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Realization of Sustainable Urban Society by Personal Electric Transporter and Natural Energy

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***Abstract*—**In regards to the energy sector in the modern period, two points were raised. First is a vast and growing energy demand, and second is an environmental impact associated with it. The enormous consumption of fossil fuel to the mobile unit is leading to its rapid depletion. Nuclear power is not the only problem. A modal shift that utilizes personal transporters and independent power, in order to realize a sustainable society, is very effective. The author proposes that the world will continue to work on this. Energy of the future society, innovation in battery technology and the use of natural energy is a big key. And it is also necessary in order to save on energy consumption.

***Keywords*—**Natural energy, Modal shift, Personal transporter, Battery.

I. Introduction

ENERGY problem is a never-ending matter of life for us as we have limited resources to use. In modern time, energy problems have a great impact on the environment due to enormous and growing energy demand, and rapid depletion of the fossil fuel that is largely consumed in transportation. It has become clear in the serious earthquake in East Japan that this depletion would raise a serious problem called WEB− Water, Energy, and Bread (food). Of these, energy is a big problem in Japan. Energy self-sufficiency rate in Japan is 4% which is less than 1/10 of the food self-sufficiency rate in Japan i.e. 40%. The purpose of this article is to address possible resolutions to this problem. The migration from a large-scale centralized power generation system by conventional fossil fuel or nuclear power to a small scale distributed power generation system by natural energy, such as solar power and wind power, is one policy. The individuals and organizations those are covered by this energy system will be forced to be responsible for its management. If that happens, it is also necessary in order to review the current energy consumption of course. The realization of a sustainable society, through the use of modal shift by an independent power source such as a personal transporter proposed to be very effective, must be addressed. In addition, the energy of the future society, innovation of the use of natural energy and battery technology is a big key. In this paper the results from experimental results are described. Subsequently, in the future work, "saving", "accumulation" and "production" of the energy will be focused. The theme of this article is our experience in the serious earthquake in East Japan that led to the transition from fossil fuel and nuclear power to renewable smart energy, which must be conveyed to the rest of the world now.

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II. Personalization of Mobile Device

Professor David JC Mackay is doing interesting research [1]. In human subjects working for the average company in the UK, he has analyzed the energy consumption of one person a day. Table I is an extension to this example Japanese representative. Energy consumption associated with the movement, such as automobiles and transportation is more than 40%. I know that it is important to think about the energy consumption associated with the movement. Especially that the oil peak is shouted, running out of oil is seen as a problem in the decades ahead is certain. It is even more so considering this reality. On the other hand, ensuring that the movement means is critical for humanity, it cannot neglect it. Comparing the CO2 emissions according to the transportation of people, the environmental impact of vehicles is about five times the railway.

TABLE I
Energy Consumed by One Person per Day [1]
Unit; kwh/Person/Day

1. Public services	4.0
2. Transporting · stuff	12
3. Stuff	48
4. Food, farming, fertilizer	15
5. Tv	1.7
6. Personal computer, Video, Cleaner	3.3
7. Lighting (Home)	2.7
8. Lighting (Workshop)	1.3
9. Air-conditioner	4.2
10. Refrigerator	2.7
11. Electric carpet	0.7
12. Warm water washing toilet bowl	0.7
13. Tableware Clothes dryer	0.7
14. Gas/Oil heating (Warm water · Cooking)	28
15. Jet Flights	30
16. Car	40
Total	195

Hatching part is followed on transportation.
Its energy consumed is 82kwh/person/day.

Therefore, the modal shift has been said to be shift from car to rail. However, the inconvenience of switching to other transportation by rail is not improved. Therefore, the shift to rail, it has not been so much support from the automobile. However, one person to carry, move the car with a weight of 1-2 tons also is contrary to the spirit of the Japanese admired by the world "mottainai"(saving). As a solution to this, has been focused recently on the electric vehicle. As shown in Fig. 2, the

fuel efficiency of the electric vehicle is about twice the gasoline engine car. [2] Electric vehicle is a vehicle to use energy efficiently. Electric car does not emit exhaust fumes, it is a vehicle and clean. Solo-wheel and Segway® are a type of personal transporters, designed for one person to ride 20~30 km. Solo-wheel and Segway® are devoid of a body configuration, as shown in Fig. 1. Personal transporter rider is capable of running on bad roads and through bottlenecks. It is also possible to run while talking to the passengers and pedestrians. Also significantly limit loose causing congestion. The amount of charge at the same distance is less than one-tenth as compared to an electric car as the automaker is attempting to spread.

