



Technical University of Košice
Faculty of Electrical Engineering and Informatics
Department of Electrical Power Engineering



Biomass and other alternative energy sources in Slovakia

Dušan Medved'

Pardubice, 7. June 2014

Why use the biomass in Slovakia?

Production and use of biomass have following ***positive effects***.
From the view of production:

- Improving the competitiveness of agriculture by the alternative land management not necessary to secure the food self-sufficiency of the state,
- Development of the economic activities in rural areas, production of fuel wood biomass on unused agricultural and other lands,
- Improving the competitiveness in forestry by sustainable increase of wood biomass production in form of fuel chips, also with a goal to improve the state of forest ecosystems (hygiene, stability, production potential),
- Improving the effectiveness of biomass use, as a waste or by-product in wood processing industry, food industry, municipal and other sectors,
- Development of the economic activities related to biomass production (technology, services etc.)

Why use the biomass in Slovakia?

Production and use of biomass have following *positive effects*:

From the view of energy production:

- Increasing of energy self-sufficiency of the state and substitution of fossil fuel with biomass,
- Stabilization of energy production costs and increasing of energy supply security,
- Improving of trade balance due to the reduction of necessity to import energy and fuels,
- Reduction of emission production, especially greenhouse gases developed during production of energy from fossil fuels and their transportation.

The current state of biomass utilizing for biogas in Slovakia

Geographical structure of Slovakia = assumption for biomass production:

- 47% of the area consists of agricultural land,
- 41% of the area consists of forest land.

In the Renewable energy directive (2009/28/EC) biomass is defined as follows:

“**Biomass** means the biodegradable fraction of products, wastes and residues from biological origin from agriculture (including vegetable and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste”.

Country Study on Policy Framework and Availability of Biomass

Size of country ¹	<ul style="list-style-type: none"> Total land area: 49,035 sq. km (4,903,500 ha) Utilised agricultural area: 50.0 % (24,517.5 km²) Utilised forest area: 42.0 % (2,000,000 ha) Nature protection area: 25.0 % (12,258.75 km²)
Population indicators ¹	<ul style="list-style-type: none"> Inhabitants: 5,402.547 Million Inhabitants per km²: 110
Economic indicators ¹	<ul style="list-style-type: none"> GDP per capita: 16,041 (http://sk.wikipedia.org/wiki/Zoznam) Growth rate of real GDP per capita: 8.2 (http://en.wikipedia.org/wiki/List_of_countries_by_GDP_(real)_per_capita_growth_rate)
Energy indicators ²	<ul style="list-style-type: none"> Gross inland consumption: 800 PJ Total production of primary energy: 800 PJ (thereof renewable energy: 7.0 %) Primary production of renewable energy: 56 PJ (thereof biomass and waste: 2.3 %) Final energy consumption: 800 PJ RES (biomass) shares of final energy consumption: 3.3 % Energy carrier imports: 89.20 % (0.00% as electric energy)
Availability of biomass resources ³	<ul style="list-style-type: none"> Theoretical potential: 800,000 ha Technical potential: 40 PJ.a⁻¹ (120 PJ.a⁻¹... energy plantations in future)

Source: Statistics Slovakia

Introduction

Slovakia is hugely dependable on the import of energy sources, it imports even more than 90% of all energy needs. In financial statements it represents almost 20% of all imports. Lowering of energy dependence of countries from imports can significantly lead to the use of the renewable energy sources (RES) that can furthermore contribute to the reduction of the greenhouse effect emissions and to the final reduction of the negative effect of the energy production on the environment. It is possible that in the half of the century the oil resources under respectable conditions will be exploited (the price influence of this prospective is markedly visible already nowadays) and the fossil energy sources lifetime can optimistically be estimated for 100 to 200 years (natural gas 85 years and coal 200 years).

Introduction

At present, Slovakia imports about 90% of its total energy demand. The Slovak primary energy requirements are heavily depended on imported oil, gas, coal and nuclear fuel, mainly from Russia. These are the decisive factors that make it necessary to look for some new, if possible RES and to emphasise their environmental reliability. Today, the share of RES in the overall primary energy consumption (OEC) is described as between 2 - 4%, depending on the source.

Because crude oil and natural gas stores are becoming exploited and mining of the remaining coal will rise in price, RES will be the most important domestic energy sources in the near future. However, Slovakia has quite a substantial RES potential, which is expected to be mostly at regional, municipal and residential levels.

