MARKET INVESTIGATION PLAN: BULGARIA

4EM-MCP is supported by:
Intelligent Energy Europe

Core partner:
AEE EEA

ENERGY EFFICIENCY AGENCY
www.seea.government.bg
stodorova@SEEA.government.bg 37, Ekzarch Josif Str., 3rd Floor, 1000 Sofia, Bulgaria +359 2 915 40 13 +359 2 981 58 02

TABLE OF CONTENTS

1. Introduction

General data for Bulgaria:

Full country name: Republic of Bulgaria
Area: 110,912 sq km
Location: Southeastern part of Balkan peninsular
Population: 7 718 750 inhabitant
Capital city: Sofia (pop 1.2 million)
People: 85% Bulgarian, 8.5% Turkish, 2.6% Roma, 2.5% Macedonian
Language: Bulgarian. Turkish and Romany are spoken by minorities.
Religion: 85% Bulgarian Orthodox, 13% Muslim
Government: Democracy
President: Georgi Parvanov
Prime Minister: Sergey Stanishev
GDP: EURO21.5 billion
GDP per head: EURO 2771
Annual growth: 5,5 %
Inflation: 6,5%
Major industries: Food processing, machine and metal building, electronics, chemicals, textiles, ferrous and nonferrous metals
Major trading partners: Italy, Germany, Turkey, Greece, Russia, USA
Member of EU: still no – expected data 01.01.2007.

The general evaluation of the EC is that Bulgaria is a functioning market economy. The continuation of the current reforms should enable it to cope with competitive pressure and market forces within the Union in the near term. Bulgaria has broadly maintained macroeconomic stability and advanced structural reforms. Progress has continued since the October 2005 report. Useful steps were taken to contain the external deficit. The privatisation process and the liberalisation and restructuring of utilities are well advanced. Some additional progress has been made in improving the business environment and in reducing non-wage labour costs. However, the current account deficit widened and warrants continued prudent fiscal and wage policies. Deepening of structural

reforms requires improving the functioning of the judicial system and further easing the regulatory burden on businesses. The regulatory framework for the labour market needs to be made more flexible.

Following a very strong expansion by 6.2% in the first half of 2005, real Gross Domestic Product (GDP) growth slowed down in the third quarter mainly as a result of the heavy floods during the summer months and reached 5.5% for the whole year. Gross fixed capital formation grew particularly strongly at a rate of 19.0%; final consumption also continued to expand at a rate of 6.8%. Both the trade deficit and the current account deficit increased further from 15.1% of GDP in 2004 to 20.4% of GDP in 2005 and from 5.8% to 11.8% of GDP. Consumer price inflation (interim HICP) accelerated towards the end of the year due to increases in oil and food prices. While average inflation dropped from 6.1% in 2004 to 5.0% in 2005, end-of-year inflation thus rose from 4.0% to 6.5%.

Energy resources

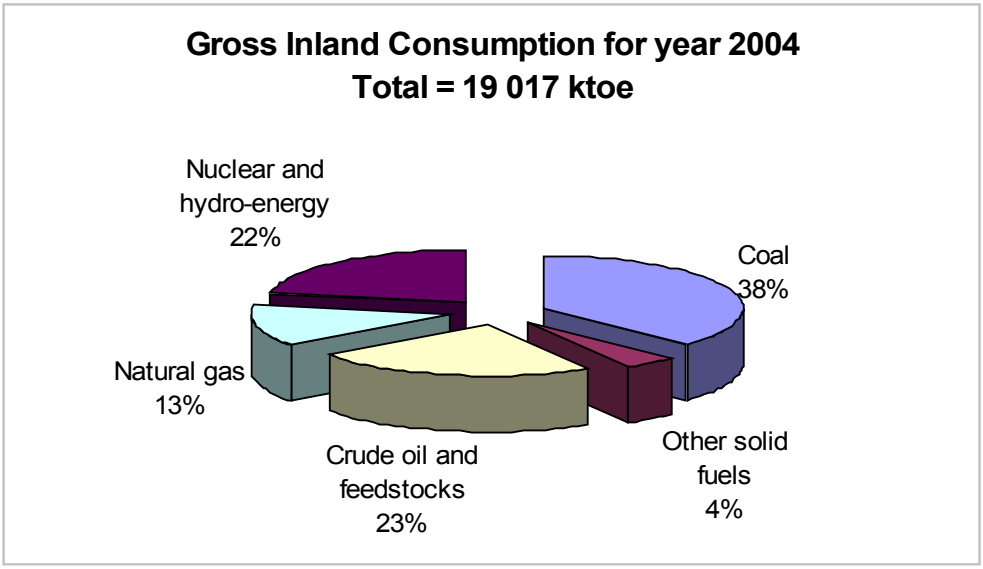


Figure 1.1 ***Source**: EEA, on the basis of Energy Balance Sheets, NSI, 2004*

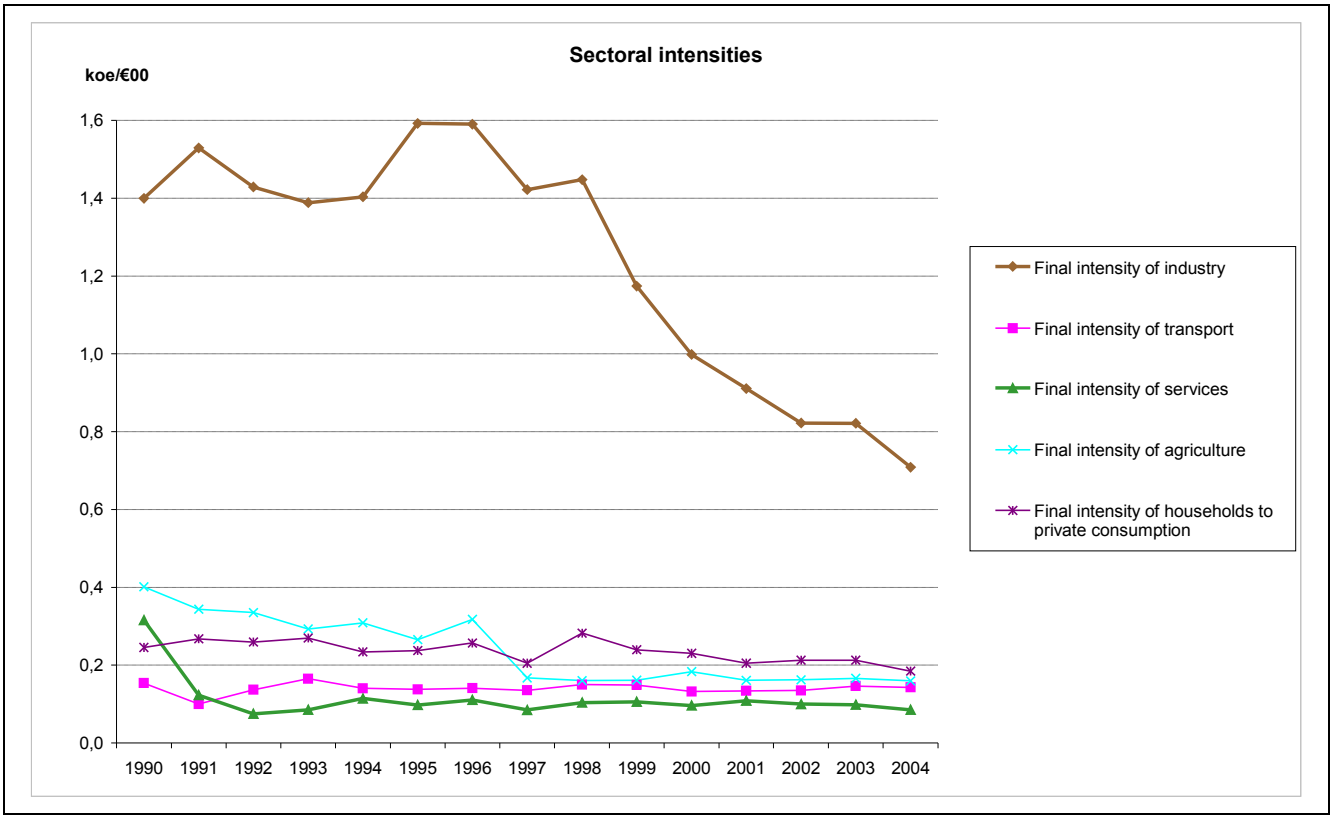


Fig. 1.2: Energy intensity by sectors

On Figure 1.2 is specified the trend of the energy intensity by sectors. Since 1997 energy intensity of industry has continuously decreased with about 14%/year, but the last values (0.71 koe/€00 or 0.21 koe/€00p) remain significant high. The trend of the energy intensity of industry copies the trend of energy intensity of manufacturing. Therefore the high level of energy intensity of industry is due to high level of energy intensity of the manufacturing (1.1 koe/€00 or 0.32 koe/€00p.) The trend of decreasing of Bulgarian manufacturing energy intensity is similar to this of final energy intensity. It means that the high level of final energy intensity of the Bulgarian GDP is due to high level of the industry (manufacturing). The most energy intensity branches in the Bulgarian manufacturing in 2004 are: chemicals (4.2 koe/€00), primary metals (4.0 koe/€00) and non-metallic minerals (3.4 koe/€00).

