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The Forecast of the World Renewable Energy Development till 2020

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Abstract

There are quite a lot of forecasts of renewable energy development in whole and its different kinds. The principal forecasts are developed by IEA, BP, IRENA, EWEA, WWEA, ISEA and some other institutions. Many of forecasts prefer a remote prospect – years 2030, 2035, and 2050. Probably it is assumed that the forecast for 2020 will be achievable with great probability. However, famous programs experience of "Wind Force-10" and "Wind Force-12" in which the problem of achieving a wind power share in the world overall electricity production by 2020, respectively 10% and 12%, was set, means that such forecast is too optimistic as already now it is clear that these results are unachievable. On the other hand, IEA forecasts concerning renewable energy share in 2020 in world electricity production are considered to be too pessimistic. The realization of the forecast offered by the authors seems to be the most probable.

Keywords: *forecast, program, renewable energy sources, electricity production*

1. Introduction

The main goal of the paper is to define the share of renewable energy sources in the world overall electricity production in 2020. For this purpose it is necessary to define the following by the end of 2020: the general electricity production in the world; the installed capacity of power plants on the basis of different kinds of renewable energy sources and the produced electric power; growth rates of installed capacity of various renewable energy plants. The forecasting procedure combines the analysis of the growth rates of capacity and energy for the previous period with the research of installed capacity utilization factor of power plants based on different kinds, taking into account forecasts of growth of use of different kinds of renewable energy sources.

2. Analysis of forecasts for renewable energy utilization

According to REN-21 data concerning the installed capacity of wind, PV, biomass and geothermal power plants during the period of 2004-2014 the average annual growth rate is calculated for the whole period and in 2014 in relation to 2013 [1].

According to IEA statistics on electricity production by renewable energy power plants and data of REN-21 on installed capacity the installed capacity utilization factors for the above power plants are calculated.

Ehe installed capacity utilization factors aor wind power for 24 countries for the period of 2000-2013 were determined. On the basis of the obtained data analysis the growth rates of installed capacity and electricity production for 2015-2020 according to three scenarios of overall electricity production were justified.

According to scenarios offered by the authors the share of renewable energy by 2020 will be: minimum – 9.3%; average – 11.2%; maximum – 13.4%.

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According to IEA (2011) the share of renewable energy will be: "New Policies Scenario" – 8.4%; "Current Policies Scenario" – 7.2%; "450 Scenario" – 10.1%.

The forecasts discrepancy is quite considerable. Below are the reasons for the optimistic forecast.

According to the optimistic forecast of wind power development made in 1997 by "Wind Force-10" program the purpose was to achieve a share of 10% of wind energy of general electricity production by 2020 (Table 1). We monitored the forecast realization within more than 10 years and the obtained result is contradictory. Until 2010 the forecast of the wind energy installed capacity was overfulfilled. But as for the energy share produced at these stations significant underrun was observed. Obviously, the installed capacity utilization factor (ICUF) was taken into account not exactly. The forecast did not indicate the data for 2011 – 2014, but the ICUF in 2015 (433 GW) shows that in 2015 the forecast indicator for the capacity (573 GW) was not fulfilled. It can be stated that the forecast of annual rate and capacity utilization factor was unnecessarily optimistic.

Tab. 1: Wind Force-10 Program (The source: «Wind Force 10» Program, *EWEA, *WWEA. Developers: EWEA, Denmark Energy and Development Forum, International Greenpeace, 1998)

