Journal of Cleaner Production 106 (2015) 565–575

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Life cycle assessment of electricity generation in Mauritius

Ravina Brizmohun [a, b], Toolseeram Ramjeawon [a], Adisa Azapagic [b, *]

[a] Faculty of Engineering, University of Mauritius, Réduit, Mauritius
[b] School of Chemical Engineering and Analytical Science, The Mill, Sackville Street, The University of Manchester, Manchester M13 9PL, UK

ARTICLE INFO

Article history:
Received 15 October 2013
Received in revised form
8 November 2014
Accepted 9 November 2014
Available online 15 November 2014

Keywords:
Electricity generation
Life cycle assessment
Environmental impacts
Mauritius

ABSTRACT

Electricity demand in Mauritius is growing rapidly but its environmental implications are as yet unknown. This is the topic of the current paper which presents for the first time the life cycle environmental impacts of electricity generation in Mauritius aiming to inform electricity generators and policy makers on how the impacts could be reduced. The majority of country's electricity is generated from fossil fuels, with coal contributing 40% and fuel oil 37%; the rest is from sugarcane bagasse (19%) and hydro-power (4%). The results suggest that electricity from oil has the highest impacts for six out of ten categories considered compared to the other three sources: acidification, freshwater, terrestrial and human toxicity, ozone layer depletion and photochemical oxidants. The remaining four impacts (depletion of resources, global warming, eutrophication and marine toxicity) are highest for coal. The lowest impacts are found for electricity from hydro-power. For example, the global warming potential (GWP) of electricity from coal is estimated at 1444 kg CO_2 eq./MWh and for oil 754 kg CO_2 eq./MWh, while for bagasse and hydro-power this impact is several orders of magnitude lower (29 and 8.6 kg CO_2 eq./MWh, respectively). Oil and coal are the main contributors to the overall impacts from electricity in Mauritius (88%–99%). The contribution of bagasse is small (<1%–12%) and that from hydro-power negligible (<0.1%). The GWP of the electricity mix is estimated at 868 kg CO_2 eq./MWh. This is equivalent to the annual GWP of 2.22 Mt CO_2 eq. in 2012, an increase of 16% since 2007. To reduce its carbon emissions, Mauritius should consider reducing the share of fossil fuels through increased use of renewables such as solar PV and wind as well as improving the efficiency of the fossil power plants and reducing energy demand.

1. Introduction

Global energy consumption is projected to double by 2040 compared to the demand in 2010, with the largest increase expected in the developing world (EIA, 2013). Being a rapidly developing country, energy demand in Mauritius is also growing, in particular its electricity consumption, which increased by 66% in the period from 2001 to 2012 (see Fig. 1). The largest consumer of electricity in Mauritius is the commercial sector, including tourism, information and communication technologies, financial services and real estate (36% in 2012), followed by households (33%) and industry (30%) (CEB, 2013; CSO, 2012). It is predicted that, with the growth and diversification of the economy, the electricity demand will continue to increase (CEB, 2013).

As illustrated in Fig. 2, the main sources of electricity in Mauritius are coal (~40%), fuel oil (~37%), sugarcane bagasse (~19%) and hydro (~3.6%), with their contribution remaining pretty constant since 2007. Around 60% of national demand is supplied by the Central Electricity Board (CEB, 2008), the sole national electricity supply corporation responsible for electricity generation, transmission and distribution. The rest is provided by Independent Power Producers (IPPs) who are associated with the sugar sector and use bagasse to generate electricity during sugarcane crop season.

Given the high contribution of fossil fuels to the electricity mix (~77%) and the expected future demand growth (CEB, 2013), it is important to understand environmental implications of different electricity options for Mauritius to help identify sustainable pathways for meeting the demand. However, although the Mauritius Government has pledged to reduce the environmental impacts and particularly greenhouse gas (GHG) emissions from the energy sector by 30% by 2025 by increasing the share of renewables to 35% (GOM, 2007; MREPU, 2009), the full environmental implications of current electricity generation are unknown.

* Corresponding author. Tel.: +44 (0) 161 306 4363.
E-mail address: adisa.azapagic@manchester.ac.uk (A. Azapagic).

http://dx.doi.org/10.1016/j.jclepro.2014.11.033
0959-6526/

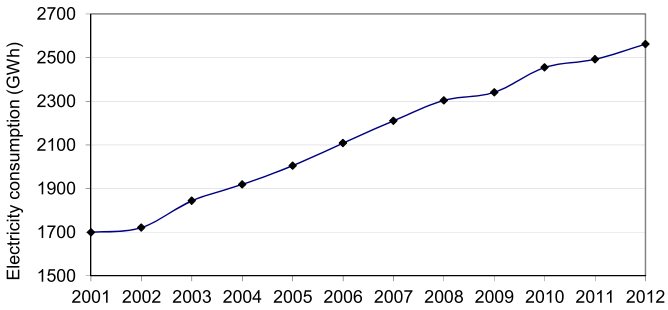

Fig. 1. Electricity consumption in Mauritius from 2001 to 2012 (based on data from CSO (2012)).

