Forecasting of Global New Investment in Renewable Energy

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Abstract. The objective of this paper is to research and forecast the global new investment in renewable energy. The classification of renewable energy was presented. Modern trends and prospects of wind power, solar energy, hydropower, bioenergy and geothermal energy are investigated in the article. Investments in developed countries and developing countries, depending on the type of renewable energy are analyzed by the authors. The model for research and forecasting of investment in renewable energy based on annual data for the period 1990-2015 years was built. In addition, authors used methods such as moving average, exponential smoothing, Holt-Winters method and different types of trends based on quarterly data for 2004-2016 years. The forecast of global new investment in renewable energy till 2025 is presented.

Keywords: Alternative energy, renewable energy, investment, "Green energy", regression analysis.

1 Introduction

XXI century considered to be the century of the environment. This means that next decades will be decisive for the natural conditions of future life on our planet. A "revolution in the energy sector" - is a project of our generation (Facts about Germany, 2015). The renewable energy is among most important themes on political arena. Renewable energy (wind energy, bioenergy, solar energy, hydropower and geothermal energy) based on inexhaustible sources is environmentally friendly and the least danger to human health; it reduces dependence on imported energy. Also it is the basis for ecologically sustainable energy in industrial countries and developing countries (Dena, 2013).

Literature Review. Pollution, global warming, climate change are commonly recognized as negative externality of power generation under fossil fuels (Hoel and Kverndokk, 1996), (Rosendahl, 1998). Renewable energy sources have been claimed to generate externalities that are more positive. The supply of energy from

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renewables are generally seen as inherently less polluting, with no significant Greenhouse gas emission during the operation. With the maximization of renewable energy production, CO_2 emissions (Moran and Sherrington, 2007) might be reduced as well as energy imports. Renewable energy generation is held to contribute mostly to energy security (Borenstein, 2012), through reduction of external dependence on foreign fuel import and debt (Vaona, 2016), and through the diversification of energy sources (Lucas et al., 2016). Renewable energy consumption highly influences economic growth (Inglesi-Lotz, 2015). It has a large potential to contribute to the sustainable development of specific territories by providing them a wide variety of socioeconomic benefits (Del Rio and Burguillo, 2009), (Bindzi Zogo Emmanuel Cedricka and Pr. Wei Long, 2017).

2 Research of global new investment in renewable energy

Global new investment in renewable energy was USD 285.9 billion in 2015 (fig. 1), as estimated by Bloomberg New Energy Finance (BNEF, 2016). This represents a 5% growth compared to the previous year and exceeds the previous record of USD 278.5 billion achieved in 2011 (REN21, 2016).

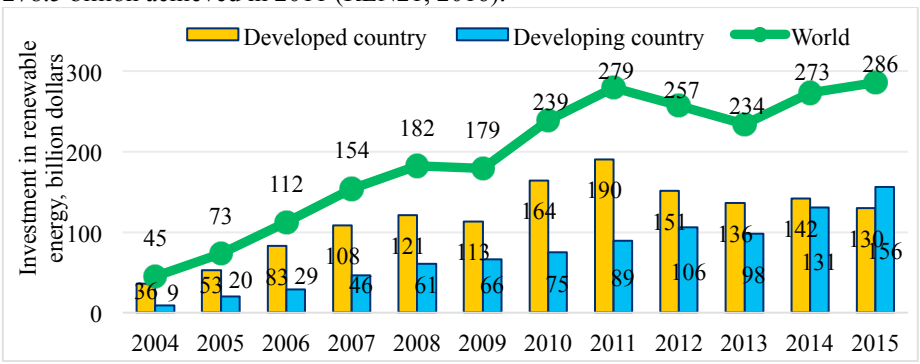

Fig. 1. Investment in clear energy in 2004-2015 (BNEF and REN21, 2016).

Reduction of investment in 2012-2013 after several years of growth was due in part to uncertainty over incentive policies in Europe and the United States, and to reductions in support in some countries. Europe's investment was down 44% from 2012, and, for the first time ever, China alone invested more in renewable energy, than all of Europe combined. The global decline also resulted from sharp reductions in technology costs. This was particularly true for solar PV, which saw record new installations in 2013, despite a 22% decline in dollars invested (REN21, 2014).

Increase in investment in 2014 was caused by the boom in solar power installations in China and Japan, totaling USD 74.9 billion, and a record USD 18.6 billion of investment for offshore wind projects in Europe. Overall, more than a quarter of new investment in renewable energy (USD 73.5 billion) went to small-scale projects in 2014 (REN21, 2015). Asset finance of utility-scale projects, such as wind farms and solar parks, was the dominant type of investment in 2015 with USD

199 billion amount. It is 6% above 2014. Small-scale solar PV installations accounted for the remainder, at USD 67.4 billion worldwide (REN21, 2016).

This growing consideration for renewable energy technologies is predominantly assigned to the un-priced side-effects of electricity generation from conventional fossil fuels through their impacts on climate, human health, crops, structures and biodiversity, which are typically expressed as externalities (El-Guindy, 2013), (Bindzi Zogo Emmanuel Cedricka and Pr. Wei Long, 2017).

