RESEARCH PAPER | Engineering | Volume : 4 | Issue : 4 | Apr 2014 | ISSN - 2249-555X

Participation of Decentralized Energy Sources in The Energy Balance

KEYWORDS: Smart Grid, renewable energy sources, energy mix

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ABSTRACT *The article summarizes the information for already built and available capacity in the power system in Bulgaria and considers the construction of wind farms, photovoltaic systems in the energy mix from renewable energy sources and energy savings by introducing Smart Grid by 2020.*

The paper provides an answer to the questions: 1) to what extent renewable energy can participate in the energy balance by 2020 and 2) what decrease in electricity can be expected from the introduction of appliances and technologies for Smart Grid in the domestic sector.

Introduction:
The main energy sources for electricity generation in Bulgaria come from nuclear energy, fossil fuels, hydro, wind and solar power. In recent years, decentralized sources (DG) of electricity have been exploited, built on the basis of renewable energy sources (RES), using a mix of renewable energy, Smart Grid and others.

The aim in this article is to answer the question "what are the trends for building DG by 2020 and how the introduction of resources for Smart Grid affects the energy balance.

Energy situation in Bulgaria
National energy policy is focused on several interrelated priority areas:

- Energy efficiency;
- Improvement of the structure of energy resources - domestic gasification and reduction of the amount of electricity used for heating;
- Reduction of energy dependence and diversification of the import of energy resources;
- Environmental policy.

The comparative analysis in the field of energy is carried out by sustainable development indicators developed by international institutions like International Energy Agency IEA, International Atomic Energy Agency IAEA and others: Gross domestic product (GDP), energy production and consumption, energy intensity (energy consumed production per unit of GDP), energy dependence (Notov and Nedeltcheva, 2009). Analysis of sustainable development indicators show the following (Nedeltcheva and Chobanov, 2013):

- After 2009, GDP increased slightly: 0.4% in 2010, 1.7% in 2011 and 0.1% in 2012;
- Energy intensity in Bulgaria is higher than the average in the European Union;
- Electricity consumption in the country increases by an average of 2-3% per year;
- Bulgaria is one of the most energy-dependent countries in Europe on imported resources (74 %).

Energy balance of the energy resources in Bulgaria. The structure of primary energy generation in recent years has almost no any variability, with dynamics, arising in the process of consumption: 44% - coal, 41% - nuclear energy, 15% - biomass, natural gas, renewable energy. For the generating sources in the energy system can be concluded the following:

- It is expected that the installed capacity of thermal power plants (TPP) in 2020 is 5388 MW.
- The power, by which the heating power plants will participate in the energy balance in 2020 is 647 MW, and the industrial - about 250-300 MW.
- The installed capacity of the hydro power plants (HPP) using seasonal, annual and perennial equalizers in 2012 was 2803 MW, while the one of hydropower and pumped storage hydropower (PSPS) is 2563 MW
- In 2012, 607 MW of wind power and 254 MW - from photovoltaic plants (PPP) are commissioned. The construction of 2113 MW of wind power and 1599 MW of photovoltaic power plants is in the pipeline (Andonov A. and J. Bakardjieva);
- To achieve the goals of electricity generation from renewables by 2020, capacities up to 5189 MW are necessary, by which to ensure the electricity generation of 7604 GWh, distributed as follows: from hydro power plants - 63% , from wind power plants - 28% , from PVPP - 6% and from biomass - 3,% (Nedeltcheva and Chobanov, 2013).

Smart Grid Implementation
The advantages of constructing a Smart Grid are related to improving the reliability of electricity supply and savings of electricity resources. The introduction of means of Smart Grid in the residential sector is considered one of the means of saving electricity. If a household implements Smart Metering and automation to switch on some electrical appliances outside the hours of the evening peak of the load pattern or at night, it is expected to reduce its electrical load by 15%. Global companies produce tools for automation of Smart Grid. Despite the increase of investments of commercial companies in Smart Metering, the consumers are hardly aware of the Smart Grid technology. The information about the benefits of Smart Grid is still scarce for the Bulgarian consumers.

