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RENEWABLE ENERGY

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How Shifting to Renewable Energies Is Morally Mandatory

Anthropogenic greenhouse gas emissions are the major contributor to climate change, which is generating severe disruptions to human and non-human lives on this planet. Risks to humans include those associated with an increasing number of extreme weather events, heat exposure, water and food security, sea level rise and subsequent disappearing islands and coastal regions, and the spread of infectious diseases; many of these climate-induced effects are already being felt and are likely to worsen over the course of this century even if warming could be kept to 1.5°C (IPCC 2018a).

The largest proportion of our greenhouse gas emissions results from the way we generate and use energy, in particular from the burning of fossil fuels (IPCC 2014). Fossil-fuel-based energy generation and consumption are thus the main drivers of climatic change. In order to mitigate climate change, we must reduce our greenhouse gas emissions substantially. This reduction will only be possible if we manage to profoundly change the way we use and generate energy (IEA 2020).

There are a number of ways to reduce emissions in order to mitigate climate change. According to Mark Diesendorf (2011), greenhouse gas emissions have three drivers:

1. Consumption per person
2. Population
3. Technology choice

Total emissions (C) are a product of the number of people on the planet (P), the energy use per person (E/P), and the emissions related to each unit of energy (C/E):

C = P x E/P x C/E (ibid.)

Diesendorf argues that in order to reduce emissions substantially, we must address each factor (2011: 562). While the first factor – population size – is politically highly problematic, many people are already addressing the second and third factors to reduce their individual carbon footprint. Individual emissions matter (Nolt 2011), and each of us can reduce their emissions by using more efficient appliances (C/E), but also by using public transport instead of driving a car, refraining from air travel, or conserving electricity domestically. But while it is necessary that individuals, especially those living in the world's ten richest countries (Oxfam 2015), consume less energy and adopt environmentally friendly behaviors, there is only so much energy each of us can save – the emissions problem cannot be resolved through individual carbon footprint reductions alone

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(Schwenkenbecher 2014). What is needed, ultimately, is a structural response (IRENA 2019). In order to reduce emissions on a significant scale, society as a whole must shift to lower-emission energy technologies (Climate Council of Australia 2018; Diesendorf 2010, 2011; IEA 2020).

There are a number of technology options for lowering GHG emissions while still satisfying the global demand for energy services (IPCC 2011). These include:

- Renewable energy (RE) technologies: wind, solar, biomass, tidal and wave, geothermal;
- "Clean" fossil-fuel-based energy technologies which produce few or no greenhouse gas emissions: nuclear, carbon capture and storage (CCS)

However, not all of these options are equally effective in mitigating climate change to the required extent, and some come with serious problems attached. The risks of nuclear energy are well known (Shrader-Frechette 2011), notwithstanding continued political appetite for nuclear energy solutions (Neumann et al. 2020; Pampel 2011). But what about so-called "clean-coal" technologies such as CCS when juxtaposed with renewable forms of energy generation?

Renewables versus "Clean" Fossil-Fuel-based Technologies

Despite its potential for being a viable future technology and various CCS technologies reaching maturity (Bui et al. 2018), the roll-out of CCS globally has been hindered by a slow technological change and a lack of complementary and targeted policy measures (IPCC 2018b; IEA 2020). As continuing global fossil-fuel dependence seems likely over the medium term (Bui 2019), however, CCS is deemed a critical technology for most of the IPCC's mitigation pathways, stressing the need for further development of the technology in the near term (IPCC 2018b; Budinis 2018).

Irrespective, various problems remain with CCS. First, the technology harbors the risk of prolonging our reliance on fossil fuels, locking in the suite of environmental, social, and political problems resulting from the extraction of fossil fuels. In addition, there are risks associated with the required carbon dioxide (CO_2) storage and potential leakage of CO_2 (Leung et al. 2014). Large quantities escaping would severely impact on greenhouse gas concentrations in the atmosphere (diminishing the technology's impact on mitigation), the local environment, and health of local populations. Diesendorf (2003) points to detrimental impacts on living organisms in waterways and ground water, given that CO_2 can dissolve to form a weak acid in water. Similarly, soil microbes can be negatively affected by carbon dioxide release into the ground. This may have impacts on local ecosystems as a whole (2003: 10). Zoback and Gorelick (2012: 10164) have argued that "there is a high probability that earthquakes will be triggered by injection of large volumes of CO_2 into the brittle rocks commonly found in continental interiors", concluding that large-scale CCS is too risky a strategy to be adopted in the reduction of GHG. While some experts judge the changes of leakage to be vanishingly small (Alcade et al. 2018), many admit that there is still a significant amount of uncertainty surrounding the risks associated with CCS projects (Anderson 2017; van der Zwaan & Smekens 2009; Vinca, Emmerling & Tavoni 2018).

