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Original Scientific Paper

MITIGATING AIR POLLUTION IN NORTH MACEDONIA: THE ROLE OF POWER ELECTRONICS IN ENERGY GENERATION AND CONSUMPTION

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Abstract: Environmental pollution and global warming are the greatest world problems today. Climate change and global warming (1.4 ˚C in 2023) as an issue of human survival on the planet Earth are a direct consequence of pollution. Environmental pollution should be divided into air pollution, water pollution, and soil contamination. This paper considers only air pollution in the Republic of North Macedonia and possible solutions thereto. All pollution types are a result of human habits, industrialization and the need for energy sources. Although the greatest environmental pollution comes from developed countries, the most polluted towns are easily found in underdeveloped countries, mainly as a result of poor standards, inadequate heating, and traffic using old buses, cars, etc. The impact of power electronics in industrialization and energy generation is very significant, and therefore it could be equally important for finding a solution to the problem. Power electronics are necessary not only for classical types of power plants (coal, hydro, oil, gas, and nuclear), but even more for renewable power sources such as wind farms, small hydropower plants, and solar plants. The industry is the greatest consumer of electricity, with electric drives accounting for two thirds of that consumption. Households are the second biggest consumer of electricity, with electric drives such as air conditioners and other HVAC (Heating, Ventilation, Air Conditioning) systems, washing machines, refrigerators, dust cleaners, and auxiliary domestic tools having a dominant share. Power electronics is a structure block of any contemporary electric drive and the best way to improve energy efficiency and reduce electricity consumption. On the other hand, they imply less need for electricity. Electric transport is a powerful way to reduce CO_2 emissions. High power fans with filters are necessary for air cleaning at power plants and industrial facilities. Water cleaning is done with the help of purification stations with pumps. In all these cases, power electronics for variable speed drives are used. High-efficiency motors (HEM) are already in use and contribute to lower electricity consumption.

Keywords: air pollution, power electronics, electricity, generation, consumption

ПОДОБРУВАЊЕ НА СОСТОЈБАТА СО ЗАГАДУВАЊЕТО НА ВОЗДУХОТ ВО МАКЕДОНИЈА: УЛОГАТА НА ЕНЕРГЕТСКАТА ЕЛЕКТРОНИКА ВО ПРОИЗВОДСТВОТО И ПОТРОШУВАЧКАТА НА ЕЛЕКТРИЧНА ЕНЕРГИЈА

Апстракт: Загадувањето на животната средина и глобалното затоплување се најголемите проблеми со кои светот се соочува денес. Климатските промени и глобалното затоплување (1,4 ˚C во 2023 година) како прашање за опстанокот на човекот на планетата Земја се последица токму на загадувањето. Загадувањето на животната средина може да се подели на загадување на воздухот, загадување на водата и контаминација на почвата. Во овој труд се разгледува само загадувањето на воздухот во Република С. Македонија и можните решенија. Сите типови загадувања се резултат на човечките навики, индустријализацијата и на потребата од извори на енергија. Иако најголемото загадување на животната средина потекнува од најразвиените земји, најзагадените градови се лоцирани во нискоразвиените земји, како резултат на лош стандард, несоодветно греење и сообраќај со стари автобуси, автомобили, итн. Влијанието на енергетската електроника во индустријализацијата и производството на енергија е многу значајно, па оттука може да биде многу важно за решавање на проблемот. Енергетската електроника е неопходна не само за класичните типови електрични централи (термо, хидро, гасни и нуклеарни), туку уште повеќе за обновливите извори на електрична енергија како што се ветерниците, малите хидроцентрали и соларните централи. Индустријата е најголемиот потрошувач на електрична енергија и во неа учествуваат електромоторните погони со 2/3. Домаќинствата се вториот голем потрошувач на електрична енергија бидејќи во него доминантно влијание имаат електромоторните погони како што се клима уредите и другите слични уреди (за греење, за вентилација, за климатизација), машините за перење, фрижидерите, електричните уреди за чистење прашина и помошни домашни уреди. Енергетската електроника влегува во склоп на секој современ електроморотен погон и е најдобриот начин за подобрување на енергетската ефикасност и намалување на потрошувачката на електрична енергија. Од друга страна, тоа значи помала потреба од електрична енергија. Електричниот транспорт е моќен начин за намалување на емисиите на CO_2. Вентилаторите со голема моќност со филтри се неопходни за чистење на воздухот во електраните и во индустриите. Чистењето на водата се врши со

