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Indonesian consortium of lithium ion battery for solar street lamp

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Abstract. Indonesia's renewable energy systems are reducing the world's dependence on fossil fuels by providing constant energy sources such as lithium ion battery (LIB) for application on solar street lamps. There are advantages of using LIB that will improve its performance and life cycle, and also reduce the maintenance cost. Due to these reasons, a National Consortium on Lithium Ion Battery for Solar Street Lamp was formed in 2016 and supported by the National Innovation System (INSINAS) from the Ministry Research Technology and Higher Education. The project was divided into four work breakdown structures (WBS), with various activities and targets. The goal of this consortium is to produce a lithium ion battery module with the specification 120 Watt hour, so as to run the 10 Watt street lamp. The module consists of 40 cylinder cells 18650. The first year's target is to produce cylinder cells 18650 with specific output of 3.2 Volt and 1 Ah. This paper will review the activities of the consortium, WBS, and the characteristic of the cylinder cells.

1. Introduction

With issues such as global warming and carbon emissions now, the demands for renewable energy technologies are continuing to grow. Solar, Hybrid, and Small Electric Vehicles such as Golf carts *etc.* require deep cycle batteries that are capable of supplying large amounts of power for both short and long periods of time [1]. Due to the future global prospect of increasing renewable energy, the research on lithium ion battery for application in solar cells of, for example, street lamps, must be considered [2]. Therefore, the government design a new strategic planning of lithium ion battery program under the National Innovation System (INSINAS). The national consortium on lithium ion battery for solar street lamp, consisting of several institutions, universities and industry, was formed in 2016. The program was run by the grant from the Ministry Research Technology and Higher Education. Its main idea is to gather the researchers who are working on battery research into one renewable energy program, with the main goal to provide a solution for energy storage based on lithium ion battery made by The Indonesian consortium. Furthermore, the goal is to build the National-Battery Research Institute (N-BRI), that can provide solutions for battery science and technology from research straight into application. The N-BRI will be started from the combination of industries, institutions and universities. Our starting point is the consortium that has been running well from 2016 to 2018, which consists already of several institutions, universities and industries [2].

In order to achieve this goal, based on various background, capacity and capabilities, the program is divided into four work break down structures (WBS), with one coordinator for every WBS (Figure1), furthermore we set the target for each WBS. The road map of Consortium is also the most important so as to determine the goal every year. This consortium is a good example of joint collaborations between multiple parties. Though its activities have been around for several years, there is no article that review about the consortium itself and their agenda. Therefore, the aim of this paper is to review the research activities of consortium, work break down structure (WBS), the road map and progress that has been achieved in the past year.

2. Methodology

As shown in diagram of WBS in Figure 1, there are several activities performed and linkage to produce the battery module. At first the WBS1 produced battery components such as the cathode $LiFePO_4$ and the anode graphite (C). The fabrication was located at the Laboratory of UNS, Solo, as described [3]. In WBS2, these componnents were assembled into cylinder cell 18650 at the Integrated Battery Laboratory, BATAN [4]. The WBS3 performed testing and standardization of cells using charge discharge instruments at BATAN. The cell grading and assembly for module was done by WBS4 at ASTRA and B4T, respectively. In addition, WBS0 is designed to work, with a separate program, to produce the raw materials for the battery components.

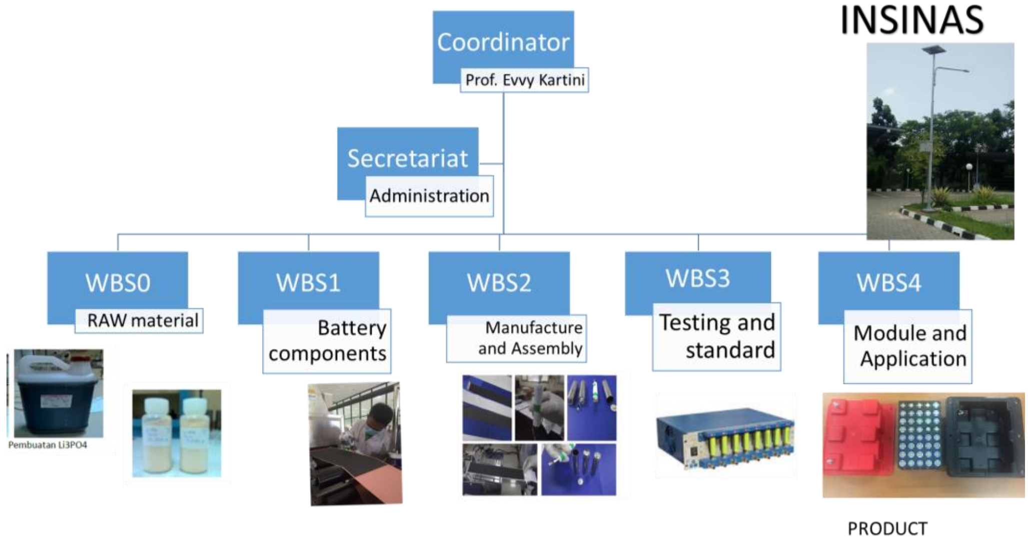

Figure 1. Diagram of the Work Break Down Structure (WBS).

