

Emerging Energy Storage Solutions for Indian Railways' applications

E-Mobility in Indian Railways
New Delhi
Sep 4, 2018



Battery operated Locomotive on the UK Rail Network



- Project for the UK Rail Network
- Goal: ***To effectively bridge the non-electrified sections of otherwise electrified routes***
- IPEMU developed by Bombardier, UK
- Tested successfully in 2015 on a 3-carriage train in UK
- 400 KWh battery gave a range of about 50 miles
- Batteries placed in pods under each carriage
- Commercial rollout expected in 2019

Product Advantage

➤ Performance & Safety

- Inherently **safe**
- **No** Heavy Metals
- **Long-Life** (3-5X Lead Acid & Lithium Oxides)
- Limited Capacity Fade **over lifetime**
- Extended **Runtime** (+2X Lead Acid)
- **Lightweight** (Less than half of Lead Acid)
- **Smaller** (2-3 Sizes Smaller than Lead Acid)


➤ Reliability & Serviceability

- No Sudden **Death**
- Accurate **Fuel Gauging** (Maximum Range with Peace-of-Mind)
- **No** Maintenance
- Extended Storage in **extreme Temperature with Excellent Energy Retention**
- Electronic **Dashboard with Remote Performance Monitoring**



"It is the opinion of Exponent that it is "improbable" that Valence's lithium phosphate batteries will incur the thermal runaway that causes other batteries to burst into flames or explode."

Applications for the Indian Railways – proposed solutions

- ✓ Application # 1: Motive – Control Supply for AC rakes
 - ✓ Application # 2: Stationery – Emergency Tunnels Lighting
 - ✓ Application # 3: Stationery – Air conditioning and ventilation systems for underground stations (with Delta Power Solutions)
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Application # 1: Control Supply of AC rakes in KMRCL



- **Proposed replacement – 115.2V 370Ah (185Ah x 2)**
- **Zero maintenance >> Reduces system downtime, reduces operating costs, hassle-free operations**
- **Payload reduction >> ~38% more compact, ~30% lesser load on the loco, enhances runtime, reduces haulage costs**
- **Longer life >> at least 5 times better life even with a higher DOD**
- **Extremely safe >> Does not explode in fire also and hence suitable for critical applications such as the railways**
- **Higher current draw >> Higher continuous discharge rates by at least 5% (cont. 720A) and by 106% (peak 1424A)**

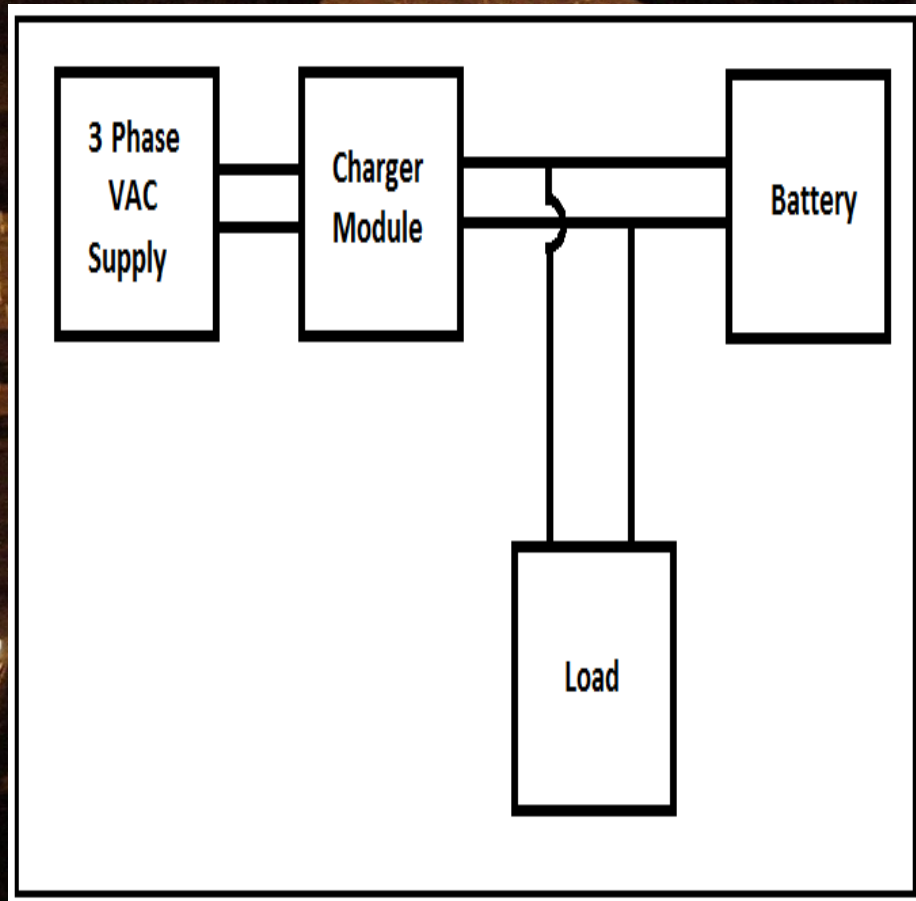
Proposed battery specifications – 115.2V 370Ah (42.4KWh)

