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STUDY ON ENVIRONMENT AND ENERGY USING BELONGING MATERIALS

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ABSTRACT

A trial to quantify CO_2 emission by utilizing our belonging materials has been conducted. For the Polymer electrode membrane Fuel Cell (PEFC) system, the reduction of more than 23% CO_2 emission was measured under a practical operation in a family of Okayama prefecture. The statistical data of the CO_2 emission obtained from the student's homes has shown that the highest CO_2 emission results from the commercial electric power, then gasoline for automobile and kerosene follow thereafter, which is consistent with the trend of the average aspect in Japan. In terms of the high efficiency lighting, the plane lighting source like Organic LED is ideal in view of heat transfer, and the multiple point lighting source is more advantageous than the small number of point lighting source.

Keywords: Fuel cell, CO_2 emission, LED, OLED, Cool earth.

INTRODUCTION

With regard to environmental and new energy research in Japan, "Cool Earth - Innovative Energy Technology Program" (Ministry of Economy Trade and Industry in Japan, 2008) was settled on by MITI (ministry of economy trade and technology in Japan) in 2008. In the program , 21 technologies that may potentially contribute greatly to substantial CO_2 emissions reduction was selected as technologies with which our country can lead the world in the fields such as power generation/transmission, transport, industry, and in the commercial/residential sectors and so forth, in order to accelerate innovative technological development in the energy field, moreover, road maps for these technologies were made to clarify R&D direction and to show milestones to facilitate the steady advancement of technological development over the long term. In the load maps, technological difficulties and economical were analysed, then the key technologies for bottle necks and the requirement of verifications have been discussed. For

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example, regarding innovative photovoltaic power generation, innovative materials and structures such as quantum nanostructures are being developed to drastically improve the efficiency of photovoltaic power generation technology and to reduce costs with the adoption of organic PV cells. MITI has been pushing nuclear power as a form of renewable energy in its greenhouse gas reduction measures. However the basic energy plan would be reviewed as a result of radiation leaks at the Fukushima nuclear power plant in 2011 due to Tohoku-Pacific Ocean earthquake and tsunami in Japan (Furuta, 2011).

Although conventionally, target specifications of industrial products were often determined by the economics and competitiveness of the products like running cost or production speed, recently the target determination process, in which the requirement of the CO_2 emissions reduction was firstly allocated hereafter the energy efficiency was assigned, has been increasing. Some of the authors have conducted researches on an OLED lighting panel manufacturing facilities and a heat transfer phenomena of the OLED lighting panels, and the target values of the equipment or panel have been assigned to a customer's requirements such a production speed, running cost, heat resistance and so on.

In any case, it has been suggested that the social contribution of the researches needs to clarify quantitatively, and the reform of consciousness and the enhancement of motive for the people are important elements to strengthen the measures against the environmental and energy issue, as well as the technological innovation and improvement. In the present work, some measures quantifying the CO_2 emission using our belongings are reported.

EXAMPLES OF STUDY ON ENVIRONMENTAL AND/OR ENERGY RELATED ISSUE

Reduction of CO_2 emission using a 1 kW PEFC system for residential usage

Background

It is widely known that PEFC system for residential usage, in which LNG or LPG is used as its fuel and the exhaust heat can be utilized for hot water supply, shows high energy efficiency around 80% or more, therefore is has high potential for the reduction of CO_2 emissions in comparison to an ordinary thermal electric power generation plant having an energy efficiency of around 39%. In Japan, a project called "Ene-Farm" (Fuel Cell Association in Japan, 2009). started in 2009, spread of the PEFC has been progressing. Panasonic has now shipped a total of approx. 21,000 units throughout Japan as of the end of December 2012, of which approx. 15,000 have been sold by Tokyo Gas. For FY2013, Panasonic will complete a production setup to enable an annual production capacity 50% greater than its current annual production forecast to more than 15,000 units, while Tokyo Gas will aim for annual sales of 12,000 units - 70% more than the

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FY2012 sales target of 7,100 units (Tokyo Gas Co Ltd Panasonic Corporation, 2013). The data of energy balance and CO_2 emission of a family introduced PEFC power generation system in Tsuyama have been investigated.

