



C-E (curtailment – Energy share) map: An objective and quantitative measure to evaluate wind and solar curtailment

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ABSTRACT

As the share of VRE (variable renewable energy) has grown rapidly, curtailment issues have arisen worldwide. This paper evaluates and compares curtailment situations in selected countries using an objective and quantitative evaluation tool named the “C-E map” (curtailment-energy share map). The C-E map is a correlation map between curtailment ratios that mean curtailed wind (or solar) energy per available energy and energy shares of wind (or solar). The C-E map can draw a historical trend curve in a given country/area, as an at-a-glance tool to enable historical and/or international comparison. The C-E map also can classify the given countries/areas into several categories, according to the current levels of curtailment ratio and historical trends. The C-E map helps institutional and objective understanding of curtailment for non-experts including policy makers.

1. Introduction

Variable Renewable Energy (VRE), mostly wind and solar, is increasing world-wide, which leads to curtailment becoming a major problem in many countries. In 1990, an early study showed that only modest shares of VRE could be realized without allowing curtailments [1]. Another study later showed that significant VRE shares would be feasible if a part of the VRE were curtailed [2]. Other research claimed that curtailment would rise exponentially with increasing shares of VRE

[3].

Curtailment can be understood as “a reduction in the output of a generator from what it could otherwise produce given available resources, typically on an involuntary basis” [4]. Although some reports, such as Ref. [5], distinguish “curtailment” (system-wide) and “constrain” (dispatch-down to local network), this paper does not distinguish between the two terms and applies a unified term “curtailment” for any reason, except a market-based economic reduction (for example, the US and Denmark data include market-based economic reductions). Ref. [4] also noted that “... Definitions of curtailment and

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