Modules in Series		3s
Modules in Parallel		4p
Total Number of Modules		12
System Discharge Voltage	V	115.2
System Charge Voltage(max)^	V	131.4
System Charge Voltage(min)^	V	124.2
System Discharge Cutoff - Minimum	V	82.8
Total Battery System Wt.	kg	234
Total Battery System Vol.	L	143
System Discharge Current Max Continous†	Amps	360
System Discharge Current Max Peak (30 seconds)†	Amps	712
Total Battery System Capacity*	Ah	185
Total System Energy*	kWh	21.3
Discharge Profile†	% DOD	100%
Utilized Battery System Capacity†	Ah	185
Utilized Battery System Energy†	kWh	21.3
# of batteries required per rake		2

Application # 2: Emergency tunnels lighting in KMRCL

- Proposed ESS: 217.6V 220Ah (to replace Lead Acid 220V 250Ah)
- 3-Phase 415 VAC is given to the charger module.
- Charger module will convert the 415 VAC to 236 - 240 VDC (required) with 30 Amps approximately.
- This will be fed to the battery system for charging it.
- From the battery system, 236-240 VDC is fed to the emergency tunnel lighting system (load).

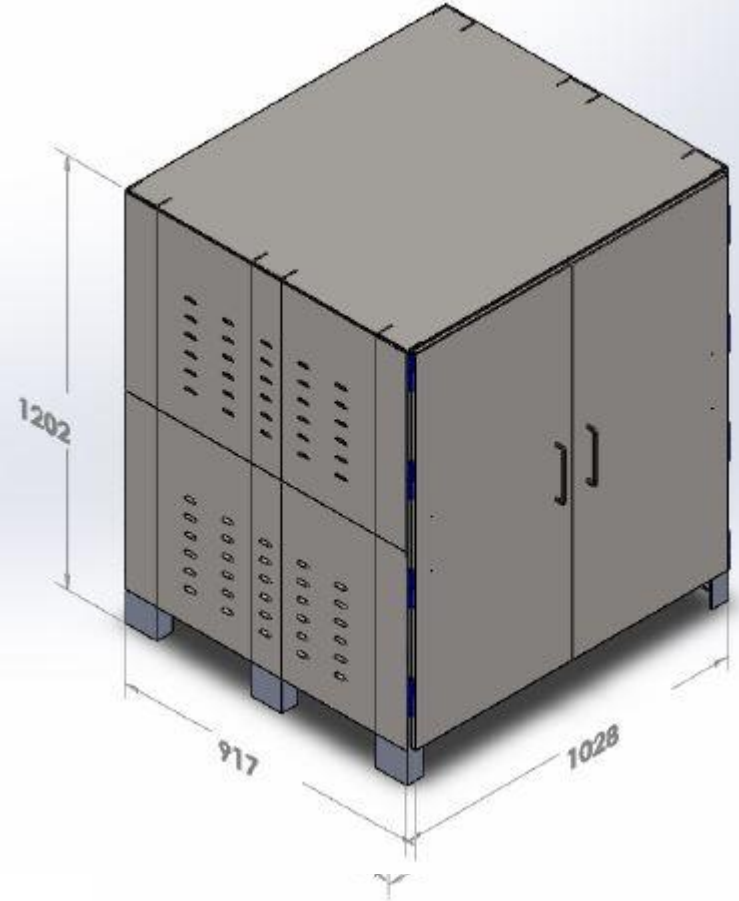
Note: Sometimes, the charger will simultaneously charge the battery system and also provide the output to the load. When this happens, the current will be shared by the load and the battery for charging.