Fig. 1 Personal transporter trial ride scenery

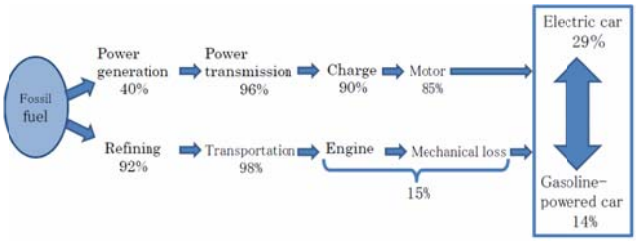

Fig. 2 Fuel efficiency comparison of an electric car and a gasoline-powered car [2]

III. Modal Shift by the Personal Transporter and Natural Energy

Kamioka describes the effectiveness of the modal shift of traffic systems [3]. Fig. 3 is an illustration of the CO2 emissions per unit volume and the number of passengers transported. The horizontal axis shows the number of persons per vehicle ride. The vertical axis shows the amount of CO2 emissions per km per person. Car is very familiar to us as many people utilize this automobile. Bus or train can carry many people together. Therefore, CO2 emissions can be reduced per person per km. That is why; it is possible to take advantage of bus and train instead of the car, so that there is a significant win for the guaranteed energy-saving and environmental affinity as shown in Fig. 3.

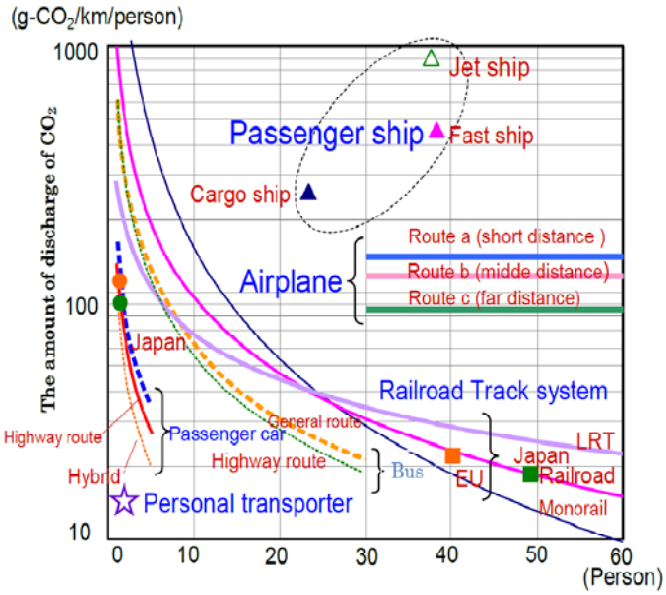

Fig. 3 The modal shift of traffic system [3]

The Segway® is powered by lithium-ion batteries that typically take 8 to 10 hours to charge and consume 1.04 kwh of energy from a wall outlet for a full battery charge. The Segway® offers riders 26 ~ 39 km range on a single charge, depending on several factors, including terrain, payload, and riding style. Using the middle of this range, the Segway® consumes 0.032 kwh/km (1.04 kwh/33 km). Based on the average fuel mix for electricity production in Japan, those 32 watt-hours create 17.9 g of CO2 emissions per km [(0.032 kwh/km) x (0.559 kg CO2/kwh) = 17.9 g CO2]. This value is one-sixth the amount of greenhouse gases emitted for an average Japanese car driven the same distance.

The above example is a calculated result of the use of the conventional power. If we supply energy by configuring a system that utilizes the natural energy such as shown in Fig. 4, the CO2 emissions would be zero, and subsequently the ultimate clean world can be achieved. Segway® can run about 30 km a whole day if you charge by solar panels of 4 m2. It is the so-called personalization of the electrical energy. Japan has about 70 million cars. There is a possibility that the 4% of car ownership if personalization, an alternative nuclear power will save all of 5 million kw.

Independent power supply by solar power embodies four main features:

1. A small number of parts.
2. There are no moving parts such as generator.
3. Efficiency does not decrease even if the small.
4. Instability of the solar power output can be smoothed by a battery.

