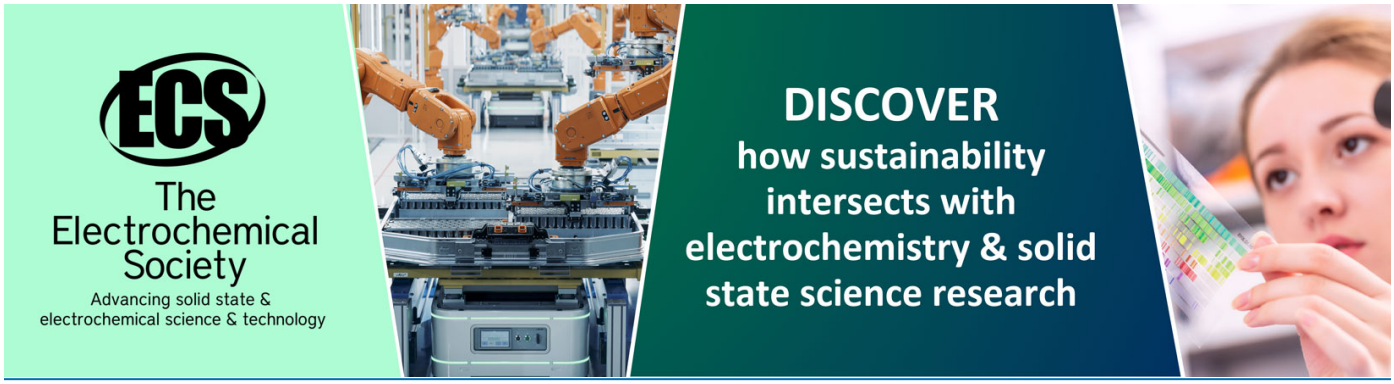
Analysis of the public transport utilization in Lublin



Analysis of the public transport utilization in Lublin

A Zalewska and T Łyszczyk

Lublin University of Technology, ul. Nadbystrzycka 38 D, 20-618 Lublin, Poland

E-mail: annazalewska91@wp.pl

Abstract. Proper public transport vehicles utilization is a key factor in effective and efficient communication in every city. Number of vehicles in use at any point in time is crucial piece of information to both transportation organizers and carriers, since it allows for control and reaction in case of an emergency. This article presents an analysis of public transport vehicles utilization in regard to day of the week and carriers responsible for public transport in Lublin.

1. Introduction

In all public transportation systems subjects responsible for its organization have to ensure effective and efficient vehicles utilization. Key action in this process is preparation of proper timetables and in order to do so, thorough analysis of passenger flows, vehicles transportation capacities and utilization as well as technical details of used routes is necessary. Having those data enables responsible subjects to select suitable vehicles and assign them to teams in the most efficient way. It is crucial for transportation organizers to account for unexpected situations and emergencies like vehicle malfunctions, traffic accidents and higher demand for public transportation services during rush hours. Proper public transport organization should be based on data that can be accessed and analysed in regard to specific hour, day of the week, vehicle type, carrier and line. Introduction of such software ensures high quality of provided services and efficient use of vehicles.

2. Public transport organization in Lublin

Public transportation system in Lublin consists of two subsystems: bus subsystem and trolleybus subsystem. As far as number of vehicles is concerned, Municipal Transport Company has the biggest bus fleet. Additionally, it has been aided by Public Transport Authority that donated 70 trolleybuses (including 12 articulated) and 100 different buses. This undertaking was accomplished within Operational Programme Eastern Poland 2007 – 2013.

Current state of Lublin public transportation system fleet vehicles:

- 20 MIDI-class vehicles (presented on figure 1) - donated by Public Transport Authority in Lublin [6]

Figure 1. Autosan Sancity 9LE 9 m bus (with Public Transport Authority branding)

- 142 MAXI-class vehicles (presented on figure 2) - this group includes 53 vehicles donated by Public Transport Authority in Lublin, 9 vehicles owned by Lublin Bus Lines and Agnieszka Kowalczyk-Skęczek TRAF Line Consortium and 11 vehicles owned by Warbus Ltd.

