Historicizing renewables: issues and challenges

Ute Hasenöhrl and Patrick Kupper

Department of History and European Ethnology, University of Innsbruck, Innsbruck, Austria

ABSTRACT
The essay discusses some main challenges involved in historicizing renewables. It highlights three approaches that we regard as central for re- and deconstructing the history of renewables, and which show potential for rethinking familiar narratives in both the history of technology and environmental history. First, we argue that the adoption or rejection of renewables was specific to place and time and thus can only be understood within a framework of socio-technological change. Second, we stress that the term renewables has its own history and that the term and its equivalents not only represented a number of technologies and energy carriers but also signified certain ideas about present and future society. Third, we explain why a deeper knowledge of how renewable energies were utilized throughout history not only leads to a better understanding of the past, but might help to identify challenges and pitfalls in current energy transitions.

KEYWORDS
Renewables; social and environmental change; technological narratives; energy transitions

Introduction
In his book The Zero Marginal Cost Society from 2014, the American futurist and influential economic and political adviser Jeremy Rifkin pictures an already ongoing transformation to a new society founded on collaborative commons. According to Rifkin, today’s capitalism will be marginalized within the next few decades and give way to a sharing economy. Our future societies will be based on three pillars: the internet of things, an intelligent infrastructure, and free energy. The communication revolution of the internet and an emerging new energy regime dominated by renewables will jointly trigger a fundamental social transformation. Rifkin expects internet technology and renewables to fuse into an all-encompassing ‘energy internet’ that will eclipse capitalism and create a sustainable global society within the next 25 to 50 years. Renewable energies are crucial to this transformation. While production from renewables will grow exponentially, their costs per unit will decline tremendously, up to the point of being virtually free and thus allowing marginal costs of production to drop to (almost) zero.¹

Rifkin’s zero marginal cost society is neither the first nor the only renewables-based vision of human society, as this volume illustrates – from the grandiloquent dreams of the US chemurgy movement (Uekötter, Manuel) to aspirations to harness the earth’s inexhaustible tidal powers (Frey), and to more modest desires of cozily heating one’s apartment (Melsted, Pallua) or independently running one’s car or machines (Kaijser, Hesse).
Past experiences on the one hand show how difficult it is to predict the success or failure of ‘green’ energies. They also indicate how insufficient simplified narratives of success and failure are for grasping complex energy transitions. Indeed, the case studies in this volume amply demonstrate that it is precisely through stories of apparent failure such as tidal energy, chemurgy, or (at times) heat pumps that the imponderability, the contingencies, as well as the transient character of technological and social change come into sharp relief. In doing so, the history of renewable energies allows us to revisit familiar topics of success and failure in both the history of technology and environmental history – disciplines that have previously been preoccupied with exploring the mechanisms of success and the impact of successful technologies on society and the environment (e.g. the combustion engine, the sewing machine, or fossil fuels). Engaging with past uses of green energies offers fresh insights not only for historians of technology and the environment, however, but also for those concerned with present energy challenges. To allow for more informed policy decisions, we believe, historical insights into the drivers, trajectories, and consequences of past energy transitions are of vital importance, especially regarding contemporary alternatives to fossil fuels.

Thus, this volume aims to expand our still-fragmented knowledge of the history of renewables. So far, most research has focused on one energy resource or region at a time. There is considerable literature on hydropower – from the mega-projects of the Global South to small-scale installations in North Rhine-Westfalia. Utilization of biomass, particularly in the early modern period, has also been frequently explored. Solar energy, wind power, and other supposedly ‘new’ renewables such as geothermal energy or fuel alcohol have received far less attention. Comparative or longitudinal studies are rare as well. Regarding renewables, historians have stressed issues of resource scarcity and energy density, dynamics of infrastructural development (e.g. Hughes’s much-cited Large Technological Systems), as well as conflicts surrounding energy production and energy landscapes. There is still much to be learned, however, about how different renewable energies interrelated both with each other and with fossil fuels, how ‘renewables’ were framed throughout history, and how they were actually employed, both at the social and the individual levels.

This special issue is, therefore, dedicated not only to past uses of renewables, but also to past energy futures, and to the reasons why those futures were realized or not. Tapping into this rich and largely unexplored field, the volume features seven case studies on different renewable energy sources and technologies, including biomass (e.g. wood gas, fuel alcohol), wind irrigation, tidal energy, geothermal energy, and heat pumps, the latter as a technology that could be fruitfully combined with renewable energies. Scrutinizing the bumpy history of renewables from an ‘envirotech’ perspective that explores the interrelations and juxtaposition of society, technology, and the natural environment, the case studies in this volume focus on technological and environmental challenges, socio-economic and cultural contexts, as well as collective and individual motives that drove people to advocate or reject usage of renewable energies and energy technologies in different geographical and temporal contexts.

