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Seeing Forests as Fuel: How Conflicting Narratives have shaped Woody Biomass Energy Development in the US since the 1970s

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Seeing forests as fuel: How conflicting narratives have shaped woody biomass energy development in the United States since the 1970s

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ABSTRACT

This article provides an historical analysis of arguments for and against using forests for fuel since the 1970s energy crises, and explores the relationship between public narratives and the implementation of renewable energy technologies. I argue that different ideas about the use of forest resources created narrative conflict between stakeholder groups, and this conflict influenced the development of biomass energy systems by limiting private investment and shaping public policy. Promoters and opponents of forest fuels both worked to achieve political goals as well as economic and environmental ones, and debates about biomass energy reflected these different views. Although this paper focuses on public perceptions about wood energy in the US, biomass advocacy in the US was influenced by efforts in other countries, particularly by innovation in Sweden and Finland. By providing an historical investigation of the cultural barriers to developing decentralized renewable energy systems in the US, and explaining how this experience compared with biomass development in other countries, this research demonstrates how conflicting narratives have shaped energy and environmental policy since the 1970s. This historical perspective contains valuable lessons about how different social groups' values and beliefs have affected – and continue to affect – decisions about new energy technologies.

1. Introduction

The chainsaw may seem like an unlikely tool for sustainable energy production, but since the energy crises in the 1970s, renewable energy advocates in industrial countries have worked to rekindle interest in the use of forests for fuel. Yet like with other decentralized sources of energy, the embers of support for biomass development have been slow to ignite. Instead, the topic has sparked conflict and debate about appropriate energy sources and the size and scope of renewable energy technologies. On a deeper level, like energy transitions in other times and places, debates about biomass development have often involved clashes between fundamentally different visions of the future. These conflicting visions were expressed through narratives that also suggested different relationships with existing power structures and scales of governance. Arguments for or against the development of biomass were often tied to political questions about the decentralization and centralization of power. These arguments were influenced by different cultural norms and attitudes towards resource extraction. An examination of the narratives employed by biomass advocates and critics since the 1970s reveals how conflicting perceptions about land management and political control have shaped, and in some ways, have failed to shape, energy decisions and policy.

Biomass energy is a large category that includes all energy produced from plant material. Liquid biofuels like ethanol or methanol can be produced from corn or perennial grasses like switchgrass. Plant-based feedstocks can also be burned to produce electrical power. This paper focuses on energy derived from wood and used primarily for heat and/or electricity, including domestic woodstoves, wood boilers, combined heat and power facilities, and large industrial-scale power plants. Aside from domestic firewood, most wood used in these applications has come as a byproduct of other forest products, and in some cases as municipal solid waste. Although in the 1970s and '80s, the US government pursued research on the economic potential of methanol, a liquid transportation fuel that can be derived from wood, this paper does not focus on debates about liquid biofuels. In addition to the unique technological factors involved in the production and distribution of liquid biofuels, methanol and ethanol have their own set of political and cultural challenges that are beyond the scope of this article [1].

Although there are several technological and economic reasons why the development of energy systems based on renewable fuels like woody biomass has been limited, less is known about the cultural barriers to decentralizing energy. This research explores

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public debates about biomass development and decision-making processes involved with renewable energy development since the 1970s. This historical examination adds to a growing pool of research that acknowledges that our energy problems are not only technological; they are also deeply social and political [2]. Using an historical approach reveals the often hidden cultural barriers to developing renewable energy systems, and helps to illuminate the complex interaction of ideas, attitudes, and policy. As historians Richard F. Hirsh and Christopher F. Jones note, historical perspectives on energy transitions provide a deeper understanding of the nontechnical aspects of emerging technologies, and can help to explain why new technologies sometimes fail, "even when they appear to have appealing technical attributes [3]." The history of woody biomass since the energy crises in the 1970s provides a compelling demonstration of this phenomenon.