Figure 2. Mercedes Conecto LF 12 m bus (with Public Transport Authority branding)

- 12 – 15 m buses owned by Municipal Transport Company Lublin
- 96 MEGA-class vehicles (presented on figure 3) - this group consists of 55 vehicles owned or leased by Municipal Transport Company Lublin, 18 owned by IREX-1 Consortium, 22 owned by Warbus Ltd.

Figure 3. Mercedes Citaro 18 m bus (with Public Transport Authority branding)

All trolleybuses used in public transportation system in Lublin are owned by Municipal Transport Company Lublin. Fleet consists of:

- 96 – 12 m trolleybuses (presented on figure 4) - including 56 donated by Public Transport Authority in Lublin [6].

Figure 4. Ursus E70110 12 m trolleybus (with Public Transport Authority branding)

- 12 – 18 m trolleybuses (presented on figure 5)

Figure 5. Solaris Trollino 18 m trolleybus (with Public Transport Authority branding)

It is worth mentioning that in trolleybus fleet 20 vehicles are equipped with additional propulsion system based on conventional, internal combustion engine and rest has traction batteries enabling them to travel distances up to 5 km.
All the vehicles used in public transportation system in Lublin are shown in table 1 with regard to type of vehicle, vehicle length and carrier.

Table 1. Public transportation in Lublin fleet vehicles

Carrier	Bus		Trolleybus	
	Vehicle length	Number of vehicles	Vehicle length	Number of vehicles
Municipal	9 m	20	~	~
Transport	12 m	142	12 m	96
Company	15 m	12	~	~
Lublin	18 m	55	18 m	12
IREX-1	18 m	18	~	~
LLA	12 m	9	~	~
Warbus	12 m	11	~	~
	18 m	22	~	~
TOTAL		275		108

At the beginning of 2017 additional contracts for vehicle leasing were signed and as a result in 2018 bus fleet will be expanded with following vehicles:

- 9 Solaris articulated buses - bought within Operational Programme Eastern Poland 2014 – 2020;
- 6 Solaris articulated buses - ought within Operational Programme Eastern Poland 2014 – 2020 (different project);
- 8 – 12 m URSUS buses - bought within Operational Programme Eastern Poland 2014 – 2020;
- 15 URSUS articulated trolleybuses - bought within Operational Programme Eastern Poland 2014 – 2020;

Several new public procurement offers are planned for 2018 in order to acquire following vehicles:

- 10 – 12 m trolleybuses - co-funded within Operational Programme Eastern Poland 2014 – 2020;
- 20 electric buses - co-funded within Operational Programme Eastern Poland 2014 – 2020;
- 7 electric buses - co-funded within Operational Programme Eastern Poland 2014 – 2020 (different project);
- 5 electric buses - co-funded within Operational Programme Eastern Poland 2014 – 2020 (different project);

Delivery of mentioned buses is scheduled for 2019 - 2020 [3].

Vehicles scheduled for delivery in 2019-2020 are shown in table 2 with regard to vehicle type, vehicle length and carrier.

Table 2. Vehicles scheduled for delivery in 2019 - 2020

Carrier	Bus		Trolleybus		Notes
	Vehicle length	Number of vehicles	Vehicle length	Number of vehicles	
Municipal Transport Company Lublin	12 m	10	~	~	Lease from URSUS BUS Ltd.
Public Transport Authority	12 m (electric buses)	32	12 m	10	Purchase co-funded by EU.

