UNIVERSITY OF NOVI SAD
Technical faculty "Mihajlo Pupin"
Zrenjanin, Republic of Serbia
In cooperation with partners

Industrial Engineering and Environmental Protection

IIZS conference

PROCEEDINGS

V International Conference – Industrial Engineering And Environmental Protection (IIZS 2015)

Zrenjanin, 15-16th October 2015.

University of Novi Sad
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ISBN: 978-86-7672-259-4

CIP - Каталогизација у публикацији
Библиотека Матице српске, Нови Сад

62:005.3(082)
502/504(082)

INTERNATIONAL Conference Industrial Engineering and Environmental Protection (5 ; 2015 ; Zrenjanin)
Proceedings [Elektronski izvor] / V International Conference Industrial Engineering and Environmental Protection (IIZS 2015), Zrenjanin, 15-16 th October 2015 ; [organizer] Technical Faculty "Mihajlo Pupin", Zrenjanin. - Zrenjanin : Tehnički fakultet "Mihajlo Pupin", 2015. - 1 elektronski optički disk (CD-ROM) : tekst ; 12 cm

Nasl. sa naslovnog ekrana.

ISBN 978-86-7672-259-4

a) Индустријско инжењерство - Зборници b) Животна средина - Заштита - Зборници

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INTRODUCTION

Departments of Mechanical engineering at Technical Faculty "Mihajlo Pupin", Zrenjanin, organized four international conferences:
1. »PTEP 2011 - Process Technology and Environmental Protection»,
2. «IIZS 2012 - Industrial Engineering and Environmental Protection»,
3. «IIZS 2013 - Industrial Engineering and Environmental Protection»,
4. «IIZS 2014 - Industrial Engineering and Environmental Protection».

Industrial engineering is a field of technique, which includes the processes and procedures, plants, machinery and equipment used in manufacturing final products in different industries. The task of industrial engineers is that on the basis of theoretical and practical knowledge, solve specific problems in engineering practice, and the development of technology in the field of industrial production process.

The theme of scientific conference «IIZS 2015», covers the fields of industrial engineering, which are defined in the program of the conference, such as: Process technology and Energy efficiency, Engineering environmental protection and safety at work, Manufacturing technology and materials, Maintenance, Design and maintenance of process plants, Basic operations, machinery and processes, Oil and gas industry, Computer technologies and engineering education, Biotechnology, Reengineering and project management, Process management.

The main goals of the conference can be indentified here: innovation and expansion of knowledge engineers in industry and environmental protection; support to researchers in presenting the actual results of research projects, establishing new contacts with leading national and international institutions and universities; popularization of the faculty and its leading role in our society and the immediate environment, in order to attract quality young population for studing at our faculty, cooperation with other organizations, public companies and industry; initiative for collecting ideas in solving specific practical problems; interconnection and business contacts; introducing professional and business organizations with results of scientific and technical research; presentation of scientific knowledge and exchange of experiences in the field of industrial engineering.

We express gratitude to:

- The pratners of the conference – University of agriculture, Faculty of agricultural engineering, Krakow, Poland; Technical university-Sofia, Plovdiv branch**,** Faculty of mechanical engineering, Plovdiv, Bulgaria; University «St. Kliment Ohridski«, Technical faculty, Bitola, Macedonia; University Politehnica Timisoara, Faculty of engineering, Hunedoara, Romania; University of East Sarajevo, Faculty of mechanical engineering East Sarajevo, B&H, Republic of Srpska; „Aurel Vlaicu" University of Arad, Faculty of engineering, Arad, Romania; University of Niš, Faculty of mechanical engineering, Niš, Serbia,
- Zrenjanin Town Hall,
- Regional Chamber of Commerce,
- The management of Technical Faculty «Mihajlo Pupin», University of Novi Sad,

for supporting the organization of the conference «IIZS 2015». We are also grateful to all the authors who have contributed with their works to the organization of the scientific meeting «IIZS 2015».

We would like our Conference to become a traditional meeting of researchers, every year. We are open and thankful for all useful suggestions which could contribute that the next, International Conference - Industrial Engineering and Environmental Protection, become better in organizational and program sense.

President of the Organizing Committee
Prof. Ph.D Dragiša Tolmač

Zrenjanin, 15 - 16th October 2015.