Most of the case studies in this volume are situated in ‘the West’ (with the notable exception of Frey’s comparative study on tidal energy in the US and the USSR) and focus on what we could call the initial phase of renewables’ long and contentious history: the previously largely overlooked time period before the current discourse on renewables
really took off in the 1970s. Not all renewables are covered in this issue (the most notable omission being solar energy), however, nor do we deal with the history of renewable energies in the Global South, a topic rarely explored in historical research so far. In the following, we would like to highlight three approaches that we regard as central for re- and deconstructing the history of renewables, and which also show great potential for rethinking familiar narratives in both the history of technology and environmental history. First, the ‘success’ or ‘failure’ of renewables was embedded in socio-technological and natural environments specific to place and time. Contemporary economic and technical rationales, social models, the obtainability of natural resources, but also collective and individual actions influenced patterns of energy production and consumption, in turn affecting social and environmental developments. Therefore, the history of renewables must be contextualized not only within energy history but within a wider framework of social change. How did renewables shape society (and vice versa), and (how) did power relations and patterns of inequality come into play? Such a broad approach reveals both how renewables were adapted to existing social and technological structures, and especially how times of crisis provided windows of opportunity for promoting, and sometimes establishing, renewables as an alternative to the incumbent (fossil-fuel-based) energy system.

Second, the term ‘renewables’ not only represents a number of technologies and energy carriers (including the ‘big five’ of biomass, solar, wind, hydro, and geothermal energy, but also hydrogen/fuel cells, or tidal waves) but also signifies certain place- and time-specific ideas of present and future society. If we wish to glean renewables’ meaning in different societies and for different social groups, we have to re- and deconstruct the narratives surrounding renewable energies and examine how those changed over time. What kind of (energy) futures did actors envision at the time and what role did they assign to renewables? Did they perceive renewable energies as ways to reform or to revolutionize their societies? As will be outlined below, the term ‘renewables’ is of rather recent origin. Thus, we must investigate contemporary expressions for what we today call renewables, and the associations and conjunctions those expressions encompassed.

Third, in current debates on a ‘green’ energy transition, renewables constitute the main pillar of our future energy supply with sometimes far-reaching social and environmental consequences, as Rifkin’s zero marginal cost society aptly illustrates. How can historical research contribute to – and challenge – topical debates on energy transitions and renewable energies? We believe that a deeper knowledge of how renewable energies were utilized throughout history will not only lead to a better understanding of the factors that shaped past energy pathways, but might also help us to identify challenges and pitfalls in our current energy transitions.

**Renewables and sociotechnical change**

Rifkin centers his predictions of the fast spread of renewables in the near future on the steep learning curves and the exponential growth rates of renewables over the past few years. He expects ‘new’ renewable energy sources and technologies to rapidly outcompete and replace ‘old’ fossil and nuclear fuels with their thermal stations and engines. However, Rifkin’s portrayal of renewable energies as new, although widespread, does not stand up to historical scrutiny. A case in point is the utilization of
biomass and hydropower that clearly has a long history, preceding the massive adoption of fossil fuels. But so does, upon closer scrutiny, the exploitation of wind and solar power or geothermal energy, resources that have been used for decades, or even centuries. Thus, renewable energies of various kinds are not new but coevolved with, and sometimes predated, fossil fuels. Indeed, the articles in this special issue make a strong case for questioning and looking beyond the familiar statistics of (global) energy use. In the past two centuries renewable energies have always competed with fossil fuels as the dominant energy carrier. As a matter of fact, our case studies show that the histories of fossil fuels and renewables are deeply entwined. There is no ‘proper’ history of renewable energies without a new history of fossil fuels – and vice versa (Manuel). Renewable energies also contested nuclear energy or competed with other renewables. This is why the history of renewables can only be understood within a wider energy history. The history of these ‘other’ energy sources (as renewables are often summarized in energy graphs) not only complicates common narratives of the ‘fossil’ or ‘nuclear’ age, but also draws our attention to the tensions between (global) fossil fuels and (local) renewable energies so often overlooked in (energy) history.

But if alternative energies and technologies have been around for such a long time, why has their usage often been marginalized and their development obstructed or prevented by the prevalence of coal and oil? While the articles in this issue highlight that renewables have thrived at some points in history, most of them (with the exception of Melsted on Iceland’s geothermal heating) also tell the story of how renewables got side-lined, and sometimes rediscovered, as time passed. To understand the reasons for these changing fortunes, the case studies in this issue emphasize two essential points:

First, renewables developed within complex social and political fabrics: pre-existing infrastructures and consumer habits, vested interests, and political cultures all played their parts when it came to renewables being embraced or rejected as means of energy production or consumption. As Irene Pallua and Odinn Melsted show, both Iceland and Switzerland embarked on a journey to de-carbonize the heating sector in the post-war period, with the objective of removing soot-producing coal from the equation. Both countries promoted oil heating systems until the 1970s. But while Iceland also heavily invested in exploiting its wealth of domestic renewables, namely geothermal energy, Switzerland did not commit to exploring alternative technologies, even though Swiss engineers had pioneered heat-pump systems in the 1930s and 1940s, not least because consumers and building standards favored easily installed and convenient oil heating. In a similar vein, Felix Frey highlights how the interplay between stakeholders, but also between politics, society, and the environment, facilitated and hampered experiments with renewable technologies, such as tidal power plants, during the Cold War. In this case economic considerations prevailed. With the most promising sites located far from potential customers, both the United States and the Soviet Union eventually decided against this costly and untested technology.