3. Public transport vehicle selection

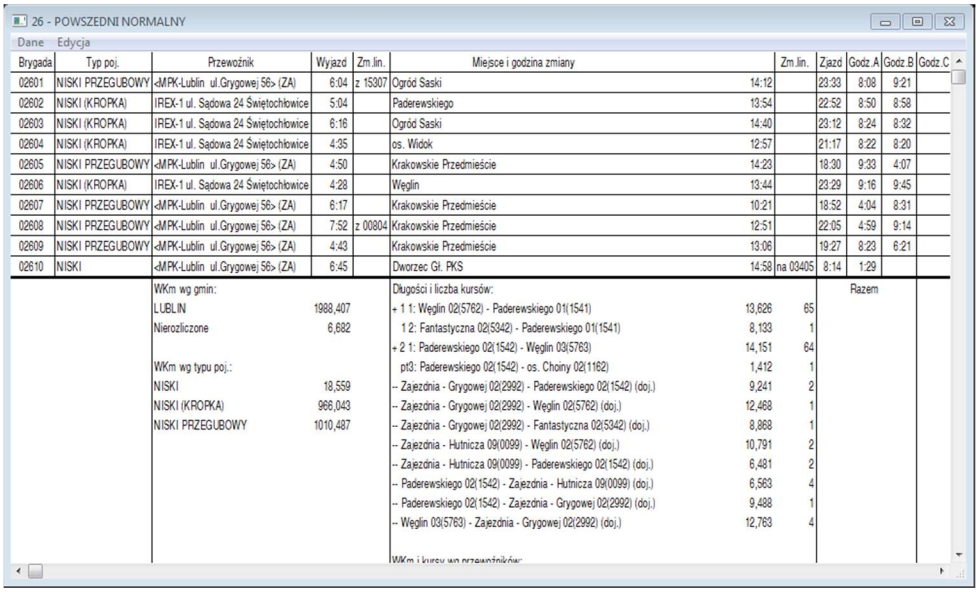
Since Public Transport Authority is responsible for public transportation organization in Lublin, one of its main goals is to appropriately assign vehicle to bus lines. Key factor taken into consideration during this process is size of passenger flows. They are analysed based on vehicles transportation capacities and passenger surveys. Data gathered in this process allows for proper vehicle assignment that meets passenger expectations. It is important to analyse passenger flows as often as possible so that gathered data is fresh and relevant. Thanks to trolleybus traction system development and trolleybuses with additional propulsion system it is possible to increase trolleybuses share in public transportation system. Moreover, when organizing public transport, Public Transport Authority has to take into consideration number of vehicles owned by contracted carriers as well as details of those contracts specifying how vehicles can be utilized. In order to meet financial expectations articulated buses are being replaced with regular, 12 m buses. Currently, such a bus after finishing one transportation task does not return to depot, but is redirected to operate on a different line as a replacement for an articulated bus. This solution decreased usage of longest vehicles during in early mornings and late evenings. On the other hand it introduced a change to drivers shifts. Another challenge connected with planning a transportation system is covering mass events, for instance Students Culture Days, organized annually. This is specifically important in Lublin known for its academic appeal. Mass events typically generate large passenger flows is narrow time windows. In order to cope with those issues additional articulated buses are directed to operate on heavily used lines. [5]

Public Transport Authority uses AGC BusMan Software when planning and preparing timetables. This program, dedicated to public transportation organizers, allows for monitoring and management of public transportation. It is used in around 50 companies in Poland.

Timetables prepared in AGC BusMan serve as work schedules for carriers and drivers. From a passenger point of view they are the main source of information about public transportation service. Timetable is a document prepared for every route variant containing times of departure from every start bus stop. Timetables are prepared for both weekdays and weekends, as well as special holidays. Timetable also serves as a basis for vehicle usage planning on a given line. Series of courses on a given line are grouped in a team. Within this team drivers change can occur, but planned vehicle change is described as a team change. [2]

Key factor in providing the best service possible is appropriately matching vehicles transportation capacities with passenger demand. To meet this requirement, only vehicle with large enough capacity should be assigned to operate on lines with known demand (not higher than vehicle capacity). For instance, in case of an emergency or a vehicle failure, substitute vehicle deployed as a replacement should not be of lower capacity than the original one. Carrier should also address changes in traffic intensity throughout the day by reassigning vehicles with different capacities to operate on different lines. This way teams with comparable transportation load are grouped in transportation tasks. [1]

Moreover, a team work load report can be prepared in AGC Busman. Such a report allows for analysis of vehicle utilization data in relation to work day and also acts as a summary of workload for a given bus line. It contains: line number and team number, vehicle type operating on this line, carrier name, start and end time of each team. [2] Sample report from AGC BusMan is presented on figure 6.



