eQUAD Battery Sizing and Selection Considerations

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Outline

- Vehicle Design Project
- Key Considerations
- Battery Sizing Methodology and considerations
- Fast or Slow Charging?
- Cooling System
- Smart Features
- Some Key Points

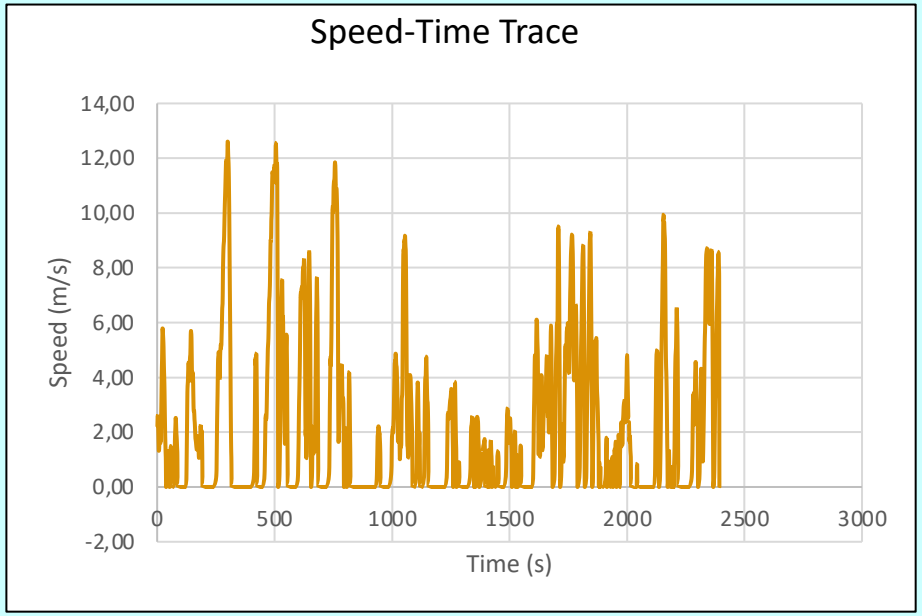
*Contact Rupprecht Consult if support with uploading media is needed

The Vehicle Design Project

Urban Living eMobility Lab

10 Living Labs: Kathmandu, **Manila/Pasig**, Hanoi, Montevideo, Quito, Kigali, Dar es Salam, Hamburg, Madrid and Nanjing (self-funded)

- **Vehicle Weight = 250 kg.**
- **Passenger/Cargo Payload = 300 kg**
- **Driver Weight = 50 kg**
- **Daily Range = 60 km**
- **Ambient Temp. = 25 – 40 C**

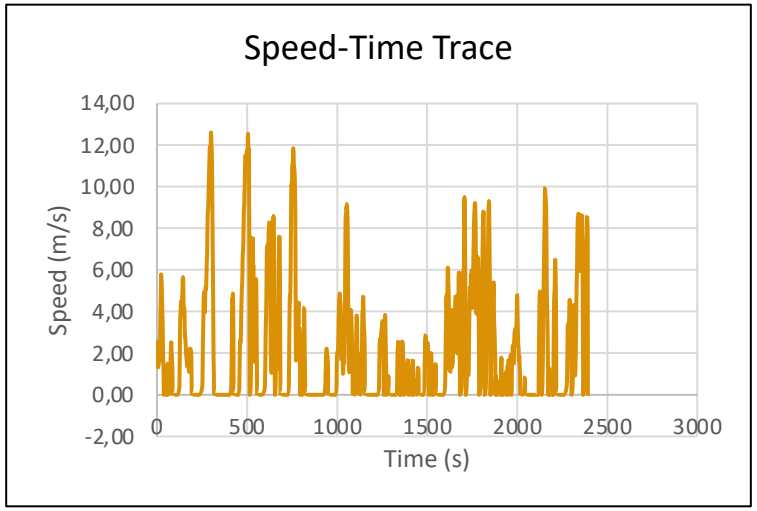


Business Model

- Vehicle Sale
- Vehicle Sale + Battery Leasing
- Vehicle Leasing
- Transport Service Leasing

