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Modeling Consumer and Industry Reaction to Renewable Support Schemes: Empirical Evidence from the USA and Applications for Russia

Svetlana Balashova[1], Svetlana Ratner[1,2]*, Konstantin Gomonov[1], Andrey Berezin[1]

[1]Faculty of Economics, RUDN University, Russia, [2] Institute of Control Science, Russia. *Email: lanarat@mail.ru

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ABSTRACT

In this work, we simulate the impact of some government support measures on the development of small-scale power generation based on photovoltaics (PV). Models constructed based on the data on the development of PV in three states of the USA, - Alaska, Pennsylvania and Washington - the climatic and infrastructural conditions in which are close to the conditions of the Russian regions included in a single energy system. Analyzing the share of electricity payments in the structure of income/expenses of the population of Russia and the United States, we prove that the constructed models are applicable to Russian conditions, but only after the enactment of the law on micro-generation and the adoption of relevant amendments to the tax code.

Keywords: Renewable Energy Sources Support Programs, Microgeneration, Photovoltaics-Installations, Econometric Modeling
JEL Classifications: O33, Q42, Q47, Q48

1. INTRODUCTION

Remarkable growth of the renewable energy sector is not a result of a single factor or event, but rather a combination of economic and societal concerns associated with the reliability and security of energy supply, the depletion of natural resources, extreme weather events triggered by environmental degradation, and decoupling of economic growth from energy consumption (Wu and Broadstock, 2015; Kyritsis and Serletis, 2017; Onishi and Vacca, 2018).

Despite the high level of development of energy based on hydrocarbon sources, Russia is slowly but steadily advancing along the path of developing renewable energy sources (RES). Since 2013, the country has been running a state support system for large renewable energy generation facilities (with a capacity of at least 5 MW) connected to unified energy system (UES), thanks to which several large solar power plants have been commissioned in recent years, and projects have begun to build wind parks (Kozlova and Collan, 2016; Ratner and Nizhegorodtsev, 2017; Smeets, 2017; Lanshina et al., 2018; Proskuryakova and Ermolenko, 2019). At the same time, the state support system has not yet extended to micro-generation facilities, although real and potential owners of solar panels and small wind turbines (mainly industrial enterprises and farms so far) consider their own generation as an effective way to reduce costs and solve connection problems to power grids (Berezin and Ratner, 2019).

In connection with the introduction of new legislative acts in the field of intellectualization of electric grids and the forthcoming adoption of the federal law “On Amendments to the Federal Law“ On Electric Power ”regarding the development of micro-generation” (adopted on first reading by the State Duma of the Russian Federation on February 6, 2019 http://sozd.duma.gov.ru/bill/581324-7) a more intensive development of RES-based microgeneration is expected in the country, which opens up new opportunities for consumers to manage their own energy consumption and change the model of consumer behavior from passive to active (Steriotis et al., 2018; Li and Just, 2018). However, for traditional power generating enterprises, this may mean a decrease in demand for their products and a decrease in profitability due to insufficient use of installed capacities (reduction of KIUM) (Kovacic and Giampietro, 2015; Connor et al., 2018).

Therefore, the demand forecast for traditional power generation in the context of partial "withdrawal" of consumers due to the development of microgeneration and intellectualization of the energy sector is of particular relevance. Despite the fact that drivers and barriers to the transition of consumers to the role of energy producer are well studied in the world scientific literature (Hanna et al., 2018; Hirsch et al., 2018; Jensena et al., 2018; Azarova et al., 2019; Parag and Ainspan, 2019; Nezhnikova et al., 2019), the construction of any forecast estimates and, especially, strict forecast models in this case is complicated by the lack of sufficient empirical data on how and to what extent these or other drivers can appear in Russian socio-economic and infrastructural realities. Nevertheless, the analysis of a international experience and application to Russian realities is a productive research approach, as expert assessments depends on the previous experience and competencies of the expert (Proskuryakova and Filippov, 2015; Makarov and Mitrova 2018; Proskuryakova, 2019; Balashova and Serletis, 2020), and surveys of potential consumers demonstrate a low awareness of the majority of the population in the issue under study (Ratner et al., 2018; Semin et al., 2019).

In the present work, an attempt is made to simulate the impact of some government support measures on the development of small-scale power generation based on photovoltaics (PV). This type of power generation is currently the most promising in Russia due to the availability of its own production base (Ratner and Nizhegorodtsev, 2017; Bout and Zhikharev, 2019).

2. LITERATURE REVIEW

Literature on forecasting the effects of the introduction of incentive measures in the field of renewable energy in Russia is presented, both in Russian and in English, in a very limited volume. The majority of authors who investigated this issue focused on predicting the possible effects of the introduction of incentives based on capacity mechanism. Among the studies that were carried out before the introduction of incentive programs, one can note the work of Marinott and Zang (Martinot, 1998; Martinot, 1999; Zhang et al., 2011). An IFC scientist Anatole Boute studied the possible consequences of incentives during the development and presentation of an incentive program based on power supply agreements (Boute, 2012; Boute, 2013), and Vasilyeva et al., and Kozlova et al., studied these issues after the introduction of incentive measures in practice (Vasileva et al., 2015; Kozlova and Collan, 2016). Of all the above works, only in studies (Vasileva et al., 2015; Kozlova and Collan, 2016) made attempts to construct quantitative forecast models in which the main modeled parameter is the price of electricity. Gomonov, Balashova and Matyushok (Gomonov et al., 2019) made qualitative assessments of Smart Grid elements' implementation and simulated its' impact on electricity consumption in Russian regions.