Second, all the articles demonstrate how times of economic and social crisis apparently presented special opportunities for renewables. Investments into renewable energies thrived during the two World Wars, in the wake of the Great Depression of the 1930s, as well as in the 1970s when many countries suffered from resource scarcity and/or disruptions of transnational energy markets. In those times of crisis, we see rationalities shift swiftly and arguments like energy autarky or reliance on domestic resources gaining
weight. This could create favorable circumstances for a ‘head wind transition’ (Kaijser) of the incumbent energy system, promoting renewable energies that did not seem very attractive in normal circumstances, as Arne Kaijser shows for the Swedish development of wood-gas generators for motorcars before and during World War Two. These times of crisis and transition not only encouraged creative technological tinkering but also the formulation of lofty ideals and dreams. The chemurgy movement in the United States is a prime example of the utopian potential of renewable energies, but also of the veto-powers inherent in economic and political realities, as Frank Uekötter exemplifies. The author vividly illustrates that when it comes to technical visions, it is not enough to have the necessary expertise, or even financial and political influence, but rather it is crucial to build coalitions with the actual users of a technology or energy – as the US chemurgists failed to do with the influential farmers’ lobby. Stemming from different social classes and having divergent urban and rural backgrounds, chemurgists and farmers did not find a way to engage in a meaningful conversation.

The chemurgy movement of the 1920s to 1940s was just one episode in the US history of alcohol fuels, as Jeffrey Manuel reminds us in his longitudinal study on alcohol-fuel advocacy and use in the United States. Manuel also emphasizes the detriments of developing and utilizing (alternative) energies and convincingly explains why those ‘dark sides’ must be part of our stories: ‘The point of highlighting renewable energy’s sacrifice zones is not to discredit such energy sources or suggest that the reality of environmental harm means the globe should continue intense reliance on fossil fuels. […] It suggests, however, that historians have an important role to play in reminding energy policymakers and the general public that all energy regimes have required environmental sacrifice and that we need a careful accounting for the winners and losers of each energy system’.13 In his own case study on biofuel production in the United States, Manuel accentuates how the intense monocrop agriculture of the Midwestern Corn Belt negatively affected the region’s soil and water, reducing biodiversity as well as creating a growing dead zone in the Gulf of Mexico as a result of fertilizer and herbicide runoff.

As a matter of fact, the case studies in this issue frequently alert us to the fact that energy use – whether renewable or not – always involves social and environmental costs. These stories help us to ‘critically revisit the tacit assumption that a “green” energy transition will invariably lead to the merry land of sustainability’.14 Renewables do not come free of charge. Their effects on the labor market, for example, are highly controversial as labor-intensive production in the coal and mining industries is increasingly replaced by renewable technologies that require a different set of skills from the workforce.15 Furthermore, the energies which were adopted and adapted by societies, but also by individual households, reflected not only technological preferences and necessities, but also inequalities between social groups (and thus class, race, and gender issues) and regions (often following an urban-rural divide). As the articles in this issue demonstrate, promoting renewables was not in itself equivalent to promoting greater energy justice.

Historical examples also provide ample evidence of the trade-offs between different uses of energy and the environment, e.g. concerning rivers. A water level suitable for creating hydropower often meant a lack of drainage for adjacent farmland and ecosystems. Thus, many conservationists opposed hydropower projects for both ecological and
aesthetic reasons. Fishermen also resented watercourses being blocked by weirs and dams as this reduced the habitat of the fish they relied on. And even though large-scale energy projects often enjoyed the support of powerful lobbying groups outside and within political administrations, these local concerns were not automatically doomed to fail, as Felix Frey exemplifies in his study. In the interwar years the Canadian government rejected initial plans for a bi-national US-Canadian tidal power plant because of its potentially damaging effects on local fisheries. Similar controversies on the ecological and visual impacts of renewable energies can be observed regarding high-voltage power lines or wind turbines, ‘steel monsters cutting through the countryside with their rotor blades’, ‘executing and annihilating’ ancient villages and pristine landscapes, as prominent German conservationist Enoch zu Guttenberg famously stated in 2012. How the environmental costs and sacrifice zones of renewable, fossil and nuclear energies compared and interrelated with each other deserves further investigation.

Past experiences also alert us to the multiple unintended consequences of technological innovations and developments, particularly rebound effects that eliminated the benefits of technical progress. Installation of low-cost, energy-efficient LEDs for street and commercial lighting, for example, has not necessarily resulted in a decrease in energy consumption or light pollution as it apparently induced municipalities and consumers to increase nocturnal illuminations (‘twice the light at half the cost’). Iceland, while turning completely to renewables, not only stayed on an energy-intensive pathway but became a nation with one of the highest levels of energy use per capita worldwide. Investigating renewables in history thus alerts us not only to hidden pathways, windows of opportunity and critical junctures in energy history, but also to the contentious sides of supposedly ‘green’ energies and the asymmetrical power relations they were subject to, supporting our argument that the history of renewable energies and technologies must be studied within a wider framework of social and political history.