An Example of the Results

An example of the results is shown in Fig.1 and Table 1. It is found that the PEFC system can reduce CO_2 emission more than 23% in comparison with the conventional systems. The reason is suggested that the PEFC system utilizes the exhaust heat for hot water of bath and floor heating.

Fig-1. Appearance of a 1 kW PEFC system

Table-1. CO_2 emission from a family introduced the fuel system compared with other systems

	Consumption	CO_2 emission [$kgCO_2$/month]		
		PEFC (Empirical)	Electric only	Electric & Kerosene
Electric(Bought) [kWh/month]	444	299	←	←
Electric(Generated) [kWh/month]	414	295	279	←
Hot water [m^3/month]	22.4	-	515	194
Total	-	594	1093	772
Ratio	-	0.77	1.4	1.0

DISCUSSION

Some of the authors have conducted research on the optimization of fluid pass shape for a fuel cell separator and the fuel cell MEA (membrane electrode assembly). The trial above mentioned is to investigate how the commercial PEFC system is operated and whether it shows the potential ability in an ordinary house. In this trial, the quantity of energy and CO_2 emissions are estimated, at the same time the obtained values should be compared with those of other electric power generation systems, thus it has been suggested that details of the CO_2 emissions structure in the world can be naturally understood by conducting this scheme.

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Energy consumption and CO_2 emission at the student's homes of Tsuyama National College of Technology

Background

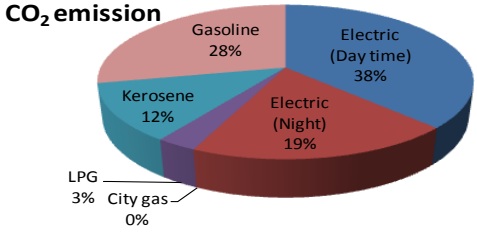
The Tsuyama Basin had historically played an important role as a posting station and a castle town, and has developed as a key traffic strategic cross point of railway network of the Kishin line, the Tsuyama line and the Inmi line. Since arrival of automobile society after the rapid economic growth, the dependence on automobile has become greater than on public transportation such as the railways and buses, it has been reported that typical family living in this area owns three to four cars, that is a grandfather's light track for agricultural usage, a father's car for commuting, a mother's car for shopping and part time job and a children's car for commuting, schooling or leisure. Therefore, the energy consumption for automobiles in this area is expected to be higher than that of large cities and Japanese average. Furthermore, main energy in Tsuyama is expected to be LPG or kerosene as network of city gas has just started, although in large cities, city gas and all electrification have become popular. Thus aspect of energy consumption and CO_2 emissions has been investigated.

An Example of the Results

The statistical data of the CO_2 emissions obtained from the student's homes are shown in Fig.2 respectively.

As shown in Fig.2, the highest CO_2 emission results from the commercial electric power, then gasoline for automobile and kerosene follow thereafter, which is consistent with the trend of the average aspect in Japan except for the higher value of the electric power. Contrary to expectation, proportion of electricity is higher than the Japanese average (Tokyo Gas Co Ltd, 2009), and proportion of LPG is lower. The reasons may be suggested that the price of LPG is not so cheap and/or the usage of night time electric power is spread. The analysis and the additional investigation have been continued.

Fig-2. Statistical result for the student's homes of Tsuyama College of Technology



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DISCUSSION

Recently the research and development of renewable energy has been enhanced so as to the reduction of CO_2 emissions, and introduction of photovoltaic power, solar heat, wind power, hydraulic power has been politically promoted. It is necessary for the people living in the northern area of Okayama prefecture to discuss the appropriate energy selection, thus the investigation of the status of energy consumption in the area has been started. It is important to convert an attitude from the audience who gives its review or regards these issues as the contents in TV or newspaper to the main actor who can estimate or investigate the economical and environmental influence quantitatively and spontaneously.

