

Engineering Research, Safety and Environmental Risk Analyses on Bioenergy Utilisation - Collaboration in Bulgaria and in International Aspect



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Abstract - The bioenergy utilisation, especially the biomass energy and bio-fuels productions, from one hand are basic ways of the renewable energy sources applications, and from other hand they are subjects a lot of R&D activities in national aspect of the European countries, and in international aspect also. Simultaneously the strong safety and environmental requirements determine the need for risk analyses, assessments and relevant measures for prevention of the negative impacts to the human health and environment in the process of the practical applications of the bioenergy utilisation' technologies. These aspects are under consideration and analysis in the present report with scope of some Bulgarian, European and other international collaborative research and engineering activities.

Keywords: Bioenergy, Biomass, Research, Safety, Environment.

1. INTRODUCTION

The biomass energy and bio-fuels productions are basic ways of the renewable energy sources (RES) applications of the bioenergy utilization' technologies with significant potential of contributing to the EU energy supply meanwhile ensuring sustainable development. The last ten-twenty years comprehensive programs for improving of energy sector in order to comply with the EU "20-20-20" targets and with Kyoto Protocol for significant reduction of the greenhouse gases (GHG) emissions are going on in parallel to the sustainable development

of the European community. The EC has recognized the need of promoting the use of bioenergy utilization' technologies, in particular biomass gasification, biomass co-firing and other for this purpose.

The waste biomass from forestry, forest industry and agriculture and also the household waste are the main renewable raw material source for energy generation in Bulgaria and other countries. There are significant studies and R&D activities for the bioenergy utilisation of the household waste for bio-fuels and energy production in the country, but general the really application is comparative low. The utilisation of the biomass, especially the forestry- and forest industrial waste, mainly with briquetting and pelletisation technologies are investigated as R&D activities and applied in the Bulgarian RES-area, including some projects of the Technical University of Sofia, Forestry University, private companies, etc. There is various applications of these for bio-fuels production and energy production. Deriving of biogas from the landfills have got less development at the moment, but the general national evaluation shows that this aspect is very perspective for the country.

Mainly these aspects are under consideration and analysis in the present report with scope of some Bulgarian, European and other international collaborative research and engineering activities, in particular with participation of Technical University of Sofia (TUS), respectively Safety and Environmental Engineering Laboratory (SE&EL) at Electrical Power Department.

2.GLOBAL REALITIES TODAY FOR ENERGY CONSUMPTION AND CLIMATE CHANGE

Different State of the Arts, development trends, prognosis and other studies show the energy consumption on world, continental, regional and national levels.

Good examples for the world, Europe and Bulgaria energy consumption development could be present, for instance till 2060 in Fig. 1.

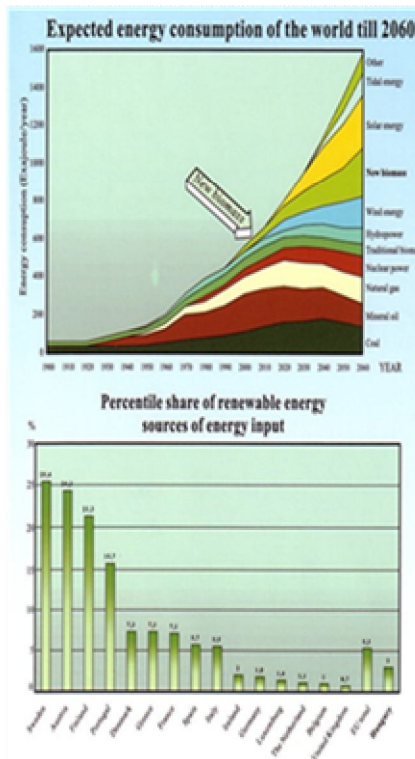


Figure. 1. Global energy consumption and share of RES in EU and some countries

Nowadays the energy system in Europe is characterised by a strong dependency on imported fossil fuels and growing emissions of CO2 leading to an unsustainable pattern of development governing in the entire continent. The European economy, steadily demanding more energy, is essentially based on oil, coal and natural gas, which make up to four-fifths of its total energy consumption and almost two-thirds of which it imports. The energy consumption in EU last decade is more than 60 % on oil and gas and about 6 %

on renewable energy sources (RES) – predominately biomass, as shown in Fig. 2.

