Nordic Light Rail Association

Maintaining trolleybus services in Bergen – expansion and the use of IMC® technology

Norconsult

Thomas J. Potter
Senior Transportation Engineer
Member, NLRA Board

Trolleybus in Norway

- Drammen: first trolleybus line in Norway, from 1909 to 1967
- Oslo: from 1940 to 1968
- Stavanger: 1947 to 1963
- Bergen from 1950 to the present day
  - One of only two trolleybus systems in Scandinavia
  - The other is in Landskrona Sweden, established in 2003

Trolleybus in Bergen

- First line established in 1950
  - Partial conversion of tram line #3 (now, Museum tramway)
- Conversion of tram line #2 to trolleybus operations in 1957
- Extensions to this line in the 1970s and 1980s
- Discussions to eliminate trolleybus operations
  - 1970s – proposed closure by city-owned operator Bergen Sporvei, but overidden by Bergen City Council
  - 1990s – purchase of duobuses (diesel / electric)
  - 2000s – purchase of new trolleybuses
  - 2010s – decision to extend line using IMC

Trolleybuses replace trams

Nordic Light Rail Association

Trolleybuses from 2003 - 2020

Nordic Light Rail Association

Tendering of public transport services

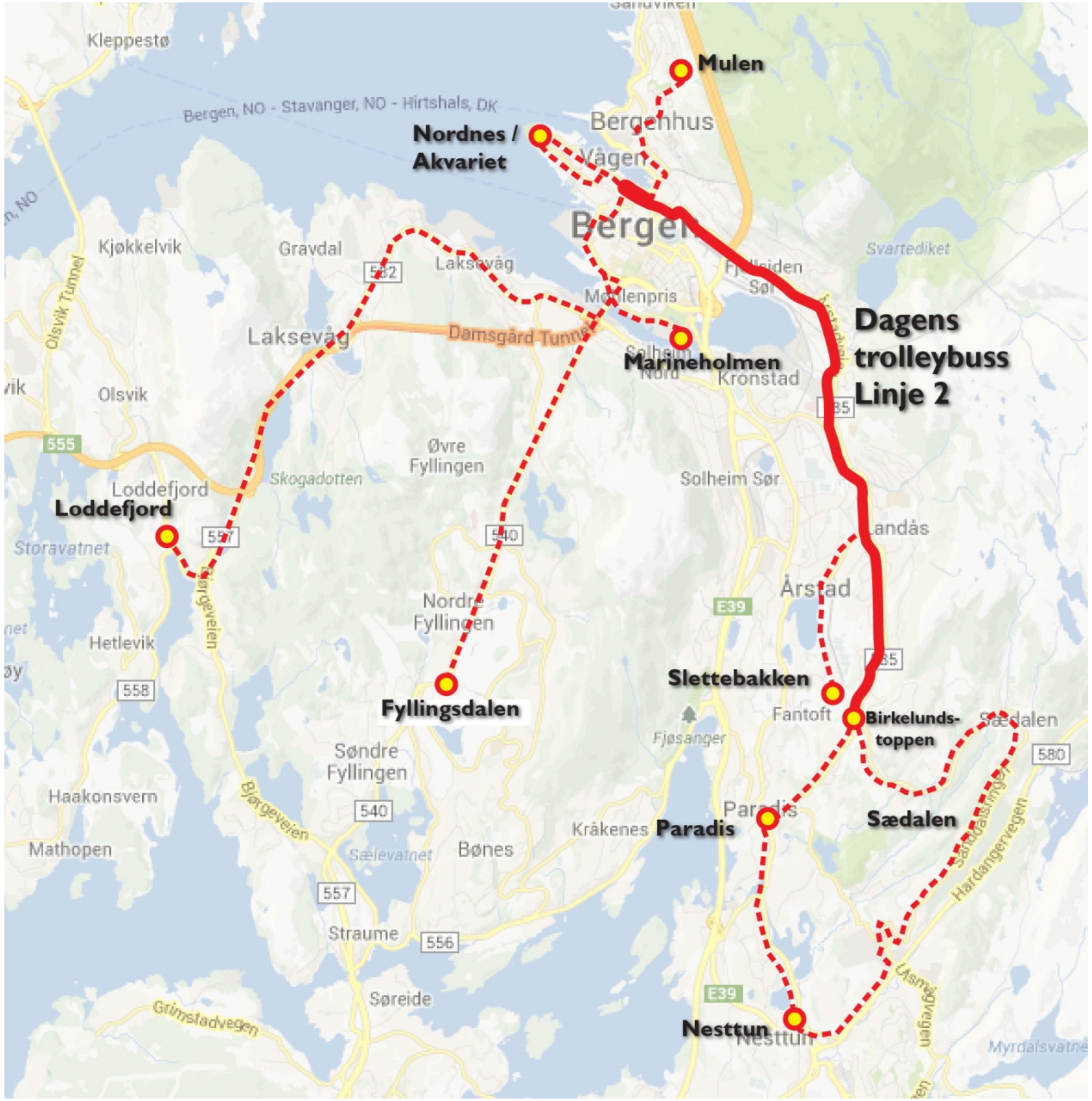
- Hordaland county (now Vestland) responsible for public transport through the PTA Skyss
- Public transport services are tendered
- Vestland county owns infrastructure
- Construction of Bybanen, the Bergen Light Rail System, established an infrastructure company, Bybanen AS
- Purchased and transfer of trolleybus infrastructure to Bybanen AS in 2016.