помош на пречистителни станици со пумпи. Во сите овие случаи се користи енергетска електроника за погони со променлива брзина. Моторите со висока ефикасност се веќе во употреба и придонесуваат за намалена потрошувачка на електрична енергија.

Клучни зборови: загадување на воздухот, енергетска електроника, електрична енергија, производство, потрошувачка.

I. INTRODUCTION

CIVILIZATION development is tightly connected with technological progress and improvement. In that process, people often forget about consequences on the nature's behavior and that they must live in harmony with the nature. Use of nature wealth (water, earth for food-producing, wood, minerals, etc.) should be very carefully and strongly planned. Man is always in battle with the nature's temper, expressed in the form of floods, droughts, forest fires, volcano activities, earthquakes, tsunamis, etc. The nature's behavior is in connection with human activities in the field of environmental pollution as unavoidable consequence of the industrialization process. Pollution of air, water, and soil contamination are all linked to energy generation and energy consumption processes. While there are many high-level global meetings and a number of international agreements in this regard, greenhouse gas emissions - GHG (expressed as CO_{2eq}) and related climate change are certainly the greatest problems of today. It is clear that the most developed industrial countries are the biggest polluters. However, the most polluted towns in the world are found in underdeveloped countries of Asia, Africa, and Europe, especially in winter, as a result of primitive heating methods, use of old buses in transport, use of old cars, low cultural, technology and industry levels. The Republic of North Macedonia is a developing country, more than 30 years of transition, with heavy environmental pollution problems and great chances to expand use of power electronics in electricity generation and consumption. This paper considers the influence of power electronics in decreasing environmental pollution. Use of power electronics in electricity generation and consumption, electric transport and electric drives is a powerful way to decrease environmental pollution [1], [2], [3], [4], [5], [7], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20]. At the same time, it provides an opportunity for better, higher, and best quality goods productivity [5], [8], [9], [10], [21], [22]. Be that as it may, regular application of power electronics necessitates knowledge and advanced technology. This paper treats only air pollution, as the most dangerous pollution in North Macedonia, as well as power electronics applications in electricity generation and consumption that could greatly contribute towards a solution to the problems.

II. AIR POLLUTION IN TOWNS

Based on word statistics, towns in the Republic of North Macedonia are heavily polluted, especially in winter [6], [23], [24], [25], [26], [27], [28], [29],[30], [33]. Almost daily, the state's capital, Skopje, is featured among the top 10 most polluted towns in the world. Other towns, including Bitola, Tetovo, Strumica, Ohrid, Veles, etc., are also often featured on this list. This is due to the geographical position of towns in windless valleys, including frequent formation of fog in winter. Other reasons include low quality of living, unsuitable heating sources, use of old buses and cars, etc. It should also be noted that there are many illegal landfills with disposed waste being burned throughout the year. Waste management is still an unsolved problem, although it could serve as energy source and can be viewed as profitable business.

Air pollution is generally measured by the Air Quality Index (AQI), as shown in Table 1.

TABLE I
AIR QUALITY INDEX VALUES

Air Quality Index Levels of Health Concerns	Numerical value	Meaning
Good	0 to 50	Air quality is considered satisfactory and air pollution poses little or no risk.
Moderate	51 to 100	Air quality is acceptable, however for some pollutants there may be moderate health concerns for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for sensitive groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects. Members of sensitive groups may experience more serious health effects.
Very unhealthy	201 to 300	Health alert: everyone may experience more serious health effects.
Hazardous	301 to 500	Health warning of emergency condition. The entire population is more likely to be affected.