Introduction

In the Slovak Republic, large-scale hydro energy is the only RES with a notable share in total electricity consumption. The share taken up by small-scale hydro energy has decreased by 15% per year on average over the same period. An extended development programme with 250 selected sites for building small hydro plants has been adopted. In the Slovak Republic, the highest additional mid-term potential of all RES lies with biomass. The Government has decided to only use this source in remote, mountainous, rural areas, where natural gas is not available.

Energy sector overlook

Kind of RES	Technically exploitable potential	Current exploitation	Unused potential
	GWh / year		
Geothermic energy	6,300	340	5,960
Wind energy	605	0	605
Solar energy	5,200	7	5,193
Hydro energy	6,607	5,093	1,514
Small hydro plants (up to 10 MWe)	1,034	202	832
Bio-fuels	2,500	330	2,170
Biomass	11,237	3,523	7,714
<i>Forest biomass</i>	1,864	494	1,370
<i>Heating plants</i>	1,837	0	1,837
<i>Wood processing industry</i>	4,406	2,638	1,768
<i>Agricultural biomass</i>	2,322	60	2,262
<i>Waste-water treatment plants (sludge)</i>	230	13	217
<i>Waste from households</i>	578	318	260
Total	26,876	4,402	22,004

Table 1. Energy production from Renewable Energy Sources

Biomass in Slovakia

Forest covers more than 41% of Slovak territory. One of the possibilities of how to replace, at least partly, the conventional energy source - fossil fuel in district heating systems (a high percentage of them are fired by coal, others by oil or natural gas) is offered by biomass.

Biomass fired boilers could offer an attractive solution. Slovakia has only a number of highly populated cities but a relatively high number of municipalities with 3 to 10 thousand inhabitants. An impressive large number of these municipalities are heated by district heating systems. A high percentage of them are fired by coal, others by oil or natural gas. Boilers are mainly well maintained but are old and require imported fuel. The amount of biomass, which could be annually used in these conditions in Slovakia for heat and electricity generation, is enormous.

Biomass in Slovakia

The most promising renewable source for heat production is biomass, with the total potential p.a. suitable for energy production purposes is some 75,6 PJ. Biomass energy has the potential to combine economic, environmental and social benefits. Current electricity production is 30 GWh from biomass and 2 GWh from biogas:

- Biomass utilization through association BIOMASA - leader in Slovakia;
- 16 producers of briquettes, 6 in pellets with production 40 000 t of briquettes and 28 000 t of pellets;
- Biomass firing in Liptovský Ondrej, Prašice, Turňa nad Bodvou, Tlmače;
- Of the total area of Slovakia (4,903,423 hectares) agricultural land covers 49,7 % and forest land 40,84 %. Decrements in the agricultural land were not significant in recent years; however it was possible to observe a change of arable land to meadows and pastures.

Biomass in Slovakia

For short term, a number of biomass energy concepts seem to be the most promising:

- Replacement of small and medium scale coal fired heating system by bio-fuels fired systems.
- Co-combustion of wood residues in existing coal fired power systems.
- Implementation of low cost anaerobic digestion systems with CHP generation.

The following concepts are expected to become more attractive for medium to long term:

- Implementation of small to medium scale CHP combustion or gasification systems provided that the electricity price has risen sufficiently.
- Cultivation and utilization of energy crops (ECs) where no wood residues are available. From an agricultural point of view, cultivation of ECs or SRCs forms attractive alternatives for food crops' growing.

Biomass in Slovakia

The highest share of used agricultural land (2,255,000 ha) is represented by arable land (61,7 %), which is the basis of intensive plant production, mainly in production areas of Slovakia. Mainly cereals (58 %), fodders (19 %) and industrial crops (15,8 %) are grown on the arable land.

Indicator	Area in ha		
	2001	2002	2003
Utilised agricultural land	2 ,54,801	2,236,424	2,236,036
Of that:			
- arable land	1,409,222	1,377,482	1,379,379
- permanent covers	28,934	27,795	28,240
- other areas including domestic gardens	32,740	32,479	33,684
- permanent meadows and pastures	783,905	798,668	794, 773

Table 2. Area of used agricultural land

Biomass in Slovakia

Biomass is the source that has the largest technical potential (46 % of all RES), closely followed by geothermal energy (26 %) and solar energy (21 %). The technically exploitable potential for wind and small hydropower have respectively a share of less than 3 % and less than 5 % of the RES technical potential.