The issues of stimulating microgeneration in Russia are considered only in (Boute, 2016) in relation to the remote Arctic and Far Eastern territories, which are not included in the UES of Russia and have significant differences in the regulatory policy. In contrast to the indicated work, we model the consequences of the introduction of incentive measures in the regions included in the UES of Russia. Incentive measures are understood as amendments to the Federal Law "On Electric Power Industry," which include the introduction of Net Metering practice for micro-generating facilities based on renewable energy with a capacity of up to 15 kW. The various aspects of the application of this incentive measure and its advantages and disadvantages compared to other popular incentive measures have been well studied in works in the USA (Li and Yi, 2014; Darghouth et al., 2016; Tan and Chow, 2016; Davies and Carley, 2017; Comello and Reichelstein, 2017). In Russia, such studies did not take place yet.

3. METHODOLOGY AND DATA

As the information base, we used data from the National Non-Profit Trade Association of Solar Energy in the United States (SEIA) and the open DSIRE database (Database of State Incentives for Renewable and Efficiency), which accumulates data on measures to support various Renewable Energy and Energy Saving technologies in the United States since 1995. In order to ensure comparability of the natural and climatic conditions for the development of PV, we selected three states for a detailed study: Pennsylvania (average annual insolation 4.0 - 5.0 kWh/m^2/day), Washington (insolation corresponds to the level of the state of Pennsylvania) and Alaska (average annual insolation 3.0 - 4.0 kWh/m^2/day).

At the first stage of the study, information was collected and presented in the form of a network diagram on the action in these states of various measures of state support for innovative energy technologies, in particular, PV in the period 2000-2019. Then, dynamic series of volumes of annual PV-panel installations in each state from 2010 to 2018 were built, as well as series reflecting the dynamics of electricity prices in each state and the general dynamics of prices for PV-modules.

At the second stage of the study, for each state, by comparing the calendar schedule and time series with the volumes of annual installations, state support measures were selected. These measures have the strongest effect on the development of PV. Hypotheses about the presence of such an effect were tested using the construction of linear regression models. Econometric methods also tested hypotheses about the influence of price factors (the price of electricity, the price of PV modules) on the volume of annual PV-panel installations.

At the final stage of the study, the constructed models of the influence of various factors on the dynamics of the development of PV were adapted to Russian conditions by recalculating price indicators and bringing them to the purchasing power index.

4. RESULTS AND DISCUSSION

4.1. Analysis of PV Development Drivers for the State of Pennsylvania

According to Solar Energy Industries Association (SEIA), a noticeable development of PV in the United States begins around

2009-2010. Prior to this period, reliable statistics on the volume of annual PV panel installations in Pennsylvania, as in other states, were not available. In Pennsylvania, the peak of PV installations in the non-residential sector falls on 2011, followed by a decrease in annual installation volumes, while in the residential sector, a similar trend is observed at first and the opposite trend since 2015. The peak of installation volumes in the residential sector is in 2017 (Figure 1).

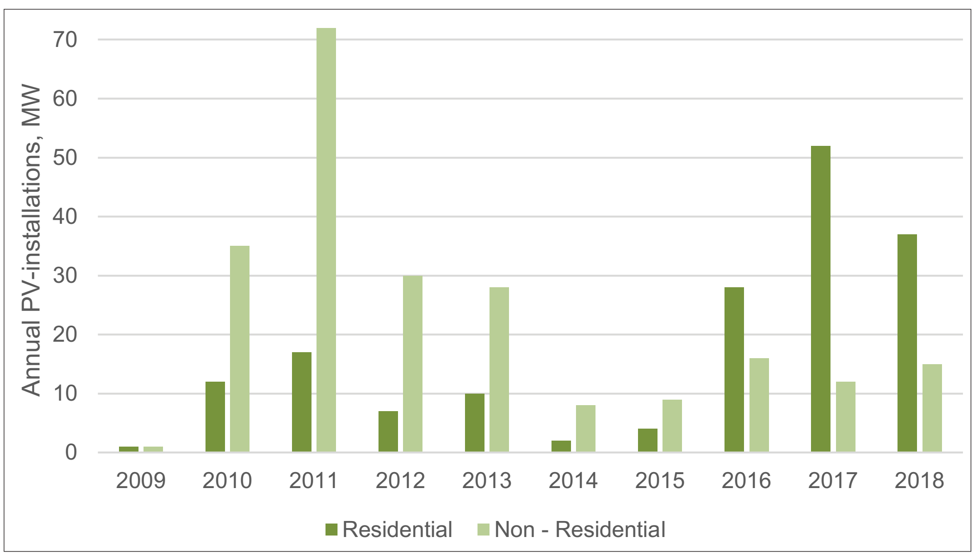
To select the government incentive measures that had the most noticeable effect on the development of PV in the state of Pennsylvania, we initially analyzed all the measures applied both at the federal level and at the state level in the period from 2000 to 2018 (Figure 2). In this case, both financial measures (grants, tax credits, benefits and deductions, loans), as well as administrative measures (requirements and norms) and technical measures (standards) were analyzed.