In addition, Table 2 provides the relation among AQI and the content of harmful materials in the air, such as particulate matters (PM10, PM2.5), 7 (seven) greenhouse gases (GHG) under the Kyoto Protocol, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), fluoride (F) gases, hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), sulfur hexafluoride (SF_6) and nitrogen three fluoride (NF_3). Sulphur dioxide (SO_2) is not GHG, but is

very dangerous when it interacts with water (rain), creating H_2SO_3. All these gases are measured per unit ($\mu g/m^3$).

For objective and practical reasons, all GHGs are presented as equivalent carbon dioxide CO_{2eq} on account of the latter's great influence, see Table 3.

TABLE II
AQI 50 IN RELATION WITH APPROPRIATE POLLUTANTS MEASURED IN RNM, [26]

AQI	PM10	PM2.5	NO_2	SO_2	CO	O_3
50	54	25	200	125	10	120

TABLE III
EQUIVALENCE AMONG GHG (SOURCE: IPCC ASSESSMENT REPORT AR4, 2007, [26])

CO_2	1
CH_4	25
N_20	298
HFC-32	675
HFC-135	3,500
HFC-134A	1,430
HFC-143A	4,470
HFC-227EA	3,220
CF_4	7,390
C_2F_6	12,200

Table 4 shows air pollution in selected towns in the Republic of North Macedonia, as measured in December 2023, with their appropriate AQI values that are close to ranges measured in the 10 most polluted towns worldwide [33].

TABLE IV
AQI IN SOME TOWNS IN RNM, DECEMBER 2023, [33]

AQI	0-50	51-100	101-150	151-200
SKOPJE	6	14	11	0
BITOLA	15	26	0	0
TETOVO	11	18	2	0
STRUMICA	6	9	14	2
OHRID	17	14	0	0
VELES	12	19	0	0

The coefficient (kg CO_{2eq}/kWh) is very useful for evaluation of air pollution in relation to the type of electricity source, whose actual value ranges from 0.3 to 2 [5]. It shows the structure of electricity sources, and in the case of fossil fuels that dominate electricity generation, its value is above 1. However, it is rarely used for measurements. Explanation of the unit 1 kg CO_2 appears necessary, as it corresponds to burning of 1kg coal or 1/2l petrol, driving a car for 3.7 km, ball with 1 m diameter full of CO_2 [23], [28].

III. THE ROLE OF POWER ELECTRONICS IN DECREASING AIR POLLUTION

A. Electricity Generation

There are no nuclear plants in the Republic of North Macedonia for power generation. Electricity generation is manly based on low quality lignite (coal), with an average calorific value of 5500 kJ/kg. Therefore, it must be enriched with oil for use in power plants. The country is fully dependent on imported oil and gas from abroad (Greece, Russia, USA, Turkey, Azerbaijan), transiting the bordering countries, i.e. Bulgaria, Greece, Albania and Serbia. Oil is necessary for road traffic, based on internal combustion engines. Use of gas is in its early stages. Most oil and gas supply is controlled by private companies. The country is developing several power and gas interconnection projects. Water sources are solid, with satisfactory quantities. Wind and photovoltaic are relatively new energy sources, with good perspectives. Many solar projects have been announced.

It should be noted that the global situation in respect to electricity generation is very confusing. Instead of closing nuclear plants by 2030, the 2023 Qatar Energy Conference resulted in a call to triple nuclear electricity generation by 2050 [27]. Power plants using fossil fuels were planned to stop work by 2030, but their operation was prolonged by 2050, under some modifications for lower pollution. Progress of renewable sources is undoubtable, under maximum possible capacity.

It is very important to know the equivalent of fossil fuels regarding 1 toe = 1616 kg coal = 1069 m^3 natural gas = 954 kg gasoline = 11.63 MWh = 41.868 GJ (1 kWh = 3.6 MJ). The total annual pollution with CO_2 from fossil fuels at global level stands at 34 Gt, where coal accounts for 45%, oil - 35%, and natural gas - 20% [23], [24], [25], [26], [27], [28]. Electricity generation is responsible for 42.5% of CO_2 emissions in the world, of which 73% belong to coal, with an average value of 950 gCO_2/kWh. (The appropriate value for natural gas is 350g CO_2/kWh).

