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E-Bus for Akita Prefecture, Japan

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Abstract

With the aim to improve technologies for EV or new energy industries and to create society with low environmental impact, Akita Prefecture has carried out the "EV Bus Technology Improvement Project". The project developed an Akita-original electric bus and it further aims to operate the E-Bus on regular bus routes throughout the year.

Keywords: BEV (battery electric vehicle), bus, demonstration, EV (electric vehicle), public transport

1 Introduction

Akita Prefecture built a conversion electric bus with the aims such as; to have technical strength improved by companies related to the Prefecture by having themselves challenge the EV technologies they face, and to build a business-to-business relationship of trust and a network of cooperation in order to implement a low carbon society. Industries related to E-Bus as well as other electric transportation vehicles are about to take off and are estimated to grow highly. Akita Prefecture is aiming at entering this business field to promote local industry and to secure employment of all regions as well as to contribute in the creation of society with less environmental impact.

Further, the Prefecture aims to implement a low carbon society in a collaboration with citizens by offering year-round operation of environmentally friendly E-Bus which may help to revitalize the downtown by recollecting shoppers once spread out into suburbs, and, to develop and activate local industries by promoting the E-Bus as vehicle to demonstrate its efforts in the development of new energy utilization or environmental initiatives.

1.1 E-Bus development consortium

In prior to the commencement of the E-Bus development, Akita Prefecture conducted a survey of companies related to the Prefecture that were considered to possess relevant applicable technologies and advertised for participation in the project. There were applications from 10 companies who agreed to establish a consortium namely the "Electric Bus Technology Improvement Consortium" and the consortium assigned a project to convert a bus into EV to a technical collaboration company, Tokyo R&D Co., Ltd. The maker of the base vehicle for modification, Isuzu Motors Limited, joined as another technical collaboration company to support the project. The completed E-Bus was utilized as an "Innovation hub" where products and prototypes of participating companies were installed and the E-Bus contributed greatly in studies of performance improvement and establishment of efficient operation system.

Equipment and devices installed are; solar panel mounted on the roof, heat shield film coated with transparent heat rays shielding coat, vehicle proximity alarm, LED interior lighting, and lightweight CFRP body panel, to name a few. Technologies of Akita Prefecture related companies are also used in operation of bus such

as; rapid battery charger, battery mounting/dismounting handcart, and self-power supplying bus stop, etc.

Figure1: Participants and their technologies implemented

Table 1: Participants in the consortium

Technologies	Participants in charge
Solar panel	Towada Solar Co., Ltd.
Heat rays shield film	Mitsubishi Material Electronic Chemicals Co., Ltd.
Bio-fuel heater	Akita Isuzu Motors Limited
Proximity alarm	Yamaguchi Electric Ind. Co., Ltd.
LED lightings	Nippo Electric Co., Ltd.
LED pictogram	Hokushin Electronics Co., Ltd
Quick charger	Shindengen Electric Mfg. Co., Ltd.
Self-power supplying smart bus stop	Aises Co., Ltd.
Battery mounting / dismounting handcart	Isuzu Mfg. Co., Ltd.
CFRP body panel	Tohsoh Corporation

1.2 Conversion specification concept

Majority of the cost of electric vehicles, not limited to conversion E-Bus, is taken up by battery. Heavy-weight, large-sized vehicles are usually filled up with batteries into every space available to secure enough battery capacity for longer duration. In case of the Akita E-Bus, bus routes are limited to circular within city centre and the operation is newly planned to adopt a rapid charging for every tour in order to minimize the volume of batteries installed with an aim to reduce the initial investment as well as the annual battery cost to be incurred in the replacement during a year-round operation. We made every effort to carry over parts/components of the original production diesel engine vehicle in order to reduce the number of bespoke EV parts aiming at cost reduction as well as reliability improvement. 6-speed diesel engine gearbox of the production bus is utilized as is, which is not only less expensive as compared to implementing a bespoke reduction gears, but also helps to provide torque enough to cover a range from the pickup on slope to mid-high speed driving even with relatively less powered motor. The companies in the consortium provided technologies such as heat shielding film for window glasses, LED interior lighting and solar panel generation to name a few, that helps to control power consumption as well as to improve overall efficiency.

2 Bus route and timetable

The E-Bus route is planned to start and end in front of the Akita station. It will be a circular route of approximately 4km that passes through sightseeing spots, hotels and commercial facilities in the city centre. Figure 2 shows an image of the circular route on map. This route will be accessible for tourists and business persons who visit Akita as well and it may create a good turnout in the city centre along with the redevelopment plan. The route has 13 bus stops and it will be driven through in approx. 20mins. The bus will stand at the terminal for a 10-minute interval hence the duration of a single operation is 30 minutes. We calculated the amount of battery capacity required for a daily operation. Amount of power consumed by use of air-conditioner is also calculated. Akita prefecture is located in the northern part of Japan with heavy snowfalls and its average temperature in winter season is around -1 degrees C. On the other hand, maximum temperature in summer exceeds 30 degrees C although for a short period of time, making air-conditioner indispensable. For cooling, the original air-conditioning system installed in the base vehicle is used as is by replacing the source of traction from the original engine to an electric motor, but for heating, replacing the heater unit to electric heater would require extra battery due to excessive heating load. We therefore implemented a combustion heater to save the winter power consumption. The

combustion heater uses bio fuel aiming at contributing to carbon-neutral. By calculating the summer power consumption by use of air-conditioner and the travels of E-Bus between bus terminal and depot, we decided to install 24kWh, general purpose Li-ion battery pack commercially available by EnerDel Inc. Here again, a commercially available, general purpose product helps to reduce cost. This battery capacity is equal to that installed in the Nissan "Leaf".