Slovakia’s total annual capacity in the production of forest biomass suitable for energy production will reach around 1,080 thousand tons by 2010 (16,9 PJ). It is realistic to increase the amount of forest biomass available after 2010 through more intensive wood cutting and growing of energy crops in an area of 45,400 ha. Energy crops are promising source of fuel biomass, which can be grown in areas unsuitable for conventional agricultural and forestry production, on land temporarily set aside from agricultural production, contaminated land suitable only for non-food production, as well as on damaged land in industrial agglomerations.

Wood-processing industry produces 1,410 thousand tons of waste annually (18.1 PJ), of which 2/3 originates from mechanical wood processing and 1/3 from black liquor. The greatest waste producers are large wood-processing companies, which also most frequently use this waste for energy purposes. Another possible source is the production of agricultural biomass – cereal, corn and sunflower straw, winter rape, orchard and vineyard wood waste.

The production of biofuels was increased significantly after 2010 due to the implementation of the objectives set out by Directive 2003/30/EC. The estimated production of biodiesel amounting to 100 thousand tons is equivalent to 11 PJ of heat.

The production of biogas from cattle manure can reach 277 million m³ annually, which corresponds with 6,9 PJ of heat. Wastewater treatment plants are important source of biogas. There are currently 24 co-generation units in operation using their own biogas and it is expected that co-generation units will be built at all wastewater treatment plants in larger towns. Theoretically, biomass with energy equivalent to as much as 46,5 PJ can be produced in agriculture without negatively affecting agricultural production.

Biomass in Slovakia

Biomass kind	Energy equivalent	
	TWh	PJ
Agricultural biomass	12.89	46.5
Forest biomass	4.69	16.9
Waste from wood-processing industry	7.36	26.5
Total	24.94	89.9

Table 3. Biomass potential in Slovakia

The current state of biomass utilizing for biogas in Slovakia

Biomass for biogas production:

- Biomass of animal origin from animal husbandry,
- Vegetable origin of green mass, silage or feed residues,
- Waste from food processing plants,
- Biodegradable industrial and municipal waste



Conditions for the development of biogas

- **Legislative condition:** Law No .309/2009 Coll. on the promotion of renewable energy sources and high-efficiency cogeneration and on amendments to certain laws,
- redemption price, purchase guarantee period, priority connection, remove the barriers for investors
- domestic production of components for the biogas technology

The current state in the number of biogas stations (BGS) in Slovakia

- **number of BGS:** at the end of 2012 – about 40 BGS (in agriculture) connected and about 50 BGS in preparation and unfinished (assumption implementation till 2014)
- **the total power output:** 32 to 34 MWe, average power output of about 840 kWe
- **share of the production capacity of energy installations in Slovakia:** 0,5%



Use of biomass and risk management

- **Price levels of BGS:** to 1 MW and above 1MW - law or ordinance of URSO do not define the lower power BGS category or composition of raw materials
- **Consumption of raw materials:** the largest share of raw materials consisting of corn silage, 70 – 80 %, the remainder being mostly other types of biomass waste (manure, liquid manure, ...)
- **Consumption of corn silage:** about 550 000 tonnes per year, that is ¼ of the total annual production of corn silage (in 2014 it can be up to 1 200 thousands tonnes)
- **Risks:**
 - lack of corn silage,
 - increase in the price of corn silage due to higher oil prices and oil products,
 - projected increase in animal production, increases in the bovine animals and higher consumption of feed.

Sources of biomass for biogas production

Area of the agricultural land in Slovakia:
(Compared with the area under the land - May 2012)

- The total area of agricultural land 2,432,979 ha
- Area of the agricultural land 1,927,449 ha
- The total arable land 1,429,040 ha
- Utilized arable land area 1,359,978 ha
- The total area of grassland 881 283 ha
- Size of used grassland 514 941 ha



Possibility of producing up to 2550 000 tons of biomass,
representing 459 million. m³ of biogas

