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REPIC Project

Market launch of Lithium batteries for electric vehicles in Nepal

Technical matters that must be observed

Final workshop

Markus Eisenring, Switzerland

This presentation **addresses the persons involved in installation, putting into operation and usage of the Lithium Battery system** and points out some issues that are important.

The following is based on **experience we encountered during the execution of the project.**

January 3, 2019

Content of the presentation

- Before Installation
- Installation
- Putting into service
- Daily use of lithium batteries
- Maintenance of the Lithium battery system



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– **Before Installation**

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Before the installation

> Battery quality

- Make sure that you only **buy best quality of batteries**. There are **up to three different qualities**. For the Chinese market not always the best quality is sold
- Make sure that you get an **ex-factory test report form the battery manufacturer**
- When you buy best quality of batteries early failures happen less



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Before the installation

> Preparations

Many things can be prepared and done before the batteries arrive in Kathmandu:

- **Battery rack**, including base frame
- **Box for BMS controller**
- Update of BMS controller
- **Settings of the BMS controller**
- Polycarbonate support for balance booster
- Pins on cell board and balance booster
- **Programming of the BMV**
- **Check the battery cells after arrival**
 - . physical inspection for damages, whether any cell is swollen
 - . voltage of each cell



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Installation



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For the installation of the batteries, the BMS and other equipment a **well-equipped workshop, tools, machines and trained workers, as well as helper are required.**



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Installation

> Handle with care

- Make sure that individual devices don't become defective due to errors in operation, wrong connection of main power wires and during installation and maintenance.
- **The people involve must be instructed how to do the work correctly and that extreme caution is required when handling this system.**

Installation

> Battery box

- The battery boxes are made here in Nepal.
- They are mounted on rubber and inside the battery box the battery cells are protected to all sides with foam.
- This is to deduce the shock to the battery cells when driving and thus to prolong the lifetime of the battery cells.



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Installation

> Connecting the battery cells together

- Use electrically conducting pole grease to connect the cells with the connectors and to fix the main current wires. This is to ensure to have less contact resistance. High contact resistance makes that the voltage decreased more with high current.
- **Make sure that the not only the bolts are tight, but also that the connector below the bolt is tight** (make sure that the bolts are not too long).
- You also may have to use new lock washers after the bolts of the poles were opened several times.

Installation

> Cell numbering

- The installation of the banks and the cell numbering must be done in the correct order.
- When it is not clear which bank and which cell it is a single cell can be heated with a hot air blower.
- Then one can see in the GUI which bank or cell gets warm and order can be adjusted.



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Installation

> Safety of wiring

- Safety in the main wiring is an important issue.
- This is why a main **wire interrupter** and in **each battery bank a fuse must be installed.**



Technical matters that must be observed
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Installation

> Balance booster

- **The Battery management system is balancing the voltage of the individual cells.**
- The cell board themselves can balance the cells with a currents of 0.2 A. Since this current is not sufficient, we are using a balance booster.
- The balance booster can balance the cell voltage with 2 A. This results in a total balancing current of 2.2 A.
- Since the balance boosters can get hot, they must be built in with a distance holder to the balance booster support.

Installation

> CAN wires

- Make sure that the wires for the CAN bus communication are connected on the right pin.



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- Before Installation
- Installation
- **Putting into service**
- Daily use of lithium batteries
- Maintenance of the Lithium battery system

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Putting into service

> Introduction

- **Check that all the connectors of the cells are tight.** Note that they may be loose when the bolts are too long
- Check that all wires are connected properly
- **Check in the GUI that the two banks and all the cells are present**

Putting into service

> Settings in BMV



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The vehicles are equipped with battery monitoring instrument called BMV.

It can read many parameters, such as V, A, Ah and other.

Before running the vehicle, the correct settings must be made in the BMV.

Putting into service

> Introduction

To put a vehicle into service, various things have to be done:

- BMS software upgrade
- **The configuration must be loaded to the BMS**
- GUI update
- Check the direction of the current for charging and for discharging



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Putting into service

> Introduction

- **Make test drives:** Drive up a steep slope with the fully loaded vehicle, check the maximum current.
- Check whether maximum speed is all right.
- **Capture data on a whole charging cycle and analyse the data.**
- Note down the kWh used for charging for each day for about 10 days.
- **Capture data on the two to three last loops before charging and analyse the data.**
- Note down the Ah used for each loop for 2 to 3 days.

