Energy Policy 123 (2018) 367–372

Contents lists available at ScienceDirect

Energy Policy

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

Renewable and low carbon technologies policy☆

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ARTICLE INFO

Keywords:
Challenges
Transition
Need for realism
Costs

ABSTRACT

Over the past twenty years there has emerged widening interest in shifting to a lower carbon world. This has primarily been motivated by fears of human-induced climatic change, growing risks to sustainable development, concerns about the continuing availability and affordability of useful energy, and opportunities for investment gains.

Promotion of renewable forms of energy, and related technologies, has been considered the way forward, for understandable reasons. But some major challenges have been overlooked, sidestepped, and/or sometimes denied on spurious grounds - examples can be noted in biomass, biofuel, wind, solar, and estuarine barrage or tidal lagoon schemes, for example.

Technologies are proposed and discussed which may, and hopefully will, assist in meeting the various challenges, but such proposals and discussions often exhibit excessive optimism about likely transition times and scale of contribution.

Already massive subsidies provided or supported by many industrialised country governments to foster renewable forms of energy have had major impacts on electricity prices, fuel poverty, and cut-offs of domestic supplies. Further down the line, the relatively low power densities of renewable forms of energy, their relatively poor energy returns on energy invested (EROI), and a tendency to overstate emissions reductions (by not including emissions 'embedded' in imports), will bring increased realisation that there may not be “a fantastic evolution just ahead of our time”, as has been claimed.

1. Introduction

Over the past two decades there have been regular pronouncements and publications on how the world can achieve an energy transition to 100% reliance on 'modern' renewable forms of energy by 2100, and in a few cases by 2050. But wherever one stands on the need to shift to a low carbon world, and the urgency of responding to what is widely considered to be 'global warming' caused by human activities, the question arises: how quickly could such a massive transition be achieved? This paper urges much greater caution and questioning about the realism of such optimistic projections, and some of the official targets (international, regional - as in the case of the EU, and national - as in the case of the UK).

The paper therefore begins by setting out the main challenges facing increased exploitation of biomass and biofuels. This is followed by sections on wind and solar power. A further section discusses other renewable energy technologies and constraints on a major expansion of their use – which includes hydro schemes, estuarine barrages, tidal “lagoons”, tidal stream, wave power – and the need for greatly increased storage and long-distance transmission capacities. Implications for energy policies are then discussed, including likely energy transition periods and the costs likely to be borne by households. Finally, the paper's Conclusions and Policy Implications are provided. The underlying theme of the paper is that there is excessive optimism about the speed with which a massive change to a low carbon economy will be achieved; a widespread failure to recognise some fundamental problems associated with operating renewable energy schemes for overall human needs; and a persistent unwillingness to face up to the costs which so many, often quite poor, people are apparently expected to bear.

2. Challenges confronting biomass and biofuels

Modern biomass can, of course, trace its origins back hundreds of thousands of years. Since 1985 the generation of electricity from biomass has greatly expanded in the USA, and since the year 2000 in Germany. Brazil's exploitation of biomass is of longer standing, but has also increased markedly since 2000, while China has increased its biomass use for electricity generation greatly since 2008 (after nearly a decade of massively expanding coal use).

☆ *This article is part of a Virtual Special Issue entitled 'Energy and Environment: Transition Models and New Policy Challenges in the Post Paris Agreement'.*

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https://doi.org/10.1016/j.enpol.2018.07.039
Received 29 June 2017; Received in revised form 16 July 2018; Accepted 17 July 2018
0301-4215/

The most evident concerns have arisen over the exploitation and destruction of forests, their impacts on natural habitats and in some cases endangered species, and their implications for food and water availability. Among the most obvious examples has been the destruction of tropical forests - in Brazil, Indonesia and Malaysia. In the case of the latter two countries the main cause has been the drive to expand palm oil production despite the large volume of carbon dioxide emissions this implies. For example, on average, for every 1 t of palm oil produced in Indonesia 33 t of carbon dioxide were emitted before the palm oil left Indonesia's shores (Childs and Bradley, 2013). Much of this palm oil goes to the USA, Germany, Italy, The Netherlands, and the UK - and a great deal of this goes to provide food products. Yet some is simply burned in electricity generating plants, and but for public opposition a much larger volume would already have been.

One example stands out to this writer: the Appeal Decision of UK Planning Inspector Alan D. Robinson of June 3rd, 2009 (Ref. APP/G2815/A/08/2088102). There the Planning Inspector allowed an Appeal against blocking burning of palm oil (along with rapeseed oil) on the ground that he "must deal with the Appeal in the light of current national planning guidance that biomass and energy fuels are regarded as sources of renewable energy." The findings of the 2008 WRI report referred to above had been brought to his attention. The "current national planning guidance" (PPS 22) and Energy Crops Scheme required feedstocks to be sourced within a range of forty kilometres, which might have been assumed to exclude palm oil from Indonesia. Mr. Robinson did acknowledge that the use of palm oil "is seen to be behind the destruction of large tracts of rain *(sic)* forest." For reasons that have never been made clear this particular development proposal has not been proceeded with, to date.

