

Flash-Charging Electric Public Transport: TOSA Buses

Geneva, Switzerland 

Geneva's breakthrough flash-charging technology for sustainable and emissions-free urban public transport

The TOSA (Trolleybus Optimisation Système Alimentation) bus planned to be running a full bus route in the city of Geneva takes only 15 seconds to charge during stationing time at a bus stop. In the time that it takes for passengers to get on and off the bus, a laser-guided arm sends 600 kW straight into onboard lightweight batteries with a brand-new flashing technology developed by engineers at ABB, a leading global technology company in power and automation. The charge allows for the propulsion until the next bus / next charging station. Since May 2013, the city is successfully running a pilot and plans to operate the full bus line by 2018.

Country/ City Profile

	Country		City	
	Population (2015)	8,286,976 [1]	Population (2015)	201,000 [3]
	Land area (km ²)	41,285 [1]	Land area (km ²)	15.93 [4]
	GDP per capita (2014, current international \$, at purchasing power parity)	57,235 [2]	GDP per capita (2014, US\$, at purchasing power parity)	52,753; canton area [5]
	Region	Europe	Region	Mountainous

City's physical geography

Location	<ul style="list-style-type: none"> ✓ On the banks of Europe's largest lake, Lake Geneva (Leman); at the mouth of the Rhone River ✓ Bordered by the Jura Mountains and the French Alps [3]
Climate	<ul style="list-style-type: none"> ✓ Situated in a cool temperate climate; heavy precipitation occurs during mild winters ✓ Marine west coast mild climate, with no dry season. The tempering effects of the lake and surrounding mountains result in pleasant weather almost year-round [3] ✓ Mean annual temperature is 9.6 °C

Initiating context

Geneva (Switzerland) is one of the world's leading cities, recognized as a financial hub, a global center of diplomacy and a technology and innovation center. It is also a popular tourist destination, offering a high quality of life to its residents. It hosts the highest number of international organizations in the world, including global headquarters of institutions like the United Nations and the Red Cross. [10]

The local transport authorities in Geneva have a vision of providing a silent and zero-emission urban mass transport for the city. The commitment is to develop citizen-focused solutions and technologies that help lowering environmental impact. [10] Alternative electric bus technology normally requires buses to be charged overnight at the depot, and carrying such large batteries requires sacrificing the space for actual passengers. The new solution came from ABB and its partners who had concluded a successful pilot operation of their electric bus system TOSA. Instead of using overhead lines, the buses power up in just 15 seconds at specific stops and at the terminus station. [9]

Project description

ABB, a leading global technology company in power and automation, that enables utility, industry, and transport & infrastructure customers to improve their performance while lowering environmental impacts, had been designing a model for future urban transport that would reinforce their vision of sustainable mobility. [10] Their project will deliver and deploy 13 flash-charging stations along an urban transit bus route in Geneva, as well as three terminal

and four depot feeding stations. This route will then use the world's fastest flash-charging connection technology taking less than 1 second to connect the bus to the charging point. The onboard batteries can then be charged in 15 seconds with a 600-kilowatt boost of power at the bus stop. A further 4 to 5 minute charge at the terminus at the end of the line enables a full recharge of the batteries. [10]

The plan to deploy TOSA on Line 23 in Geneva was the result of collaborative efforts of the public and private sector partners who invested in this vision. The decision was undertaken after the successful pilot of the first e-bus on the route from the Geneva Airport to the Palexpo Exhibition Center. The Line 23 bus route will be slightly modified in order to provide a fast connection to a new suburb being built to accommodate 11,000 flats and office space for about 11,000 employees. After it will be fully commissioned in 2018, the high-capacity articulated buses will depart from both terminuses at 10-minute intervals during peak times, and the line will be able to carry more than 10,000 passengers a day, thus replacing the diesel buses. [10]

The innovation of the rechargeable TOSA buses is that they provide large-capacity (up to 133 passengers), 100% electric propulsion without the use of overhead lines and with batteries that are small and light enough to ride on the roof of the bus. At certain stops, a robotic arm on the roof of the bus comes out automatically and connects to the overhead charging station, giving the batteries 15 seconds of recharging time through a technique called "flash" charging. Though 15 seconds is the normal time it takes for passengers to disembark and embark, it's enough to store up the energy needed to get to the next recharging station at an upcoming stop or the terminus. [9]

