Assessment of the Volga Hydropower Cascade Transformation using The Case Study method

At present, the Volga has ceased to be a flowing river and has turned into a system of interconnected reservoirs (Figure 1). Reservoirs provide a high level of water required for the movement of vessels with a draft of 3.5 m and the production of electricity from hydroelectric power plants. In addition, a constantly maintained water level is important for water intakes in a number of large cities, such as Nizhny Novgorod, Kazan, Samara and Volgograd. The cost of solving the above problems is the flooding of several thousand square kilometers of floodplain lands. As a result, the historical settlements of the Upper and Middle Volga were flooded and significant climate change occurred near large reservoirs. In the lake part of the reservoirs, the current slows down due to stable density stratification of water. Stable density stratification is accompanied by algal blooming in the upper mixed layer. Blooms make navigation difficult and create bad smells in recreational areas on riverside areas. The change in the ecosystem of the reservoir is also accompanied by a decrease in the population of valuable fish species, oxygen starvation in the bottom layer and the accumulation of heavy metals in sediments.

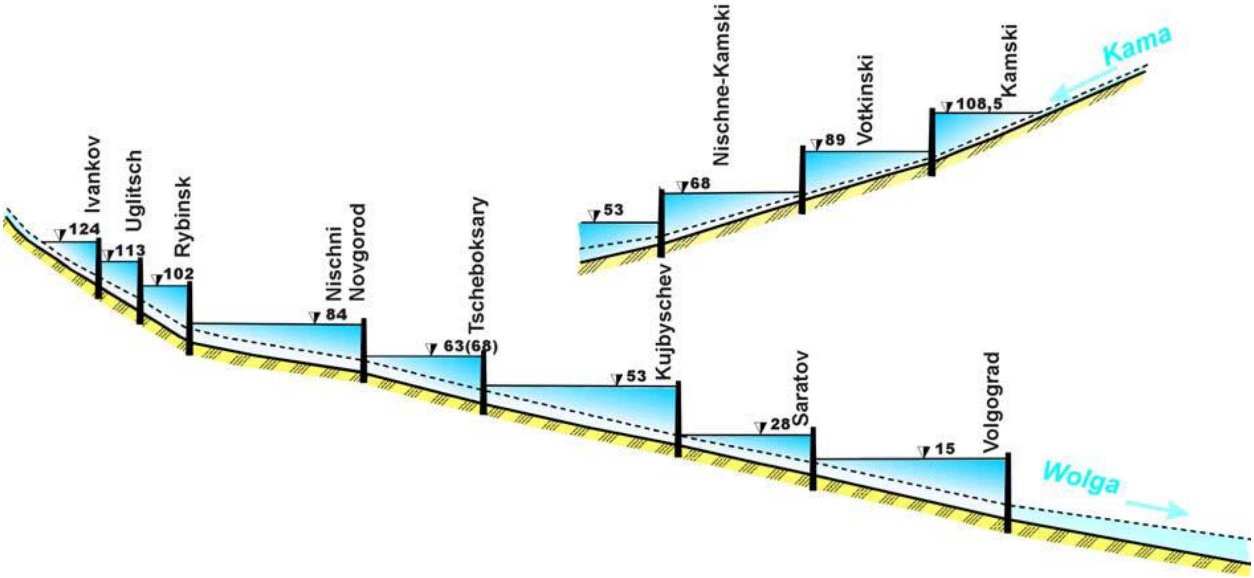

Figure 1 The Volga river is a set of reservoirs due to the Hydropower cascade on the Volga and Kama.

A comprehensive solution to the above problems is possible on the basis of the proposed concept of integrating traditional hydropower plunts (HPP), pumped storage plants (PSP) and floating photovoltaic plants (FPP) into integrated no carbon plants. The main idea of the transformation of the cascades of hydroelectric power stations existing on a large flat river is to create a cascade of integrated no carbon plants on the basis of a hydroelectric power station, including a floating photovoltaic power plant, a pumped storage station and a traditional hydroelectric power station. The new concept idea is that the upper pool of the PSP is located inside the headwater of the existing HPP, and the FPP is located inside the upper pool of the PSP (an analogue of a Russian nesting doll) (Figure 2). This arrangement allows avoiding the use of valuable floodplain lands and compactly locating three types of renewable energy facilities within the existing flooded areas.

The proposed concept will reduce the area of flooded lands, Operation of pumps in a wide range of depths of the headwater will allow for a controlled change in the water level of the headwater, which will allow both cleaning the channel from silt contaminated with heavy metals and returning previously flooded lands as a floodplain or used agricultural destination. In some situations, a controlled rise in the water level in the reservoir is also possible.