Most of the literature on energy transitions in the top three energy journals has focused on markets, policy mechanisms, climate change, and pricing [4]. Moreover, Frank Laird and Kathleen Araújo have noted that the literature on energy transitions has emphasized changes in dominant fuel sources and technologies; less has been written about the social and political dynamics surrounding distributed power systems [5]. Hancock and Vivoda suggest that although the field of international political economy began in the 1970s and has concerned itself primarily with global dynamics involved in the fossil fuel-based economy, future energy scholars should pay more attention to community interests and renewable energy [6]. On a related note, Araújo advocates for paying greater attention to the sociopolitical aspects of distributed power systems and the agency of a wider range of actors involved in energy transitions [7]. This paper aims to help fill some of these research gaps by employing human-centered methods and historical perspectives to help shed light on the cultural barriers involved in energy transitions.

More specifically, this historical analysis of different ideas and attitudes towards woody biomass energy since the 1970s helps to illuminate how public narratives about forest-based fuels were linked to broader ideas about political power, pollution, and resource management. In this way, the paper reveals the "interpretive flexibility" of emerging biomass-based energy systems, where the meaning of new kinds of energy technologies arose from the negotiation of different groups' ideas and values [8]. These conflicting ideas and values contributed to a sense of uncertainty about biomass technologies. That sense of risk limited private investment and, in combination with the relatively low price of fossil fuels, worked to prevent the widespread adoption of biomass-based energy technologies in the US in the late-twentieth century.

This research primarily focuses on the US, but discusses how wood energy innovation in Nordic countries and conflict over biomass development in the UK shaped public debate in the US. Although most energy research has focused on North American countries and there is need to explore other parts of the globe – developing nations in particular – because energy decisions made in the US have played such a significant role in affecting global economics and climate, studies like this can help to illustrate how cultural factors helped to reinforce centralized, fossil-fuel-based energy systems. As the leading consumer of fossil fuels, the US has played the most significant role in affecting the earth's climate and resources in the past half century. Between 1970 and 2013, the US produced more carbon dioxide emissions than any other country, and over 4/5th of the energy consumed in the US during that time came from fossil fuels [9]. In contrast, by 2009, 2.5 billion people – over a third of the global population – continued to rely on wood as a primary energy source, and most of those people lived in developing nations [10]. Because the political and cultural dynamics surrounding decision-making processes in the US were completely different from those in places where most of the world's wood energy users lived, this research may not translate into direct policy prescriptions for decision-makers in developing countries. Instead, the study shows how different ideas about centralized versus decentralized energy technologies reflect underlying values and political ideals. This broader lesson has important implications that extend beyond any one nation's borders.

This paper begins with a brief history of wood energy and the international context within which renewed interest in biomass energy arose in the US in the 1970s, first after the oil embargo in 1973 and then more strongly after the decline of Iranian oil output produced fears of fuel scarcity in 1978–1979. It then explores the arguments made by biomass advocates – those who promoted a range of new wood-burning technologies such as residential woodstoves, wood boilers, combined heat and power (CHP) facilities, and municipal electricity stations – for relocalizing energy systems through the use of wood. Like the rhetoric and rationales promoted by energy entrepreneurs in other times and places, biomass advocates had visions about how the revival of wood energy would help to rearrange social and political relationships [11]. The paper then examines narratives constructed by critics of wood energy, and explains how conflicting narratives contributed to the sense of risk surrounding biomass-based energy systems, and inadvertently limited private investment and influenced public policy. I conclude by exploring the implications of this historical analysis for current renewable energy initiatives and policy makers in the US and elsewhere.

2. Discussion

2.1. Forest fuels: from wood energy to biomass advocacy

Like most nations until the nineteenth century, the US's energy economy was powered primarily by wood. Trees provided fuel to heat homes and businesses, to move trains and goods, and, through the creation of charcoal, to make iron. From domestic use to early industrial production, to railroad construction and operation, wood sustained nearly all aspects of life, and fueled the great accumulation of wealth by industrialists by the end of the nineteenth century. The rise of the railroads was inextricably linked to the growth of the timber industry, and the federal government contributed to wood-based economic growth by providing financial payments and land grants. Timber barons' ability to take advantage of these kinds of federal subsides played a key role in establishing wood as the basis of the US economy in the nineteenth century, and provided precedent for federal involvement in wood-powered industries [12].

