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Original article

An alternative to carbon taxes to finance renewable energy systems and offset hydrocarbon based greenhouse gas emissions

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ABSTRACT

Carbon taxes are frequently proposed as a means to mitigate the hydrocarbon industry's environmental impact. This paper assesses the potential benefits of an alternative to carbon taxes (ACT), where hydrocarbon producers directly invest a fixed amount per unit produced into renewable energy systems (e.g., wind farms). Producers maintain ownership of the assets and reinvest a portion of revenue from them to further grow the renewable assets. This proposal could help producers gradually evolve from hydrocarbon to renewable energy companies – avoiding the job losses associated with sudden industry shifts. We present an in-depth case study of the Athabasca oil sands, and extend the results to other regions. We find that wind turbines purchased with an ACT of $12/barrel where $0.03/kWh of produced power is reinvested could offset all the greenhouse gas emissions from extracting and refining the region's bitumen, provided wind turbines were located at good wind sites. Finally, to increase the grid's ability to use the wind power generated, energy storage and grid systems should also be an option for ACT investing. Future work should focus on North Dakota, which has extensive hydrocarbon resources collocated with good wind resources.

Introduction

The production and utilization of hydrocarbon resources is increasingly of concern with regard to global warming issues. The production of the Athabasca oil sands, for example, is particularly contentious due to the energy requirements for mining and the nature of the oil extracted; however, it is an integral part of the Albertan economy [1]. The denial of the Keystone XL Pipeline sent a clear signal that the perceived environmental impact of the oil sands is preventing its growth. Accordingly, there has been renewed interest in increasing carbon taxes in Alberta to C$30 (Canadian dollars) per ton of carbon dioxide (CO_2) in 2018 [2]. Traditional carbon tax schemes have two potential issues: first, the revenue collected can be diverted by political action to other perceived important but non-environmental issues, which for example has happened with some U.S. state tobacco taxes [3]; and second, corporations typically oppose perceived business harm induced by downstream tariffs/taxes.

To investigate an alternative to a carbon tax, this paper studies three questions:

1. How much of the GHG emissions of hydrocarbon (e.g. oil) production and use could be offset by a commensurate investment in renewable energy systems (e.g. wind power)?
2. Could such a scheme be achieved if hydrocarbon producers invested a fixed fee per unit (e.g. $/barrel) produced into renewable energy systems, where they maintained ownership of the asset, instead of having a carbon tax where they pay the tax to the government?
3. Does this become more financially viable if hydrocarbon production companies also reinvest a fraction of the revenues from electricity generation from the renewable energy systems into growing the renewables resource?

To answer these questions quantitatively, we present an in-depth case study examining the Athabasca oil sands. The Athabasca oil sands produce bitumen as a raw product through a diverse set of extraction methods. The bitumen is then processed, upgraded, and/or refined by one of several methods. To focus on evaluating these three questions, this paper simplifies the process diversity by using an average value for the GHG emissions of refined oil derived from the oil sands on the basis of a barrel of refined product.

The Athabasca region has been devastated by the drop in oil prices, which have fallen from a 2013 average (in Cushing,

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Nomenclature

$	U.S. Dollar	GHG	greenhouse gas
ACT	alternative to carbon tax	kWh	kilowatt hour
bbl	barrel	kWh_{wind}	kilowatt hour of electricity generated by wind power
C$	Canadian Dollar	MT	megatons
CO_2	carbon dioxide	SM	supplemental material
CO_2e	CO_2 equivalent	U.S.	United States

Oklahoma of West Texas Intermediate) of $98 (U.S. dollars) per barrel (bbl) to a 2015 average of $50/bbl [4]; $50 is close to, if not below, the cost of producing and upgrading bitumen from the oil sands [5]. Morgan Stanley estimates crude oil production costs from the oil sands are between $47–$84/bbl, which is significantly higher than Middle East oil production which costs between $10–$36/bbl [5]. Canada's largest synthetic crude oil producer announced in August 2015 that its break-even production cost for refinery-ready crude oil was $43.46/bbl and $47.27 for fully upgraded crude oil [6]. Because of low market prices for crude oil, schemes to offset environmental impact must be creatively funded and cost efficient.