26 - POWSZEDNI NORMALNY

Dane Edycja

Brygada	Typ poj.	Przewoźnik	Wyjazd	Zm.lin.	Miejsce i godzina zmiany		Zm.lin.	Zjazd	Godz.A	Godz.B	Godz.C
02601	NISKI PRZEGUBOWY	<MPK-Lublin ul.Grygowej 56> (ZA)	6:04	z 15307	Ogród Saski	14:12		23:33	8:08	9:21	
02602	NISKI (KROPKA)	IREX-1 ul. Sądowa 24 Świętochłowice	5:04		Paderewskiego	13:54		22:52	8:50	8:58	
02603	NISKI (KROPKA)	IREX-1 ul. Sądowa 24 Świętochłowice	6:16		Ogród Saski	14:40		23:12	8:24	8:32	
02604	NISKI (KROPKA)	IREX-1 ul. Sądowa 24 Świętochłowice	4:35		os. Widok	12:57		21:17	8:22	8:20	
02605	NISKI PRZEGUBOWY	<MPK-Lublin ul.Grygowej 56> (ZA)	4:50		Krakowskie Przedmieście	14:23		18:30	9:33	4:07	
02606	NISKI (KROPKA)	IREX-1 ul. Sądowa 24 Świętochłowice	4:28		Węglin	13:44		23:29	9:16	9:45	
02607	NISKI PRZEGUBOWY	<MPK-Lublin ul.Grygowej 56> (ZA)	6:17		Krakowskie Przedmieście	10:21		18:52	4:04	8:31	
02608	NISKI PRZEGUBOWY	<MPK-Lublin ul.Grygowej 56> (ZA)	7:52	z 00804	Krakowskie Przedmieście	12:51		22:05	4:59	9:14	
02609	NISKI PRZEGUBOWY	<MPK-Lublin ul.Grygowej 56> (ZA)	4:43		Krakowskie Przedmieście	13:06		19:27	8:23	6:21	
02610	NISKI	<MPK-Lublin ul.Grygowej 56> (ZA)	6:45		Dworzec Gł. PKS	14:58	na 03405	8:14	1:29		

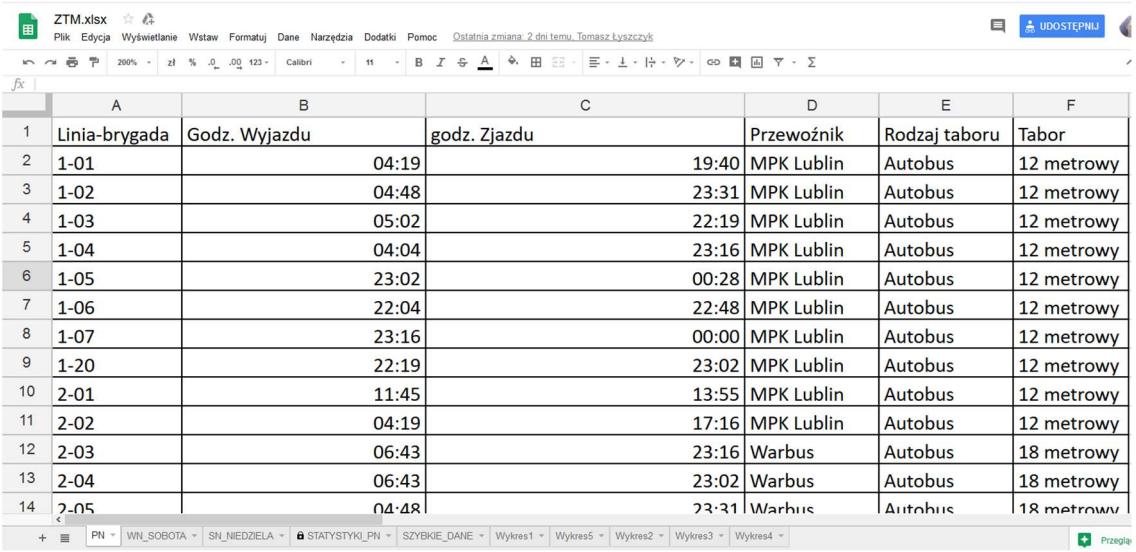
WKm wg gmin:	
LUBLIN	1988,407
Nierozliczone	6,682
WKm wg typu poj.:	
NISKI	18,559
NISKI (KROPKA)	966,043
NISKI PRZEGUBOWY	1010,487

