Press Releases

Lithium-ion Battery Powered Trains – Coming to a European Rail Near You

YVERDON-LES-BAINS, Switzerland, July 15, 2020 – Even dedicated environmentalists have trouble "doing the right thing" when it comes to traveling by today's railroads. In December 2019, activist Greta Thunberg was headed from Lisbon to Madrid to speak at a United Nations conference dealing with climate change, when she ruled out a flight due to its impact and instead opted to journey by rail. But the lack of fully electrified rails between Vilar Formoso, Portugal and Salamanca, Spain still required a heavily polluting diesel locomotive for more than an hour of her journey.

Change is coming to the global railroad industry. Next generation locomotives, powered by lithium-ion (Li-ion) battery solutions, are becoming increasingly common and are ready to replace diesel engines or co-exist in hybrid diesel or electrified locomotives. Working together with diesel engines, batteries provide a pathway towards less polluting trains and operation in areas where diesels are prohibited. For electric locomotives, add-on battery packs help them to traverse non-electric portions of the right-of-way and to operate seamlessly during power failures.

Providers like Leclanché SA (SIX: LECN), one of the world's leading energy storage companies, are forging partnerships with major rail transportation manufacturers to help bring these solutions to market in Europe and beyond.

The State of Electrified Rail in Europe

Rail currently stands as Europe's most electrified transport mode, especially in urban areas. Sixty percent of the continent's main line network is electrified, and 80% of rail traffic runs on it. Europe has also committed to using electrification to decrease its carbon footprint over time. For example, European railways vowed to cut total CO_2 emissions 30% by 2030 relative to 1990. Electrified rail utilizes a considerable portion of renewable energies; according to the International Energy Agency, 40% of the electricity mix used by European railways is low carbon.

The underlying economics of electrification, and accompanying greenhouse gas emission reductions in Europe, are worth consideration. Industry estimates for electrifying existing rail infrastructure in Western Europe are 750k euros per km. That's considerably more costly than the capital expense of new rail locomotives with lithium-ion traction batteries for non-electrified rail segments.

The environmental cost is even more dramatic – according to the TREN2020 study published by WWF, Greenpeace and Promocio Del Transport Public – which indicates diesel trains emit an average of 1.42 kg of CO_2 per km. and 255gr. per kWh of energy used. As an example, a typical AGC diesel train in France consumes 1.6lts of diesel fuel per km. That means that a train covering 300km daily on a non-electrified route can easily spend200k euros in diesel fuel per year. By contrast, the cost of electricity consumed by battery-powered trains is about one-third the cost or about 66k euros according to Leclanché'.

However, the cost for electrifying existing rail infrastructure must be considered on a case-by-case basis. It may be cost and environmentally beneficial on heavily traveled stretches of rail. By contrast, on lower density routes, its justification may be more difficult.

Enter hybrid or dual-mode propulsion systems. Rail locomotive manufacturers are developing hybrid locomotives in diesel-battery or electric-battery configurations to achieve balanced economic and environmental objectives.

Locomotive Battery Technology

Li-ion battery technology, whose creators – John B. Goodenough, M. Stanley Whittingham and Akira Yoshino – won the 2019 Nobel Prize in Chemistry, is ubiquitous in our smart phones and laptops, and presents a solution for cleaner rail transport. Aside from emitting zero NOx, battery-powered locomotives are 50% quieter than diesel. They run reliably on non-electrified parts of the network, or portions that are prone to power outages. In fact, using today's technology, a battery-operated locomotive can travel 140 km in catenary-free mode. Battery-powered trains also offer more flexibility as diesel hybrids.

A locomotive equipped with the latest battery packs eliminates the need to build and maintain new infrastructure. Batteries can be recharged at dedicated charging stations, when the train is braking or traveling on sections of electrified rail. The battery packs are long-lasting and versatile. Even with daily operation, they

have a lifespan of five to eight years, can charge in seven to ten minutes and can power any type of commuter or regional train.

