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The location as an energy efficiency and renewable energy supply measure for data centres in Europe

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HIGHLIGHTS

- A data centre energy model was developed using TRNSYS.
- The potential of direct air free cooling integration was evaluated around Europe.
- A set of energy indicators describing the operation of data centres were defined.
- The location of a data centre could significantly affect its operation and impact.
- Smart management of the IT load can reduce energy consumption and CO_2 emission.

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ABSTRACT

The massive data centre energy consumption has motivated significant efforts to use energy efficiency strategies and the implementation of renewable energy sources that reduce their operational costs and environmental impact. Considering that the potential of many of these measures is often closely linked to the climate conditions, the location of data centres can have a major impact on their energy demand. Moreover, from a holistic approach, differences among regions become even more important when accounting for the electricity attributes from the grid. To assess these differences this work compares by the use of energy indicators the behaviour of a data centre located at different representative emplacements in Europe. To do so, a dynamic energy model which incorporates free cooling strategy and photovoltaic energy is developed. The paper concludes by suggesting that future data centre developments could consider site selection as a new strategy to limit the environmental impact attributable to this sector.

1. Introduction

During the last decade, the information technologies (IT) sector has experienced a strong increase of cloud computing and high performance computing and a vast growth of the Internet use. To meet this demand, the number of data centres expanded rapidly. Considering the aforementioned phenomenon and the fact that they are working 24 h a day the 365 days of the year, the energy consumption of these facilities has increased considerably. Actually, world data centre electricity consumption doubled from 2000 to 2005. However, from 2005 to 2010, due to the increased prevalence of virtualization and the implementation of energy efficiency strategies, the growth rate was 56% accounting for about 1.3% of the world electricity consumption [1,2]. The data centre industry has taken consciousness of the need of the implementation of energy efficiency strategies and the use of renewable energy in data centres [3,4], not only to show their environmental commitment, but also to reduce the operational costs.

Energy efficiency measures include many strategies which allow reducing the energy used to operate a data centre. Several works have been published recently about best practices and techniques for energy savings in these facilities [5–7]. These measures can be directed towards reducing the consumption of the IT equipment itself by means of virtualization and consolidation [8], the power supply infrastructure through direct current distribution [9], efficient uninterrupted power systems [10], etc. and especially the cooling system. The industry and researchers have been focused in reducing the cooling demand using the well know techniques as hot and cold aisle containments [7], increase the allowable IT temperatures [11] and air–water side free cooling [12,13]. Currently, one of the most used energy efficiency strategies is so called direct air free cooling technology which uses the cold outside air directly to remove the heat generated inside these

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facilities. Lee and Chen [12] used a dynamic building energy simulation program to examine the potential energy saving of using direct air free cooling in data centres for 17 climate zones. The results showed a significant potential for data centre locations in mixed-humid and warm-marine climate zones. But in the zones with lower dew point temperatures such as very-cold and cold–dry climate zones, the power and water consumed by the humidification system can be important and they should be accounted. In a similar study, Siriwardana et al. [13] investigated the use of direct air free cooling in different Australian climate conditions. They highlighted that there is a potential use of this strategy in some states that could lead to significant energy saving and thus CO_2 mitigation. The use of district cooling systems [14] to provide more efficient cooling into data centres and the use of cooling roofs [15] to reduce the building energy consumption are other strategies to be investigated.

Once energy efficiency measures are applied, the electricity consumption should ideally come from renewable energy sources. In this sense, companies can follow different strategies to incorporate renewable energies into their overall energy portfolio. They can decide to generate their own renewable energy, either on-site or off-site, or to buy it to a third body through different legal instruments (electricity tracking certificates, power purchase agreements, etc.) as Fig. 1 shows [5]. Even though the use of on-site renewable energy into real data centres is still in the early stage, some companies have been implemented different green energy solutions in their portfolio. Emerson's data centre implemented a 100 kW solar panel in Missouri, Intel has installed a 10 kW of electricity in a data centre in New Mexico and Goiri et al. [16] developed Parasol, a prototype green data centre which comprises a small container, a set of solar panels, an electrical battery blank and a grid-tie. A small data centre in Illinois became the first 100% on-site wind power data centre in the US by switching its daily operations energy needs over to a 500 kW wind turbine [17]. Other on-site renewable energy data centre integration such as combined heat and power [18,19] and fuel cells [20] are under investigation.