Długości i liczba kursów:		Razem
+ 1 1: Węglin 02(5762) - Paderewskiego 01(1541)	13,626	65
1 2: Fantastyczna 02(5342) - Paderewskiego 01(1541)	8,133	1
+ 2 1: Paderewskiego 02(1542) - Węglin 03(5763)	14,151	64
pt3: Paderewskiego 02(1542) - os. Choiny 02(1162)	1,412	1
-- Zajezdnia - Grygowej 02(2992) - Paderewskiego 02(1542) (doj.)	9,241	2
-- Zajezdnia - Grygowej 02(2992) - Węglin 02(5762) (doj.)	12,468	1
-- Zajezdnia - Grygowej 02(2992) - Fantastyczna 02(5342) (doj.)	8,868	1
-- Zajezdnia - Hutnicza 09(0099) - Węglin 02(5762) (doj.)	10,791	2
-- Zajezdnia - Hutnicza 09(0099) - Paderewskiego 02(1542) (doj.)	6,481	2
-- Paderewskiego 02(1542) - Zajezdnia - Hutnicza 09(0099) (doj.)	6,563	4
-- Paderewskiego 02(1542) - Zajezdnia - Grygowej 02(2992) (doj.)	9,488	1
-- Węglin 03(5763) - Zajezdnia - Grygowej 02(2992) (doj.)	12,763	4

Figure 6. Team data report generated by AGC BusMan

4. Vehicle selection process analysis

Vehicle selection process analysis is based on usage of data generated from AGC BusMan. It contains: line number and team number, vehicle type operating on this line, carrier name, start and end time of each team. Based on this data another program (shown on figure 7) that groups data into days, was developed by authors. It counts all vehicles in use at any particular point in time based also on carrier, vehicle length and line assignment. This provides additional statistical results which are useful in vehicle utilization analysis and public transport management.



ZTM.xlsx

Plik Edycja Wyświetlanie Wstaw Formatuj Dane Narzędzia Dodatki Pomoc Ostatnia zmiana: 2 dni temu, Tomasz Łyszczyk

UDOSTĘPNIJ

	A	B	C	D	E	F
1	Linia-brygada	Godz. Wyjazdu	godz. Zjazdu	Przewoźnik	Rodzaj taboru	Tabor
2	1-01	04:19	19:40	MPK Lublin	Autobus	12 metrowy
3	1-02	04:48	23:31	MPK Lublin	Autobus	12 metrowy
4	1-03	05:02	22:19	MPK Lublin	Autobus	12 metrowy
5	1-04	04:04	23:16	MPK Lublin	Autobus	12 metrowy
6	1-05	23:02	00:28	MPK Lublin	Autobus	12 metrowy
7	1-06	22:04	22:48	MPK Lublin	Autobus	12 metrowy
8	1-07	23:16	00:00	MPK Lublin	Autobus	12 metrowy
9	1-20	22:19	23:02	MPK Lublin	Autobus	12 metrowy
10	2-01	11:45	13:55	MPK Lublin	Autobus	12 metrowy
11	2-02	04:19	17:16	MPK Lublin	Autobus	12 metrowy
12	2-03	06:43	23:16	Warbus	Autobus	18 metrowy
13	2-04	06:43	23:02	Warbus	Autobus	18 metrowy
14	2-05	04:48	23:31	Warbus	Autobus	18 metrowy

PN WN_SOBOTA SN_NIEDZIELA STATYSTYKI_PN SZYBKIE_DANE Wykres1 Wykres5 Wykres2 Wykres3 Wykres4

Figure 7. Developed software and data it contains

Using mentioned software it is possible to assess number of vehicles in use owned by a particular carrier at any point in time. Table 3 presents results for morning and evening rush hours (8:00 and 16:00 respectively). Additionally it is possible to assess number of vehicles in use during whole day.