Development of farm animal production in SR – biomass production

POČET HOSPODÁR SKYCH ZVIERAT	ROK 2009	ROK 2010	ROK 2011
Stavy hospodárskych zvierat			
Hovädzí dobytok spolu	471 890	467 125	463 360
z toho: kravy	203 885	204 386	201 285
Ošípané spolu	740 851	687 260	580 366
z toho: prasnice	43 925	41 261	37 364
Ovce spolu	376 541	394 175	391 593
z toho: bahnice	254 245	263 764	263 613
Hydina spolu	13 581 557	12 991 916	11 375 603
z toho: sliepky	6 252 192	6 266 205	6 183 382

Produced biomass in the form of animal manure, liquid manure or excrement, in the amount of about 10 million tonnes of which can be achieved by anaerobic fermentation of 270-300 million m³ of biogas.

Biomass from the municipal waste

- In the municipal sector are produced each year about 1 700 000 tonnes of municipal waste, from which about 50 % is biodegradable waste (BDW).
- From 800,000 tons of BDW and biogas utilization of about 100 m³/t, we can get to 80 million m³ of biogas.



To increase the utilization there may be added also waste from the food industries of all kinds, and in addition also the kitchen and restaurant biological wastes. For specified types of waste, however, the conditions of hygienisation, stated by EC and Council Regulation (EC) no. 1069/2009.

The outlook of building biogas plants in terms of biomass resources

- Biomass from unused agricultural land, production approx. 2 550 000 tonnes a year, maybe production of 459 million m³ of biogas, sources of biomass for 100 BGS per 1 MWe.
- Biomass from animal production (manure, liquid manure, ...), production of about 10 million tonnes a year, possible production of biogas from 270 to 300 million m³, sources of biomass for 170 – 190 BGS per 300 kWe.
- Biomass from municipal waste, BDW, production of 800 000 tonnes per year, sources for about 100 BGS 150 kWe.
- Totally, biomass sources for 380 BGS with electric output of 169 MWe.



The outlook of further development of building biogas plants Slovakia

Conditions for further development:

- preparation of the legislative environment, the Law on the renewable energy support,
- the definition of raw materials to BGS, the minimum classification to:
 - purposely grown biomass,
 - waste biomass and municipal waste,
- size categorization of BGS, according to electric power, for example up to 250 kW, to 500 kW, to 1 MW and above 1 MW.
- in support to take into account impacts on the environment, the landscape and the social sphere.

The Rural Development Programme for the years 2014 - 2020 prepare the proposals for projects support of building BGS for all categories of farmers, support only the waste biomass without demanding of arable land.

Biogas in Slovakia

The utilization of biogas in Slovakia is completely negligible. There are only few biogas plants, which use agricultural biomass.

However; there aren't a biogas plant in many regions yet, therefore, we speak about large potential for development in this are; but from existent five projects are two, which should be presented as a biogas research and development centre of excellence at the Slovak Agricultural University in Nitra and the second – biogas unit based on green biomass or silage in Hurbanovo represents a best practice of biogas technology based on sustainable raw material – 100% of biomass. This biogas unit works as commercial unit for green electricity generation and it is connected to an electricity supply – distribution network.

A Chance of Biogas

The commonest biochemical process used to convert high-moisture waste biomass resources to bioenergy is anaerobic digestion, whereby bacteria produce biogas. In Western Europe, the recent years mean a breakthrough in biogas production and technologies in countries such as Denmark, Germany, Austria, etc. Although the potential is great especially in countries such as Latvia, Slovakia, Hungary, Bulgaria, Romania, Croatia, Slovenia or Greece, the biogas industry has begun to develop in Central and South-Eastern Europe, too. More and more biogas plants are expected to be built in the above mentioned countries due to the stricter EU regulations for agricultural waste handling as expected by energy analysts. Biogas production facilities intentionally convert high-moisture organic waste to methane and then they use it as a substitute for fossil fuels, thereby reducing GHG emissions. Under some circumstances the high ammonia content can inhibit the conversion process, but this can be avoided by mixing the animal waste with another, lower nitrogenous waste to maintain the optimum C:N ratio. On the other hand, waste with high fat content can enhance and increase methane output. The residue left after digestion can be used as a soil conditioner and fertilizer if contaminant free.