The location of an operating data centre significantly affects its energy demand especially if free cooling technology is integrated and its renewable energy supply potential. Moreover, the attributes of the electricity grid by means of the energy mix would affect the CO_2 emissions, the primary energy consumption and the cost of the energy. This issue was studied by Shehabi et al. [21] who quantified how the electricity use and the CO_2 emissions varied for a data centre in several sites in the United States. In this paper, the potential integration of direct air free cooling and the implementation of on-site generation system represented by a roof-mounted photovoltaic (PV) system are evaluated at different European locations. London, Amsterdam and Frankfurt were selected as hotspots for data centre activity and Barcelona and Stockholm were added to incorporate Mediterranean and Nordic climates to the study (Fig. 2). To do so, a dynamic energy model was developed to evaluate the data centre behaviour in an hourly basis. The results of this analysis quantitatively demonstrate how data centre location and direct air free cooling use can influence energy demand and CO_2 emissions among other indicators.

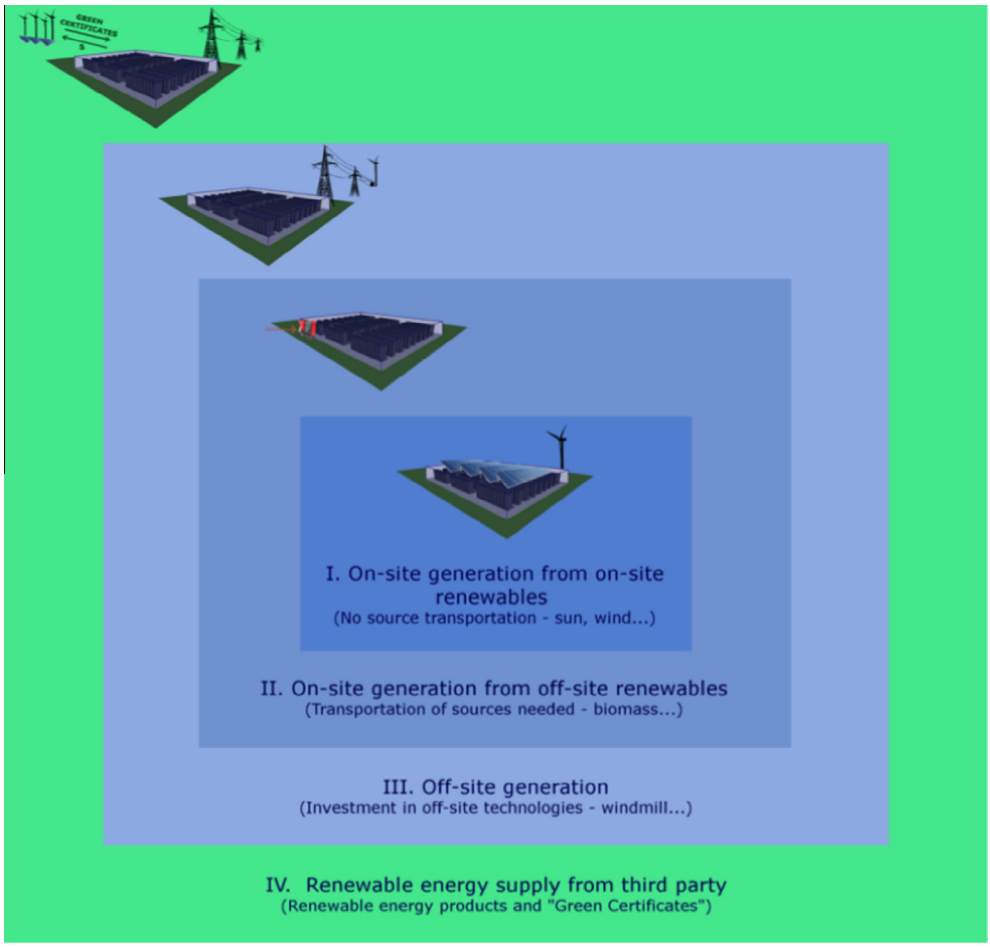

Fig. 1. Overview of possible renewable supply options for data centre industry [5].