Economic Analysis of Solar Energy Using in Oil Sector Economy in Republic of Tatarstan

L I Kulikova, A V Goshunova, D I Nutfullina
Department of Financial Accounting, Institute of Management, Economics and Finance, Kazan Federal University, 18, Kremlyovskaya street, Kazan 420008, The Russian Federation

E-mail: anna.goshunova@mail.ru

Abstract. In the current economic conditions further increase of the profit or maintenance of its current level on the base of extensive development factors is no longer possible. The example of the oil-extracting company in the Republic of Tatarstan demonstrates that in the future it will be possible to replace traditional energy sources with solar energy; it will reduce energy costs for oil extraction, production costs and provide an increase of corporate efficiency. The economic analysis results show that the use of solar electricity can lead to 4.68% reduction in total electricity costs. In addition, the energy consumption per ton of oil produced is reduced. The share of electricity costs in the oil cost is reducing from 12.13% to 11.56%. Consequently, in the long term, the impact of total energy costs reduction can become more significant. In this way solar energy can become quite a real alternative in ensuring the energy needs of the economy of the oil-extracting sector of the Republic of Tatarstan and become a driver of intensive economic development.

1. Introduction
Difficult economic conditions which developed in the world market of hydrocarbonic raw materials have significant effect on activities of the Russian companies of oil-extracting sector. Taking into consideration accepted by the international oil cartel of oil-exporting countries about oil extraction restriction the Russian Federation within the arrangement with OPEC also undertook liabilities on reducing quotas for oil production.

This means that in the current economic conditions, further growth of profits or maintenance of its current level due to extensive development factors is no longer possible. In this regard, Russian oil companies are forced to look for new ways to improve their efficiency.

In particular, minimization of expenses which will allow to increase profit in the conditions of restriction of quotas for production and impossibility of accretion of physical sales volume can become one of such allowances of growth. In this article we will consider the prospects of minimization of costs of the oil-extracting companies by replacing traditional sources of electricity with solar energy.

2. Integration of solar energy into world economy.
Mohiuuddin et al. [1] consider that among the renewable energy sources in this world, solar energy is the most abundant and most reliable compared to others. Bazmi and Zahedi [2] suppose that solar
power can be economical where electricity prices are especially high, where peak load pricing occurs, or where government incentives are available. According to their statistics world net solar electricity generation will be increasing from 95 billion kWh in 2015 up to 165 billion kWh in 2035, so that average annual percent change solar generation for 2007-2035 calculated by Bazmi and Zahedi [2] makes 12.7%. At the same period total annual percent change for the world net renewable electricity generation makes only 3%. It demonstrates high intensity of the development of solar electric power industry.

According to Cabrera-Tobar et al. [3] the total global capacity installed for utility purpose around the world is expected to grow from 76.512 GW at 2014 up to 250 GW by 2019.

Alashkar and Gadalla [4] describe different technologies which are used for harvesting the sun's energy. They suppose the Concentrated Solar Power (CSP) technology is the most effective for power generation plants. Numerous CSP methods are available, such as the Parabolic Trough Solar Collector (PTSC), Solar Power Tower (SPT), Linear Fresnel Reflector (LFR), and Parabolic Dish System (PDS). According to Alashkar and Gadalla [4] the PTSCs are the leading CSP technology due to their relatively cheap cost and high power output.

Liu et al [5] consider that renewable energy resources have been increasingly used because of their sustainability and low carbon emissions and solar photovoltaic energy is one of the potential industries that offer clean and renewable energies. Akella et al. [6] evaluated social, economical and environmental impacts of renewable energy systems. They consider that the potential of renewable energy sources is enormous as they can in principle meet many times the world’s energy demand.

Timilsina et al. [7] strongly criticize potential of solar energy. They don’t believe in worldwide use of renewable energy technologies because of cost competitiveness. According to Timilsina et al. [7] despite a large drop in capital costs and an increase in fossil fuel prices, solar energy technologies are not yet competitive with conventional technologies for electricity production even when the environmental externalities of fossil fuels are taken into consideration.

