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**Conference Paper**

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50th Congress of the European Regional Science Association: "Sustainable Regional Growth and Development in the Creative Knowledge Economy", 19-23 August 2010, Jönköping, Sweden

**Provided in Cooperation with:**

European Regional Science Association (ERSA)

*Suggested Citation:* Miyata, Yuzuru; Han, Shuai (2010) : Renewable Energies and Low-Carbon Society: Application of CGE Model to Toyohashi City in Japan, 50th Congress of the European Regional Science Association: "Sustainable Regional Growth and Development in the Creative Knowledge Economy", 19-23 August 2010, Jönköping, Sweden, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/119288>

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# Renewable Energies and Low-Carbon Society: Application of CGE Model to Toyohashi City in Japan

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## 1. Introduction

Today, global warming is one of the buzz discussions among the scientific scrutiny. Global warming is the increase in the average temperature of the Earth's near-surface air and oceans since the mid-20th century and its projected continuation. Global warming does not merely mean the increases of the earth temperature, it causes other problems such as, rising sea, shrinking glaciers, shifting seasons, ocean acidification, arctic ice, Antarctic warming, permafrost retreat, changed precipitation, storms, desertification etc., that human being are experiencing on earth.

The Intergovernmental Panel on Climate Change (IPCC) remarks that most of the observed temperature increase since the middle of the 20th century was caused by increasing concentrations of greenhouse gases resulting from human activity such as fossil fuel burning and deforestation. From the industrialization in 17<sup>th</sup> and 18<sup>th</sup> century more demand of power supply made people depends on coal, natural gas, and oil for running the industries for higher economic performance. For same energy input compared with coal (40% higher), oil (25% higher) than natural gas is a cleaner and environmentally friendly fuel though, all these emitted carbon-di-oxide (CO<sub>2</sub>), the main green house gas that make the earth warmer. Although industrialization has enhanced faster economic growth, atmospheric levels of carbon dioxide (CO<sub>2</sub>) have increased steadily on the other hand and these levels are projected to increase even more rapidly as the global economy grows.

The causes and impact of CO<sub>2</sub> emissions or global warming has present broadly through the documentary and book of Al Gore (2006), "An inconvenient Truth, as well through Kyoto Protocol, Intergovernmental Panel on Climate Change (IPCC). In the latest IPCC report indicates that the global surface temperature will probably rise a further 1.1 to 6.4 °C (2.0 to 11.5 °F) during the twenty-first century. Since, it is expected that between now and 2050, the global economy is to grow by a factor of four and as much as a factor of 10 in developing countries like China and India (OECD/IEA 2008). The expecting such level of economic growth will inevitably require increased energy use. The International Energy Agency forecasts a 70 percent increase in oil demand and a 130 percent increase in CO<sub>2</sub> emissions by 2050. An increase in CO<sub>2</sub> emissions will increase the global temperature that causes further the change of climate pattern severely.

Thus at present it has become very important to take initiatives from the local level of all parts in the world to reduce the emissions of CO<sub>2</sub>. We must also concentrate on the global economic development, where industries are playing significant role. Therefore, it has become necessary to find a solution in such manner where industrializations are moved forward with no or significantly less CO<sub>2</sub> emission. The renewable energy could be the best solution for reduction of CO<sub>2</sub> emission and energy utility maximization.

Renewable energy is energy generated from natural resources sunlight, wind, rain, tides and geothermal heat, biomass which is renewable (replenished). The majority of renewable technologies are powered by the sun. It is measured that if the renewable energy can be used properly, these are enough to maximize the world energy demand. The total energy absorbed by the earth's atmosphere, oceans and land masses is approximately 3850000 exajoules (Ej) per year. In 2002, this was more energy in one hour than the world used in one year. In 2005 the total 487 Ej amount of primary energy and 56.7 Ej electricity was consumed, whereas relatively solar, wind, and biomass fluxes was 3850000 (Ej), 2250 (Ej), and 3000 (Ej). Therefore, it is seen that solar, wind or biomass would be sufficient to supply all our energy needs. However, the increased use of biomass has had a negative effect on global warming and dramatically increased food prices by diverting forests and crops into bio-fuel production.

