Challenges and Opportunities for Customer-Driven Distributed Generation in the Republic of Srpska

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Abstract—**Investing in distributed generation (DG) may result in various techno-economic benefits for electricity customers. This paper investigates the possibilities for distributed energy generation which would be driven by industrial and commercial customers in the Republic of Srpska.**

Keywords-distributed generation (DG); customer perspective; Republic of Srpska.

I. Introduction

Distributed generation (DG) is an electric power source connected directly to the distribution network or on the customer side of the meter [1]. This definition covers all applicable power generating units regardless of their rating, technology, mode of operation and ownership. This paper particularly focuses on the utilization of distributed generation which is driven by the customers, with special attention to the customers in the Republic of Srpska.

Investing in distributed generation may represent a successful measure for electricity customers towards satisfying their energy demand in a cheaper and more efficient way. The customers may invest in the fossil fuel burning units like microturbines and diesel generators or renewable energy sources such as photovoltaic devices and wind turbines. The level of utilization of DG may vary from covering only a little portion of the customer electricity needs, up to satisfying demand in total, or even exporting the surplus energy back to the utility grid. The profitability of a customer investment in distributed generation depends on several inputs. One of the most influential factors is the pricing policy for fuel and electricity. This part includes regulation, tariffs, and price levels. The nature of the customer also plays a very important role. The viability of the customer-driven DG significantly depends on the shape of the customer load diagram, reliability requirements, needs for cooling/heating, reactive energy consumption, etc. The next important issue refers to the technology of DG including the capital and fuel costs. Finally, the mode of operation as well as the efficiency and reliability of the distributed generating units should definitely be included in the analysis.

II. Regulation and Tariffs

Profitability assessment of distributed generation should begin with an analysis of the electricity tariffs and price levels as well as their comparison with the tariffs and prices of fuel consumed by the distributed generating units. It is clear that this step is very important, because the cost effectiveness of the customer energy generation will become greater if electricity prices increase and fuel prices fall. The customers we cover in this paper are relatively small consumers, and as such, are exposed to the retail prices of energy rather than the wholesale prices. The retail energy prices compared to the wholesale prices have certain specific features which should be taken into account. While prices in the wholesale level are usually left to market fluctuations dictated by supply and demand, the retail prices are far more subject to regulation by the public authority. The general template for the retail price formation that applies to both electricity and natural gas is shown in Fig. 1. The top two blocks are the components of energy price which are usually regulated by the state. The contribution of "pure" energy price in the total end-user price is presented by the block at the bottom. This net energy component may be either regulated or liberalized. The tendency is towards the full liberalization, which is usually first introduced to large customers, then to the small industrial and commercial customers, and the households at the very end. The liberalization process has been fully implemented in several European countries, such as Austria, Germany, the UK, and the Nordic countries. In contrast, as of 1 January 2010, in a significant number of countries (18 in electricity and 15 in gas) the end-user regulated prices still exist on at least one of the various market segments [2]. In the Republic of Srpska, the prices of both electricity and natural gas are fully regulated [3].

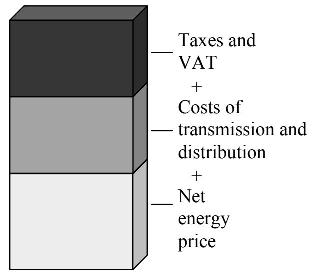

Fig. 1 The components of the end-user price for fuel and electricity

A. Electricity Tariff and Prices

Electricity customers in the Republic of Srpska, just as the most customers in developed countries, are billed by using time-of-use rates (TOU). The TOU rate design, in general, features prices that vary by time period, being higher in peak periods and lower in off-peak periods. The prices are typically

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changed once or twice a year, with relatively predictable long-term rise. The simplest rate involves just two pricing periods, a peak period and an off-peak period (Fig. 2a). More complex rates also have one or more part-peak periods (Fig. 2b). In addition to daily price variations, there is a distinction between summer and winter rates reflecting seasonal fluctuations in customers' demand. All these rate structures may optionally include a fixed fee to cover costs of billing, meters, and other equipment. Finally, in contrast to residential customers, the commercial and industrial customers are usually billed not only for energy but also for the peak amount of power that they use.