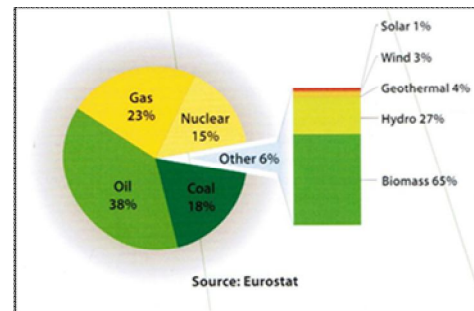


Figure. 2. The energy consumption in EU

The EU's own energy production covers barely half of its needs. If nothing is done, by 2030 the share of fossil fuels is going to increase making the energy imports much higher, amounting to 70% of total needs.

Our survey for transposition of Directive 2001/80/EC for Large Combustion Plants (LCP) in Bulgaria shows increased trend after 2000 of the energy composition [1], as shown in Fig. 3.

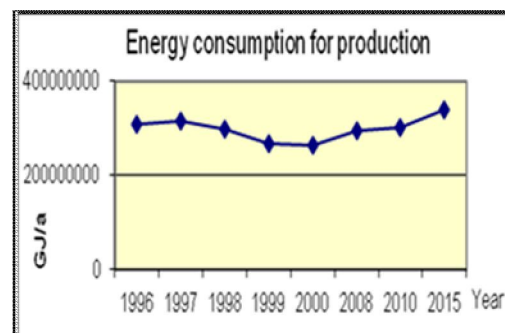


Figure. 3. Trend of the energy composition in Bulgaria

There are lot of examples, but today only the world consumption of energy fuels causes about 150 million tons of CO2 into the atmosphere every day. The whole world is affected by global warming. It doesn't matter where are the greenhouses (GHG), mainly CO2 emissions into the atmosphere, the earth's rotation and the uneven heating of the atmosphere by the sun ensure that the CO2 is distributed randomly, and the effect on the climate is global, as shown in Fig. 4.

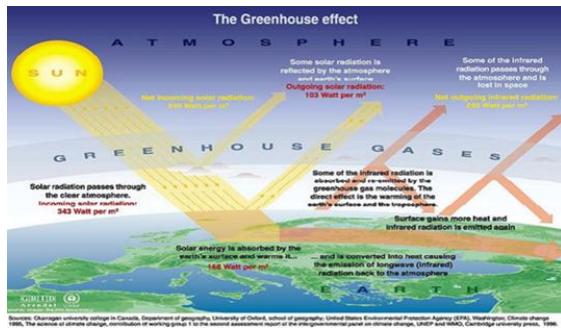


Figure. 4. The GHGs effect

That's why the UN negotiations of COP21 - 2015 Paris Climate Conference aim a legally binding and universal agreement for keeping global warming below 2°C above pre-industrial levels.

3. ENERGY POTENTIAL OF THE BIOMASS AND THE WASTE AND SOME R&D ACTIVITIES IN BULGARIA

The Bulgarian share of renewable energy in gross final energy consumption for 2016 is about 18,8 %, and electricity generated from renewable sources as share of gross electricity consumption is 19,2 %, but there are significant resources for increasing of the RES input [2]:

- the solar power theoretical potential is about 580 mill. TJ/year,
- the wind power potential is more than 3 mill. TJ/year, etc.
- the forestry and agricultural economy are inexhaustible basis of resources for obtaining of power from the biomass – the forestry spaces covers of about 33%, and the agricultural lands 45% of the Bulgaria territory.

One of the priorities of the Bulgarian governmental energy policy is encouraging of the RES development in the country [3]. In accordance with the new Directive 2009/28/EC Directive 2001/77 of EU [4], there are foreseen measures for promotion and sustainable RES usage, incl. introduction of the systems of traded green certificates for covering the additional costs of the power generation from RES. The producers are motivated to reduce prices of the power in

the RES basis, take in account the heat energy price for the end user.

Practically the RES theoretical- and technical potentials in Bulgaria seem as is shown respectively in Fig. 5 and in Fig.6 [5].