Framings and narratives of ‘Alternative Energies’

Decisions in favor of or against renewable energies were also intrinsically linked to the perceptions and preferences of engineers, decision makers, and consumers. In this respect, narratives mattered greatly. Perhaps surprisingly from today’s point of view, environmental issues seldom stood at the core of past narratives of renewables, which revolved much more around economic rationales, costs and prices, security of supply and political (in-)dependence, cleanliness and healthiness, as well as operating safety and user convenience. For example, as Nicole Hesse outlines in her contribution, early wind energy was praised not for its renewability but for its self-reliant operation and maintenance. It furthered the formation of specific knowledge and practices and also opened spaces of economic possibilities and societal progress in peripheral regions of both Germany and France. As a matter of fact, as all the papers exemplify, proponents of renewable energies frequently utilized and promoted popular notions of ‘energy autarky’ and self-reliance.

While today, renewables are regarded as almost synonymous with ‘green’ or ‘clean’ energies, in earlier times, cleanliness was not their unique selling point. In the 1950s and 1960s, for example, oil for heating shared a clean image in contrast to the smoke, soot and grime associated with coal heating. As Odinn Melsted explains in his contribution, oil
was not only perceived as a good substitute for coal, but actually preferred by many users to renewable alternatives such as geothermal heating, which could come along with foul-smelling water. Moreover, until the 1970s, most promoters of renewable energies did not pursue an environmental agenda – and were not expected to do so by public or politics. As Felix Frey shows, Lev Bernshtein, who became the long-time champion of tidal power in the Soviet Union, did not promote his schemes to produce energy by stating that they were environmentally friendly but, much in line with the Stalinist ideology of large-scale modernization, by framing huge infrastructure projects as ‘the most daring plans to subdue nature’ – and as a means to demonstrate the superiority of the Soviet system.22

Several articles in this volume utilize framing as an analytical tool to deconstruct historical actors’ legitimation strategies and disentangle the polyphonic negotiation processes surrounding renewable energies. Most remarkably, while renewables were framed in many ways – as local, domestic, self-sufficient, inexhaustible, or free of charge – they were for most of the time neither framed nor named as renewable. Indeed, in the present environmentally tinged discourse on renewables, it is not the natural resources or the technologies involved that are new, but rather the term and its ecological setting, which gained currency from the 1970s onwards.23 This is significant as each labelling evoked specific associations and embedded the ‘renewable’ energy in particular contexts. Thus, the authors of this special issue are sensitive to what terms were used to what effect in the past to denote what we call renewables today.

Rifkin is only one case in point, with his interpretation of renewables as a cornerstone of an upcoming great social transformation and bright energy future. Naturally, he was not the first to associate (renewable) energies with technological and social change. Throughout the 19th and 20th centuries, energy had been a fruitful field for utopian and visionary thinking. Major changes in energy regimes regularly evoked the conviction that they would also transform, if not revolutionize, society. The advent of electricity at the turn of the twentieth century raised many speculations that humankind was on the brink of a new era. ‘Communism is Soviet power plus the electrification of the whole country’, Lenin famously declared in 1920, and a few years later Lewis Mumford saw electricity as the carrier of a new post-industrial era, the ‘neotechnic age’.24 Visions of the ‘atomic age’ and of the benefits that nuclear power would provide went even further. Starting with the Atoms for Peace campaign of the 1950s, nuclear energy was publicly promoted as the one-technology-fits-all solution to all future (energy) problems. It was expected to change everyone’s life fundamentally, to provide energy that was both clean and abundant and at prices so incredibly low that it would be ‘too cheap to meter’.25 Expectations about future energy demands also had immense practical and operational consequences as they became an integral part of energy supply planning and informed the orchestration of complex transnational electricity systems.26

Renewables were part of these bright energy futures. As Frank Uekötter details in his contribution, biofuels were at the core of the chemurgy movement that became popular in the United States in the interwar years. Its proponents, particularly millionaire William J. Hale, aimed at a social revolution along chemical principles and led by chemical experts. The future chemurgy envisioned in the 1930s and 1940s is strangely reminiscent of later promises associated with nuclear energy (as well as arguments made by today’s enthusiastic advocates of renewables): ‘given an unlimited amount of organic
waste and a receptacle for its controlled decomposition, there is every possibility that the spirit of ethyl alcohol that distils therefrom [sic] may record a cost approaching nothing’. 27

The history of (renewable) energies thus encompasses many alternative (and overlapping) energy futures. The plural ‘futures’ is deliberately chosen here to emphasize the multiplicity of visions, present in several scenarios that branch off from each other and interweave depending on public choices made at particular points in time, often based on long-standing cultural experiences and historical path-dependencies – and not just the one and only future that actors often tend to focus on. Leading representatives of science and technology studies have conceptualized tools to grapple with the visionary elements embedded in energy technologies and innovations. 28 Sheila Jasanoff has coined the concept of ‘sociotechnical imaginaries’, which she defines as ‘collectively held, institutionally stabilised and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology’. 29

Societal discourses about technology are not only intimately connected with desirable futures, however; they also frequently revolve around undesirable ones. Most prominently, the authoritarian ‘nuclear state’ 30 was contrasted with decentralized grassroots solar democracy by the environmental movement of the 1970s and 1980s. 31 Most ‘energy futures’ thus have strong normative underpinnings, denoting sometimes opposing notions, preferences, and fears about what kind of societies might (or should) emerge in the future. This also means that the history of renewables is not a straightforward story of good (renewables) vs. bad (fossil and nuclear fuels), even if it might be in the eyes of some of its protagonists, but a complicated and contradictory mélange of perceptions and preferences, symbols and worldviews, constantly shifting and realigned over time.