Finally, if CCS were employed on a large scale, in contrast to renewable energies (REs), the environmental costs of harvesting coal, including methane release, the loss of carbon sequestration capacity through vegetation removal, the emissions from extraction machinery and transport (see Keith et al. 2012: 23), would, in fact, increase. Capturing carbon dioxide is energy-intensive and consumes roughly 20–25% of the energy a CCS plant produces. Therefore, CCS plants require more coal per energy unit produced than current coal-fired power plants, because some of the produced energy will be used for the capture and storage process. This means that a large-scale employment of CCS is only possible with increased coal production (Biegler 2009: 66f).

Furthermore, unlike wind and solar energy, coal as a resource is finite: “clean-coal” technologies postpone the problem of long-term energy security, instead of solving it. According to the Intergovernmental Panel on Climate Change, successful mitigation is more likely to be achieved if a complete substitution of fossil-fuel-based energy generation takes place: “Individual studies indicate that if RE deployment is limited, mitigation costs increase and low GHG concentration stabilizations may not be achieved” (IPCC 2011: 24). In light of the current carbon lock-in globally “clean coal” technologies are considered vital for effective mitigation (IPCC 2018b). Nonetheless, there are good reasons to think that in order to achieve effective and timely GHG mitigation, while also securing long-term energy security, we must shift to RE technologies, away from fossil fuels (for a third option – geo-engineering – see chapter on *Geoengineering*).

Wider Benefits of Renewable Technologies

Apart from being instrumental in reducing emissions and stabilizing greenhouse gases in the atmosphere, there are other morally compelling reasons for shifting from conventional, fossil-fuel-based technologies to REs. The IPCC (2011: 7) asserts that RE “can provide wider benefits. RE may, if implemented properly, contribute to social and economic development, energy access, a secure energy supply, and reducing negative impacts on the environment and health”. For these reasons, RE investments are currently being promoted for the economic recovery from the Covid-19 pandemic as part of a Green New Deal in countries such as Germany and Korea (Jung 2020).

Compelling reasons for endorsing renewables arise from concerns about the negative environmental impacts of conventional energy generation. The environmental impact of energy technologies is usually measured by way of producing the so-called “lifecycle assessments” (LCAs). LCAs attempt to quantify the environmental impact of technologies over an entire lifecycle, from resource extraction, via manufacturing to operation and disposal (for a discussion of LCA, see IPCC 2011: 730). As a general tendency, RE technologies are clearly favored in LCA (IPCC 2011). Even for solar photovoltaic (PV) systems, which traditionally had poorer LCAs (Varun et al. 2009), technological changes in recent years have greatly improved the environmental performance of PV (Muteri et al. 2020).

Environmental impacts have a direct influence on human health. Conventional power plants (coal-, gas-, and oil-fired) emit “thousands of tons of emissions of sulphur dioxide, nitrogen oxides, carbon monoxide, particulate matter, hydrocarbons, mercury, and other pollutants” (Rosenberg 2008: 523) every year, while REs such as wind and solar produce no such emissions when in operation (see also Kaswan 2009: 1146). Moving away from fossil-fuel-based energy technologies will reduce these so-called co-pollutant emissions, which, in turn, will have a positive impact on human health (WHO 2012).

Commonly, the health burdens of conventional energies are very unequally distributed. Given that pollution is always limited to certain areas, the distribution of health impacts often exacerbates existing inequalities. For decades, environmental justice advocates have been raising awareness of the problem of unequal distributions of exposure to environmental hazards within populations. According to Kaswan (2009: 1146), emissions and air pollution “are disproportionately concentrated in disadvantaged areas, since many of the most significant emission sources, like refineries, power plants, transportation corridors, and other industrial land uses, are located in poor and minority neighborhoods”. High-income communities or neighborhoods, in contrast, are less affected by air, water, or soil pollution. Technologies that do not cause such pollution, like RE technologies, are inherently fairer. In this sense, a shift from conventional energy generation to RE will be especially beneficial to those who are disproportionately affected by these adverse impacts. Kaswan argues that “[b]y reducing fossil fuel combustion, greening the grid could serve a critical environmental justice function” (ibid.; see also Rabinowitz 2012 and McCauley et al. 2019).