Putting into service
> Current calibration



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The current sensor must be calibrated, read the value in the GUI, adjust the Offset and the Gain



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Putting into service

> Battery protection wiring DCL (Discharge Current Limit)

Adjust the reduction of vehicle speed:

- Jack up the vehicle on one side.
- In the BMS GUI Menu Test/Analog output/DCL → Set 0% (output 5V)/override.
→ Output voltage goes to 5V
- Full throttle, turn potentiometer to the right until minimum speed, very slow rotation, is set. Sometimes it must be turned fully to the right.
- Restore automatic control (if the vehicle does not react, swap the lower two Control plugs on the Curtis Controller).
- The circuit for influencing the power was developed by Thomas and is made here in Nepal.



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- Before Installation
- Installation
- Putting into service
- **Daily use of lithium batteries**
- Maintenance of the Lithium battery system

Technical matters that must be observed
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Daily use of Lithium batteries

> Speed reduction and safety switch off of the drive system (DCL)

- The BMS has an output signal, called DCL (Discharge Current Limit). The DCL is connected to the potbox.
- The DCL is activated when any parameter of the BMS is below a **low** value. When it is activated the vehicles speed is reduced.
- When any parameter reaches a **minimum** value the vehicle stops.
- The concerned parameters are the following:
 - The voltage of the most discharged cells
 - The pack voltage
 - The temperature of the coldest and hottest cells



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Daily use of Lithium batteries

> Speed reduction and safety switch off of the drive system (DCL)

Very important!

- **Never drive without connection of the battery protection wiring signal to the potbox**
- **In some vehicles with a BLDC drive system this has been done → connect it again immediately**
- **This must be done so to protect the batteries and thus assuring a long lifetime of the batteries**
- **If you run the Safa Tempo without the battery protection wiring disconnected, you risk that the lifetime of the batteries is reduced or that the batteries are damaged!!!!**

Daily use of Lithium batteries

> Number of loops

By the time, the number of loops may be reduced. There are several reason why this may happen.
In most of the cases it does not mean that the capacity of the batteries is reduced.

Possible reason why this may happen is:



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Daily use of Lithium batteries

> Number of loops



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Loose connectors

→ tighten the connector

Cells not balanced well

→ keep the charger on for at least 36 hours
to allow the cells to be balanced

More traffic jam

→ cannot be influenced a lot

Worse road conditions

→ cannot be influenced a lot

Lower outside temperatures

→ will be better again when temperature rises

Low air pressure in the tires

→ inflate the tires



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Daily use of Lithium batteries

> Number of loops

Drive system, motor or
motor controller getting worse

→ replace the DC drive system with an AC drive
system, replace the axle

Number of passenger

→ reduce number of passenger

Rough way of driving

→ instruct driver how to drive smoothly,
Look ahead when driving

Driver telling wrong number of loops

→ check number of loops with a GPS

Daily use of Lithium batteries

> Defective micro switch

- Sometimes the vehicle stop due to a defective micro switch.
- Make sure that you only use good quality pot box and micro switch.



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Daily use of Lithium batteries

> Electromagnetic noise

- The data in the BMS are influenced by electromagnetic noise, which come from the motor controller or from the motor.
- The wrong data may reduce the DCL and because of this power of the vehicle may be reduced or Safa Tempo may even stop.
- Many measures have been taken to reduce this stopping problem -> It could not yet be eliminated.
- We the new AC drive system this problem should no more be present.

Daily use of Lithium batteries

> Current calibration

- When data acquisition is made the current is also recorded.
- Sometimes it is giving wrong values or it never goes down to 0 A.
- In this case the current sensor must be calibrated.



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Daily use of Lithium batteries

> Decreasing Ah

- Over the time the capacity (Ah) of the batteries may decrease.
- Use only 80 % of the available capacity.
- At the beginning when the capacity is 100%, out of 300 Ah → 240 Ah are usable