The answers to these three questions are inevitably influenced by the wind speeds in the Athabasca region, which are not high. Lower wind speeds imply that an investment in wind energy as a renewable energy source would be more efficient if sited elsewhere. However, given the massive GHG emissions of the Athabasca oil sands and their large land footprint, we nevertheless set out to understand how much benefit could be gained from wind power in the region. The sensitivity study of this scheme will help to quantitatively assess the viability of similar schemes in higher wind areas.

As a benchmark for any GHG reduction scheme, California's 2015 cap and trade prices for greenhouse gas (GHG) emissions have ranged from $11–$13/ton of CO_2 equivalent (CO_2e) [7]. Creyts et al. reported that for less than $50/ ton of CO_2e, the U.S. could offset between 1300 and 4500 megatons (MT) of CO_2e annually [8]. Therefore, viable mitigation schemes need to be more cost efficient than $50/ ton of CO_2e.

The framing of the three questions we set out to investigate assumes a model of corporate ownership that has been typical of the U.S.' history of wind power development [9]. Models of corporately owned wind farms neglect the European experience that has shown that community owned wind projects: reduce community resistance to wind projects, access capital at a cheaper rate than debt-based financing of limited-liability corporate entities, and create smaller projects that are distributed more evenly across the grid [9]. However, due to the scale of the Athabasca oil sands and their GHG emissions, an equally large wind project will be required. At this scale, community-owned projects are not typically an option. We however note that before the full-scale project would begin, community-owned and financed wind power projects could help to increase community buy-in and build momentum for the larger project.

Typically large wind projects are financed using a limited liability structure which shifts the project risk onto the lending agency [9]. This financing model increases the cost of capital and slows down the project evaluation phase [9]. The proposed scheme would fund the wind farm with a per-barrel fee – thus enabling a debt-free funding source and allowing the use of limited-liability structures without their typical drawbacks. With oil companies having direct ownership of the asset, they are apt to care more about its success, and will with time learn how to manage the resource as they potentially transform themselves into renewable energy companies.

Public opposition to wind projects is nuanced [10,11]; the most common reason for public resistance to major wind farms is the undesirable visual impact of wind farms [11,12]. As such, we note that one additional benefit to co-locating wind turbines with oil extraction sites is that these sites are typically far from the public eye and are already aesthetically compromised.

In this paper we present a Excel-based Modeling tool to test the hypothesis that allowing oil producers to invest in on-site or if needed remote wind turbines, instead of being subject to a government-collected carbon tax, can help to offset the GHG emissions from the production and end-use of crude oil from the oil sands. The tool also allows for including the condition that producers reinvest a fraction of the revenue from the wind turbines towards the installation of more wind turbines.

Methods

An Excel-based modeling tool

Uncertainty is high with projects such as the one proposed in this paper; we address this uncertainty by clearly stating the values we have used in the model and by providing the Microsoft Excel-based modeling tool in the Supplementary Material (SM) so that readers can adjust model inputs to match their circumstances, location, or perspective on what an appropriate value should be for any one of the many estimations made in this paper (Fig. 1). (For more details on fine-tuning the model, see the SM.)

The use of U.S. dollars for currency accounting

Most of the published cost and price estimates for wind turbines and crude oil are reported in U.S. Dollars ($). Given the volatility of the U.S.–Canada exchange rates from 2000–2015, the model's accuracy would be compromised by working in Canadian dollars (C$) [13]. Instead, U.S. Dollars are used exclusively and where needed converted for reference to Canadian dollars using a rate of C$1 = 0.75$ [13]. As such, these findings exclude currency exchange risk.

Accounting for the GHG emissions of the Athabasca oil sands

To account for the climate impact of the Athabasca oil sands, we use the metric of CO_2e per barrel of refined crude oil (CO_2e/bbl). We account for these GHG emissions by using three categories:

1. *incremental emissions*: the difference in GHG emissions between crude oil derived from the oil sands and the 2005 average GHG emissions of crude oil refined in the US;
2. *production emissions:* the total GHG emissions caused by production, upgrading, refining, and transportation of crude oil from the oil sands (well-to-tank); and
3. *total emissions:* the total GHG emissions caused by all steps from production through end consumption of crude oil from the oil sands (well-to-wheel).