Years	Annual growth, %	Annual capacity, MW	Total installed capacity by the end of the year, MW		Annual electricity production at wind power station, TWh		Annual electric energy consumption in the world, TWh		Share of wind power, %	
	Forecast	Actual	Forecast	Actual *	Forecast	Actual	Forecast	Actual	Forecast	Actual
1999	20	3120	13273	13520	29.1		14919	14764	0,19	
2000	20	3744	17017	18449	37.3	31.3	15381	15379	0,24	
2001	20	4493	21510	23794	47.1		15858	15476	0,30	
2002	20	5391	26901	30278	58.9		16350		0,36	
2003	20	6470	33371	39357	73.1		16857	16661	0,43	
2004	30	8411	41781	46880	91.5		17379	17450	0,53	
2005	30	10939	52715	59084	115.4	103.8	17918	18235	0,64	0,54
2006	30	14214	66929	74223	146.6	124.9	18474	18930	0,79	0,66
2007	30	18478	85407	94123	187.0	173.3	19046	19854	0,98	0,87
2008	30	24021	109428	121188	268.4	266	19937		1,37	
2009	30	31228	140656	157899	245.0		20245		1,70	
2010	30	40596	181252	196692	444.6	341	20873	21559	2,13	1,6
2014				370000						
2015	20	94304	537059	433000	1333.8		23894		5,58	
2020	10	150000	1209466		2966.6		27351		10,86	
2030	10	150000	2545232		6242.9		33178		18,82	
2040	10	150000	3017017		7928.7		38509		20,60	

In 2011 the International Energy Agency released the forecast for electrical energy production in the world, including renewable energy, until 2030 according to 3 scenarios. Table 2 shows the forecast data for 2020.

"New Policies Scenario" – is the central scenario combining a wide range of political obligations and plans of countries all over the world in the field of energy security, climate changes, environmental conservation, etc.

"Current Policies Scenario" – development with conservation, without changing the existing policy including obligations and plans.

"450 Scenario" provides aggressive schedule of actions necessary for limiting long-term increase of greenhouse gases concentration in the earth atmosphere up to 450 ppm of CO_2 equivalent.

Tab. 2: International Energy Agency scenarios, 2011

	Actual data				"New Policies Scenario"		"Current Policies Scenario"		"450 Scenario"	
	1990		2009		2020		2020		2020	
	bln. kWh	%	bln. kWh	%	bln. kWh	%	bln. kWh	%	bln. kWh	%
Fossil fuels	7490	63.4	13445	67.1	17593	63.1	18757	65.7	15835	59.0
Nuclear power	2013	17.0	2697	13.5	3576	12.8	3495	12.2	3741	13.9
Hydropower	2144	18.1	3252	16.2	4380	15.7	4254	14.9	4547	16.9
Renewable energy	173	1.5	650	3.2	2332	8.4	2063	7.2	2712	10.1
Renewable energy, including hydropower	2317	19.6	3902	19.5	6712	24.1	6317	22.1	7259	27.1
Whole world	11819	100.0	20043	100.0	27881	100.0	28569	100.0	26835	100.0

According to the scenarios the electric energy production in 2020 is to be 27881 – 28569 – 26835 bln. kWh, the share of renewable energy: 8.4 – 7.2 – 10.1%, accordingly.

This forecast is unduly pessimistic as it contradicts the actual status of the world energy balance. According to REN 21.2016 the share of organic fuel in the energy balance for electric energy production is 59.3%, nuclear power stations - 17% (total – 76.3%), renewables – 23.7%. The share of hydropower plants is 16.4%, "new" renewable energy power stations – 7.3%, including wind power stations - – 3.7%, biofuel power plants – 2.0%, PV power plants – 1.2%, the rest renewables – 0.4%.

The question is: what renewable energy share in the electric energy production is the most obvious?

To answer this question it is necessary to give proof of the electric energy production forecast in the world and also the forecast of growth of capacity utilization factor and electric energy production on the basis of some renewable energy sources.

3. Main results

The forecast of the word electric energy production for 2020 was made on the basis of the analysis of growth rates of electric energy production for the period of 1995 – 2014 (Table 3) taking into account a general slowdown in global economic growth. The average annual growth rate for the period of 1995 – 2014 was 3.07%; for the period of 2004-2014 – 3.0%; 2012-2014 – 2.0%, 2014 in relation to 2013 – 1.52%.

Taking into account the above data three scenarios have been accepted:

a) "Hardly probable" with the growth rate of 3.0%;

b) "Possible" with the growth rate of 2.6%;

c) "Probable" with the growth rate of 2.0%.

The comparison of the forecasts of the International Energy Agency (IEA) and Power Engineering Institute (PEI), Russia, shows high matching degree of the data for electric energy production for 2020 with the only difference that the "Probable scenario" (c) of PEI coincides with the least probable "450 Scenario" of IEA (Table 4).