Apart from promoting environmental justice, reducing pollution can entail substantial economic benefits for all. According to Kaswan, "The consequences of these public health threats fall not only on those directly exposed, but on society as a whole through higher medical costs, lost school and work days, and lower productivity" (2009: 1147, see also Biegler 2009; Gielen et al. 2019; Groosman et al. 2011: 600).

RE can – subject to policy settings (Monyei et al. 2019; Samarakoon 2019) – also play a crucial role in the eradication of poverty and for reaching the United Nations' *Sustainable Development Goals* (Swain & Karimu 2020). "Historically, economic development has been strongly correlated with increasing energy use and growth of GHG emissions, and RE can help decouple that correlation" (IPCC 2011: 18, see also Cherni & Hill 2009). The availability of affordable energy is critical to the economic development of a community. According to the IPCC, under favorable conditions, RE will in some locations be cheaper than non-RE technologies, for instance, through avoiding expensive energy imports. This often makes them the only feasible option in remote and poor rural areas (ibid.). This means that "RE can help accelerate access to energy, particularly for the 1.4 billion people without access to electricity and the additional 1.3 billion using traditional biomass" (ibid., see also Florini 2012: 297). RE is seen by many as a key factor in ensuring that economic development is sustainable and equitable (Stephens 2019). The IPCC *Special Report on Renewable Energy* mentions other aspects in which RE can aid development: "RE deployment might reduce vulnerability to supply disruption and market volatility if competition is increased and energy sources are diversified" (IPCC 2011).

In fact, long-term energy security is not only desirable for developing economies, but for all economies. Just how much of an improvement independence from fossil fuels would be becomes clear when considering the economic and political costs of securing continuing supply, for instance, through military presence and political engagement in oil-producing countries (Babson 2019). Furthermore, even large fossil-fuel deposits that will last for several centuries from now will eventually be exhausted or too expensive to extract; fossil-fuel energy-return-on-investment ratios are already beginning to fall (Brockway 2019). In the meantime, those who control the resources can control those who depend on it, economically and politically (Lehmann 2019). REs, such as wind and solar, provide long-term energy security and independence. They are potentially unlimited, available at no (extraction) cost, and harvesting them does not diminish their availability to anyone else, neither present nor future people.

In sum, there are morally compelling reasons for shifting to RE other than mitigation of dangerous global warming (Florini 2012; IPCC 2011; Jamieson 2011; O'Neill 1993; Shue 2005). A broad scale adoption of RE can generate considerable public health benefits and broader environmental benefits, bear the potential for sustainable and just economic development and equitable energy access, and, finally, provide long-term energy security.

The Feasibility of a Zero-Carbon Economy

Even though overwhelming moral and prudential reasons seem to speak in favor of shifting to REs and away from conventional fossil-fuel-based technologies, some may doubt that this shift is politically, economically, or technologically feasible. In the following, we will briefly address each aspect, in turn.

Is the shift *technologically* feasible? There are an increasing number of low-emission and zero-emission technologies available for large-scale deployment, including hydro, solar PV, and concentrated solar thermal (CST), wind, biomass, and geothermal power. Expert opinions on the viability and capacity of the currently available low-emission and zero-emission technologies differ, but these differences concern merely the timeframe within which conventional energies can be completely substituted by low-emission and zero-emission technologies; they do not usually doubt that this substitution is technologically feasible (see Diesendorf 2011, 2019; Lund 2007; Rissman et al. 2020).

RE pioneers such as Denmark, Finland, Iceland, Norway, and Sweden are already covering large portions of their energy needs with renewables and

> [e]ach has a series of longstanding policy goals; each has binding climate targets; each are attempting to become entirely or mostly "fossil fuel free" or "carbon neutral," with Denmark, Sweden, and Norway committed to 100% renewable energy penetration, Finland 80%, and Iceland 50–75%.
>
> *(Sovacool 2017)*

But some experts, in fact, think that even for a country with the energy needs of Australia, a complete shift to RE is technologically feasible within 10 years to 20 years (The Australian Greens 2019; Diesendorf 2019; ZCA 2010; for an overview of zero-carbon blueprints, see Wiseman & Edwards 2012).

