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Hydropower development in Romania. A review from its beginnings to the present

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ABSTRACT

Water is a prime element both for sustaining life on Earth and for complex human activity. In 2015 in Romania the average electricity production was of 7343 MW h and the average consumption was of 6590 MW h. The average hydropower generated was of 1894 MW h, which is equal to 26% of the total production.

In this paper, we aim at reviewing the hydropower system in Romania from its beginnings, in 1884, to its present development. The first hydropower plant in Romania was in Sinaia and had an installed capacity of 4×250 kW. Now, Romania has more than 200 HPPs, with a total installed capacity of 6.443 MW. In Romania, hydropower is the first main source of energy among RES, followed by wind energy.

Between 1950 and 1990 were built 115 hydropower stations. This period is characterized by the construction of most of the hydroelectric power plants in Romania, including the largest. The development of the hydro potential has begun in Bistrița basin. After 1990, in the transition period, after the fall of communism, the number of installed hydropower plants decreased, by 2010 totaling an installed capacity of only 838 MW, which means less than 14% of what was done before 1990. About 54% of Romania's hydropower potential is now arranged, and there are plans to reach 63.5% by 2025.

The largest artificial lake of Romania is Lake Iron Gates I (Porţile de Fier I), constructed between 1964 and 1972 behind a 60 m' dam. Iron Gate I rank position 52 out of 66, in the list of largest hydroelectric power stations in the world. Iron Gates I system is one of the largest hydro constructions in Europe and the largest on the Danube.

1. Introduction

Population and economic growth in developing countries, is demanding high levels of energy in order to meet increasing modern life conveniences [1]. Electricity production is rising significantly in order to provide higher economic welfare, using hydropower as an advantageous alternative for clean energy at a stable price [2]. Energy consumption is very crucial factor for every aspects of the life [3]. The increasing penetration of renewable energy sources (RESs) in the power system has highlighted the benefits of being able to store energy in a more efficient manner, and the need of holding additional operating reserves to manage the system under more demanding conditions due to the inherent uncertainty and variability of wind and solar power [4]. Hydropower is the energy created from the force of falling or flowing water (rivers, dams and waterfalls). This kind of energy has many advantages: it can be stored (unlike the sun or wind), there isn't any fuel purchase costs, it is a multiple-use resource, it is less expensive than mining fossil fuels and does not contribute to the greenhouse effect. The large hydro power plants require the construction of dams, disrupting the river flow and fish migration and generating various environmental damage. In small hydro projects the river flow is diverted through a large pipe to a downstream turbine that generates electricity, so the environmental effects are lower [5]. The power of falling water has been used since ancient times for different purposes, but to produce electricity is used just for 138 years.

Sustainable development has been defined by political and corporate leaders as the combination of environmental protection and economic growth. As a result, the concept of eco-efficiency has been promoted as the primary tool for achieving industrial sustainability [6]. Access to electric power supply has always had a significant role in promoting improvements in all the society sectors, nevertheless nowadays 1.3 billion of people still do not have electricity access [7].

Abbreviations: EU, European Union; RES, Renewable energy sources; GC, Green Certificates; ANRE, National regulatory authority for energy; GHG, Greenhouse-gas emissions; HPP, Hydroelectric power plant; RES-E, Electricity from renewable energy sources

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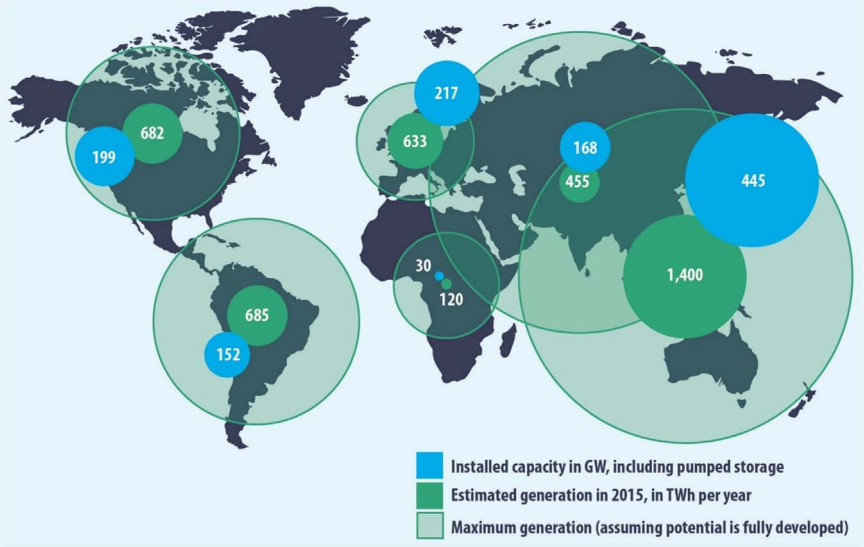

Fig. 1. Hydropower's contribution in 2015, in the World [11].