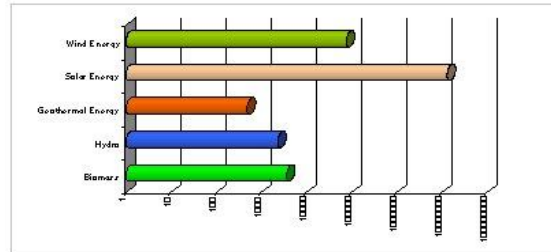


Figure. 5. RES theoretical potential of Bulgaria

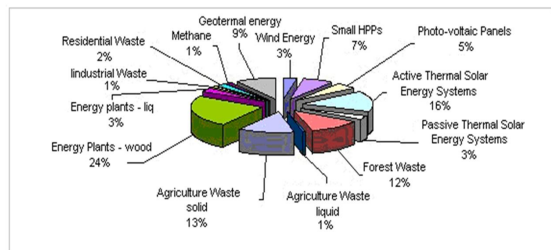


Figure. 6. RES technical potential of Bulgaria

In particular the shares of the eligible RES for bio-fuels production as biomass energy potential and biogas energy potential are shown in Fig.7.

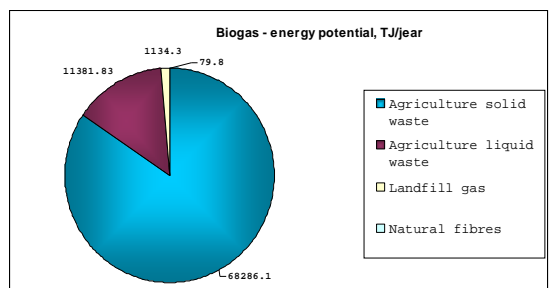
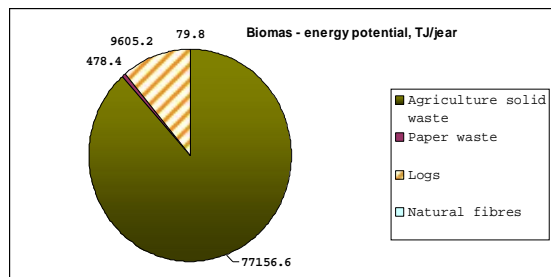


Figure. 7. Biomass- and biogas energy potentials of Bulgaria

Some R&D activities and results of TUS and partners (Forestry University, IVECOL Co., etc.) for utilization of biomass for energy production and bio-fuels production are [2]:

- ❖ Design of an industrial installation 430 kW for briquetting of wood waste with capacity 6000 t/y. The applied technology by the showed schema is wood waste treatment to sawdust and pressing in briquettes ($Q=5860$ KJ/kg) without combine substances, shown in Fig.8.

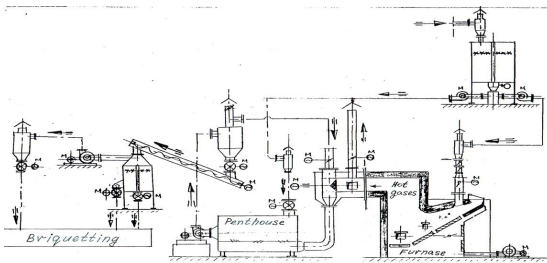


Figure. 8. Industrial installation 430 kW for briquetting of wood waste in Bulgaria

- ❖ Investigations and applications for briquetting and pelletisation of waste lignocelluloses biomass (lop-pings, bark, saw-dust, sanding dust, etc.), shown in Fig.9.



Figure. 9. Briquettes and pellets from waste lignocelluloses biomass

Other examples for R&D activities and results of TUS and partners (UCTM, MGU, IVECOL Co., etc.) for utilization of biomass and household waste for biogas production are [2]:

- ❖ Studies on waste management, improvement of the state of the landfills and on the possible energy usage in the municipalities of Sofia, Burgas, Devin, Panagourishte, etc.
- ❖ Identification of the basic gases in the landfill for solid industrial and domestic waste of Plovdiv, near Tzalapitza village was carried out, with 8 drillings to the 8 m depth. The estimation is for gas potential ~ 200 m³/t and 4.5 kWh/m³ by the burning of this gas. The proposal on this basis is to be designed and built a facility for collection of the gas and energy production.
- ❖ Deposition and utilization of energy from veterinarian antibiotic waste.
- ❖ Investigations for content of biogas and methane by the treatment of the waste water from pig farm, collection in methane tanks and utilization.