As the population increased and industry expanded after the Civil War, concern about the fear of timber famine spread. Just as renewable energy advocates in the twentieth century worried about peak oil, energy entrepreneurs in the nineteenth century expressed concern about the decline of the wood supply. Concerns about timber famine inspired many of the conservation reforms of the Progressive Era, and Gifford Pinchot's work to develop a national forest system. By the early twentieth century, however, coal began to replace wood as the nation's primary energy source, and the public's fears about running out of energy were assuaged by boosters' promises of the quality of life and sense of connectedness that would come from more concentrated forms of energy [13].

Although wood continued to heat homes in many rural, forested communities throughout the twentieth century, its role as a major economic driver subsided as coal and oil took on greater importance [14]. After World War II, the suburbs sprawled, the middle class grew, and the American automobile transformed lifestyles and landscapes [15]. This growth and prosperity was largely based upon

fossil fuels – oil in particular – and the political infrastructure that surrounded and reinforced fossil fuel industries [16]. As fossil fuel consumption increased, wood-based energy consumption in the US was relegated to poorer rural areas. Although wood had provided three-quarters of the US energy supply in 1870 and a quarter of the supply in 1900, by 1972, wood provided less than two percent of the country's total energy [17]. Instead of using trees to feed, heat, and transport themselves, Americans had became increasingly dependent on oil produced in the Middle East by the final decades of the twentieth century.

When the Arab members of the Organization of the Petroleum Exporting Countries (OPEC) announced the oil embargo in 1973, energy became front-page news and the search for domestic energy supplies was on. *The Washington Post* dubbed the fuels crisis "the biggest long-term problem we have [18]." In addition to daily concerns about getting to work and rising heating bills, Americans and Europeans grew increasingly anxious about their growing dependence on foreign oil—and on political regimes in the Middle East. Leaders within the forest products industry responded to this widespread anxiety, and entrepreneurs began to explore new ways to produce energy from wood. New wood burning technologies included more efficient woodstoves, new types of wood-fired boilers, cogeneration facilities that could produce both heat and power, and mechanisms that could help convert large, industrial coal- and oil-fired power plants to wood and other biofuels. As more advanced technologies were developed in the late 1970s and 1980s, "wood" became "biomass," and an ancient fuel was rebranded with a new sense of technological modernity and purpose. Some of these new wood-fired – now "biomass" – technologies included combined heat and power (CHP) facilities, industrial power plants, and district heating systems based on European designs.

Interest in forest-based fuels began slowly in the early 1970s after the oil embargo, but gained greater traction by the end of the decade. As the Iranian Revolution broke out and that country's oil output declined, forestry professionals met at the Joint Convention of the Canadian Institute of Forestry and the Society of American Foresters. Forest economist G. Robinson Gregory noted that the control of energy prices by politically motivated nationalists in the Middle East had "created an element of uncertainty that hangs over almost every decision made in business or government today [19]." The oil shocks of 1978–1979 provided renewed motivation for new wood-burning technologies like boilers and cogeneration plants. Benjamin Russell, a large forest landowner in the southern US and leader in the forest products industry, predicted that by 1985, the United States would depend on foreign oil for 60–70% of its energy needs, which would "make government price control academic, since most of the oil would not be subject to US price regulations but to the dictates of OPEC [20]." To attempt to control energy prices, he advocated for the development of domestic energy sources, including wood. These sentiments reflected a concern that was shared by a growing number of residents in western nations about the consequences of energy dependency and the concentration of power in politically unstable places.

Like other renewable energy advocates in the 1970s, biomass advocates argued that a political economy based on local sources of renewable energy would look much different than a global economy based on massive reserves of fossil fuels. Estimates of just how much biomass-based energy could contribute to the US's energy portfolio varied widely. Some predicted that wood could contribute 3 1/2% to the energy budget of the nation, while others predicted it could be 10% or more in forested parts of the country [21]. In testimony before the US House Subcommittee on Forests in 1978, Dr. Tom Ripley, Director of Forestry for the Tennessee Valley Authority, argued that if logging wastes, mill residues, intensive biomass production and other available harvestable material were combined, the US could generate enough BTUs to exceed the amount of oil the country imported each year [22].