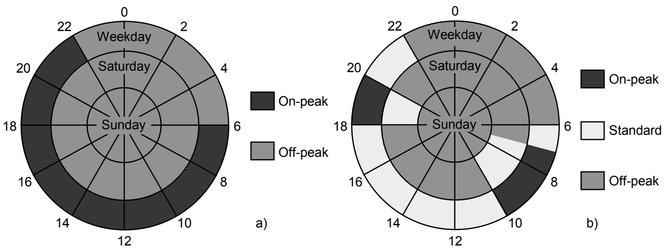

Fig. 2 TOU tariff examples

The price levels for the industrial customers in the Republic of Srpska (tariff group I) are listed in Table I. These levels are constant throughout the year, unlike the prices for households that are different in summer and winter periods. The schedules for on-peak and off-peak periods correspond to the scheme given in Fig. 2a.

TABLE I. REGULATED ELECTRICITY RATES IN THE REPUBLIC OF SRPSKA (TARIFF GROUP I)

Component of the bill	Unit	Rate
On-peak kWh	BAM/kWh	0.108
Off-peak kWh	BAM/kWh	0.054
Peak demand kW	BAM/kW	15.867
Reactive kVArh	BAM/kVArh	0.049

Source: Elektrokrajina a.d., Banja Luka

Other tariff systems that are most common in the world are the critical peak pricing (CPP) and the real-time pricing (RTP). The CPP pricing is similar to TOU pricing, with addition of special rates during the certain peak days. The RTP pricing means that prices may freely change as often as hourly. Price signal is provided to the customer on an advanced or forward basis, reflecting the utility's cost of generating and/or purchasing electricity at the wholesale level.

B. Fuel Prices

Unlike photovoltaic and wind generators which do not need specific fuel, the other various DG technologies like microturbines, diesel generators or fuel cells require fuel for their operation. The fuel is purchased from a supplier at retail prices. Different types of fuel may be available such as natural gas, diesel or hydrogen. In this paper, we will take natural gas as a representative example.

The price for natural gas is most often formed in accordance to the template shown in Fig. 1. Thus, the retail price represents the net energy price increased by the taxes and costs of distribution. The main difference between countries comes down to regulation of the net energy price. In deregulated markets, the net energy price reflects the fluctuations from the wholesale level. On the other hand, in regulated environments, the net price of energy, and therefore the total retail price of fuel, is determined by the public authority.

The Republic of Srpska still belongs to areas with regulated prices of natural gas. The structure of the natural gas retail price is listed in Table II.

TABLE II. THE STRUCTURE OF NATURAL GAS PRICE IN THE REPUBLIC OF SRPSKA (INDUSTRIAL CUSTOMERS)

Component of the price	Rate in BAM/m^3	Approx. rate in BAM/kWh
Net energy price	0.8500	0.082
Distribution cost	0.1023	0.010
Supply cost	0.0677	0.007
Value added tax	0.1734	0.017
Total retail price	1.1934	0.116

Source: Sarajevo-gas a.d., Istočno Sarajevo

C. Comparison with Prices in Europe

In order to distinctly compare prices in the Republic of Srpska (and Bosnia and Herzegovina) with the prices in the surrounding countries, we have constructed the chart shown in Fig. 3. The data are retrieved from Eurostat [4]. Besides Bosnia and Herzegovina (BA), the chart includes information for 25 other European countries (the codes are listed in Appendix A). The prices for electricity and natural gas are represented by bars, while the solid line stands for their mutual ratio. Varieties in tariff systems are taken into account by calculating the equivalent prices in EUR per kilowatt-hour by employing the Eurostat methodology. It is observed that customers in Bosnia and Herzegovina enjoy in the cheapest electricity, while the price they pay for natural gas is amongst the highest in Europe. Out of all countries included in the chart shown in Fig. 3, it is obvious that Bosnia and Herzegovina has the lowest electricity to natural gas cost ratio. This is not too surprising for a country which is a net exporter of electricity and 100% importer of natural gas.