Therefore, this paper sets out to estimate the life cycle environmental impacts of electricity in Mauritius and provide baseline data for monitoring progress (or otherwise) in reducing the impacts from the sector. Although many life cycle assessment (LCA) studies of electricity have been carried out for different countries, as far as we are aware, there are no studies of electricity generation in Mauritius. The only exception is a study by Ramjeawon (2008) but that only considered electricity from bagasse rather than the whole electricity system.

The LCA studies of electricity generation for other countries include those for Japan (Hondo, 2005), Singapore (Kannan et al., 2007), Belgium and Spain (Foidart et al., 2010), Mexico (Santoyo-Castelazo et al., 2011), Nigeria (Gujba et al., 2011), the UK (Stamford and Azapagic, 2012) and Turkey (Atilgan and Azapagic, 2015), to name but a few. Many studies have also been carried out for individual electricity technologies as opposed to an electricity mix. Those relevant to the technologies present in the Mauritius electricity mix include studies of coal and oil by Hondo (2005), Santoyo-Castelazo et al. (2011) and Peiu (2007); sugarcane bagasse by Ramjeawon (2008), Renouf et al. (2011) and Lopes Silva et al. (2012); and hydro-power by Gagnon et al. (2002), Góralczyk (2003) and Suwanit and Gheewala (2011). The results obtained in some of these studies are compared to the results obtained in the current study later in the paper (Section 3.2). Prior to that, the following section details the methodology used in the study, together with the data and the assumptions. This is followed by the discussion of results in Section 3 and conclusions in Section 4.

2. Methods

The LCA methodology applied in this work follows the ISO 14040 and 14044 standards (ISO, 2006a; b). The LCA software SimaPro 7 (PRé Consultants, 2008) has been used to model the system. The impacts have been estimated according to the CML 2 Baseline 2001 method (Guinée et al., 2001). This is a problem-oriented method, often referred to as a 'midpoint' approach, because it considers environmental burdens at an intermediate point between the point of intervention (extraction of resources or emissions to the environment) and the ultimate damage caused by that intervention. This method has been chosen here as one of the most commonly used to allow comparison of our results with other relevant studies.

The impact categories included in the CML method and considered in this study are: global warming potential (GWP), abiotic depletion potential (ADP), acidification potential (AP), eutrophication potential (EP), human toxicity potential (HTP), freshwater aquatic ecotoxicity potential (FAETP), marine aquatic ecotoxicity potential (MAETP), ozone layer depletion (ODP), photochemical oxidants creation potential (POCP) and terrestrial ecotoxicity potential (TETP). The impacts are calculated based on the global impact ('characterisation') factors for most categories, except for the AP and POCP which refer to European conditions. Although the latter is a limitation, no other method relates these impacts specifically to Mauritius or Africa.

2.1. Goal and scope definition

The goal of the study is to estimate the life cycle environmental impacts of electricity generation in Mauritius. As illustrated in Fig. 3, the scope of the study is from 'cradle to consumer', considering the following stages:

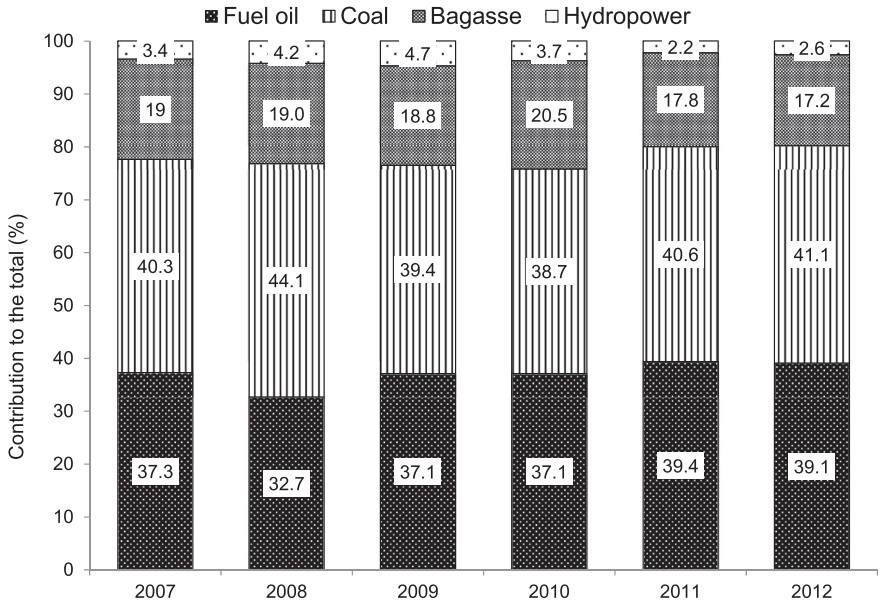

Fig. 2. Electricity mix in Mauritius over the period 2007–2012.
Source: CSO (2012).