From a comparison of the time for the introduction of various support measures and peaks of annual installation volumes, the following most likely support measures that had the most significant impact on the development of PV can be distinguished: (1) Solar Alternative Energy Credits program; (2) SUNSHINE program.

During a detailed analysis of these programs, the Solar Alternative Energy Credits program can be singled out as the most likely candidate for the role of the main driver in the non-residential sector, in which any owner of a PV installation receives SREC certificate for 1 MW of generated electricity sold on the local certificate market "Clean energy." Prices for SREC certificates were the highest during the launch of the program and gradually decreased, which, in general terms, repeats the dynamics of annual PV-panel installations in the non-residential sector (Figure 3). The SUNSHINE program, which ran from 2009 to 2013 in the state, provided for compensation payments to owners of solar panels from the residential sector and small business after the purchase of generating equipment.

We will test the hypotheses about the influence of the considered government support measures on the development of PV in the residential and non-residential sector of Pennsylvania by

Figure 1: Dynamics of the annual volume of photovoltaics-panel installations in Pennsylvania



Source: Built by the authors according to https://www.seia.org/

Figure 2: Schedule for the introduction and implementation of state support programs, including photovoltaics (federal measures are highlighted in light green; state-level support measures are highlighted in dark green)

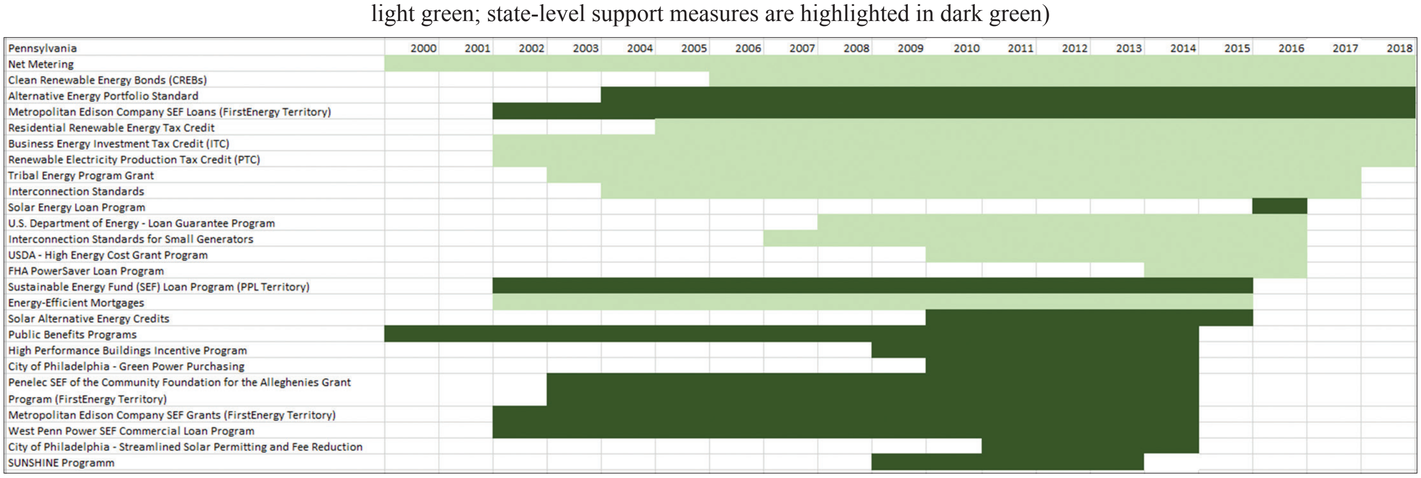
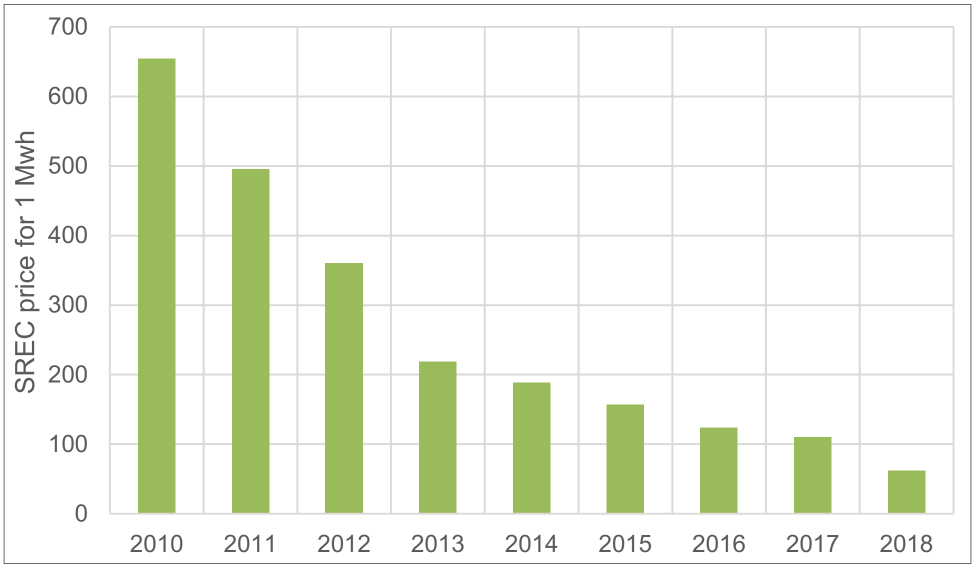