The technology developed by ABB, together with partners, not only automatically flash charges an electric bus in 15 to 20 seconds, but also enables to obtain high transportation capacity and energy efficiency. The system for overhead flash high-power charging is inherently safe because the overhead connectors are only energized when they are engaged, and the electromagnetic fields associated with inductive charging concepts are therefore avoided. [8] TOSA comprises of flash-charging stations at selected bus stops (components: an energy transfer receptacle; a grid connection; AC/DC converter and an energy storage unit) and onboard traction equipment (components: an entirely automatic energy transfer system; a battery unit; traction converter with integrated auxiliary converter, and traction motors). [9]

Implementation process

The Swiss city of Geneva has run a pilot with this technology since May 2013, which proved to be a great success so that the city is now going to run a full bus route, Line 23. The Geneva Public Transport operator (TPG) had signed a contract with ABB and the Swiss bus manufacturer HESS to deliver an operational line by spring 2018. [8] As part of a separate assignment by HESS, ABB will supply 12 flexible drivetrain solutions for the buses including integrated traction and auxiliary converters, roof-mounted battery units and energy transfer systems (ETS), as well as permanent magnet traction motors. Both contracts include five-year maintenance and service agreements to ensure operational reliability, efficiency and safety. [10]

For Geneva's line 23, ABB will supply and deploy:

- Onboard equipment for 12 TOSA e-buses
- Flash-charging stations for 13 of the 50 bus stops
- Three terminus feeding stations
- Four depot feeding stations

Projects implementation details

Operation

The operation of the project takes advantage of the fact that the bus must stop to let passengers on and off, and that the route is known. The charging stations are placed along the route and the bus's battery is recharged while passengers are getting on and off the bus.

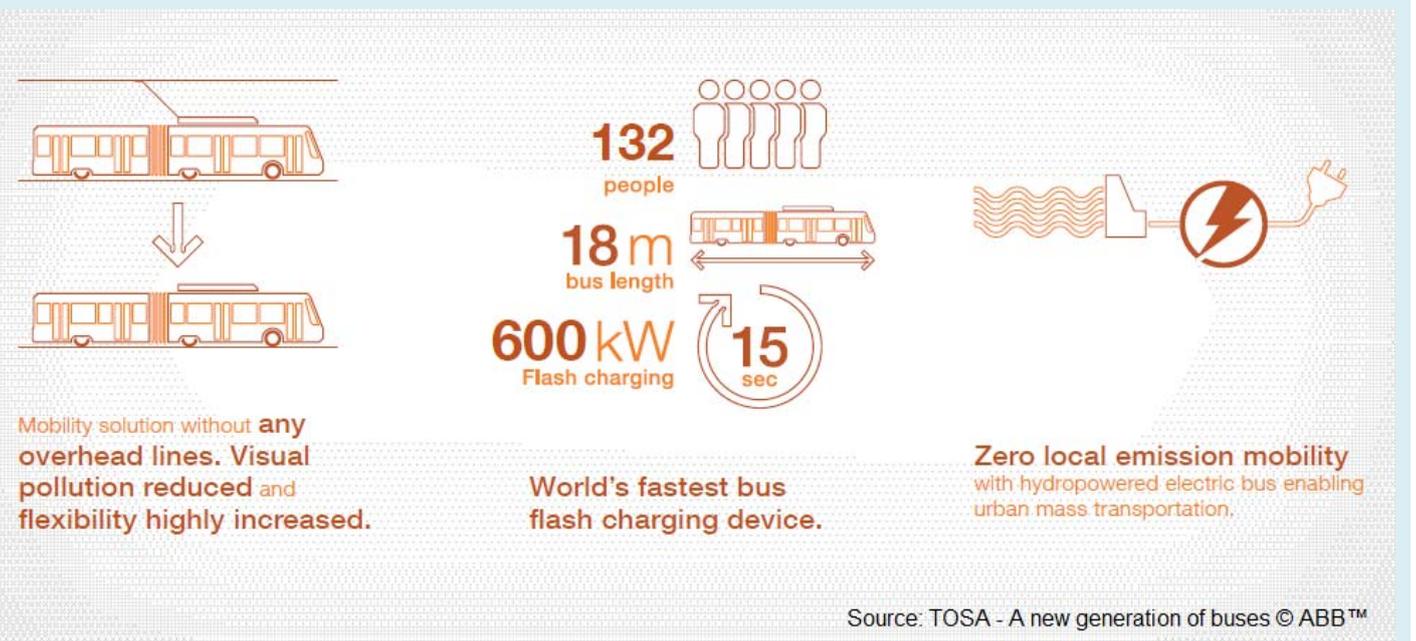
There are two types of chargers along the route:

