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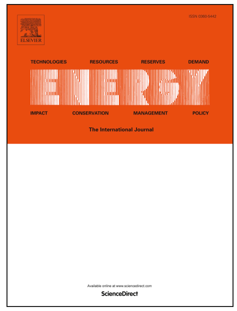

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Computing Life-Cycle Emissions from Transitioning the Electricity Sector Using a Discrete Numerical Approach

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Abstract

We present a discrete numerical computational approach for modelling the CO_2eq emissions when transitioning from existing legacy electricity production technologies based on fossil fuels, to new and potentially sustainable alternatives based on renewable energy. This approach addresses the dynamic nature of the transition, where the degree of transition has an ongoing, beneficial and compounding effect on future technological deployments. In other words, as the energy system evolves, renewable energy technologies are made increasingly with renewable energy, thus becoming renewable energy 'breeders'. We apply this routine to four previously published scenarios for the transition of the Australian electricity sector, which at present accounts for about one-third of the country's annual CO_2eq emissions. We find that three of the four scenarios fail to satisfy the electricity sector's proportion of Australia's share of the 2.0°C/66% IPCC carbon budget, and none of them achieves the 1.5°C budget. Only the High Carbon Price scenario could be deemed to have made any meaningful impact. An urgent, rapid transition to 100% renewable energy must be made in the whole energy sector, not just electricity, if the 1.5°C budget is to be satisfied.

Keywords: Renewable Energy, Scenario, Life Cycle Analysis, Discrete Numerical Computation, Dynamic Model

1. Introduction

As the major economies of the world face increasing pressure to meet the various international accords and agreements with regard to acceptable cumulative greenhouse gas (GHG) emissions over the forward century, challenges arise when attempting to model an energy system, which, almost certainly will need to be turned completely on its head if these agreements are to be satisfied. Presently ratified by just-under two-thirds of all parties to the United Nations Framework Convention on Climate Change and coming into effect on 4 November 2016, the Paris Agreement[28] has set a global goal to limit mean global temperature to well below 2°C, if possible to 1.5°C, relative to pre-industrial levels. The parties that have currently ratified the agreement in total contribute over 80% of global emissions so perhaps the immediate half-century will witness the single largest transition in energy supply that post-industrial human society experiences.

Under the assumption that the above agreements are necessary and valid, in order to facilitate the radical changes required, almost all nations throughout the globe will be required to modify how they produce their energy. The question addressed in his paper is the calculation of GHG emissions resulting from transitioning the electricity sector from fossil fuels to renewable energy, taking into account both life-cycle emissions and dynamic effects.

Life-Cycle Assessment (LCA)[15, 16, 17, 32] and Input-Output (IO) modeling[26, 27] remain powerful tools to understand, respectively, the cradle-to-grave emissions and the resources required per unit of production. However, from a macro perspective, when modeling such a drastic shift in the paradigm of how energy is produced, this problem becomes inherently dynamic in nature. In 20-50 years, the ensemble of technologies may have changed from

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