2024 energy needs in the Republic of North Macedonia are estimated at approx. 2750 ktoe. Final consumption is forecasted at approx. 2075 ktoe [29], [30]. Oil derivatives as energy source account for 43%, followed by coal - 30%, gas - 10%, biomass - 9%, hydropower - 4%, solar - 2.5%, wind - 0.3%, geothermal - 0.2%, and other - 1%. Electricity generation is estimated to cover 26.2% of total energy needs. Gross domestic electricity generation covers 90.2% of gross domestic consumption; with coal (lignite) being the dominant energy fuel - 99.7% [30]. Distribution of the total electricity generation per energy source is as follows: 53% - thermal power plants (coal and oil), 23% - hydropower plants, 16% - natural gas (co-generation TE-TO), 7.8% - renewable sources (approx. 350 ktoe, i.e. 45% by mini and micro hydropower plants, 22% by wind, 18% by solar, and 15% by biogas) [26] [30]. It is easily concluded that consumption of oil products is dominant.

1) Fossil Fuel Sources (Oil, Coal, Gas)

The three basic fossil fuels are coal, oil and gas. The Republic of North Macedonia has only coal, i.e. low-quality lignite with average calorific value of 5500 kJ/kg). Oil and gas are fully imported from different routes and with difficulty. There are two coal-fueled power plants: REK Bitola (675 MW) and REK Oslomej (125 MW), with total installed power of 800 MW, both constructed in the early 1980s with parts manufactured in the former Soviet Union and Poland. TEC Negotino is an oil-fueled power plant with installed power of 195 MW and the oldest plant, dating back at the end of 1970s, also a production of the former Soviet Union. A more recently opened plant (2020) is the gas-fueled co-generation facility (electricity and heating) TE-TO in Skopje, with installed power of 150 MW, but unfortunately it is not in regular work.

All electric machines are synchronous generators, with high speed 3000 1/min for 50 Hz.

Application of power electronics in these power plants is very poor. While being the oldest, TEC Negotino has ASEA automatic voltage regulation (AVR) for excitation. There are no variable speed drives (VSD) for self-used drives – pumps, compressors, fans, transport bands, etc.

TE-TO uses the newest technology available, but is not in regular operation due to occasional lack of gas supply and no thermal energy consumers in summer.

2) Hydro Power Sources (Large, Mini and Micro HPPs)

Hydro sources were the first electricity sources in the Republic of North Macedonia since the beginning of the 20th century. Nowadays, these can be classified as: large (>10 MW), mini (1-10 MW), and micro (<1 MW). The total installed power of large HPPs is 634.4 MW. The total installed power of mini HPPs is estimated at approx. 100 MW. The total installed power of micro HPPs is estimated at approx. 30 MW. Equipment at large HPPs has been largely produced by former Yugoslav manufacturers. Electric machines used are low speed synchronous generators. There is only negligible application of power electronics.

Equipment at mini and micro HPPs is different and variable.

3) Renewable Power Sources

This group includes mini and micro hydro power sources, wind and photovoltaic power sources. It should be noted that the Republic of North Macedonia maintains its top-ranking place among the Western Balkans in terms of energy transition regarding use of renewable sources [31], [32].

4) Wind Power Sources

Key wind power installations in the country include the wind parks in Bogdanci (16x2.3=36.8 MW) and Bogoslovec (8x4.5=36 MW).

The wind park in Bogdanci consists of 16 turbines (Siemens SWT - 2.3 MW - 93 m), which drive induction generators (2200 kW, 1500 rpm, 690 V), speed control range (600 – 1800 rpm), and utilize modular multilevel converters operating in grid-feeding mode.

The wind park in Bogoslovec features double-fed induction generators (4.5 MW, 690 V, 50/60 Hz), manufactured by *Siemens Gamesa*. Power converters linked to the rotor are back-to-back converters rated at 30% of nominal output power.

