Renewable Energy 66 (2014) 62–68

Contents lists available at ScienceDirect

Renewable Energy

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

Carbon neutral mine site villages: Myth or reality?

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ARTICLE INFO

Article history:
Received 14 October 2013
Accepted 19 November 2013
Available online 20 December 2013

Keywords:
Carbon neutral
Carbon reduction
Mine site villages
LCA
NPC

ABSTRACT

This paper focuses on the calculation of the carbon footprint of a typical West Australian mine site village and the ways by which it can be reduced to a point where the village can be legitimately described as 'carbon neutral'. The study contributes to a broader ARC joint research program by Murdoch and Curtin Universities entitled 'Decarbonising Cities and Regions'.

The term carbon neutral has a far from uniform definition. For the purpose of the carbon accounting that follows carbon neutrality is achieved when there is a net zero carbon footprint across the full life cycle or when total emissions are balanced by total offsets. As much of the full life cycle of the village as is practical is included in the process and acknowledges any omissions made. The paper will show how the carbon footprint of a mine site village in Western Australia's mid-west has been measured, calculated and reduced effectively to a point where carbon neutrality can be claimed. This will commence with calculation of the embodied and operational energy in constructing and operating the village, followed by methods towards achieving carbon neutrality. The latter includes energy efficiency opportunities; an environmental and economic sustainability assessment of renewable energy and construction materials; design modification of the infrastructure; and assessment of accredited biomass offset mechanisms. The whole process has been termed LEVI©, Low Energy Village Infrastructure.

An economic assessment of the carbon neutral strategy is the key to implementation. Mining companies are particularly drawn to the 'bottom line' when making investment decisions and only sound financial analysis will facilitate substantial carbon neutral expenditure. LEVI© significantly includes a net present cost (NPC) analysis of all such investment and belies the myth that carbon neutral mine site accommodation cannot be achieved. The paper then presents a carbon accounting methodology of the case study mine site village and set out the results and overall carbon emissions the village is responsible for. This life cycle analysis (LCA) is done from cradle to gate in terms of LCA terminology and represents the manufacture, construction, installation and operation. Energy efficiencies and behavioural changes are then applied and estimated as to their carbon reductive effect on the total carbon, followed by verifiable renewable energy offsets. These offsets are substantiated by a vigorous renewable energy analysis and selection supported by an NPC analysis. An optimum renewable energy system (RE) is then selected (best value for money) and its carbon reducing effect over the current power system calculated. This amount, together with that produced by energy efficiencies and behavioural changes, makes a total carbon reduction and is annualised.

The paper clearly shows that the projected life of the mine, and therefore the village, is a critical factor in the overall carbon analysis and that the optimum time period within which carbon neutrality of such a mine site village can be claimed lays somewhere between 7 and 10 years. Another key finding was that the capital expenditure (CAPEX) savings by developing such a village as a standalone facility produces clear advantages over connection to a mine power generation system as is the case study example. The optimum standalone RE system for introduction from 2014 was found to be 110 kW fixed amorphous photovoltaic array and two 100 kW wind turbines with one 150 kW and one 100 kW low-cycle diesel generators as a backup. The projected cost was approximately $2 million.

It is contended that the metrics produced from the results can provide a pro-rata basis with which to model future carbon neutral villages of similar construction. The model accommodates dependencies such as life of mine, size of village, number of workers and location. The paper will describe some innovative solutions and outcomes from this research that may be applied to the built environment on a broader scale.

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0960-1481/$ – see front matter © 2013 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.renene.2013.11.058

1. Introduction

Access to a typical mine site village was essential for the research and determination of the carbon footprint during its life cycle from manufacture to operation. Black Cat Camp (MMG) in Mt. Magnet, Western Australia, owned by Ramelius Resources Ltd. (RMS) was agreed to be the site of this study. Flights and access over the research period were made available by RMS for installation of an extensive online monitoring system and information gathering from the staff operating the camp. Data has been collected for 20 months from 44 power circuits and 7 water meters the analysis of which has been completed. MMG is typical of many throughout the nation, if not the world, in that it is made up of lightweight transportable accommodation and amenities buildings shipped to site by road, accessible by road and air.

Five main research questions form the essence of this paper:

1. What is the carbon footprint of a typical mine site village?
2. In the context of mine site village development what does the term “carbon neutral” mean?
3. What are the constituents of this footprint and how are they calculated?
4. How can the footprint be sustainably reduced to a point of carbon neutrality?
5. Is the Carbon Neutral mine site village a viable proposition or merely a desirable objective in the context of sustainable development of the built environment?