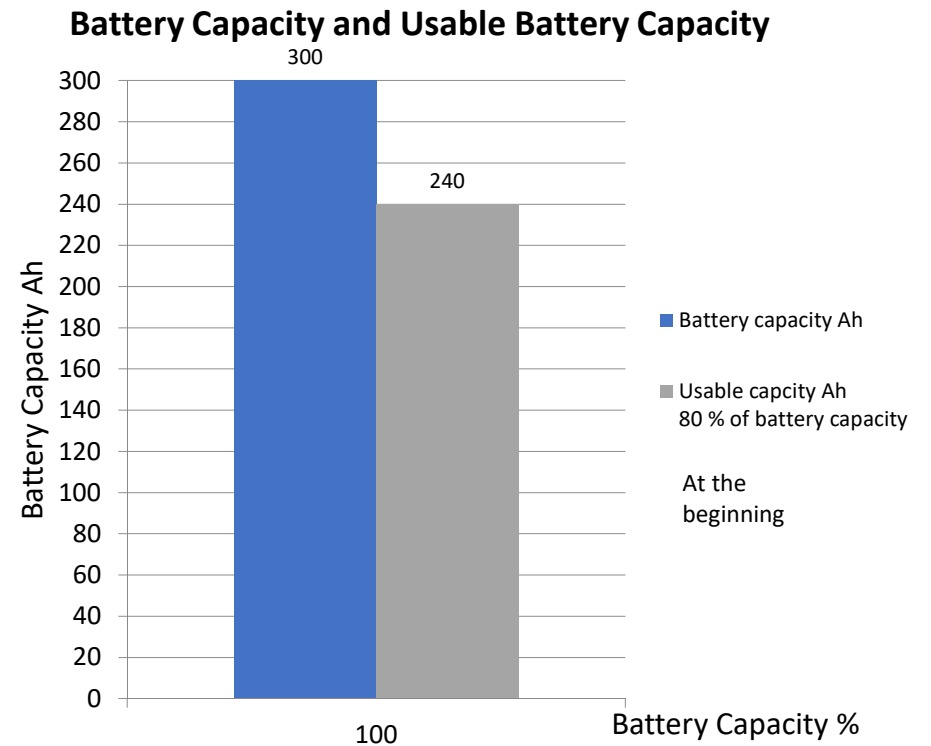
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Daily use of Lithium batteries

> Decreasing Ah

- Over the time the capacity (Ah) of the batteries may decrease.
- Use only 80 % of the available capacity.
- After some years the capacity may only be 90%, out of 270 Ah → 216 Ah are usable

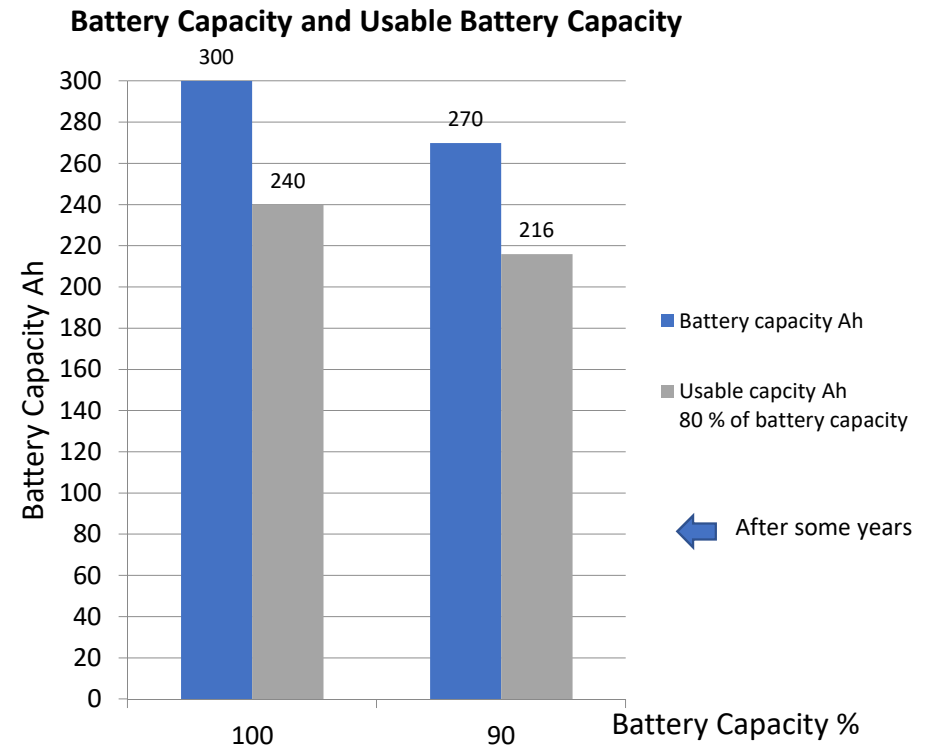
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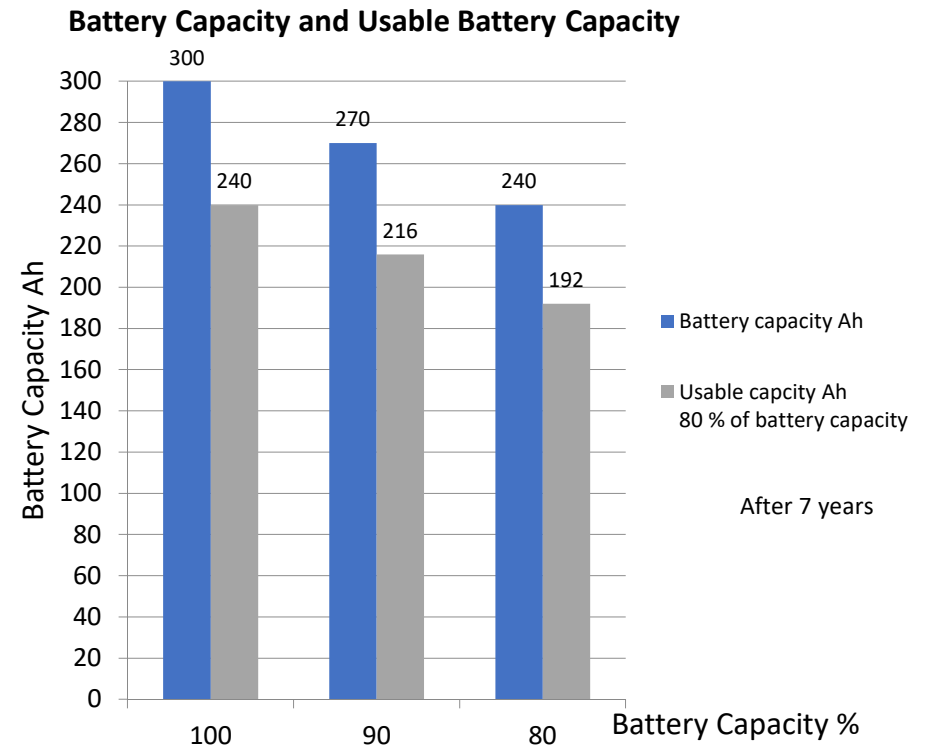