Figure 3: Dynamics of average annual prices of the SREC certificate in the state of Pennsylvania



Source: Compiled by the author according to https://www.srectrade.com/markets/rps/srec/pennsylvania

constructing linear regression models (Table 1). We will consider the volume of annual PV installations as a dependent variable (this variable is included in the model under the logarithm). As independent variables we will consider the following: (1) The price of PV modules taken with a lag of 1 year (*PV modul prices* (−1)), enters the model under the logarithm; (2) the difference between the price of 1 kWh of electricity under the SREC certificate and the regular retail price of electricity for the residential sector (*Dif_res*); (2) the ratio of the price of 1 kWh of electricity under the SREC certificate to the regular retail price of electricity for the industrial sector (*Rat_ind*) and (3) the commercial sector (*Rat_com*) in the state. To take into account the time-distributed effect of the price of the certificate on the volume of PV module installations, the ratios of *Rat_ind* and *Rat_com* prices were taken as averages over two periods. Since the variables enter the models under the logarithm, the corresponding regression coefficients are the elasticity coefficients.

The action of the SUNSHINE program is taken into account through the introduction into the model of the dummy variable SUNSHINE, which is equal to 1 in the period from 2009 to 2013 and 0 in subsequent periods.

Analyzing the results of the constructions presented in the Table 1, we can conclude that for the residential sector the price of PV modules is a significant factor: price elasticity is −5.63, the assessment of the corresponding coefficient in model 1 is significant at all levels. The coefficient for the variable *Dif_res* in model 1 has the expected sign and is significant at the 5% level. The action of the SUNSHINE program is evaluated as stimulating, although in the control of other variables, the assessment with a dummy variable is significant only at the 10% level. After the completion of this program, the volume of installations fell sharply, which is well described by model 2. The action of the SUNSHINE program in the non-residential sector can also be rated as stimulating. As can be seen from the assessment of model 3, the coefficient for the dummy variable SUNSHINE is positive and statistically significant, while the price of PV panels is insignificant for the non-residential sector.

Table 1: Dependence of the volume of annual PV installations on the price of the SREC certificate in comparison with the base price of electricity and the operation of the SUNSHINE program

	Annual PV installations				
	Residential		Non-residential		
	1	2	3	4	5
PV modul prices (−1)	−5.63***		−0.24		
Dif_res	0.07**				
Rat_com				0.90**	
Rat_ind					0.89**
SUNSHINE	1.56*	1.2***	1.37**		
Const.	7.18***	2.45***	2.64***	2.2***	1.9***
R^2	0.79	0.77	0.78	0.62	0.60
P (Fstat.)	0.04	0.002	0.01	0.01	0.01

***: 1% significance level, **: 5% significance level, *: 10% significance level

Acceptable quality also has an assessment of the dependence of the volume of installations on the ratio of the price of the certificate to the price of kW for the commercial sector and industry (models 4 and 5). The elasticity score is significant at 5% and is 0.9 for both sectors.

4.2. Analysis of PV Development Drivers for Washington State

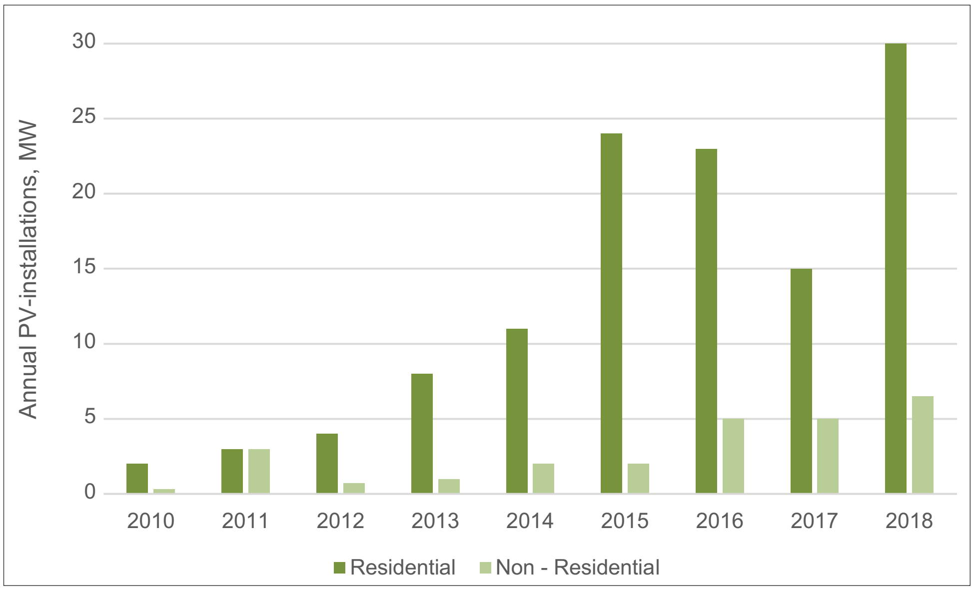
Comparing the calendar schedule for the introduction of various government incentive measures for PV in Washington state with the dynamics of annual installations in the residential and non-residential sector (Figure 4), as well as with the dynamics of electricity prices in the residential, commercial and industrial sectors (Figure 5), as the most likely factors that have a positive impact can be identified price as well as the following programs:

- Program Residential Solar Permit Requirements (launched July 1, 2014), which simplifies, and in a certain cases one

cancels, the permitting procedure to install PV-panels on the roofs and facades of houses;
- WSHFC Sustainable Energy Program (no launch year specified, however the active phase resumed in 2015), which provides loans for renewable energy projects for all sectors;
- The Energy Efficiency and Solar Grants program (2015-2017), under which grants are provided for municipalities, educational institutions, etc. for the installation of RES. Budget $ 25 million;
- Pacific Power - Blue Sky Community Project Funds program (in force since 2016), which provides grants for renewable energy projects for the non-residential sector. A feature of the program is the fact that funds are formed from voluntary deductions from consumers.

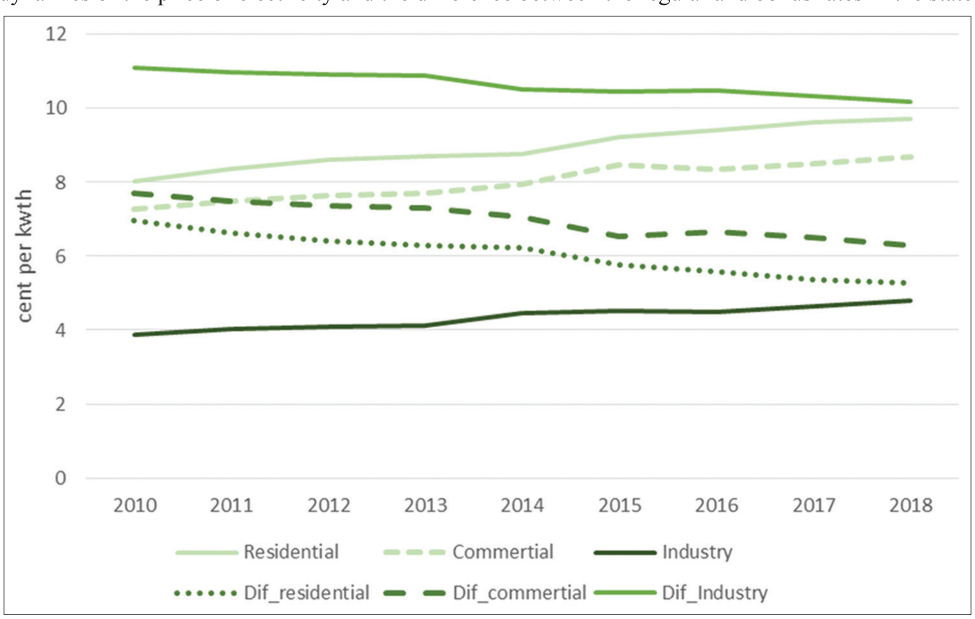
In addition, the state has a Renewable Energy Cost Recovery Incentive Payment program (in effect since August 2006), which sets bonus rates for electricity generated from a wide range of RES, including PV. The minimum bonus tariff for PV energy is stable throughout the years of the program and is equal to 15 cents/kWh, the maximum amount of payments for the bonus tariff should not exceed $ 5 thousand/year, which is equivalent to generating more than 33.3 MWh/year. When using a PV module and an inverter manufactured in Washington, a factor of 3.6 is used (2.4 and 1.2 when using only the local module or only the local inverter, respectively). However, it is not possible to quantify the effect of the increasing coefficient on the actually used size of the bonus coefficient. If we consider the difference between the real

Figure 4: Dynamics of annual photovoltaics panel installations in various sectors of the state of Washington



Source: Built by the authors according to https://www.seia.org/

Figure 5: The dynamics of the price of electricity and the difference between the regular and bonus rates in the state of Washington



Source: calculated by the authors according to Electric Power Monthly (https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a) current electricity tariff and the bonus tariff, then this difference is reduced over the study period, which most likely indicates the absence of a significant effect of bonus tariffs on the dynamics of PV installations.

When constructing regression models for the residential sector, as a dependent variable, as before, we will consider the volume of annual PV installations (the variable is included in the model under the logarithm). The results of constructing models with various independent variables are presented in Table 2. Here, the dummy variable responsible for the operation of the Residential Solar Permit Requirements program is designated as *Permit*; through *Price_residential* and *Price_residential* (−1) indicated by the price of electricity for the residential sector in the year of installation and in the previous year; *PV modul prices* (−1) - the price of PV modules in the year preceding the installation.