Another strange biomass example comes from the cutting down of hardwood forests in a number of US States (mainly, but not confined to Louisiana and Florida) for burning in electricity generating plants. Some of this hardwood is broken up into wood chips, which are hence referred to as 'waste wood' or 'wood pellets', and shipped off to Germany and the UK (National Resources Defense Fund, 2015). Quite a large volume goes to the UK's largest single electricity generating site in Drax, Yorkshire, where most of the original coal-fired plants have recently been converted to burn this 'waste wood' or 'wood pellets'. The operator has spent £ 750 million on converting the plant. Why did they? They did so in the expectation of receiving between £ 450 million and £ 500 million a year in subsidies. For Drax the most recently announced plan is to widen its sourcing of wood to Brazil's Rio Grande do Sul. Meanwhile the International Institute for Applied Systems Analysis (IIASA) announced in its May 2017, Analyst Newsletter that it will be studying and reporting on the restoration potential of tropical degraded areas - namely Brazil, Indonesia, and the Congo Basin. As IIASA reports, "the issue of land-use change is of critical importance". Perhaps IIASA should also focus on what is happening in forests close to its own backyard.

Across the Carpathian mountains, from Poland in the West to Romania in the East, large areas of forest are now being cut down, defended by those who explain that if the EU's 2020 renewable energy targets are to be met then 16 million hectares of energy crops will be required (and wood is a much denser source of energy than crop residues). Other examples can be drawn from Germany and France, several of them discussed by Pearce (2015) What seems also to be strange in this exploitation and burning of woodlands is that serious analysis of lifecycle carbon emissions of wood compared with the burning of coal suggests the emissions can be higher for wood than coal (Stephenson and MacKay, 2014).

The use of crops for biofuel applications has also not gone smoothly. The efforts in the USA to divert maize and soya for biofuel use in the transportation sector have been blamed for creating food shortages and food price rises, resulting in food price riots (in 47 countries alone in 2008), and blamed by many as an element in the commencement of "the Arab Spring". Elsewhere the growing of *Miscanthus* and other crops on good quality agricultural land for the purpose of burning them or using them as biofuel has been questioned, not least in countries where substantial quantities of food products are imported.

Over the past twenty years there has been much discussion in some circles about 'second-generation' biofuels, using non-food residual parts of crops through fermentation to produce lignocellulosic ethanol, and 'third-generation' biofuels using algae, but apart from the large-scale Iogen demonstration plant in Canada and their involvement in a single mill in Brazil little progress had been reported until REN 21's 2017 Report that plans for cellulosic ethanol plants announced or commissioned in 2015 had begun to come online in half-a-dozen countries (REN 21, 2017, pages 50–51). The scale of the contribution of cellulosic ethanol remains unclear.

3. Challenges confronting wind energy

The biggest challenge for those reliant on electricity generated by wind power is its intermittency. This is an issue which is usually localised, being dependent on mean wind speeds, and is likely to have a much greater impact on larger-scale developments rather than 'mini-turbines'. Propelled by concerns about human-induced climatic change, and subsidies offered to developers in consequence, the capacity offered of major wind energy developments around the world has greatly expanded since 2004. World wind power capacity, having reached almost 60 GW in 2005, grew to almost 500 GW in 2016, an increase of over eight-fold (REN 21, 2017, page 88). However, at a global level wind power contributes just about 4% of electricity generation, although in the EU its contribution is about 12%. The industry has shown little public interest in capacity factors actually achieved, which is the true measure of the efficacy of developments and often reflects mean wind speeds where developments are located. In the UK, for example, the wind energy industry associations (British Wind Energy Association, followed by Renewable UK) have claimed for many years that wind energy developments anticipated to achieve a capacity factor below 30% would not be supported, and most developers have echoed this claim. Yet even as late as 2016 almost 30% of onshore wind energy developments in England failed to achieve a capacity factor of 20%. Insufficient emphasis has been placed on taking obvious steps to improve such matters. For example, in the case of one development in Northamptonshire, the average annual capacity factor achieved, employing Enercon turbines and commissioned in 2006, has been just over 18%. An extension of this development employing General Electric turbines, on the same site but commissioned in 2014, has been achieving 37.5%.

A further problem, most notably found in China - where the largest additions to capacity have taken place in recent years - there has been difficulty in linking turbines to transmission systems and thus to major centres of population. Clearly closer attention should be paid to the longstanding issue of linking turbines to the grid system unless they are small modules (mini-turbines) intended for local use.

The intermittency of wind power remains its main drawback, with the need for large-scale energy storage still lagging far behind needs. The potential for pumped storage remains largely unrealised, and the recent focus on improving battery technology is only just beginning to produce some results. One such potentially positive advance has been the start of linking offshore developments to dedicated battery systems. DONG Energy's second phase of its Burbo Bank wind energy development offshore Merseyside in the North-West of England is to have batteries placed onshore to store surplus energy when its wind-generated electricity permits, to be released when wind-powered generation falters (Ambrose, 2017). If extended to most large-scale wind energy schemes this would begin to address (though only partly resolve) the frequently voiced concerns about the intermittency of wind power which exist. The energy return on energy invested (EROI) of such integrated schemes would need to be examined closely (Hall, 2017).

The potential contribution that integrated battery storage could make to wind energy's total contribution to power supplies obviously