Daily use of Lithium batteries

> Decreasing Ah

- Over the time the capacity (Ah) of the batteries may decrease.
- Use only 80 % of the available capacity.
- After 7 years the capacity may only be 80%, out of 240 Ah → 192 Ah are usable





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- Before Installation
- Installation
- Putting into service
- Daily use of lithium batteries
- **Maintenance of the Lithium battery system**

Maintenance of the Lithium battery system

Regular maintenance must be done to get a long lifetime of the batteries.



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Maintenance of the Lithium battery system

> Service centre

- To do regular maintenance a well-equipped service centre is required.
- More people need to be trained to do the technical maintenance



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Maintenance of the Lithium battery system

> 2-monthly maintenance work (1)

- Check all connections, cables, insulation.
- Check for loose contacts.
- Connect laptop, check with GUI if something extraordinary needs to be done.
- In the GUI check whether the settings are still ok, since we had cases where it changed by itself.
- In the GUI check whether both banks and all cells are present.
- Capture data for a short charging phase.
- Capture data for a short driving cycle.



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Maintenance of the Lithium battery system

> 2-monthly maintenance work (2)

- In the files with the captured data check whether something extraordinary is found, e.g. one day we found out that 2 cells have slightly lower voltage values, which could indicate that the screws have to be tightened at the poles
- When the individual cell voltage is much different charge the battery pack continuously for at least one and a half days, to allow the battery cells to be balanced
- Optical inspection of the batteries, tightening the screws at the cells
- Make sure that no short circuits happen
- Train more persons to do the regular maintenance
- Others



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Maintenance of the Lithium battery system

> Collection of operational data

- Not only collect data before and after charging, but also data such as:
 - Energy consumption per loop (Ah)/ per day (kWh)
 - Cost of energy / day / month
 - Km covered
 - Maintenance costs, watering, manpower for changing of batteries etc.

- If there are any unusual changes in the data, this may be an indication that something is wrong.

Maintenance of the Lithium battery system

> Single cell having lower voltage

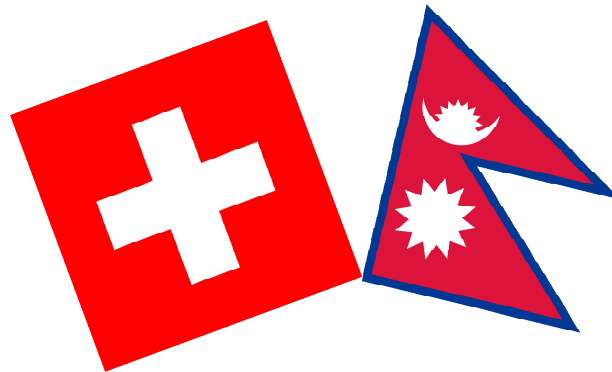
- Check whether booster or balance booster are all right.
- Check all connections.
- Apply single cell charging.



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Thank you for your attention



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