Rapid Electric Vehicle Charging

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The Electric Vehicle (EV) Industry

The growth of EV industry must be supplemented with appropriate means or technology of replenishing the energy spent from the batteries which keep the EVs in operation.

Slow Charge, Swap or Fast Charge?

The three common methods of replenishing the energy source of EVs are:

1) Slow Charging
   - takes 6 to 8 hours
   - use of charger on-board the vehicle
2) Battery Swapping
   - usually done in a station which replaces discharged batteries with a fully charged back-up.

Slow Charge, Swap or Fast Charge?

3) Fast Charging (Rapid Charging)

- Use of a fast charging station capable of as quick as 30 minutes charging time.

Slow Charge, Swap or Fast Charge?

The choice of appropriate method to use depends on several factors:

1) Location
2) Population Density
3) Safety
4) Convenience
5) Operation, Maintenance and the corresponding cost

Slow Charge, Swap or Fast Charge?

Example Scenario 1:

Provincial or Rural Setting

- Relatively smaller population density
- Relatively less activity during the evening

Slow Charge, Swap or Fast Charge?

Example Scenario 1:

Provincial or Rural Setting

- Slow charging is most likely the best option
  - less costly
  - scenario allows charging at longer period of time
  - scenario also allows the possibility of arranged/scheduled transport

Slow Charge, Swap or Fast Charge?

Example Scenario 2:

Urban Setting

- Higher Population Density
- Busier lifestyle

Slow Charge, Swap or Fast Charge?

Example Scenario 2:

Urban Setting

- Scenario will translate to:
  - increased transport operation day & night
  - more revenues
  - faster charge depletion in attempt to provide continuous operation

Slow Charge, Swap or Fast Charge?

Example Scenario 2: Urban Setting

- Two options that are possible are:
  - Battery Swapping
  - Fast Charging

- Slow charging become less viable
  - longer charging time
  - Safety issues (chargers can't just be connected at any available AC lines)

Battery Swapping vs. Fast Charging

CONVENIENCE

Battery Swapping

- Additional manpower or equipment needed to carry out swapping. Needs to lift heavy battery for replacement. Needs to disconnect and reconnect cables every time replacement is made.

Fast Charging

- Works similarly like a gas refueling station. Fuel is now electricity and nozzle is replaced by a charge plug connector.

"BETTER"

Battery Swapping vs. Fast Charging

COST COMPARISON

Battery Swapping

- Generally higher capital cost
- Higher O&M cost because of additional personnel and battery maintenance

Fast Charging

- Lower maintenance cost for charging station components
- Charging can be performed solely by the user hence no need for additional personnel

"BETTER"

Battery Swapping vs. Fast Charging

DEPENDENCE ON BATTERY QUALITY

Battery Swapping

- Time and availability of many back-up batteries to recharge allows for slow charging in case batteries cannot accommodate higher charging rate.

"BETTER"

Fast Charging

- One limiting factor is the battery technology. Generally, faster charging rate causes accelerated degradation.

Why Rapid Charging?

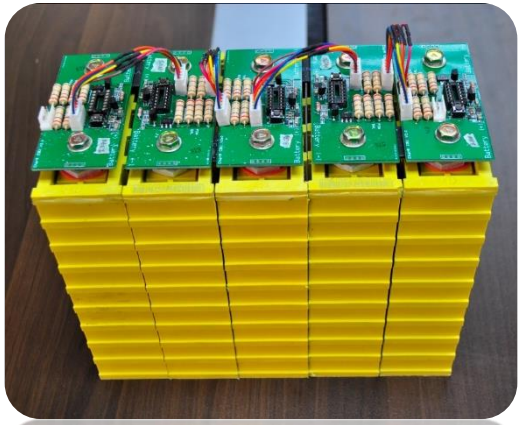
1. Time saving.
2. No major behavioral adaptation on end-users of automobiles during re-*fueling* (re-charging).
3. Advancement in battery technology combined with proper charging algorithm and protection even at higher charging rates can prolong the battery life
4. Can reduce operating cost in relation to extra equipment (battery swapping) and operation time (reduced productivity).

Project Components

Rapid Charging Project
CharM – Charging in Minutes

Li-Ion Battery Research

Battery Management System



Rapid Charging System

Project Methodology

Phase A

Lithium-ion battery laboratory testing and characterization.

Phase B

Development of rapid charging protocol and battery management system.

