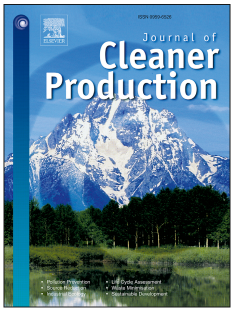
Accepted Manuscript



Determining the consequential life cycle greenhouse gas emissions of increased rooftop photovoltaic deployment

Christopher Jones, Paul Gilbert

PII: S0959-6526(18)30453-0

DOI: 10.1016/j.jclepro.2018.02.140

Reference: JCLP 12087

To appear in: *Journal of Cleaner Production*

Received Date: 15 June 2017

Revised Date: 12 February 2018

Accepted Date: 13 February 2018

Please cite this article as: Jones C, Gilbert P, Determining the consequential life cycle greenhouse gas emissions of increased rooftop photovoltaic deployment, *Journal of Cleaner Production* (2018), doi: 10.1016/j.jclepro.2018.02.140.

Determining the Consequential Life Cycle Greenhouse Gas Emissions of Increased Rooftop Photovoltaic Deployment

Christopher Jones[a*] c.w.jones@manchester.ac.uk, Paul Gilbert[a] p.j.gilbert@manchester.ac.uk,

[*]Corresponding author

[a] Tyndall Centre for Climate Change Research, School of Mechanical, Aerospace and Civil Engineering, University of Manchester, United Kingdom, M13 9PL

Abstract:

Increased power flows on electricity distribution networks, caused by growing photovoltaics (PV) uptake, can result in the implementation of solutions to maintain network function. This study takes a consequential life cycle assessment (LCA) approach to assess the greenhouse gas emissions (GHG) of aggregated PV electricity generation at the distribution network level. The study also considers how future changes in the manufacturing phase of Chinese and Malaysian PV modules, over the period of increasing PV deployment, may affect their GHG emissions. The study finds rooftop PV life cycle values of 21 to 107 gCO2e/kWh, for various UK PV output yield estimates and module types (Chinese made mono-crystalline (c-Si) and multi-crystalline silicon (Mc-Si), and Malaysian made cadmium telluride (CdTe)) installed in 2015. Prospective assessment of proposed future material efficiency and grid decarbonisation reduces the range to 21 to 87 gCO2e/kWh for modules installed after 2030. Consequential life cycle emissions from network solutions to accommodate growing PV generation shows increased GHG emissions attributable to PV by up to 13% (c-Si and Mc-Si) and 17% (CdTe) where 100% of network users connected install rooftop PV. There is however only a negligible increase in emissions if <60% of network users install PV. Voltage control solutions to network constraints caused by PV are found to minimise the contribution of network solutions to aggregated PV life cycle emissions to 2% (c-Si and Mc-Si) and 6% (CdTe) at 100% user uptake. The study concludes that even with network solution for high penetrations of rooftop PV, there is a minimal (<6% with voltage control) increase in PV GHG emissions when assessed at a network level. Future changes in PV manufacturing could offset the effect of network solutions.
Keywords: LCA; consequential LCA; PV; electricity distribution networks; decarbonisation

1. INTRODUCTION

The global impacts from climate change are a major driver for changes in national electricity systems, meaning that countries are seeking to implement strategies for reducing their emissions of greenhouse gases (GHG) (UNFCCC, 2015). A period of cost reductions for solar photovoltaics (PV) has seen it become a significant pathway for decarbonising such systems (Fraunhofer ISE, 2015), including in regions with relatively low solar irradiance such as the UK (Barnham et al., 2013). While overall global PV capacity remains below 1% of electricity generation (Fraunhofer ISE, 2015), in some countries it is already a significant proportion of the electricity mix, such as Germany where 7.4% of electricity consumption annual was met by PV in 2016 (Wirth, 2017),.