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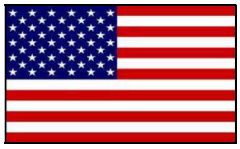
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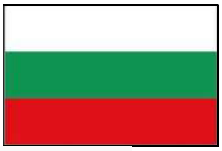
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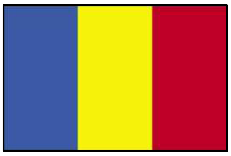
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THE TECHNO-ECONOMICAL AND ENVIROMENTAL RESULTS OF GASIFICATION IN THE SLAVONIA REGION (Croatia)

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Abstract: The paper provides a brief historical overview of the beginning of the use of natural gas in Slavonia, construction of main and distribution pipelines, the number of consumers and consumption in this Croatian region. It implies a change of consumption structure of substitutional energy and increased share of natural gas in total energy consumption in the region. Especially indicated techno-economical and the environmental importance of the completion of the gasification of the region started 40 years ago and emphasized new opportunities for better energy supply with renewable energy sources.
Key words: gas distribution, gas pipelines, gas consumption, natural gas, Slavonia

INTRODUCTION

Usage of Natural gas in Slavonia started after the discovery of oil fields Beničanci (1968) and gas field Boksic-Lug. (1973), [1], [2]. Production (and usage) of natural gas in Croatia at the time was not developed, system of main gas pipelines were missing. Production of natural gas in that period is presented on Figure 1. which emphasizes the importance of the contribution of gas from the Slavonian field since 1972, and especially since 1975.

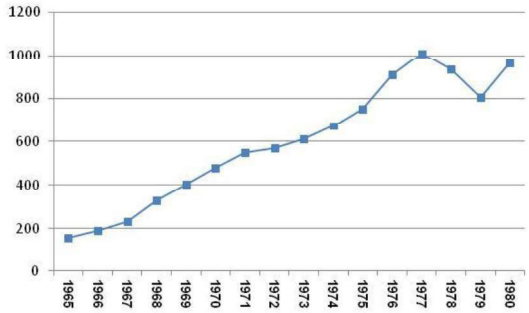

Figure 1. Natural gas production in Croatia from 1965 up to 1980 ($10^6 m^3$), [3]

Balance between production and consumption of natural gas in the first years of usage (1972-1985) in Slavonia is presented with data in Table 1.

Table 1. Production and consumption of natural gas in Slavonia from 1972 up to 1985 (106 m3); [2]

Year	Production	Consumption	Difference (delivered to in system)
1972	60.0	0.5	burned
1973	57.7	3.4	burned
1974	56.5	3.4	burned
1975	175.9	14.0	161.9
1976	312.4	74.4	236.0
1977	387.2	82.4	304.8
1978	358.1	106.4	251.7
1979	318.5	149.5	169.0
1980	507.2	152.4	354.8
1981	589.8	176.7	413.1
1982	485.7	213.6	272.1
1983	433.1	232.0	201.1
1984	442.7	239.4	203.3
1985	440.0	240.0	200.0

GASIFICATION PROCESS IN SLAVONIA

The first natural gas consumer in Slavonia the Brickyard "Slavonia" in Našice was connected to fields Beničanci in 1972. On this source from end of 1975 Kombinat "Belišće" is also connected. At that time the production and consumption of gas from fields Beničanci was balanced. At the end of 1975 on natural gas from the gas field Boksic Lug connected the brickyard " Graditelj" Sladojevci (P. Slatina), which is located next to the main gas pipeline Boksic - Zagreb.
The company "Elektroslavonia" Osijek join to the process of gasification in the region a few months after discovery of the gas field Boksic Lug thru: a) the construction of gas turbine power plant in Osijek, and b) the appointment (by local authorities) for holders of gasification activities at the regional level. By appointment for holders of gasification activities in the area of Slavonia and Baranja - in the summer of 1975 „Elektroslavonia“ established the Department for the development of gasification in 1979, "Gas distribution" grown-up and in 1981 became legal business entity. Gas turbine power plant in Osijek consumes natural gas from February 1976. In 1977 to the gas network of Osijek are connected: a brickyard "Opeka" and the Agricultural Institute for seed drier and for heating of residential buildings in the Settlement of solidarity. In Miholjac street gas network (10 km) was built and put into operation in 1977. At mid-year of same year pipeline for wood combine "Đurđenovac" was commissioned and the first section of (3 km) street pipeline in Nasice,[2] [5].
Experts of "Elektroslavonia" created in 1978. "The program of gasification areas Slavonia in the period 1979.- 1985" which was adopted during the 1979 Assembly of all 14 municipalities in the region and the Assembly of the Slavonia region. This program analyzed introduction of natural gas problems in 25 cities and municipal centers and have established priorities and stages of gasification of the region, [6]. Since that time, continuously expansion of regional gas pipelines gradually leads to the creation of Croatian gas-supply system.