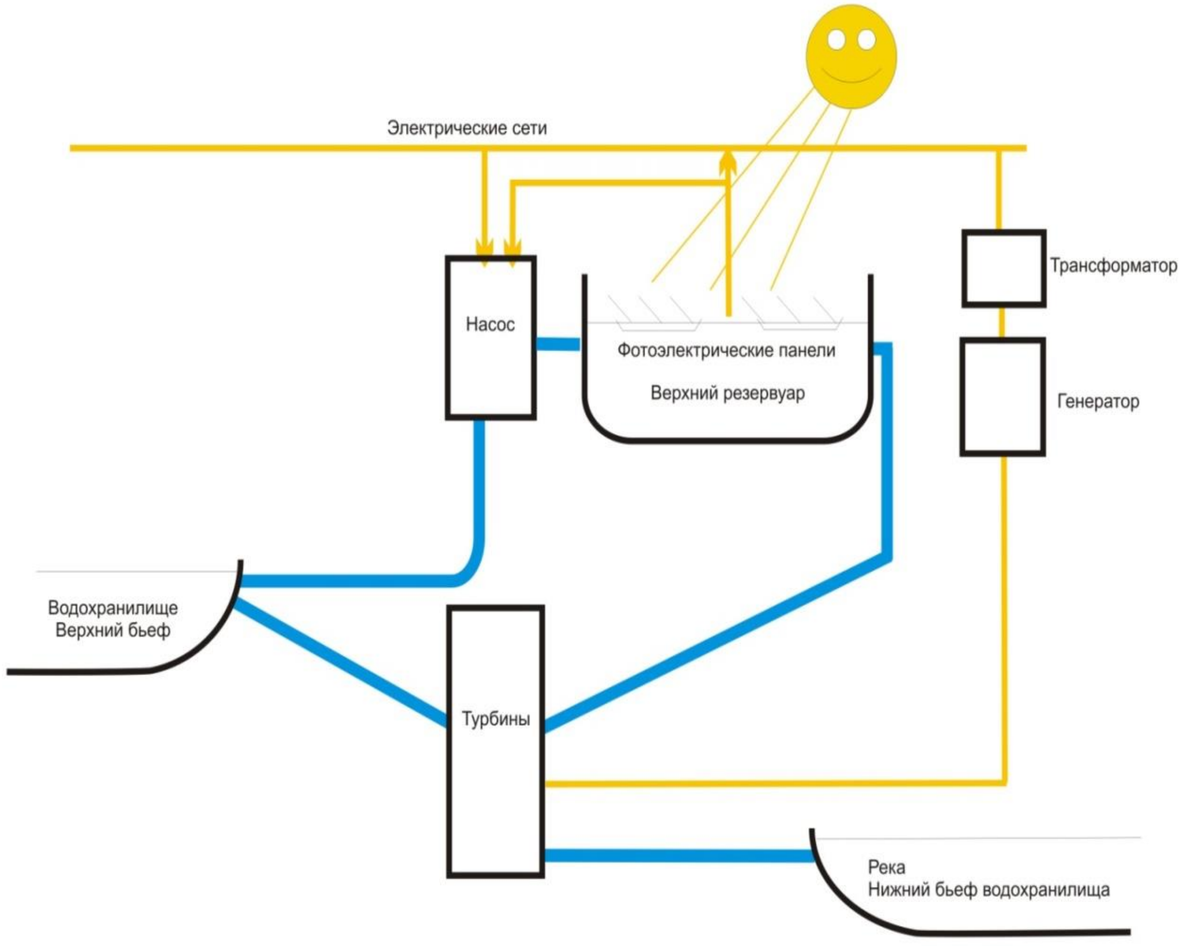

Figure 2. Scheme of integration of a floating photovoltaic plant, pumped storage plant and conventional hydroelectric power plant on a plain river (blue – water nets, yellow – electric nets)

A preliminary analysis suggests that the bulk of electricity will be generated by floating solar photovoltaic plants and PSP, which will allow a gradual decrease in the water level in the reservoir and the return of flooded floodplain lands to their natural state. This will lead to an acceleration of the flow in the lake part of the reservoirs, the mitigation of blooming and will require constant work on the profiling of the river bed to ensure navigation. Accordingly, changes in aquatic ecosystems and fish stocks are currently an unresolved issue. This proposal requires an integrated assessment of the social, environmental and economic impacts of establishing the integrated plants. For the assessment of the proposed case study, experts from SGEM, partners from Sweden, Azerbaijan, as well as all interested specialists, regardless of nationality, are invited.