The total energy independence of Bulgaria for year 2004 is 54%.

The distribution of electric energy consumption by main activities in 2004 is presented in table 1.1 and Figure 1.3.

Table 1.1: Electric energy consumption by main activities in year 2004

	GWh	%
Electricity Consumption	**24 679**	**100%**
Industry	9 711	39,3%
Transport	419	1,7%
Households	8 769	35,5%
Agriculture	151	0,6%
Others	5 629	22,8%

The industry has the highest percent in the electrical energy consumption with 39,3%, followed by the residential sector - 35,5%.

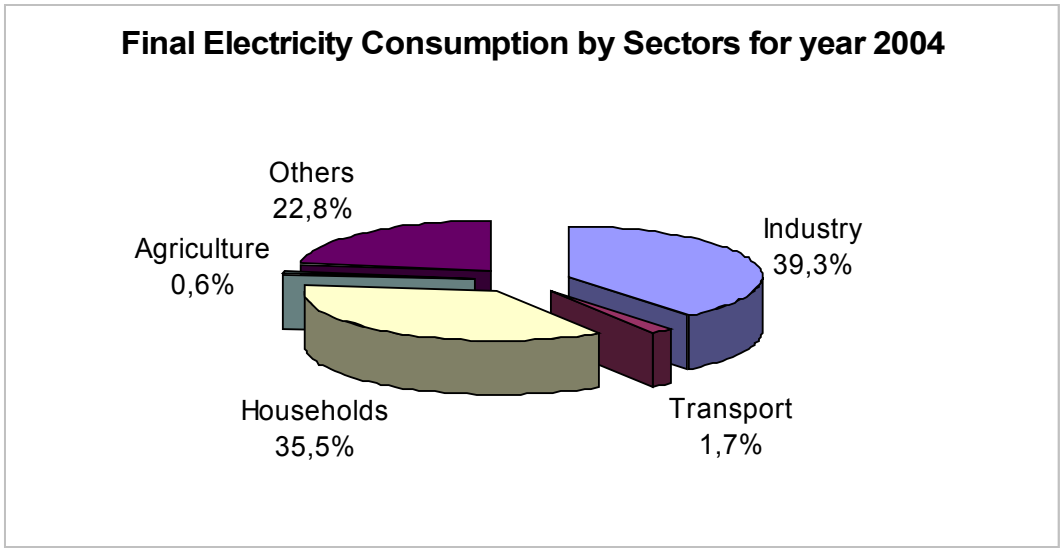


Figure 1.3 ***Source**: EEA, on the basis of Energy Balance Sheets, NSI, 2004*

2. Legislation, strategy, programmes on energy efficiency and environment in Bulgaria

2.1. Legal Instruments and Regulation in the field of energy efficiency in Bulgaria

The Energy Strategy of the Republic of Bulgaria, approved in 2002, is targeted mainly on rational use of energy resources, establishment of competitive energy market and effective energy consumption. Its main targets are:

- Stimulation of investments in energy efficiency (EE) at end users;
- Support through state guarantees to projects of energy management , which have considerable social effect;
- Encouragement of more efficient methods for electric energy use;
- Redirection of electric energy to high technological use in the economy, building of more efficient heating systems;
- Improvement of efficiency in energy transformation processes;
- Reduction of energy losses, etc.

The main legal documents in the field of the EE, concerning in particular the EE in the industrial sector, are as follows:

- **Energy Act,** adopted in 2003, at the moment to be amended and ratified by Parliament. It puts the basis for implementation of a regulatory mode for energy markets in the country that is in harmony to the EC directive for common market for electric energy and natural gas.
- **Energy Efficiency Act,** adopted in 2004, planned to be harmonized this year to Directive 2005/32/EC for EE at end consumers. The Act puts the EE as a national priority, stipulates the commitments and support of the state and regional governments for the successful implementation of this policy in the country, the obligation to adopt municipal energy efficiency programs, requirements for energy efficiency labeling, the use of minimum standards resulting from the EU Directive on energy efficient appliances, obligatory audits of energy consumers, manufacturers of goods and services, whose annual consumption is above 3000 MWh etc. The EE Act is to be amended by the end of the current year;
- **The relevant secondary** legislation, related to the EE Act, like:

- Ordinance for Energy Performance of Sites of 2004 – construction and industrial systems; It will be updated due to the requirements of the Building Performance Directive by the end of this year.
- Ordinance on Energy Efficiency Audits of 2004;
- Ordinance on Terms and Order for Registering Persons, Performing Certification of Buildings and Energy Audits, and for Receiving Information of 2005;

The National Long-term EE programme till 2015 is a strategic document, targeting at reduction of GDP intensity in all economic sectors, end users of fuels and energy, like industry, transport, services, household and agriculture.

The programme defines the optimum measures and impacts per sectors, the possibilities and obstacles for executing the EE policy in Bulgaria, a number of mechanisms and measures for improving EE at the end users, as well as the financial mechanisms for their execution. Its realization will be done during a ten years period 2005-2015 at the conditions of uninterrupted growth of the GDP and with its integration in the common policy for economic and social development of the country.

Based on the analysis of the GDP status and of the energy consumption and energy intensity for the period 1997-2003, the Programme reaches to the following conclusions:

The balance value of the Primary energy intensity is equal to 0,35 kilogram oil equivalent for 1€ to year 2000 and is considerably higher than the average value for the EC (0,2), while the final energy intensity value for year 2003 is with 40% higher than the average European one equal to 0,13 .

For the year 2003 the share in the FEC (final energy consumption) per sectors is the following:

- chemical industry	30%;
- metallurgy (black and color):	30%;
- non metal mineral resources production:	16%.

Within the industry as for the consumed fuels and energy, the highest share is given to liquid fuels, following by electric energy, natural gas and coals.

The forecasts for FEI by the year 2015, is illustrated in Fig. 2.1.1. After the slight increase ate the begging of the period, after year 2006 it is expected to have a decrease of the FEI till it reaches 0,24 koe/€00p in 2015.

Fig. 2.1.1: Final energy intensity of the industry by the year 2015 - Forecast

The forecast for FEC in the sector are on the following Figure 2.1.2, made on the basis of forecasted values for Gross Added Value and the FEI of industry.

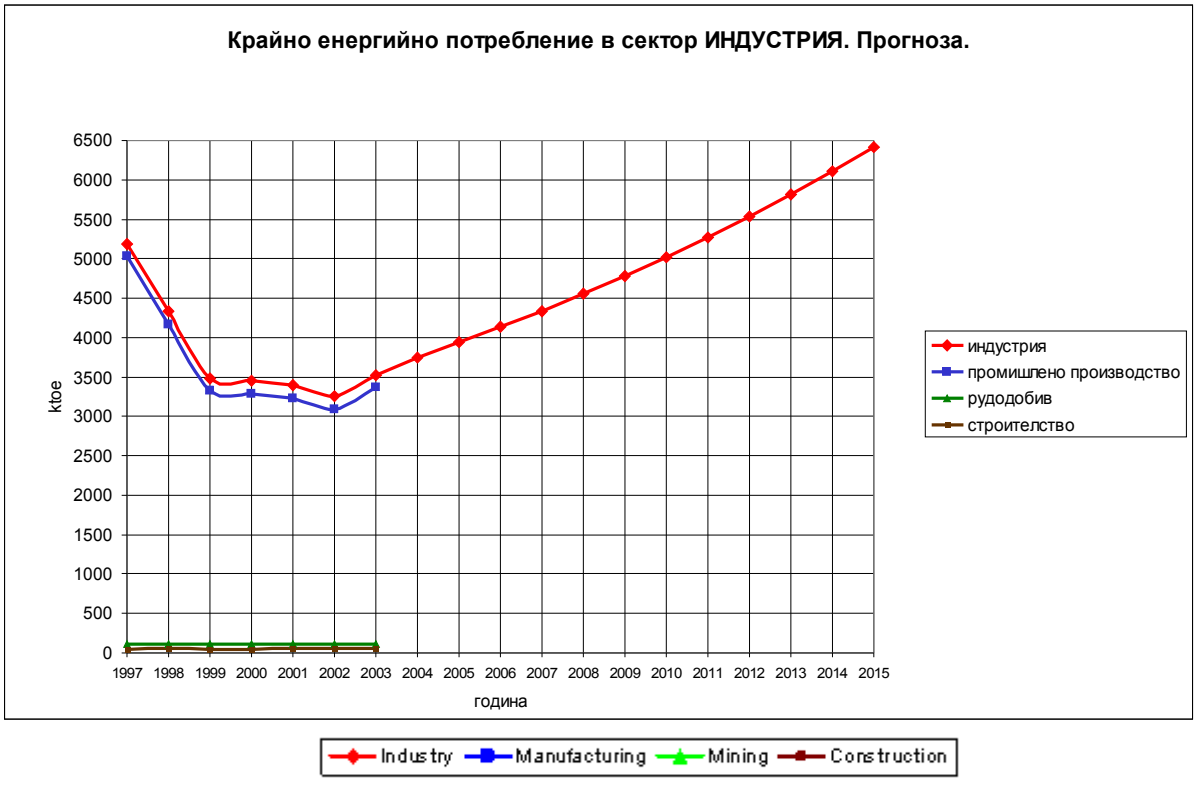


Fig. 2.1.2: Final energy consumption in the INDUSTRY - Forecast

For the above period 2005-2015 the FEC in industry is increased with 4,8% per year.