The construction of main gas pipelines and distribution networks

The main gas pipeline was financed and constructed by "INA-Naftaplin", Zagreb (Fig.2) and distribution network was built by local investors (Fig.2). The development of gasification Slavonia describe data on: construction of gas networks, the number of consumers and consumption of natural gas in the region.

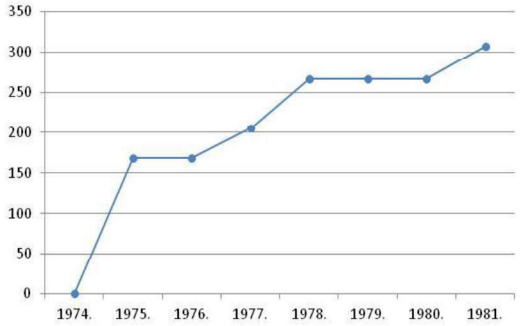

Figure 2. The length of main gas pipelines built in Slavonia from 1975 to 1981 (km) [7]

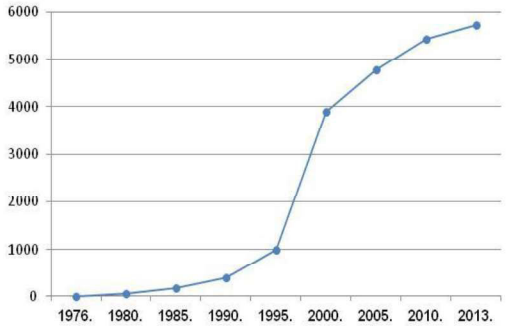

Figure 3. The length of distribution gas networks in Slavonia from 1976 to 2013 (km) [8]

The development of natural gas consumption

Number of natural gas consumers in the Slavonia region in the period from 1976 to 1991 is shown in Table 2. from which exponential growth of number of consumers in the industrial and utility organizations (service and public sector) and households can be seen. Connection of new consumers depended primarily on the amount of available natural gas, connection between local consumption with the main network, size of consumption and state of construction of locally funded distribution network.

Table 2. Number of consumers of natural gas in Slavonia from 1976 to 1991 [1] [4] [9]

Nº		1976	1977	1978	1979	1980	1981	1983	1985	1987	1989	1991
	Total	**2**	**386**	**812**	**1,380**	**2,186**	**3,218**	**5,383**	**6,672**	**8,372**	**15,473**	**20,093**
a	Ind. & comunall.	2	16	38	63	99	207	356	497	578	694	894
b	Households	0	370	774	1,317	2,087	3,011	5,017	6,175	7,794	14,749	19,219

Available quantities of natural gas were not sufficient at that time, and the "Program of gasification of Slavonia" did not achieve planned dynamics and capacities due to lack of gas consumption and distribution pipelines gas was directed to the existing large customers in other parts of the Croatia (Zagreb and surroundings). From a total of 14 Slavonian municipalities in 1991 gas used 9. Without access to gas were: Beli Manastir, Đakovo, Nova Gradiska, Vukovar and Županja. However, during period of time intensive work was done on the preparatory work for the installation of gas on their territories; for the municipality Nova Gradiska recorded potential gas consumption, and for municipality Beli. Manastir, Đakovo and Županja made the conceptual designs of connection to the gas system and the outcome of gas pipeline network in municipal centers with associated cost estimates, while in Vukovar was already made and detailed design of the main distribution pipeline. [1] [4] [9] [10]

In addition to natural gas consumption in Slavonia through distributors "Elektroslavonija" natural (free and water intake) gas used and the so-called direct consumers: it is a large industrial facilities to which the gas was delivered "INA - Naftaplin".[1]

Bringing the exploitation of oil and gas fields Ilača, Đeletovci and Privlaka enabled during 1984 continued construction of the gas network. About ten million m^3 of gas captured from these fields is spent (since 1986) in Vinkovci building materials industry "Dilj" and PIK Vinkovci (1987). However, this amount of gas is not just paying the annual needs "Dilj" and the gas network until 1991 did not spread to other consumers in Vinkovci.