Other good example for our collaboration is with Dutch company Grontmij in the frame of the Dutch-Bulgarian Green Project [6] when are implemented:

- ❖ Investigations for application opportunities of advanced technologies for waste energy utilization as:
 - Methane emission reduction of landfills by extracting, flaring and utilisation of the gas with production of electricity;
 - Anaerobic digestion of organic waste as attractive biological treatment under conditions with deficient oxygen;
 - Up flow anaerobic sludge blanket treatment of the waste water from food, agro, paper and other industries, etc.
- ❖ Studies regarding some existing landfills and regarding the selection

of the possible grounds and choice a place for new regional landfill in the region of Burgas, shown in Fig.10.



Figure. 10. Existing landfill and site selection for new regional landfill

4.SOME INTERNATIONAL R&D ACTIVITIES ON BIOENERGY UTILISATION

In the frame of the Gasification Guide Project (2006-2009) of the Intelligent Energy – Europe (IEE) Programme of the European Commission, coordinated from the Netherlands, TUS and partners from different European countries implemented the aim to strengthen the market uptake of biomass gasification technology by developing a Guideline on Health, Safety and Environment (HSE) issues and incorporation of the HSE aspects in the design, construction and operation of the gasification biomass installations as main practical goal. The process chain of a gasification plant has been considered in the risk assessment and the main potential Health & Safety hazards were defined, as is illustrated in Fig 11 [7].

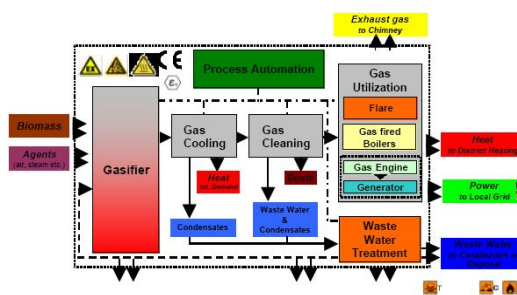


Figure. 11. Potential Health & Safety hazards of Biomass Gasification plants

This HSE project resulted in a Guideline for safe and eco-friendly biomass gasification and a Software Tool for easy and systematic assessment of HSE hazards in biomass gasification plants.

In the same research area are the results of TUS joint with Spray Engineering Devices Limited, Punjab, India at the project “Study and application of very high temperature biomass gasification technology for clean gas production” in the frame of the “Bulgarian-Indian inter-governmental programme of cooperation in science and technology”, 2009-2012. There were studied and analysed the biomass potential, the policy and legislation in Bulgaria. The experience in India was considered regarding biomass gasification and possibilities for utilisation of biomass at low investments and high efficiencies. There was demonstrated application of the method of very high temperature biomass gasification technology with significant technical advantages [8].

Detailed studies and analyses of TUS on the environmental issues by biomass energy production, especially as legal framework in the frame of the “Integrated European Network for Biomass Co-firing”, NETBIOCOF Project (2005-2009) of the 7FP of the European Commission, coordinated from Germany with 25 European partners were implemented. These shown on one hand that the energy system in Europe is characterized by a strong dependency on imported fossil fuels and growing emissions of CO₂ leading to an unsustainable pattern of development governing in the entire continent.

On other hand these investigations shown that the efficient and advanced co-firing technologies have significant potential to

change this picture not only in Europe but also worldwide, because:

- Co-firing of biomass has been recognized as a promising short-term technology to use secondary fuels, consisting on the simultaneous combustion with a primary fuel in plants originally designed and optimized for the combustion of coal or gas alone.
- Co-combustion of biomass together with coal in large-scale firing systems offers several advantages, such as the possibility to utilize large quantities of biomass at low co-combustion rates in state-of-the-art combustion systems, lower investment costs and higher conversion efficiencies compared to systems exclusively fired with biomass, etc.
- Therefore, biomass co-firing activities, both in retrofitted and new plants, are expected to expand significantly world-wide within the next years contributing to the overall target of the Kyoto protocol.