In high modernity, utopic and dystopic technological fictions were almost omnipresent in scientific, political, and public discourses, and became an integral part of its popular culture. Patrick McCray has called the forward-oriented shaping of new technologies ‘visioneering’, based on the power of ‘visioneers’ to imagine how the future might be radically changed by technology. To him, nuclear fusion is perhaps the best example of such a visioneering. 32 Our volume shows that renewables such as fuel alcohol or tidal energy were also a subject of this technological visioneering – inspiring enthusiastic support and actions, but often with little practical impact on the energy market. Indeed, our findings suggest that it was rather the modest, down-to-earth renewable energies and technologies, such as geothermal energy or heat pumps, that proved to be most transformative in ‘real life’ – another case in point for the importance of looking beyond large meta discourses on energy dominated by political stakeholders and the media, and to investigate ‘technologies in use’ and the utilization of ‘everyday energies’ on the ground, two entangled, but not coinciding perspectives. 33

Renewables and energy transitions

With the exception of the large-scale development of hydroelectric plants since the 1930s, historical energy transitions of the past 200 years have been based on non-renewable resources, namely coal, mineral oil, and nuclear fission. 34 In light of the global challenges facing this form of energy economy, most notably climate change, we may interpret the
history of renewables since industrialization as a history of missed opportunities. Some renewable pathways were there for the taking, most notably wind and solar power, but were dismissed as inefficient, inconvenient, or simply unfashionable (Hesse, Pallua). Other renewables have flourished in specific regional (and environmental) settings, such as geothermal energy in Iceland (Melsted). Sometimes, renewables served as stopgaps in times of crises, such as wood gas in Sweden during World War Two, or as ‘bridging technologies’ to overcome situations of temporal scarcity till more ‘modern’ solutions could be made available (Kaijser, Hesse). A few renewable pathways, such as tidal energy or fuel alcohol, might not have been worth taking, at least not at the time (Frey, Uekötter). Some re-emerged when the time seemed right (Manuel, Hesse, Pallua). Other renewables, particularly biomass, have formed a continuous baseline within our energy mix – in the industrial ‘West’, but even more so in the Global South. Here, many citizens living in the countryside or in informal settlements primarily rely on biomass (wood, dung, organic residue) to (barely) satisfy their energy needs. These stories complicate, but still support the familiar narrative of the ‘fossilization’ of post-war societies and their recent turn to ‘green energies’.

What hampered the advance of renewables in the past – besides the obvious answer that they just could not compete economically with fossil fuels and nuclear energy? Besides adding the above-mentioned symbolic dimension to the equation, the case studies in this volume suggest at least two additional factors that complement and differentiate the familiar story of fossil fuels within the Anthropocene. First of all, geography greatly mattered in shaping (but not determining!) historical trajectories of energy production and consumption, on all scales, from the local and regional to the national and global levels. Most energy resources were (and are) distributed unevenly around the globe. In contrast to coal and mineral oil, renewables were more difficult to mobilize or transport over long distances to sites of consumption, and often needed to be utilized on the spot. Over time, technical solutions such as long-distance high-voltage lines loosened this tie to specific locations, but still involved sometimes substantial transmission losses when covering large distances. However, it is still more economical to ship (or pipeline) high-density energy carriers such as mineral oil than, for example, to utilize biomass technologies, or transmit solar energy from North African deserts to Europe’s load centers, as the ill-fated Desertec project amply illustrates.

Second, this ties in with the scales and modes of production and consumption that different energy sources demand. One of oil’s greatest advantages – besides its price – is that it is more flexible in use, and thus easier to adapt to existing schemes, than renewables (e.g. Pallua on heat pumps). Oil is both easily integrated into economies of scale, centralizing electricity production in large power stations, and utilized at the household level, fueling individual furnaces and boilers. Renewables also come in many sizes and forms, but are often less flexible. They depend on natural conditions, which are subject to daily and seasonal fluctuations and sometimes hard to predict and control. In addition, the heat, kinetic, or electric energy renewables produce is harder to store and commodify and, thus, to integrate into economic systems, be they capitalist or socialist. However, it is important to bear in mind that renewables’ image as decentralized, bottom-up, ‘soft’ energies and technologies is largely a myth, spurred by eco-legends of civil society tinkerers defying both state power and capitalism. As the articles in this volume show, large-scale installations such as the projected tidal power plants (Frey) or huge biofuel
farms (Manuel, Uekötter) are also part of the story, interfering with ecosystems and causing environmental and social damage. Renewable, thus, is not necessarily equivalent to sustainable.

