Applied Energy 219 (2018) 187–198

Contents lists available at ScienceDirect

Applied Energy

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

Prioritizing mitigation efforts considering co-benefits, equity and energy justice: Fossil fuel to renewable energy transition pathways

Andrew J. Chapman[a,*], Benjamin C. McLellan[b], Tetsuo Tezuka[b]

[a] International Institute for Carbon-Neutral Energy Research (I²CNER), Kyushu University, 744 Motooka Nishi-ku, Fukuoka 819-0395, Japan
[b] Graduate School of Energy Science, Kyoto University, Yoshida Honmachi, Sakyo-ku, Kyoto 606-8501, Japan

HIGHLIGHTS

- Qualitatively evaluates the energy policy impacts of transition from coal to RE.
- Augments mitigation cost curves to encompass social impacts.
- Incorporates social and energy justice ideals to energy policy making.
- Findings can guide policy development processes which prioritize sustainability.

ARTICLE INFO

Keywords:
Equity
Energy justice
Health
Employment
Transition
Renewable energy

ABSTRACT

Transitioning from fossil fuels to renewable energy (RE) is one of the core strategies in developing sustainable future energy systems. But in planning such a transition, it is common to consider primarily cost and greenhouse gas reduction, as typified by cost-mitigation curves that have become widespread. Such assessments tend to leave important considerations of energy justice on the periphery. This paper puts forward an alternative assessment technique, incorporating various indicators of social equity in order to assess the priority of power plant replacement that would lead to the greatest improvement in benefits, while placing the burden of system changes away from the most vulnerable. An example of the application of this approach is presented for prioritization of the retirement and replacement (with RE) of Australia s ageing fleet of coal-fired power plants. The assessment shows very different results from a standard cost-mitigation approach, with the retirement of the large brown coal power plants (including the recently retired Hazelwood power plant) and the replacement with wind power (where applicable) promoting the best overall outcomes on both cost and equity. Considering a selection of high priority indicators with many locally-specific data sets, the approach adds significant contextual relevance to prioritization, and is considered to offer useful findings for policy-makers.

1. Introduction

Transitioning to a sustainable energy system is an important component of global sustainable development goals [1], and an important priority within these goals is the reduction of the use of fossil fuels and subsequent emissions of greenhouse gases (GHG), in order to reduce the possibility of excessive climate change [2]. Mitigation or abatement cost-curves are often used to compare the potential economic competitiveness and absolute mitigation potential of alternative measures [3]. However, as has been argued elsewhere [4–6], the co-benefits approach to evaluating mitigation technologies or efforts can often show alternative value associated with GHG reduction strategies that can potentially provide greater motivation for making such investments. Viewed from a different angle, it has been identified [7] that there is a lack of consideration of the holistic environmental, economic and particularly social impacts of energy policy. The equitable distribution of benefits, a key consideration of energy justice, and impacts of energy policy are addressed only after the policy is in place, if at all [8]. In this paper, we apply a multi-indicator evaluation, which quantitatively evaluates the distribution of social equity alongside traditional evaluation criteria, to examine a more-holistic prioritization of alternative mitigation choices in Australia, as an example.

Australia has one of the highest greenhouse gas emissions levels per capita among developed nations, due largely to its heavy reliance on black and brown coal within the electricity generation system which, in the case of the National Electricity Market (NEM) accounts for 74% of

* Corresponding author.
E-mail address: chapman@i2cner.kyushu-u.ac.jp (A.J. Chapman).

https://doi.org/10.1016/j.apenergy.2018.03.054
Received 4 October 2017; Received in revised form 6 March 2018; Accepted 19 March 2018

electricity output [9].

One strategy to ameliorate this dependence on coal-fired power generation and to reap the benefits of reduced greenhouse gas emissions and other pollutants is to retire coal-fired power plants, replacing them with renewable energy (RE) based alternatives. Due to the scale of Australia's largest (and most polluting) coal-fired power stations (13 generating complexes ranging from 1000 MWe to 2840 MWe are considered in this paper) this transition requires a massive deployment of RE in order to replace the lost generation within the NEM. This large scale (mega) wind or solar (PV) deployment which replaces coal-fired generation will have multiple impacts on both the energy system and society.

Building on the Energy Policy Sustainability Evaluation Framework (EPSEF) developed by the authors [7], an evaluation methodology is constructed to consider the employment, health, electricity price and greenhouse gas impacts of the transition from coal-fired to RE based generation.

The overall aim of this study is to determine a priority order for the retirement of the NEM's largest (> 1000 MWe) coal-fired power stations based on a range of Australian policy sustainability impacts, considering multiple policy priorities – particularly considering the energy justice ideal of the equitable distribution of benefits and impacts across society.