Feasibility studies for trolleybus

- Determined that the existing trolleybus line in Bergen is too short and not used enough to be effective
- Greater intensity of service and/or expansion necessary to increase the effectiveness of the system
- Low energy costs
  - Can offset costs for the maintenance of infrastructure if service is intense enough
- Synergy with light rail system
- General government policy to encourage electric mobility
- Uncertainty about battery bus operations, especially for articulated buses (18 or 24 meter)

Possibilities

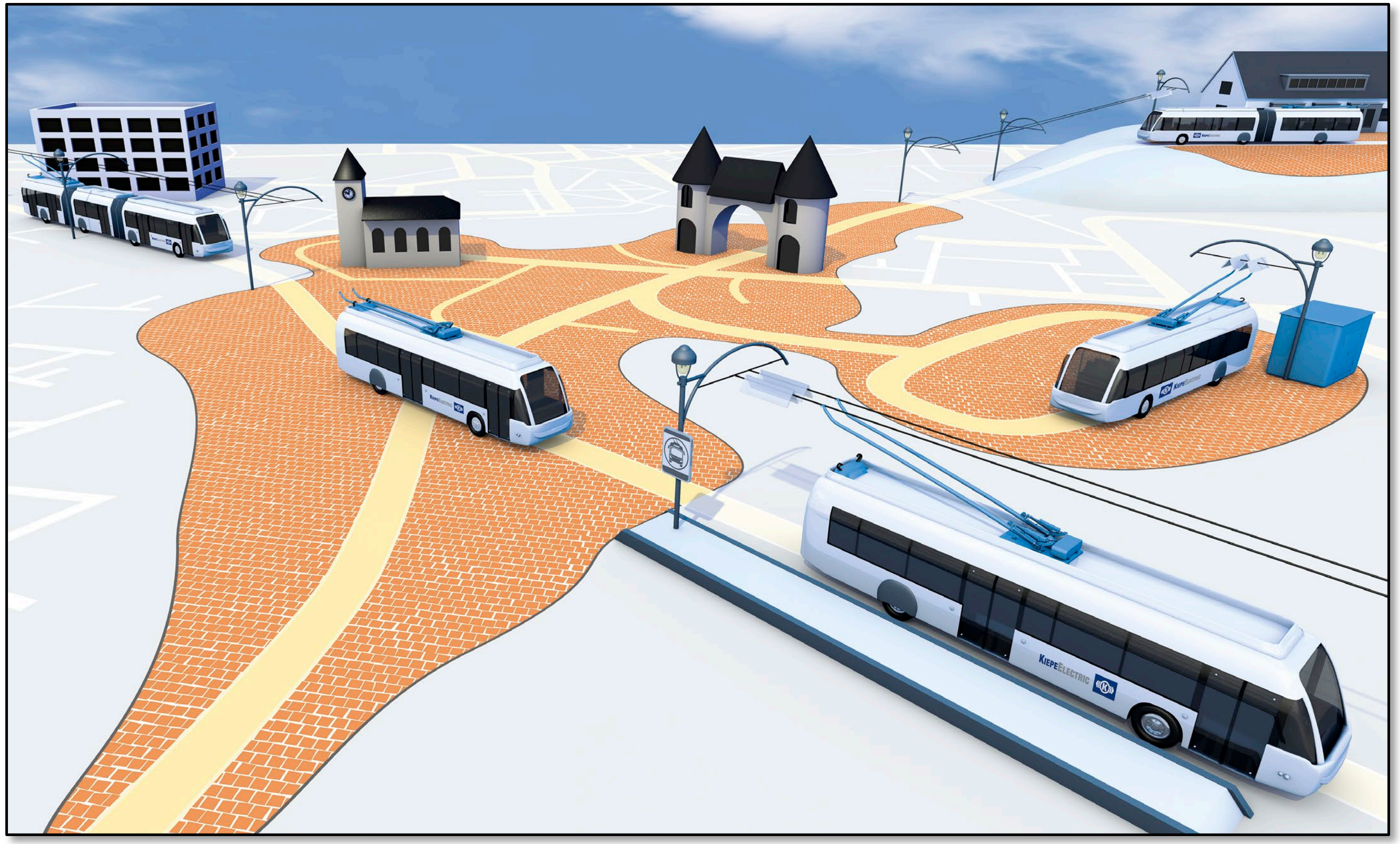
- Many possible extensions investigated
- Use existing infrastructure as a backbone
- Decision to use in-motion charging



