



City of
Ljubljana



CIVITAS FORUM 2015

CIVITAS ANNUAL CONFERENCE | 7-9 OCTOBER 2015 | LJUBLJANA

CIVITAS FORUM 2015, Sesion 7

FULLY ELECTRIC BUS- A FORTHCOMING CONCEPT OF CLEAN AND ENERGY EFFICIENT CITY BUS IN BELGRADE

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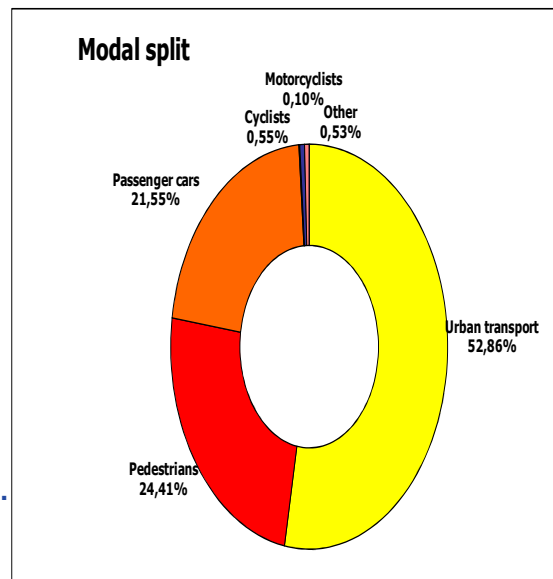
About public transport in Belgrade

CITY OF BELGRADE

- 12 city communities
- area of 133.5 ha
- with app. 1.466.177 inhabitants.

PT OPERATORS:

- JKP GSP –Beograd- 876 vehicles
- Private operators: 387 buses
- Belgrade’s Train “Beovoz” :9 trains
- During a work day, the whole system transports app. 2.100.000 passengers.
- The share of PT in total mobility is 53%.

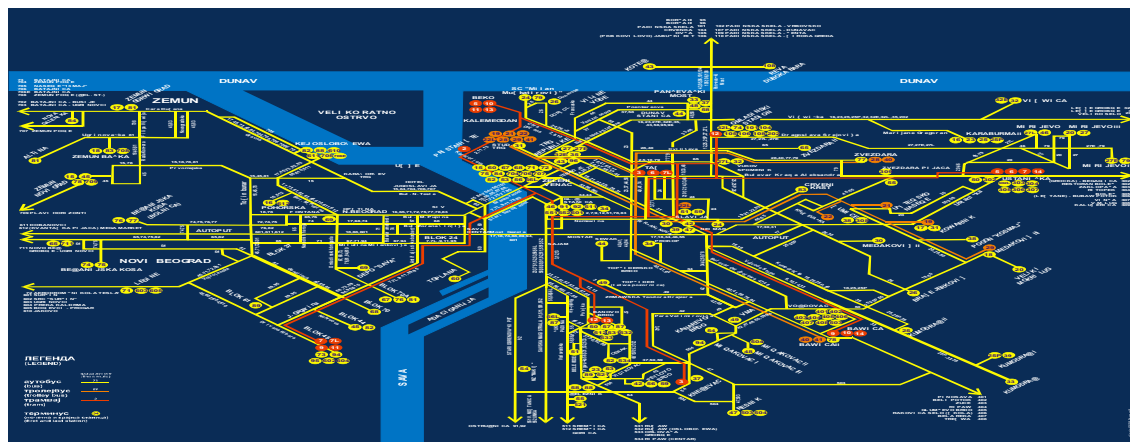


City Public Transport Company “Belgrade”



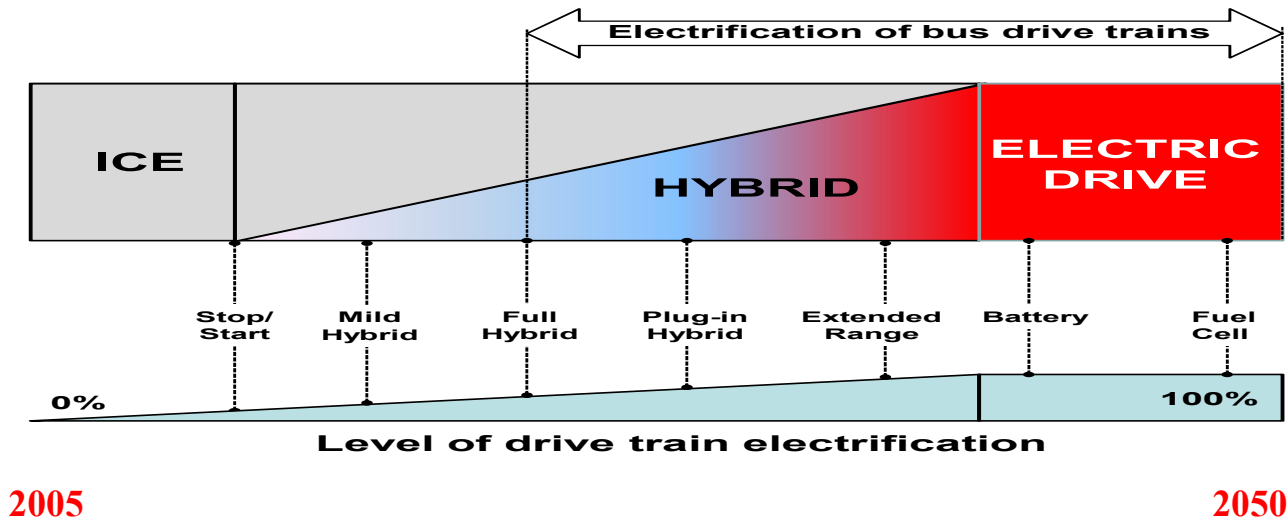
(JKP GSP “Beograd”) is the carrier of the public transportation function in Belgrade