1.1. Fossil fuel to renewable energy transitions evaluation and energy justice considerations

A review of recent literature which evaluates energy transitions, specifically from fossil fuel to RE alternatives has identified that their focus is almost exclusively on the technological, environmental and economic outcomes, with limited concern for social impacts. For example, Wang et al. found that research related to a transition to low-carbon electricity followed trends over time, focusing on technological responses [10]. These began with a recognition of the reliance on coal and nuclear baseload generation in the 1990's, generating an interest in the low-carbon alternatives of wind and CCS by the 2000's, followed by PV and natural gas in the 2010's. Energy efficiency was a constantly prominent research focus throughout, and the authors identify policy analysis and lifecycle assessment as future focuses. In terms of specific transitions from coal to alternative energy sources, Fakhry investigates the United States as a case study nation retiring coal in favor of renewable alternatives [11]. Her findings suggest that coal retirement offers an opportunity to transition to RE generation which will increase resilience while reducing emissions at a lower cost than the status quo. Through a regulation based approach it is identified that energy efficiency, and integration of RE into a responsive grid will deliver environmental and economic benefits to households and businesses. In an analysis of the Chinese transition to a sustainable energy system, Sun et al. assess 5 factors including the systemic factors of total capacity and excess generation, one economic factor of total annual costs, one environmental factor of CO_2 emissions, and one social factor, direct job creation [12]. This small set of factors is used to assess sustainability, based on scenario energy mixes, and the authors identify the need for policy intervention to encourage greater RE deployment and cost as a barrier to a clean energy transition. In assessing the transition a more sustainable, lower emission generation supply in developing countries, Merzic et al. consider three aspects of sustainability: techno-economic indicators, environmental indicators and social indicators [13]. However, while economic and environmental indicators are robust, including a number of factors, social indicators only incorporate employment opportunities and electricity availability in qualitative terms, providing a ranking for each assessed scenario. It is common in the literature to find "social welfare" and "social impacts" being addressed by a single indicator – cost of electricity in the former case [14,15], and jobs in the latter [16]. Some studies – particularly those addressing external costs of energy supply – have utilized health impacts, for example one study compared RE to energy efficiency [17]. None of these studies focuses heavily on social impacts, even when their goal is to assess sustainability.

The concept of energy justice provides an avenue to bring social impacts of energy policy to the fore. In academic terms energy justice is a relatively recent phenomenon, studied as a defined concept since 2013 [18]. The energy justice research agenda seeks to apply justice principles to broader energy issues and policy [19], and is sometimes divided into three tenets, namely distributional, procedural and recognitional justice [20]. Distributional justice is concerned with how the benefits and burdens of energy policy implementation are shared across society, i.e. who pays, who benefits, and why [21]. Procedural justice on the other hand is concerned with an open and fair policy decision making process, such that all stakeholders have a voice, and the ability to participate in a meaningful way [20]. Finally, justice as recognition seeks to identify groups who are misrepresented or discriminated against as a result of policy outcomes due to their views, social standing, cultural background or gender [19].

Distributional justice has been somewhat of a focus in Germany in particular, due to the large uptake of renewables and the question of affordability of the feed-in-tariff (FiT). One study examined the household expenditure as an indicator of social impact, finding greater impact on poorer households from increasing energy prices [22]. Others have applied the Atkinson Index as a measure of societal inequality to study social welfare impacts [23] and sustainability [24] as a result of the German energy transition. But in these cases it is a national level consideration of energy justice that does not focus on specific locations or a ranking of technologies.

In terms of combining energy justice and energy transitions, in the short history of this research field, national level analyses have emerged. A pertinent example is that of the US, and the movement away from coal and oil based generation toward RE alternatives [25]. This analysis considers the energy justice risks and opportunities for the implementation of five decarbonization strategies: divestment, carbon tax, cap and trade, deploying renewable energy and energy efficiency. The analysis brings energy justice concerns to the fore, identifying risks and opportunities for distributive, procedural and recognition justice across each decarbonization strategy. Disproportionate burden allocation in the energy sector is identified as an issue, in qualitative terms including 'clusters of ill health' and risks for politically and economically marginalized populations. Analysis of the UK, specifically with regard to nuclear power incentivization has also been undertaken, focusing on procedural justice, specifically transparency in allocating responsibilities.

Focusing on divestment, Healy and Barry identify the need for a rapid transition from fossil fuel based energy, agro-food and transport to low-carbon systems [26]. Their focus is on the role of divestment in the political economy, in a "just" transition process. They pursue this analysis considering the democratizing of energy system transitions in order to deliver energy justice, considering fossil fuel divestment and associated labor issues. To accelerate the phase out of fossil fuels, the necessity for political action by civil society is highlighted, so as to reduce injustices in the transition, and to ensure that the transition is democratic. They identify the specific delegitimization of carbon as a possible approach, through the articulation of negative impacts and how these negatively affect not only the environment but also exploited communities at the point of extraction.

Jenkins et al. identify the need to not only make energy policy participatory and more transparent, but a need to engage with energy justice concepts in order to overcome a moral vacuum in energy decision making [27]. They advocate policy frameworks which prioritize transparency, such that the positive and negative energy justice implications can be identified and responsibility for these implications can be allocated.