Consequences of future data centre deployment on North American electricity generation and environmental impacts: a 2015–2030 prospective study

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***Abstract*—**The environmental impacts of data centres that support information and communication technologies (ICT) are strongly related to electricity generation. Considering that electricity generation is a major source of green house gases (GHG) emissions, ICT and data centre usage are partially responsible for these emissions. With the increased use of ICT, more data centres are expected to be deployed in the future. Consequently contribution of data centre to global GHG emissions are expected to rise. However, electrical networks are very complex and dynamic systems. Therefore, an environmental evaluation of future data centres is uncertain. Indeed, the ecological footprint of the electricity consumed by the future data centres will directly depend on the technologies used to generate this electricity. In that context, this study proposes a new approach to investigate the consequences of future data centre deployment in Canada and optimize this deployment. This new methodology is based on the use of two combined tools. First, the Energy 2020 technico-economic model that is used to simulate the future evolution of the North American electric grid mix. Secondly, the life cycle assessment methodology (LCA) that evaluates the environmental impacts of electricity generation based on its entire life cycle and according to several environmental indicators (not only non-renewable energy consumed or GHG emissions): human health (6 indicators), ecosystems quality (6 indicators), climate change (1 indicator) and natural resources depletion (2 indicators). The main energy sources used in US and Canada are considered: biomass, coal, diesel, heavy fuel oil, hydro, natural gas, uranium and wind. Several prospective scenarios of data centre deployment in Canada are investigated: from adding 30 MW up to 750 MW by 2030 to the Canadian power demand of data centres. This method makes it possible to determine specific electricity sources that will power the future Canadian data centres by comparing each scenario with a business as usual scenario. Therefore, the consequence on the Canadian electric mix can be modeled and the environmental impacts can be attributed specifically to the future data centres depending on the quantity of deployed data centres. Then the comparison of the environmental impacts per MW of deployed data centres makes it possible to optimize the global data centre deployment. Of the studied scenarios, the largest deployment of data centres (+750 MW) leads to the least impacts per MW of deployed data centres for most of the environmental indicators. Non-linear effects between power demand, electricity generation and environmental impacts are highlighted, disqualifying intermediate data centre deployment scenarios (+150 MW or + 300MW) due to their significant environmental impacts in comparison to other scenarios. It was also found that an increase in power demand by data centres would lead to a reduction in Canadian electricity exports to the US, driving the US to generate more domestic electricity to meet its energy demand. Since electricity generation in the US is globally more polluting than in Canada, the deployment of data centres in Canada is indirectly linked to an unwanted increase in environmental impacts due to the reduction in Canadian electricity exports. However, while an optimal solution should be found to mitigate world GHG emissions, it is not clear whether the environmental burden related to US electricity generation should be attributed to the Canadian data centres.

Keywords—consequential life cycle assessment, electricity modeling, environmental impacts, greenhouse gas emissions, data centre deployment optimization.