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Renewable Train and Railway Station

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Abstract - We propose an electricity supply system suitable for public transportation .In this system, solar cells are installed on the roof of the platform. Wind turbines and water wheels are built around the station. Electric double layer capacitors (EDLCs) are installed at the station, and EDLCs are always charged by renewable energy. EDLCs are also mounted on the railcar. When the railcar stops at the station, EDLCs of the railcar are rapidly charged from EDLCs of the station.

The battery driven light rail vehicle developed by Railway Technical Research Institute consumes the electricity of 2.5kWh per kilometer. Assuming that interval between stations is 500m; a railcar needs 1.3kWh to reach the next station.

If we assume that railcars arrive and depart every 10 minutes, and railcars are operated for 18 hours a day, the power generation capacity of 99,000kWh is necessary at each station in one year.

The quick social economic development of Vietnam stimulates great demand of quality as well as quantity on transport service by the increasingly growing needs of customer for transportation. The railway passenger transport is currently still an important branch of a country's transport system because it is safer, more eco-friendly and much more efficient in comparison to another means. However, the increasing of the number of passengers is the main causes of fast increasing waste amount from the rail service. The aim of this paper is to study how the organic waste from rail service is managed and treated today by the Vietnam railways. The paper ends with some proposal solutions for treating and disposing of organic waste by applying renewable energy technologies for climate change mitigation to protect human health and the environment.

Index Terms—Renewable energy, Solar energy, Wind energy, Biogas system

I. INTRODUCTION

Is a vehicle that runs on electricity really environmentally friendly? Table 1 shows composition of electricity generation of Japan. In Japan, fossil fuel power generation accounts for over 60% of all electric power. This means that more fossil fuels are consumed, when electric vehicles spread. If railways, especially light rails, could run on renewable energy such as solar power, wind power and micro hydropower, wouldn't that be truly environmental friendly? In this document, we propose an exactly environment friendly LRT (Light Rail Transit) system using renewable energy and we are going to verify feasibility.

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Generally, rail operation may cause many kinds of waste mainly disposed of by passenger rail service and by passenger terminals. The types and amount of waste depend totally on the number of passengers handled and the services provided (IFC, 2007). The solid waste generated from trains and passenger train terminals in Vietnam includes food waste, paper and newspaper, a variety of used plastic bags and plastic water bottles, beer cans, disposable food containers, in additional is a big volume of human waste from passengers on trains. The management of this waste source by the Vietnam Railway Cooperation is becoming extremely imperative at present time because the volume of waste is growing more and more.

II. SUMMARY OF THE SYSTEM

A. Method of supplying electric power

How can we supply electric power by renewable energy to the railcar? First of all, we can devise easily the railcar on which the solar cells are mounted on th roof, like a solar car. But there are two problems in this method. The railcar cannot run in cloudy or rainy days and during the night. In addition, it is hard to use wind turbine and water wheels in this method.

Next, the method of replacing thermal power plants and nuclear power plants with renewable energy power plants is devised. The electric power is supplied to the railcar from not the thermal power plants and nuclear power plants but the renewable energy power plants through the contact wire. However, the railcar cannot start in cloudy or rainy days even by this method. Moreover, the power transmission loss cannot be neglected. The transmission loss in Japan is about 5.6%. In 2008, while being sent from the power plants which exist in the distance, not less than 45 billion kWh electric power was lost.

We propose the rechargeable run system. Solar cells are installed on the roof of the station and around the station. Wind turbines and water wheels are built around the station. The charging devices are installed at the station and charging devices are always charged from these generator. There is the short contact wire for rapid charge at the station. The charging devices are also mounted on the railcar. When the railcar stops at the station, electricity is rapidly transmitted from the charging device of the station to the charging device of the railcar. The railcar charges the electric power only to reach the next station at each stop. By this method, the railcar can run on the day of cloudy weather and rain. Moreover, we do not need to worry about transmission loss. Fig. 1 shows the schematic diagram of this system.

