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TENDENCIES OF DEVELOPMENT OF GLOBAL BATTERY MARKET WITH EMPHASIS ON REPUBLIC OF CROATIA

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ABSTRACT

Starter and traction batteries are build in vehicles with internal combustion engine or electric engine. Similar, stationary batteries supply power to communication or computer centres. The use of these products indicates the specific market for them, because the battery producer is not often in connection with the final consumer, almost always there is someone between them, connecting them. Thus, between the user and the battery manufacturer intermediate distributors, service installations in which this product are build in or vehicle producers (OEM – original equipment of the manufacturer, first installation of the starter battery).

Battery production is a strategic industry branch, because starting a vehicle depends on the availability of fuel and the availability of the starter or traction batteries. This paper contains a review of the battery manufacturing industry, as a industry branch, on global and Croatian market.

The development has been reviewed by the structure, but also by the sources of applied technologies, especially modern technologies. The paper has been focused mainly on the development of Croatian battery industry and its only representative, company Munja d.d. Zagreb. Beginnings of the Munja d.d. company are correlated with the beginnings of the automobile industry at all.

Business activity of any company cannot be considered in isolation from the environment. Therefore, the business of the Munja d.d. company has been observed with regards to the technological development in the last century, but compared to other battery manufacturers, in the former two common states, and also compared with the world manufacturers.

KEY WORDS

battery industry, the global market, Republic of Croatia, production, consumption

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INTRODUCTION

Very few activities in human history have in such a short time played such a significant role and changed the world and human surroundings by so much, as the automotive industry has done.

The eternal pursuit of man to move, has gained a full affirmation with the discovery of the device that will be called the engine, and with the invention of the internal combustion engine in the last decades of the nineteenth century, the era of the automotive industry and motor sports has begun.

Man's constant need for transportation aligned the automotive industry into one of the most important industries of the world, with an invaluable influence on the development and viability of other branches of industry such as: rubber industry, glass, plastics, paints and varnishes, electronic industry, and especially on the industries of petroleum products, motor fuels and oils.

Without the automotive industry road development would be unthinkable, and therefore part of the construction industry as well, the number and type of motor vehicles (both cars and trucks and heavy machines) determines a country's level of development and the standard of its population. The intense development of the automotive industry "dragged" along with it the development of spare parts of the car (auto components), as well as machines for the automotive industry.

Due to political flops and failures, especially in the last twenty years, the Republic of Croatia does not have its own car manufacturing. However, this does not mean that there is no production of auto components and spare parts. One of the main components in a motor vehicle, without which a motor vehicle can not be started nor be in operation, is the starter battery. In literature the croatian word for a starter battery is "akumulator" (SLI battery – start, light, ignition).

The aim is to show trends and the expected direction of global and Croatian battery market development. The work is largely focused on the development of the Croatian battery industry and its sole representative, the company Munja d.d.

The origins of this business enterprise correlate with the beginnings of the automobile industry in general. The business activity of any company cannot be observed in isolation. Therefore, the business of the Munja d.d company has been observed with regards to the technological development in the last century, but compared to other battery manufacturers, in the former two common states, but also with the world's battery manufacturers.

The paper contains an outline of the development of the battery industry depending on: (1) the state of the market of basic raw materials, ie, lead and environmental protection, (2) the market potential of production and sales, and (3) present trends in the global and domestic battery market stemming from development demand.

Through the work the main facts are pointed out which marked past events related to the battery industry, which determines the present and greatly affects the future of this branch of the automotive industry. In particular, the problems and gaps through which the production of batteries in Croatia have gone through, were analyzed, and despite all the obstacles the production is still successfully operating for 92 years. Today's successful business Munja d.d. company is a pledge for the future, which is especially important in a crisis period of high unemployment.

TRENDS OF THE GLOBAL BATTERY MARKET

The manufacture of accumulators followed the development of vehicles (cars and commercial vehicles) in the world. By the II. World War production was significantly smaller

in volume compared to the period after the war, especially towards the end of the 20th and beginning of the 21st century when it experienced an expansion. The rapid development of the automotive industry increases the need for lead-acid batteries and the development of telecommunications and information industries further stimulate demand, development and manufacture of various types of batteries.

It is believed that during the 20th century the lead-acid battery had one of the largest global growth rate. On the market of car makers there is a limited number of vehicle manufacturers. However, the number of battery manufacturers, especially starter batteries, is several thousand worldwide. The exact number of battery manufacturers is nearly impossible to determine because there are no accurate records and statistics. Therefore, it is very difficult to determine the exact number of batteries produced and sold, in some regions of the world it is relatively simple, because they keep statistics, while in other regions there is no baseline data. It is also significant that the globalization process has been a clustering of companies – manufacturers of batteries and accumulators in such a way that large companies strategically took over the smaller ones.

When it comes to batteries differ the following types: (i) primary batteries that do not recharge and after use, that is, discharge can be recycled or disposed of as waste; (ii) secondary batteries include various types of batteries that after discharge can be recharged or expanded. Secondary batteries are the following types: nickel metal hydride, lithium ion batteries (eg mobile phones) and lead acid batteries.

Lead-acid batteries are subdivided into automotive starter batteries-acumulators, traction batteries and stationary batteries. The largest companies in the production of automotive batteries in the world market in the year 2010 are shown in Table 1.