Whatever its total contribution, biomass was an inherently decentralized source of fuel. Most advocates acknowledged that wood would never completely replace other forms of energy. Instead, they argued that biomass should be part of a broader, more diverse portfolio of energy sources. They suggested that instead of looking for a silver bullet like nuclear power to replace fossil fuels – and thus continuing the path of concentrated power and centralized control – countries should pursue a "silver buckshot" approach [23]. This involved a system of power generation that would place decision-making power in the hands of local or regional authorities instead of Middle East oil cartels or politicians in national centers. A successful biomass project, according to advocates from the World Resources Institute, was one that involved an active, diverse group from within the community where the facility was to be located. They argued that biomass technologies must be designed for "social as well as physical efficiency. There may never be a single 'biomass transistor' that can be 'plugged in' anywhere, anytime [24]." As an inherently local fuel source, new wood-burning energy technologies could thus help to create social and political systems that would not only decentralize the means of energy production, but in doing so, would also decentralize decision-making processes about energy technologies more broadly.

Although many biomass advocates believed that decentralized energy systems could help redistribute physical power as well as political power, their public narratives often conveyed visions for the future that differed from those promoted by other renewable energy advocates. Frank Laird has shown how in the mid-twentieth century, a subset of solar advocates envisioned a particularly bright future in which decentralized sources of fuel and methods of distribution would help to create a more just and egalitarian society. Radical social thinkers like Murray Bookchin touted solar energy as a means to promote widespread social and economic reform [25]. For Bookchin and many solar advocates in the late 1970s, restructuring systems of energy production and distribution involved the fundamental reconfiguration of existing political infrastructure.

Advocates of wood energy tended to be less explicit about creating radical social reform through the use of forest fuels. Instead, the narratives they used to promote wood energy expressed a vision that was pragmatic, based on immediate economic needs and resource availability. This pragmatic approach was nurtured by the fact that using trees for energy required direct involvement in land management decisions on a broad scale, and wood energy advocates typically had professional backgrounds in forestry and natural resource management. Their experiences in the field helped to hone a particular problem-solving orientation that had characterized a kind of environmental pragmatist tradition since the early twentieth century, particularly in the US as exemplified by figures such as Aldo Leopold and Benton MacKaye [26].

In addition to this active, problem-solving orientation, wood energy advocates in the late 1970s routinely emphasized that the effectiveness of converting to biomass technologies depended on the particular needs, available resources, and viable energy alternatives in a given locale. They acknowledged that forests were not equally distributed across the planet and therefore not a universal solution to energy problems everywhere. Yet at the same time, they argued that forest resources were "much more evenly distributed than are fossil fuels, which tend to be concentrated in a few regions [27]." This pragmatic, place-based approach to pioneering a new industry of renewable wood-based energy technologies was one that advocates hoped would slowly usher in a new era of distributed power generation. The end result of this vision would be a world in which local officials, landowners, institutions, and woods workers exerted more control over decisions about energy.

Wherever biomass projects were promoted – be they in the sylvan hills of New England or in the frozen flatlands of Fennoscandia – many argued that the decentralized nature of biomass energy was one of its greatest strengths. Because transporting and processing wood added additional costs in terms of labor and fuel, and because of the distributed nature of the forest resource, many biomass advocates agreed that developing distributed systems of several smaller-scale operations would be more successful than concentrating development in a fewer larger-scale ones [28]. It simply did not make sense to burn fossil fuels to process and transport woodchips long distances; therefore, biomass technologies could not concentrate power in the same ways that fossil fuels could. Furthermore, advocates pointed out that the problems associated with small generating plants in terms of economies of scale became less pronounced as capital became scarcer during recession in the 1970s [29]. As a result, they argued that biomass, an inherently decentralized power source, was becoming an increasingly attractive alternative to unstable power systems associated with fossil fuel.