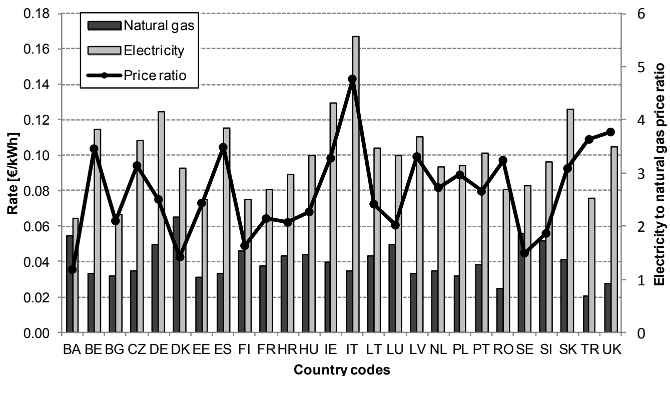

Fig. 3 Price levels for electricity and natural gas for industrial customers in selected European countries

D. Prices and Incentives for Distributed Generation

In the worst possible case, the price offered to a customer for energy produced by their distributed generation is equal to the retail price which is set by a supplier. This is the case regardless of whether the produced energy is exported to the grid or used for customer own consumption. However, distributed generation is usually encouraged by various support mechanisms. The support beneficiaries are predominantly owners of renewable energy sources and highly efficient cogeneration. The most frequent mechanisms of support are the government or local investment grants, tax rebates, and feed-in tariffs. In the Republic of Srpska, the feed-in tariffs were adopted on January 1, 2012. The prescribed rates for representative types of DG technologies are given in Table III. On the other hand, the investment grants and tax rebates are not offered by the local and state governments. Nevertheless, grants are sometimes available as a part of some project or research.

TABLE III. THE FEED-IN PRICES IN THE REPUBLIC OF SRPSKA

Generation technology	Price BAM/kWh
Wind power plants up to and including 10MW	0.1652
Photovoltaic plants up to including 50kW	0.5357
Photovoltaic plants over 50kW up to including 1MW	0.4521
Photovoltaic plants over 1MW	0.4013
Power plants on agricultural biogas up to and including 1MW	0.2254
Power plants on solid biomass up to and including 1MW	0.1988
Power plants on solid biomass over 1MW	0.1730
New gas-fired cogeneration facilities	0.1505
Old gas-fired cogeneration facilities	0.1351

III. MODE OF OPERATION

The cost effectiveness of customer-driven DG is highly influenced by the mode of operation. In the remainder of the section we will describe three conceptually different modes of operation, available for the customers in the Republic of Srpska, namely peak shaving, buyback control and isolated operation.

A. Peak Shaving

In this mode of operation the customer-driven generating units work in parallel with the utility grid. The generated power may partially or fully satisfy the customer demand but injecting the power back to the grid is never allowed. Potential deficit is compensated by the purchasing from the electricity supplier.

The dispatch strategy is of a crucial importance. The cost savings achievable by the customer is dictated by the way how the generating units are scheduled to run. The most simple but the less economical dispatch procedure is a continuous operation of DG. A quite better solution is dispatching the units at certain periods of day or year, during the hours of peak demand or high price of electricity [5]. A further improvement represents the threshold control, where DG is run whenever the customer load is greater than the predefined threshold value [5][6]. The best results are achievable by employing the heuristic dispatch methods which take into account the probabilistic nature of the input variables [7][8].