In Table 1 , the country of origin of the manufacturer is indicated, and its factories are located around the world. World Battery Market 2010th totaled 60 billion USD and includes primary and secondary batteries. It is estimated that the total turnover of primary batteries accounted for 18.5 billion USD, while the secondary batteries had a total turnover of 41.5 billion USD in the year 2010. Therefore, it is evident that the value of the market for lead acid battery is almost 1.5 times higher than the total value of primary batteries. This data does not include batteries for military and special purposes for which there is no publicly available data.

Introduction of a new concept of zero-emission pollution in the West, has opened the way for the development of electric vehicles (EV) and hybrid electric vehicles (HEV). An increase in the use of lead-acid batteries is expected with further technological advances in the market of electric cars. Although efforts to create a “miracle battery” for electric vehicles, lead-acid batteries are one of the few technologies that is considered the “workhorse” of today’s fleet of electric vehicles.

Table 1. The world’s largest manufacturers of automotive batteries in the year 2010 [11].

Manufacturer	Country	Production, mil. pieces	Market share, %
Johnson Controls	Milwaukee, USA	135	35
GS Yuasa	Kyoto, Japan	31	8
Exide Technologies	Milton, USA	26	7
East Penn	Pennsylvannia, USA	22	6
Exide Industries	India	12	3
Camel	Xiangfan, China	12	3
Fengfan	Zheijang, China	12	3

Placement of the battery market is focused on two important parts. The first part refers to the market of Original equipment of manufacturer (OEM) (in Croatia usually called "First installation") that consists of manufacturers of motor vehicles that immediately install batteries in vehicles during the time of their production. The second part relates to the market "Second installation", which makes replacing worn discharged batteries, after the vehicle is already in use.

It is believed that the market for lead-acid batteries-acumulators, had one of the highest rates of growth, and hence consumption, until the year 2008. The global crisis that occurred in 2009, after the financial sector, the most affected sector was of the automobile industry, and hence the battery industry.

Table 2 shows the total sales of automotive batteries in the year 2010 by region through both markets, that is, the market for first installation (OEM) and the second installation (replacement). In doing so, we want to emphasize that it is almost impossible to determine the exact number of batteries produced and sold in the world, these are estimated figures. Other countries include South America, Africa, India and the Russian Federation.

It can be concluded that the market for lead acid batteries was hit hard by the global economic deceleration. Needs on a global level recorded a heavy fall of over 8 % in 2009 in comparison of the previous year. The OEM market was severely affected (reduction of 12 %), because of the significantly decreased sales of new cars.

Several car companies have introduced a decrease in production in the struggle with reduced requirements for new vehicles. Car production in major markets (USA, Europe, China) remained at negligible levels during the downturn, leading to significant saturation of the OEM market. On the market for replacement batteries traders have also reduced stocks in order to overcome the situation of reduced customer interest. Battery manufacturers are also faced with the challenges of volatile prices of lead and other raw materials on the fluctuating metal market. The turning point in the market is primarily dependent on the revival of the automotive sector and the growth of sales of passenger and commercial vehicles.

The European market in 2010 was at the level of 2009, but predictions are that there will be an increase in OEM and an overall growth at 1 % – 2 % in the period of 2011-2013 Due to the increased quality of the battery, we expect a slight drop in demand for replacement batteries. There was an increase of 9 % in 2010 in relation to the year 2009 in the United States. Predictions are that it will reach 3 % growth until the year 2013 with a stronger recovery of OEM market.

China is growing very strongly on the level of 8 % to 10 % per year. A large increase was recorded in production capacity due to the introduction of continuous development of plates and the full automation of the assembly, but the pressure due to the introduction of environmental

Table 2. Automotive batteries market 2010 – sales by region [11].

Region	First installation, mil. pieces	Replacement, mil. pieces	Total, mil. pieces
Western Europe	14	33	47
Eastern Europe	3	14	17
North America	15	105	120
Asia – Pacific	28	122	150
Other countries*	10	41	51
In total	70	315	385
In total, %	18	82	100

*Other countries: South America, Africa, India, Russian Federation.