Thus, this research aims to analysis (through statistics survey) a comprehensive evaluation of the renewable energy in reducing CO2 emissions to environment protection and utility maximization for a local area Toyohashi City, Japan.

Reduction of CO2 using Renewable Energy has been well studied in recent years. Here we mention a few of them. In 2004, David White et. al. published a study on Reduction in C2 Emissions: Estimating the potential Contribution from Wind-Power. Here the authors studied on Wind Energy only. Renewables Global Status Report 2009 Update is published by REN21 Renewable Energy Policy Network for 21<sup>st</sup> Century. In April 2009, ASME on its report studies on Technology and Policy Recommendations and Goals for Reducing CO2 emissions. The paper provides a technology and engineering perspective, with policy and technology goals. In 2001, Toyohashishi Kankyobu presents a Survey report on Regional New Vision Decision of Toyohashi where the paper describes on promote the use of solar energy, cogeneration, wind energy, biomass mainly in public facilities.

In our research work, we plan to study the Comprehensive Evaluation of Renewable Energy in Reducing CO2 Emissions in Toyohashi City. We first comprehensively study and analysis CO2 emissions in Toyohashi City. Then we study, analysis and evaluate the Renewable Energy that are more applicable for Toyohashi City. We also plan to establish a Renewable Energy Model for Toyohashi City. Finally, we study how local initiatives could impact on reducing CO2 emissions globally.

## **2. Renewable Energy**

Renewable energy is energy generated from natural resources sunlight, wind, rain, tides and geothermal heat which is renewable (replenished). The majority of renewable technologies are powered by the sun. The Earth-Atmosphere system is in equilibrium such that heat radiation into space is equal to incoming solar radiation, the resulting level of energy within the Earth-Atmosphere system can roughly be described as the Earth's "climate". The hydrosphere (water) absorbs a major function of the in coming radiation. Most radiation is absorbed at low latitude around equator, but the energy is dissipated around the globe in the form of winds and ocean currents. We have motion may play a role in the process of transferring mechanical energy between the atmosphere and the ocean through wind stress. Solar energy is also responsible for the distribution of precipitation which is tapped by hydroelectric project and for growth of plants used to create bio-fuel.

Renewable energy is derived from the natural processes that are replenished constantly. In its various forms, it derives directly from sun or from heat generated deep within the earth. Included the definition is electricity heat generated form solar, wind, ocean, hydropower, biomass, geothermal resources and bio-fuels hydrogen derived from renewable resource.

- Wind power is the conversion of the wind energy into a useful form of energy; such as using wind turbines to make electricity, wind mills for mechanical power, wind pumps for pumping water or drainage, or sails to propel ship. It is renewable and produces no green house gases during operation. The “Global Wind Energy Outlook 2008”, published by the Global Wind Energy Council (GWEC) and Greenpeace International, looks at the global potential of wind power up to 2050 and found that it could play a key part in achieving a decline in emissions by 2020. By 2020, wind power could save as much as 1.5 billion tons of CO<sub>2</sub> every year, which would add up to over 10 billion tons in this timeframe.
- Energy in water can be harnessed and used. Since water is about 800 times denser than air; even a slow flowing stream of water or moderate sea swell, can yield considerable amounts of energy.
- Plants use photosynthesis to grow and produce biomass can be used directly as fuel or to produce bio-fuels. There is variously bio-fuel such as liquid bio-fuel, soil bio-mass, biogas etc.
- Geothermal energy is obtained by tapping heat of the earth itself both from kilometers deep into the earth crust in some places of the globe or from meters in geothermal heat pump in all the places of the planet. There are three types of power plants are used to generate power from geothermal energy such as dry steam, flash and binary.
- A solar energy comes from solar cell. Solar cell converts sunlight energy into electric power and delivers this power to a load. Solar energy can be harnessed in different levels around the world. Depending on a geographical location the closer to the equator the more “potential” solar is available.