B. Buyback Control

The buyback control is another mode of operation where the customer DG works in parallel with the grid connection. On the contrary to the peak shaving, the buyback control includes the opportunity to sell the portion or total generated electricity back to the utility. There are two alternatives of buyback control: simple buyback control and net metering. The simple buyback control assumes different tariffs (and different meters) for purchased and sold electricity. The customer compares their production costs with the offered buyback rates and determines whether or not to schedule available generating units. On the other hand, the net metering assumes the existence of a sole meter, recording in both directions. Although not being standardized, this principle most often means that the customer-driven distributed generation is used to offset the traditional electricity bill on a dollar for dollar basis.

C. Isolated Operation

Isolated operation of distributed generation is used in occasions where is cheaper to invest and operate customer own generating units than to connect to the existing grid. The examples are base stations for mobile telephony or highway rest areas.

IV. NATURE OF THE CUSTOMER

Some customers are more suitable for successful utilization of DG than others. It depends on several factors such as location, availability of fuel, characteristics of the electric and thermal load, reliability requirements, etc.

A. The Customer's Own Fuel

The customers may possess their own sources of fuel. Representative examples are wood waste in sawmills or biogas from digesters in farms. For such customers, investments in DG facilities would be much more competitive than for others who have to buy fuel from the external supplier.

B. Location Advantages

A prestigious location is also an influential factor. In advantages of the good location we count, for example, the cheaper and easier available different types of fuel, good meteorological conditions for application of photovoltaic or wind generation, lower installation and maintenance costs of the equipment, cheaper land for rent or buying etc.

C. The Electric Load Characteristics

The characteristics of the electric load can cause that some customers are more suitable for the application of DG than others. The most important features of the customer load are summarized in the following paragraphs.

1) Load that Cannot be Changed or Shifted in Time

The cost-saving potential of DG will be higher for customers having rigid loads. Otherwise, if the load control was possible, demand side management would lead to better results, either by decreasing the peak demand or shifting the load to the periods with lower price of electricity.

2) Load that is Concentrated to the Periods of High Prices of Electricity

If the customer requirements for energy most often coincide with the periods of expensive electricity, the contribution of DG will be more influential.

3) High Peak Demand

DG will be more profitable for customers who experience significant participation of the peak demand component in their electricity bills. The cost savings are achievable even if the operating costs of DG are considerably higher than the volumetric costs of electricity.

4) High Sensitivity on Power Interruptions

By using DG as a backup source, customers that are sensitive on interruptions in power supply will avoid large damages. In such a case, the costs of DG operation are of a much lower priority.

D. Cogeneration and Trigeneration

For customers that purchase heat and electricity separately, it may be cost effective to invest in a cogeneration facility. Efficiency of modern combined heat and power (CHP) solutions amounts up to 90%, which is a large improvement in comparison with 35%, achievable in "electricity only" mode of operation. The utilization of waste heat is not limited just to the cold days. During the summer, waste heat can be converted to cooling energy by absorption chillers.

E. Reactive Power

Although distributed generating units are primary intended to produce just the real power, in some cases they may be the sources of the reactive power as well. The reactive capabilities depend on the technology, especially the type of generator and/or the power converter. Certainly, the potential benefits should be compared against the effects achievable by conventional compensation devices.

V. Numerical Illustrations

A. Peak shaving

For testing purposes, we used the load data recorded for a real industrial customer – a manufacturer of electronic devices from Banja Luka, the Republic of Srpska. The data cover one full year, ranging from April 1, 2011 to March 31, 2012. Annual peak demand is about 350 kW. Primarily due to electrical heating, the consumption is greater during the colder months. The full year load diagram is shown in Fig. 4, while characteristic weekly loads recorded during the summer and winter are presented in Fig. 5 and Fig. 6, respectively.