Nordic Light Rail Association

Trolleybuses – charging on the go

- In-motion charging
- Smaller batteries
- No standing time for charging
- Trolleybus can be used continuously



County decides for trolleybus

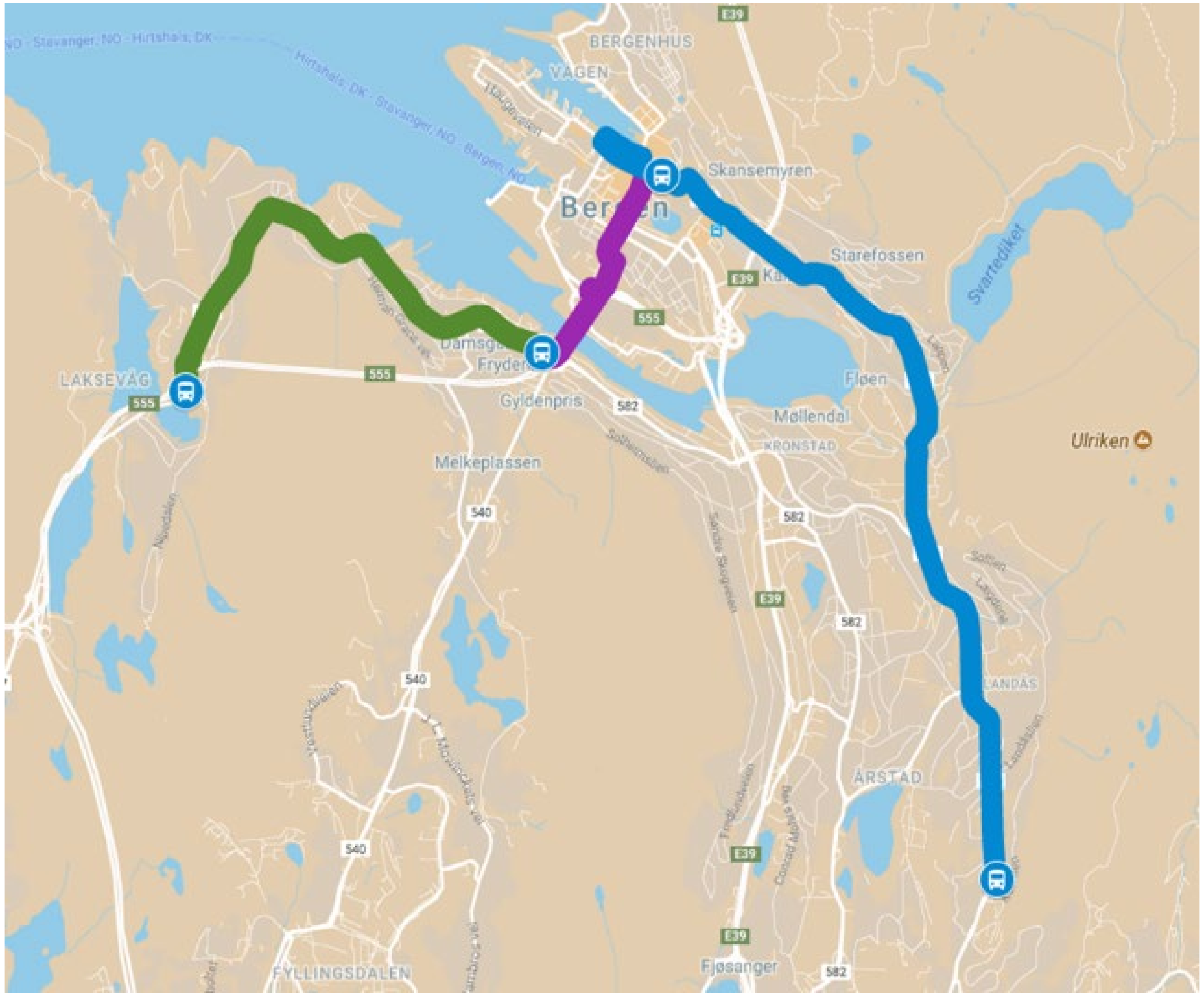
- Decision to extend the existing trollybus line 2, invest in new infrastructure in 2017 and operate using in-motion charging.

Vestland fylkeskommune

Trolley 2020

Extension to open in 2021

- Existing line, 7 km (blue)
- Battery operations (purple) through the city centre, 2 km
- New infrastructure (green), 4 km.
- Total length, 13 km