An inventory then on the application of co-firing worldwide shows that over 240 coal-powered plants have experience with co-firing biomass or waste, as is shown in Fig.12 [9].

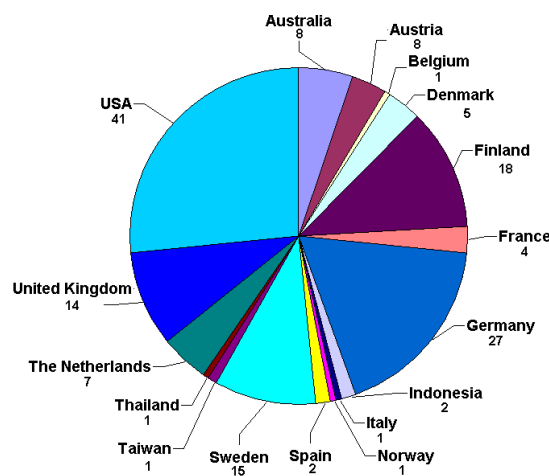


Figure. 15. Potential Health & Safety hazards of Biomass Gasification plants

Obviously the application of the co-firing technologies with utilization of large quantities of biomass is emerging as one of the main routes for further bioenergy utilization in industrial and energy production scale.

In international scale there is necessary to underline the growing interest in bioenergy utilization and relevant R&D and innovation activities. Good example for this trend is IoT approach' application for waste management system in India, which is a precondition for better waste energy utilization [10]. Concerning the renewable energy effective using should be indicated also the research efforts for continuing improvement of RES technologies. Some RES technologies are so developed that for instance even shading on Solar Panel are subject of research in the College of Engineering & Technology at Bambhori, Jalgaon, India [11].

Of course, many good examples can be given in different countries around the world, but it is also important to seek more opportunities for international cooperation between universities and research organizations.

5.CONCLUSION

Some of our investigations briefly presented with this paper outline the big technical potential of the RES in Bulgaria, in the European and in other countries, and a broad spectrum of opportunities for bioenergy utilization, especially with using of biomass for bio-fuels production and energy production, biomass gasification, co-firing technologies, etc. Most of them have not only high level of efficiency for energy production but also important input for GHG emissions reduction and climate change mitigation. One example for such opportunity is presented as rational approach on the 14th China Chongqing International Investment and Global Sourcing Fair & World Emerging Industries Cooperation Conference & 4th Global Outsourcing Summit, MaAnShan City, Anhui Province, May 2011, China [12].

Our interest in further R&D cooperation in international aspect in the field of bioenergy utilization is motivated,

- from one side with our estimations of the actuality and necessary of joint decision of the existing environmental problems and at the same time – the signification of the biomass and waste as energy sources.
- from another side with our understanding that there is necessary to gain and transfer good new knowledge and advanced experience for R&D and for practical uses.

The above partial presented our expertise could be on the attention of investors and companies on one hand, and also of authorities and municipalities on other hand, in Bulgaria and other countries, not only as research results and recommendations. These could be continued joint with interested partners as relevant effective measures and activities for possible contributions and achieve of safe and environmentally sound sustainable development of the investment process and the economics in national and international scale.

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AUTHOR PROFILE

Ivan Vassilev Ivanov is a Research Projects Manager at R&D Sector of the Technical University of Sofia, Bulgaria. He is a Professor and Head of Safety and Environmental Engineering Laboratory at Electrical Power Department with more than 30 years' experience as researcher and university lecturer. Prof. Dr. Ivanov is an Environmental Impact Assessment (EIA) Expert and Team Leader in the register of Bulgarian Ministry of Environment and Water since 1989. In 2011 Prof. Dr. Ivan Ivanov is nominated as Asia-Pacific CEO Association Worldwide (APCEO)' Senior Expert. In 2013 Prof. Dr. Ivan Ivanov becomes a member of the Global Science & Technology Forum (GSTF). He has more than 50 completed national and 10 international projects as Project' leader or Team' leader in the fields of Energy, Nuclear Energy, Renewable Energy, Environment, Safety, EIA and Risk assessment in the energy and industrial sectors. Prof. Dr. Ivan Ivanov has more than 140 publications, 10 textbooks, etc.