2/year)	181.6t	Not including emission during the life cycle

Figure 33: Solar energy from panels information

※Calculation background

1. Power generation

Quantity of solar radiation: Chiba prefecture

Temperature: Chiba

Installation direction: Southwest

Installation angle: 3°

Efficiency inverter: 92.0%

2. Electricity charge

Power Company: Tokyo electric power company

Electricity unit price: Basic charge 1,638yen/kW

Usage charge A 13.75yen/kWh (July to September)

Usage charge B 12.65yen/kWh (Except July to September)

3. CO_2 emission reduction 0.360kg-CO_2/kWh[45]

Yearly power generation (kWh/year) 504,576 ×CO_2 emission reduction=181,674 tones

4. Conversion into Crude Oil (kl)

Yearly power generation (kWh/ year) 504,576×caloric value conversion coefficient 0.00997×Crude oil conversion coefficient 0.0258= 129.8kl

5. Conversion CO_2 emission reduction into cedar trees

CO_2 emission reduction (kg-CO_2/year) 181,647/ 14(trees/year)[46]= 12,975 (trees/ year)

From above information they could reduce CO_2 emission and electricity charge after introducing solar power technology. Therefore, the number of CO_2 emissions in Building mentioned above should be compared to CO_2 emission reduction by solar panels and calculated how much real CO_2 emissions are emitted. Yearly CO_2 reductions through solar panels are 181.674tonnes and yearly CO_2 emissions are 225.491tonnes. These figure leads to 43.817tonnes as net CO_2 emission from Narashino Office. The

[45] http://www.env.go.jp/press/press.php?serial=14702

[46] Organization for management of forest 関東森林管理局

monthly average of the energy use is 137,191.5kWh of which electric power from solar panels is 41,460kWh/month. In other words the electric power is being saved up to 30% by solar energy.

In addition there is one hybrid external light which are producing energy from solar and wind at the entrance. However, there is no available data regarding this light. Other lights inside storage and office use initial intensity adjusted LED down lights with motion sensor which turn the light automatically on and out when people go through the area. They are trying not to waste energy by turning out unnecessary light.

Air conditioner ventilation equipment

The office installs an electric heat pump air conditioner. They consider the usage of equipment for a long period and save energy by reducing number of start-ups on compressor. The thicker plumbing than normal is used as the air plumbing which supplies air to workroom.

7. Conclusion and Recommendation

The global warming is caused by GHG such as CO2, NOx and other gasses. It is however the CO_2 that contributes the most for the global warming. The emission of CO_2 comes from variety of sources but as shown in Figure 3 the energy supply industry and the transport industry are two major emitters. Furthermore the corporate sector uses 20% of the global energy supply implying that the sector should be the major contributor of CO_2 emission. Needless to say the corporate sector has a main financial contributor for the world economy at the same time. If the corporate sector only chases their profit and ignores the environmental issues chances are that the public would not allow survival of such corporations. In other words a corporate must pursue both its profitability and the contribution to the public simultaneously. There are now increasing number of companies trying to achieve a sustainable business by accommodating the social needs without reducing its profitability.

Historically the industrial awareness on environmental issues changed. In 1970's the industrial pollutions were acute issues but the issue was about the direct influence to human health and no attention was given to the environment at large. However the depletion of ozone layers by felon gases and the possibility of global warming by GHG emerged. The new awareness leads many of the countries to signing up Kyoto Protocol in 1997. Consequently many of the developed countries started to put effort in the reduction of CO_2. As of today, however, achieving the reduction target turned out to be difficult for most of the countries except for EU countries. Each nation in turn

put pressures on industrial sectors for the CO_2 reduction as they are the largest contributors of CO_2 emission.

Among the industrial sectors transport industry may be the key sector for the reduction of the CO_2 emission since the transport industry includes not only production of the transport equipment but the use of it.

With above conjectures in mind the researcher investigated a Japanese subsidiary of a German automotive company by looking at some business processes in this company. This subsidiary company does not manufacture automotive equipment but import and sell in the Japanese market. They also import car parts and provide technical services to the Japanese customers. The Japanese subsidiary company has 3 offices in Japan but the researcher only investigated the one in Narashino where they import car parts, manage the usage of cars by the consumers and they own a dedicated building for the company.

Initially all the business processes of this company were mapped out and three processes were selected for investigation in terms of CO_2 emission. They are the parts importation process, the car user management process and the Narashino office management.

The first investigation was about this parts import as the import process includes air and ocean transport which in itself emits CO_2. The researcher conducted calculation of CO_2 emission associated with this business process. However the result was not

compared with equivalent figures calculated by the company as they do not conduct such an investigation. The number the researcher obtained showed a fairly high CO_2 emission by this business process.

The second business process investigated was the usage of the cars driven by the customers. It is a duty of Narashino Office to monitor the amount of CO_2 emitted by the cars when driven by the customers in Japan. Obviously the amount of CO_2 emission heavily depends on the vehicle itself which is developed and manufactured in Germany. The researcher compared some recent models in terms of CO_2 emission against their old version and found a significant reduction has been achieved. However the company suggested that there could be a further improvement possible in this area.

The final step of investigation was conducted on the electricity use of the office building in Narahisno and its CO_2 emission was calculated. The investigation result showed the usage of electricity for air conditioners is relatively small and the majority of the electricity is consumed by lighting. At Narashino office they have solar panels on the roof. The panel generate up to 30% of their total electricity requirement.

From the above three investigations the key issues for this company in terms of reduction of CO_2 emission are technological improvement of the vehicles, more effective parts importation operation and employment of more renewable energy sources for the electricity requirement.

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