The road map of the consortium is shown in Figure 2. In 2016 the target is to produce battery components, including cathode and anode materials, based on local resources. The next target is to produce the cylinder cell 18650 with the specification of 1 Ah and 3.2Volt. In 2017, a battery module will be designed to provide 40 cells with the specification 120 Watt hours.

3. Results and discussion

As shown in Figure 1, the target of every WBS is different, depending on the various activities and targets. The WBS1 has activities consisting of mainly research and development of battery components. The WBS2 has a target to assembled the battery components into cylindrical cells 18650. The WBS3 has the duty to perform battery testing and standardization of the lithium ion battery (LIB) cells. The design of battery module and application in a solar street lamp will be performed by WBS4. The activities were performed conjointly among the scientists from various universities, institutions and industry, such as Institut Teknologi Sepuluh November (ITS), Surabaya; Bandung Institute of Technology (ITB), Bandung; Universitas Sebelas Maret (UNS), Solo; University of Indonesia (UI), Jakarta; Politeknik Negeri Jakarta (PNJ), Jakarta; National Nuclear Energy Agency (BATAN); Agency for Assessment and Application Technology (BPPT); National Standardization Agency (BSN); B4T, Ministry of Industry; Indonesian Institute of Science (LIPI) and industry EDC-ASTRA. As shown in Figure 3, all the laboratories have different job descriptions, depending on the availability of laboratory and the main focus of the research.

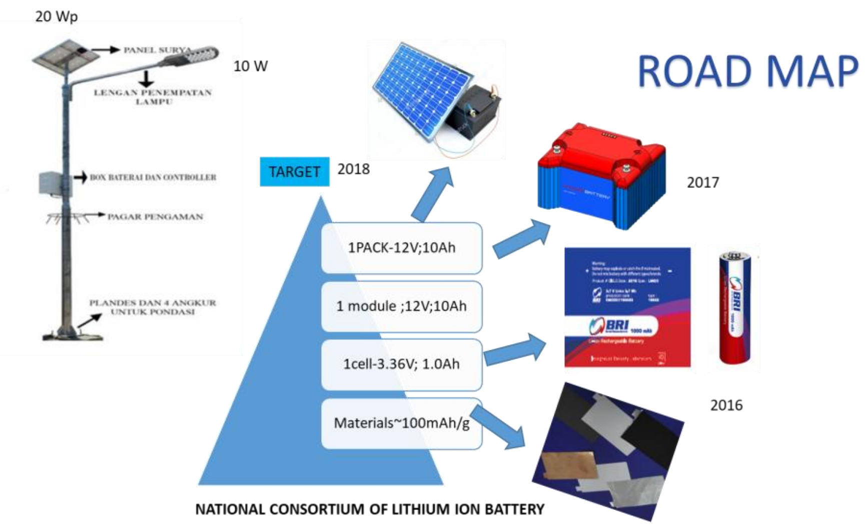

Figure 2. Road map of the national consortium of lithium ion battery.