A comparative study of renewable energy investments of developed versus developing countries shows that, even though in 2004, developed countries have the majority of new investments, almost four times more than the developing countries. The gap slowly closes and now developing countries almost matched the investment of developed countries (Voica et al., 2015).

For the first time in history, in 2015 total investment in renewables in developing countries exceeded the same figure in developed economies. The developing world, including China, India and Brazil, committed a total of USD 156 billion, up 19% compared to 2014. China played a dominant role in this turnaround, increasing investment by 17% to USD 102.9 billion. It is 36% of the global total. In 2015, renewable energy investments also increased significantly in India, South Africa, Mexico and Chile. Other developing countries, including Morocco, Uruguay, the Philippines, Pakistan and Honduras, invested more than USD 500 million in 2015.

By contrast, investments in renewables in developed countries declined by 8% in 2015, to USD 130 billion. The most significant decrease in investment was seen in Europe, down 21% to USD 48.8 billion, despite its record year financing offshore wind (USD 17 billion, up 11% from 2014). In the United States, investment increased by 19% to USD 44.1 billion. It was the country's largest increase since 2011.

The shift in renewable energy investment from developed to developing economies is not surprising, as the latter ones have rapidly rising electricity demand and the need in the most additional power generation capacity (REN21, 2016). Developed countries did a lot of research and development in this field and as the costs of renewable energy capacities tend to get cheaper and therefore accessible to lower income countries. Another conclusion might be that the financial crisis had a bigger impact on developed countries than developing ones as it is seen in the period 2008-2010 (Voica et al., 2015).

Trends in renewable energy investment varied by region in 2015, with increased investments in China, India, Africa and the Middle East, and the United States, and decreased investments in Canada and Europe. In 2015, the top 10 national investors consisted of six developing countries and four developed countries: China (USD 102.9 billion), the United States (USD 44.1 billion), Japan (USD 36.2 billion), the United Kingdom (USD 22.2 billion), India (USD 10.2 billion), Germany (USD 8.5 billion), Brazil (USD 7.1 billion), South Africa (USD 6.5 billion), Mexico (USD 3.9 billion) and Chile (USD 3.4 billion).

Investment by technology. In 2015, solar power was the leading sector with the amount of USD 161 billion (up 12%), or more than 56% of total new investment in renewable energy. Wind power followed with USD 109.6 billion, or 38.3% of the total (up 4%). The remaining 5.7% was made up of biomass and waste-to-energy power (USD 6 billion), biofuels (USD 3.1 billion), small-scale hydropower (USD 3.9

billion), geothermal power (USD 2 billion) and ocean energy (USD 215 million). Other technologies faced investment decline comparing to 2014: geothermal was down by 23%, ocean by 42%, biofuels by 35%, biomass and waste-to-energy by 42% and small-scale hydropower by 29%.

Until 2014, developed countries (namely Germany, Italy and Japan) were dominant investors in small-scale solar power. In 2015, China, India, Chile, South Africa and other developing countries ramped up deployment of both utility-and small-scale investment in solar PV, and to some extent CSP, closing the gap to less than USD 1 billion; solar power investment in developed countries was USD 80.8 billion, compared to USD 80.2 billion in developing economies. A similar trend has been seen with wind power. In 2015, developing countries invested USD 67.4 billion in wind power, while developed countries invested only USD 42.2 billion.

Large-scale hydropower (projects greater than 50 MW in size) was the third most important sector for renewable energy investment in 2015 (after solar and wind power). BNEF estimates that asset financing for large-scale hydropower projects reaching financial go-ahead in 2015totaled at least USD 43 billion (REN21, 2016).

Different financial actors contribute to varying technology directions: some have balanced portfolios, while others have strongly directed ones toward particular technologies, where particular actors may have a disproportionate influence on a technology's deployment. Actors also differ in their risk direction towards high or low-risk technologies, with private ones favoring low risk much more than public ones, and individual high-risk technologies pushed mainly by just two or three financial actors (Mazzucato and Semieniuk, 2016).

«Green energy» and fossil fuel. In 2015, global investment in new renewable power capacity, at USD 285.9 billion, was twice higher comparing to the USD130 billion allocated to new coal- and natural gas-fired generation capacity. This represents the largest difference in favour of renewables to date (REN21, 2016).This trend is forecast to continue for the rest of this decade (Word Energy Outlook Special Report, 2015), (Mazzucato and Semieniuk, 2016).

3 Construction of econometric models for forecasting of global new investment in renewable energy

To investigate the dynamics of investment in "green energy", annual data for the period from 1990 to 2015 was selected. Here are the main indicators (factors that can influence the investment): global GDP, population, CO_2 emissions, electricity consumption per capita. Optimal regression is (Table 1):

*Investment = 28636.48 – 918.73*ln(CO_2) + 228.18*ln(GDP) + 0.72*energy - - 966.51*ln(Population).*

The model is adequate (p-value = < 2.2e-16 <0.05), all regression's coefficients are significant (Pr (> | t |) <0.05) with the level of reliability of 95%. The coefficient of determination R^2 = 0,97, which indicates the close links between the factors and modeled indicator. To test the effectiveness of the model, authors built forecast for 2016 year with an error RMSPE, which is 9.3%.

