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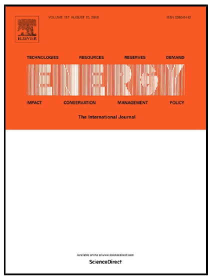

Cooling towers performance in a changing climate: Techno-economic modeling and design optimization

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Cooling towers performance in a changing climate: Techno-economic modeling and design optimization

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ABSTRACT

This paper presents a model of a natural draft wet type cooling tower, which is based on the conservation laws of thermodynamics. The model assesses the cooling abilities of a tower, the evaporation rate, and the amount of required make-up water, all represented as a function of the atmospheric conditions. The purpose of the model is to estimate the effects of extreme weather conditions on the thermodynamic efficiency of a natural draft wet type cooling tower. World climate is changing and average temperatures are anticipated to rise in the near future, thus affecting the electrical energy generation. To that aim, we study the climate change effects on the ability of natural draft wet type cooling towers to reject heat and hence on the electricity generation of thermal power plants. Additionally, we perform cost-based analyses of a cooling tower considering the long-term projections for air temperature increase, and exemplify our model with reference to a location in France. The results show a remarkable drop in the cooling tower efficiency, and, hence, significant electricity generation losses even when a small increase of atmospheric temperature above the cooling tower design temperature occurs. Furthermore, the results of the cost-based analysis show that large electricity losses are expected. However, the performed cost-based analyses, considering climate change projections, show that even with the highest temperature increase, there is no need for additional tower height. In other words, the concrete costs outweigh the generated revenues from the curtailed power as result of insufficient cooling.

Keywords: Natural draft wet cooling towers; efficiency; wet bulb temperature; climate change; thermodynamics; psychrometry.

1. Introduction

As the world population is growing, energy requirements are increasing dramatically in all sectors, i.e. industry, transport, and residential [1]. Hence, the sustainable supply of energy and secure efficient energy generation, i.e. maximum resource utilization, are becoming key objectives. Energy systems in most countries heavily rely on thermal power plants such as fossil, nuclear, biomass, and geothermal [2], consisting 70% of total installed capacity worldwide [3]. The majority of them uses water for cooling via once-through or wet type cooling towers [4]. However, the efficiency of these cooling technologies heavily

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