Present v/s Proposed



V/S



3.5 x 3.0 x 4.0 feet (approx. 40 cu. feet)

Proposed battery specifications – 217.6V 220Ah (46KWh)

Modules in Series			17s
Modules in Parallel			2p
Total Number of Modules			34
System Discharge Voltage	V		217.6
System Charge Voltage(max)†	V		248.2
System Charge Voltage(min)†	V		234.6
System Discharge Cutoff – Minimum	V		170.0
Total Battery System Wt.	kg		537
Total Battery System Vol.	L		344
System Discharge Current Max Continuous†	Amps		300
System Discharge Current Max Peak (30 second)†	Amps		600
System Charging Current	Amps		80
Total Battery System Capacity*	Ah		220
Total System Energy*	kWh		47.9
Discharge Profile†	% DOD		96%
Utilized Battery System Capacity†	Ah		211
Utilized Battery System Energy†	kWh		46.0

Application # 3: ESS for Air conditioning and Ventilation systems of under ground stations in KMRCL

- At present, fed by an auxiliary transformer which gets input from 11KV supply of traction substations
- In occasions like failure of incoming supply at 11KV, there is no backup currently
- Hence, emergency parallel feed of 11KV supply for auxiliary transformers is required
- The solution (ESS + Inverter) should either be centrally located at the terminal ends (stations) of the tunnel or distributed at each node (stations).

USPs through Technological Advancements

- ✓ Modular & Scalable
- ✓ Containerized ESS
- ✓ Easily integrated into existing cabinets, if required
- ✓ Recharges in < 2 hours from 20% SOC
- ✓ Automatic cell and system level balancing
- ✓ Excellent float life characteristics for UPS & Inverter Systems



Battery Council International (BCI) standards –
Group Number U1R,
Group 24 and Group 27



Proposed battery specifications – 768V 896Ah (688KW) x 2

Modules in Series			30s
Modules in Parallel			16p
Total Number of Modules			480
System Discharge Voltage	V		768.0
System Charge Voltage(max)^	V		876.0
System Charge Voltage(min)^	V		828.0
System Discharge Cutoff - Minimum	V		600.0
Total Battery System Wt.	kg		7584
Total Battery System Vol.	L		4830
System Discharge Current Max Continuous†	Amps		1792
System Discharge Current Max Peak (30 seconds)†	Amps		2720
Total Battery System Capacity*	Ah		896
Total System Energy*	kWh		688.3
Discharge Profile†	% DOD		100%
Utilized Battery System Capacity†	Ah		896
Utilized Battery System Energy†	kWh		688.3

Inverter - features

Efficient



- Peak /CEC efficiency: **98.6%**
- Internal Aux. Power Consumption

Safety



- AC and DC side protections
- Fire retardant design
- IP 54 cabinet

Response



- System response time < 100 ms
- Seamless interface with EMS

Access



- Built-In HMI
- Web access enabled



Scalable



- Parallel configuration option

Thermal



- Liquid cooled System
- Inbuilt heat exchanger

Flexible



- On-Grid/Off-Grid
- Configurable Applications

Reliable



- Compliant with IEC/IEEE/EN Standards



Inverter specifications

AC Side	AC Connection	3-phase, 3-wire
	Rated Output Power	1000 kW
	Rated Output Current	1440 Arms
Grid-tied Operation	DC Voltage Range	630 V-930 V
	Rated Grid Voltage	415V AC ,(+/-10 %)
	Rated Grid Frequency	50/60 Hz
	Frequency Range	+/-5 Hz
	Current THD	<2.5% at rated power
	Power Factor	-1 to 1, adjustable
Environment	Acoustic Noise	<78 dB
	Pollution Degree	3
	IP Degree	IP54
	Operating Temperature	-10 to +55 °C(de rating>55°C)
	Cooling	Liquid + Air
	Humidity	5-96 %, non-condensing, no dripping water
	Altitude	2000 m; beyond which derating of 1% per 100mts
Operation & Communication	Emergency Stop	Local EPO button & remote control
	User Interface	10 " HMI
	Communication	Modbus TCP/IP
System Characteristic	Peak Efficiency / CEC Efficiency	98.6%
Standard Compliance		IEC62109, IEEEE519, IEC61683,IEEE1547, FGWTR3/BDEW2008,IEC60529, IEC60068 IEC61000,

Thank you for your time and attention.