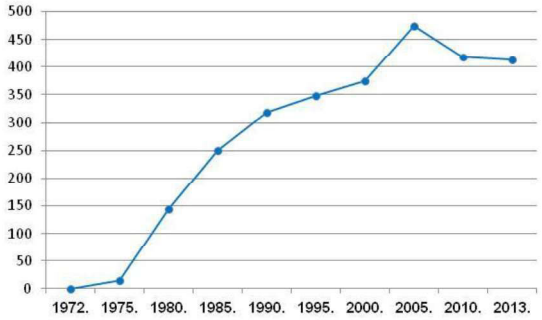

Figure 4. Total consumption of natural gas in Slavonia and Baranja 1996 - 2014th (10^6 m^3); [4] [8] [11] [12] [13]

From 1991 up to 1995 damage from military destruction to the gas system were repaired and process of gasification of the region of Slavonia was continued - so in the period from 1996 to 2014 was built about 4,000 km of new distribution pipelines. Natural gas consumption in Slavonia and Baranja has been increasing from 1996 until 2009 when - because of the economic downturn - industrial

[1] Direct consumers of natural gas were then: Kombinat Belišće, Cementara Našice, „Dilj“ Vinkovci, IGM „Slavonija“ - Našice, „Graditelj“ - P. Slatina, „Radnik“ - Donji Miholjac, PIK „Đuro Salaj“ - Valpovo, Holding „Đuro Đaković - Slavonski Brod, „Domin“ - Sl. Brod i PIK Vinkovci;

production was reduced, and in the public sector and household consumption is reduced or rationalized due influenced of the implementation of energy efficiency measures. Figure 5 shows the changes of natural gas consumption in the region of eastern Croatia.

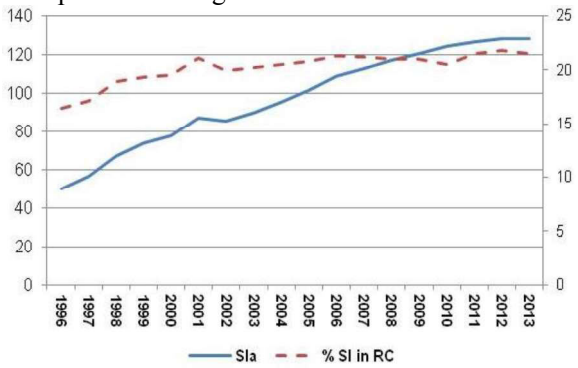

Figure 5. Number of households of natural gas consumers in Slavonia for period 1996-2014 (000); [4] [8] [11] [12] [13]

SIGNIFICANCE OF GASIFICATION IN ENERGY SUPPLY OF SLAVONIA

The advantages of natural gas in energy consumption

Significant advantages of natural gas in energy consumption compared to other energy sources can be classified in three groups:
a) Energy benefits of natural gas
b) Environmental benefits of natural gas
c) Economic advantages of natural gas

Benefits of using natural gas in relation to other energy forms can be seen in: [9], [12] and [13]. General conclusion is that usage of natural gas in the energy sector brings to the significant energy, environmental and economic benefits / advantages compared to the same amount of energy required from other energy forms, and ultimately increase social functionality of energy consumption, ie. lower energy costs per GDP.

Changes in the structure of energy consumption in Slavonia

Energy consumption of industry (households and communal consumption) in the region of Slavonia and Baranja in the early days of gasification essentially was based on coal, table 3 and table 4.

Table 3. Energy consumption of industry in the Slavonia area, [1] [2] [9]

Nº	Energy source	Unit	1972	1977	1978	1979
1.	Electricity	MWh	281,593	432,458	495,539	503532
2.	Anthracite	t	0	605	17	4
3.	Coke	t	16,679	21,168	23,847	22,273
4.	Stone coal	t	4,962	0	400	465
5.	Brown coal	t	247,201	174,445	169,495	145,310
6.	Lignite	t	59,381	44,904	50,614	41,315
7.	Fuel oils	t	19 ,690	22,525	27,034	25,629
8.	Oil fuel	t	75,503	93,212	111,967	112,520
9.	Natural gas	10^3m^3	500	84,830	104,527	129,141
10.	LPG	t	3,094	3,512	2,850	3,751
	Total: (recalculated)	10^3m^3	300,518	382,582	435,211	444,185

The development of the gas network and the use of natural gas almost kicked out coal from Slavonia. So at the beginning of XXI c. hundreds of thousands of tons of coal were replaced by natural gas. Natural gas reduced transportation costs, enable more efficient management of technological processes, raise living standards and community and reduced greenhouse gas emissions.

