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ORIGINAL ARTICLE

Agent-based community coordination of local energy distribution

Muhammad Yasir · Martin K. Purvis · Maryam Purvis · Bastin Tony Roy Savarimuthu

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Abstract The diminishing availability of fossil fuels will necessitate a shift toward renewable energy resources to supply vital electrical energy needs in the future. Two abundant renewable energy sources, solar and wind, are increasingly cost-competitive and also offer the potential of decentralized, and hence more robust, sourcing. However, the intermittent nature of solar and wind power can present difficulties in connection with integrating them into the main electric power grid. In this paper, we present an agent-based architecture for coordinating locally connected micro-grids, thereby supporting more cost-effective integration into the main power grid. These interconnected micro-grids, with renewable energy sources and energy storage devices, employ agents so that each micro-grid can choose to save or resell its stored energy in an open market in order to optimize its utility and costs. We show via simulation experiments how the micro-grid agent society operates and adapts under varying conditions of renewable energy availability and energy demand patterns. Such a system provides not only financial advantages but also local autonomy and a more robust energy distribution. In addition, these interconnected agents can also facilitate the reduction of carbon emission. In this connection, we compare five different micro-grid energy trading strategies. Thus, the experimental design and evaluation are motivated by a policy modeling perspective whereby the utility of an energy policy to a community (i.e., the strategy) is computed based on two attributes, the financial gain and the reduction in carbon emissions. Further, by means of "what-if" analysis, different energy policies that can potentially be employed by a community are compared against one another. Also, the implications of these policies for a community are discussed.

Keywords Micro-grids · Renewable energy · Agents

1 Introduction

Low-cost and seemingly ample nonrenewable energy sources from fossil fuels were used to fuel the twentieth-century economies. But, there was a growing awareness that available fossil fuel resources were running out and that their heavy usage had serious negative consequences on human health and the environment (Asif and Muneer 2007). With increasing population and living standards worldwide, demand for energy is increasing relentlessly. According to one study, the population of the world will reach to 9.1 billion by 2050 (Asif and Muneer 2007), and this entails at least a corresponding increase in energy consumption. Thus, at an annual growth rate of 2.3 %, the world energy, was generating 19.1 terawatts (TW) as of 2008, is expected to grow 84 % by 2,035, to 35.2 TW (Conti and Holtberg 2011). Yet, available energy resources to satisfy this demand are declining. So nowadays, it is

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M. Yasir (✉) · M. K. Purvis · M. Purvis · B. T. R. Savarimuthu
Department of Information Science, University of Otago, Dunedin, New Zealand
e-mail: muhammad.yasir@otago.ac.nz

M. K. Purvis
e-mail: martin.purvis@otago.ac.nz

M. Purvis
e-mail: maryam.purvis@otago.ac.nz

B. T. R. Savarimuthu
e-mail: tony.savarimuthu@otago.ac.nz

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