Following sections will answer these research questions and include: a methodology and conceptual model of the carbon accounting process with emphasis on the boundaries of such an LCA, limitations of the study, the tools used and understanding of carbon neutrality in the context of this research; a results section of the carbon emissions of MMG over village lifespans of 5, 10, 15 and 20 years; conclusions and recommendations to achieve carbon neutrality in future mine site villages and application to the built environment more generally. For the purpose of comparison of the results with per capita carbon emissions attributed in the literature the overall emissions calculated in this research is divided by 162 which is the individual capacity of MMG. This highlights the magnitude of how dramatically a fly-in fly-out working regime can increase a person’s annual carbon footprint just by going to work. Once established the carbon account needs to be offset by considering energy efficiency and behaviour change measures followed by renewable energy offsets. A final mechanism to achieve carbon neutrality is not considered here, that is the purchase of permits emanating from accredited forestry or alternative biomass.

A definition of the term ‘Carbon Neutral’ answers Q2 above. The term has been defined largely by popular usage in the past [10]. Even within scientific literature the academic definitions are few and varied, despite a raft of papers on life cycle analysis, input and output methods and tools for carbon accounting, especially when considering which emissions of the built form life cycle are actually to be included [16]. Ref. [10] discusses the terms ‘carbon neutral’ and ‘carbon footprint’ with several references on the subject [6]. In the context of this paper the calculation of the carbon footprint is regarded as comprising of the carbon emissions from the life cycle of the mine site village that can reasonably be calculated, from a clear site for development through to the end of life estimated to be between 5 and 20 years.

2. Methods

Previous research has developed a conceptual model (Fig. 1 below) to organise calculation of the carbon emissions MMG is responsible for [6]. The areas of emission accounting are set out in Fig. 2 below.

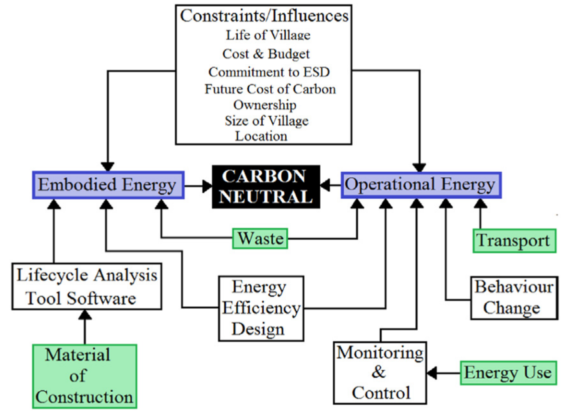

Fig. 1. Conceptual model for calculating carbon neutrality in mine site villages.

2.1. Embodied energy

Three methods were used to calculate the embodied energy of MMG: carbon inventory analysis of scope 1 and 2 emissions, as defined by the Commonwealth Government [3]; life cycle analysis (LCA), a method supported by the International Energy Association outlined in AS/NZS ISO standard *14040:2006* which states that the assessment is conducted for impacts throughout a product’s life, in this case from ‘cradle to gate’; and finally, carbon profiling, a modification of LCA to include the emissions associated with land development itself according to the fuel consumed and its emissions factor when applied to a specific location [7]. The carbon account requires the system boundaries of where the responsibility for the emissions lay to be defined.

Once the overall footprint of the village is calculated, following the National Carbon Offset Standard guidelines [11] then process of offsetting begins. This included: reduction of the embodied energy of construction; implementation of operational energy efficiency measures; renewable energy system offsets to achieve carbon neutrality within a defined period achieved, each process measured by the mass of carbon they are reduced by. The energy efficiency measures and behavioural changes, in terms of carbon reduction, could only be estimated at this stage using personal experience across the building industry. The results are tabled in Section 3 along with quantification of Table 1.

2.2. Explanation of Table 1

2.2.1. Accommodation & general buildings

The embodied energy of buildings, and the infrastructure to service them, consumes up to 40% of global energy consumption

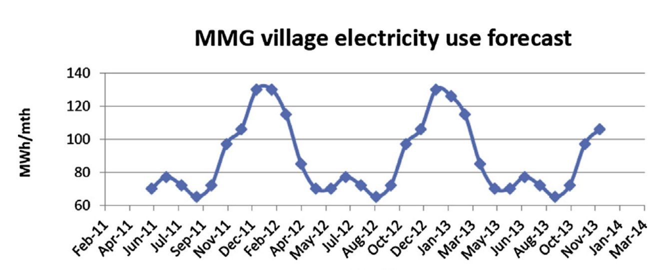

Fig. 2. MMG village electricity use forecast from June 2011 to November 2013 (BEC engineering, 2011).