As can be seen from the calculation results presented in Table 2, the price elasticity of the modules decreases after the introduction of the variable responsible for the Residential Solar Permit Requirements program into the model. The introduction of this dummy variable into the model of the dependence of the installation volume on the price of electricity does not significantly change the quality of the model; the coefficient of the dummy variable has the expected sign (positive), but is statistically insignificant.

For the volume of PV installations in the residential sector, the price of electricity for the residential sector is more important than the price of panels. The *Price_residential* (−1)/*PV modul prices* (−1) ratio shows the combined influence of two price factors: an increase in the ratio of these two prices (for example, an increase in electricity prices at constant panel prices or a decrease in panel prices at constant electricity prices) stimulates use of PV.

The results of constructing models for installations in the non-residential sector with various independent variables and for different time periods are presented in Table 3.

As can be seen from the results of constructing various linear regression models, the price of modules is significant only at the 5% level. The price elasticity of electricity in both the commercial and industrial sectors is very high. The dependence on purely price factors is moderate (the determination coefficient of models 2 and 3 does not exceed 70%). However, since 2012, the relationship between the volume of installations and price factors is more clearly expressed.

4.3. Analysis of PV Development Drivers for Alaska

Comparing the timetable for the introduction of various government support measures for PV and other renewable energy technologies in Alaska with the dynamics of annual PV-module installations in the residential and non-residential sector (Figure 6), only Alternative Energy can be identified as a potential driver Conservation Loan Fund, which was launched at the end of 2013. The program is designed only for the commercial sector and involves the provision of soft loans for up to 20 years to finance renewable energy projects.

Comparing the dynamics of the development of PV with the dynamics of electricity prices for various sectors in the state (Figure 7), we can assume that price factors play the role of the main drivers in this state.

Table 2: Dependence of the volume of annual PV installations on price factors and the operation of the Residential Solar Permit Requirements program (all variables are included in the model in a logarithmic form)

	Annual PV installations Residential				
	1	2	3	4	5
PV modul prices (−1)	−1.8***			−1.44**	
Price_residential		13.8***			9.5***
Price_residential (−1)/*PV modul prices* (−1)			0.58***		
PV modul prices (−1)**Permit*				0.7*	
Permit					0.7
Const.	4.27***	−28.1***	1.81***	3.57***	−18.94**
R^2	0.76	0.87	0.82	0.87	0.91
P (Fstat.)	0.005	0.000	0.002	0.006	0.000

***: 1% significance level, **: 5% significance level, *: 10% significance level. PV: Photovoltaics

Table 3: Dependence of the volume of annual PV installations in the non-residential sector on price factors (all variables are included in the model in a logarithmic form)

	Annual PV installations – nonresidential				
	1	2	3	4	5
	2010-2018	2010-2018	2010-2018	2012-2018	2012-2018
PV modul prices (−1)	−1.4**				
Price_Industrial		11.3***			
Price_commerce			13.05***		
Price_commerce (−1)/*PV modul prices* (−1)				2.0***	
Price_industry (−1)/*PV modul prices* (−1)					1.96***
Const.	2.35***	−15.9***	−26.5***	−1.38***	−0.14
R^2	0.52	0.67	0.65	0.92	0.92
P (Fstat.)	0.04	0.007	0.008	0.000	0.000

***: 1% significance level, **: 5% significance level, *: 10% significance level. PV: Photovoltaics

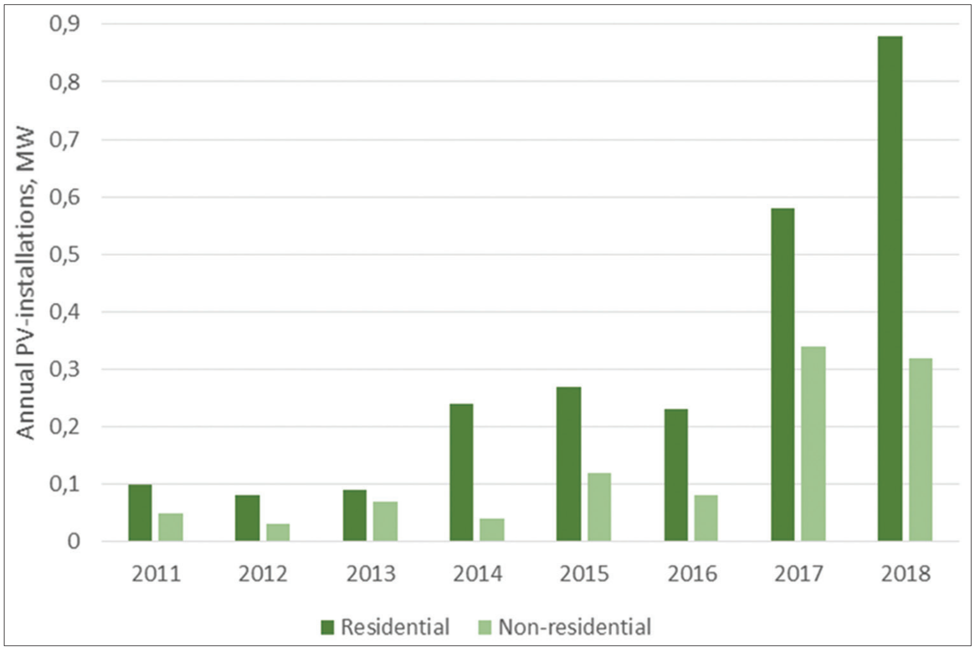
The results of constructing models with various independent variables are presented in Table 4.

