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SECTION 6

MACHINES AND EQUIPMENT APPLIED MECHANICS.

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TRANSCOM 2013
10th European conference of young researchers and scientists

TRANSCOM 2013, the 10th international conference of young European researchers, scientists and educators, aims to establish and expand international contacts and co-operation. The 10th international conference TRANSCOM is jubilee. It will be held in the year when the University of Žilina celebrates 60 years since her constitution (1953 – 2013).The main purpose of the conference is to provide young researchers and scientists with an encouraging and stimulating environment in which they present results of their research to the scientific community. TRANSCOM has been organised regularly every other year since 1995. Between 160 and 400 young researchers and scientists participate regularly in the event. The conference is organised for postgraduate students and young researchers and scientists up to the age of 35 and their tutors. Young workers are expected to present the results they had achieved.

The conference is organised by the University of Žilina. It is the university with about 13 000 graduate and postgraduate students. The university offers Bachelor, Master and PhD programmes in the fields of transport, telecommunications, forensic engineering, management operations, information systems, in mechanical, civil, electrical, special engineering and in social sciences.

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CONTENTS

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Application of fuel cell in micro-cogeneration units

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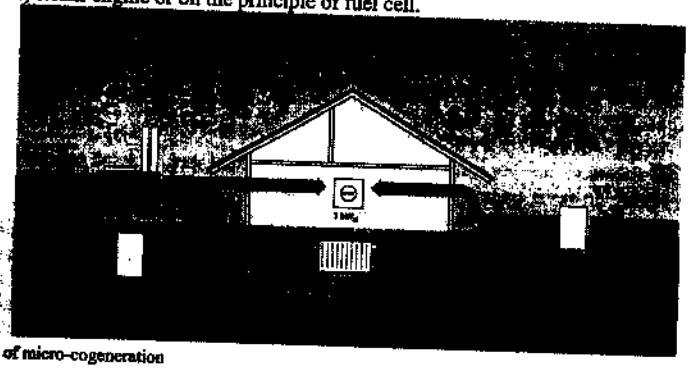
The aim of the article is micro-cogeneration for family houses. It is aimed at perspective and fast field of micro-cogeneration with small performance. High sophisticated technology for combined heat and electric power is application of fuel cell which uses natural gas as a fuel. Combined of heat and electric power is one of the best way how utilize energy which is contained in fuel. The article is verification of availability of micro-cogeneration units with fuel cell applying in . The verification was evaluated through total fuel price and difference between total fuel price produced electric power.

micro-cogeneration, fuel cell, natural gas

duction

generation means combined production of heat and electric power (CHP – combined wer), eventually heat and mechanical power, or heat power and combination of electric ical power. Combined production of heat and electric power is one of the best way how y which is contained in fuel. The principle of cogeneration is heat utilization that would ot utilization during electric power production. This heat would be heat loss, but it is for heating or for heating of domestic hot water. Thankfulness of this technology we can affects of fuel energy content utilization. Description of micro-cogeneration is relevant tion units with performance up to 50 kWe.

, all devices on the market offered for family houses technologies which provide oduction of heat (condensing boiler, heat pump, solar collector,...) or electric power (photovoltaic panel, small hydroelectric power plant, wind-power plant,...). On the market offers micro-cogeneration units (micro-CHP) with small performance, which d in single family houses. These units work on the principles of combustion engine, ine, steam engine or on the principle of fuel cell.



e of micro-cogeneration

The usage philosophy of these units is in production of thermal energy for h
domestic hot water and electric power getting is as a bonus. Produced electric power is
home consumption, not for sale to distribution grid. Sale to electric distribution grid
amount of licensees, administration and dues which are not suitable. The c
performance of units and the resulting low expectation of electric power selling. The
which would be sold into electric distribution grid will be purchase as an electric pow
The price of electric power for losses is approximately doubly lower then price of elec
customers. Electric output of these units is satisfactory to cover house consumption;
is bought from distributor in the case of higher consumption.

The principle of micro-cogeneration for family houses is shown in the figure 1.
harmonization of heat and electric power requirement. The problem is partly minimiz
the heat accumulating tank. Micro-CHP unit can partly work in case when we need
without thermal power at the same time. Next problematic season is summer when w
only for domestic hot water preparation but electric power requirement is practic
during all year. This season reduces quantity of working time of micro-cogenerati
thereby extends pay-back period. The ideal working condition is continuous run
Insufficiency of some technologies especially fuel cells is low thermal production, it
source of heat requirement. This source of heat covers peak heat demand.

2. The fuel cell

The fuel cell is electro-chemical device which transforms chemical energy of fuel di
electric power. It utilizes oxidation-reduced reaction. The principle of operation is in
electrolysis. Oxygen O_2 is supplying to cathode, cathode reduces oxygen into oxygen
After that, oxygen anion proceeds to anode where reacts with hydrogen and releases two
at the same time. Anode and cathode are connected by electric conductor; two free
traverse the electric conductor to anode where oxygen receives them again. Electric
produces by this process, water is created at the end and by-product is thermal power.

Types of fuel cells are different of material of electrodes, used electrolyte, working te
and chemical reactions on the electrodes. The fuel cells are divided into six groups
electrolyte and these groups are divided into three main categories by working temperature.