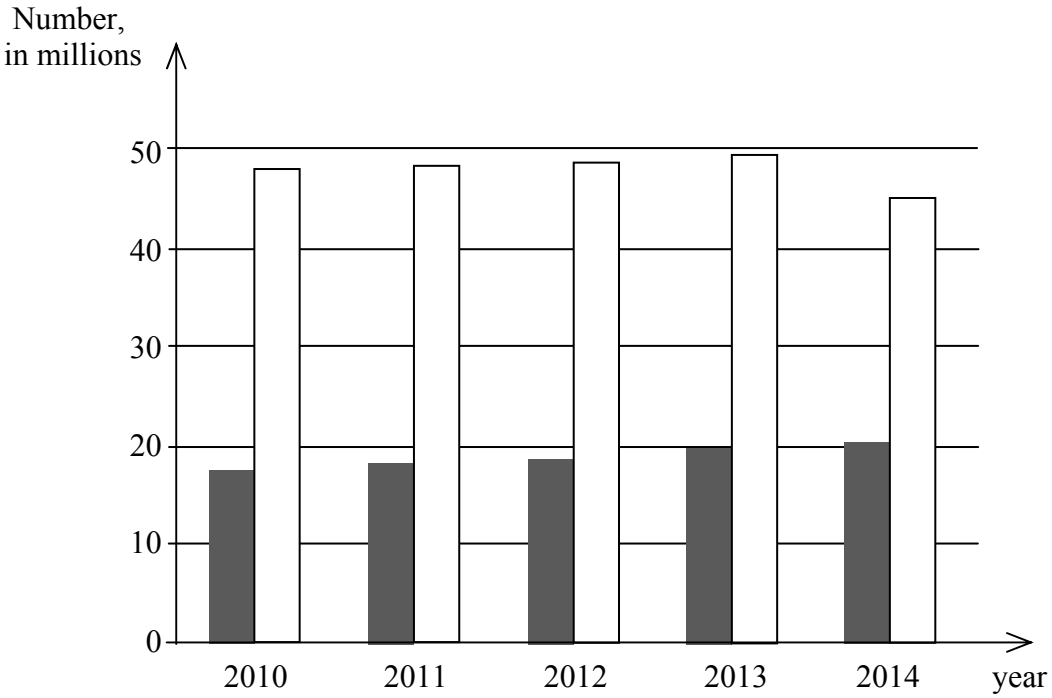

Figure 1. Indicators of the European market for automotive batteries – numbers for 2010 and predictions for 2014, adapted from [4]. Grey bars denote "First installation" and white bars "Second installation".

protection standards certainly has its diminishing influence. In addition to nearly 2000 battery manufacturers, China has about 1000 plants for the recycling of waste batteries.

Production is growing in other parts of the world. Continued improvement of battery life with a better design and new electrical systems in vehicles: 5 – 6 years in areas with temperate climates, but 2 – 3 years in hot climates.

CROATIAN BATTERY MARKET TRENDS

At the beginning of this section, it is important to emphasize the basic characteristics of the Croatian market battery. Munja d.d. company is the only manufacturer of batteries and acumulators in Croatia. The factory has been operating since the foundation of the industry to date. It is one of the oldest manufacturers of these products, both in Europe and in the world, with sustained production from its inception to the present. In addition to the company no one has ever produced in Croatia, nor produces batteries and acumulators.

Regardless of the two wars (World War II and the Homeland War) through which it passed, Munja d.d. never ceased with the complete production cycle, except in the period 2009-2010 as the result of the "gas crisis".

The Croatian battery market, from a position of production, and from a position of spending will inevitably be viewed through two periods: (i) the first period: up to the year 1990 and the independence of the Republic of Croatia, and (ii) the second period: from the year 1990 to date.

The following subsections describes the characteristics of these two periods.

PERIOD UP TO 1990

Manufacture of accumulators in this period is shown in Table 3. In the period between 1920 to 1945, Munja d.d. is the only manufacturer of these products in the Kingdom of Yugoslavia,

and thus also in Croatia, although in Maribor (Slovenia) there was a workshop "Vesna", which is mainly engaged in installing the battery, not the production.

After 1945 and the nationalization up to 1958, beside Munja and Vesna (which still has only negligible production and assembly) nobody else in Yugoslavia produced batteries [8]. The characteristic of this period is that a complete nationalization of the economy was made and that everything was socialized.

There was no market economy, just a fully planned economy. By the directed and planned economy towards the end of the 50s and early 60s of the last century battery factories and batteries are being built in each republic of the former Yugoslavia, and whose head is just Munja d.d.

The following Table 3 gives a comprehensive overview of battery production in the period from 1939 up to 1983. The only possible data was used for the year 1939 and the period from 1946 to 1983.

In the period of the Second World War, Munja has consistently had a production in this period and it was predominantly for military purposes. Significant production in Yugoslavia begins, as it can be seen from Table 3, after the year 1968.

For this period the following fact is very important. In this period of time there is a restoring and nationalization of diplomatic relations between Yugoslavia and the USSR, and therefore with the other countries of the then CMEA. By political normalization, economic cooperation between these parties was established. Yugoslavia is more and more economically "turning" toward these countries, exporting a variety of goods and final products to that area, and importing energy and military equipment (the Cold War era).

An intensive economic cooperation is established between Yugoslavia and other CMEA countries, and predominantly with the former USSR, but not the "classic" export or import, but through trade, or through so-called "barter arrangements" and the first clearing of import-export transactions, which are systematically arranged at state level [10]. These matters also referred to the export of batteries and Munja d.d. achieved significant exports during this period. These arrangements are held until the dissolution of CMEA, that is, dissolution of the Yugoslavia and the USSR at the beginning of the nineties. As noted, Munja d.d. had a dominant and leading role in production in the former state up to the year 1970 and the famous political events in Croatia, after which there is a significant stagnation of Munja d.d.

It is also important to emphasize that, in the period from 1945 up to 1990 battery imports were banned in Yugoslavia. Exports took place only on the clearing market by the beginning of the 70s, until the collapse of CMEA countries and the USSR. After that the first export contracts to Western markets begin, due to events in 1971 and then the production for the YPA.

PERIOD FROM 1990 TO TODAY

This period is necessary to observe in two parts: (i) The period from 1990 to the year that includes the dissolution of Yugoslavia and the Homeland War and post-war period until year 2000, and (ii) after the period in year 2000 and times of global crisis after the year 2009. Factory Munja d.d. in 1990 was a typical socialist-mastodon company, with a large number of workers (706), outdated equipment and technology. It is important to stress once again the delay in the development of the early '70s. Because of events in Yugoslavia and the collapse of the USSR, Munja d.d. loses a market in the early nineties.