5) Photovoltaic Power Sources

On the account of its geolocation and climate conditions, the Republic of North Macedonia has around 280 sunny days per year, with an average daily radiation of 3.4-4.2 kWh/m2. The field of solar energy is very dynamic, with the situation changing very fast. It could be estimated that currently more than 400 MW in use come from photovoltaic sources [31], [32]. Dominant installations are connected to the electricity grid, with minor battery use, multi MPPT string, and grid-supporting power inverters.

Example 1 concerns the biggest solar power plant in the Western Balkans, located in Novaci, near REK Bitola, with 3 blocks, equal to a total 675 MW coal-fueled power plant.

Example 1: Solar Power Plant in Novaci [32]

With installed power of 55 MW, this plant was built over a period of ten months by *Mey Energy* and started operation in September 2023. Its investment price amounted to EUR 40 mil. and lifespan of 25 years. The solar plant stretches over 57 ha of land (570,000 m^2), with 101,000 panels (544.55 W/panel) and 856 km of cables, and is connected to the 110 kV grid. Annual electricity generation is estimated at 85 GWh. Figure 1 shows a photo of the solar power plant in Novaci.

Fig. 1. Solar power plant Novaci

6) Biogas Power Sources

To present, there are only 5 facilities using biogas for electricity generation with total installed power of 12 MW ((3+3+3+2+1) MW), relying mainly on chicken waste.

B. Electricity Consumption

The Republic of North Macedonia has the second lowest per capita energy consumption in Europe, which is more than two times lower than EU average. The country's per capita energy consumption in 2022 stood at 1.3 toe (which is by 58% lower than the EU average), including 3200 kWh of electricity (44% lower than the EU average) [23]. The situation in terms of electricity consumption is very similar. ESM (Power Plants of North Macedonia), a state-owned company, accounts for around 2/3 of total electricity generation [24], [25], [26], [27].

Final energy consumption is mainly distributed across four sectors: transport - 35%, households - 27%, industry - 25%, commercial, business and services - 10%. The agricultural sector accounts for consumption of only 1% of energy [29]. Electricity consumption is mainly driven by households, industry and commercial, business and

services [29], [30]. A very important remark in this regard is that the industry practically works at very low capacity.

It is worth saying that in the Republic of North Macedonia oil derivatives are necessary for traffic with internal combustion engines. In reality, there are not enough electricity sources for fast transfer to electric vehicles over a short period of time, because the installed power of vehicles is approx. ten times higher than the installed power of electricity sources. Globally, plans are in place to replace use of internal combustion engines by 2030, but this deadline was prolonged to 2035. Be that as it may, the situation remains unclear and would heavily depend on worldwide policy and wars, including in Europe.

It should be noted that in June 2023 and for the first time, the Republic of North Macedonia noted its peak of electricity consumption in summer. It further justifies the fact that nowadays households and other buildings are the biggest consumers.

1) Industry

Overall, industry in the Republic of North Macedonia is mainly "dirty", with a plethora of metal mines and adequate smelting and other auxiliary capacities. There are two iron mines (Tajmiste and Damjan) and steel work in Skopje, with 5 reduction furnaces (20 MVA each), 1 arc furnace (60 MVA, 120 t) and more rolling mills, hot and cold, with total installed power above 50 MVA, including other auxiliary lines for galvanizing (zinc covering), plasticizing, and strip cutting. At the moment, all these plants are privately-owned and not in regular operation. Furthermore, three lead-zinc mines (Zletovo, Makedonska Kamenica and Toranica) and a smelter are located in Veles, also privately-owned and not in operation. One nickel mine with a smelter are present in Kavadarci, currently not in operation. The chromium mine and accompanying smelter in Jegunovce and its vicinity is not in operation as well. Another mine and smelter (copper, in Radovis) is out of operation as well. While many of the above-listed plants are not in regular operation, main foreign exchange flows in the country come exactly from these industries.

Domestic electricity generation is not sufficient to maintain operation of all these plants at the same time, necessitating electricity import to ensure regular operation.