Table 3. Number of vehicles in use by carriers

Carrier	Number of vehicles in use at 8:00		Number of vehicles in use at 16:00	
	Buses	Trolleybuses	Buses	Trolleybuses
Municipal Transport Company Lublin	274	83	278	84
IREX-1	16	~	16	~
LLA	6	~	8	~
Warbus	30	~	30	~
TOTAL	326	83	332	84

Following figures present charts generated using developed software. Figures from 8 to 11 present number of vehicles in use with regard to carrier, week day, vehicle type and line. What appears to be a noise on those charts are changes in the number of vehicles is use which is always an integer number.

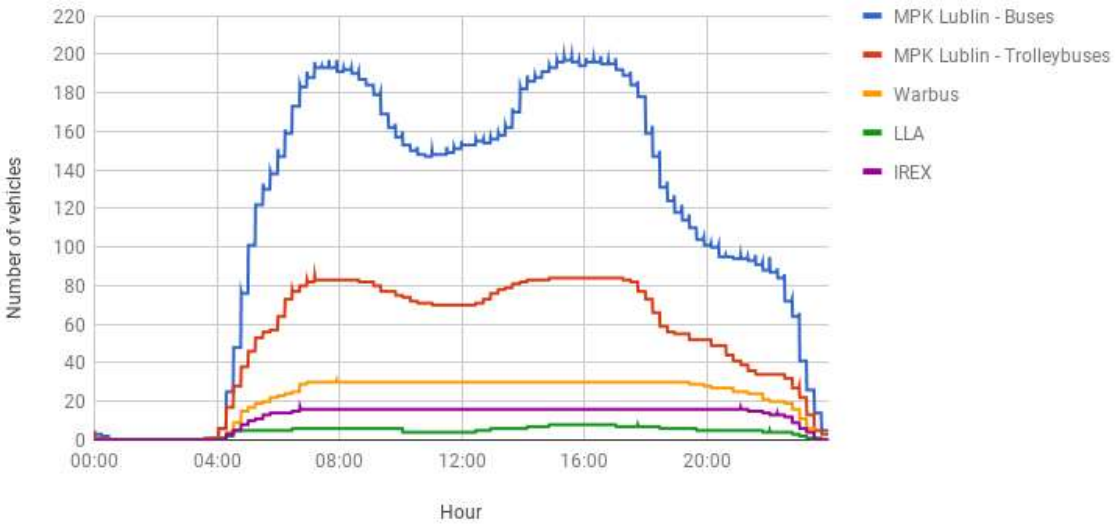


Figure 8. Number of vehicles in use by carriers

Figure 8 above shows number of vehicles in use during the day by carriers (on weekday). It clearly shows disproportion between vehicles owned by Municipal Transport Company Lublin and those owned by other, contracted carriers. Additionally, morning and evening rush hours are clearly visible - highest number of vehicles are deployed to operate during those hours.
Developed software also allows for comparison of number of vehicles in use during weekday as well as Saturday and Sunday. Figure 9 presents this relation.