Although the company management in late 1989 and early in 1990, made plans for a complete modernization of company, warfare, collapse of the banking system in Croatia, and therefore lack of lending, stoped this project.

Table 3. Production of acumulators in the Kingdom of Yugoslavia and SFRY in the period of 1939 to 1983 by manufacturers [9].

Year	Total in all locations	UNIS TESLA Brčko		MUNJA Zagreb		ZLETOVO Probištip		VESNA MEŽICE Maribor		SVETLOST ISKRA Bujanovac		TREPČA K.Mitrovica, Peć		TREPČA Sombor		ENERGOINVEST Srebrenica	
	Tons	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%
1939	115			108	93,9			7	6,1								
1946	272			267	98,2			5	1,8								
1947	516			513	99,4			3	0,6								
1948	841			839	99,8			2	0,2								
1949	1 145			1 144	99,9			1	0,1								
1950	1 165			1 154	99,1			11	0,9								
1951	999			980	98,1			19	1,9								
1952	1 309			1 284	98,1			25	1,9								
1953	1 437			1 386	96,5			51	3,5								
1954	1 678			1 163	96,1			65	3,9								
1955	1 881			1 795	95,4			86	4,6								
1956	1 601			1 495	93,4			106	6,6								
1957	2 145			1 968	91,7			177	8,3								
1958	2 666			2 425	91,0			227	8,5	14	0,5						
1959	2 919			2 564	87,8			250	8,6	105	3,6						
1960	3 929			3 446	87,7			263	6,7	220	5,6						
1961	4 091			3 300	80,7			620	15,2	171	4,2						
1962	5 361			3 626	67,6			1 099	20,5	116	2,2			520	9,7		
1963	5 937			3 791	63,9			1 030	17,3	241	4,1			875	14,7		
1964	9 187	617	6,7	3 941	42,9			2 141	23,3	989	10,8			1 499	16,7		

Table 3. continuation from p.324.

Year	Total in all locations	UNIS TESLA Brčko		MUNJA Zagreb		ZLETOVO Probištip		VESNA MEŽICE Maribor		SVETLOST ISKRA Bujanovac		TREPČA K.Mitrovica, Peć		TREPČA Sombor		ENERGOINVEST Srebrenica	
	Tons	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%
1965	11 908	1 159	9,7	4 471	39,5			2 812	23,6	1 349	11,3			2.117	17,8		
1966	13 671	1 329	9,7	5 868	42,9			2 789	20,4	1 516	11,1			2.169	15,9		
1967	10 874	1 048	9,6	5 218	48,0			2 583	23,8	1 042	9,6			983	9,0		
1968	11 221	1 365	12,2	5 170	46,1			2 626	23,4	1 215	10,8	257	2,3	588	5,2		
1969	18 708	1 603	8,6	5 841	31,2			5 347	28,6	1 627	8,7	3 720	19,9	570	3,0		
1970	20 442	1 875	9,2	4 780	23,4			6 691	32,7	1 182	5,8	4 700	23,0	1 214	5,9		
1971	26 801	3 420	12,8	6 114	22,8			8 151	30,4	1 784	6,7	4 748	17,7	2 584	9,6		
1972	34 732	5 211	15,0	7 304	21,0			9 841	28,3	2 203	6,3	6 170	17,8	4 003	11,5		
1973	38 397	5 270	13,7	8 022	20,9			11 474	29,9	2 297	6,0	6 955	18,1	4 379	11,4		
1974	42 372	6 286	14,8	7 663	18,1			12 662	29,9	1 996	4,7	8 847	20,9	4 918	11,6		
1975	47 970	6 665	13,9	8 088	16,9			14 700	30,6	2 517	5,2	11 000	22,9	5 000	10,4		
1976	50 814	6 841	13,5	8 100	15,9	1 424	2,8	17 098	33,6	1 996	3,9	11 253	22,1	4 101	8,1		
1977	59 775	6 678	11,2	8 376	14,0	3 796	6,4	18 229	30,5	2 517	4,2	13 868	23,2	6 311	10,6		
1978	65 264	8 460	13,0	7 696	11,8	5 085	7,8	20 157	30,9	2 581	4,0	14 681	22,5	6 604	10,1		
1979	63 229	8 737	13,8	6 845	10,8	6 700	10,6	16 378	25,9	3 183	5,0	14 906	23,6	6 480	10,2		
1980	64 253	8 889	13,8	5 691	8,9	6 240	9,7	17 295	26,9	3 776	5,9	15 622	24,3	6 740	10,5		
1981	64 996	9 026	13,9	6 009	9,2	5 930	9,1	14 429	22,2	4 146	6,4	18 198	28,0	7 240	11,1		
1982	69 242	9 512	13,7	5 500	7,9	6 089	8,8	14 492	20,9	3 664	5,3	23 214	33,5	6 791	9,8		
1983	77 807	11 299	14,5	6 276	8,1	6 312	8,1	15 002	19,3	4 083	5,2	25 067	32,2	7 558	9,7	2 210	2,8

The war period from 1991 to 1995, the era of the Homeland war, struck Munja d.d. even more, which allocated and donated a value of almost 11.5 million DEM (it is almost identical to the value of the company) to the Croatian army, and all of the war-affected areas in Croatia but also in Bosnia and Herzegovina. Without batteries, after the termination of electricity supply, there was no possibility of work in hospitals and all other institutions, agencies, etc.