The defined values of the FEC are the basis to prognosis the consumption per types of fuels and energy , Fig. 2.1.3.

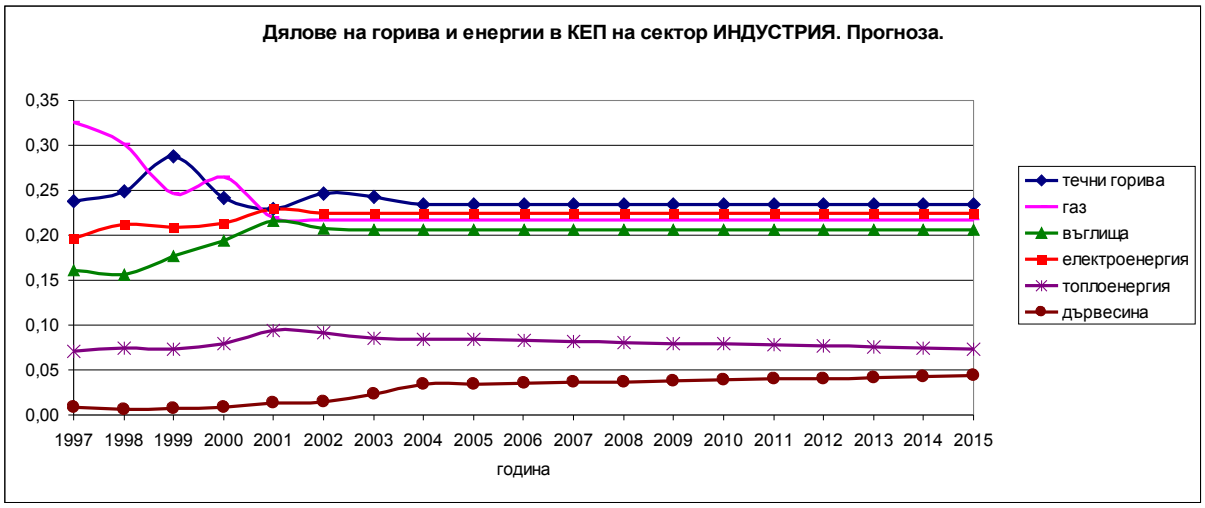
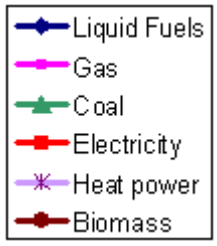


Fig. 2.1.3: Share of fuels and energy per types in the final energy consumption of the industry - Forecast



The National Short-term EE programme 2005-2207 defines a set of projects and gives an assessment of the necessary funds for its execution. It includes 552 projects, as a result of its implementation there will be saving of fuels and energy equal to 140 kilotonnes oil equivalent, what represents 1,5% from the FEC of the country in the year 2003. In sector industry it foresees the implementation of measures fro improvement of EE in industry.

2.2. Legal Instruments and Regulation in the field of climate change in Bulgaria

The most important laws related to climate change are:

- **The Environmental Protection Act and Clean Air Act** and related secondary legislation, including a permit system for meeting minimum standards in accordance with European Union (EU) regulation on IPPC, large combustion plants, the introduction of the EU ETS and technical inspection (e.g. for cars). . In September 2005 the Parliament adopted an amendment in the Environment Protection Act, which provides the background for the implementation of the EU scheme for greenhouse gas emissions in Bulgaria in line with the Directive 2003/87/EC. At the moment on preparation is new ordinance on order and procedure for issuing and reviewing of permits for greenhouse gas emissions and implementation of monitoring by operators of facilities involved in greenhouse gas emissions quota trading scheme.
- The United Nations Framework Convention on Climate Change (UNFCCC) of 1992 was signed by Bulgaria in June 1992 through the Law for Ratification of the UNFCCC published in the State Gazette No. 28/28.03.1995. The 1997 Kyoto Protocol introduces obligatory rules and requirements towards the Parties, related to the principles and obligations introduced by the Convention. The Protocol was signed by Bulgaria in Sept. 1998 and ratified through the Law for ratification of the Kyoto Protocol to the UNFCCC in 2002.

Electricity tariffs

The current electricity price, paid by the Bulgarian industrial companies is about 140÷157 leva/MWh, VAT of 20% included (ca. 6÷6,7 eurocents/kWh, VAT excluded) depending on the tariff of the electric power distribution companies. The electricity prices are subject to regulation by the State Energy and Water Regulatory Commission.

There are no cross subsidies between the industrial and household users.

3. National motors and motor systems manufacturers

3.1. Description of major national manufacturers

Bulgaria has several electrical motors producers. Most of them are manufacturing three-phase squirrel cage asynchronous motors (TPSCAM), the most common type of motors and the first to be addressed for a higher efficiency.

The repartition of Bulgarian manufacturers for TPSCAM with powers between 0,09 to 315 is depicted in table 3:

An investigation on these manufacturers was performed within 4EM-MCP, by interviews and a questionnaire.

Table 3: Bulgarian manufacturers of TPSCAM for the power range from 0,09 to 315 kW

POWER [kW]	"MMotors" - Etropole	Elprom-Harmanli	Elmot - Veliko Turnovo	Elma-Troyan	Elprom-zem - Sofia
0,09				#	
0,12	#		#	#	
0,18	#		#	#	
0,25	#		#	#	
0,37	#	#	#	#	
0,55	#	#	#	#	
0,75	#	#	#	#	
1,1	#	#	#	#	
1,5	#	#	#	#	
2,2	#	#	#	#	
3	#	#	#	#	
4	#	#	#	#	
5,5		#	#	#	
7,5		#	#	#	
11		#	#	#	#
15		#	#	#	#
18,5		#	#	#	#
22			#		#
30			#		#
37					#
45					#
55					#
75					#
90					#
110					#
132					#
160					#
200					#
250					#
315					#

These five producers are manufacturing now TPSCAM with powers belonging to the power range from 0,09 to 315 kW.

All current manufacturers of TPSCAM, and a research institute connected with energy efficient motors (EEMs) design and research are presented in the next.

a) "MMotors"Joint Sock Company is located in the town of Etropole. (www.mmotors-bg.com)

The company was established in 1961 as a State Industrial Factory named "Metal Products". Gradually, the company starts launching a variety of small electro-motors to be used with both elevating- transport machine and household.

Several types of fans to be used in electro-digital technology were adopted and released following the characteristics of a licensed French product.

"MMotors" JSC produces:

- Over 100 modifications of single-phase and three-phase motors for common use with height of the turning axis equal to 63, 71, 80, 90 and 100 mm /power varying from 120W to 4,0 kW ;
- Special induction motors with various applications in concrete mixers, washing machines, fans, automated garage doors, etc.;
- A series of axial fans of five different types: BA 9/2, BA 12/2, 12/2K, BA 14/2, and BA 16/2.
- A series of 8 different types of ventilators (domestic fans) used for household and sales purposes;
- A series of 14 different types of in-line axial fans used with air-conduits and fireplaces
- A series of 3 different types of industrial fans.

The company is an already well established manufacturer and supplier for the market not only in Bulgaria, but also in European countries like Germany, France, Slovenia, Macedonia, as well as countries from the Near East.

b) "Elprom - Harmanli" JSC is located in the town of Harmanli. (www.elprommotors.com)

The company was established in 1950 as a factory for production of general and special-purpose asynchronous electric motors. Both single-phase and three-phase motors with rotation axis heights 71÷180 mm are included in the company's diverse product list. The quality products of the company are successfully sold in Bulgaria as well as in Europe and all over the world. Elprom-Harmanli is an ISO 9001 quality assured firm.

"Elprom - Harmanli" JSC produces:

- *Standard Execution*

  Three-phase induction electric motors
  AT series with height of rotation axis 71 ÷ 180mm is produced.
  Single-phase induction electric motors
  Height of rotation axis - 71 ÷ 100mm.
  The following product series is produced:
  ASR - motors with starting and running capacitor
  AS - motors with starting capacitor
  AR - motors with running capacitor.

- *Specific Executions*

  Motors - tropic operations
  Motors with thermal protection
  Motors with lateral terminal box (right or left)
  Motors for supplying voltage and frequency on request
  Motors with duty cycle S2, S3, S6
  Motors with cable gland on request
  Motors with specific technical dimensions
  Special purpose electric motors with technical parameters on request.