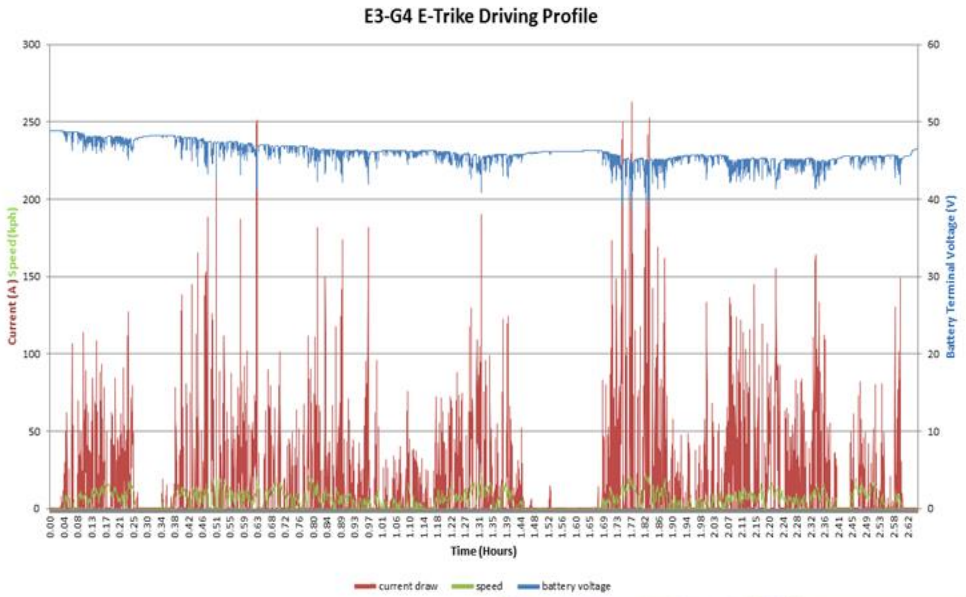
Phase C

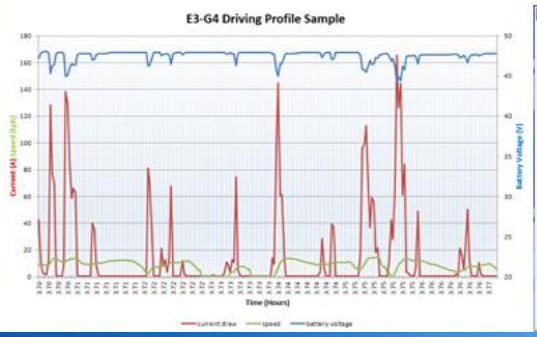
Development of rapid charging system and infrastructure.

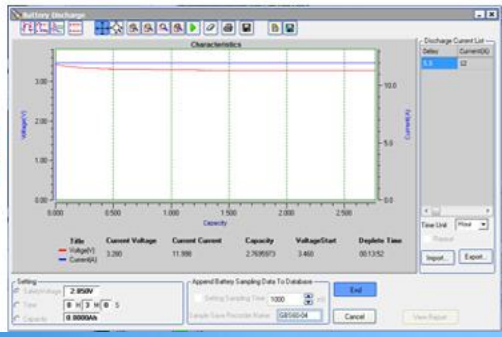
Phase D

Pilot testing / deployment.

Phase A: Battery Characterization



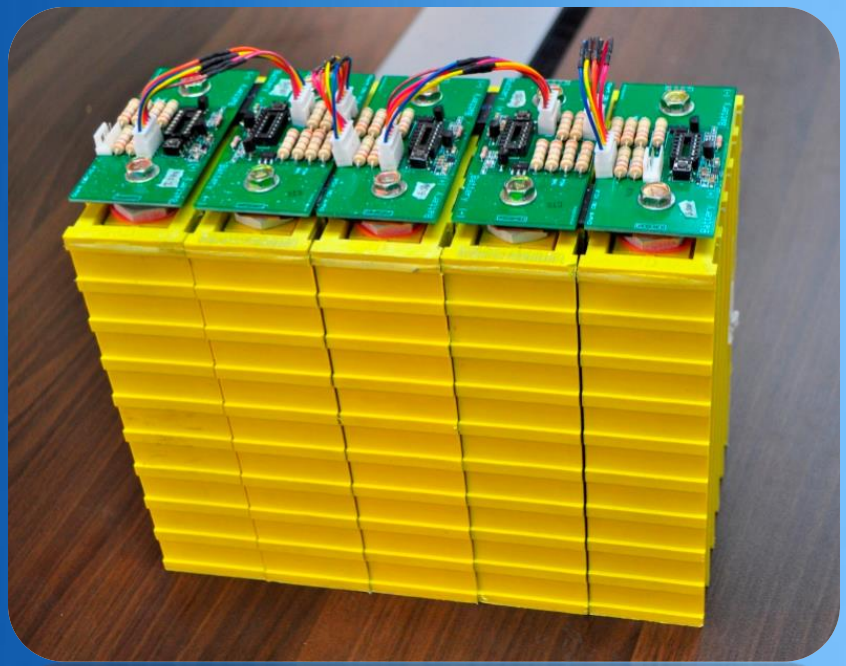




Characterization of drive cycle of eTrike for laboratory loading simulation.