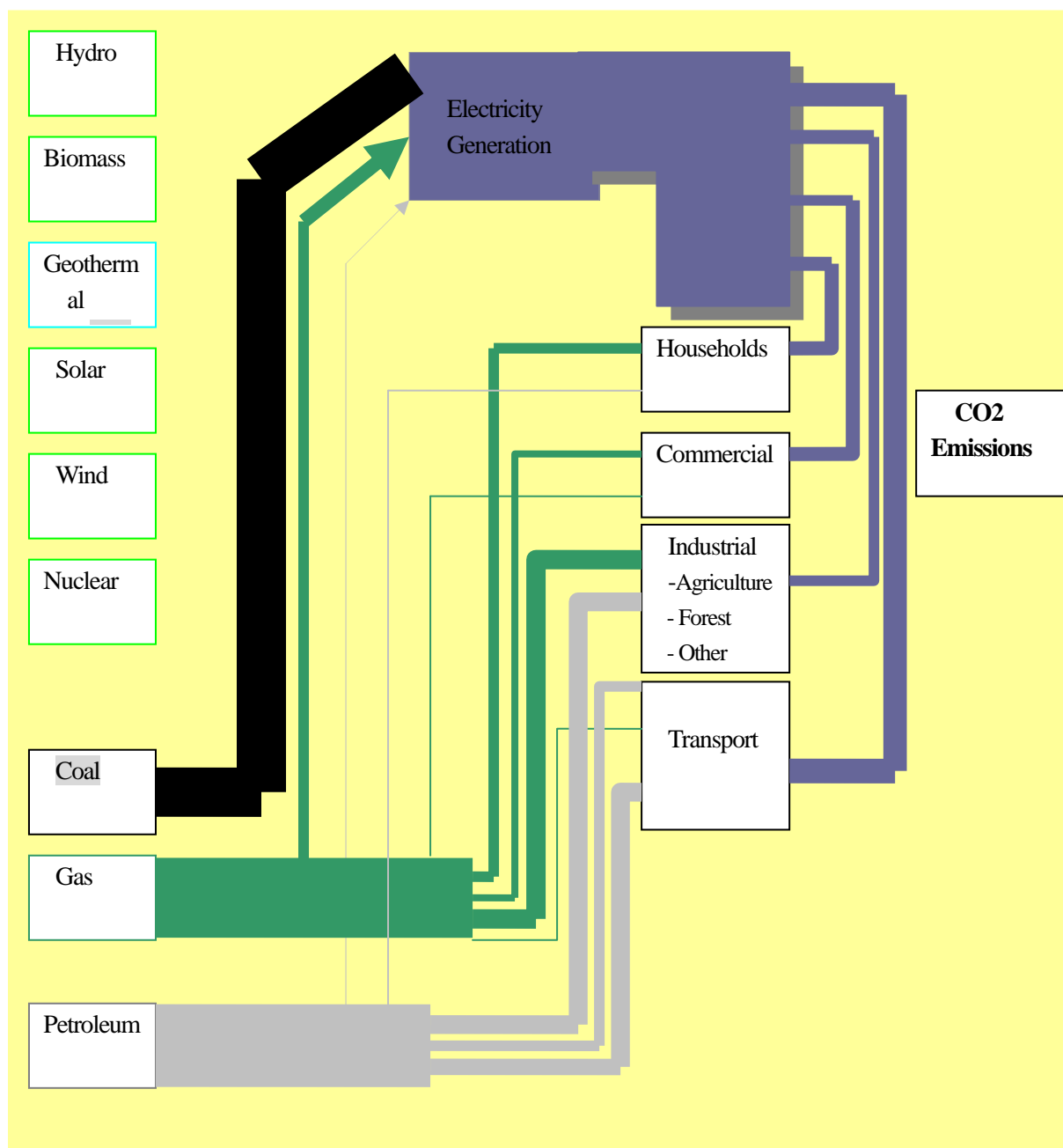
### **3.A General Pattern of Energy Use and CO<sub>2</sub> Emissions, and The Importance of Renewable Energy**

Currently, approximately 65 percent of global anthropogenic GHG (green house gas) comes from energy-related activities and the remaining 35 percent comes primarily from agricultural and land-use practices. For most industrial countries, the most significant anthropogenic GHG is CO<sub>2</sub> (ASME, 2009). Most CO<sub>2</sub> is emitted as a result of using fossil fuels. Globally, 89 percent of primary energy consumed comes from fossil fuels.