Nordic Light Rail Association

Today's Line 2 → Future Line 6

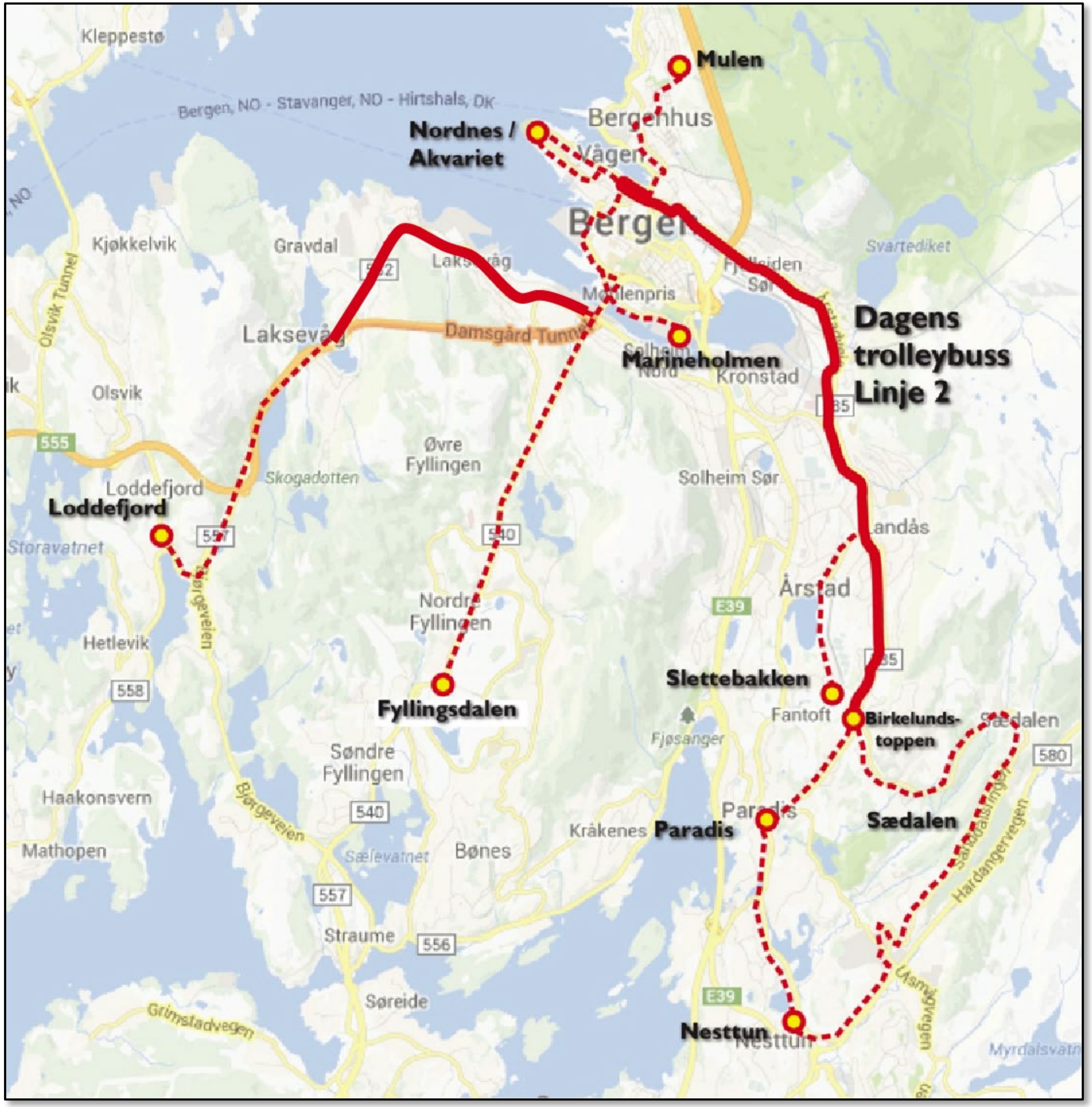
- Existing line 2 will be renumbered to line 6
- Construction of 4 kilometres of new OCS infrastructure including 3 rectifier stations
- Through the city centre with battery operations
- Investment costs for infrastructure about EUR 10 million
- Special assistance from Norwegian government through ENOVA (40%)

Rolling stock: new buses from Solaris / Škoda

- Solaris / Škoda Electric
- 10 new 18 meter trolleybuses
- Auxiliary power: 55 kWh battery
- First bus in August 2010
- Start of passenger operations 1st Dec 2020
- Extension to open in May 2021