Not surprisingly, forest products industries in Scandinavian countries and the US were first to switch to wood fuels to power their own operations. In 2002, 14% (89TWh) of Sweden's total energy supply came from biomass and of that total, 57% was used in the forest products industry [30]. Similar trends occurred in the US where by 1976, 30% of the total energy needed to power the US lumber industry came from burning its own wood wastes, and by 1981, the US pulp and paper industry was 50% self-sufficient in energy [31]. The rationale for using energy from wood in these cases was not necessarily to transform society, but rather to help solve the immediate problem of rising energy costs with an abundant resource at hand: wood waste [32]. In this sense, the leadership of the forest products industry in pioneering biomass energy innovation contributed to the pragmatism of biomass enthusiasts.

Energy entrepreneurs in Sweden, Finland, and Norway were among the first to realize the potential of forests to address not only the energy needs of the forest products industry, but the world energy crises of the 1970s. In 1973, Sweden depended on foreign oil for 70 percent of its energy needs [33]. Forest industries in Sweden and Finland had long served as important components of each nation's national economy and contributed to cultural identity—two critical themes that surfaced in the rhetoric promoted by biomass advocates in those countries' efforts to develop wood energy. Although Sweden's tax policies favored nuclear power as a domestic energy strategy in the 1970s, by 1990 growing concerns about the safety of nuclear power combined with a strong carbon tax spurred the rapid growth in forest fuel technologies. These technologies transferred quickly to Norway and Finland, neighboring countries that shared similar cultural and biophysical geographies and strong public appreciation of forested landscapes [34]. As biomass became an important part of Swedish, Norwegian, and Finnish energy policy in the 1990s, wood energy advocates in those countries increasingly tied their arguments about biomass energy to sustainable development and the promotion of local livelihoods, particularly in northern regions of these countries where forestry continued to serve as an important source of income for large agrarian populations [35]. These arguments about identity and community development were also common in narratives produced by advocates in places like Austria, the UK, and the US who sought to develop wood-burning technologies.

To promote the use of local forests for fuel, biomass advocates often employed rhetoric that was infused with appeals to a strong sense of local identity and autonomy. Many claimed wood to be a "native" or "indigenous" energy source [36]. Northern New England was especially dependent on oil because of the region's remote location, severe winter weather, and depressed rural economy. Biomass advocates there claimed that burning wood for heat was becoming cheaper than burning oil and gas imports, but more fundamentally, they argued that harvesting trees and burning wood were part of the region's cultural heritage. Wood energy fit neatly into the image of rugged individualism and self-sufficiency that characterized the region and other rural places in the United States. Robert Monks, the Director of Maine's Office of Energy Resources advocated for a $10 million plant to make methanol from wood. In 1975, 86 percent of the state's energy sources were imported, and a significant portion of that was from petroleum-based heating oil. Monks claimed that "here the necessity of life in the coldest damn place imaginable is controlled by foreigners [37]." Without new sources of local energy like the methanol plant, he believed that Mainers would be "utterly without the capacity for helping ourselves [38]."

In Vermont, Governor Thomas Salmon appointed a task force to study the potential of wood energy in 1975. The task force found that locally produced wood could provide up to 25 percent of Vermont's power, including industrial and home heating needs. In addition to creating new jobs, saving money, and increasing returns to forest landowners, the task force claimed that harvesting wood for energy would help free Vermonters from the clenching jaws of energy dependence [39]. Similarly, in the winter of 1983–1984, wood provided heat to nearly one-third of New Hampshire homes, with another 16 percent of households burning wood as a supplemental source of heat. A member of the Society for the Protection of New Hampshire forests claimed, "New England had returned to its origins [40]." These examples from Maine, Vermont, and New Hampshire illustrate how the use wood for fuel was inextricably linked to questions about cultural identity, political autonomy, and decentralized control.