Figure 1 shows a probable flow chart of CO<sub>2</sub> emissions from primary energy use in the Toyohashi City, Japan. Four electric power production accounts for the most CO<sub>2</sub> emissions, such as transport sector, industrial sector such as agriculture, forest and other industries e.g., chemical, automobile, manufacture, households, and other production and consumption. In our future research work we plan to estimate and investigate the usage amount of energies in various sectors that generates CO<sub>2</sub>.

It is expected that between now and 2050 the global economy is expected to grow by a factor of four and as much as a factor of 10 in developing countries like China and India (OECD/IEA 2008). Such growth will inevitably require increased energy use. The International Energy Agency forecasts a 70 percent increase in oil demand and a 130 percent increase in CO<sub>2</sub> emissions by 2050. An increase in CO<sub>2</sub> emissions will increase the global temperature that causes further the change of climate pattern severely.

Thus, it has become very crucial now to use renewable energy to reduce CO<sub>2</sub> emission. Table 1 shows Shows the yearly solar fluxes and human energy consumption. Data shows that the total energy absorbed by the earth’s atmosphere, oceans and land masses is approximately 3850000 exajoules (Ej) per year. In 2002, this was more energy in one hour than the world



**Figure 1. A Probable Flow Chart of Energy Use and CO<sub>2</sub> Emissions in Toyohashi City, Japan.**

**Table 1. Yearly Solar Fluxes and Human Energy Consumption**

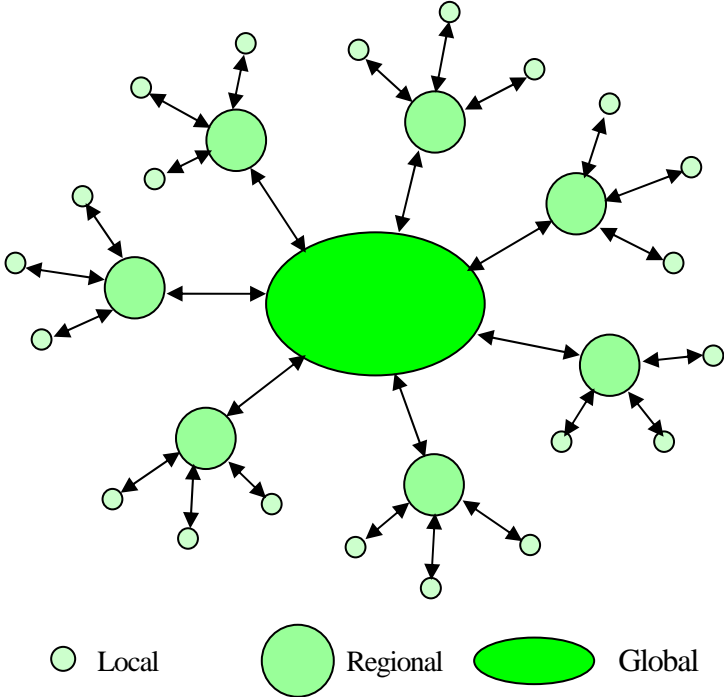
<b>Yearly Solar Fluxes and Human Energy Consumption</b>	
Solar	3850000 Ej
Wind	2250 Ej
Biomass	3000 Ej
Primary energy use (2005)	487 Ej
Electricity (2005)	56.7 Ej

used in one year. From this study it is clear that the renewable energy is well enough to maximize the world energy demand. It shows that solar, wind or biomass would be sufficient to supply all our energy needs. However, the increased use of biomass has had a negative effect on global warming and dramatically increased food prices by diverting forests and crops into bio-fuel production. Thus a comprehensive evaluation of renewable energy is very much necessary.