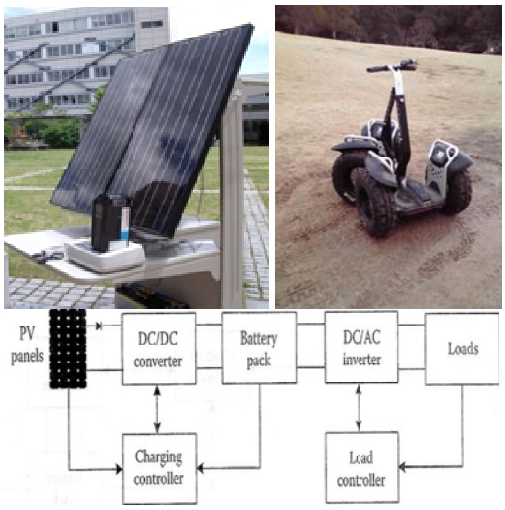

Fig. 4 Independent power supply system by the use of natural energy

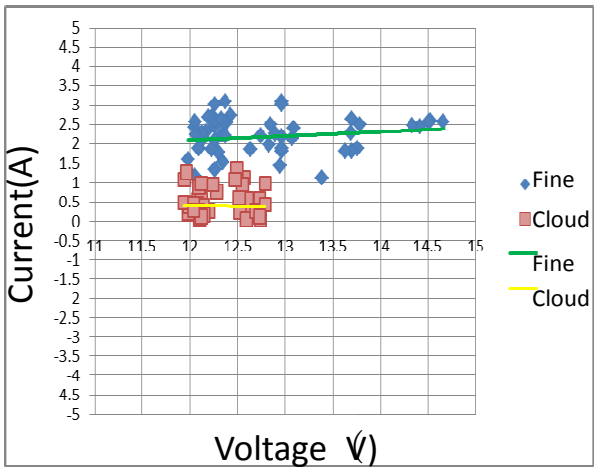

Fig. 5 The voltage-current experimental characteristics of a solar panel in East-Japan. The amount of rated max power is 70w

If you convert to using less battery that can be connected directly, you can expect increased efficiency. In conjunction with improving the efficiency of solar panels, it is possible to charge less area. By binding a personal transporter and solar power, the distributed energy system is achieved. This direction is consistent with the fact that people on their computers or phones become ubiquitous in society towards the personalization.

In the future, the Japanese system is introduced fixed price purchase of renewable energy. Modal shift will be more active in a residential solar power spreads, and the more use of natural energy such as wind power in the community.

IV. Personal Transporter Driving Test

Obtain driving data for lead-acid battery-powered personal transporter equipped with driving characteristics measuring device by making it drive through a specific course (surrounding area of Yagiyama campus of Tohoku Institute of Technology). Conduct a driving test for a micro EV equipped with data logger and GPS while measuring voltage value (V), ambient temperature (‘C), current value (A), battery temperature (‘C) and elevation differences as well as taking images.

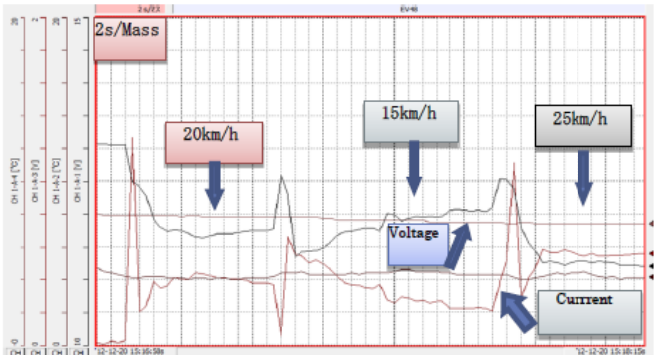

Fig. 6 Battery voltage, current and temperature during driving

Fig. 6 shows driving data when the EV traveled 500m through a slope with an elevation difference of 37m. This chart shows data of battery voltage, current and ambient temperature at the time.

It is said that those who rule battery rule the world. What is considered to be core measure to save, store and create energy in the future is battery. Various techniques are required for innovating battery. First of all, we have made it possible to perform virtual driving tests based on an environmental setting with large degree of freedom by achieving electrical load with respect to personal transporter driving based on a simulator and battery. Secondly, life prolongation and regenerative technique of battery is indispensable for effective use and saving of finite resources. As it has been recognized from a result of lead-acid battery regeneration test that discharged electric energy increased and internal resistance decreased, it is understood that removal of sulfation was useful for life prolongation and regeneration of battery.

In consideration of expected spread of personal transporter in the future, further innovation in battery technique is required. With urgent needs to work on lead-acid battery for driving and lithium-ion battery in the wake of defect in main battery of Boeing 787 found on January in 2013, we will not just work on virtual driving test using actual batteries reaffirming its importance but focus on accelerated deterioration test in the future [4].

V. Summary

To the realization of a sustainable society, is very effective modal shift of personal transporter with an independent power supply, we must tackle. It will be important in the future the research of "discovery", "accumulation" and "saving" in the field of energy. In particular, human resource development and innovation in battery technology is the key. Major shift in thinking is required in big turning point. It is necessary to abandon the arrogance and deception, seize the crisis as an opportunity.

From fossil fuels and nuclear power, and those of us who experienced the Great East Japan Earthquake, smart transition

to renewable energy is a serious topic should go to the world now [5].

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