Waste treatment facilities combining anaerobic and aerobic digestion are able to provide energy for aerobic digestion from self-supplied methane if 25 % or more waste is digested anaerobically. There are many types of designs for digester reactors throughout the world, ranging from capacities of 1 to 15,000 m³, some of them being more efficient than the others. Virtually any biomass substrate within a wide range of moisture contents can be biomethanized, and the purpose-designed digesters may mobilize a greater proportion of the organic feedstock for energy production. Typically, however, the process remains inefficient, with only 40 % of the total energy potential being converted into **methane gas**.

Continuous stirred, tank reactor, anaerobic fermentation technology has been used for over 100 years. Today, there are special automated feeding mechanisms with a degree of automatic control, which enables the solid concentrations of the feedstock to be doubled. The semi-continuous, completely mixed, mesospheric single-stage tank digestion process (without recycling) is the most popular system used on farms, particularly where feedstock is in the form of a slurry with 2-10 % total solids rather than more solid form. *Note:* Other designs such as plug flow, batch, two-stage and filter digesters are more costly and complex than a stirred tank.

Current situation – biomass in Slovakia

Waste biomass in countries where there is a paper- and pulp- and a wood-processing industry, is already utilized at a considerable amount for process heat and electricity production. It is a by-product of the processes and if not utilized for producing energy it would create a waste disposal problem. Big plants allow technologies for cogeneration (economies of scale) and the mostly energy-intensive processes need both electricity and process heat. A further extension of bio-energy in this sector will mainly depend on the development of the structure of this industrial branch.

Branches of industry which are not involved in processing of wood will only be interested in bio-energy if it is cheaper for them, as compared to fossil fuels, which will only be the case with the help of, for example, energy taxes on fossil fuels.

Current situation – biomass in Slovakia

Electricity of Biomass will mainly be produced in the wood processing industry. However, besides that, plants for the production of electricity (or combined heat- and power production plants) will be possible where there are special regulations which favour them. Examples for such regulations are:

- Minimum tariffs for delivering electricity to the grid (like in Italy, Spain or Germany).
- Special financial support, subsidies (Denmark).
- Higher taxation of fossil fuels.
- Minimum amount of Biomass-electricity for everyone operating a grid – otherwise penalty.

Without regulations a higher amount of electricity from biomass will not be possible.

Current situation – biomass in Slovakia

Other sources of biomass like bio-gas, sewage gas or traffic fuels presently play a modest role as compared to the importance of biomass in the low temperature heat market. Often a coordination between agricultural- and energy policy of the Union is missing and, consequently, wanted. For introduction of bio-fuels, different strategies are deployed (mixing with fossil fuels, utilization in environmentally sensitive areas, usage instead of heating oil), but sometimes the raw material is scarce because for farmers other (food) crops offer more profit.