In addition, it should be noted that there is a specific energy supplying structure in Cyu-goku area, that is coal combustion thermal power generation dominates the supply showing a proportion of 35% and atomic power generation has a proportion of 8% in electric power supply, in comparison to the Japanese average values of 20% and 18% respectively. In order to reduce CO_2 emissions, it is effective to reduce the proportion of coal combustion thermal power generation to the average. Therefore, it has been suggested that modification and/or improvement of the energy consumption and the system of electric power generation are the further theme.

Reduction of CO_2 emission applying the high efficiency lighting source

Background

The efficiency of lighting is expressed in a unit of lm/W, and the characteristic of the typical lighting sources are shown in Table2. LED and OLED (Organic LED or Organic Electro Luminescence) have been developed rapidly and applied in many practical fields. However the energy loss from the LED and OLED are exhausted as heat from the lighting appliances, therefore the solution of the problems in heat transfer technology is important especially for the LED which is a point heat source.

It is preferable for OLED to be operated below 70 to 80 centigrade for fear of the degradation under elevated temperature. Fortunately due to the aspect of the thin and plane light source, the heat generation is dispersed and the heat flux is small, that is the control of temperature is relatively easy. The other hand, LED which light emission device is made of inorganic, has relatively good heat resistance, but it shows thermal degradation so that the device is molded in transparent organic resin, further LED is a small tip generating high luminescence and great heat flux from the point, namely it is a high density heat source. Therefore, in order to obtain high light flux with LED, a large number of LED tips need to be placed depressively on a flat substrate, resulting in high cost for the parts and assembling . To overcome the weak point, small number of LED tips having higher power is generally mounted on the substrate with Aluminum

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plate for heat conduction, that is the point heat source needs to be converted to a plane heat source.

Table-2. Characteristic of the typical lighting sources

	Efficiency[lm/W]	Mercury	aspect
Light bulb	15	Free	Bulk
Fluoresce	60-100	contain	Bulk
LED	40-100	Free	Bulk, Point
OLED	15-60	Free	Thin, Plane

An Example of the Results (1)

When a heat generation of 30W on a glass substrate in a dimension of 1.4x300x300 mm is assumed, temperature distributions of the following four cases were analyzed by an Excel base program (Tomimura *et al.*, 2005), (a)a plane light source(30W/piece, 330W/m^2), (b)81 pieces LEDs (0.336W/piece), (c) 18 pieces LEDs (1.65W/piece), (d)9 pieces LEDs (3.3W/piece) as shown in Fig.3.

The results are shown in Fig.4. It is shown that a uniform temperature of 36 centigrade for the plane light source (a)(OLED), and temperature of the case (b) (81pieces LED) is also relatively uniform although the maximum value has a peak value of 42 centigrade. However, in the case of (c) (18pieces LED) and (d) (9pieces LED), the high peak temperature of 150 centigrade and greater than 250centigrade were obtained respectively, which means that the metal heat conduction plates are required. As a conclusion, in view of heat transfer, the plane lighting source like OLED (Fig.4.a) is ideal, and the multiple point lighting source (Fig.4.b) is more advantageous than the small number of point lighting source (Fig.4.d)

Fig-3. Arrangement of LED chips (a)OLED, (b) 81pieces LED, (c) 18pieces LED, (d)9pieces LED

