The future of data centre cooling, energy consumption and climate change

Bryan Coyne, Department of Economics, Trinity College Dublin (Ireland), +353 87 1163979, brcoyne@tcd.ie
Prof. Eleanor Denny, Department of Economics, Trinity College Dublin (Ireland), +353 1896 1043, dennye@tcd.ie

Overview

Increasing energy consumption poses a serious threat to limiting the impact of climate change. Decreasing the use high-carbon fossil fuels and increasing the presence of low-carbon energy generation is key to achieving global objectives. The increasing presence and energy consumption of data centres runs counter to these objectives. Currently, data centres are estimated to consume roughly three per cent of global energy consumption, accounting for two per cent of global emissions (Bawden, 2016). In an increasingly connected society, the data centre market is expected to grow, especially when universal, affordable internet access is part of the United Nation's Sustainable Development Goals (SDGs) and a report by the World Economic Forum estimates that four billion people are currently without internet access. Research underscores the economic importance of internet connectivity, finding a long run relationship between economic growth and internet connectivity (Pradhan et al., 2013) and between more recent broadband internet penetration and economic growth for OECD countries (Koutroumpis, 2009).

Although efficiencies in data centre energy consumption have been made, innovations in computer processing power (typically following Moore's Law) persist. If gains in power exceed gains in efficiency, then the net energy consumption of a given facility will rise. Estimates in the US note that the sectoral annual energy consumption will rise by four per cent by 2020 (Shehabi et al., 2016). This research looks toward the next generation of computing; one that will possibly require liquid-cooling (instead of conventional fan cooling) due to the high levels of heat emitted by a more advanced computing equipment and what the implications of this for energy consumption are.

This paper will study the hypothetical roll-out of liquid-cooled data centres in the context of the Repulic of Ireland, a relatively small country with a concentrated data centre sector. In the Republic of Ireland, data centre energy consumption is expected to be responsible for approximately 18 per cent of peak system demand by 2025 (EirGrid, 2016) and approximately 20 per cent of the annual total electricity requirement (EirGrid, 2017). This research estimates the energy consumption and emissions-related benefit for a representative data centre and scales this to national level and studying across a number of scenarios ranging from "business as usual" to a more energy efficient ecosystem using different rates of diffusion. There will also be with an additional discussion on the potential reuse of waste heat for space heating, as has been used in other contexts (Apple, 2015).

Methodology

The method in this paper features two distinct parts. Firstly, we adopt a bottom-up approach to estimating the energy consumption and emissions for a representative data centre. We build a representative facility due to the private ownership and lack of information for most data centres. We compare a representative air cooled facility to a hypothetical liquid cooled facility and compare the savings associated with this. Given that liquid cooling is not yet widespread, we apply findings from existing research. Our justification for this is to estimate the energy consumption for a future scenario where society is more reliant on cloud computing technology and data centres, which requires the use of liquid-cooled data centres. A similar approach has been applied in other studies, but has ushed actual data (Huang et al., 2016; Alberini et al., 2014). We scale up our reference data centres to model the Irish data centre sector to obtain an estimate of the national emissions associated with this level of data centre activity.

Secondly, we apply a model of diffusion to calculate the energy savings of the roll-out of new liquid-cooling technology over a number of years. We need a model of diffusion as it is likely that liquid cooled data centres would not immediately replace the entire population and would take a number of years to be naturally phased in. Not using some model of diffusion would be unrealistic and may overstate any improvements in energy efficiency or saved energy. The approach considers a sigmoid (s-shaped) form of diffusion, which has been used previously to study the development of renewable generation technologies (Davies and Diaz-Rainey, 2011). Our work would rely on past market trends to help inform the diffusion of this technology as existing facilities reach the end of their economic lifetime and are upgraded to liquid-cooled servers to accommodate growing demand. We believe this approach has merit as newly opened facilities tend to use the latest technology and over time, older facilities get upgraded to the latest technology a few years after it has arrived.

Results

This research is currently ongoing, but results will be presented at the conference.

This research will provide insights into the potential reductions in energy consumption caused by a transition to liquid-cooled data centres. Given the significant electricity requirements of data centres, results will also be able to quantify the reduction in terms of reduced carbon emissions from avoided electricity generation.

Our research will add to the existing literature on technology diffusion, with a new application to the context of data centres. Another extension to this work is the study of district heating, which could deliver even further benefits by avoiding additional energy consumption elsewhere. An example of this is district heating being used to heat water for nearby buildings. This would displace the need for conventional fuel use, which can be quantified in terms of fuel avoided and emissions abated.

Conclusions

The findings of this research have important implications for industry and policy. For policymakers, an estimate of the potential efficiencies of liquid-cooled data centres matters for electricity generation, supply and efforts towards reaching climate change targets and decarbonisation. This work also provides an estimate of the additional potential benefit of using a district heating system to reduce fuel demand for adjacent buildings, which could aid future urban planning and development. For industry stakeholders, results of this research should clarify the business case for using liquid cooling in data centres and possibly foster additional discussion on how the data centre sector can contribute to climate change mitigation efforts through increased energy efficiency.

References

Alberini, Anna, Markus Bareit, and Massimo Filippini. “Does the Swiss Car Market Reward Fuel Efficient Cars? Evidence from Hedonic Pricing Regressions, Matching and a Regression Discontinuity Design.” (2014).

Apple (2015). “Apple to Invest €1.7 Billion in New European Data Centres.” Retrieved from https://www.apple.com/ie/newsroom/2015/02/23Apple-to-Invest-1-7-Billion-in-New-European-Data-Centres/

Bawden, T. (2016). “How liking something on Facebook can damage the planet.” Retrieved from http://www.independent.co.uk/environment/global-warming-data-centres-to-consume-three-times-as-much-energy-in-next-decade-experts-warn-a6830086.html

Davies, Stephen W., and Ivan Diaz-Rainey. “The patterns of induced diffusion: Evidence from the international diffusion of wind energy.” Technological forecasting and social change 78.7 (2011): 1227-1241.

EirGrid (2016): “All-Island Generation Capacity Statement 2016-2025.” Dublin: EirGrid.

EirGrid (2017): “All-Island Generation Capacity Statement 2017-2026.” Dublin: EirGrid.

Huang, Yun-Hsun, Yi-Lin Chang, and Tobias Fleiter. “A critical analysis of energy efficiency improvement potentials in Taiwan's cement industry. Energy Policy 96 (2016): 14-26.

Koutroumpis, Pantelis. 2009. “The Economic Impact of Broadband on Growth: A Simultaneous Approach.” Telecommunications Policy 33(9): 471–85.

Pradhan, Rudra P, Samadhan Bele, and Shashikant Pandey. 2013. “Internet-Growth Nexus : Evidence from Cross-Country Panel Data.” Applied Economics Letters 20(16): 1511–15.

Shehabi, A., et al. “United States data center energy usage report.” Lawrence Berkeley National Laboratory, Berkeley, California. LBNL-1005775 Page 4 (2016).

United Nations (UN). “Transforming our world: The 2030 agenda for sustainable development.” New York: United Nations, Department of Economic and Social Affairs (2015).

World Economic Forum and The Boston Consulting Group. “Internet For All: Framework Accelerating Internet Access and Adoption.” Geneva: World Economic Forum. (2014)