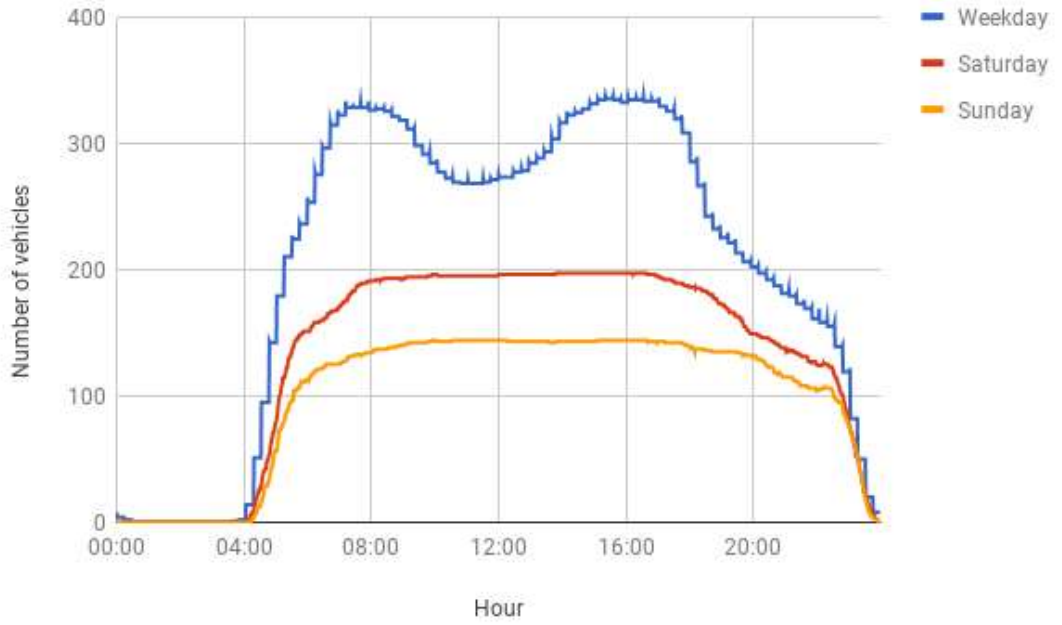


Figure 9. Number of vehicles in use during weekday, Saturday and Sunday

Figure 10 presents relation between hours and type of vehicles in use. It is possible to assess that public transportation system in Lublin owns 96 12 m trolleybuses, but only 74 vehicles are in use on weekdays. It means that 22 vehicles are treated as backup. Similarly, from 12 articulated trolleybuses, only 10 are in use between 7:00 and 20:00. Following the same principle only 79 of 115 articulated buses are in use on weekdays and 150 of 162 12 m buses. Last numbers relate to rush hours on weekdays.