The elasticity of the volume of installations at the price of the panels is negative in both the residential and non-residential sectors. In the residential sector, elasticity is very high at the price of electricity. In the non-residential sector, the price elasticity of electricity for the commercial sector is high enough, the coefficient is significant at a 5% level. However, the impact of electricity prices for industrial enterprises on the annual volume of installations in the non-residential sector is not observed. The dependence is detected only when using as a factor the ratio of the price of electricity to the price of the panel. No influence of the dummy variable reflecting the effect of the Alternative Energy Conservation Loan Fund program on the dynamics of PV installations in the non-residential sector was found.

5. POLICY APPLICATIONS

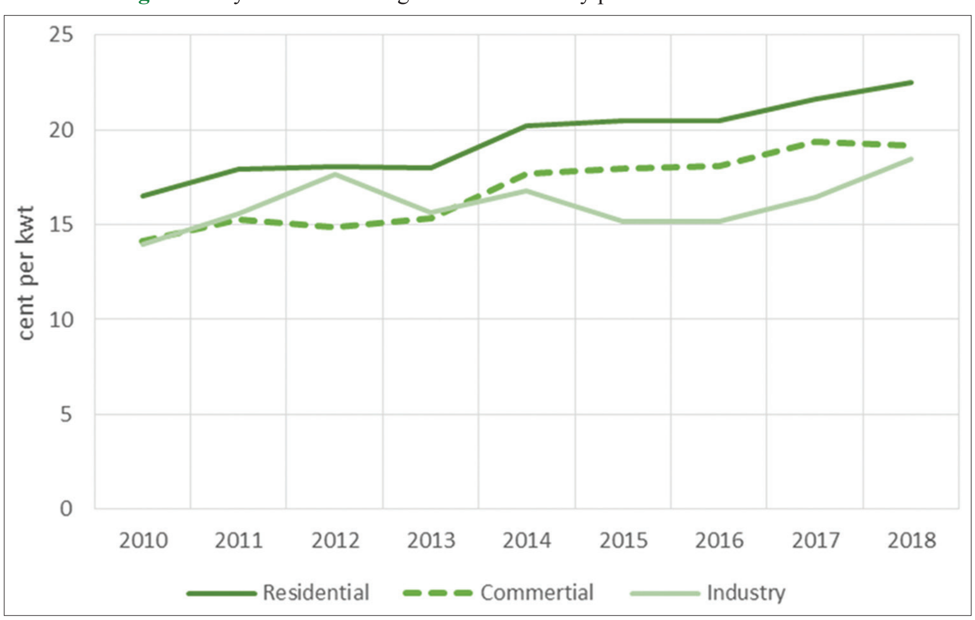
In order to apply the constructed models in solving the problem of predicting the possible dynamics of PV installations in the Russian regions, we consider the question of how Russian consumers can be sensitive to changes in electricity prices. To do this, we calculate

Figure 6: Dynamics of annual photovoltaics-panel installations in Alaska



Source: Built by the authors according to https://www.seia.org/

Figure 7: Dynamics of average annual electricity prices for various sectors in Alaska



Source: Calculated by the authors according to electric power monthly (https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a) the share of payments for electricity in the income structure of the population living in the US regions and the population of the Russian regions selected for research. The calculation results are summarized in Table 5. The calculations were made according to the statistics of 2017-2019. Per capita income data from source https://www.deptofnumbers.com/income/pennsylvania/ for the USA and the statistical yearbook "Regions of Russia. Social and Economic Indicators, 2018" (www.gks.ru). Data on electricity tariffs in Russian regions are taken from the source https://energovopros.ru/spravochnik/elektrosnabzhenie/tarify-na-elektroenergiju/, in various states of the United States - calculated as annual average values based on monthly static compilations of the US Department of Statistics and Analytics Electric Power Monthly (https://www.eia. gov/electricity/monthly/epm_table_grapher.php? t = epmt_5_6_a) The data on the average monthly electricity consumption per capita in the USA and Russia were taken from the official website of the World Bank (https://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC)

As can be seen from the data in Table 5, electricity payments on average make up about the same share in the income structure of the US and Russia, which allows us to use the obtained estimates of elasticity coefficients to predict the effects of rising electricity tariffs in Russia, at least in the residential sector. It should be noted that all the constructed models are applicable only to the case when in the country/region such basic forms of stimulating the development of PV as permitting the sale of energy produced using PV panels to the grid (Net Metering), tax benefits, income received from the sale of "green" electricity, tax breaks on property tax equipped with solar panels (or programs similar to the US Residential Renewable Energy Tax Credit program), as well as fully regulated technical procedures for connection of PV panels to the grid (programs similar to of Interconnection Standards). In the presence of such minimum institutional conditions necessary for the development of PV, a forecast of the annual installation volumes depending on the dynamics of electricity prices, prices for PV modules and some additional financial incentive measures can be carried out using the calculated values of elasticity coefficients.