**4. The Importance of a person or local level initiatives to reduce CO2 Emissions**

The Intergovernmental Panel on Climate Change (IPCC) remarks in it’s forth assessment that most of the observed temperatures increase from human activity. Although the responsibilities and ranges are varying from country to country, almost all the countries in the world are experiences the impacts of global warming. Figure 2 demonstrate that regional and/or local level activities are responsible to increase the global warming though, a local and/or regional initiatives could reduce the global warming.

Let us consider that X number of people generates X percent of CO2, of which x1 and x2 are generated from the ignorance and from the activities which could be saved while hampering the purpose, respectively. Thus it could be seen that X-(x1+x2) percentage of CO2 emission could be easily reduced through making awareness only.



**Figure 2. Relationship of Impacts by Global Warming among Different Types of Space**

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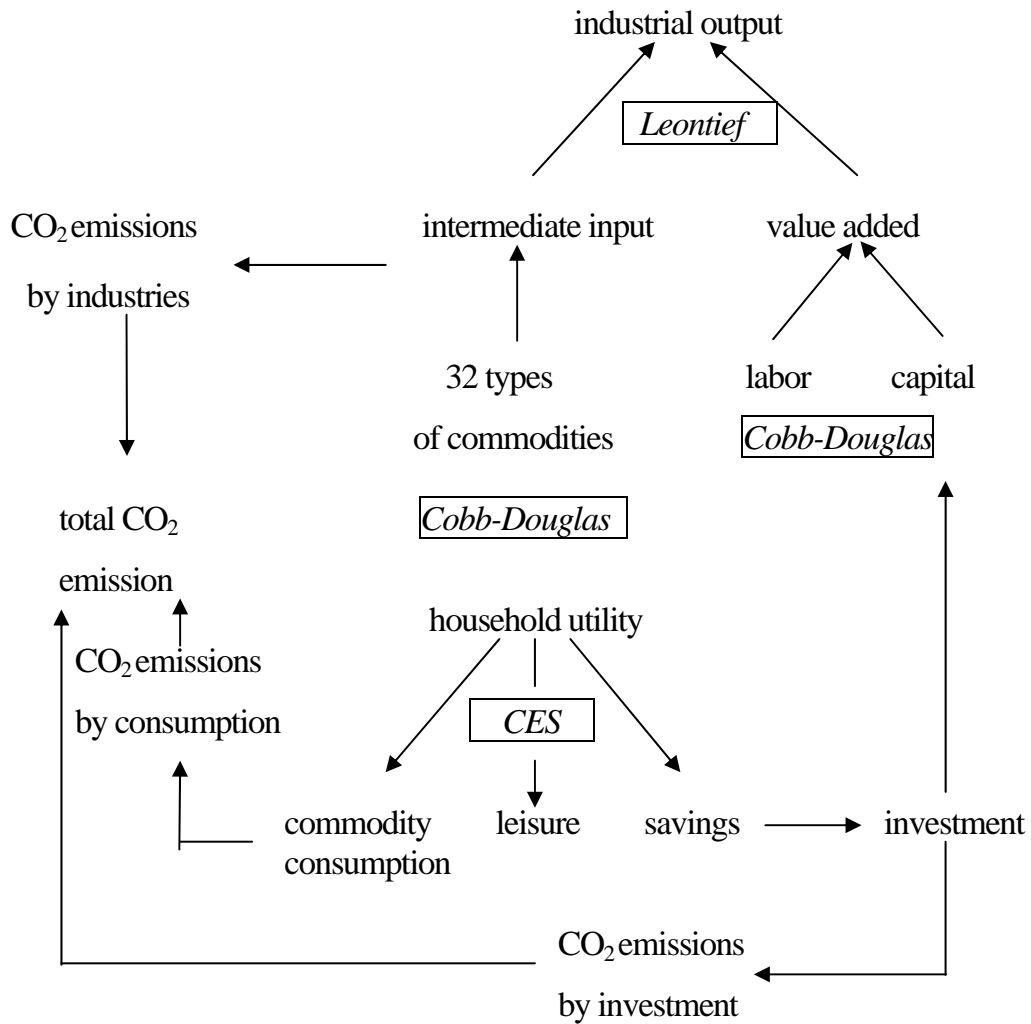


Figure 3. A Possible CGE Model of Low-Carbon Society