TABLE 1: COMPOSITION OF ELECTRICITY GENERATION IN JAPAN (2007)

Nuclear	25.6%
Petroleum etc.	13.2%
LNG	27.4%

Coal	25.3%
Pumped-storage	1.0%
Hydropower	6.6%
New Energy etc	1.0%

B. Charging devices

Rechargeable batteries are famous charging device. However, we propose to use electric double layer capacitors (EDLCs) as charging device in this system. In this system, charging devices repeat charge and discharge. Advantages of EDLCs such as long life, high input-output power, low pollution, are suitable for our system. The amount of energy stored per unit weight is lower than that of batteries. But usually distances between stations of trams are shorter than that of railways. Therefore that cannot become a disadvantage in this system.

VERIFICATION

C. Amount of required electric power

According to research on battery-driven light rail vehicle (LRV) developed by the Railway Technical Research Institute in Japan, their LRV consumes the electricity of 8.9MJ (about 2.5kWh) per kilometers at the maximum air conditioning load (13) (14) . Table 2 shows the experimental result. Assuming that interval between the stations is 500m, a railcar requires 4.5MJ (about 1.3kWh) of electricity to reach the next station.

If a railcar arrives and departs every 10 minutes, a power generation capacity of 16kWh per hour is necessary for the station to transmit electricity to each railcar. When we assume that the first train of the day is 6:00 a.m. and the last train is 0:00 a.m., the electric power necessary for a day is 270kWh, for one year is 99000kWh.

D. Photovoltaic generation

In Japan, the amount of power generation of the solar cells per year can be calculated the rough estimate in rated power [kWh] 1100 [hours]. If all required electric powers of 99,000kWh are supplied by the solar cells, the solar cells which are rated at about 90kW are needed. When using the HIT solar cells (energy conversion efficiency: 19%), about 470 square meters is required.

Roofless platforms or small roof platforms for tram are usual in Japan. If the roof of 2m in width and 30m in length is installed at each station, and the whole surface is covered with HIT solar cells, about 13% of required electric power is obtained. An insufficient electric power is filled with the solar cells, wind turbines and water wheels which were installed near the station.

E. Wind power generation

Since they are installed around the station, the small-scale wind turbines are suitable for this system. Assuming the wind turbines like table 3, ten wind turbines of 10kW are necessary to generate 270kWh a day at the site of average wind speed 4m/s. “Kaze Nagasu Kujira”(Fig. 3) developed by Daiwa Energy Co., Ltd. was referred to for these.

III. SPECIFICATIONS

Since the vertical axis wind turbine is quieter than a horizontal axis wind turbine, the vertical axis wind turbine fits this system (1) . Fig. 5 shows a street light that combine the savonius wind turbine with the solar cells. The supplementary role is expected by installing these along the street. 3.4 Micro hydropower. The micro hydropower can be used if there are rivers or waterways near the station. A steadier power supply is expected compared with the photovoltaic generation and wind power generation.

$$P = 9{:}8QH[kW] \qquad (1)$$

The electric power obtained by hydropower can be calculated from eq. (1). The power generation capacity of 11kW is necessary to generate electricity 270kWh a day. When we assume efficiency to 0.72, and a fall is 5m, the flowing quantity of 0.32m 3/s is needed. Similarly, when a fall is 3m, the flowing quantity of 0.53m 3/s is needed.

IV. PROBLEM WITH SAFETY

Compared with a battery, the danger of EDLC of ignition or explosion is low. However, very low internal resistance causes rapid discharge when shorted. The container of EDLC which does not break even if a traffic accident occurs is required. Furthermore, it is effective to make it locomotive style. Safety improves by not installing EDLC on passenger cars.

V. ORGANIC WASTE FROM PASSENGER RAIL SERVICE

Vietnam railway currently has a total length of about 3000 km including 7 routes. The system is organized at two levels: the Thong Nhat route (from Hanoi to Ho Chi Minh City) and the regional level. According to the statistical report of the Vietnam Railways (2012), daily on the longest route Thong Nhat (of more than 1,700 kilometers long) in 2011 there were 18 - 33 Thong Nhat passenger trains and 10 regional trains in operation carrying approximately 13,700 passengers. The trip from Hanoi to Ho Chi Minh City is usually 29 to 44 hours. The rest 6 routes with the trips lasting from 4 to 8-hours carried about 16,200 passengers per day. One of the main reasons of a enormous amount of waste from passenger trains is that, there is a large number of 300 up to 700 of passengers on a train, the duration of journey is too long, as well as there is lack of understanding of environmental protection from the passengers, and in additional the eating habits of local people.