Across the world, cities and municipalities have adopted ambitious emission reduction plans: the Copenhagen Climate Plan (2009) aims at carbon neutrality for the city of Copenhagen by 2025. The Australian Capital Territory, home to Australia's capital Canberra, envisages it for 2060 (ACT Government 2012); indeed, various jurisdictions in Australia have made pledges to carbon neutrality (ClimateWorks Australia 2020).

But on a large scale, globally, is such a shift possible in a short time while maintaining current levels of energy consumption? A common argument against a radical shift is that we critically depend on GHG emissions – we cannot currently have decent lives without emitting. Importantly, transition plans to RE will usually see a major role for increasing energy efficiency. However, the German Advisory Council (WBGU) finds that "even in a world characterized by rapidly growing energy consumption, it is possible to transform global energy systems such that they become sustainable" (WBGU 2009: 129). Since WBGU operate with very high growth rates of energy use and economic development, they arrive at a more conservative model which achieves 90% coverage of energy needs by renewables by 2100. Further, as the 2011 IPCC Special Report points out: "The theoretical potential for RE greatly exceeds all the energy that is used by all economies on Earth" (p.165).

What about the *economic* feasibility of a shift to renewables? According to the IPCC, in principle, the employment of REs does not hinder economic growth or limit projected future energy demand:

> The global technical potential of RE sources will also not limit continued market growth. A wide range of estimates are provided in the literature but studies have consistently found that the total global technical potential for RE is substantially higher than both current and projected future global energy demand.
>
> *(IPCC 2011: 165)*

It should be noted, though, that some scholars argue that in order to successfully mitigate climate change and create sustainable future societies, fundamental changes to our economic system are imperative (Diesendorf 2010, 2019).

Another way of thinking about economic feasibility of transitioning to RE is the comparative economic cost of "business as usual". The *Stern Review on the Economics of Climate Change* focuses on the cost of climate change adaptation and mitigation on a global scale and concludes that timely mitigation is less costly than later adaptation:

> The Review estimates that if we don't act, the overall costs and risks will be equivalent to losing at least 5% of global GDP each year, now and forever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more. In

> contrast, the costs of action – reducing greenhouse gas emissions to avoid the worst impacts of climate change – can be limited to around 1% of global GDP each year.
>
> *(Stern 2006)*

These figures, as confirmed by other studies (Garnaut 2008), indicate that, from an economic perspective, substantial climate change mitigation is preferable to business-as-usual.

Finally, let us very briefly look into the question of *political* feasibility. It is obvious that for some countries, the shift is (or has been) possible, with some countries, including the Nordic Five mentioned above, meeting a large proportion of the energy demands with RE. Yet, it may be argued that for most countries and on a global scale, while the shift is not *impossible*, it is politically *unfeasible*. But what does that mean?

According to Holly Lawford-Smith (2012: 14), "[f]easibility is a concept that treads a fine line between possibility, on the one hand, and likelihood, on the other". She suggests a scalar understanding of feasibility: "the probability of the outcome given the best (or best equal) action" (ibid. 13). Outcomes that are possible are made less probable and therewith less feasible through the so-called soft constraints, the most common of which are economic, institutional, and cultural constraints (ibid.). However, it is possible to influence these constraints – for instance, by attempting to change the culture or values of a given society: "In some instances, if we want the reforms badly enough, we will have to be prepared to really manipulate people's incentives in order to secure success" (ibid.).

On this analysis, the shift *is* politically feasible in that it has a positive probability, given the best available action. We can also see that the best available actions are not currently taken by many governments. Why this may be so will be discussed in the following. Second, it also reveals that in order to increase the feasibility of the shift (and its probability), given the best action, one must address those soft constraints: facts about the current political and economic system, facts about the current system of energy governance and ownership, but also facts about people's values regarding the environment and climate change.