But what about the comparative costs of using batteries versus various other energy alternatives? That's what The Norwegian Railway Directorate set out to learn in 2019 prior to selecting an approach for converting the country's five remaining non-electrified railways from diesel power to zero emission technology. The government agency commissioned a study to review the use of hydrogen, biogas, biodiesel and battery-powered locomotives to learn which alternative energy solution would represent the most efficient use of public funds and achieve its environmental objectives.

The study found that partial electrification, combined with traction batteries, would be the preferred solution for non-electrified stretches of railway. From an operating expense standpoint for railcars on its Nordland line, after considering cost per passenger and per kilometer, the partial electrification and battery solution would cost half that of diesel and less than 60% compared to hydrogen. The solution would help Norway speed reduction of the 30% greenhouse gas emissions from its transport sector while helping the country reach its overall national target of cutting emissions by 45% by 2030.

How Battery Technology Works

Energy storage through lithium-ion batteries in trains can provide 1MWh with graphite-nickel manganese cobalt (G-NMC) high-energy density cells, a gigantic leap compared to the auxiliary batteries used in trains nowadays. Leclanché also produces lithium titanate oxide (LTO) batteries which are suitable for demanding, high-power applications.

Locomotive batteries can recharge at stations, on sections of electrified track and through regenerative braking. The batteries power a traction convertor which provides energy to the motor. Leclanché is actively developing a proprietary battery management system that communicates with the locomotive and provides real-time updates on charging status, temperature, battery health and other parameters. The system will also allow thermal control of battery cell temperature thanks to an integrated cooling system. Both Leclanché's G-NMC and LTO batteries have a benchmark cycle life that meets the long life-span train operators need.

Europe appears to be taking the lead with respect to implementing battery-powered trains. Bombardier launched its Talent 3 electro-hybrid train in Berlin, the first of its kind in Europe in more than 60 years; Alstom will launch its first battery traction units covering the Leipzig to Chemnitz line in Germany in 2023. Irish carrier Iarnród Éireann put out an RFP in May 2019 to purchase 600 new train carriages by 2040 – all electric and up to half battery powered.

For more information on European rail electrification, contact Gerardo Gimeno, VP of Sales, Commercial Vehicles, Leclanché at gerardo.gimeno@leclanche.com or visit www.leclanche.com.

# # #

Caption for How Lithium Ion Batteries Work in Electric Locomotives:

1. Battery charging when on an electrified line.
2. Battery powering the train when on a non-electrified line.
3. Battery being charged while a train is slowing/braking on a non-electrified line.

Caption for Battery Powered Train System:

1. Catenary wire
2. Traction converter
3. Main choke (DC), Suction choke (AC), Air choke
4. Isolating transformer
5. Sinus-filter, AUX-Transformer
6. Board network
7. Board converter
8. LCL-Filter
9. Battery Lithium G-NMC & LTO + Battery Management System, Aux-Battery
10. Heating
11. Pump
12. Fan
13. Actuator
14. Adapting transformer - BSE
15. Dynamo
16. Passenger compartment

17. Sockets
18. Train lighting
19. Trac-Battery
20. Battery Lithium G-NMC & LTO + Battery Management System
21. LCL-Filter

About Leclanché

Headquartered in Switzerland, Leclanché SA is a leading provider of high-quality energy storage solutions designed to accelerate our progress towards a clean energy future. Leclanché's history and heritage is rooted in over 100 years of battery and energy storage innovation and the Company is a trusted provider of energy storage solutions globally. This coupled with the Company's culture of German engineering and Swiss precision and quality, continues to make Leclanché the partner of choice for both disruptors, established companies and governments who are pioneering positive changes in how energy is produced, distributed and consumed around the world. The energy transition is being driven primarily by changes in the management of our electricity networks and the electrification of transport, and these two end markets form the backbone of our strategy and business model. Leclanché is at the heart of the convergence of the electrification of transport and the changes in the distribution network. Leclanché is the only listed pure play energy storage company in the world, organised along three business units: stationary storage solutions, e-Transport solutions and specialty batteries systems. Leclanché is listed on the Swiss Stock Exchange (SIX: LECN).

SIX Swiss Exchange: ticker symbol LECN | ISIN CH 011 030 311 9