Edalati et al. [8] suppose that in the last two decades, the attention to renewable energy, especially to solar and wind power, has increased to a high degree for the governments, policy makers, scientists, and environmentalists due to the benefits of the application of renewable energy for sustainable development. Opposite to Timilsina et al. they believe that solar energy technologies may be competitiveness and efficiency. In example of Iran Edalati et al. [8] show that preferred electricity escalation at a rate of 20% has positive NPV with an investment payback period less than 10 years.

Bayrak et al. [9] consider that the solar energy is not a complete energy solution for residential applications because it is dependent on the climatic conditions. Thus, the hybrid power plants that consist of solar and hydrogen energy are capable of fulfilling a continuous energy demand of the residential plants.

3. Application of the potential of solar energy in the oil sector of the Republic of Tatarstan

In this paper application of potential of solar energy in the oil sector of the Republic of Tatarstan was studied in example of oil-extracting company, located in Aznakaevco city, in the Republic of Tatarstan. The main activity of the oil-extracting company of Aznakaevco consists of the extraction, preparation and transfer of oil and gas.

Cost value of oil and gas represents a cost assessment of natural resources used in the course of oil and gas extraction, reagents, materials, fuel, energy, depreciation of fixed assets, labor and other costs. Analysis of oil cost calculation of oil-extracting company of Aznakaevco for 2014-2015 showed that a relatively high share in the cost of gross output was occupied by energy costs - on extracting oil for 10.11%, on pumping water into the layer for 2.21%. In 2015 costs under this item increased by 6.36% and amounted to 2 272 million rubles. Dynamics of electricity costs for oil production and unit cost of 1 ton of oil in the oil-extracting company of Aznakaevco is depicted in Figure 1.
Depending on the type of consumption the cost of electricity in the oil-extracting company of Aznakaevo varies from 2.48 rubles/kWh to 6.74 rubles/kWh. For example, in 2015 production cost of 1 ton of oil, which amounted to 6,413.98 rubles, included 645.01 rubles on electricity costs for oil extraction and 18.82 rubles on electricity costs for water injection. In this regard, the question of use of alternative energy sources in the oil-extracting sector of Tatarstan economy, in particular, the use of solar energy, is becoming topical.

Russian Federation already has a positive experience of application of renewable energy technologies. Today in Russia dozens of generating facilities are put into operation on the base of photovoltaic solar energy technology. The largest active solar power plants based in Russia are depicted in Table 1.

Effective work of solar power plant requires enough sunny days in the region of basing the plant. In order to assess the suitability of geographical and meteorological features of Aznakaevo city for placement of solar power plant we carried out a comparative analysis of dynamics of sunny days for the locations of main existing solar power plants in Russia (Table 2).

Analysis of the dynamics of sunny days for 2016 showed that percentage of sunny days per year in Aznakaevo is the lowest of all regions, where solar power plants are located (37%). At the same time low sunshine is typical for the city of Orsk, where Sakmarskaya PVPP is located with total capacity of 25 MW, and for Kuyurghazinsky district of the Republic of Bashkortostan, where several lines of Bugulchanskaya and Buribaevskaya PVPP are located with total capacity of 35 MW.
Table 2. Dynamics of sunny days during 2016.

|                | Republic of Crimea | Altai Republic | Orsk | Zabaikalsk | Kumertau (Republic of Bashkortostan) | Aznakaev (Republic of Tatarstan) |
|----------------|--------------------|----------------|------|------------|--------------------------------------|----------------------------------|
| January        | 6                  | 13             | 9    | 14         | 6                                    | 6                                |
| February       | 8                  | 15             | 9    | 15         | 8                                    | 9                                |
| March          | 15                 | 17             | 10   | 21         | 13                                   | 11                               |
| April          | 17                 | 19             | 11   | 16         | 10                                   | 11                               |
| May            | 19                 | 20             | 17   | 13         | 21                                   | 20                               |
| June           | 21                 | 21             | 19   | 17         | 23                                   | 17                               |
| July           | 27                 | 17             | 17   | 21         | 19                                   | 14                               |
| August         | 25                 | 20             | 17   | 19         | 18                                   | 13                               |
| September      | 21                 | 16             | 13   | 16         | 12                                   | 14                               |
| October        | 14                 | 6              | 7    | 20         | 6                                    | 3                                |
| November       | 11                 | 9              | 6    | 13         | 6                                    | 5                                |
| December       | 8                  | 12             | 4    | 15         | 3                                    | 2                                |
| **Average annual number of sunny days** | **16** | **15** | **12** | **17** | **12** | **10** |
| **Percent of sunny days per year** | **57%** | **55%** | **41%** | **59%** | **43%** | **37%** |