But why is so little happening? Why do politicians mostly fail to take the "best" action for steering our societies toward RE? Why do some countries embrace these new technologies more than others? The reasons for the lack of appropriate policy responses in so many countries are diverse and cannot be discussed in any detail here, but we will indicate some possible explanations. Richard Norgaard (2011) argues that part of the problem lies in the economic analysis of the problem of climate change itself and its theoretical foundations. Cost-benefit analysis – a major decision-making tool for public policy – is best used in small-scale contexts, but is not suitable as a decision-making tool when it comes to addressing global problems such as climate change where costs and benefits are dispersed over time and space (p. 191). According to Norgaard, because not all relevant outcomes can be adequately captured, decisions made on the basis of traditional cost-benefit analyses are flawed (ibid.).

Ann Florini considers defects in institutional design and the lack of power one of the greatest problems of energy governance: "almost no country has a coherent and sensible energy policy implemented by a well-designed set of institutions" and existing institutions do not have the "necessary institutional clout" (2012: 299). In addition, there exist strong vested interests in the oil and coal industries. Florini remarks that "Transparency International's 'Bribe Payer's Index' has ranked the oil and gas sector as the fourth worst sector (out of 19) for bribing public officials" (ibid., 298). On the global level, there is currently no comprehensive energy organization and no coherent global energy governance: "the current system of global energy governance is a mess, with many actors, many priorities, little coherence, and limited effectiveness" (ibid.). Furthermore, governments have been passing the buck on climate leadership for some time in order to avoid possible national disadvantages from making unilateral efforts (Schwenkenbecher 2013; Shue 2011).

Why some countries have managed to overcome these problems cannot be discussed here, unfortunately. However, it does not seem far-fetched to assume that at least some of the political determination to execute the shift to renewables resulted from necessity. For instance, Denmark's economy suffered enormously during the 1970s oil crises as it was extremely dependent on oil imports. Together with a strong anti-nuclear movement, this led to a complete shift in domestic energy policy and cleared the way for renewables. Hence, it appears to have been partly a need for greater levels of energy security which prompted the Danes to adopt those changes (Rüdiger 2019). The political feasibility of shifting to renewables depends on countries' geographic and socioeconomic contexts, including the ability of political actors to intervene in the economy in a range of interdependent ways (Jewell & Cherp 2020).

Even though we have merely hinted at some of the obstacles to national and global sustainable energy regimes, it is safe to say that the transition to RE is economically, technologically, and politically feasible (at least in many of the OECD countries) at this point in time. However, in order to significantly increase the likelihood of such a transition, what is needed is a political shift, or rather many political shifts on the national, regional, and local levels. We can and must work toward such a shift in our own societies and globally.

The Ethical Problems of (Some) RE

Yet, even if there is agreement on the necessity and feasibility of a transition to an RE regime, we will still be required to make choices between different possible pathways toward that goal. Each of these choices will involve some undesirable consequences that we will need to balance. Some of these undesirable consequences will result from technology choices and others from policy and economic measures. Some decisions will concern different ways of living: Do we have to give up our current living standard for a sustainable (energy) future? If a trade-off is needed, how does the value of high living standards compare against that of a sustainable energy regime? Fundamentally, changing the way we generate and use energy will entail tough choices, sometimes between equally desirable aims, and sometimes between options that seem impossible to compare.

In the following, we will not conduct a comprehensive analysis of all available RE technologies, but rather provide a number of examples of tough ethical choices entailed by solar, wind, and hydro power. We will also attempt to rebut some of the common misconceptions regarding RE technologies.

Hydropower – Green Electricity in Exchange for Environmental Destruction?

Hydropower is a paradigmatic example of a controversial RE technology (Diesendorf 2011; Jamieson 2011). On the positive side, it generates energy at extremely low cost and offers "significant potential for carbon emissions reductions" (IPCC 2011: 442). If replacing conventional fossil-fuel-based energy technology, hydropower helps secure environmental benefits, because it does not cause air pollution and soil contamination. Furthermore, in contrast to open pit mines, dams often provide recreational benefits for humans. On the negative side, dams severely interfere with landscapes and ecosystems, altering existing waterways and disrupting a river system's ecology with possibly devastating effects on fauna and flora (see Kahn, Freitas & Petrere 2014). Depending on local conditions, hydropower may even potentially result in higher emissions than the fossil-fuel-based power generation it seeks to replace (Giles 2006). The decision to build and use a hydropower plant necessarily entails a decision as to which of these conflicting aspects are more important: significant emission reductions at low cost or (possibly) the preservation of an existing ecosystem; further, there are often significant impacts on local communities and their livelihoods to consider (Moran et al. 2018). Whether or not building any particular hydro power plant is overall the ethically best choice will depend on the specific circumstances. In some cases, the potential to gain access to cheap energy may override environmental concerns and the interests of the local community (where these conflict with the project). It should also be noted that not all hydropower systems are equally problematic from an environmental point of view. For example, run-of-river hydropower systems do not alter a river's flow regime in the way systems with reservoirs do and have therefore more benign ecological impacts (IPCC 2011: 463).