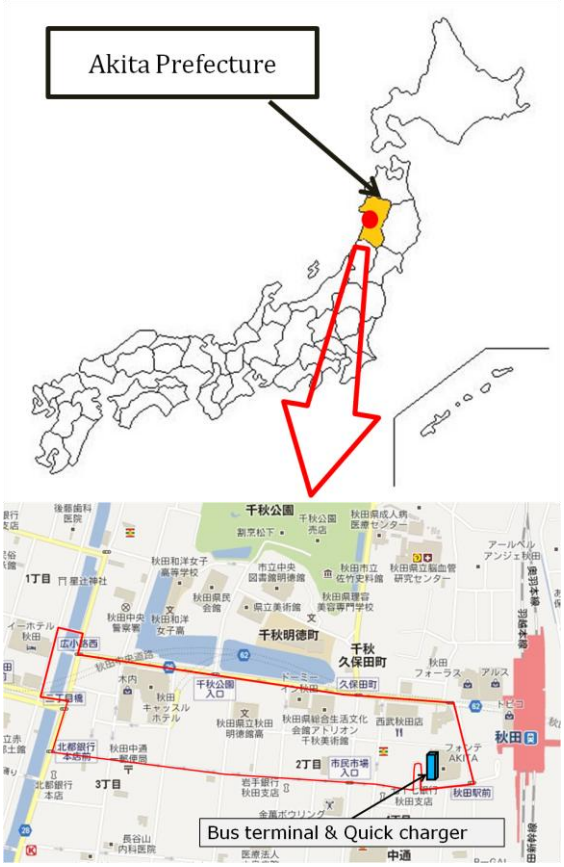

Figure2: Image of the bus route

3 Specification of the Akita E-Bus

We chose a flat-floor, mid-sized bus named "ERGAmio" by Isuzu Motors Limited as the base vehicle for the conversion. It originally carries 55 passengers, and by minimizing the battery capacity and by controlling the impact by modification we managed to install battery pack inside the engine compartment and use passenger seats and standing space without changes, thus maintaining the original passenger capacity. Table 2 shows the general specification of the E-Bus.

Table2: General specification

Base vehicle	Manufacturer	Isuzu Motors Limited
	Type / Name	PDG-LR234J2 ERGAmio
Dimensions (mm)		8,990(L)×2,300 (W) × 2,980 (H)
Number of passengers		55
GVW (kg)		11,235
Motor type		3-phase brushless PM
Maximum speed (km/h)		100 (calculated)
Duration (km)		33 (calculated, w/o air-conditioning)
Maximum power (kW)		150
Maximum torque (N･m)		650
Drive system		6 M/T rear wheel drive
Battery type / capacity		Lithium-ion/ 24kWh

4 Verification tests

Verification test program commenced in July 2012 aiming at kicking off the actual operation in August 2013. We logged driving data through road tests in short periods carried out every season. Traction battery gets heated by discharge generated by running load and it gets further heated by repetitive rapid charging hence cooling of the battery is inevitable. Battery cooling becomes essential during summer time. Figure 4 shows the battery capacity change and battery temperature rise according to the simulation of actual battery use. We evaluated the battery temperature rise under high load driving by repetitively driving uphills including those which were not planned in the bus routes. As a result of the verification tests, we confirmed the performance had no problem in the year-round operation. Performance of the combustion heater was confirmed in the winter season. General passengers are invited to test ride the E-Bus, and we are continuously logging data to prepare for the year-round actual operation.

Figure3: Verification test at Akita Station

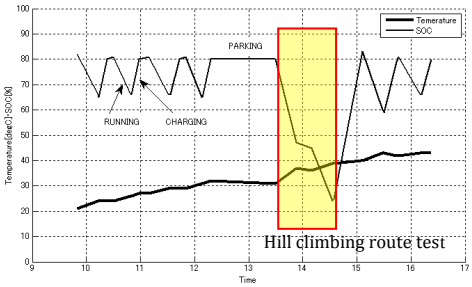

Figure4: Graph of capacity and temperature

Figure5: Verification test in winter

Figure6: Monitor passengers in full-capacity on a verification test drive

5 Conclusions

Through tests, we were able to verify that even the battery capacity of passenger EV provides enough practical performance for a route-bus by devising the operation. Through the next year-round operation, we will implement further improvements to make this E-Bus and the operation system a vehicle for regional revitalization as well as development of businesses in the consortium.

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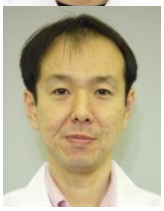

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