Annex 2 is presenting characteristics of Elprom-Harmanli's Series AT, as un example.

c) "Elma–Troyan" JSC is situated in the town of Troyan. (www.elma.hit.bg)

"Elma –Troyan" JSC is established in 1945. In 1997 the plant was privatized, with majority owner AKB-FORES Industrial Concern. In 2000 "Elma –Troyan" JSC was certified with ISO 9001 quality system, certificate Q5609 by the English company SGS Yarslay.

"Elma –Troyan" JSC produces:

- single-phase induction motors with squirrel-cage rotor for universal application with power from 0,16 kW up-to 2,2 kW, speed-3000 rpm and 1500 rpm on customers' special requirements;

- Single-phase induction 2-speed motors for automatic washing machines;
- Single-phase motors with power 1/2 HP and 1/3 HP for ordinary washing machines;
- Three-phase induction motors with squirrel-cage rotor for universal application with power from 0,26 kW up to 11,0 kW with electromagnetic or rotor brake;
- Frameless motors for lawn mowers, shredders, concrete mixers, washing machines and others, with or without built-in rotor brake with power from 120 W up to 1600 W;
- Single-phase induction generators and generating sets with power 1,5 kW, 2,0 kW, 3,0 kW, 5,2 kW.
- Three-phase induction generators and generating sets with power 4,0 kW and 6,0 kW.

d) "Elmot -Veliko Turnovo" JSC is situated in the town of Veliko Turnovo. (www.elmot.dir.bg)

"Elmot -Veliko Turnovo" JSC produces:
- Electric brake motors with cone rotor
- Rope electric hoists with capacity from 1 to 20 t
- Rope overload limiters type BOT
- Reduction gears and geared motors
- Elastic couplings for driving systems
- Winches with capacity from 100 to 1000 kg
- Crane components, DC traction motors

The quality management system applied in the company is ISO 9001:2000 certified by Lloyd's Register Quality Assurance.

"Elmot -Veliko Turnovo" JSC has a special competence in production of asynchronous brake motors with cone rotors and power up to 30 kW. They propose decisions for various customer needs within the following characteristics:
- Power from 0.12 up to 30 kW
- Duty cycle up to 50%
- Switch rating up to 300 h^{-1}
- Single-speed (2; 4; 6; 8 poles) or two-speed (2/8; 4/12; 4/24; 4/30; 6/24 and 6/30 poles) motors
- Intended for each necessary value of supply voltage and current frequency
- Designed for numerous specific working conditions upon customer's request (including requirements of tropical, marine and chemically-aggressive environments)
- Different types of flange joining
- Explosion-proof brake motors up to 8 kW, certified by accredited laboratories.

f) "Elprom-zem" JSC is situated in capital city of Sofia. "Elprom-zem" JSC was founded in 1950 and is the greatest manufacturer of electrical machinery in Bulgaria. Its production is well known in all countries from CIS and East Europe, as well as in many West European countries, Asia, Africa and Latin America.(www.elprom-zem.com). The company has been privatized in 1997 and 67% from its capital are private property.

"Elprom-zem" JSC designs, produces and sells a wide range of electric machines, such as:
- different series asynchronous electric motors with squirrel cage rotor for common industrial use with degree of protection IP 23, IP 44, IP 54 and IP 55, from 2 to 8 poles, power outputs from 11 to 315 kW, for supply voltage 380 V, 50 Hz, with shaft height from 160 up to 355 mm.
- series asynchronous electric motors with squirrel-cage rotor for supply voltage 3 and 6 kV with degree of protection IP 23, from 2 to 8 poles, power from 200 to 1000 kW, height of rotation axle from 355 to 450 mm;
- series synchronous electric motors with squirrel-cage rotor for supply voltage 6 kV, 50 Hz, power from 315 to 2000 kW , with degree of protection IP 23;

- synchronous self-exciting generators for stabilized voltage 390/225 V, 50 Hz, corresponding to Bulgarian State Standard 10604-77 and international standards, power from 2.5 kVA to 250 kVA and speed of rotation 1500 min^{-1}. The generators are brushless, with built-in exciting system. On the basis of license bought from AEG Company, the series is completed with ship generators for stabilized voltage 230/400 V, 50 Hz, power 500, 700, 900 kVA and speed of rotation 1000 min^{-1}.
- single synchronous el. motors for driving of ball-mills, compressors, water pumps, etc. with power 9000 kW, voltage up to 10 kV and asynchronous el. motors designed for special conditions of operation and used for driving of water pumps in Nuclear Power Plants, blowers and belt conveyors in Heating Power Plants and mines etc., with power up to 3150 kW;
- hydro generators up to 235 MVA capacity. The biggest ones, produced by “Elprom-zem”, are two motor-generators of 235 MVA capacity for 19 kV and rotation frequency 600 min^{-1} as per documentation supplied by "TOSHIBA-JAPAN" and in cooperation with that company;

“Elprom-zem” provides for the clients in the country and abroad repair of its production in own production base - synchronous and asynchronous el. motors for high voltage in different execution and modification, special el. motors and hydro generators. Repair and replacement of stator and rotor windings, replacement or partial repair of the magnet line, replacement of bearings and bearing assemblies, as well as repair of other parts and units are carried out for this nomenclature of electric machines. A great number of the leading specialists, as well as the top managers of the company have been trained in the factories of "Toshiba" - Japan.

There are several producers of variable speed drives (VSDs) in Bulgaria. The most important are:

AMK Drives and Controls Ltd., Gabrovo (www.amk-drives.bg)

AMK Ltd. is a daughter firm of German company AMK-Arnold Müller GmbH & Co.KG and offers:
- all AMK products: asynchronous and synchronous servo-motors, digital single and multi-axis servodrive control systems, CNC control for single and group of machines, frequency inverters, motors for hoisting and hauling technics, geared motors;
- following services: designing, producing and delivering of systems for processing control; retrofitting of metal-cutting, textile, packing and other technics;

The energy efficiency is achieved on all levels of control:
- Motors: by using of synchronous and asynchronous servomotors with special design. All motors are equipped with torque, speed and position feedback.
- Servo drive – servo modules.

The field control, combined with vector control, allows to achieve a power factor, greater then 0,9. Practically, the motor is fed with so much energy, as it is enough for the motion.
In the modular AMKASYN KE/KW systems the internal distribution of the energy is happened. When one of the motors returns back the energy, the other can use it owing to the common DC bus.
- Servo drive – power supply module. The power recuperation is performed. AMKASYN servo systems have the possibility to return back the accumulate energy to the network at the stopping of motors.

Electroinvent, Sofia, produces a range of frequency inverters:
- type ELDI with motor power 0,18 to 5.5 kW;
- type ELFI/B with motor power 0,75 to 3.0 kW;
- type ELDI/D with motor power 5,5 to 55 kW;
- type ELDI/DF with EMC filter with motor power 7,5 and 11 kW;

Above mentioned VSDs are applicable in the following fields: pump and fan control, food industry, textile industry, conveyors and transport lines, woodworking machines, industrial washing machine.

3.2. Review of production characteristics

The TPSCAMs, made in Bulgaria, correspond to the Bulgarian standards, specified in Annex 3. The motor starting, working and energy performance is equal to the performance of the induction motors (IMs) with the same size, power and rotating frequencies, manufactured in the EU. The dimensions and the weight of Bulgarian made IM are equal to these ones of the similar EU IM.

The European Committee of Manufacturers of Electrical Machines and Power Electronics (CEMEP) introduced in 2003 efficiency classes for the new EEMs, as in Annex 1. The efficiency of the electric motors, made in Bulgaria, is specified on Tables 1 & 2 of Annex 1. As can be noticed, the majority of the Bulgarian made motors correspond to efficiency class eff3, and the highlighted ones belongs to eff2.

Elprom – Harmanli developed EEMs with rotation axes heights 100, 112, 132 и 160 mm, which was achieved by increase of consumption of active materials (steel, copper, aluminium). Actually the prices of active materials on the international market have increased approximately by 300%, while the selling prices of the EEMs have increased by 20-30%. This circumstance makes the manufacturing of EEMs unprofitable for the time being.

Annex 4 shows a view of a typical product of “Elma–Troyan” JSC.

More details on the products of the Bulgarian companies can be found on their web sites.

The price level of the Bulgarian made IM is slightly lower than this one of EU made IM.

4. Importers and dealers

On the Bulgarian market at the present on the Bulgarian market there are several electrical motors dealers, representing European companies, offering TPSCAM, as well as high efficient motors and systems. The more significant among them are, as follows:

ABB Bulgaria Ltd., Sofia, (www.abb.com) imports and offers: motor and drives - LV motors of 0,12 to 5600 kW, AC drives – frequency converters for speed and torque control of 2,2 to 630 kW squirrel cage motors; direct torque control method.

SIEMENS BG, Sofia, (www.siemens.bg) deals in automation systems, LV equipment, motors and drives of 0,06 kW to 35 MW, frequency converters (with sensorless vector control) up to 630 kW; direct torque control method.

