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A 'System' Integration for Energy Recovery within Data Centres Using Combined Cooling and Power Technology

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Abstract

Data Centres (DCs) are emerging as a large industrial sector, consuming about three percent of the global electricity supply, contributing for about two percent of total greenhouse gas emissions and the amount of energy used by DCs is doubling every four years. Despite the innovations in energy management system in DC that incorporate renewable energy solutions to reduce energy consumption and cap their carbon footprint, as much as half of electricity is used for cooling purposes and is ultimately wasted as heat. An innovative system is presented here which integrates a DC cooling process with a zero-emissions power and cooling utilising a novel cryogenic engine technology. The integration enables DCs to take advantage of opportunities for thermal management, rather than electrical power, to control peak temperature environments and electricity price mitigation through cryogenic energy storage. Substantial improvement in DC energy efficiency together with reduction in greenhouse gas emission has been discussed.

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Keywords: Energy efficiency, Heat recovery, Liquid-air engine, Process integration, Energy storage, Carbon footprint reduction;

1. Introduction

With the rapid advances in computer and electronic technology, dramatic growth rate in the demand for digital information management, such as data processing, data storage, digital communications, have been observed during the past two decades. As a result, Data Centres (DCs) are of paramount importance responsible for information

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management and communication functions in nearly every sector of the economy. In 2009, energy statistics revealed that an estimated 330 terawatt-hours of energy (equivalent to about 2% of the global electricity production) was consumed to operate DCs worldwide [1,2]. In 2014, the DC sector in United States was estimated to have consumed 70 terawatt-hours of energy [3], representing 2% of the country's total energy consumption. This is a 4% increase in total DC energy consumption from 2010 to 2014. The ongoing growth of the DC sector coupled with the development of higher power density server components, it is expected that the US DC energy consumption will grow by 4% between now and 2020, reaching about 73 terawatt-hours [4].

Despite increased energy demand by the DCs, typically about 44% of the electrical power is used directly to support IT equipment, while the remaining are attributed to cooling and indirect uses such as building management, lighting, etc. (Fig. 1)[5]. DCs must be adequately cooled as almost all the energy supplied to the server is dissipated into heat, requiring the use of large scale cooling systems to keep the server rack temperature in a safe operational range [6]. This problem addressed by this paper is how the "next generation combined cooling and power" technology can be utilised to provide energy efficient operation of DCs.

Currently there are around 8 million private and commercial DCs globally. With the digital world projected to grow 44 times from 2009 to 2020, the industry is experiencing an exponential growth in DC deployment. Indeed, International Data Corporation (IDC) reports that global DC capacity will grow to 1.94 billion square feet by 2018 from around 1.6 billion today. Another 600,000 DCs will be built in the coming years; 450,000 of which are anticipated to be in the Asia-Pacific region with Malaysia alone seeing 8,600 new DCs. However, despite these substantial growth figures, DC services and products are largely seen today as commodity products owing to the fact that there is very little differentiation between quality, type and price of offerings. DC operators are grappling with high energy costs, space scarcity, energy security, sustainability compliance and a lack of unique selling propositions (USPs). There is a great need to tackle these challenges and create the basis for a commercial USP offering energy cost reduction and increased energy security while simultaneously adding sustainability credentials through greenhouse gas emissions reduction and abatement of air pollution. These outcomes could be achieved by a substantial reduction in DC energy consumption and emissions through the innovative integration of DC cooling process with zero-emissions power and cooling utilising the novel cryogenic engine technology. This integration will enable DC operators to take advantage of opportunities for thermal, rather than electrical, control of peak temperature environments and electricity price mitigation through cryogenic energy storage.

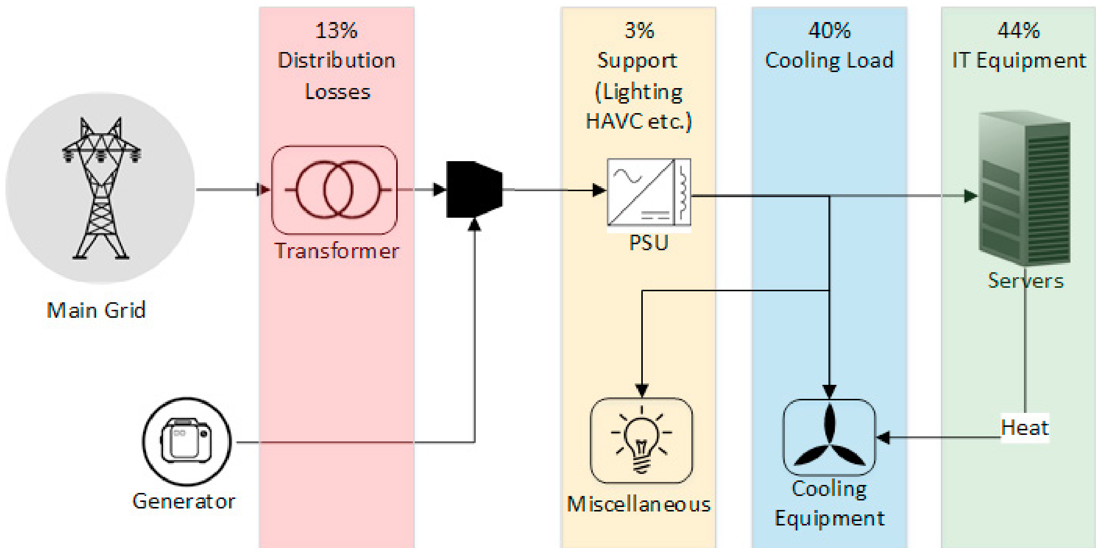

Fig. 1. DC energy attributes, adapted from [5]