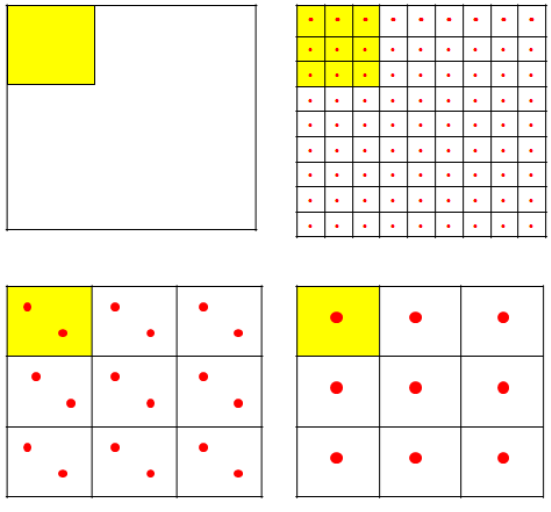

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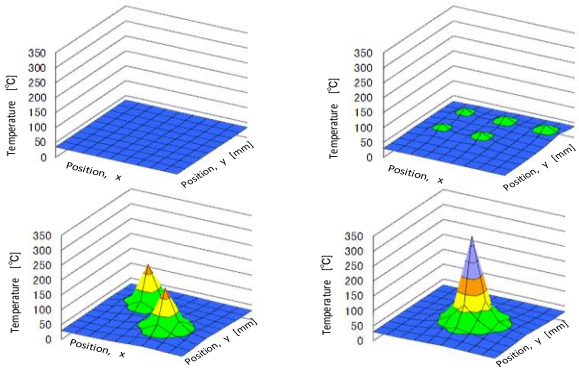
Fig-4. Temperature distributions of OLED and LED under the conditions of 50lm/W, a) plane light source(OLED), b) 81 pieces LED, c) 18pieces LED, d) 9 pieces LED on a 300x300x2mm glass



An Example of the Results (2)

As mentioned above, it was found that OLED, which is a plane light source, is preferable from a point of the peak temperature resulting in shorter life. Next, OLED panel has multi layers structure because OLED device layers have to be encapsulated by a glass cover plate for the prevention of degradation due to humidity. Normally the capsulated space is filled with dry nitrogen or insulation oil. Therefore the temperature distribution and the thermal strain induced by the temperature distribution should be analyzed to obtain a sound product. The analysis using FEM (Cybernet systems Co Ltd, 2010) has being conducted. An example of the results is shown in Fig.5.

DISCUSSION

Conventionally customer's requirements or specifications of equipment or machinery had been mainly considered at a research and development stage, that is in the case of OLED or LED lighting, it was considered luminescence, temperature, cost, life, efficiency and so forth. Recently it has been, however, considered that the effect of CO_2 emissions reduction is also discussed. For example, introduction of high efficiency lighting can contribute to the reduction of electricity for air-conditioning in summer as well as for the lighting because of the reduction of heat exhaust. From an estimation, for a office building adopting a heat pump as air-conditioning heat source, a peak electric demand of 1.4 to 1.6 kW in the whole building can be reduced by electric demand reduction of 1kW for its lighting and OA equipment (Optoelectronic Industry and Technology Development Association in Japan, 2006).

By conducting these research and understanding quantitatively, the contribution to the improvement of industrial performance for OLED and LED lighting is directly expected, then it can be also expected that the social contribution to the reduction of CO_2 emissions.

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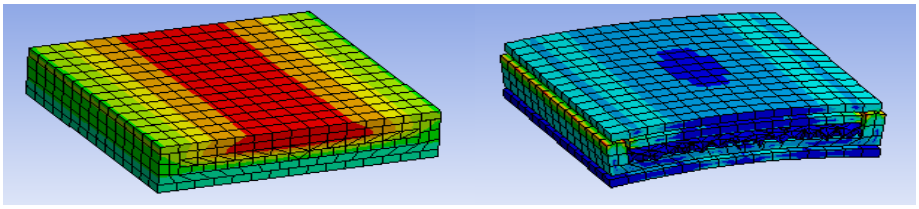
Fig-5. Examples of FEM analysis for temperature distribution(top) and thermal deformation and stress(bottom) of OLED lighting panel.



CONCLUSIONS

(1)The research on the key technologies which is consistent with the road map of "Cool-earth – Innovative Energy Technology program" settled by MITI has been conducted in the authors laboratory. I t has been recently necessary to quantify the social contribution such as the reduction of CO_2 as well as the improvement of economics and performance.

(2)In this paper, a trial to quantify CO_2 emission by utilizing our belonging materials has been reported. The materials investigated are a 1 kW PEFC system, student's homes of Tsuyama College of Technology and high efficiency lightings. Furthermore, the meanings of the quantification of CO_2 emissions reduction have been discussed. (a)understanding of a whole energy consumption structure, (b)consideration of energy supply structure and ideal future aspect in cyu-goku area and the northern area of Okayama prefecture, (c)understanding of social contribution quantitatively by CO_2 emissions reduction in addition to the economical and performance. The trial is expected to contribute to the reform of consciousness and the enhancement of motive for the people.

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