SCHNEIDER ELECTRIC, Sofia, (www.schneiderelectric.bg) offers LV switchgear and automation equipment.

CURTIS/BALKAN, Sofia, (www.curtisinst.com) deals in industrial electronics for electric powered transport devices, programmable controllers for internal combustion motors, capacitance meters for traction batteries.

Westinghouse Energy Systems Bulgaria Branch, Sofia, (www.westinghousenuclear.com)
Company Description: Power generation equipment and services for nuclear power plants; local branch - implementing the Kozloduy Nuclear Power Plant Units 5&6 Modernization Project.

Several Bulgarian companies are dealers of leading European companies, producers of pumps with VSD:
Aquastart, Sofia, represents Vogel Pumpen (www.aquastart.net)
Danfoss Ltd., Sofia, (www.danfoss.com)
Grundfos Bulgaria, Sofia
B. A. P. Bulgaria Ltd. imports the system Hydrovar (VSD type) for frequency control of electric motors ranged from 1,1-45 kW, designed especially for pumps.

The above companies offer special energy saving calculators for the evaluation of economic profitability of the use of VSD for pumps, fans and compressors.

Romer Ltd., Sofia, sells electronic controllers Power Planner of the American company Energy Smart. A considerable number of such of controllers is used in IM with rated power 22 kW for textile machines in Montana AD, town of Montana.

QMI Bulgaria Ltd., Sofia, (www.QMISX6000.com) is importer of electronic controllers PowerBoss, for IM, driving wood processing machines, hydraulic presses, extrusion machines, transportation systems etc.

5. Evaluation of motor penetration to end users

5.1. Motor electricity consumption by sector, industry and process

Till now no energy auditing programmes have been implemented for the whole of the Bulgarian industry, which could allow the identification of the industrial energy saving potential of the EE motor driven systems.

Motor electricity consumption by sector

There are no statistical data in Bulgaria regarding the share of motor electricity consumption. Relying on known shares from previous studies, in Table 5.1.1 it is estimated the distribution of electricity consumption in motor systems as share from the electricity consumption in each sector. The base year for the characterization of motor electricity use is 2004.

	GWh
Industry	6 312
Transport	251
Households	1 314
Agriculture	60
Other (incl. construction)	1 970
Total Electricity Consumption	**9 908**

Table 5.1.1: Electricity consumption of the motor driven systems by sectors, Bulgaria, 2004, GWh

The total electricity consumption of the motor driven systems is estimated to 9,9 TWh.

Industry is by far the sector which accounts for the major part of electricity consumption in motor driven systems, more than 6 TWh. In EU, the studies showed that the electric motor driven systems account for 65% of industrial electricity consumption.

The distribution of motors electricity consumption by sectors is shown in figure 5.1.1. 64% of total electricity consumption in motor driven systems appears in industry.

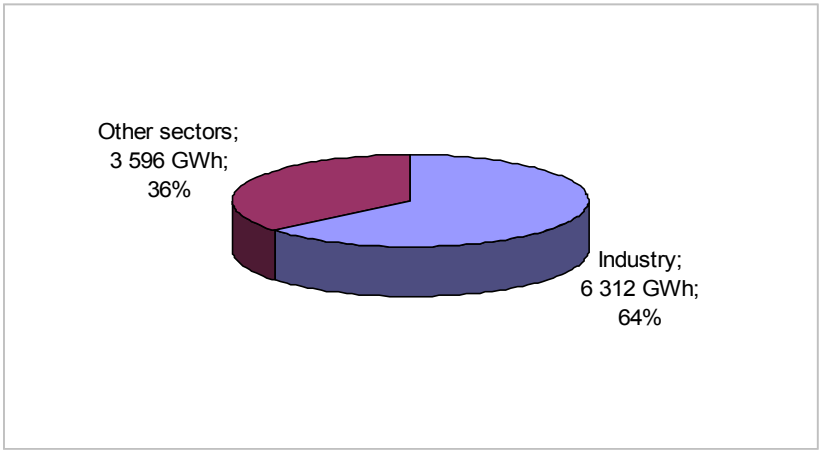


Fig. 5.1.1: Share of electricity consumption of the motor driven systems by sectors, Bulgaria, 2004, GWh

Motor electricity consumption by industry.

Iron and steel, non-ferrous metal, chemical, food, drink and tobacco sectors of the industry are the main electricity consumers in Bulgaria (see Figure 5.1.2). These industrial sectors are responsible for 54% of the total industrial electricity consumption in Bulgaria.

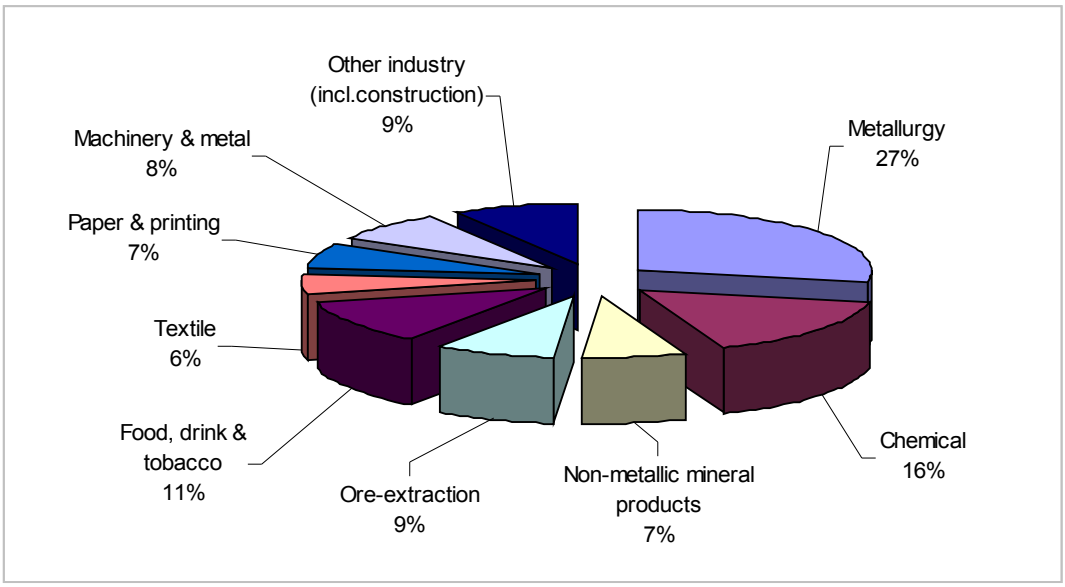


Fig. 5.1.2: Electricity consumption by industry, 2004. Total = 9711GWh

There are no specific data issued in statistics or studies in Bulgaria for the estimation of the share of motor electricity consumption by type of industry. Therefore, for this purpose we have to rely on best expert estimates and similarity with figures known in European studies.

Main motor driven systems electricity consumption appears in iron and steel, non-ferrous metal, chemical, food, drink and tobacco sub-sectors of the industry (see figure 5.1.3 and Table 5.1.3). These industrial sub-sectors are responsible for 55% of the total motor driven systems electricity consumption in the industry.

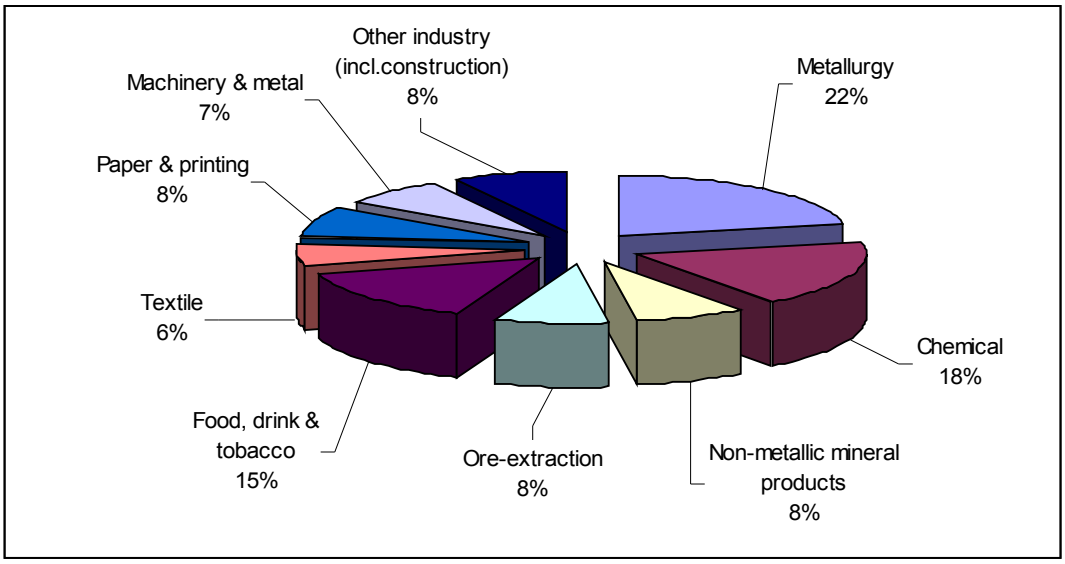


Fig. 5.1.3: Motor driven systems electricity consumption by industry, 2004. Total = 6312 GWh

Metallurgy	1 359,9
Chemical	1 166,2
Non-metallic mineral products	488,5
Ore-extraction	500,9
Food, drink & tobacco	958,7
Textile	352,0
Paper & printing	514,9
Machinery & metal	455,1
Other industry (incl.construction)	515,8
TOTAL	**6312,0**

Table 5.1.2: Motor electricity consumption by industry, Bulgaria, 2004, GWh

Motor electricity consumption shared by end user process in industry.