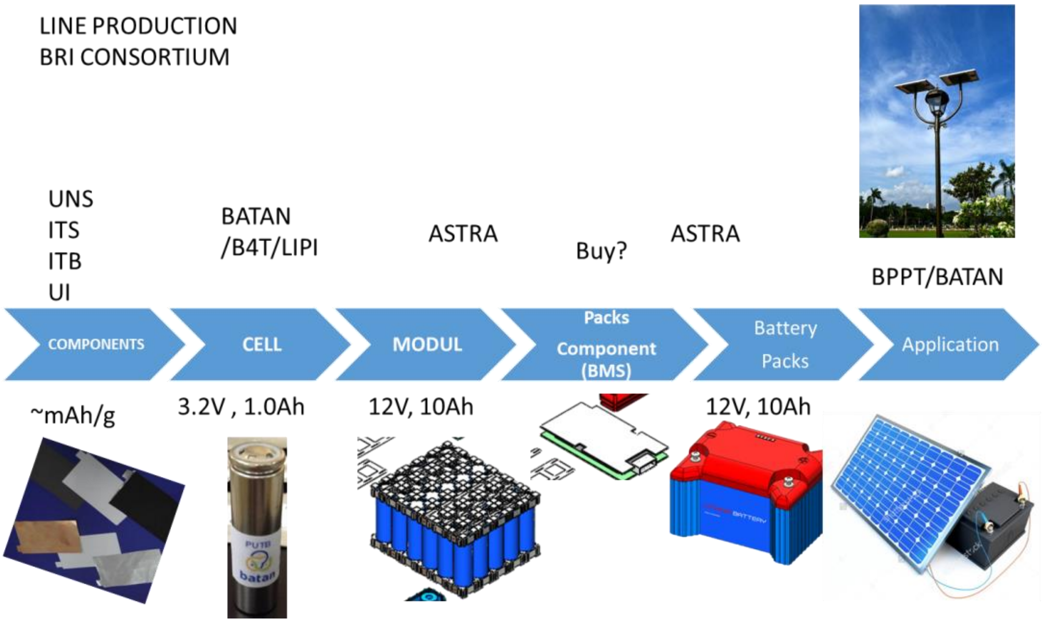

Figure 3. The line production of consortium activities.

In the first year, the consortium has decided to apply $LiFePO_4$ and Graphite as the cathode and anode materials respectively for the battery cell [5, 6, 7]. The choice of these electrodes is due to increased stability during charge and discharge, simplicity in preparation and their environmentally friendliness [4, 5, 8]. The battery components such as cathode and anode sheets were prepared at the Battery Laboratory, UNS. The battery assembly into cylinder cell 18650 was done at the Integrated Battery laboratory, National Nuclear Energy Agency (BATAN), Indonesia. Prior to the fabrication, the cathode and anode materials were characterized and compared with the commercial components. The cylinder 18650 testing was performed at BATAN by using charge-discharge analyzer.

The cathode $LiFePO_4$ and anode graphite sheets were cut using a slitting machine with the width of 65 mm and 58 mm respectively. The lengths of the cathode and the anode were optimized to achieve higher capacity, then the sheets were assembled into cylindrical cell 18650, named there after as empty cell length was 650 mm, and the diameter was 18 mm. The polymer cellgard and $LiPf_6$ were used as separator and liquid electrolyte, respectively. The assembly was done in a glove box with flowing argon containing 0.01 ppm O_2. The use of the glove box is a requirement to avoid the absortion of moisture that can destroy the cell. The testing of the cylinder cell was performed to determine initialization, charge-discharge and cycling performance. Some of prototypes cylinder cell 18650 is shown in Figure 4.

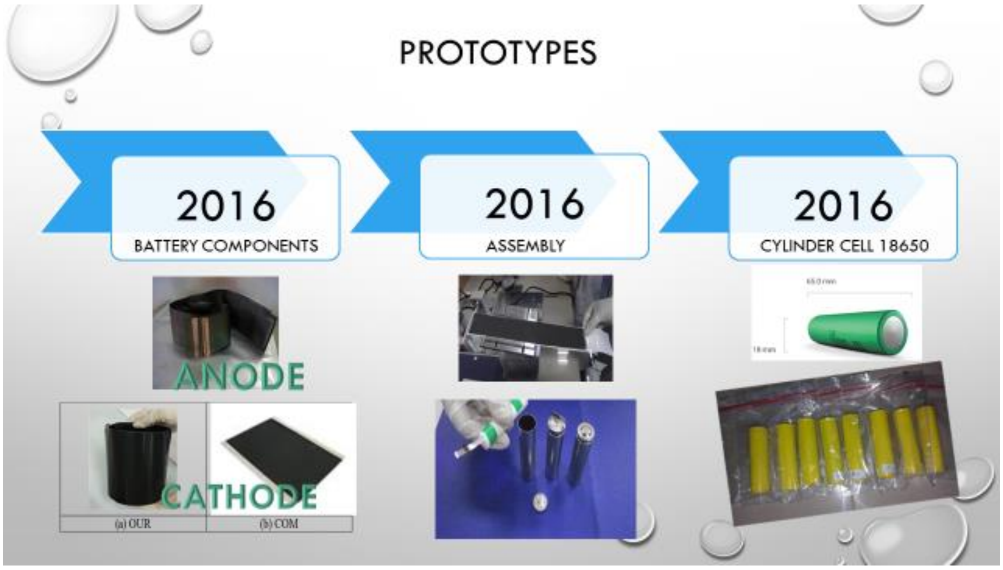

Figure 4. Prototypes of cathode, anode, and cell 18650.