Battery Sizing Methodology

1. Gather and load speed time trace



2 Input Vehicle parameters

Technical Parameters	
Vehicle Curb Mass (kg)	250
Passenger Mass (kg)	70
Average Number of Passengers inc driver (based on 82% load factor)	5
Total Passenger Mass (kg)	1
Cargo Mass (kg)	300
Charge-Discharge Efficiency	95%
Mechanical Efficiency	95%
Motor Efficiency	
Tire to Road Friction Factor (f)	0.01
Drag Coefficient (Cd)	1.00
Frontal Area (m2)	2.00
Tire diameter (m)	0.61
Car aircon power (kW)	0.00
Battery Depth of Discharge (DOD)	20%
Current Battery Pack Voltage (V)	48.00
Discharge Rating (xC) assuming 1.25 safety factor	2.40
Target Vehicle Range (km)	60.00

3 Define Drive Train parameters (Motor Power, rated speed and over-all gear ratio)

Drive Train Specifications	
Rated Power (kW)	**6**
Rated Torque (N.m)	**19.10**
Rated speed (rpm)	**3000**
Over-all gear ratio	**15**

4 Generate Minimum Battery Specs

Output	
Max Current discharge (A)	182.94
Energy Economy (km/kWh)	14.73
Minimum Battery Size Based on Discharge Rate (kWh)	3.66
Minimum Battery Size Based on Range (kWh)	5.09
Recommended Minimum Battery Capacity (kWh)	5.09
Battery Module Voltage (V)	48.00
Minimum Battery Module Capacity (Ah)	106.08
Minimum Battery Energy Capacity (kWh)	5.09
Estimated Range Between Charge (km)	60.00
Recommended Over-all Gear Ratio	15

Fast charging vs Slow Charging Batteries

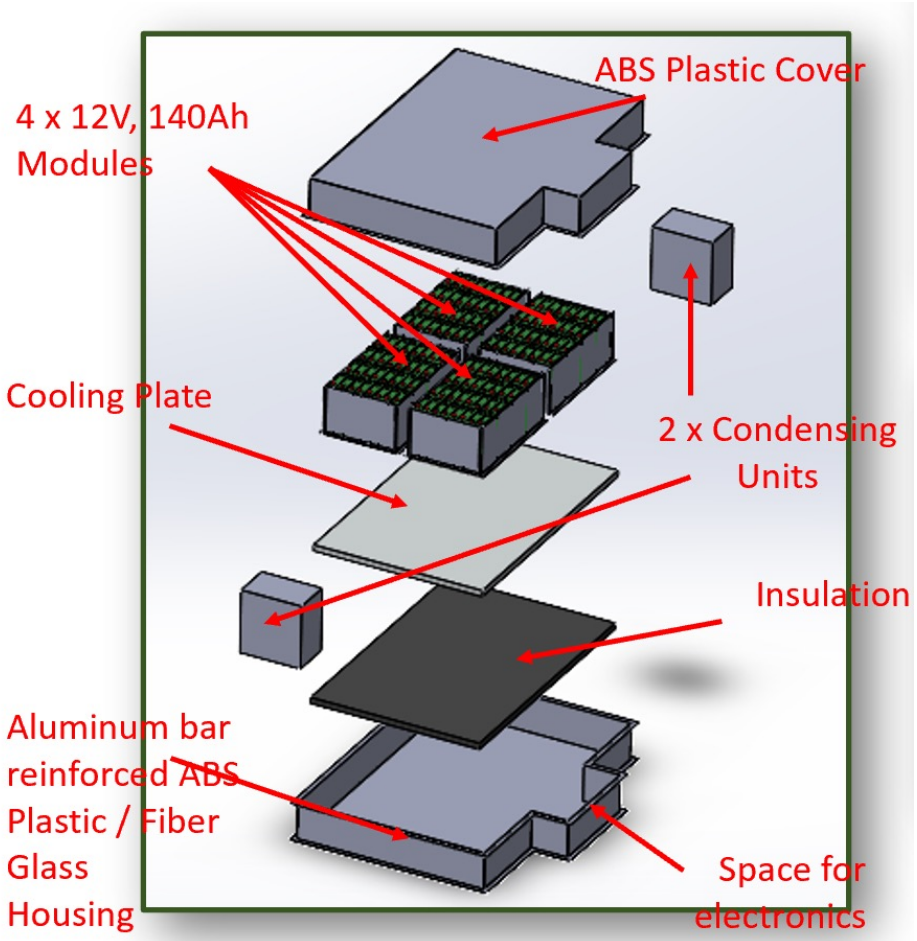
	Economics	Operatiions		
Battery Option	Cell Upfront Cost (Php)	Range (km)	Charge per Day	Charging Time (min.)
LFP	39,286	60.0	1	180
LpTO	55,556	40.0	2	60
LTO	61,667	30.0	2 to 3	30