**Outlook**

So, looking back and forward again, what are the lessons we might learn from the history of renewable energies for the history of technology, but also for future energy transitions? One important conclusion that we might accentuate in public discourse is to take optimistic forecasts such as Rifkin’s with more than a grain of salt. Time and again, energy visionaries have promised that the solution to all our energy needs is just beyond the horizon, bringing peace and plenty for all, and transforming – if not revolutionizing – society. History suggests that we should be wary of such forecasts. There is little reason to believe that our energy future(s) will suddenly unfold free of the burdens of asymmetrical power relations and the unexpected contingencies that have afflicted our past. But history can also demonstrate that fundamental transformations of energy production and consumption are possible, even on short notice – on the large scale, from agrarian to industrial energy regimes, but also on the small scale, driven by individual consumer choices. How people perceived – and embarked on – alternative energy pathways, but also how societies interacted with energy’s material dimension over time, not only shaped the incumbent energy system, but also has important implications for tomorrow’s energy policies. To tackle the present energy challenge successfully, historical insights into the drivers, trajectories, and consequences of past energy transitions will be of utmost significance. To name just a few, this volume’s contributions point to the importance of political and social framing, the ability to detect and seize windows of opportunity (often provided by social, political, or environmental crises), the ability to adapt to or break up socio-technological (infra-)structures, and the ability to acknowledge and successfully mediate social and environmental costs of change.

Secondly, we believe that renewable energy history provides a resource to rethink and scrutinize familiar narratives in the history of technology and environmental history such as narratives of technological success and failure or environmental sustainability and degradation. The history of renewable energies particularly challenges the notion of the modern era as the era of fossil fuels, by revealing hidden pathways, windows of opportunity, and critical junctures in energy history, thus highlighting the transitory character of ‘modern fossil-fuel society’. The articles in this volume demonstrate not only the analytical benefits of integrating an energy (or resource) perspective in the history of technology – a dimension often neglected in this field – but also the need to move the debate on energy transitions beyond the macro scale. Here, energy history might profit from the debates in the history of technology that have emphasized the study of technologies-in-use as well as ‘hybrid’ blends of ‘old’ and ‘new’ technologies. There is much to be gained by taking an envirotech approach to the history of renewables. This is a rich area of study, with many questions still up for debate – from renewables’ history in the Global South and the gender dimensions of renewable energies and technologies, to specific actors that promoted (or hampered) the development of renewables, particularly transnational organizations and corporations.
Notes

1. Rifkin, The Zero Marginal Cost Society. Rifkin’s predictions of an inexhaustible energy utopia outline a brave new world – a vision of a collaborative future that many are likely to embrace, but at the same time a questionable one. Is it reasonable to assume that energy production from renewable sources will expand so massively that it will meet the lion’s share of the global energy demand in only a few decades? Who will decide upon the necessary infrastructures for zero marginal cost systems to function – and who will supply and maintain them? And how desirable are Rifkin’s notions of interlinked smart, self-replicating systems that eliminate the need for human labor and carry many risks of misuse?
2. See Kupper, Melsted, and Pallua, “On Power”; Hasenöhrl and Meyer, “The Energy Challenge in Historical Perspective.”
3. Tischler, Light and Power for a Multiracial Nation; Hoag, Developing the Rivers of East and West Africa; Werner, The Politics of Dams; Swyngedouw, Liquid Power; Pritchard, Confluence; Zumbrägel, “Viele Wenige machen ein Viel.”
4. See Kander, Malanima, and Warde, Power to the People, 35–128. On wood: Radkau, Wood.
5. Heymann, Die Geschichte der Windenergienutzung; Perlin, Let it Shine.
6. With notable exceptions: Kander, Malanima, and Warde, Power to the People; Smil, Energy Transitions.
7. E.g. regarding wood shortages: Grewe, “Power, Politics, and Protecting the Forest”; Hözl, Umkämpfte Wälder; Warde, “Fear of Wood Shortage and the Reality of the Woodland in Europe, c.1450–1850”; on matters of energy density: Kander, Malanima, and Warde, Power to the People.
8. Hughes, Networks of Power; Högselius, Kaijser, and van der Vleuten, Europe’s Infrastructure Transition.
9. E.g.: Jørgensen and Jørgensen, “Aesthetics of Energy Landscapes.”
10. The case studies were first presented and discussed at an international workshop at the Deutsches Museum in Munich: “How New Are the Renewables? Historicizing Energy Transitions,” February 21–23, 2018. See the conference report by Melsted: https://seeingthewoods.org/2018/05/21/how-new-are-the-renewables-historicizing-energy-transitions/, accessed 26 February 2019.
11. E.g. Mavhunga and Trischler, “Energy (and) Colonialism.”
12. Rifkin, The Zero Marginal Cost Society, 81–84.
13. See Manuel, this issue.
14. Hasenöhrl and Meyer, “The Energy Challenge in Historical Perspective,” 298.
15. Umweltbundesamt, Klimaschutz und Kohleausstieg.
16. Blackbourn, The Conquest of Nature; Hasenöhrl, “Weiße Kohle” oder ‘Ausbeutung der Natur?”
17. Cited in Hasenöhrl, “Just a Matter of Habitation?,” 78.
18. Hasenöhrl and Meyer, “The Energy Challenge in Historical Perspective.”
19. E. g. Meier et al., Urban Lighting, Light Pollution, and Society.
20. See the contribution by Melsted. https://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE?year_high_desc=true, accessed on 25 February 2019.
21. As has been done for fossil fuel history i.a. by Mitchell, Carbon Democracy and Malm, Fossil Capital.
22. Frey, this issue.
23. See https://seeingthewoods.org/2018/05/21/how-new-are-the-renewables-historicizing-energy-transitions/, accessed 26 February 2019.
24. https://www.marxists.org/archive/lenin/works/1920/nov/21.htm, accessed 26 February 2019; Mumford, Technics and Civilization.
25. Cohn, Too Cheap to Meter; Kupper, “From Prophecies of the Future to Incarnations of the Past.”
26. Trischler and Bud, “Public Technology.”
27. Cited in Uekötter, this issue.
28. See Grunwald, “Assigning Meaning to NEST by Technology Futures.”
29. Jasanoff and Kim, “Sociotechnical Imaginaries and National Energy Policies.”
30. Jungk, *The Nuclear State*.
31. E.G. Milder, *Greening Democracy*.
32. McCray, *The Visioneers*.
33. See Edgerton, “From Innovation to Use”; Arnold, *Everyday Technology*.
34. See Kupper, “Energy and Progress.”
35. Singh et al., “India’s Biophysical Economy.”
36. See Jones, *Routes of Power*.
37. On non-networked technologies and energies, see recently Tarr, “Illuminating the Streets.”
38. Lovins, *Soft Energy Paths*.
39. Hård and Jamison, *Hubris and Hybrids*; Edgerton, *The Shock of the Old*; Hessler and Weber, *Provokationen der Technikgeschichte*.