All of the above has led to the inability of investment, lagging behind the competition and thus complete technical and technological obsolescence. With the dissolution of Yugoslavia, Croatia abandons planning (socialist) economy and "turned" towards market economy, but in a completely wrong way (which will later be shown by time) and with the declared totally wrong approach.

This approach consisted of a policy of complete de-industrialization of the country and "turning" to the economic policy of "land services" (tourism), which had disastrous consequences for Croatia's industry and manufacturing in general. A market for "anything and everything" opens without quality control of imports, not taking into account the "self-domestic" production, which leads Croatia from one industrialized republic, into a position of almost complete collapse of industrial production and the dominance of imported goods and "import lobbies". The same happens with the battery market. While Munja was "pressed" on one hand, significant commitments toward the Croatian Army (donations, unpaid accounts, as well as everyday mobilization of hundreds of workers), and on the other hand, the loss of market with the disintegration of the former USSR and Yugoslavia, outdated equipment and technology, poorly managed economic policy of the state almost "stimulate" batterie import, all kinds of quality, and without any control.

Absolutely dominated by imports, and almost exhausted by the war, then, expensive loans, the lack of financial markets and the banking crisis of the 90's, up until 2000 prevented investment and after 1995. Such a situation is more conducive to import batteries from foreign producers, who did not have these problems. All of this has led to a decrease in production volume in Munja d.d. and increased import of batteries.

The same economic policy in the country (as noted earlier) continue after the year 2000 and continues to this day, no matter which political option and which government had a mandate. Table 4 outlines acumulator import, traction and stationary batteries and realization of acumulators in the period from year 2001 to 2011.

Table 4. Imports of starter batteries, traction and stationary battery imports and acumulator realization since 2001 to 2011 in the Republic of Croatia. Source: Internal data of Munja d.d.

Year	Starter battery imports			Traction and stationary battery imports			Acumulator realization		
	Number of pieces	Tons	Value in USD	Number of pieces	Tons	Value in USD	Number of pieces	Tons	Value in USD
2001	311 104	5343	7 530 223	862 497	1400	3 426 461	121 181	2 676	4 326 302
2002	334 876	6125	8 649 553	39 301	468	1 004 969	79 025	2 012	3 578 665
2003	337 768	6239	10 337 088	421 665	272	784 388	58 572	1 580	3 727 751
2004	347 078	6492	12 045 590	26 934	314	906 830	73 668	2 145	3 975 932
2005	377 199	6485	12 837 681	114 932	341	875 321	93 724	2 049	4 412 948
2006	380 203	7053	14 203 279	80 379	507	1 434 889	1 866	2 127	4 992 917
2007	357 740	6615	18 656 532	77 195	469	1 862 145	60 820	1 878	5 704 122
2008	311 106	5728	18 554 412	315 606	457	2 121 061	35 321	1 065	5 008 962
2009	325 391	5931	16 747 545	49 935	304	1 183 302	21 803	1 115	4 634 786
2010	338 788	5993	17 005 469	49 541	409	1 569 868	32 868	1 187	2 731 530
2011	305 139	5191	16 370 200	449 564	1395	6 934 353	43 152	1 202	3 339 593

From Table 4, a huge potential is obvious on the Croatian market, as well as a great need for this product in the Republic of Croatia and the profitability of investing in this product. Munja d.d. launched an investment cycle that is necessary to conduct by program (program accumulators; program of industrial and specialty batteries, recycling program) and stages.

This approach was used due to the specifics of the production, which is characterized by the inability and unprofitability of long interruption of the production cycle, as well as a long period of development of industrial equipment and installation of the same. From the tehnological and temporal aspect it was planned to be implemented in two phases: Phase I. as the period from 2005 to 2008, and Phase II. as the period from 2009 to 2013.

At the end of the first phase of modernization, the year 2008 stage of battery production, comes the global crisis, which continues to this day, which has for Munja d.d. culminated 2009, the result of the famous "gas crisis" in which newly acquired machines were destroyed, due to the disconnection of gas. With that, continuous production was interrupted for a long time (18 months), which has stopped production in Munja d.d. for the first time in its history.

This has resulted in the loss of equipment and machinery, new financial costs, especially the serious consequences resulting from the loss of contracts and markets, after a period of investment. Consequences of damage are still being repaired, because certain parts and whole equipment must be replaced with new one. From up above, it is evident that the Croatian market is dominated by imported batteries.

Despite all the difficulties and weaknesses that Munja d.d. has itself, as well as all other circumstances already mentioned, for the situation in the market, most of the blame is on misguided economic policy of the Croatian Government in terms of industry and manufacturing in the past 20 years, and especially the automotive industry.

Not only has nothing been done to "bring" some of the car manufacturers and establish a production, and thus create conditions for the development of other industries depending on the car production (as almost all other transition countries have done) but the dominant "import lobbying" policy "choked" what little car industry remained in the Republic of Croatia.

It is impossible without a clear national vision and strategy for future development of the national economy to develop future business. This is particularly expressed in the auto industry for the following reasons:

- first, car production is virtually impossible without the involvement of the state, and nowhere in the world did this investment happen without the state included in it,
- second, the production of cars, means OEM for a lot of other products from the auto industry but also other industries (plastics, textiles, rubber, ...) and is always in direct contact with the "protection and arrangements" on a higher state level,
- third, regardless of market liberalization in the world, especially in the EU, it is difficult to develop a market without the "interference" of the state and "interesting state protectionism" exists because each state "protects" its producers, though not more through duties and taxes, but through "industrial protectionism",
- fourth, the regulations of the "original parts" and "the original production" of lack of entry to the OEM, enhanced control and the necessary certificates, "financial protectionism": through cheaper funding for manufacturers, regulations prompt payment of imported goods produced in the domestic market, the lower the credit rating, or through "political protectionism" information about the uncertainty of investment, poor protection of invested capital, an uncertain transition area and the like.