- Tram subsystem (150 trams operating on 11 routes),
- Trolley subsystem (87 trolleys operating on 8 routes),
- Bus subsystem (639 buses operating on 118 routes).
- Daily CPTC “Belgrade” transports about 1,580,000 passengers
- Participation of bus subsystem in achieved transport work is about 70 %



Why E.bus in Belgrade

- Study of a new network of public transport lines in Belgrade, defined introduction of the first line of buses to electric drive.
- Positive an experience of the use of E-bus in many cities
- The first step in a long-term strategy of introducing the zero-emission vehicles



- " 0 " pollution emissions
- lower noise levels
- High energy efficiency
- lower maintenance costs (no oil, ad blue, filters, brake pads ..)

Trial test of E.bus BYD E12 on line No.41



BYD E-12

Technical characteristics of BYD E-12 bus

Length/width/height/... 12000/2550/3360 mm
 Curb weight.....14300 kg
 No. of doors.....3
 Pneumatics.....275/70/R22.5
 Max. speed.....70 km/h
 Electric motorasynchronous AC
 Max. power.....90x2 kW
 Max. torque.....350x2 Nm
 Batteries.....Li FePo4
 Capacity.....324 kWh
 Autonomy.....250 km
 Power of charge.....30x2 kW
 Charging time at the depot.....5



IK-112N (Euro 4)



Trolleybus BKM-321

Bus subsystem	Curb weight (kg)	Average load (%)	AC (off)	
			Recuperation of energy (%)	Energy consumption (kWh/km)
Diesel bus IK-112N (Euro 4)	12,090	40	0	4.82
Trolley BKM-321	11,100	40	15	1.46
BYD E-12	14,300	40 (2.500kg)	25-30	1.24

Possible proposal of the first line in Belgrade with E.bus 1E (Vukov spomenik– Djordja Stanojevića TC “Delta City”)

- The new line, which connects the Old and New Belgrade
- Regeneration of electrical system in New Belgrade
- Line passing through the center of city
- High attraction lines

Line No. 1E				Number E.bus in operation (5)		
Total length (km) (L1+L2)	Driving time (min)	Charging time (min)	Turnaround time (min)	interval (min)	freq. (bus/h)	Q (pass/h)
15,7	50	12 (6+6)	62	12-13	4,8	408



High attraction lines

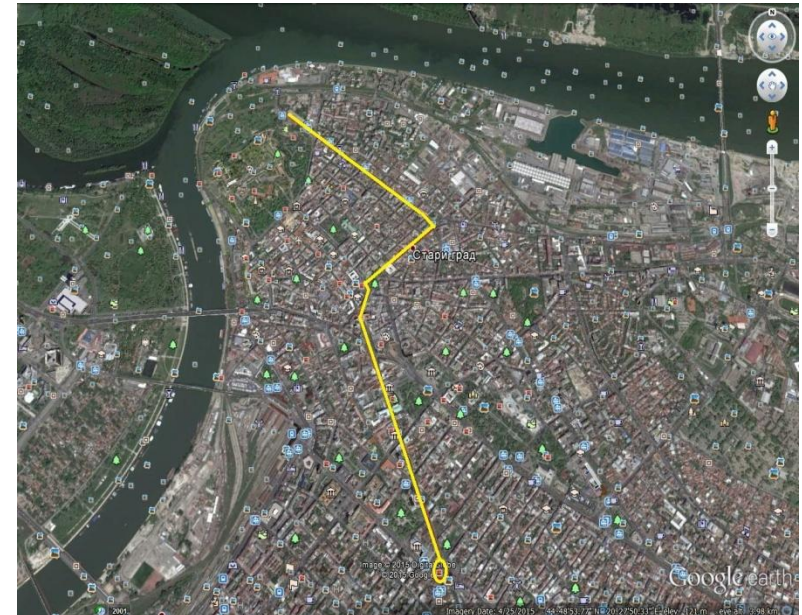


Other proposals of the first line with E.bus

Line 2E: Vukov spomenik – Vladimira Popovića



Line 3E: Slavija - Beko



Our choice of concept charging E.bus

Opportune charge on Terminus via pantograph

- Acceptable charge time
- Ability to connect to the trolleybus and tram contact network (DC), or public distribution electric grid (AC)
- E.bus can work all day (especially important in summer when air conditioning is used as a large consumer)



