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Renewable and distributed resources in a post-Paris low carbon future: The key role and political economy of sustainable electricity

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ABSTRACT

Three recent "roadmap" analyses outline routes to a low-carbon economy that model the decarbonization of the electricity sector and the pervasive electrification of the transportation and industrial sectors. Using independent cost estimates and sequentially "relaxing" the constraints on resource selection, this paper compares the resource costs of the resulting portfolios of assets needed to meet the need for electricity. It supports the claim that the long run costs of the 100% renewable portfolios are less than business-as-usual portfolios, and finds that the "environmental merit order" of asset selection is quite close to the "economic merit order." Neither fossil fuels with carbon capture and storage nor nuclear power enters the least-cost, low-carbon portfolio. Rigorous least-cost constraints on decarbonization render the pollution constraint is superfluous. The paper evaluates the Paris Agreement on climate change in light of these findings. The Agreement is described as a progressive, mixed market economic model with a governance structure based on a polycentric, multi-stakeholder approach for management of a common pool resource. It also notes that the political economy of the Agreement is consistent with current academic analysis of policy responses to the challenges of climate change and management of a large, focal core resource system.

1. Introduction

1.1. Purpose

This paper argues that, while the recent Paris Agreement marks an important turning point in global policy toward climate change,[1] underlying technological and economic forces not only made this turning point possible, but also set its general direction. There is broad consensus that technology, primarily renewable and distributed generation and demand management, is available to respond to climate change. As a result, we are passing from the phase of technology assessment into a phase of scenario development, asset selection and institution building. The Paris agreement represents a strong move toward institution building, which tends to follow a technological breakthrough and the formation of a new techno-economic paradigm.[2]

The paper focuses on the decarbonization and expansion of the electricity sector as the platform on which decarbonization of the economy must be built for two reasons. The electricity sector is the largest source of greenhouse cases. In addition, it is also the best path to economy-wide decarbonization is through the electrification of the transportation and industrial sectors. There will certainly be challenges in the electrification of the broader economy that merit careful consideration, analysis and policy, but the transformation and expansion of the electricity sector is the key launch pad for the response to climate change. If that effort falters, the chances of successfully dealing with climate change will be dramatically reduced, if not eliminated. The bulk of the paper addresses the economics of decarbonization in the electricity sector.

1.2. Approach

In the run up to the Paris Conference on climate change, several major scenario studies were released with strong, positive messages for the economics of decarbonizing the electricity sector and electrifying the rest of the economy.

- Three "roadmap" studies of the route to decarbonizing the global economy were released. Two of these excluded all fossil fuels and

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[1] United Nations Framework Convention on Climate Change, 2015.
[2] Perez, 2002.

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nuclear power, relying solely on renewables (Jacobson et al. [74][3] for 139 countries and a Greenpeace study of climate change[4]). One of them focused only on decarbonization, allowing the use of fossil fuels with carbon capture and storage and nuclear power.[5]
- Two independent cost projections of various energy technologies were released – Lazard's annual estimate of the *Levelized Cost of Energy Analysis 9.0*[6] and the *Australian Power Generation Technology Report*[7] – both of which found that the costs of low-carbon, low-pollution resources continue to fall dramatically.

All of the roadmap studies project a sustainable path to a low-carbon future.[8] Using long-term price projections,[9] all three studies conclude that, as a result of the technological revolution in the electricity sector, the economy, in general, and the electricity sector, in particular, can be decarbonized with at most a very modest increase in the cost of energy services. All three studies envision continued, sustainable economic development, while delivering significant environmental and public health benefits.

The paper recognizes that other considerations can influence the selection of resources, like environmental impacts and uncertainty, but the analysis focuses on the economic cost of resources, which has traditionally been the first and primary consideration. The importance of economics is magnified by the challenge of system transformation in a context where the goal of continued economic growth and sustained standards of living is strong. It also reflects the fact that the harm of climate change has been frequently and powerfully represented as a question of economic costs, which sets up a cost benefit framework for evaluating low carbon resources.

This paper uses four lenses to examine the political economy of the current phase of the response to climate change.

- It places the studies in the context of the Paris Agreement.
- It uses the independent cost estimates to examine the robustness of the price assumptions that played a key role in the roadmap analyses.
- It uses a strictly economic lens to evaluate the roadmaps by asking how closely the portfolios of resources selected based on the environmental constraints resemble a portfolio of assets that would be assembled without those constraints.
- It concludes by applying a formal "theory" of asset acquisition (portfolio analysis) to the selection of electricity resources in the next couple of decades, which are considered vital to the effort to respond to climate change.

