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M.Sc. in Environmental and Resource Management

A future electric system based on renewable energy for Madeira
Island: implementation of offshore floating wind turbines



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Abstract

Considering the political challenges respecting to climate and energy worldwide, as for example the goals from European Union for 2020 and further (referring to increase renewable energy, energy efficiency and a reduction of greenhouse gases emissions), peripheral islands like Madeira are also working to meet these goals, and in addition, more independency from fossil fuels in their energy system. The future challenges expected to occur on, for example the overall European grid system, are already being experienced in isolated islands. Therefore, the importance of such islands is considerable, as if they find their way to have a renewable energy based system, that implementation on continental regions which are all connected, should be easier.

In this thesis, the role of two energy systems with differences regarding their implementation period and uncertainty about their installation, are studied for continuously overturning the dependence of Madeira's electric system on foreign fossil fuels. First, the new philosophy being applied in some of the hydroelectric power plants on the island, for converting them into pumped hydro storage (PHS) systems is analysed, as well as their role in islands similar to Madeira. By combining hydropower and wind energy, an optimisation of those systems can be achieved when compared to using them separately. When there is an excess of wind energy, the hydro system can use that surplus for pumping water to a higher reservoir for later usage, as on the other hand, when there is no wind, the stored water can be used for producing electricity when demanded.

In a longer term perspective, and considering the future limitations of the existent renewable energy systems in the island, it is carried out a first introduction to the possibility of harvesting the wind offshore in Madeira, specifically through floating wind turbines - a new concept at a testing phase of development worldwide. A successful implementation of these systems, combined with expected developments in the supply and demand side of energy, as well as, on the integration of a "smart grid" in the future, can accelerate the process for reducing the importation of fossil fuels and their environmental impact. In order to completely minimise the dependency of non-renewable resources in the electricity supply, it will also be required the introduction of new storage systems, that are efficient and reliable enough to replace the actual role of conventional power plants, on regulating the system and securing a fast answer to peak demand periods.