Phase B: Development of Charging Protocol and BMS

- CC-CV and Pulse Charging Protocol evaluation for rapid charging.
- Cell balancing circuits for charge equalization for serial battery configuration.
- Vehicle Management System incorporating the Battery Management System for battery bank protection and vehicle-charger communication.



Li-ion battery cells fitted with cell-balancing units (CBU)

Phase C: Development of Rapid Charging System

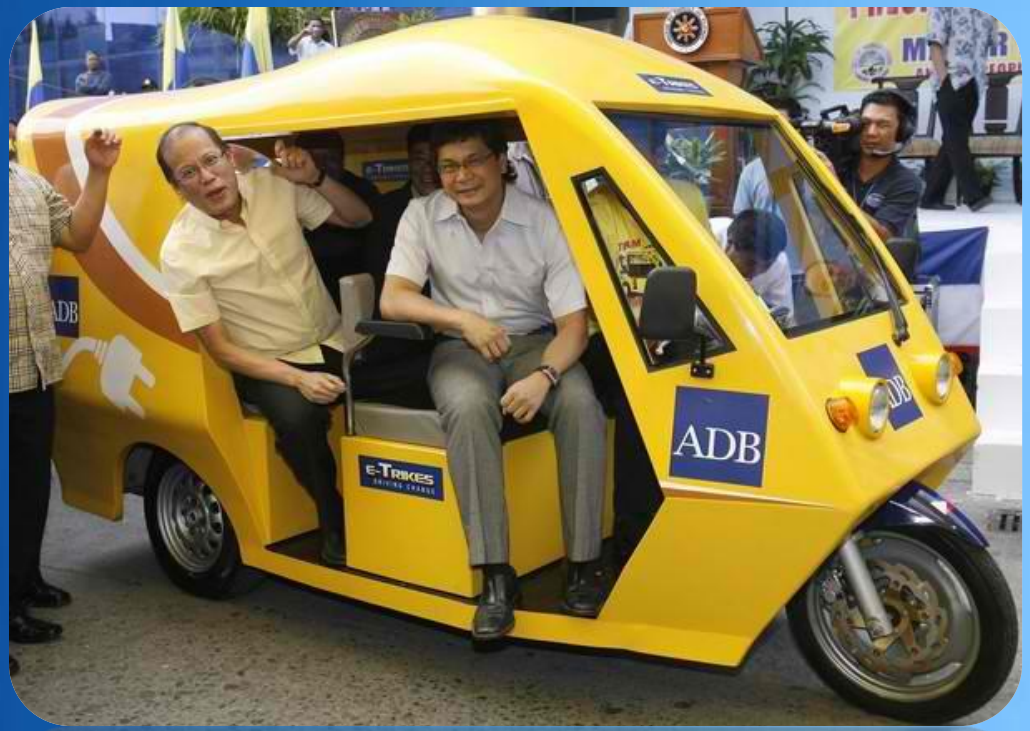
- Charger-Vehicle Smart Link
- 0 – 100 Vdc Automatic Regulation
- 32kW Rated Power

- Cashless transaction via tap card Payment
- Touchscreen interface

- CHAdeMO compliant charge couplers
- CHAdeMO compliant charging and safety protocols

Phase D: Pilot Testing

- Donated by Aquino Govt. with the aid of ADB.
- 20 initial E-trike units.
- 50PhP worth of charge to run for 10 hours compared to almost 200PhP/day worth of gasoline.
- Runs on 50Ah and 100Ah Li-ion batteries.



Mandaluyong City E-Trike

Future Research Activities

Future research activities would include:

1) Cost reduction and optimization of the fast charging station by catering to a specific type of EV having a certain range of power.
2) Identification of strategic locations, site planning, technical and economic feasibility studies for putting up a charging station network.
3) Possible roll out of optimized fast charging stations and performance evaluation.

Looking at the Bigger Picture

The development of fast charging stations will:

- promote the growth of EVs by increasing its reliability for continuous operation
- encourage the development of batteries with more superior technology to accommodate fast charging
- promote the growth of power generation industry due to increase in electricity demands

Rapid Electric Vehicle Charging for Green Development

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