Motor electricity consumption is very difficult to be disaggregated by power range and by the main end-use applications, such as pumps, fans, compressors, conveyors and others. Again we should rely on expert estimations to approach the figures specific for Bulgaria. The share of motor driven systems electricity consumption in the industrial sector in Bulgaria by end use type of load is given in Table 5.1.3 Figure 5.1.4. Pumps, fans and compressors are the main electricity consumers in industrial sectors. These first estimations will serve as basis for further improvements and checks.

Equipment	Industry
Pumps	1 287
Conveyors	457
Fans	1 270
Refrigeration	542
Others drives	1 795
Compressed air/gas	961
TOTAL	**6 312**

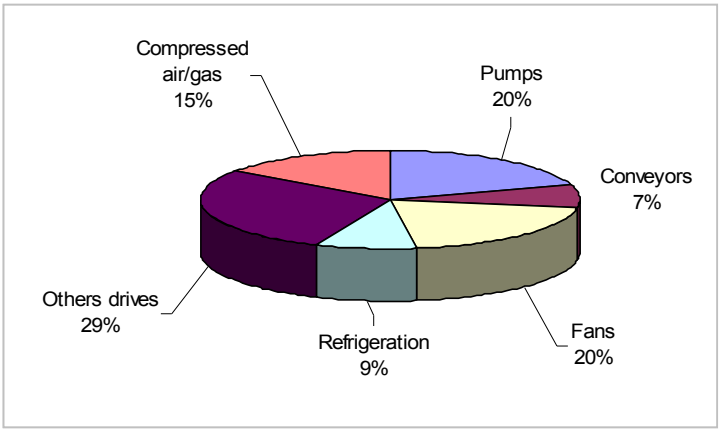


Table 5.1.3 & Figure 5.1.4: Estimated electricity consumption by application part of the motor system, Bulgaria, 2004. Total = 6 312 GWh

The consumption of industrial motor driven systems of 6 312 GWh for year 2004 is responsible for the greenhouse gas (GHG) emission of 5,239 million tonnes CO_2 eqv. (CO_2 eqv. emission factor = 0,83 kg CO_2 eqv. per kWh).

5.2. Case examples of motors use

Katex AD, Kazanlak, (www.katex.com) is a producer of a wide range of worsted and woolen fabrics in different compositions, weaves, yarn counts, weight and design. The results of a study of the use of motor driven systems, made in 2006 by way of a questionnaire are presented in the Table 5.2

Table 5.2: Electric motor performances in Katex AD

Equipment	Drive - asynchronous electric motors 0,75 - 315 kW							
	Rated tension	Efficiency	Rated output	Load coefficient	Working output	Annual use	electric power consumption	notes
	kV	%	kW	%	kW	hours/year	kWh/year	
PUMPS								
1. Water supply	0,4	92	55	69	38	4 300	163 000	
2. Water supply	0,4	89	22	82	18	2 000	36 000	
3. Water supply	0,4		20	85	17	3 500	59 500	12 units
4. Water supply	0,4		10	80	8	3 500	28 000	5 units
5. Water supply	0,4		5,5	91	5	3 500	17 500	2 units
FANS								
1. Air-conditioning	0,4		100	65	65	5 800	348 000	2 units
2. Air-conditioning	0,4		75	60	45	5 800	261 000	5 units
3. Air-conditioning	0,4		40	80	32	5 800	185 600	
4. Air-conditioning			15	80	12	5 800	69 600	
COMPRESSORS								
1 Compressed air	0,4		75	93	70	5 800	406 000	
2. Compressed air	0,4		75	93	70	3 500	245 000	
3. Compressed air	0,4		45	100	45	3 500	157 500	
4. Compressed air	0,4		30	100	30	3 500	105 000	3 units
5. Compressed air	0,4		55	100	55	5 800	319 000	
6. Compressed air	0,4		22	91	20	3 500	70 000	

The study shows that the predominant number of the IMs is operating more than 4000 hours per year that allows the implementation the energy saving potential by the use of the VSDs. The

payback period of the investments may be expected to be from 6 months to 1 year for the different electric drives.
Part of the IMs is operating at a lower load and as a result the energy efficiency is lower. In this particular case the specific energy consumption may be reduced in the following way:
- in case the mechanical load is constant and does not change, it is necessary to replace the used IM with another one, with more suitable lower output.;
- in case the lower load changes cyclically within a wide range, it is necessary to be used a suitable electronic controller which will be changing the consumed output and the losses depending on the load.

5.3. Comments on EE motors penetration to end users

The constraints for the wider use of energy efficient asynchronous motors and electric drives in Bulgaria may be summarized in the following order:

a) ignorance of the mechanical load performance;
Usually to define the loads we use empiric dependencies, which do not record sufficiently the loadings and especially the dynamic ones during start up, reversing, repeating switching, transfer from low to high speed and vice versa, etc. There are no methods and measuring systems fro experimental recording of the dynamic and static loadings elaborated by now.

б) pre-gauging of power;
There is a practice IM to be chosen on the basis of higher power in order to have potential for more reliability and future updates. There are no sufficiently accurate methods for the selection of IM and for their testing for warming up and admissible short time overloading with recording of the dynamic and static loadings as well.

c) work at loading different from the nominal one;
The static data of the research institute on electric energy show that 60% of all IM work with loading of up to 60% and even less for which they have been designed. The analysis of the loading of IM used in Bulgaria show similar results. At the same conditions and in some applications IM may separate as losses up to 70% of the electric energy consumed.

d) low mechanical efficiency of the technological equipment;
A bigger part of the working mechanisms used have a low efficiency that leads to decrease of the total efficiency of the electro-mechanical system.

e) use of EEM;
The number of EEM used in Bulgaria from classes eff2 and eff1 does not exceed 500 units, almost all from import.

f) use of regulated EEM;
The control of IM by electronic devices may reduce the energy consumption with 30-40%. The leading firms like ABB, Siemens, Schneider Electric and OMRON offer various regulated electrical motors with built-in functions for " energy saving". The part of these regulated ones from the total number is very small - less than 10%. The mass use of regulated IM is for pumps, ventilators and compressors. Due to the big savings of electric energy and the short pay back period the sales of these units are increasing with 20% per year.

g) lack of methodologies, algorithms and models;
In Bulgaria there are no elaborated methodologies, algorithms and models for the definition of:
- The moment values of the consumed active, reactive and complex powers, of the efficiency coefficient and power factor of the IM at dynamic and stable modes of work;
- The working and energy performances at dynamic and working stable modes via the measurement of their electric values;
- The average fro a period and for a cycle of time energy performances and of the cyclic efficiency coefficient of elevating mechanisms;

- The function of losses in IM at dynamic and stable modes;
- Unified criterion for assessment of energy efficiency of IM and ED.

h) lack of information from producers ;
The producers and importers do not inform completely and sufficiently their potential clients for the availabilities of energy saving;

k) issues, related with operation and repair work ;
The mass practice is to repair the electric motors with broken coils, instead of their replacement with new, more energy effective ones.

6. Research and studies on energy efficient motors and motor systems

The research and studies on EEMs and motor driven systems date from the late ninetys. The leading institution in this area is the Technical University of Gabrovo.

Two projects were implemented within the framework of the EC INCO-COPERNICUS Program, which are dealing with the efficiency use of water pumping systems, entitled as follows:
- Project ICOP-DISS-2148-96 “Follow up Activities Concerning the Promotion of Hybrid Renewable Energy Source in Eastern Europe”;
- Project ICOP-DEMO-2154-96 “Development and Application of a Water Pumping System for Remote Areas Consisting of Photovoltaic (PV) Modules with Inverters Integrated into the PV Modules and a New Type of Asynchronous Pump Motor”.

In the framework of University Programme “Scientific Studies” of the Technical University - Gabrovo, funded by a special fund with the same name, were implemented four contracts, as follows:
- Contract № I.2/2003 “Rational and Efficient Energy Use. Photovoltaic Systems for Obtaining and Use of Energy”;
- Contract № I.8/2004 “Energy Efficiency of Electric Equipment”;
- Contract № I.12/2005 “Energy Efficient Electric Motors and Drives”;
- Contract № E.601/2006 “Energy Efficient Electric Motors and Drives”.

The studies, carried out under the above projects, have been focused on the systems which have a large technical and economic potential for improvement of the EE by the use of the VSDs, EEM and electronic controllers.

It is difficult to notice an apparent connection between the results of the research and studies and their implementation in practice.