Unfortunately, in 20 years of its existence Croatia has done very little to protect and preserve its production, and nothing at all to bring production to its area, and especially not for the auto industry, which has caused a lot of damage and has serious consequences, both for the development of the country, and lagging behind the countries in transition and in the region, especially in the EU.

TENDENCIES IN THE AUTOMOTIVE INDUSTRY AND PRODUCTS OF MODERN TECHNOLOGY – IDENTIFICATION

It is estimated that at this moment there are around 800 million vehicles of various types, of which the most numerous are standard vehicles with internal combustion engines (gasoline or diesel). There are great monetary investment in the development of other types of vehicles: (i) hybrid electric vehicles, (ii) electric vehicles, and (iii) fuel cell vehicles [13, 14].

When comparing the various sources of energy, it may be best to compare the energy density per unit weight of the various sources of energy, which is shown in Table 5.

It is obvious that gasoline has a huge advantage in this category, but given the limited oil resources, as well as modern trends in environmental protection, there are more and more investments in research and development of other types of vehicles that are powered by internal combustion engines [1].

Table 5. Energy density per unit weight for different types of batteries [11].

Energy sources	Energy density, Wh/kg
Lead-acid batteries	40
Ni/MH batteries	80
Li-ion batteries	150
Gasoline	13000

HYBRID ELECTRIC VEHICLES

At the end of the twentieth century consumption of petroleum fuels in the world has significantly increased and the emergence of the first symptoms of the oil crisis occurred, which resulted in organized activities at the level of many countries, including the European Union [3]. Car manufacturers have decided to cut spending by combining an electric motor with a combustion engine, thus developing a hybrid electric vehicle (HEV). Depending on the inclusion of electricity (battery) to power the vehicle, several types of HEV were developed:

- **Full HEV**: a car driven by only an electric motor can move a small distance. The system of electric battery is only used when the internal combustion engine works with small efficiency and when high forces are needed. The battery is partially discharged while the electromotor works and is recharged by the internal combustion engine. Regenerative breaking too, plays an important role in charging the battery. The electrical system works above 200 V. The fuel consumption has been reduced by 40 %,
- **Range HEV**: the electrical system is called mainly for acceleration phases and for starting the vehicle. Regenerative charging of the battery when the vehicle slows down is paramount to reducing fuel consumption. The electrical system works for between 100 V and 200 V, and the reduction of fuel consumption is in the range of 15 % - 20 % depending on the manner of driving,
- **The micro HEV**: uses a start-stop system that switches off the engine when the car stops and the battery takes over the necessary electricity. In city driving, fuel consumption is reduced about 8 %,

- **Plug in HEV**: this version of the HEV uses an external power source to charge the battery. It has the characteristics of an electric car of the classic internal combustion engine. When the battery is discharged, the internal combustion engine works as a "back up" source of strength (ILZSG Insight, 2010).

Fully electric cars use only the electric motor, powered by batteries that can be recharged by an external power source. For now, only nickel-metal hydride (Ni/MH) batteries can do the task and meet the requirements for power and energy in complete HEV. Intensive research and development has been conducted in order to make lithium ion batteries suitable for HEV market.

Fully HEV is currently being produces by Toyota (Prius and the Hybrid Synergy Drive), Ford (model Ford Escape and Fusion) and more recently General Motors. Range HEV also use Ni/MH batteries (Honda Civic, Chevrolet Silverado, GM Saturn and Malibu, BMW Concept 7 Series, and others. Lead acid batteries are generally used in micro-HEV (mainly in Europe BMW, Daimler and Citroen).

THE MAIN PROBLEM IN THE APPLICATION OF LEAD ACID BATTERIES IN HEV

Problems are mainly related to the negative plate: (i) a negative plate can not receive the high charging current generated in regenerative braking and (ii) batteries work in a partial state of charge, which leads to a rapid sulfatisation of the negative plate.

Batteries in Micro HEV's and in conventional cars operate at over 90 % state of charge, and up to 5 % depth of discharge. In such circumstances, negative plates do not suffer from sulfatisation. Batteries in moderate HEV's work from 70 % to 90 % charge. Under these conditions, the battery is subject to slow sulfatization and requires s special treatment to reverse this process.

The most difficult conditions are for full HEV batteries. Their zone of charge ranges from 30 % to 80 %, which supports rapid sulfatisation on negative plates and makes lead-acid batteries unsuitable for use in these types of HEV.

The most logical approach to solving the problem was to look for an alternative to the conventional leaded negative panel or reduce its contribution to the battery. For this role carbon super capacitors were selected.

Axion Power International has completely replaced the negative plate VRLAB with carbon super capacitors. CSIRO and Furukawa Battery have developed and tested their battery (they called it the Ultra battery) with a negative plate, which consists of half a regular lead plate and half of a carbon super capacitor. Energy (USA) uses carbon foam instead of lead bars to hold the negative active material and to maintain a stable 3D structure of NAM with wide open pores.