- ✓ Flash-charging stations at selected stops, which provide a short high-power boost at 600 kW for 15 to 20 seconds.
- ✓ Terminal feeding stations, which deliver prolonged charges of 4-5 minutes at 400 kW to fully top-up the on-board batteries. [8]

Projects implementation details

Financing In July 2016, ABB has been awarded orders totaling more than \$16 million by Transports Publics Genevois (TPG), Geneva's public transport operator, and Swiss bus manufacturer HESS, to provide flash charging and on-board electric vehicle technology for 12 TOSA fully electric buses (e-buses) which will run on Line 23, connecting Geneva's airport with suburban Geneva [10]

Involved stakeholders ABB, Transport Publics Genevois (TPG), HESS - Swiss bus manufacturer



Timeline The Line 23 e-bus route is scheduled to be operational by 2018 [8]

Competitiveness To measure the competitiveness of a TOSA line, the parameters taken into account are determined by price and by the needs of bus operators and technological constraints. The model developed took into account infrastructure and component cost (batteries, connection to the electricity network, recharge station placement) as well as the life expectancy of the components. It also incorporated parameters such as the bus driver's salary and the electricity rate. All in all, 56 variables have been taken into consideration to determine the most cost-effective and efficient system.

The algorithm was based on a model that the Haute Ecole ARC developed based on the requirements of the buses (electric, electronic and power) and the charging stations (at the end of the line, on the route, or at the depot) as a function of route conditions. This included variables like the number of passengers, the recuperation of braking energy, altitude, speed and even weather conditions.

The entire modeling and cost optimization project was integrated into a web interface, making it possible to design a virtual TOSA line for a given city and estimate its cost. Many cities have expressed interest in TOSA technology, but Geneva will be the first city to adopt a regular TOSA line. The upcoming challenge will be to optimize costs for a complex bus network that includes several TOSA lines. [9]

Results

The entire Line 23 is expected to be fully operational in 2018, after which the monitoring of results will start. The new infrastructure of overhead lines and ultrafast charging times at bus stops will pave the way for the next generation of silent, flexible, zero-emissions urban mass transit. [7] It has been estimated that if Geneva replaces all of its diesel buses with TOSA buses, it will reduce about 1,000 tons of CO₂ emissions every year, another breakthrough to make the cities of the future cleaner and smarter than today's state of art. [10]

Project benefits

Emission free urban transport	Reduction of 1,000 tons of CO ₂ emissions per year	Large capacity: 133 passengers per bus	Flexible routing and timetable	Reduced investments and operational costs
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Charging at the bus stops means that cities don't need to have any overhead lines along the route, cutting down on infrastructure costs and freeing up the city spaces.

Lessons learned

The TOSA model of emissions-free urban mass transport can be given to cities worldwide, not only in Europe, with the objective of improving public transportation towards increased environmental sustainability.

Considering that urban transport planners around the world are looking for ways to avert gridlock and reduce pollution, the electric TOSA bus system is an attractive model for mass urban transportation. Being quiet, entirely emissions free and using long-life, compact batteries, the visual clutter of overhead electric lines that is often a barrier to trolleybus acceptance can be made a thing of the past. [8]

With diesel buses are becoming increasingly less attractive, both environmentally and financially, and operators seeking towards an attractive, modern form of transportation without having to hang wires in the street, flash-charging is well situated to replace both, existing trolleybus routes and urban diesel routes. [8] This innovative project opens the way for the future of mobility, by providing a sustainable and environmentally-friendly mass transport solution for the well-being of urban communities.

References

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