The average hydropower exploitation has exceeded 60% of the total resources in developed countries [8]. In 2015, hydropower development continued its strong growth trend. Globally, the drivers for this include a general increase in demand not just for electricity, but also for particular qualities such as reliable, clean and affordable power. In 2015, the new installed capacity of hydropower was 33.7 GW (including 2.5 GW pumped storage, with significant capacity under construction or in the planning stages), bringing the World total hydropower capacity to 1212 GW. The share of hydropower contribution, by region, in 2015, in the World is presented in Fig. 1. The year 2016 also witnessed the global community adopting a new sustainable development agenda and global agreement on climate change, which will catalyze further actions and investment towards a low-carbon, resilient and sustainable future. This brings a particular focus on clean and renewable energy. Hydropower will play a significant role in supporting energy and water systems in their transition towards a more sustainable future. In September 2015, the UN Sustainable Development Goals were officially adopted. Superseding the Millennium Development Goals, the SDGs include a specific goal related to energy: "ensure access to affordable, reliable, sustainable, and modern energy for all," which calls for a substantial increase in the share of renewables by 2030. In December 2015, the parties to the UNFCCC agreed to reduce anthropogenic greenhouse-gas emissions in order to limit global warming to "well below 2 °C". Both agreements will drive further growth in the hydropower sector, especially in emerging and developing economies [9]. A top five on total hydropower capacity in the World, by countries, include China on the first place, Brazil on the second, United States on third, Canada on forth and Russian Federation on five [10].

Hydropower is the largest source of renewable electricity in the world, but despite being a mature and clean energy technology it has also been the subject of ecological and social conflict [12]. In many parts of the world, large and medium reservoir based hydropower projects have been in the line of fire for their multiple, large scale socio-economic and environmental impacts such as submergence due to formation of reservoir, displacement of native people and emission of greenhouse gases [13–16]. Hence, the focus is now on construction and development of small hydropower projects (SHPs) [17].

The European Union (EU) is committed to the deployment of electricity from renewable energy sources (RES-E) [18]. The breadth and complexity of energy-related issues are increasing in a globalized world with economic and environmental constraints. The EU is called to face an increasing dependence on fossil fuels, growing energy imports and rising energy costs-although recent drastic changes due to unconventional worldwide discoveries of oil and gas reserves may change the latter. These challenges are making European societies and economies vulnerable and in order to deal with them, progress towards a sustainable energy development seems the only way. The European Commission has risen by proposing a range of policies that aim to address these challenges and trans- form them into opportunities for global economic and technological leadership [19]. In November 1997, the European Commission (EC) adopted a White Paper on "*Energy for the Future: Renewable Sources of Energy*" [20]. Its scope was to contribute, by promoting RES, to the achievement of the overall energy policy objectives: security of supply, environment and competitiveness, and protection of environment. To reach this aim, the White Paper proposed to double the contribution of RES to the EU's gross inland energy consumption, establishing an indicative Community objective of 12% by 2010. Shortly after, June 1998, the Council adopted a Resolution on RES [21], embracing the White Paper aims as a basis for actions at Community and national levels, considering the indicative objective of 12% by 2010 as a useful guide. The same welcome was expressed by the European Parliament that, inter alia, asked for: a Task Force on RES and the incorporation of an energy chapter in the Treaty for any future review. An equal approval came from the Committee of Regions, that asked for the creation of a "European Agency for Renewable Energy", and from the Economic and Social Committee that, in turn, give attention to the economic effects on the manufacturing, building and agricultural industry [22–25]. In Europe, the Hydropower potential, the gross hypothetical capability in TW h/year is presented in Fig. 2. Romania has joined the European Union (EU) in 2007 [26]. The EU target for 2020 regarding the share of electricity produced from RES in the national gross final energy consumption is 20%, while the target of Romania is 24%, which means Romania will probably face no difficulties in fulfilling this target [27].

Renewable sources of energy play an important part in the sustainable supply of energy and in the sustainable [29]. economic and social development, mostly by climate change mitigation. Romania is a country with a great potential of renewable energy sources [30]. Most of the energy projects in Romania (very similar with megaprojects defined by [31] as multi-billion dollar infrastructure projects, and characterized by [32] as being commissioned by governments and delivered by private enterprises) were financed, during 2007–2013 period, through Operational Sectoral Program Increase of Economic Competitiveness, Priority Axis 4 Increasing Energy Efficiency and Security of Supply, in the Context of Combating Climate Change, which