Future plans

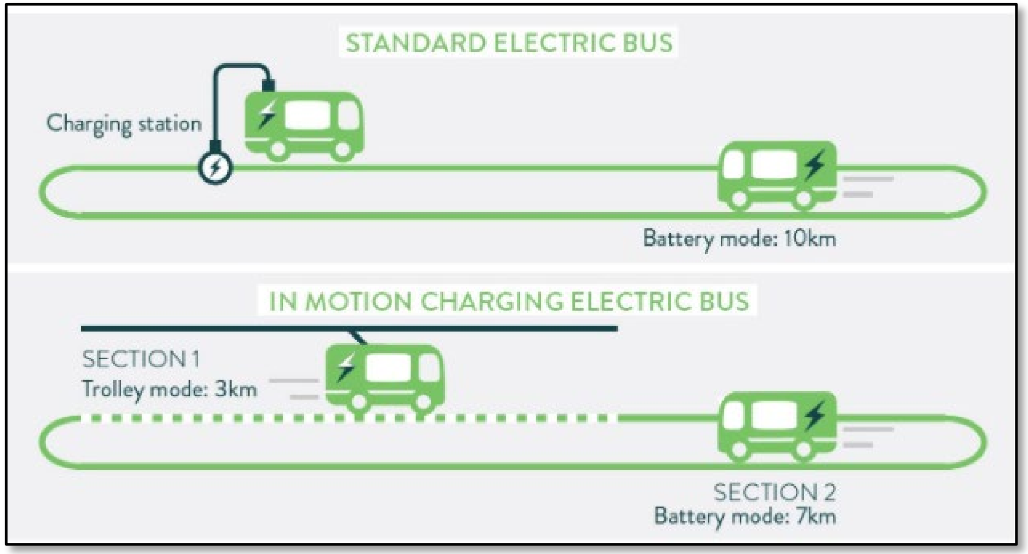
- 11 kilometers of overhead infrastructure can be used by five bus lines in the next years

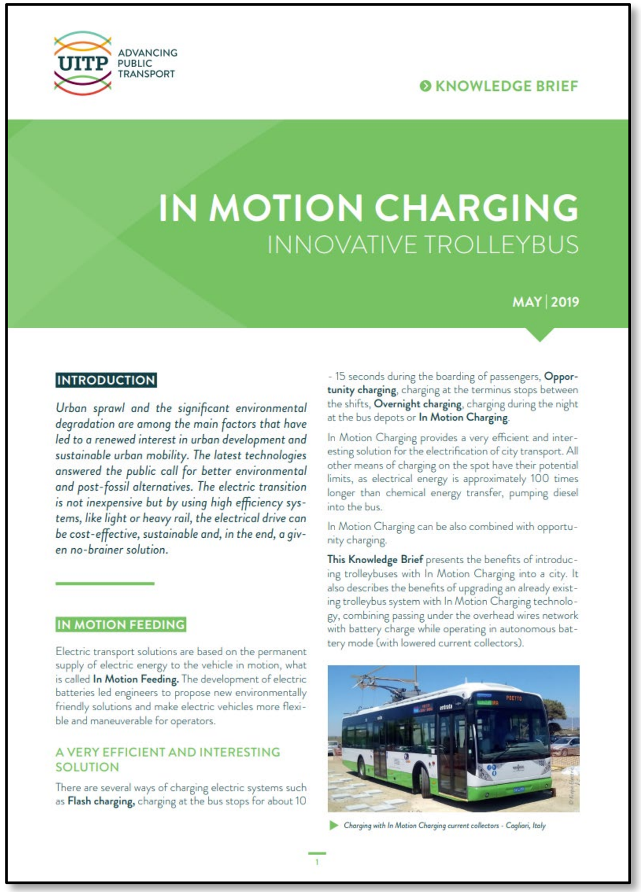


Nordic Light Rail Association

UITP Knowledge Brief:
In Motion Charging – Innovative Trolleybus

- https://cms.uitp.org/wp/wp-content/uploads/2021/01/Knowledge-Brief-Infrastructure-May-2019-FINAL.pdf





UITP ADVANCING PUBLIC TRANSPORT

KNOWLEDGE BRIEF

IN MOTION CHARGING
INNOVATIVE TROLLEYBUS

MAY | 2019

INTRODUCTION

Urban sprawl and the significant environmental degradation are among the main factors that have led to a renewed interest in urban development and sustainable urban mobility. The latest technologies answered the public call for better environmental and post-fossil alternatives. The electric transition is not inexpensive but by using high efficiency systems, like light or heavy rail, the electrical drive can be cost-effective, sustainable and, in the end, a given no-brainer solution.

IN MOTION FEEDING

Electric transport solutions are based on the permanent supply of electric energy to the vehicle in motion, what is called **In Motion Feeding.** The development of electric batteries led engineers to propose new environmentally friendly solutions and make electric vehicles more flexible and maneuverable for operators.