Equipment and technology applied at these plants date back from the 1970s. VSD mainly use DC motors. Application of VSD with AC motors is in its early stages.

Before the transition, the metal industry (MZT Skopje) was the leading industry in the region, but has nowadays fallen out of use.

The electronics industry is also out of work (EMO - Ohrid, Rade Koncar - Skopje, Cable Factory – Negotino, etc.).

Once a leader in the region, the organic chemical industry (OHIS - Skopje), is currently decommissioned.

The textile industry is plagued by a deep crisis. Back in 1976, GEC Technology in Skopje started work with AC VSD for production of artificial fiber and was among the first in the world, but nowadays it is not in operation. Only a handful of factories across different towns (Stip, Tetovo, Veles, Bitola, Ohrid, Struga, Skopje, etc.) are currently in in regular operation.

Being an agricultural country, the Republic of North Macedonia had great potential for the food processing industry, which dwindled on the account of growing markets in the neighborhood markets and severe competition. A recently emerged trend in this industry with signs of progress concerns small, modern facilities.

Hence, it can be concluded that the industry in the country is in very dire state, often marked by halted production. This has led to the industry loosing its primacy as serious electricity consumer compared to the period before the transition. Moreover, technology applied is already old and obsolete, without any efforts for modernization.

2) Households, Building Needs (HVAC Systems)

Households are a major electricity consumer in the country throughout the year, which is mainly due to use of HVAC systems. Water heating, cooking, washing, home cleaning all heavily rely on electricity consumption as well. Elevators and pumps in multistorey buildings also need electricity.

3) Communal Water Systems

The Republic of North Macedonia has relatively good water sources, with 3 natural lakes (Ohrid, Prespa and Dojran) and many rivers and artificial lakes. However, many towns across the country (Tetovo, Struga, Veles, Prilep, Kumanovo, Berovo, etc.) lack good communal water systems. Water pipelines are old, with only minor application of power electronics and modern drives. It is worth saying that there are more (approx. 10) great water pump stations for water supply in agriculture. Almost all of them use HV 6 kV induction motors, which was considered very advanced at the time of their installation 40-50 years ago, but are currently in bad condition and out of operation.

4) Water Treatment Plants

In the Republic of North Macedonia, water treatment plants are mainly in the stage of planning. Actually, the only operational water treatment plant is located in Kumanovo. Hence, this field opens great possibilities for application of power electronics and modern drives.

5) Transport

Transport in the Republic of North Macedonia almost exclusively uses internal combustion engines. According to most recent statistics [28], the number of passenger vehicles accounts for 477,820, trucks – 44,400, buses – 2,900, and the number of towing vehicles is 6,300, with total population of 1,836,713 (559,418 households). On average, the age of passenger vehicles stands at 19.5 years, 88% of which are older than 10 years. In 2018, the total consumption of diesel accounted for 535,000 t and total consumption of petrol stood at 120,000 t. It could be approximated that the total installed power of vehicles is cca 30000 MW, i.e. 10 times more than the installed power of electricity sources. Moreover, use of 1l of diesel creates 2.68 kg CO_2. All this allows the conclusion that transport is the main reason for air pollution. Trolleybuses, trams, subways, electric buses, etc. are not used for public transport.

The next example presents a case for implementation of electric buses for public transport in Skopje in an attempt to decrease air pollution.

Example 2: Concept of Dynamic Charging System for Public Transport in Skopje [34]

