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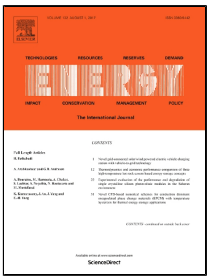

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Estimation of the failure probability of an integrated energy system based on the first order reliability method

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ABSTRACT

In this paper, we investigate the impacts of intermittent renewable energy sources (RESs) and stochastic energy loads on the operation and uncertainties of an integrated energy system (IES). In our analysis, we use a first order reliability method (FORM) to estimate the failure probabilities, which are crucial for ensuring the reliability of the gas supply and surplus power absorption. The Hasofer Lind and Rackwitz Fiessler (HLRF) algorithm is introduced to solve the FORM optimization model while considering the stochastic behaviours and dependencies of multiple energy sources. A mathematical case is presented to demonstrate the use of the FORM in the estimation of failure probability, and the results are validated using the Latin hypercube sampling theories, including the Iman and Stein methods. The results of a failure probability analysis for an ideal IES are provided to illustrate the proposed technique. The failure probability can be used to improve IES operation and planning and ensure better reliability.

1. Introduction

An integrated energy system (IES) is a custom-designed configuration of different renewable technologies. The term IES refers to the interactions and interdependencies of energy supply systems, e.g. combined electricity and district heating systems; combined electricity and gas systems; and combined electricity, gas, and district heating systems. The development of IES technology promises to help resolve issues of energy safety, improve social efficiency, and promote the development of new energy resources and renewable energy sources. Because there are so many potential benefits associated with IES technologies, it is now an important strategic research direction in the field of international energy. Europe is home to the most influential IES designers who first presented the concept of IES and put it into practice. The collaborative optimization of multiple energy sources and other related research questions in IESs have been included in the 7th framework programme (the future of European Union research policy published 9 July 2012) [1]. A host of programmes with great international influence have been presented, such as the trans-European network and intelligent energy. The United States Department of Energy approved an ambitious IES development plan [2], which was promoted to the national strategic level in subsequent policy statements.

Much of the recent energy research in IESs has demonstrated the use of multi-energy complementary technology in the operational analysis of IESs. Combined heat and power (CHP) technology, which is a positive method of energy conservation, is one of the basic concepts of multi-energy complementarity, and can provide electrical power and thermal energy for space heating, cooling, domestic hot water, industrial processes, and so on. There are two common operating modes for CHP systems: a grid-orientated operation mode and a heat-orientated operation mode [3], and the relative priorities between the power and heat

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