A VERY EFFICIENT AND INTERESTING SOLUTION

There are several ways of charging electric systems such as **Flash charging,** charging at the bus stops for about 10 - 15 seconds during the boarding of passengers, **Opportunity charging**, charging at the terminus stops between the shifts, **Overnight charging**, charging during the night at the bus depots or **In Motion Charging**.

In Motion Charging provides a very efficient and interesting solution for the electrification of city transport. All other means of charging on the spot have their potential limits, as electrical energy is approximately 100 times longer than chemical energy transfer, pumping diesel into the bus.

In Motion Charging can be also combined with opportunity charging.

This Knowledge Brief presents the benefits of introducing trolleybuses with In Motion Charging into a city. It also describes the benefits of upgrading an already existing trolleybus system with In Motion Charging technology, combining passing under the overhead wires network with battery charge while operating in autonomous battery mode (with lowered current collectors).

Charging with In Motion Charging current collectors - Cagliari, Italy

1

WHAT IS IN MOTION CHARGING?

The development of battery technology enabled the trolleybus to become one viable solution in the electrification strategy of cities. While driving, the trolleybus charges its on-board batteries, which enables in average, for each kilometer under the catenary to drive one, two or even three kilometers without catenary in commercial conditions. The range depends on the energy consumption of the operation (vehicle length, gradients, etc) and the power limits of the equipment (e.g. IMC500 charging model for 500 kW energy transfer enables maximum recharging).

CHARGING ROAD INSTEAD OF CHARGING STATIONS

This is not taking any investments in new charging infrastructure and **does not take additional time in to charging batteries during the operation**, if there already exists a trolleybus infrastructure, which can then be used. Traditional trolleybuses that used to feed braking energy back to the grid were only efficient when another trolleybus was in the same section. By storing this energy in the onboard battery, the energy, as well as the flexibility of the operation can be increased without harming the timetable.

So In Motion Charging has a traction battery for full electrical operation including comfort devices such as electrical heating. To connect and disconnect the current collector system for In Motion Charging works reliable around the world at all weather conditions and is done simply by pressing a button.

When installing new overhead wires, it should preferably be installed at the least expensive places (e.g. using straight lines) or most meaningful places (e.g. at stops with waiting times or at gradients with a higher energy demand). Most relevant is the time under the overhead wire.

Generally, when the bus drives with low speed under the wire, it increases the charging is time, compared to when it is higher speed. Therefore, it is more cost effective to install In Motion Charging roads on route sections in which lower speeds are used than on higher speed motorways.

Ideally, several routes served by electric buses can be bundled to one In Motion Charging road. This would improve the synergy for several routes sharing the same infrastructure and result in an even more costs effective investment.

COMPARISON WITH OPPORTUNITY CHARGING

Stationary contact charging involves the necessity to stop the vehicle while it is being charged, which means that **the operator is losing time, thus money during forced operational break**. Moreover, it may result in the need to increase the number of vehicles necessary to operate the line. The table presents an example of 4 different charging times for different vehicle sizes when operating a route of 15 km and charging stations are localised at both terminuses.

Heating of the vehicles / overnight battery charging & conditioning possible - Solingen, Germany

VEHICLE'S LENGTH	CHARGING TIME
12 meters	9 min.
15 meters	10 min.
18 meters	12 min.
24 meters	16 min.

Energy consumption: 2,2 - 2,6 - 3,2 - 4 kW/h

The necessity of stopping the vehicle during the time of charging is of critical importance in the event of traffic congestion. They cause a delay in the arrival time to the final stop, which consequently shortens the time left to recharge the vehicle. In the case of stationary contact charging, this may lead to situations where the remaining stop time is too short to charge the vehicle **and may trigger the necessity to use a reserve vehicle**.

2

Nordic Light Rail Association

- Thank you for your attention!

- Thomas J. Potter
  Senior Transportation Engineer
  Norconsult AS – Bergen

e: thomas.potter@norconsult.com
t: +47 95747275