The targets of consortium in the first year (2016) are to produce good quality battery components and to produce the cylinder cell 18650 that delivers the capacity as designed. Furthermore, to produce several cylinders repeatedly and reproduceably, in order to obtain similar output of cylinder cells. Figure 4 shows the battery components of $LiFePO_4$ cathode and graphite anode that were ready for fabrication into cylinder cells. The products of cylinder cell 18650 are also shown in the Figure 4.

4. Battery testing

Figure 5 shows the initial charging for the first 5 cylces of the cylinder cell 18650 produced by the consortium. As shown in Figure 5, the input charge and discharge current was 250 mAh, with higher and lower limit voltages at 3.7 Volt and 2.5 Volt respectively. The output voltage for the cell is 3.2 Volt, in agreement with the $LiFePO_4$/C battery. The discharge capacity and efficiency (%) curves are shown in Figure 6. The capacity during the first cycle is still 1.3 Ah, but is increased to 1.5 Ah for the second cycle up to 5th cycle. The continuing cycles are now in progress, until 200 cycles to observe the cycle ability and stability of the battery. The output of the cell, has met not only requirement as designed at the begininng, which was 1 Ah, but also shows better capacity. The reproduceability was shown by production of another 100 cells, with the same condition of preparation and testing.

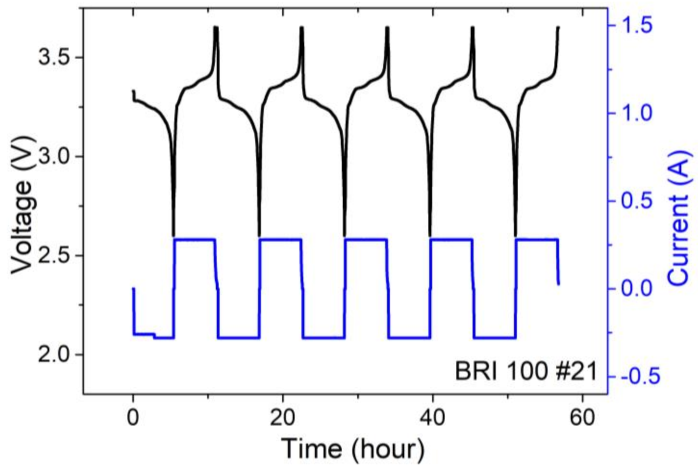

Figure 5. Battery testing of cylinder cell 18650.

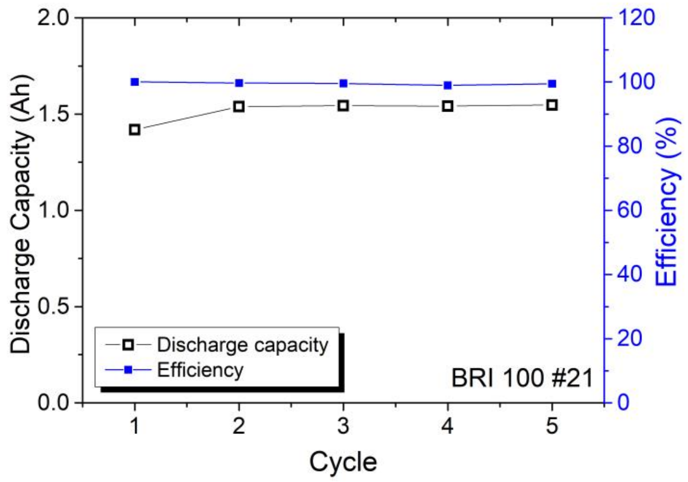

Figure 6. Discharge capacity and efficiency of cylinder cell 18650.

In addition, WBS1's researches are to develop new materials for battery components such as: Preparation of lithium iron phosphate $LiFePO_4$ added polypyrrole PPy as cathode materials for li-ion battery [9]; The improving conductivity of $LiFePO_4$ by optimizing the calendaring process [10]; Synthesis of $Li_4Ti_5O_{12}$-Sn by ultrasonic method as anode materials for lithium ion battery [11]; Effects of annealing temperature on the electrochemical characteristics of ZnO microrods as anode materials of lithium ion battery using chemical bath deposition [12]; Comparative study on the ionic conductivities and redox properties of $LiPF_6$ and LiTFSI electrolytes and the characteristics of their rechargeable lithium ion [13]; The effect of acetonitrile as an additive on the Ionic conductivity of imidazolium-based ionic liquid as the electrolyte for li-ion battery [14]; and Development of battery performance data acquisiton system for monitoring battery performance inside solar cell system [15].

5. Conclusion

The consortium has been performed well for the last two years. It can be shown from the results achieved, which coincide with the target at the beginning. Several international publications related to the battery components produced have been published. The prototypes of cylinder cell 18650 have shown a good performance and can be further applied for the battery module. The cooperation among institutions plays an important role in this consortium.

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