Solar Photovoltaic – A Sham Package?

Solar PV is a versatile RE technology and often used for small-scale, self-supporting electricity generation. It enables households and communities to have greater independence from the electricity grid. While governments all over the world have provided economic incentives for homeowners to install solar PV systems, these measures have been criticized for reinforcing inequality as people in low-income groups are less likely to benefit from them (see Hitzeroth, Jehling & Brueckner 2017; Macintosh & Wilkinson 2011). However, while this may be true for relatively well-off urban and suburban residents, small-scale solar PV can provide enormous benefits to remote communities subject to country-context and policy setting (Baurzhan & Jenkins 2016; Okoye & Oranekwu-Okoye 2018). It can provide those who have not formerly had access to electricity with affordable energy, therewith improving their living standard and benefiting those who are usually disadvantaged in society (IPCC 2011: 66).

One downside of solar PV is that, in contrast to wind and hydro technologies, it has been a comparatively costly way to generate electricity (IPCC 2011: 188, Figure 1.19), though this is changing rapidly. However, the relative cost would vary depending on circumstances: "In some applications, PV systems are already competitive with other local alternatives (e.g. for electricity supply in certain rural areas in developing countries)" (ibid. p. 68). In terms of the environmental record of PV, lifecycle emissions of first-generation PV systems have been considerable and were, on average, greater than those from hydro and wind (Varoun et al. 2009). Improvements in manufacturing processes and PV performance, however, have seen dramatic reductions in PV systems' environmental footprint and overall energy amortization (Muteri et al. 2020).

On a large scale, solar PV has less clear economic and ethical benefits than CST and wind power. It is both more expensive and less effective in terms of climate change mitigation (Desideri & Campana 2014). Depending on the subsidy structure, it may often benefit primarily those who are already well-off. However, it can play a very important role as a small-scale technology in providing remote communities with electricity and resulting benefits, therewith in some cases benefiting those who are often comparatively worse-off.

In contrast, CST has overwhelming ethical benefits and few downsides. Employed on a large scale, it can contribute substantially to emission reductions and climate change mitigation (Sonawane & Bupesh Raja 2018). It is furthermore inexpensive, safe, and effective. However, it is not suited for small-scale employment, but rather as a substitute for conventional power plants.

Wind Power – Saving the Climate While Destroying the Landscape?

Wind energy, after hydropower, is the world's most widely used RE resource (Ritchie & Roser 2020), and is a desirable way of generating electricity in many respects. Wind turbines have low lifecycle emissions (AER 2009: 52–53, Biegler 2009) and wind power "has significant potential to reduce (and is already reducing) GHG emissions" (IPCC 2011: 99). Wind energy is currently the cheapest of the REs available. Notwithstanding some noted negative economic impacts (Dorrell & Lee 2020), implementing wind energy on a large scale in many places has been shown to positively influence the job market and manufacturing sector, creating new jobs and establishing a (or expand the existing) renewable technology industry. (See e.g. IPCC 2011: 719; Ortega-Izquierdo & Río 2020; for the U.S., this is confirmed by Wei et al. 2010. See also Patterson 2012 and *Zero Carbon Australia Stationary Energy Plan* 2020.) Also, wind farms can constitute a source of income for the rural population, safeguarding them from the impacts of droughts or other unforeseeable events (IPCC 2011:195, see also Rosenberg 2008: 525f). It has been suggested that the value of properties can be negatively affected by views of wind turbines (Sunak & Madlener 2016), but also that this impact is correlated with acceptance of (or opposition to) wind power (Vyn 2018).