The organic wastes from passenger rail service on trains include:

- Disposable food containers: milk cartons, tea bags, coffee grounds, etc.
- Human waste: passenger’s urine and feces • Food waste from food establishments: vegetables, fruit peel, meat, poultry, seafood, rice, etc.
- Paper and newspaper: napkins, paper towels, paper plates, paper toilet, etc.

VI. PASSENGER’S HUMAN WASTE

One of considerable problems is that how human waste disposed of by passengers on trains will be treated. The research on the environmental management in rail (TRICC_JSC, 2009) showed that in average, a passenger excreted about 0.988 liters of urine and 0.232 kg of faeces per day.

In general, passenger's waste treated under sanitary technologies shows many limitations, it is carried out only on several new wagons with small scale.

During the past periods of time, all passengers' waste was untreated and disposed of directly from trains on railroad. At present, only 70 (make up about 6.77%) from total 1034 passenger wagons are equipped with smart septic tank Biofast of the company PETECH. Therefore, the The main environmental impacts are pollution to soil, current applied management method of 95.23% of human surface and underground water source. It was found that, waste is still disposal of from trains on the rail. It is also year-to-year the volume of organic and human wastes revealed that about untreated 1066 m 3 urine and 431 tons generated by passenger activities on trains is expanding faeces are daily disposed of in territories. This current considerably. Figure 2 shows the comparison of generated disposal method has led to numerous environmental and organic waste from Vietnam railway from 2009 to 2011 social problems. (Vietnam Railways, 2009, 2010, 2011).

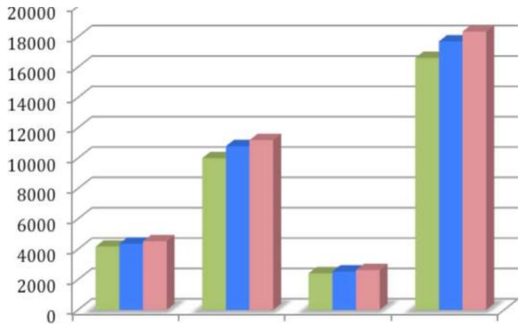

Figure 2. Comparison of organic wastes by year Organic waste from passenger terminals

There are in total 278 railway stations in Vietnam (The Vietnam Railways, 2012), all of them are provided passenger operations and service. The organic waste generated from passenger terminals consists:

- Waste generated from passengers waiting for the train;
- Waste generated from terminal's activities
- Waste taken from stationed trains.

At stations, food, paper and also other wastes, except human waste are disposed of in railroad, because all toilets have to be closed when trains stop in accordance with the Vietnam railway rules and regulations (see Figure 1). However, inside stations many waste containers are provided for waste collection without classification. At the large passenger stations as Hanoi and Saigon main stations there are station's groups of garbage collectors, who will remove waste containers and often classify recyclable and reproductive wastes, then sell them to recycling facilities. The rest wastes will be loaded up into waste vehicles of Public Urban Environment Companies and sent to landfill or treatment facilities once daily. Human waste inside stations is collected by pipes into sewerage system of urban for treatment or disposal of. The research on the environmental management in rail (TRICC_JSC, 2009) was summarized, that volume of generating living solid wastes at whole passenger stations in Vietnam is about 18.9 tons/day. Forecast to 2015 it will be 23 tons/day, among which about 8.5 tons to 13 tons are organic solid wastes. Therefore, the whole volume of organic wastes from passenger trains and terminals in Vietnam exceeds 30,000 tons per year.

Figure 1. Waste from train at Hanoi main station

VII. SOLUTION FOR ORGANIC WASTE MANAGEMENT

Facing the problem of municipal waste disposal in order to reduce environmental burden, there are different approaches to manage organic waste, including:

- Landfill;
- Incineration;
- Composting;
- Anaerobic digestion.

Landfill is not sustainable in Vietnam because it leads to rapid depletion of the limited landfill space and formation of green house gases such as methane, and wastewater at landfills, imposing severe burden on environment.