Since 2004 The Advanced Lead-Acid Battery Consortium sponsored research adding electrochemically activated carbon to the negative active material, thus increasing the surface on which the reaction takes place, hence speeding up the process.

All these innovations are in development and testing, and are not commercially available, but can be expected to mark the third phase in the development of technology for lead-acid batteries.

AUTOMOTIVE BATTERIES – THE OVERALL IMPACT OF HYBRID ELECTRIC VEHICLES

The HEV market is growing, it is dominated by Toyota and Honda, but the other big players are preparing to enter. In year 2010 it accounted for 1 % of the global market and is expected to grow at 2 % – 3 % to the year 2015, and 5 % – 7 % by 2020. In this area, a major influence is on legislation for the protection of the environment, reducing of greenhouse gasses emission, etc.

Currently, HEV are using Ni/MH, but it is expected that Li-ion batteries will become important. "Soft" or micro-hybrids used lead-acid batteries for "stop & go" driving. Full Hybrids still use a small, 12 V lead-acid battery for lighting, motor and electrical system of the vehicle. HEV is expected to have a modest effect on the market of automotive batteries in the next 10 years.

In these systems, the engine switches off when the vehicle stops and on again when the vehicle is moving, and thus saves fuel and reduces emissions of harmful particles in the air.

Battery cycles are much more intense: multiple engine start-standard lead-acid batteries have a limited life under such conditions. VRLA AGM batteries behave well in these conditions, ELF (Extended Life Flooded – submerged Extended Life) have been developed to meet these requirements with lower cost.

In this category, Europe is a key market. It is expected that these systems will become standard on most vehicles by 2015, when the predicted market would be 19 million units for the OEM, and 53 million pieces to replace [11].

North America is much less important, there is a lot more HEV, the technology "stop & start" has a problem with the automatic transmission, which is massively represented in the United States.

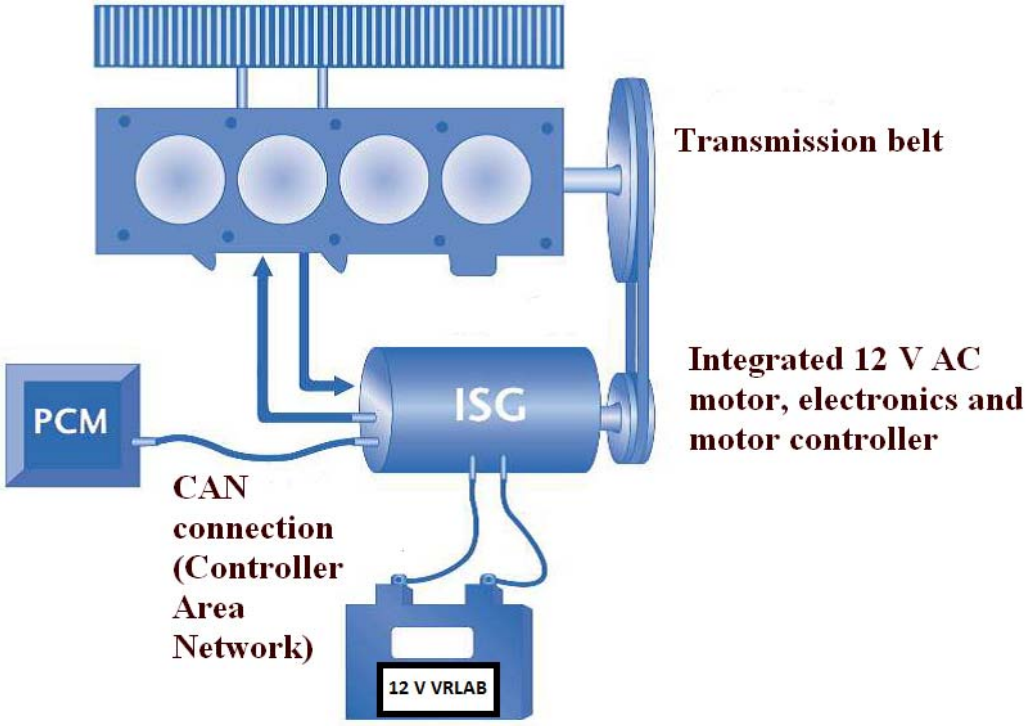

Figure 2. Lead-acid batteries in the "Stop & Start" system [11].

SALES OF HYBRID ELECTRIC VEHICLES – HEV

According to data [11] in the year 2010, 900 000 units were sold, according to the manufacturer: Toyota 78 %, Honda 16 %, Ford 4 %, other 2 %, or according to the country of sale: Japan 55 %, U.S.A. 30 %, Europe 11 %, other 4 %, or according to technology: Ni/MH 95 %, Li-ion 5%. The main suppliers of batteries for HEV's are Panasonic and Sanyo (owned by Panasonic). Expectations by 2020 are: sales of around 3,5 million while the share of Li-ion batteries is to increase to 35 %. Therefore, a limited impact is expected on the market for lead-acid batteries for at least another 10 years.

Lead-acid batteries have good power density, which is important, while they have poor energy density (due to the high specific gravity of lead). Working in HEV's damages lead-acid batteries, and so solutions have been developed to solve this problem by improving the collection of electricity and adding special carbon additives to the negative panel [2].

After the battery performance, another important parameter is the price (Table 6). It is obvious that the kWh of energy from a lead-acid battery is at least three times cheaper than those derived from other types of batteries.