**Acknowledgments**

We would like to thank the journal editors, the anonymous reviewer, as well as the contributors to this special issue for their helpful reflections and comments on previous versions of the paper. University of Innsbruck’s Faculty of Humanities 1 (Philosophy and History) has kindly provided us with funding for proof-reading and language editing.

**Disclosure statement**

No potential conflict of interest was reported by the author(s).

**Bibliography**

Arnold, D. *Everyday Technology: Machines and the Making of India’s Modernity*. Chicago: University of Chicago Press, 2013.
Blackbourn, D. *The Conquest of Nature: Water, Landscape and the Making of Modern Germany*. London: Jonathan Cape, 2006.
Cohn, S. M. *Too Cheap to Meter: An Economic and Philosophical Analysis of the Nuclear Dream*. New York: State University Press, 1997.
Edgerton, D. “From Innovation to Use: Ten Eclectic Theses on the Historiography of Technology.” *History and Technology* 16, no. 2 (1999): 111–136. doi:10.1080/07341519908581961.
Edgerton, D. *The Shock of the Old: Technology and Global History since 1900*. London: Profile Books, 2007.
Greve, B.-S. "Power, Politics, and Protecting the Forest: Scares about Wood Shortages and Deforestation in Early Modern German States." In *Exploring Apocalyptic: Coming to Terms with Environmental Alarmism*, edited by F. Uekötter, 12–35. Pittsburgh: University of Pittsburgh Press, 2018.
Grunwald, A. “Assigning Meaning to NEST by Technology Futures: Extended Responsibility of Technology Assessment in RRI.” *Journal of Responsible Innovation* 4, no. 2 (2017): 100–117. doi:10.1080/23299460.2017.1360719.
Härd, M., and A. Jamison. *Hubris and Hybrids: A Cultural History of Technology and Science*. New York: Routledge, 2005.
Hasenöhrl, U. “‘Weiße Kohle’ oder ‘Ausbeutung der Natur’? Konflikte um die Nutzung der Wasserkraft im (Vor-)Alpenraum am Beispiel bayerisch-österreichischer Grenzflüsse.” *Bohemia* 54, no. 1 (2014): 119–141. doi:10.18447/BOZ-2014-3904.
Hasenöhrl, U. “Just a Matter of Habitation? The Contentious Perception of (Post)energy Landscapes in Germany, 1945-2016.” *Environment, Space, Place* 10, no. 1 (2018): 63–88. https://www.jstor.org/stable/10.5749/envispacplac.10.1.0063.
Hasenöhrl, U., and J.-H. Meyer. “The Energy Challenge in Historical Perspective.” Technology & Culture 61, no. 1 (2020): 295–306. doi:10.1353/tech.2020.0003.

Heßler, M., and H. Weber, eds. Provokationen der Technikgeschichte: Zum Reflexionszwang historischer Forschung. Paderborn: Ferdinand Schöningh, 2019.

Heymann, M. Die Geschichte der Windenergienutzung: 1890–1990. Frankfurt am Main: Campus, 1995.

Hoag, H. J. Developing the Rivers of East and West Africa: An Environmental History. London: Bloomsbury Academic, 2013.

Högsetius, P., A. Kaijser, and E. van der Vleuten. Europe’s Infrastructure Transition: Economy, War, Nature. Basingstoke: Palgrave, 2016.

Hölzl, R. Umkämpfte Wälder: Die Geschichte einer ökologischen Reform in Deutschland 1760–1860. Frankfurt am Main: Campus, 2010.

Hughes, T. P. Networks of Power: Electrification in Western Society, 1880–1930. Softshell Books ed. Baltimore: John Hopkins University Press, 1993.