Besides, today unique technologies for production of thin-film photovoltaic modules which under conditions of strong cloudiness capture solar energy and convert it into electricity are developed by the Russian scientists. For example, scientists at The Ioffe Physical-Technical Institute of the Russian Academy of Sciences in Saint-Petersburg developed a heterostructural technology for depositing amorphous silicon layers on a silicon wafer using the method of plasmochemical deposition to increase the conversion coefficient of solar energy into electric energy [10]. This technology is already successfully implemented on production of photovoltaic modules at the plant of Hevel company in Novocheboksarsk.

4. Results and discussions

Results of previous section demonstrate that potentially photovoltaic power plant can be located in the Republic of Tatarstan, in Aznakaev. In this section we assess the impact of solar electricity utility on financial indicators of oil-extracting company of Aznakaev.

According to Trabelsi et al. [11] the levelized cost of electricity (LCOE) is the most frequently used when comparing the technologies of electricity generation. LCOE calculates the cost of solar electricity during the whole lifetime of the systems. The LCOE is the cost of electricity generated with respect to various aspects. It includes the cost of installation, discount rate, the operating and maintenance costs, fuel as well as the project period. Timilsina et al. [7] consider that the levelized costs of solar energy are still much higher compared to conventional technologies for electricity generation, with the exception of gas turbine. For example, the minimum values of levelized cost for solar technologies (US$192/MWh for photovoltaic) are more than four times as high as the minimum values of the levelized cost of supercritical coal without carbon capture and storage (US$43/MWh).

According to Cabrera-Tobaretal. [3] the price of photovoltaic technology for utility is around 1.77$/Wdc, but for residential is around 3.73$/Wdc. Analysis of current state of development of electricity-generating technologies, adopted by Bazmi and Zahedi [2] shows that generating cost of solar-photovoltaic technology amounts to 10-20 US$/kWh, generating cost of concentrating solar technology amounts to 15-25 US$/kWh.
Table 3. Economic analysis of solar electricity utility in the oil-extracting company of Aznakaev.

| Indicator                                                                 | Unit of value | 2014        | 2015        |
|---------------------------------------------------------------------------|---------------|-------------|-------------|
| Total electricity costs (for oil extraction and water injection)          | thousand Roubles | 2 631 521.00 | 2 798 963.00 |
| Total electricity costs (for oil extraction and water injection)          | thousand kWh   | 516 397.87  | 533 574.97  |
| Average cost of 1 kW-hr of traditional electricity                        | Roubles       | 5.096       | 5.246       |
| The cost of 1 kW-hr. of solar electricity                                | Roubles       | 5           | 5           |
| Solar electricity costs for oil extraction                               | thousand Roubles | 1 632 374.00 | 1 684 698.60 |
| Solar electricity costs for water injection                              | thousand Roubles | 949 615.33  | 983 176.27  |
| Total solar electricity costs                                            | thousand Roubles | 2 581 989.33 | 2 667 874.87 |
| Total solar electricity costs per one ton of oil                         | Roubles       | 740.17      | 757.27      |
| Total traditional electricity costs per one ton of oil                   | Roubles       | 754.37      | 794.48      |
| The share of traditional electricity costs in the cost of oil            | Percent       | 12.31%      | 12.13%      |
| The share of costs for solar electricity in the cost of oil              | Percent       | 12.08%      | 11.56%      |

In Table 3 we made calculations of economic effect of using an alternative energy source - solar energy on oil-extracting company of Aznakaev. According to Association of the entities of solar power industry of Russia today average cost of 1 kWh of solar electricity makes 5 rubles/kWh. These data were used in further calculations (Table 3).