Table 6. Price of kWh per unit of energy for different types of batteries. From [11].

Type	Price, US$/kWh
Lead acid batteries	150-200
Ni/MH baterries	600-800
Li-ion baterries	600-1200

CONCLUSION ON NEW TECHNOLOGIES

New technologies in the production of accumulators suggest the following trends. First, the market for lead-acid batteries is going to grow for a long time and the impact of new technology vehicles will be limited. Second, currently there is no new energy storage system to replace lead acid batteries in existing applications, except when it comes to applications in very small spaces.

Third, the lead-acid battery is widely applied for micro hybrids and has the potential for full hybrids (that is dominated by Ni/MH, in the future, Li-ion). Fourth, regarding the application of the car, AGM VRLA batteries or ELF are critical to satisfying life in the "Stop & Start" application [12].

CONCLUSION

The battery industry in future development is under influence of different events and trends.

One of the most important trends, but also the need for our common future, is environmental protection. Since accumulators and batteries have a tremendous negative impact on the environment in the event that they are not stored and recycled in a proper way, of primary importance is to ensure the two levels of Environmental Protection. Firstly, it is necessary to strive for an even greater extent of the use of raw materials and production processes that ensure the protection of the environment as much as possible. Secondly, it is necessary to provide recycling options for a large number of used batteries, and in doing so also use the procedures that will ensure the protection of the environment as much as possible. Innovations such as "green production" should be the main driving force in achieving these goals. Such changes are a necessity in the medium term [6, 7].

The most important lever in the development of the battery industry is the possible change of the industrial paradigm in Croatia. On the territory of the European Union and Croatia, the competition is very high, while the Croatian market is open to all producers. Although one cannot expect the closing market, nor should it be ultimately desirable, Croatia should actively support the development of industries, and by the fiscal and monetary policy.

To a large extent the development of industries is based on cooperation with subcontractors, small and medium enterprises. Therefore, an active support of the development of industrial enterprises would contribute to not only increase their competitiveness, but also the competitiveness of small and medium enterprises, and general economic activity and ultimately employment.

The battery market is largely influenced by the domestic industry. Countries where there is a production of batteries together with the automotive industry, provide a much better starting position to their economic operators from both industries. Economic operators from the battery industry are able to better plan production and inventories of raw materials and finished products, since much of the loans are provided by the automobile industry in the country. Economic operators from the automotive industry are also in a better situation because of the greater ability to control the quality and the volume and timing of production. The above changes would be of primary importance in the short term. Major impact on the battery industry can also have changes on a global scale. It is possible that due to unforeseen circumstances, such as military activities, there is a high demand for batteries for military vehicles. The economic subject in this case should also be able to quickly adapt to such changes.

However, the ability to quickly adapt is not acquired overnight. Instead, it is constantly required to work within the economic entity on the ability of rapid change. Such changes should be planned in the long term. Although they appear unexpectedly, businesses that are prepared for them can have a significant strategic advantage in the case of such an event.

It is possible that in the medium term (five years) no major changes occur, and that the industry achieves approximately the same terms and conditions as it has been until now. Such a scenario can be called a status quo. However, the hope is that it will be an active policy to stimulate economic growth, which will increase and better the starting position for achieving competitiveness of undertakings from the battery industry.

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TENDENCIJE RAZVOJA GLOBALNOG TRŽIŠTA BATERIJA S NAGLASKOM NA REPUBLIKU HRVATSKU

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SAŽETAK

Akumulatori i trakcijske baterije ugrađuju se u prijevozna sredstva, koja se pokreću motorima na sagorijevanje fosilnih goriva, kao što su kopnena, zračna i plovna vozila. Slično je i sa stacionarnim baterijama koje napajaju strujom stacionarne objekte. Upotreba ovih proizvoda ukazuje na posebnosti tržišta, jer najčešće nije krajnji potrošač, onaj koji je u tržišnoj vezi sa proizvođačem, nego gotovo uvijek je netko između njih, koji ih povezuje. Prema tome, između proizvođača i korisnika posreduju distributeri na veliko i malo, serviseri postrojenja u kojoj se ovaj proizvod ugrađuju, ili proizvođači koji vrše prvu ugradnju u automobilu. Industrija proizvodnje akumulatora strateška je industrija, budući da pokretanje vozila ovisi, osim o dostupnosti goriva i o dostupnosti akumulatorskih i trakcijskih baterija. Rad sadrži pregled grane proizvodnje akumulatora, kao grane industrije, na globalnom i hrvatskom tržištu. Prikazan je razvoj po strukturi razvoja, ali i po izvorima primijenjenih tehnologija, posebice suvremene tehnologije. U najvećoj je mjeri rad usredotočen na razvoj hrvatske industrije akumulatora i njezinog jedinog predstavnika, poduzeće Munja d.d. Začeci poslovanja navedenog poduzeća koreliraju sa začecima automobilske industrije uopće. Poslovanje niti jednog poduzeća ne može se promatrati odvojeno od okoline. Stoga se poslovanje poduzeća Munja d.d. promatra s obzirom na razvoj u prošlom stoljeću, ali u odnosu na druge proizvođače akumulatora, u bivše dvije zajedničke države, ali i svjetske proizvođače akumulatora.

KLJUČNE RIJEČI

industrija akumulatora, globalno tržište, Republika Hrvatska, proizvodnja, potrošnja