To estimate the growth rate of the electric energy production on the basis of some renewable energy sources the data of REN21 (Renewable Energy Policy Network for the 21st Century) for 2016, 2015 and 2014 was used. Table 5 shows the growth rate of the installed capacity for the period 2004 – 2014, (2004 ÷ 2015) and in 2014 in relation to 2013, in 2015 in relation to 2014 for all renewable energy sources [1].

Tab. 3: World electric energy production, TWh (Source: BP Statistical Review of World Energy Workbook)

1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
13258.3	13686.9	14010.6	14360.3	14776.9	15409.0	15641.1	16191.6	16787.7	17573.3
2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
18333.8	19032.4	19926.9	20308.6	20131.7	21425.5	22100.6	22630.4	23184.0	23536.5

Tab. 4: Forecasts of the world electric energy production, TWh

IEA		PEI		Forecasts discrepancy, %
"New Policies Scenario"	27881	Possible	27866 (b)	0.05
"Current Policies Scenario"	28569	Hardly probable	28656 (a)	0.3
"450 Scenario"	26535	Probable	26764 (c)	0.8

Tab. 5: The dynamics of the world renewable energy characteristics

Characteristic	**Annual values**			**Annual average growth rate for 2004-2014/ 2004-2015, %**	**Increase in 2014 to 2013/ in 2015 to 2014, %**
	2004	**2014**	**2015**		
New annual investments, bln. USD	45	273	285.9	19.62/18.34	16.37/4.7
Renewable energy capacity (without hydropower stations), GW	85	665	785	22.7/22.39	17.32/18.04
Renewable energy capacity (with hydropower stations), GW	800	1701	1849	7.9/7.9	8.49/8.7
Hydropower capacity (hydropower stations), GW	715	1036	1064	3.7/3.7	3.63/2.7
Biomass capacity, GW	<36	101	106	9.95/10.31	5.68/4.95
Biomass electric energy production, TWh	227	429	464	6.67/6.71	9.34/8.16
Geothermal stations capacity, GW	8.9	12.9	13.2	3.7/3.5	5.78/2.32
PV stations capacity, GW	2.6	177	227	52.5/50.1	28.26/28.25
Thermodynamic PV stations capacity, GW	0.4	4.3	4.8	27.1/25.34	29.41/11.63
Wind power stations capacity, GW	48	370	433	22.65/22.13	15.99/17.03
PV heat water systems capacity, GW (heat)	86	409	435	16.79/15.88	8.85/6.36
Ethanol annual production, bln. l	28.5	94.5	98.3	12.67/11.91	7.06/4.02
Biodiesel annual production, bln. l	2,4	30.4	30.1	28.6/24.85	12.93/-1.0
Number of countries with specified goals for renewables	48	164	173	13.07/12.52	13.89/5.49

Taking into account that with the increase of installed capacity the annual average growth rate inevitably slows down and considering the growth rates slowing down in 2014, for the forecasts for 2015 and 2020 quite moderate growth rates have been accepted.

To determine the electric energy production it was necessary to define the installed capacity utilization factor (ICUF) for all renewable energy sources.

According to the analysis the most complicated thing is to determine the ICUF for wind power stations. The calculations of ICUF of wind power stations on installed capacity of first 24 countries for the period of 2000-2013 (2012) according to World Wind Energy Association (WWEA) data on installed capacity of IEA have

been made. On the basis of this data the ICUF of a wind power station was accepted to be equal to 0.25; for a PV station – 0.12-0.13; for a geothermal station – 0.75.

Table 6 shows the forecast of ICUF and electric energy produced by renewable energy sources by 2015. This forecast was made in 2013 and the degree of its matching with the reality turned out to be quite high (In brackets the actual capacity in 2015 is indicated.)