As for the commercial and industrial sectors, it is difficult to make any average comparisons in this case when analyzing sensitivity to changes in price factors, since the share of electricity costs in the cost structure of commercial and industrial enterprises will vary significantly depending on the industry. Therefore, it is necessary to use the obtained values of elasticity coefficients for building forecasts with great caution, recognizing the estimates thus obtained as the first rough approximation of the predicted parameters.

When discussing the possibilities of adapting models constructed according to the US for use in Russian conditions, it is necessary to make one more important point. A study of the joint dynamics of the average per capita income in the states of Pennsylvania, Washington and Alaska and the average annual electricity prices shows that, despite the increase in prices over 2010-2019, the share of electricity payments in the structure of household income remains approximately at the same level. However, despite the fact that the increase in electricity prices was offset by rising incomes, the fact of a gradual increase in prices served as a driver for the part of the population to refuse the services of electricity generating companies and the transition to new forms of electricity generation. Projecting this conclusion on Russian conditions, it can be predicted that an increase in electricity tariffs even within

Table 4: Dependence of the volume of annual PV installations in the residential and non-residential sectors on price factors (all variables are included in the model in a logarithmic form)

	Annual PV installations						
	Residential		Non-residential				
	1	2	3	4	5	6	7
PV modul prices (−1)	−2.3***		−2.4***				
Price_residetial		9.77***					
Price_commerce				6.7**			
Price_industry					2.21		
Price_commerce (−1)/*PV modul prices* (−1)						1.89***	
Price_industry (−1)/*PV modul prices* (−1)							2.54***
Const.	0.77*	−30.7***	−0.05	−21.4***	−8.57	−5.86	−6.97***
R^2	0.904	0.96	0.86	0.62	0.03	0.86	0.92
P (Fstat.)	0.000	0.000	0.002	0.02	0.67	0.003	0.000

***: 1% significance level, **: 5% significance level, *: 10% significance level. PV: Photovoltaics

Table 5: The share of electricity payments in the income structure of the US and Russia (some regions)

Parameter	Alaska	Washington	Pennsylvania	Moscow region	Primorsky Territory	Krasnoyarsk Territory
Average monthly per capita income	$ 2851	$ 3081	$ 2725	41268 rub.	33155 rub.	28047 rub.
The price per kWh of electricity for the residential sector	22.52 cents	9.62 cents	14.33 cents	3.89-5.56 rub.	3.04-3.8 rub.	1.56-2.52 rub.
Average monthly electricity consumption per capita		1082.83 kWh			550 kWh	
Share of 100 kWh in revenue structure, %	0.79	0.31	0.53	1.35	1.14	0.89
Share of average monthly electricity consumption in revenue structure, %	8.5	3.5	5.8	7.4	6.3	4.9

Source: Author's calculations

inflation will be a driver for the development of micro-generation based on PV, provided that the basic forms of PV support have already been introduced and are in effect.

6. CONCLUSIONS

As a result of our study of the experience of stimulating PV in the United States, the main drivers of growth in the annual installation of PV panels, both in the residential and non-residential sectors, were allocated the price of electricity, the price of PV modules and some measures of financial and non-financial support related to PPP. Regression models have been constructed that describe the separate and combined effect of the drivers on the dynamics of the volume of annual new installations. Elasticity coefficients are calculated, which allow predicting how much the increase/decrease in the price of electricity or PV-modules can influence the volume of annual installations.

Analyzing the share of electricity payments in the structure of income/expenses of the population of Russia and the United States, it was proved that the constructed models are applicable to Russian conditions, but only after the introduction of the law on micro-generation and the adoption of relevant amendments to the tax code. Given the minimum institutional conditions necessary for the development of PV, the forecast of annual installation volumes depending on the dynamics of electricity prices can be carried out for such regions as Tuva, Transbaikal Territory, Amur Region, Jewish Autonomous Region, Primorsky Territory, Irkutsk Region, Republic of Sakha (Yakutia), Magadan Region, Khabarovsk Territory, Sakhalin Region, Republic of Buryatia, Altai Region, Altai Republic, Chelyabinsk Region, Orenburg Region, Samara Region, Volgograd Region t, the Astrakhan region and the Stavropol Territory based on the use of models constructed according to the states of Washington and Pennsylvania. For regions in which the development of PV has a certain history, for example, in the Orenburg region, use of models built according to the case of Pennsylvania is preferable. For regions in which the development of PV just begins, use of models built according to the state of Washington is preferable.

For the entire European part of Russia, except for the regions listed above, as well as the Tver, Novgorod, Murmansk and Arkhangelsk regions, the entire Ural Federal District and Krasnoyarsk Territory, the forecast can be carried out on the basis of models built for the state of Alaska. The development of PV in the Tver, Novgorod, Murmansk and Arkhangelsk regions in the coming years is hardly advisable due to the low level of solar insolation in these regions.

It should be noted once again that the results obtained are the first approximation of the predicted parameters of the dynamics of changes in demand for products and services of generating and network companies, and their use in practice is advisable so far only in conjunction with expert estimates. The refinement of the constructed forecast models is possible as data on the dynamics of the development of PV in the Russian regions accumulate.

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