- Small Daily Range Requirement
- There is enough space
- Cheaper upfront
- No need for charging in-between runs

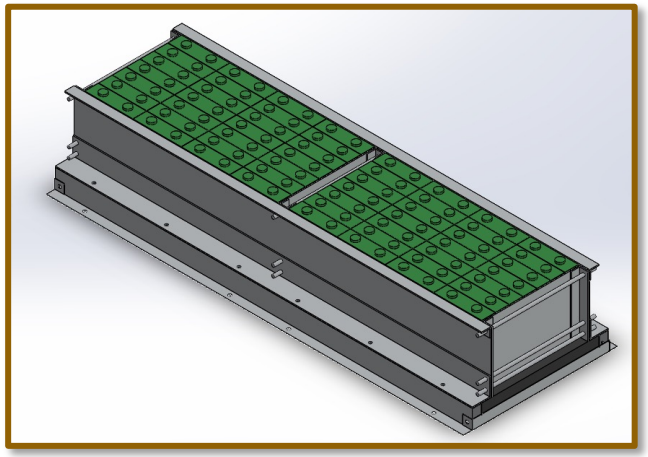
When to go Fast Charging?

- High daily mileage
- Physical space restrictions
- Continuous operations
- Wide operational area

Battery Pack and Cooling System Design

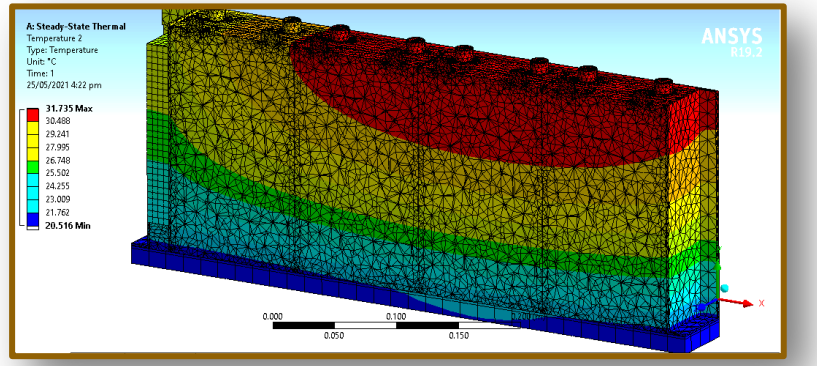


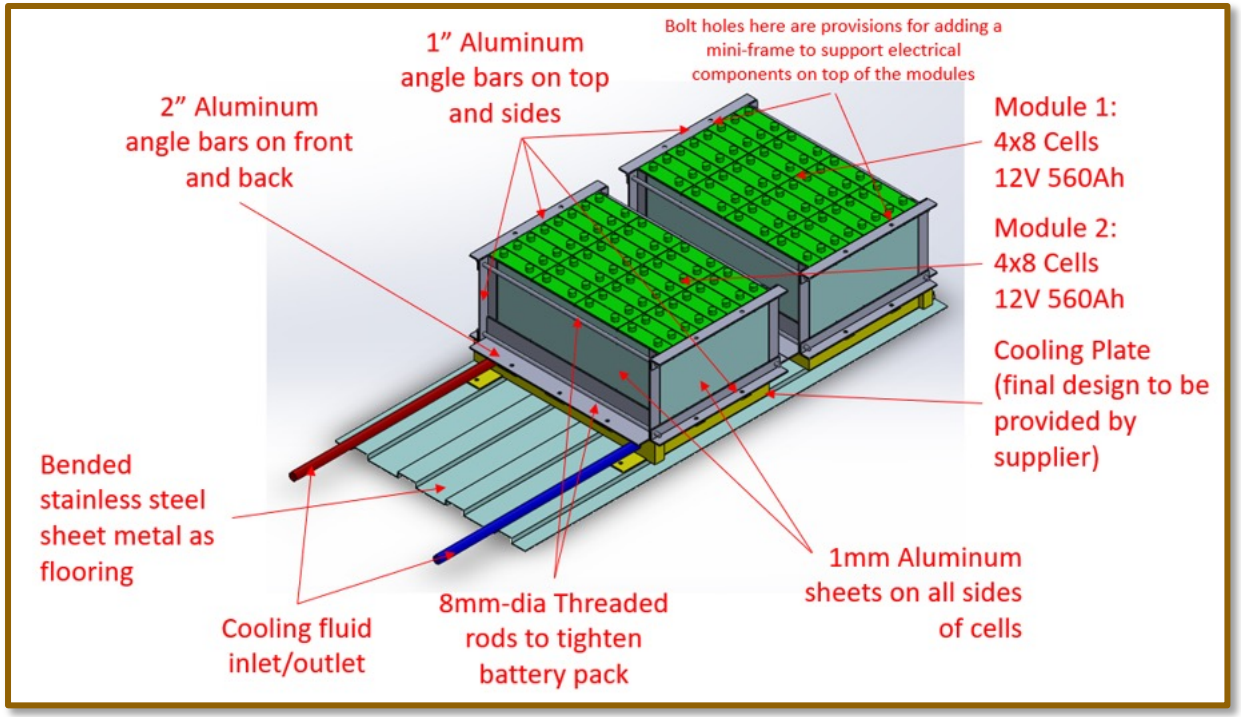
Integrated Cooling system



Forced or Natural Convection

DC Thermal Simulation





External Cooling System

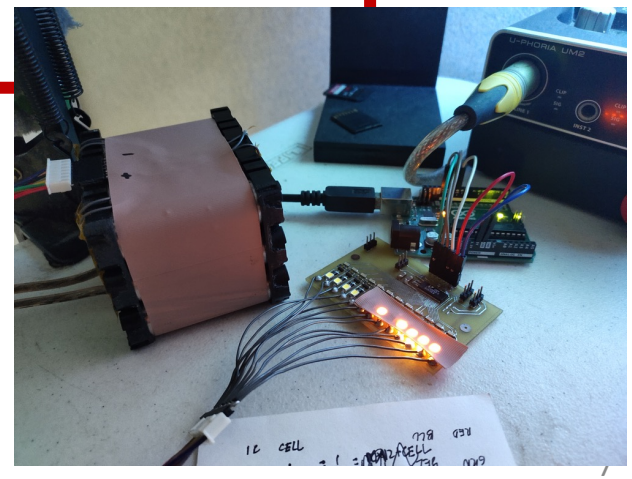
Smart Features

Business Model

- **Vehicle Sale**
- **Vehicle Sale + Battery Leasing**
- **Vehicle Leasing**
- **Transport Service Leasing**

Required Battery System Features

- Battery Location Tracking
- Remote real time state of charge (SOC) tracking
- Cell level condition monitoring
- Charging encryption
- Remote management capability
- Enhanced physical security and remote intrusion detection



Key Points

- Electric Vehicle Battery Selection needs to take account of vehicle performance requirements, operational characteristics, Business model and economics
- Battery sizing should satisfy both peak discharge and range requirements
- Battery type should take strong account of operational requirements and economics
- Cooling system should account for DC, climate conditions and practicality
- Battery module smart features to depend on business model and operational requirements

[Thank You]