Figure 2. Impact of solar electricity utility on indicators of oil-extracting company of Aznakaev.

Table 3 shows that the use of solar electricity can lead to a reduction in total electricity costs by 4.68% (from 2 798 963 to 2 667 874.87 thousand rubles for 2015).
Consequently, in the long term, impact of total energy costs reduction can become more significant. In addition, the energy consumption per ton of oil produced is reduced. If using traditional energy the cost of electricity per 1 ton made 794.48 rubles in 2015, then with the use of solar energy the costs would be reduced to 757.27 rubles at the same period. Thus, share of electricity costs in the cost of oil is reducing from 12.13% to 11.56% (according to 2015). Potential impact of solar electricity utility on financial indicators of oil-extracting company is depicted in Figure 2.

5. Conclusion

Thus, economic analysis of using the solar energy in the oil-extracting company of the Republic of Tatarstan confirms our hypothesis. In future the use of solar electricity can replace traditional power sources, that will reduce electricity costs and the cost of oil production in general. This is able to lead to the growth of efficiency of the organization as a whole. In this way solar energy can become quite real alternative in ensuring the energy needs of the economy of an oil-extracting sector of the Republic of Tatarstan and become a driver of intensive (i.e. more qualitative) economic development.

References

[1] Mohiuddin A K M, Bin Sabarudin M S, Ali Khan A and Ihsan S I 2017 Design and development of hybrid energy generator (photovoltaics) with solar tracker IOP Conf. Series: Materials Science and Engineering 184 012043
[2] Bazmi A A and Zahedi G 2011 Sustainable energy systems: Role of optimization modeling techniques in power generation and supply-A review Renew Sustain Energy Rev 15(8) pp 3480–500
[3] Cabrera-Tobar A, Bullich-Massagué E, Aragüés-Peñalba M and Gomis-Bellmunt O 2016 Review of advanced grid requirements for the integration of large scale photovoltaic power plants in the transmission system Renew Sustain Energy Rev 62 pp 971–87
[4] Alashkar A and Gadalla M 2017 Thermo-economic analysis of an integrated solar power generation system using nanofluids Appl Energy 191 pp 469–91
[5] Liu J and Xu Fand Lin S 2017 Site selection of photovoltaic power plants in a value chain based on grey cumulative prospect theory for sustainability: A case study in Northwest China J Clean Prod 148 pp 386–97
[6] Akella A K, Saini R P and Sharma M P 2009 Social, economical and environmental impacts of renewable energy systems Renew Energy 34(2) pp 390–6
[7] Timilsina G R, Kurgdelashvili L and Narbel P A 2012 Solar energy: Markets, economics and policies Renew Sustain Energy Rev 16(1) pp 449–65
[8] Edalati S, Ameri M, Irmanesh M and Sadeghi Z 2017 Solar photovoltaic power plants in five top oil-producing countries in Middle East: A case study in Iran Renew Sustain Energy Rev 69 pp 1271–80
[9] Bayrak Z U, Bayrak G, Ozdemir M T, Gencoglu M T and Cebeci M 2016 A low-cost power management system design for residential hydrogen & solar energy based power plants Int J Hydrogen Energy 41(29) pp 12569–81
[10] Ablayev G M, Abramov A S, Nyapshaev I A, Vygranenko Y K, Yang R and Sazonov A Y 2015 Flexible photovoltaic modules based on amorphous hydrogenated silicon. Semiconductors Maik Nauka-Interperiodica Publishing 49(5) pp 679–82
[11] Trabelsi S E, Chargui R, Quaider L, Liqreina A and Guizani A 2016 Techno-economic performance of concentrating solar power plants under the climatic conditions of the southern region of Tunisia Energy Convers Manag 119 pp 203–14