7. Bulgarian standards and regulations on motors and EE motors and motor systems

In Annex 3 are presented IEC publications for electrical machines and their identical Bulgarian standards versions, as well as the identical ones are bold.
At the present 89% of Bulgarian standards for electrical machines are harmonized with the European ones, and the rest are in process of harmonization.

8. Major Bulgarian stakeholders related to motors and EE motors topic

Public administration

Ministry of Economy and Energy (MEE)

The energy policy of Bulgaria is implemented by the Minister of Economy and Energy. He is responsible, inter alia, for developing and submission for adoption by the Council of Ministers the Energy Strategy of Bulgaria. The state policy on promotion of energy efficiency is implemented by the Minister of Economy and Energy as an integral part of the energy policy of Bulgaria. (www.mi.government.bg)

Energy Efficiency Agency (EEA)
The EEA is legal person financed from the budget - a secondary administrator of budgetary credits, with headquarters in Sofia, set up as an executive agency to the Minister of Economy and Energy. The measures and activities on energy efficiency enhancement are implemented by the Executive Director of the EEA, jointly with the central and territorial bodies of the executive authority and the other state bodies. (www.seea.government.bg)

Energy Efficiency Center in Industry (EECI) to the Ministry of Economy and Energy
The EECI's main objective is the reduction of the energy consumption in the industrial sector and related environmental protection, performing energy audits. The center has cooperated with the Japanese International Cooperation Agency (JICA) in the field of energy efficiency. (www.eeci.doe.bg)

State Energy and Water Regulatory Commission (SEWRC)
SEWRC is an independent state body which regulates energy sector activities, in particular - issues, revises, amends, suspends, terminates and withdraws licenses and performs price regulation. (www.dker.bg)

Ministry of Environment and Water (MoEW)
MoEW is responsible for the development of the general environmental policy and specific legislation related to water management and environmental protection. (www2.moew.government.bg)

Companies

Bulgarian Industrial Association (BIA)
The BIA is a non-profit making association, non-governmental organization of the Bulgarian industry, established in 1980. The membership of the association involves 87 branch (sector) organizations, 26 regional organizations and 58 local bodies, the Bulgarian Academy of Sciences, universities and scientific and technical unions, over 150 000 commercial companies, out which 263 are among the largest 300 companies in Bulgaria. (www.bia-bg.com)

Bulgarian National Chamber of Electrical Engineering (BNCEE)
The BNCEE was founded in 1994 as a national non-profit organization and is a nation-wide representative of the main part of the Bulgarian electrical engineering industry. Members of the BNCEE are more than 130 companies from the electrical branch with manufacturing, engineering, commercial, consultant and R&D activities. Priority objectives of the chamber are, in particular - to assist its members in their efforts for integration with the European electrical engineering and to assist them in their attempts to improve their competition capabilities and technological level with the aim – to fill market niches with new products, as well as to promote attracting foreign investments, to help establishing joint ventures and other forms of transborder economic co-operation. (www.bcee-bg.org)

Bulgarian Chamber of Commerce and Industry (BCCI)
The BCCI is established in 1895 as a non-governmental public organization that supports, promotes, and represents the interests of its members, It makes for the development of the international economic cooperation. (www.bcci.bg)

Energy Analyses Association
The Energy Analyses Association is established in 2005 as a non-governmental public organization that supports, promotes, and represents the interests of its members - companies and natural persons, performing energy studies and audits, energy audits in the industrial systems included.

Education and research

Several chairs in known Bulgarian universities in Sofia, Varna, Gabrovo and Rousse are dedicated to electrical machines topics. See for this:

Technical University of Sofia	(www.tu-sofia.bg)
Technical University of Varna	(www.tu-varna.acad.bg)
Technical University of Gabrovo	(www.tugab.bg)
University of Rousse “Angel Kanchev”	(www.ru.acad.bg)

Other structures

Energy for Sustainable Development - Bulgaria Ltd. (ESD Bulgaria Ltd.)
ESD-Bulgaria Ltd. operates mainly in EE, GHG emission trading, combined heat and power and renewable energy sources (RES) as a consulting company and engages in the development and implementation of sustainable energy projects. It works with a range of organizations (local authorities, industries, financiers, and investors) active in the field of sustainable energy, implementation of demonstration projects, and development of commercial projects. (www.esdb.bg)

Black Sea Regional Energy Centre (BSREC)
The BSREC was established in 1994 at the joint initiative of the European Commission under its SYNERGY programme and eleven countries of the Black See region. The BSREC activities are aimed at the implementation of the EU aquis and harmonization of the energy policy of the BS region countries with the EU. The Centre co-operates closely with all the BS. Apart from its international activities, the BSREC devotes significant efforts to Bulgarian energy issues and in this role the Centre is acting as a Bulgarian energy society. (www.bsrec.bg)

Local energy efficiency agencies, established within EU SAVE programme in the towns of Sofia, Plovdiv, Khaskovo, Lovetch, Rousse, Stara Zagora, Popovo, Varna, Dobrich and Bourgas.

Bulgarian Energy Efficiency Fund (BEEF),
The BEEF is established in 2004 as an independent public private organization which manages the financial resources Bulgaria received from the Global Environmental Fund (GEF), as well as from other sources. The total initial capital base of the fund amounts to ca. USD 17 million. The fund provides loans and guarantees for energy efficiency projects in Bulgaria, in particular for industrial EE projects. (www.bgeef.com)

GLOSSARY OF ACRONYMS

Acronym		Description
CEMEP		European Committee of Manufacturers of Electrical Machines and Power Electronics
EE	=	energy efficiency
EEA	=	Energy Efficiency Agency
EEM		energy efficient motor
EU	=	European Union
FEC	=	Final energy consumption
FEI	=	Final energy intensity
GDP	=	Gross Domestic Product
GHG	=	greenhouse gas
GWh	=	gigawatt hours
IM		induction motor
kWh		kilowatt hours
MoEW	=	Ministry of Environment and Water
MW	=	megawatt
NSI	=	National Statistical Institute
RES	=	renewable energy sources
SEWRC	=	State Energy and Water Regulatory Commission
TPSCAM	=	three-phase squirrel cage asynchronous motors
UNFCCC	=	United Nations Framework Convention on Climate Change
VAT	=	Value Added Tax
VSD	=	variable speed drive

Annex 1

Efficiency classes (1, 2 and 3) as they were introduced by the CEMEP in 2003, for 2 poles – table 1, and 4 poles – table 2.

Table 1

kW	*eff1* *η*	*eff2* *η*	*eff3* *η*	Elprom-zem - Sofia				Elprom-Harmanli	MMotors Etropole	Elma-Troyan
				M	MO	MOM	AD			
0,09										63,0
0,12										64,0
0,18									66,0	64,0
0,25									69,0	69,0
0,37								67,0	68,0	71,0
0,55								72,0	70,0	71,0
0,75								75,0	69,0	72,0
1,1	*≥ 82,8*	*≥ 76,2*	*<76,2*					77,0	72,0	77,0
1,5	*≥ 84,1*	*≥ 78,5*	*<78,5*					80,0	78,0	77,0
2,2	*≥ 85,6*	*≥ 81,0*	*<81,0*					81,0	80,0	80,0
3	*≥ 86,7*	*≥ 82,6*	*<82,6*					83,0	82,0	82,0
4	*≥ 87,6*	*≥ 84,2*	*<84,2*					83,0	84,0	83,0
5,5	*≥ 88,6*	*≥ 85,7*	*<85,7*					86,0		85,0
7,5	*≥ 89,5*	*≥ 87,0*	*<87,0*					87,0		85,0
11	*≥ 90,5*	*≥ 88,4*	*<88,4*				88,0	88,0		88,0
15	*≥ 91,3*	*≥ 89,4*	*<89,4*				88,0	88,0		89,0
18,5	*≥ 91,8*	*≥ 90,0*	*<90,0*				88,0	88,0		90,0
22	*≥ 92,2*	*≥ 90,5*	*<90,5*				90,5			
30	*≥ 92,9*	*≥ 91,4*	*<91,4*			89,5	92,0			
37	*≥ 93,3*	*≥ 92,0*	*<92,0*		90,5	89,5	92,0			
45	*≥ 93,7*	*≥ 92,5*	*<92,5*		91,5	91,0	91,0			
55	*≥ 94,0*	*≥ 93,0*	*<93,0*		91,0	91,0	92,0			
75	*≥ 94,6*	*≥ 93,6*	*<93,6*		91,0	91,0	93,0			
90	*≥ 95,0*	*≥ 93,9*	*<93,9*		92,0	92,0	93,0			
110				93,0	92,0	92,0	92,0			
132				93,0	93,0	92,0				
160				93,5	94,0					
200				94,0	94,0					
250				94,3	92,0					
315				94,6						