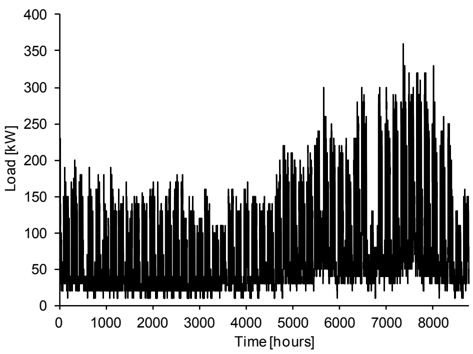

Fig. 4 The annual load diagram of a test customer

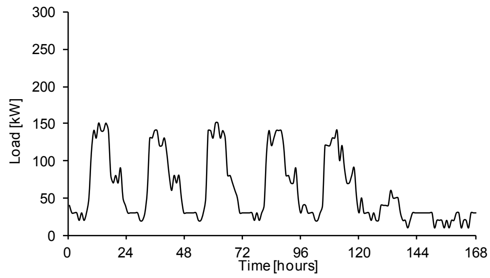

Fig. 5 A summer week from the test customer load diagram

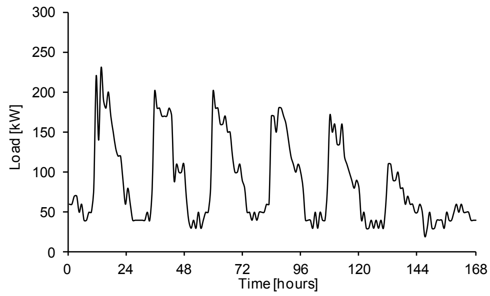

Fig. 6 A winter week from the test customer load diagram

We analyzed the financial effects of investing and utilization of a natural gas fired microturbine. The selected rated power is 60kW. The capital cost amounts up to $100,000. Efficiency curve is assumed to be non-linear, as declared by Capstone, one of the leading microturbine manufacturers. The microturbine is operated in the "electricity only" mode, being dispatched by enhanced threshold control as described in [8]. Assuming the same annual load diagram, the application of the microturbine is tested under the conditions in (a) the Republic of Srpska, (b) average European country, (c) California, the United States. The main financial inputs and outputs of our simulation are summarized in Table IV. A disparity in the overall simple payback periods is very eye catching.

TABLE IV. The Republic of Srpska DG investment scenario in comparison with a European and American case

		(a) RS	(b) EU	(c) US
On-peak kWh price	BAM/kWh	0.108	0.189	0.209
Off-peak kWh price	BAM/kWh	0.054	0.094	0.125
Peak demand kW price	BAM/kW	15.867	27.767	17.685
Natural gas price	BAM/m^3	1.193	0.824	0.371
Total potential annual costs	BAM	104,490	180,750	169,300
Possible annual savings	BAM	3,707	15,682	34,097
Simple payback period	years	40.5	9.6	4.4

For a more detailed analysis of obtained distinction, Fig. 7 shows the near-optimal real-time dispatch schedule of a microturbine for the customer load measured during October 2011. Fig. 7a corresponds to prices in the Republic of Srpska, while Fig. 7b covers conditions prevailing in California, the United States. A huge difference between the two scenarios is observed. While it is the most economical to dispatch just several peak-shaving starts for the customer in the Republic of Srpska, the microturbine in California would very often run at its rated capacity. The final conclusion is that investing in a natural gas fired microturbine which would be used for peak shaving is not reasonable in the Republic of Srpska. On the contrary, the United States thanks to cheap natural gas and relatively expensive electricity is ideal area for application of microturbine-based peak shaving.