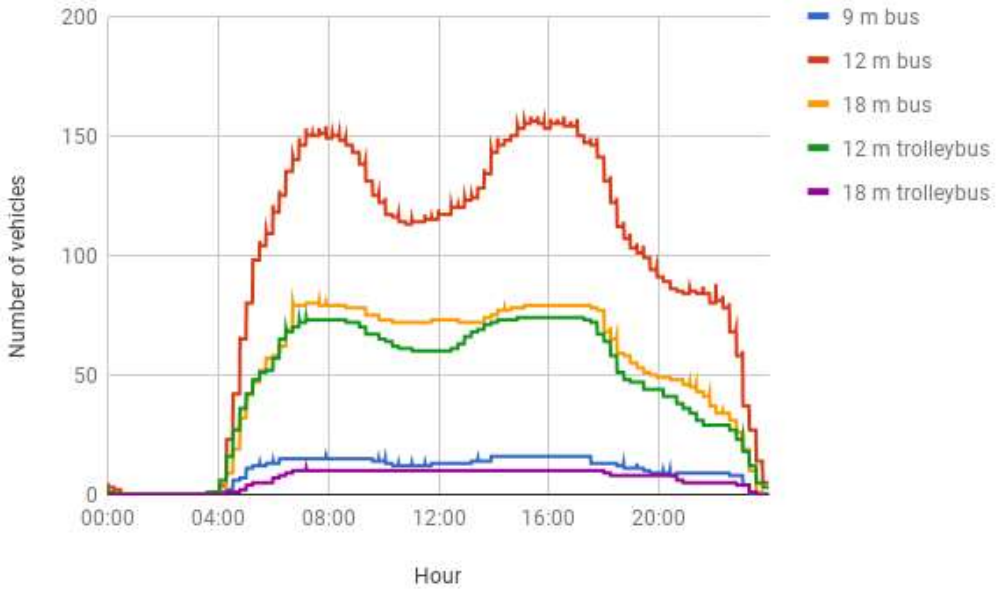


Figure 10. Number of vehicles in use by vehicle type

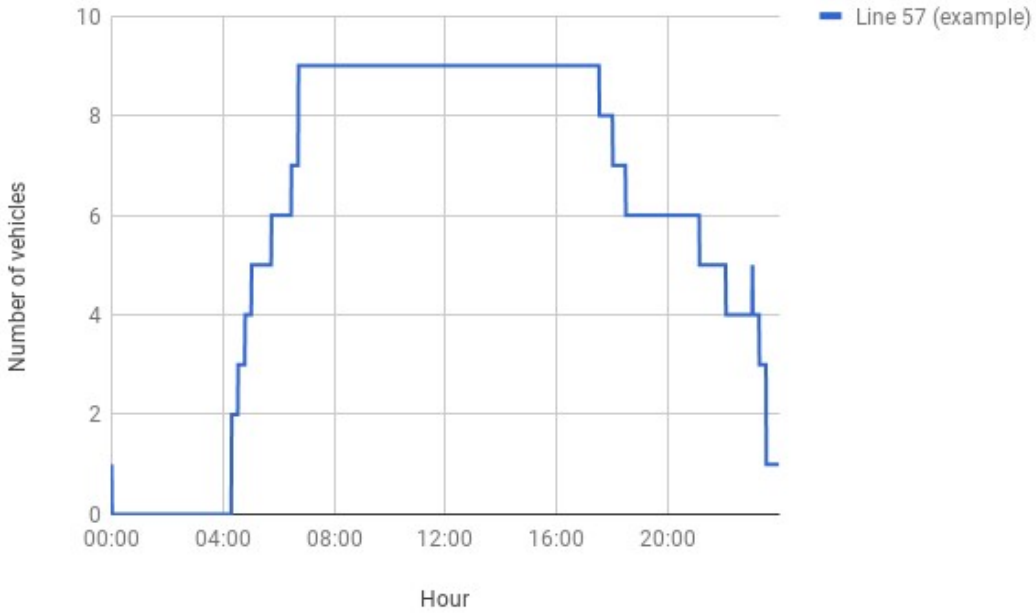


Figure 11. Number of vehicles in use by line

Finally, developed software allows for analysis of vehicles in use by line they operate on (presented on figure 11).

5. Conclusions

Analysis of vehicle selection process presented in last chapter is vital for public transport organizers - Public Transport Authority in case of Lublin. It is useful because it allows for vehicle usage analysis, comparison to what is planned including backup vehicles. Additionally, it allows for clearly presenting gathered data on charts depending on set variables. Such an analysis allows for optimization of vehicle usage that in turn is beneficial to both passengers and organizers and ensures higher quality of service delivered to passengers.

References

[1] Bryniarska Z, Starowicz W, *„Wyniki badań systemów publicznego transportu zbiorowego w wybranych miastach”* wyd. PiT, Kraków 2010 r.
[2] Madej B, Pruciak K, Madej R *„Publiczny Transport Miejski Zasady tworzenia rozkładów jazdy”* wyd. Akademia Transportu i Przedsiębiorczości Sp. z o.o., Warszawa 2015
[3] Materiały własne ZTM w Lublinie
[4] www.mpk.lublin.pl
[5] Zalewska A *„Dobór środków transportu zbiorowego do linii komunikacyjnych w mieście Lublin”* Czasopismo Autobusy – Technika, Eksploatacja, Systemy Transportowe – 2017 nr 6
[6] Zalewska A *„Wpływ środków Unii Europejskiej na rozwój transportu zbiorowego w Lublinie”* Czasopismo Transport Miejski i Regionalny 4/2016