RES in Slovakia

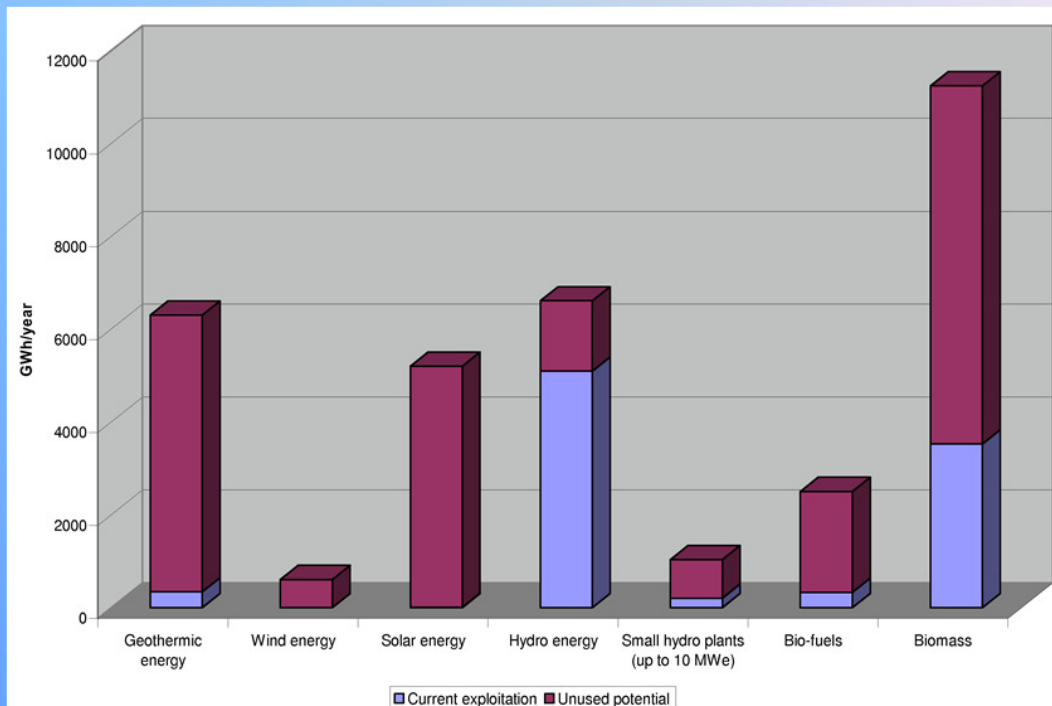


Fig 1. Renewable energy sources potential and share in Slovak Republic

RES in Slovakia

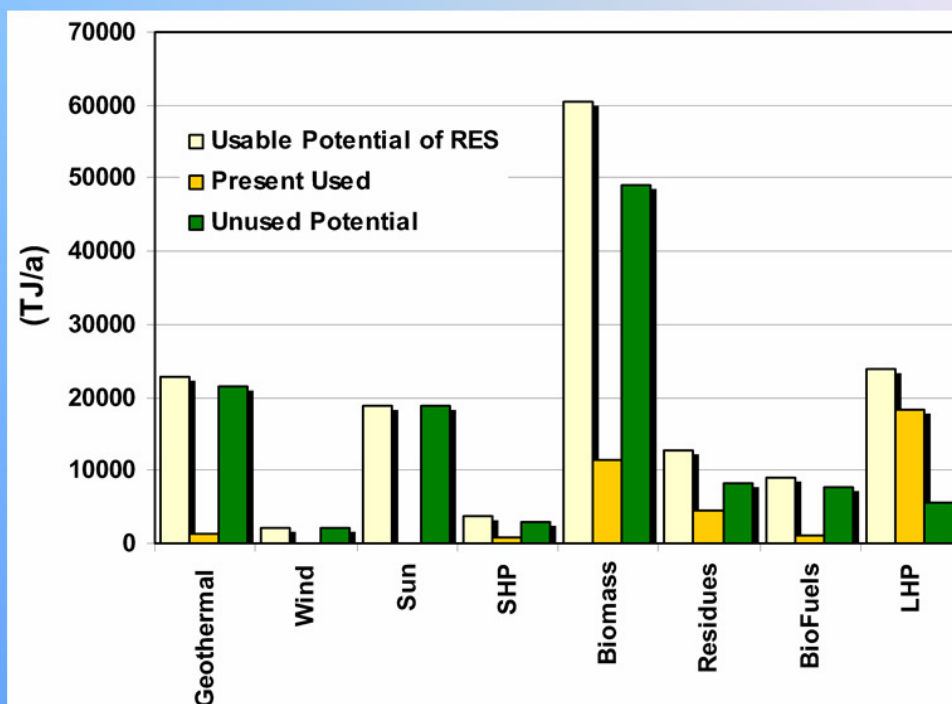


Fig 2. Renewable energy annual potential and share in Slovak Republic

Current difficulties in RES implementation

- Weak implementation of mechanisms of developing renewable energy sources production
- No interest in production of green electricity and green heat by investors
- RES development is not main issue in national energy plan and interest of government
- No guaranties of green energy buying price
- Lack of information about possibilities of RES development
- Huge problems with reaching set levels of production
- Small geothermal energy usage and no interest of investing in geothermal energy by government
- Resignation of big hydro energy systems connected with environmental impact. Whole possibilities of using this energy is used concerning current policy and trends
- No interest in landfill gas utilization

Current difficulties in RES implementation

- Competition on market
- Huge improper financial support
- No clear renewable energy policy. Current depends only on lobby of industry and energy producers sector
- Low usage of European Union financial support for developing renewable energy production installations
- Not enough money found in potential investors.



Thank you for your attention

Technical University of Košice
Faculty of Electrical Engineering and Informatics
Department of Electrical Power Engineering
Mäsiarska 74, 041 20 Košice
Slovak Republic
E-mail: kee.fe1@tuke.sk
<http://web.tuke.sk/fei-kee/web/>
Tel: +421 / 55 / 602 3550
Fax: +421 / 55 / 602 3552