Aiming at sustainable development the organic waste as an alternative source of renewable energy has to be reused. Composting and anaerobic digestion are the most favored options that were commonly also successfully used in other developing countries as China, Nepal, India (Müller, 2007); and nowadays they are started being used in some urban and rural areas of Vietnam. Adopting the innovative biological technologies - composting and anaerobic digestion is a suggestion for the Vietnam Railways to assure cost-efficiency and sustainability in long-term management of organic waste from passenger operations and services. The technologies are used to convert the organic waste to useful compost products and produce biogas for energy recovery, concurrently reduce fossil CO2-emissions. Biogas is recovered and transformed into heat or any other form of energy. The remaining digested material is a nutrient rich fertilizer and can be used in agriculture. Today there is a large number of different types and designs of anaerobic digester technologies for the treatment of organic waste available, depending on feedstock material type, the composition of the substrate and the volume of the waste stream. It is recognized that decomposition of one metric ton of food can potentially release up to 500 m3 of methane (equivalent to 0.43 ton of petrol) (Holliger, 2008). So if the food waste from railway in Vietnam is converted into energy through anaerobic digestion technology, it will release approximately 2,262,500 m3 of methane (equivalent 1,945.25 ton of petrol) per year.

For example, the well-known and reliable DRANCO technology by Company OWS (DRANCO, 2012) can release 100 to 200 Nm³ of biogas per ton of waste and 220 to 440 kWh of electricity production per ton of waste. So over 30,000 ton of organic waste per year from the railway of Vietnam (see Table 1) can be turned to 3 million to 6 million Nm³of biogas and total power generation capacity will be 6.6 MWh to 13.2 MWh through the DRANCO process - that is the meaningful numbers for developing country as Vietnam.

Nowadays many composting plants for waste treatment have been constructed in some urban and rural areas of Vietnam. A successful biological treatment of organic waste from railways at these plants plays a significant role is source-separation of waste on trains and at passenger stations by the Vietnam Railways. In general, some solutions are suggested to management of waste from railway service:

- Developing regulations of collection, storage, transportation and processing of waste in railway of Vietnam.
- All wagons and passenger terminals should be supplied with waste containers to classify waste on trains.
- Encouragement of passenger train operators to segregate wastes in the trains by separating the collection of food, papers, plastic and metallic containers.
- Toilets of all wagons of trains should be installed with septic tank Biofast to collect the passenger's human wastes as shown in fig. 2

Fig2 : septic tank in Rajdhani express.

• All collected separated wastes from passenger trains and terminals will be loaded up into waste vehicles and sent to biological treatment facilities as shown in fig.3

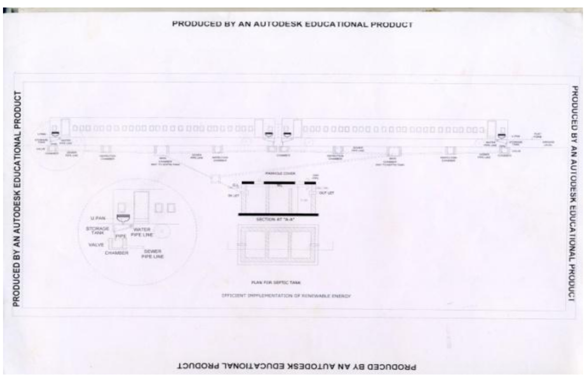

Fig3: Efficient implementation of renewable energy.

In summary, the current living organic waste management of the Vietnam Railways is unsatisfactory and needs to be addressed in a dire way. Investment for organic waste treatment by biological technologies has a central meaning and requires tasks of the Vietnam Railways nowadays for promotion of the urban agricultural activities on green space, protection of environment and for sustainable development.

VIII. CONCLUSION

Assuming that interval between stations is 500m; a railcar needs 1.3kWh of electricity to reach the next station. If we assume that railcars arrive and depart every 10 minutes and railcars are operated for 18 hours a day, the power generation capacity of 99,000kWh is necessary at each station in one year. If required electric power can be supplied, it is feasible in the calculation to run the light rail only by renewable energy. If we assume the voltage of EDLC to be 600V in this system, the required capacitance of EDLC is 25F. The stoppage time in the case of charging by 500A is 30 seconds, and in the case of charging by 1,000A is 15 seconds.

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