Table 2

kW	eff1 η	eff2 η	eff3 η	Elprom-zem - Sofia				Elprom-Harmanli	MMotors Etropole	Elma-Troyan
				M	MO	MOM	AD			
0,09										56,0
0,12									55,0	59,0
0,18									60,0	62,0
0,25								65,0	57,0	65,0
0,37								68,0	61,0	66,0
0,55								70,0	68,0	69,0
0,75								72,0	73,0	71,0
1,1	≥ 83,8	≥ 76,2	<76,2					76,0	76,0	75,0
1,5	≥ 85,0	≥ 78,5	<78,5					78,0	78,0	76,0
2,2	≥ 86,4	≥ 81,0	<81,0					82,0	81,0	79,0
3	≥ 87,4	≥ 82,6	<82,6					82,0	81,0	81,0
4	≥ 88,3	≥ 84,2	<84,2					83,0		82,0
5,5	≥ 89,2	≥ 85,7	<85,7					85,0		85,0
7,5	≥ 90,1	≥ 87,0	<87,0				87,5	86,0		86,0
11	≥ 91,0	≥ 88,4	<88,4				89,0	86,0		89,0
15	≥ 91,8	≥ 89,4	<89,4				89,0	86,0		90,0
18,5	≥ 92,2	≥ 90,0	<90,0				90,0	90,0		
22	≥ 92,6	≥ 90,5	<90,5				90,0	90,0		
30	≥ 93,2	≥ 91,4	<91,4			91,0	91,5	90,0		
37	≥ 93,6	≥ 92,0	<92,0		92,0	91,0	91,5			
45	≥ 93,9	≥ 92,5	<92,5		92,3	91,5	91,5			
55	≥ 94,2	≥ 93,0	<93,0		92,5	92,3	93,0			
75	≥ 94,7	≥ 93,6	<93,6		92,5	92,0	93,5			
90	≥ 95,0	≥ 93,9	<93,9	93,2	93,0	92,2	93,0			
110				93,5	93,5	93,0	92,0			
132				94,0	94,0	93,5				
160				94,3	94,0					
200				94,3	94,0					
250				94,9	94,0					
315				95,0	94,4					

Annex 2

"Elprom - Harmanli" JSC manufacturer- AT Series Characteristics

THREE-PHASE ONE-SPEED ELECTRIC MOTORS

THREE-PHASE ELECTRIC MOTORS	SERIES	AT	TECHNICAL DATA 380V. 50Hz

	TYPE	Rated Output		Parameters at Rated Output				Starting Characteristics			Weight	
		P_n		n_n	I_n	η	cosφ	I_s/I_n	M_s/M_n	M_{max}/M_n	Fe	Al
		kW	HP	min^{-1}	A	%	-	-	-	-	M kg	
2 poles3000 rpm	AT 71 A2	0.37	0.50	2760	0.95	67	0.87	4.0	2.1	2.4	-	5.2
	AT 71 B2	0.55	0.75	2780	1.4	72	0.82	4.3	2.3	2.5	-	5.7
	AT 80 A2	0.75	1.00	2850	1.9	75	0.82	6.0	2.3	3.0	13.1	8.0
	AT 80 B2	1.10	1.50	2850	2.6	77	0.85	6.0	2.7	3.2	14.9	9.0
	AT 90 S2	1.50	2.00	2830	3.3	80	0.86	6.5	2.1	3.0	18.5	12.0
	AT 90 L2	2.20	3.00	2850	5.0	81	0.83	6.8	2.3	2.8	20.0	14.0
	AT 90 LB2	3.00	4.00	2880	6.5	83	0.85	6.5	2.5	3.2	24.0	15.5
	AT 100 L2	3.00	4.00	2850	6.6	82	0.84	6.4	2.4	3.0	28.5	20.0
	AT 100 LB2	4.00	5.50	2840	8.3	83	0.88	6.1	2.3	3.0	30.8	21.5
	AT 112 M2	4.00	5.50	2860	8.3	83	0.88	6.5	2.2	3.0	38.1	25.0
	AT 112 MB2	5.50	7.50	2880	11.1	85	0.88	6.0	2.1	3.0	40.5	27.3
	AT 132 Sk2	5.50	7.50	2900	11.0	86	0.88	7.2	2.0	3.0	54.0	-
	AT 132 S2	7.50	10.00	2880	14.7	87	0.89	6.9	2.0	2.8	59.0	-
	AT 160 Mk2	11.00	15.00	2915	21.0	88	0.90	7.2	2.3	3.0	89.0	-
	AT 160 M2	15.00	20.00	2900	28.7	88	0.90	7.0	2.3	3.0	95.0	-
	AT 160 L2	18.50	25.00	2900	35.4	88	0.90	7.0	2.3	3.0	105.0	-
4 poles1500 rpm	AT 71 A4	0.25	0.34	1350	0.83	65	0.70	3.1	2.0	2.1	-	5.2
	AT 71 B4	0.37	0.50	1360	1.15	68	0.72	3.3	2.0	2.1	-	6.1
	AT 80 A4	0.55	0.75	1400	1.6	70	0.77	4.0	2.1	2.5	13.5	8.0
	AT 80 B4	0.75	1.00	1400	2.1	72	0.77	4.3	2.5	2.8	15.2	9.1
	AT 90 S4	1.10	1.50	1400	2.8	76	0.80	4.66	2.5	2.8	18.5	14.0
	AT 90 L4	1.50	2.00	1400	3.7	78	0.80	4.6	2.6	2.9	21.3	15.2
	AT 90 LB4	2.20	3.00	1400	5.2	79	0.81	5.2	2.4	2.6	26.0	18.0
	AT 100 LK4	2.20	3.00	1420	5.0	82	0.81	5.2	2.2	2.6	28.0	20.1
	AT 100 L4	3.00	4.00	1430	6.8	82	0.82	5.3	2.3	2.8	31.0	23.3
	AT 100 LB4	4.00	5.50	1410	9.2	80	0.83	5.2	2.5	2.9	33.3	25.3
	AT 112 M4	4.00	5.50	1420	8.9	83	0.82	6.3	2.6	3.0	39.7	29.0
	AT 112 MB4	5.50	7.50	1410	12.2	83	0.82	6.9	2.6	3.0	44.0	32.0
	AT 132 S4	5.50	7.50	1430	12.0	85	0.82	6.5	2.2	2.9	56.0	-
	AT 132 M4	7.50	10.20	1450	16.0	86	0.83	7.0	2.2	2.9	79.0	-
	AT 160 M4	11.00	15.00	1450	23.4	86	0.83	7.1	2.2	3.0	95.0	-
	AT 160 L4	15.00	20.00	1450	31.1	86	0.85	7.0	2.2	2.9	110.0	-
	AT 180 M4	18.50	25.00	1460	34.8	90	0.85	7.2	2.0	2.2	145.0	-
	AT 180 L4	22.00	30.00	1460	41.8	90	0.86	7.2	2.1	2.3	160.0	-
	AT 180 LL4	30.00	40.00	1400	58.7	90	0.86	7.2	2.1	2.3	180.0	-
	AT 180 M4	18.50	25.00	1460	34.8	90	0.85	7.2	2.0	2.2	145.0	-

Annex 3

IEC publications for electrical machines and their identical Bulgarian standards versions

IEC, ISO, DIN, БДС-EN	TITLE
EN 60034-1 DIN EN 60034-1 БДС EN 60034-1	Rotating electrical machines - Part 1: Rating and performance
IEC 60072-1 DIN 42673	Joining dimensions and accordance of output ratings or type IM B3
IEC 60072-1 DIN 42677	Joining dimensions and accordance of output ratings or type IM B5, IM B10, IM B14
EN 60034-5 DIN EN 60034-5 БДС EN 60034-5	Rotating electrical machines-Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code)
EN 60034-6 DIN EN 60034-6 БДС EN 60034-6	Rotating electrical machines-Part 6: Methods of cooling (IC code)
EN 60034-7 DIN EN 60034-7 БДС EN 60034-7	Rotating electrical machines - Part 7: Classification of types of construction, mounting arrangements and terminal box position (IM code)
EN 60034-9 DIN EN 60034-9 БДС EN 60034-9	Rotating electrical machines - Part 9: Noise limits
EN 60034-12 DIN EN 60034-12 БДС EN 60034-12	Rotating electrical machines - Part 12: Starting performance of single-speed three-phase cage induction motors for voltages up to and including 690 V, 50 Hz
EN 60034-8 DIN EN 60034-8 БДС EN 60034-8	Rotating electrical machines. Terminal marking and direction of rotating
EN 60034-14 DIN EN 60034-14 БДС EN 60034-14	Rotating electrical machines. Level of vibrations
IEC 60072-1 DIN 748 Tell 3	Cylindrical shaft ends of rotating electrical machines
IEC 60038 DIN IEC 60038	Standard voltages recommended by IEC
EN 60252 DIN VDE 560-8	Capacitors
EN 55014 DIN VDE 0875 БДС EN 55014	Electromagnetic compatibility
EN 60034-18-1 БДС EN 60034-18-1	Rotating electrical machines – Part 18: Functional evaluation of insulation systems

Annex 4

View of a typical product of "Elma–Troyan" JSC manufacturer