1.3. Outline

While the paper focuses on economics and technology, it begins with a discussion of the Paris Agreement because it sets the context for the economic analysis. The evolving electricity sector in the context of climate change creates pressure for the political economy (social and political institutions and policy) to evolve in a general direction. The fact that the Paris Agreement moved strongly in a direction that is consistent with the underlying economic forces is important and, frankly, remarkable. Section 2 presents a brief discussion of the political economy of the Paris Agreement to underscore the profound relevance of the techno-economic basis of the response to the challenge of climate change. The political commitment to decarbonization is intended to and, if pursued, will certainly be the dominant driver for energy resource development and selection. Policy choices are the essence of political economy and in this case, their impact is indisputable.[10]

Section 3 describes our approach to the economic analysis and the key features of the decarbonization road map studies that define the structure of this analysis. It focuses on the Jacobson et al. [74] analysis, since it provides the greatest detail.

Section 4 reviews the current estimates of resource costs. It uses those costs to demonstrate the methodology for assessing the impact of placing constraints on the selection of assets for the electricity portfolio. It then reviews projections of future costs and applies the "merit order" methodology to those projections.

Section 5 provides summary estimates of the impact of the resource constraints on the cost of electricity. It adds a scenario that assumes a higher level of efficiency. It also examines how the consideration of other factors, e.g. non-carbon externalities, timing, affects the attractiveness of resources. It includes a specific evaluation of why nuclear power has no place in the low carbon future of two of the three deep decarbonization scenarios and explain why this is the correct outcome for low carbon resource selection.

Section 6 deals with the problem of decision making in the face of the significant uncertainties that policy makers face at present. Given the urgency of climate change and the need for swift action, embodied in the Paris Agreement, policy makers do not have the luxury of delaying decisions. This section presents a framework, portfolio analysis, that is a widely used tool for decision making under uncertainty in a number of fields. Applying portfolio analysis to the cost data used throughout the paper, the paper concludes that the prudent course of action is to move quickly toward a portfolio of 100% renewable resources.

[3] Jacobson et al. [74].
[4] Greenpeace International [63].
[5] Deep Decarbonization Pathways Project [40].
[6] Lazard [92,93].
[7] 2015.
[8] Needless to say, examination of 100% renewable approaches to climate change have been appearing in the research literature for some time. See, for example, Ghisetti Quatraro [59], Krajac, Duic and da Graca Carvalho [87], Connolly et al. [25], Jacobson et al. [74], Delucchi and Jacobson [41]; Elliston MacGill and Diesendorf [50], identifies studies prior to 2013, Cochran et al. [24], compare a dozen studies, Jacobson et al. [74] provide more recent examples. There is a second professional trade literature, particularly from financial analysts that has demonstrated the economics of deep decarbonization, both in comprehensive reviews [21] and, in particular, assessments of the economics of renewables [47,48,55,14]. The number of possible scenarios is infinite. With respect to the selection of studies, the three wehave chosen are recent and included comprehensive, high level decarbonization scenarios. We focus on Jacobson because it had a great deal of detail within the focused analysis of a 100% scenario. The studies we have chosen share the attribute of identifying specific paths to a specific target, which is a strength compared to studies that say "anything" is possible. The fact that they offer paths to the future, which in the case of Jacobson and Deep decarbonization are differentiated by nation, is also consistent with the sentiment of the Paris agreement, which encourages individual nations to pursue routes that make sense to them, but also do so in focused and expedited manner.
[9] Throughout this analysis we use long-term and long run interchangeably: "In microeconomics, the ""long run"" is the conceptual time period in which there are no fixed factors of production, so that there are no constraints preventing changing the output level by changing the capital stock or by entering or leaving an industry. The long run contrasts with the short run, in which some factors are variable and others are fixed, constraining entry or exit from an industry," https://en.wikipedia.org/wiki/Long_run_and_short_run
[10] We use the term political economy in the traditional, positive sense and say comeback because, by some accounts, political economy was the traditional approach to economic analysis at the beginning of the science. As Pearce [119], p. 342, put it in defining the term: "Until recent times the common name for the study of the economic process. The term has connotations of the interrelationship between the practical aspects of political action and the pure theory of economics. It is sometimes argued that classical political economy was concerned more with this aspect of the economy and that modern economists have tended to be more restricted in the range of their studies." Three decades later in urging social scientists to engage in the "old-fashioned" practice of political economy, Piketty [121], p. 574, took an even more striking stance, arguing that economics is set apart from the others social sciences "by its political, normative and pragmatic purpose. . . and asked. . . What public policies and institutions bring us closer to the ideal society?"