Energy Distribution Companies in Bulgaria are private companies and are not interested in any awareness activities promoting energy efficiency measurements for their clients. The peculiarities of Bulgaria at „shrinking" electricity consumption in the residential sector and the lack of consumer awareness about the benefits of Smart Grid, are indicators that not all customers would install in their homes "smart" appliances. Due to the introduction of Smart Grid, the entire household sector is expected to reduce electricity consumption in the residential sector by no more than 2-3% in the next 6-7 years.

Following the global trends in energy, Smart Grid technology will gradually enter the residential sector, but during the next

Volume : 4 | Issue : 4 | Apr 2014 | ISSN - 2249-555X

6-7 years, it can be expected the electrical load to reduce by no more than 2-3%.

Development perspectives of renewable energy sources
According to the National Plan for renewable energy, the required capacity of RES should be 5189 MW in 2020, i.e. about 63% coming from hydro power plants. This means that the installed power of the HPP should reach 3269 MW, i.e. over the next seven years 706 MW of new hydropower facilities have to be built. Given that the water potential of most major rivers has long been utilized by the already built cascades of hydropower and pumped stations, by the constructed large number of small hydropower plants with capacity up to 5 MW and the restrictive regime for constructing small hydropower plants in the protected areas "Nature 2000" (covering 60% of the rivers in the country), one can question the construction of new power capacity of 706 MW hydropower by 2020.

According to the target set in the National Plan for renewable energy sources, 28% of the necessary capacity of 5189 MW must come from wind power. This means an installed capacity of 1453 MW of wind power by 2020. The available power from wind farms is significantly lower for the following reasons:

- 20% of the wind power plants in Bulgaria operate at about 25% of their installed power;
- 40% of the wind power plants operate at approximately 17% of their installed power;
- 40% of the wind power plants operate with very small annual utilization hours and reach only 5-7% of their installed power.

Therefore, the approximate size of the available power from wind is about 207 MW at capacity of 1453 MW, i.e. about 14%. In Britain, this value is about 25%, Germany - 17%, in Denmark - 19% (Rosenbloom, 2006). The more the country depends on wind energy, the more it is confronted with two major technical problems:

- It is more difficult to maintain a constant power supply for the consumers due to the fluctuations in the incoming power from wind farms;
- It is necessary to keep replacement capacities with size equal to the available power from the wind farms that work very inefficiently in most of the time.

The constructed capacities from PVPP are 607 MW in 2012. Additional 1599 MW remain to be constructed. The total installed capacity of photovoltaic power plants will be 1853 MW. The average annual generation of electricity from photovoltaic power plants depends on the weather and climate factors. The average value of solar radiation in Bulgaria and the average utilization hours, suggest the available capacity of the installed 1853 MW to be around 960 MW.

The combination of the different renewables gives an „energy mix" of available capacity of over 2000 MW. However, the problem in Bulgaria is that when there is no production from photovoltaic power plants at night or from wind farms when there is no wind, there are no other alternative renewable resources to cover the load.

The energy from wind and photovoltaic power plants is intermittent and is not reliable to form the major part of the load curve.

Results:
- Smart Grid technologies will gradually enter the residential sector, but over the next 6-7 years they may cause a reduction of the electrical load up to 2-3%.
- The water potential of more of the large rivers in Bulgaria is utilized with powerful cascades of HPP and a large number of small hydropower plants with capacity up to 5 MW. The absorbed potential of the large rivers and the introduction of restrictive or prohibitory regime for the construction of small hydropower plants in protected areas like „Natura 2000" casts doubt on the possibility of building new capacity of 706 MW of hydroelectric power by 2020.
- The estimated available power from the constructing wind power plants is about 1200 MW when developed capacity is 5189 MW.
- The estimated size of the available power from photovoltaic power plant is about 960 MW when developed capacity is 1853 MW.
- Energy mix with a capacity of over 2000 MW can be constructed from wind, small hydro and photovoltaic power plants. The problem is when there is no generation of electricity from photovoltaic power plants at night or from wind farms in the absence of wind as there is no any other alternative resource of RES to substitute them. Furthermore, the energy from the wind power stations and from the photovoltaic power plants is intermittent and cannot be relied upon to form the main part of the load curve.

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