The Public Transport Company Skopje - JSP operates more than 50 urban and 50 suburban bus lines, making it the biggest passenger carrier in the country. The company's bus park is mostly comprised of double-deckers (Yutong, China) and LAZ models from Ukraine, but in much lower numbers. Consequently, the City of Skopje attempted several plans for introduction of tram transport, but with no success. Against the background of global warming and air pollution, the most reasonable and cheap solution to the problem of gas emissions is seen in dynamic charged electric busses. Moreover, a number of city boulevards are facing rush hour congestion, with Blvd Partizanski Ordredi being the most affected by high intensity traffic throughout the entire day. A total of 14 bus lines are operated along this boulevard at all hours, connecting the downtown area with other urban and suburban areas. Use of electric charged buses as part of the In Motion Charging (IMC) system is a possibility for this boulevard, having in mind the multiple lines to be operated and taking into consideration construction of overhead contact line along the boulevard. If constructed, such infrastructure can be used by many vehicles, reducing unit cost (per vehicle or per transport load) of construction and maintenance. The trolleybus route and vehicle charging network suggested as part of the IMC system is shown in Figure 2. Also, Table 5 provides an overview of existing bus lines that use dynamic charging. The trolleybus overhead traction line is 3.5 km long.

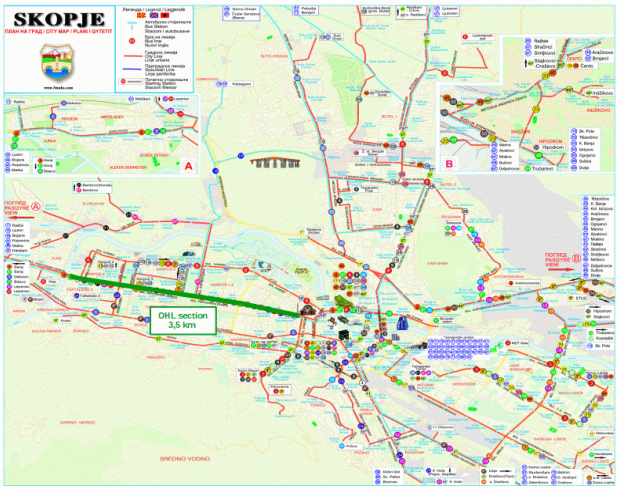

Fig. 2. IMC concept system in Skopje, based on www.jsp.com.mk

While boasting the first line in the Balkans, Thessaloniki-Skopje, constructed in 1873, the railways are in deep crisis. Plans are in place for an east-west connection (Bulgaria-Albania) and a fast line to Serbia, as part of the Budapest-Athens route. The number of hybrid and electric cars in use is negligible, opening great possibilities for power electronics and modern drives in public and private transport. Both public transport projects (modern railway and city electric transport) are given high priority and have great potential to decrease air pollution.

TABLE V
JSP BUS ROUTES PREDESTINED BY IMC OPERATION

Bus route	Route length [km]	Length of route under OHL [km]	Covering of route by OHL
2	13.5	3.5	0.26
2A	14.6	3.5	0.24
4	9.1	3.5	0.38
12	14	3.5	0.25
15	10	2.5	0.25
21	12.5	3.5	0.28
22	12	3.5	0.29
22A	11	3.5	0.32
26	8	2.5	0.31

6) Additional Consumers

As electricity consumers and pollution generators, civil engineering companies are another group that should be noted. In this regard, the main possibility for decreasing pollution is the use of modern technologies.

V. CONCLUSION

Environmental pollution is unavoidable. Unfortunately, the human kind does not demonstrate sufficient care for nature and its own health. However, continuation of life on planet Earth necessitates environmental pollution to be put under control. More especially, environmental air pollution above limits is dangerous for human health and life expectancy. The most important consequences of environmental pollution include climate change and global warming. Human activities are the reasons behind environmental pollution. Even in developed countries, pollution sources do not fully and equitably comply with protection rules. On the other hand, environmental conditions in underdeveloped countries are much dire, including inadequate public and domestic heating systems, use of old buses and cars, low levels of culture and standard, etc. As a developing country and more than 30 years of transition experience, the Republic of North Macedonia faces both the problem of environmental pollution and low application of power electronics. Use of power electronics in electricity generation from renewable sources, modernization of industrial and domestic electric drives, as well as electric transport, can significantly contribute to decrease environmental pollution, even by 50%. It is clear that investments, mainly foreign, are needed, but human health is the most important and has no price tag attached. Such investments usually have a 3 to 5 years rate of recovery, depending on annual operation hours of plants.

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