Tab. 6: Forecast for renewable energy sources development for 2015

Power station type	2010 (actual)			2015 (forecast)		
	Capacity, GW	ICUF	Electric energy production, TWh	Capacity, GW	ICUF	Electric energy production, TWh
Wind power stations	198	0.197	341	429 (433)	0.25	939
PV stations	40	0.12	42	230 (227)	0.12	242
Solar thermal power stations	1.1	0.15	1,4	5 (4.8)	0.15	6.5
Biomass power stations	64.9	0.55	313	98 (106)	0.53	456
Geothermal stations	11	0.75	72.3	13.5 (13.2)	0.75	88.5
Total	315		769.7	775.5 (785)		1728

Tab. 7: Forecast of the world renewable energy development until 2020 (without hydropower stations)

Power station type	2020			
	Annual average growth,%, 2020/2015	Capacity, GW	ICUF	Electric energy production, TWh
Wind power stations	10	690	0.25	1511
	13	790		1730
	15	863		1890
PV stations	15	462	0.13	526
	20	572		651
	25	702		799
Solar thermal power stations	10	8	0.15	10,5
	12	8,8		11,5
	15	10		13
Biomass power stations	3	113	0.53	524
	5	125		580
	10	158		733
Geothermal stations	3	16	0.75	105
	5	17		112
	10	22		144
Total		1289		2676
		1513		3084
		1755		3579

The forecast for electric energy production on the basis of renewable energy sources is shown for three values of annual average growth rate. For each renewable energy source the accepted growth rates were considerably lower than in 2014 (Table 7).

The estimation of renewable energy share with three options of development forecasts of electric energy production by all power stations and three options of electric energy production by renewable energy stations becomes a multiple-option task.

The estimation of renewable energy share according to the average values has been made. The average value of the world energy production according to three options is equal to 27768 TWh. The average value of the renewable energy production according to three options is equal to 3113 TWh. Therefore, the renewable energy share in the total electric energy production (without hydropower stations) will be 11.2 %.

Maximum renewable energy share corresponds to the largest value of renewable energy production (3579 TWh) and to the minimum value of the total electric energy production (26764 TWh) and is equal to 13.4%.

The minimum renewable energy value corresponds to the inverse ratio, 2676 TWh and 28656 TWh, respectively, and is equal to 9.3%.

The wind energy share in the total electric energy production is: 5.3 % (minimum), 6.1 % (average) and 7% (maximum). Table 8 provides the comparison with the IEA forecast.

Tab.8: Renewable energy share in the world total electric energy production in 2020 (in brackets – the wind share forecast)

	Minimum, %	Average, %	Maximum, %
PEI	9.3 (5.3)	11.2 (6.1)	13.4 (7.0)
IEA	7.2	8.4	10.1

4. Discussion

The present paper considers the renewable energy development in the near future. This process is affected by many different factors. The research confirms that in spite of obstacles the renewable energy will develop with the rates exceeding the growth rates of the world economy and traditional energy.

The significance of the performed investigation is determined by the role the renewable energy will play in the world policy and economy. This role is defined by the following factors:

- possibility to provide energy independence or considerable decrease of fuel import dependence;
- possibility (for developed countries) to win the market of high-technology equipment, to provide the diversification activity of a country industrial complex;
- inexhaustibility of renewable energy sources and impossibility of their privatization or capture by other countries (unlike oil or gas fields);
- ecological cleanness.

5. Conclusion

The average annual growth rate of installed capacity of wind, PV and other renewable energy power stations as compared with the previous year is determined. For the period of 2015-2020 the growth rates will be: for wind power stations – 13-15%, PV stations – 15-25 %, biofuel power stations – 3-10%, geothermal power stations – 3-10 %.

For all types of renewable energy power plants the installed capacity utilization factors are defined. The coefficient for the weighted average value of wind power stations will amount to 0.25, PV stations – 0.13, biofuel power stations – 0.53, geothermal power stations – 0.75.

The forecast of installed capacity and produced electricity for 2015 and 2020 for all main renewable energy power stations is made.

It is shown that overall installed capacity of renewable energy power stations in the world will be about 1500 GW, including wind, PV and biomass power stations, respectively, 800 GW, 570 GW and 125 GW.

By 2020 the electricity production at renewable energy power stations will be approximately 3000 TWh.

6. References

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