Storage using super capacitors or Battery (Advantage for UC)

- Principle: Electro static
- High power
- High efficiency 92-98%
- Temperature range: -40 +65 C.
- Short charge on terminal 5-8 min
- The flexibility of the rapid charging and discharging
- Larger lifetime: min 8 years
- Suitability of recycling



Our expectations

- **Start regular exploitation, spring 2016**
- **Promotion of clean and sustainable public transport (environmental benefits, greater attraction of public transport)**
- **Expected average consumption: 1,06 kWh/km (AC-off)**

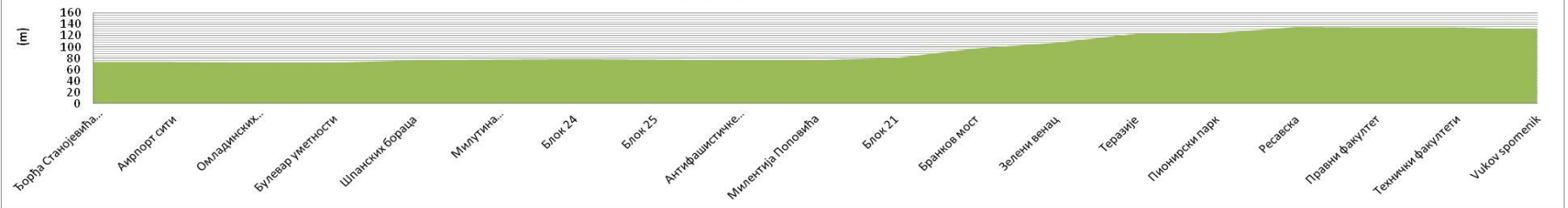
Type of Bus	E-bus (pantograph)	Diesel bus
Annual mileage (km)	80,000	
Consumption of electric power (kWh/100 km)	106	-
Price of electric power (Euro/kWh)	0.07	-
Consumption of diesel fuel (l / 100 km)	-	44
Price of diesel fuel (Euro/l)	-	1.17
Total cost of energy (Euro)	6,944	45,115

- **Saving as a result of the high energy efficiency ,cheaper electricity prices and maintenance. Profitability after 5-6 years.**

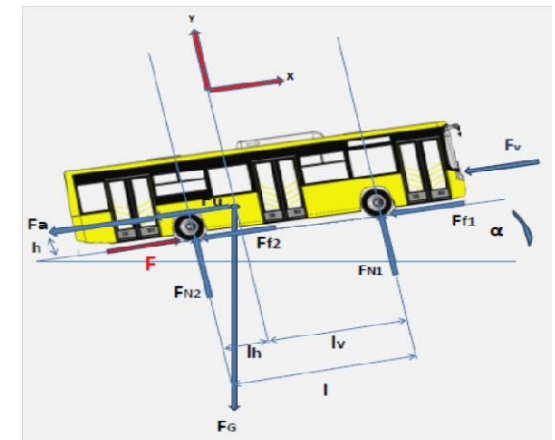
Simulation of operate E.bus on the line No.1E



Topography of the line 1E



Simulation of E-bus (with pantograph charge) on the line No. 1E (peak hour)	Driving between stations	Waiting on the stations	Total
Time (hh:mm:ss)	0:43:18	0:18:37	1:01:55
Mileage (Km)	15.64		15.64
Exploitation speed (Km/h)			15.48
(1)-Consumed energy for vehicle (KWh)	16.77		16.69
(2)-Consumed energy for aux.equipment (KWh)	5.26	1.84	7.08
(3)-Consumed energy for AC-on (KWh)	5.15	2.17	7.14
(1)+(2)			23.77
(1)+(2)+(3)			30.91
Average Consum. Energy (1)+(2) (KWh/Km)			1.520
Average Consum. Energy (1)+(2) (KWh/Km) RECUP (30%)			1.06
Average Consum. Energy (1)+(2)+(3) (KWh/Km)			1.977
Average Consum. Energy (1)+(2)+(3) (KWh/Km) RECUP (30%)			1.4



- **Introduction of fully electric buses into regular exploitation presents a significant qualitative move forward in the public city transportation in Belgrade.**
- **The presented analysis showed that exploitation of electric buses in Belgrade, offered better energy and economic effects of the application compared to the trolleys and especially to the diesel buses**
- **Fully electric buses, proven as ecologically “clean” and energetically efficient vehicles, during the next period, will give growing contribution to sustainable development of the cities, with the ultimate goal that by the 2050 year they will be the primary system of the public transportation .**



Thank you!

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