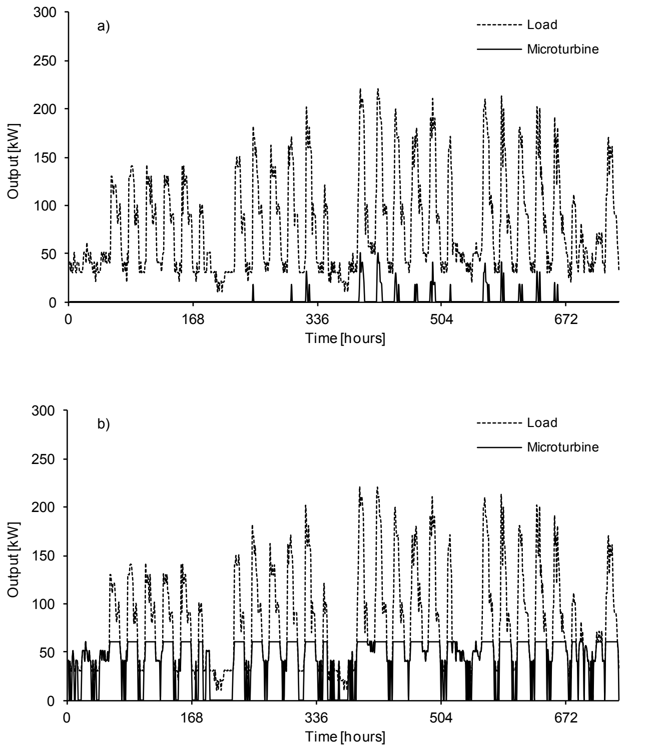

Fig. 7 The real-time dispatch schedule of a microturbine (in October 2011) for conditions in (a) the Republic of Srpska and (b) California, US

B. *Buyback control*

The calculation is conducted using a sample manure-based biogas cogeneration facility which is described in detail in [9]. The key features of the facility are summarized in Table V.

TABLE V. THE MAIN FEATURES OF A SAMPLE MANURE-BIOGAS COGENERATION FACILITY

Variable	Value	Unit
Biogas production rate	1.4	m^3/day
Biogas heat value	6.4	kWh/ m^3
Electric efficiency	36	%
Thermal efficiency	52	%
Annual production of electric energy	508.889	kWh/year
Annual production of thermal energy	773.427	kWh/year
Thermal energy used for fermentation process	15	%
Total capital cost (building + equipment)	900.000	BAM
Annual costs of operation and maintenance	18700	BAM/year

We assume that customer sells all generated electricity at the tariff prescribed for agricultural biomass generation in the Republic of Srpska. Therefore, the customer load diagram is not included in the analysis. After applying the corresponding feed-in rate of 0.2254 BAM/kWh and the price of heat energy of 0.13382 BAM/kWh (obtained by public heating plant "Toplana a.d." Banja Luka), the expected annual income would be computed as follows

$$I = 0.2254 \cdot 508889 + 0.13382 \cdot 0.85 \cdot 773427 - 18700$$
$$= 114704 + 87975 - 18700 = 183979\, BAM\,/\,year$$

Taking into account that the total capital costs amount up to 900.000 BAM, the simple payback period equals 4.9 years. Clearly, the simple payback period is not sufficient economic indicator for making a final decision but the obtained value of 4.9 years indicates that the project is worth considering.

VI. CONCLUSIONS

Investments in distributed generation, in the general case, are much less profitable in the Republic of Srpska than in the rest of Europe or in the United States. The crucial reasons for this claim are low price of electricity and high price of fuel. However, there exist several circumstances which may boost DG investments to be competitive even under the conditions prevailing in the Republic of Srpska. Such drivers are primarily customer qualifying for feed-in tariffs, possession of own source of fuel and utilization of waste heat in a form of cogeneration or trigeneration. It is evident that no general rule can be stated but each customer deserves a careful individual analysis.

APPENDIX A. ABBREVIATIONS

BA	Bosnia and Herzegovina
BE	Belgium
BG	Bulgaria
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
EU	Europe
FI	Finland
FR	France
HR	Croatia
HU	Hungary
IE	Ireland
IT	Italy
LT	Lithuania
LU	Luxembourg
LV	Latvia
NL	Netherlands
PL	Poland
PT	Portugal
RO	Romania
RS	Republic of Srpska
SE	Sweden
SI	Slovenia
SK	Slovakia
TR	Turkey
UK	United Kingdom
US	United States of America

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