Fuel cell with low working temperature (60-120°C)

- AFC – Alkaline Fuel Cell
- PEMFC – Polymer Electrolyte Membrane Fuel Cell
- DMFC – Direct Methanol Fuel Cell

Fuel cell with middle temperature (160-200°C)

- PAFC – Phosphoric Acid Fuel Cell

Fuel cell with high working temperature (600-1000°C)

- MCFC – Molten Carbonate Fuel Cell
- SOFC – Solid Oxide Fuel Cell

Fuels for fuel cells are generally pure hydrogen or natural gas. Natural gas using is bet
fuel cell in home; however natural gas have to be without sulfur. For natural gas using in fue
it is necessary applying process called reforming. Natural gas reforming is process how to
hydrogen from natural gas molecule CH_4. This process can be steam external reforming or in
reforming. The base of steam reforming is reaction of methane with water. The reacti
endometrial and heat balance is compensated with combustion of a part of methane. I
reforming can be divided to direct and indirect process. During indirect internal reforming, m
comes to catalytic converter which is in direct contact with fuel cells bundle. During direct in
reforming, reforming reaction is into fuel cell anode.

CHP units with fuel cells

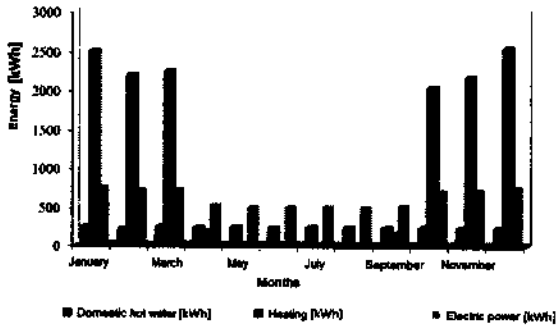
t table specifies main technical parameters of chosen micro-CHP units with fuel cells,
are or will be on the market in the near future. Operating costs were compared with
boiler. Main operating cost was fuel price.

	BlueGen	ClearEdge5	GenSys E-60	Panasonic EneFarm	Tropical RLN-1000	Condensing boiler
Nominal [kW]	1,5	5,0	4,6	0,75	1,2	
Range [kW]	0,5 - 1,5	0,5 - 5,0	0,3 - 4,6	0,2 - 0,75	0,25 - 1,2	
Efficiency [%]	60	60	33	39	30	
Maximal [kW]	0,54	6,0	9,0	0,6	2,2	14,5
Efficiency [%]	25	25	55	56	50	98
ncy [%]	85	85	88	95	80	98

ical parameters of micro-CHP units

for calculation

calculation we choose single family house which is situated in village near Žilina. Heat loss
g is 7,8 kW, its total annual consumption of heat for heating and domestic hot water
on is 63,05 GJ/yr. All electric power production is consumed in house; it is not sold into
grid. The price of electric power was set by SSE, a.s. price list for tariff D2, without subsidy
-cogeneration. The price of consumed natural gas was set by SPP, a.s. price list for tariff
sumption curve of heat and electric power have been made for chosen house. Data for
ion curve ware obtained by reading of gauges in periodic interval. Consumption curve is
the figure 2. Electric power consumption is practically constant during the year; low
is in summer-time what is caused by shorter time of lighting. Heat for domestic hot water
on is constant during the year too. The biggest variations are in heat demand value. It is
house does not have swimming pool or alternative way how consume heat power during
, house uses thermal energy for heating only during heating period. This fact decreases
of operating hours, lengthen pay-back period and electric power has to be buy in this



Consumption curve of power

sults

The table 2 contains results of operating costs calculating for chosen micro-CHP units with fuel
We assumed that micro-CHP units with lower performance don't cover requirement of heat
. Remaining heat power is covered by condensing boiler. Main operating cost was price of

fuel, we didn't make provision for maintenance and service costs. The profit was from consumed electric power which we made and consumed in the house and we didn't have to buy form electric power distributor.

	BlueGen	ClearEdgeS	GenSys E-60	Panasonic EneFarm	Tropical RLN-1000	Condensing boiler
Covering of heat demand [%]	7	77	100	7,7	28,21	100
Covering of total annual heat consumption [GJ/yr]	4,37	48,5	63,05	4,85	17,78	63,05
Amount of operation hours [hr/yr]	2245,5	2245,5	1946,02	2245,5	2245,5	1207,9
Produced electric power [kWh/yr]	3368,1	11117,03	8951,7	1684,05	2694,5	–
Annual fuel consumption – FC [m^3/yr]	509,8	5664,3	3347,1	252,87	1038,5	–
Annual fuel consumption - FC [kWh/yr]	5206,2	57846,34	34182,0	2582,5	10605,2	–
Fuel price - FC [€]	251,10	2788,20	1647,60	124,50	511,20	–
Lump sum expenses [€]	59,76	59,76	59,76	59,76	59,76	–
Total price of fuel - FC [€]	310,86	2847,96	1707,20	184,46	570,96	–
Price of produced electric power [€]	216,50	721.67	575,41	108,25	173,20	–
Heat from alternative heat source [GJ/yr]	58,69	14,55	0,00	58,20	45,27	63,05
Annual fuel consumption – AHS [m^3/yr]	1748,5	433,5	0,00	1734,0	1348,7	1878,5
Annual fuel consumption – ASH [kWh/yr]	17855,7	4427,1	0,00	17,708,1	13773	19183,8
Fuel price - AHS [€]	860,64	213,38	0,00	853,53	663,86	924,66
Total fuel price – FC+AHS [€]	1171,34	3061,34	1707,33	1037,76	1234,78	984,42
Difference between total fuel price and price of produced electric power [€/yr]	954,84	2339,66	1131,91	929,51	1061,58	984,42

Tab.2 Results of calculation (FC – fuel cell, AHS – alternative heat source)

6. Conclusion

The results of calculation show that difference between total fuel price and profit from produced electric power is not important. The profit is too low in compare with traditional ways of heating, fuel consumption is higher. The cost of acquisition is incomparably higher than condensing boiler. Even though technology of micro-CHP units with fuel cells is perspective and in the near future they expand and their prices drop down.

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