Table 4. Consumption of substitutable energy in Slavonia in 1982 [14]

Nº	Energy source	Unit	Consumption			
			Economy	Utility	Households	Total
1.	Coke	t	25,217	-	-	25,217
2.	Stone coal	t	159	-	-	159
3.	Brown coal	t	259,037	7,706	42,515	309,318
4.	Lignite	t	72,745	4,475	171,845	249,072
5.	Wood and wood wastes	t	115,491	11,715	405,581	532,785
6.	Fuel oils	t	23,800	36,400	27,800	88,000
7.	Oil fuel	t	82,629	20,040	-	102,669
8.	LPG	t	5,900	3,012	8,000	16,952
9.	Natural gas	10^3m^3	197,512	8,279	7,749	213,540

Biomass for heating

Heating is a sector that can benefit the most biomass. Abandoning the use of fossil fuels and switch to renewable energy is a worldwide trend. Development of technology enabled the cheap fuel from cellulose waste material by mechanical means, without the use of a binder. Briquette burns evenly with a little smoke and no fly ash (a 10 times less ash than coal). Combustion practical environmental friendly compared with other solid fuels, as it contains little sulfur (100 times less than coal). Manufacturing of briquettes is developed so that it can be applied to different materials - from the waste material in the industry to bulky cellulosic combustible residues grains from agricultural fields.
The use of biomass create new and maintain existing employment, increase local and regional economic activity, create additional income in agriculture, forestry and wood industry through the sale of biomass-fuel. In addition - outflow of funds for the purchase of fossil fuels is reduced and cash flows in the local community are established (investments - profit - taxes). The impact on employment and socio-economic aspects represents the biggest advantage of using biomass.
Our research of biomass potential from crop residues, fruit and grape growing Slavonia and Baranja [10] [16] determine the energy potential of this type biomass amounting to over 800,000 tons of oil equivalent per year (Fig. 6). So, this is a very significant potential that can be used for heating in households, but also in other sectors.

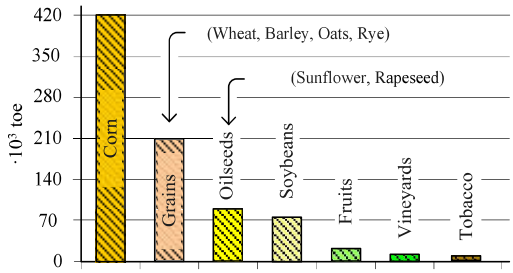

Figure 6. Total energy potential of biomass from crop residues, fruit and grape production in the area of Slavonia [16]

CONCLUSION

a) The process of gasification of Slavonia began with oil discovery in the region Beničanci (1968) and gas discovery in Boksic-Lug (1973). In the past 43 years a respectable system of main and distribution pipelines has built. Gas consumption includes all consumption sectors: industry, agriculture and services, public institutions, households, boiler and heating plants. Process of gasification of the region was stopped in 1991 and started again in 1995 after eliminating significant damage from sever military destruction. In the period from 1996 to 2014 development of gasification was continued with new

dynamics, more than 4,000 km of new distribution pipelines was built, which allowed the gasification of a number of settlements in the region in all sectors of consumption from industry to households.

b) Natural gas consumption in Slavonia and Baranja has been increasing from 1996 until 2009 when - because of the economic downturn - industrial production was reduced, and in the public sector and household consumption is reduced or rationalized due influenced of the implementation of energy efficiency measures.

c) Our analysis of gasification of Slavonia and consumption of natural gas emphasize the economic and ecological importance of the introduction of natural gas as energy supply for region. Instead of several hundred thousand tons of coal a year Slavonia and Baranja is now using natural gas. gasification, reduced transportation costs of energy supply, enable more efficient management of technological processes, raise living standards and community and reduced greenhouse gas emissions.

d) Along with the good performance of gasification of the region paper emphasized strategic importance of utilization of large biomass potential for households and public institutions heating. The use of biomass for heating reduce imports of natural gas, reduce CO_2 emissions and contribute to local economic development through local employment and local cash flows.

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