While generating electricity from wind instead of from fossil fuels avoids a number of health hazards and environmental damage resulting from conventional energy generation (e.g. GHG emissions, air, water, and soil pollution and degradation), wind turbines have been suspected to sometimes have adverse health effects on the people living in the immediate vicinity of the turbines. Problems have been said to result from infrasound noise, electromagnetic interference, shadow flicker, and blade glint. Yet, according to several studies surveyed by the National Health and Medical Research Council (NHMRC 2010), there is no evidence for a positive link between wind turbines and adverse health effects: "There are no direct pathological effects from wind farms and … any potential impact on humans can be minimized by following existing planning guidelines" (ibid). The German Advisory Council comes to a similar conclusion: "[p]rovided adequate distances to settlements are maintained, noise emissions from modern wind power plants are therefore no longer a problem" (WBGU 2004: 64). This suggests that rather than being the result of the actual impact of wind turbines, health problems that people experience in the vicinity of turbines seem to be resulting from anxiety surrounding the turbines and be correlated with people's attitudes toward them (see CSIRO 2012; NHMRC 2010). Anxiety issues and negative attitudes may successfully be addressed by involving local populations early in the decision-making process and providing them with the relevant information to prevent such problems (see Schwenkenbecher 2017).

Wind farms do have some adverse environmental impacts, too (for an overview, see Nazir et al. 2020). For example, there is proven interference of rotating blades with local fauna, especially birds and bats (Baisner et al. 2010; Biegler 2009; Drewitt & Langston 2008; Mindermann et al. 2012). However, studies suggest that careful planning can avoid or minimize these effects (IPCC 2011: 100, see also Australian Greenhouse Office and Australian Wind Energy Association 2004: 3). Overall, the environmental impacts appear to be negligible compared to those of conventional energies: "attempts to measure the relative impacts of various electricity supply technologies suggest that wind energy generally has a comparatively small environmental footprint" (IPCC 2011: 99).

The only impact of wind farms that cannot be mitigated is their visual impact on the landscape. Wind farms usually feature prominently in the landscape and alter the visual composition of their surroundings (and this applies to hydro power plants, and to a lesser extent to CST, too). Concerns about landscape alterations seem to be at the heart of a lot of opposition to wind farms (Wolsink 2007). Bell et al. (2005: 470) have argued that "there is no 'technical fix' for the problem of landscape impact. Instead, the only way of accommodating people's landscape concerns is to site wind farms in places that people find more acceptable". People's concerns regarding landscape impacts of wind turbines can be addressed in a number of ways. The Australian Greenhouse Office and Australian Wind Energy Association (2004) suggest that communities should always be consulted on turbine placement and important viewpoints should be agreed upon early in the process (see also Auswind & ACNT 2007 and Gross 2007). Another possibility is to compensate communities affected by RE developments, including wind farms, for loss of "environmental qualities that people might otherwise have expected to keep" (Cowell et al. 2012: 12; see also Cowell et al. 2011). Compensation should hence be combined with consultation to ensure that legitimate complaints are heard and that compromises are found if possible. It appears then that many of the seemingly negative aspects of wind power are based on attitudes and prejudices, which can be moderated or overcome if stakeholders are involved in the decision-making process (Bell and Rowe 2012; see also Toke 2002 & Zoellner et al. 2008 and Schwenkenbecher 2017).

Finally, another downside of renewables, in particular wind and solar power, is the intermittent energy supply and resulting issues of energy security. We cannot go into any detail, but it should be noted that the technological challenges of intermittency appear to be perfectly resolvable (Jacobson et al. 2015) and that from a socio-political perspective, RE can be seen as affording greater energy security than fossil fuels (Valentine 2011; Viviescas et al. 2019).

In sum, there are downsides and limitations to each RE technology which must not be ignored and – where possible – must be mitigated. Addressing them will ensure that the shift is as equitable, socially just, and environmentally sustainable as possible. Those orchestrating the transition must be sensitive to these goals – the process should be fair and ecologically sound so as not to replicate many of the energy justice problems of conventional modes of energy generation.

Concluding Remarks

The moral, economic, and prudential reasons for a transition to REs globally and domestically not only, but most urgently, to mitigate climate change are overwhelming. Some countries are pioneering this shift in an exemplary way. Other countries, especially large and historically large GHG emitters must follow in due course and help developing nations in their efforts to shift to RE. The major obstacles to doing what needs to be done are not technological, but seem to result from lacking political will and power as well as vested economic interests in perpetuating the status quo.

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Related Topics

20. Moral Bases of Responses to Climate Change
29. Hydropower
32. Energy Poverty
33. Urban Sustainability

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