Table 1. Regression lm(Investment~log(CO_2)+log(GDP)+log(Population)+energy), that was built on data from BNEF and World Bank at program RStudio Desktop

Coefficients	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	28636.4792	5665.3723	5.821	8.89e-06
log(CO_2)	-918.7265	352.3050	-2.937	0.0079
log(GDP)	228.1770	85.8766	2.975	0.0072
log(Population)	-966.5102	183.9643	-5.391	2.39e-05
energy	0.7212	0.1265	5.700	1.17e-05
Multiple R-squared:	0.9747	Adjusted R-squared:		0.9699
F-statistic:	202.6 on 4 and 21 DF	p-value:		< 2.2e-16

However, the model is characterized by heteroscedasticity and autocorrelation. After the usage of the method of weighted least squares, the following model was built: *InvestmentW = 27872.94*x0 + 193.69*logGDPW - 1069.36*logCO2W + 0.78*energyW - 777.11*logPopulationW*. To test the effectiveness of the model, authors built forecast for 2016 year with an error RMSPE, which is 12%.

The usage of the method of generalized least squares did not help get rid of autocorrelation, because there is higher-order autocorrelation (the criterion of Broysha-Godfrey with reliability level of 95% show, that exists autocorrelation of fifth order).

To check the seasonality, authors use quarterly data of renewable energy investments in the period 2004-2016 years and construct regression: *Investment* = $=b_0+b_1t+b_2S_1+b_3S_2+b_4S_3$, where t - the trend; S_1, S_2, S_3 - dummies for the 1st, 2nd and 3rd quarters, respectively. The fourth quarter is considered as basic.

Assessing this regression, using the method of least squares and checking the hypothesis about the significance of factors, following model was built: $Investment=19.30+1.19*t–8.47*S_1+4.83*S_2–3.81*S_3$, in which significant coefficients are only b_0, b_1, and b_2, that is showing the relationship between the volume of investment in "clean" energy, trend and a dummy variable for the first quarter. Investments in the first quarter always decrease, as indicated by a negative factor.

Usage of the moving average, exponential smoothing, and Holt-Winters method for investigate of investments in "green energy" allows you to get forecasts in which the error RMSPE ranges from 5% to 15%. Among all available trends the most accurate forecast can be obtained by constructing logarithmic trend (*y=20,7*ln(x)-13,4*), in which error RMSPE is about 17.6%.

Using of neural networks for investigate of investments in "green energy" allows you to get forecasts in which the error RMSPE is 9.2%. Errors are small and this information system for forecasting (regression model, neural network and other methods) can be used to predict the future dynamics of investment in "clean energy" (fig. 2).

The growing importance of renewable energy in addressing climate change and improving energy security will boost renewable energy investment growth in the coming years. The analysts predict the global renewable energy investment market to exceed USD 320-350 billion by 2020.

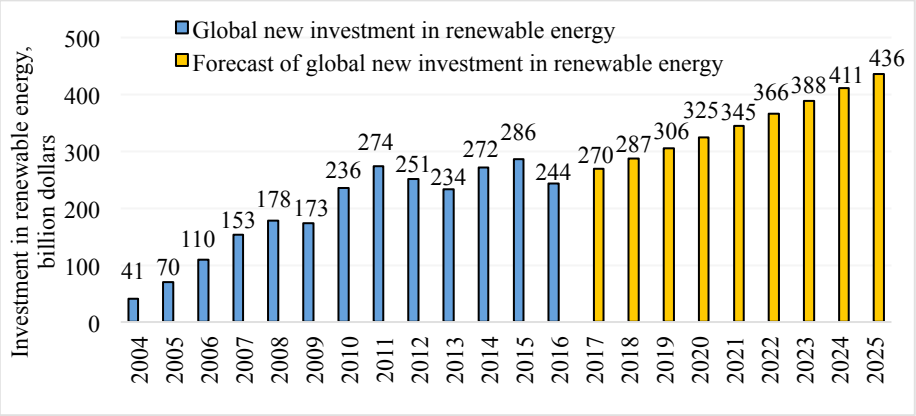

Fig. 2. Forecast of global new investment in renewable energy.

4 Conclusion

Calculation of experts of climate change estimates that investments in water, agriculture, telecoms, power, transport, buildings, and forestry should reach 5 trillion USD per year to 2020, to achieve a sustainable growth. This effort cannot be made from public resources; therefore, more attention must be steered in attracting private finance, by creating suitable policy for it. There are additional incremental investments needs of 0.7 trillion USD per year, for clean energy infrastructure, low-carbon transport, energy efficiency and forestry, to limit the global average temperature increase by 2°C above preindustrial levels (The Green Investment Report, 2013), (Voica et al., 2015).

Built econometric models can be used to predict the future dynamics of investment in renewable energy.

Renewable energy sources are set to represent almost three quarters of the $10.2 trillion the world will invest in new power generating technology until 2040, thanks to rapidly falling costs for solar and wind power, and a growing role for batteries, including electric vehicle batteries, in balancing supply and demand.

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