Jasanoff, S., and S.-H. Kim. “Sociotechnical Imaginaries and National Energy Policies.” Science as Culture 22, no. 2 (2013): 189–196. doi:10.1080/09505431.2013.786990.

Jones, C. F. Routes of Power: Energy and Modern America. Cambridge: Harvard University Press, 2014.

Jørgensen, D., and F.A. Jørgensen. “Aesthetics of Energy Landscapes.” Environment, Space, Place 10, no. 1 (2018): 1–14. doi:10.5749/envispacplac.10.1.0001.

Jungk, R. The Nuclear State. Platform Books. London: Calder, 1979.

Kander, A., P. Malanima, and P. Warde. Power to the People: Energy in Europe over the Last Five Centuries. Princeton: Princeton University Press, 2013.

Kupper, P. “From Prophecies of the Future to Incarnations of the Past: Cultures of Nuclear Technology.” In Cultures of Technology and the Quest for Innovation, edited by H. Nowotny, 155–166. New York: Berghahn, 2006.

Kupper, P. “Energy and Progress: Understanding Energy Transitions from a World History Perspective.” In Energie.wenden: Energy Transitions as Chance and Challenge in Our Time, edited by C. Newinger, C. Geyer, and S. Kellberg, 12–15. Munich: oekom, 2017.

Kupper, P., O. Melsted, and I. Pallua. “On Power: Neue Literatur zur Energiegeschichte.” NTM 25, no. 1 (2017): 143–158. doi:10.1007/s00048-017-0165-8.

Lovins, A. B. Soft Energy Paths: Toward a Durable Peace. Harmondsworth: Penguin, 1977.

Malm, A. Fossil Capital: The Rise of Steam-Power and the Roots of Global Warming. London: Verso, 2016.

Mavhunga, C. C., and H. Trischler, eds. “Energy (and) Colonialism: Energy (In)dependence: Africa, Europe, Greenland, North America.” RCC Perspectives, no. 5 (2014). 10.5282/rcc/6554.

McCray, W. P. The Visioneers: How a Group of Elite Scientists Pursued Space Colonies, Nanotechnologies, and a Limitless Future. Princeton: Princeton University Press, 2013.

Meier, J., U. Hasenöhrl, K. Krause, and M. Pottharst, eds. Urban Lighting, Light Pollution, and Society. New York: Routledge, 2015.

Milder, S. Greening Democracy: The Anti-Nuclear Movement and Political Environmentalism in West Germany and Beyond, 1968–1983. Cambridge: Cambridge University Press, 2017.

Mitchell, T. Carbon Democracy: Political Power in the Age of Oil. London: Verso, 2011.

Mumford, L. Technics and Civilization. London: Routledge, 1934.

Perlin, J. Let It Shine: The 6,000-Year Story of Solar Energy. Novato: New World Library, 2013.

Pritchard, S. B. Confluence: The Nature of Technology and the Remaking of the Rhône. Cambridge: Harvard University Press, 2011.

Radkau, J. Wood: A History. Cambridge: Polity, 2012.

Rifkin, J. The Zero Marginal Cost Society: The Internet of Things, the Collaborative Commons, and the Eclipse of Capitalism. New York: Macmillan, 2014.

Singh, S. J., F. Kraussmann, S. Gingrich, H. Haberl, K.-H. Erb, P. Lanz, J. Martinez-Alier, and L. Temper. “India’s Biophysical Economy, 1961–2008: Sustainability in a National and Global Context.” Ecological Economics 76, no. 100 (2012): 60–69. doi:10.1016/j.ecolecon.2012.01.022.
Smil, V. Energy Transitions: History, Requirements, Prospects. Santa Barbara: Praeger, 2010.
Swyngedouw, E. Liquid Power: Water and Contested Modernities in Spain, 1898–2010. Urban and Industrial Environments. Cambridge: MIT Press, 2015.
Tarr, J. A. “Illuminating the Streets, Alleys, Parks and Suburbs of the American City: Non-networked Technologies, 1870–1920.” History and Technology 36, no. 1 (2020): 105–128. doi:10.1080/07341512.2020.1739816.
Tischler, J. “Light and Power for a Multiracial Nation: The Kariba Dam Scheme in the Central African Federation.” Cambridge Imperial and Post-Colonial Studies Series. New York: Palgrave, 2013.
Trischler, H., and R. Bud. “Public Technology: Nuclear Energy in Europe.” History and Technology 27, no. 2 (2019): 1–26. doi:10.1080/07341512.2018.1570674.
Umweltbundesamt, ed. Klimaschutz und Kohleausstieg: Politische Strategien und Maßnahmen bis 2030 und darüber hinaus? Dessau-Roßlau: Umweltbundesamt, 2019.
Warde, P. “Fear of Wood Shortage and the Reality of the Woodland in Europe, c.1450–1850.” History Workshop Journal 62, no. 1 (2006): 28–57. doi:10.1093/hwj/dbl009.
Werner, H. The Politics of Dams: Developmental Perspectives and Social Critique in Modern India. New Delhi: Oxford University Press, 2015.
Zumbrägel, C. 'Viele Wenige machen ein Viel': Eine Technik- und Umweltgeschichte der Kleinwasserkraft (1880-1930). Paderborn: Ferdinand Schöningh, 2018.