In some ways, the desire for "native" fuels and the search for "indigenous" energy sources may have reflected anti-Arab sentiment that arose in the 1970s and 1980s. As fear of resource dependency and competition for energy resources arose, Arab Americans increasingly encountered racist attitudes and stereotypes. One Arab American woman living in Detroit noted that the oil shortages of 1973 and 1979–1980 had helped to produce the stereotype of the rich oil sheik, who was portrayed as being "intent on buying up America and the world with his newfound wealth." Moreover, she commented that, "American institutions and media sources promote depictions of Arabs as grissly-faced [sic], hook-nosed characters, dressed in traditional garb, looming menacingly over helpless Americans at the gas pump [41]." These images were perpetuated by the US Department of Energy in a campaign to encourage energy conservation and lower speed limits in the late 1970s. Playing on Americans' xenophobia, the agency distributed bumper stickers that read "The faster you drive, the richer they get" and "Driving 75 is sheik, driving 55 is chic [42]." These kinds of initiatives reflected the broader cultural and political context in which debates about domestic sources of renewable energy occurred.

Whether framed as the promotion of self-sufficiency or the perpetuation of xenophobic attitudes towards the Middle East, biomass advocates in the US and around the world routinely emphasized that forest-based fuels could help to diversify the global energy economy. In the 1990s, their motivation for diversifying energy systems shifted from energy security to incorporate a greater focus on environmental concerns, particularly in relation to the problem of global warming. Biomass advocates noted that compared to burning coal, burning wood produced fewer of some greenhouse gases like sulfur dioxide and nitrogen oxides. Also, depending on what type of fuel biomass replaced, the technology used, the particular application (for heat versus electricity), and the methods of reforestation, biomass could be considered a carbon neutral source of energy [43]. Essentially, carbon emitted during the combustion of woody material could be sequestered elsewhere by

new growing trees if proper forest management techniques were employed.

Although advocates had noted some of the environmental dimensions of using wood energy in the 1970s, the focus on climate mitigation became more pronounced by end of the twentieth century [44]. In *The Woodburners Encyclopedia*, Jay Shelton noted that "There is no denying the environmental impact of greatly increased wood use. The questions are how, and how much, to limit the impact and how the impact compares to that of alternatives (oil, coal, nuclear power, etc.) [45]." Between the 1970s and 1990s, the focus of environmental concern broadened from issues like forest health to include human impacts on climate, and the rhetoric of biomass advocates reflected this shift. Starting in the 1990s and continuing into the twenty-first century, biomass advocates maintained that "perhaps the greatest environmental benefit of burning biomass for energy is its positive impact in moderating climate change [46]." In this way, the narratives produced by biomass advocates reflected changing environmental values and the shifting priorities of the environmental movement. The integration of economic and environmental rationales for using wood energy revealed an important shift in environmental discourse, and the movement towards a more encompassing framework of sustainability.

In some ways, biomass advocates' problem-solving orientation and their desire for a more pluralistic approach to energy production helped to overcome an increasingly polarized political landscape in the late twentieth century. In other cases, however, the narratives conveyed by biomass advocates clashed with new ideas about the recreational, aesthetic, and ecological values of forests. These conflicting narratives would prove to have important implications for policy and private investment in the final decades of the twentieth century.

2.2. Embers of contention: concerns about biomass energy

Like those who advocated for the use of forest-based fuels, those who argued against biomass employed a wide range of narratives to express concern about the potential consequences of using wood for energy. These consequences included ecological and aesthetic impacts on forests, and air pollution threats to human health. Others expressed concern about increasing competition for forest resources. Though critical narratives came from disparate groups, they expressed overarching themes: an increasingly uneasy relationship with working forests and concern about the public health and social justice implications of renewable energy technologies. These perceptions of environmental and human health risks threatened the economic viability of those distributed energy technologies, and may have contributed to making private investors and policy-makers less inclined to support new energy systems.

Perhaps one of the greatest cultural barriers to using trees for energy in the US was that it forced communities to see the consequences of their energy consumption embedded in forested landscapes. These were places that in the 1970s, 1980s, and 1990s, more people increasingly valued for recreation, aesthetics, wildlife habitat, and other non-productive values [47]. By the 1970s, many had grown particularly critical about certain silvicultural practices like clearcutting and of harvesting trees in general. One study reported that 77 percent of Americans thought that clearcutting was bad, and over 50 percent believed that loggers were cutting the country's forests down faster than they could regrow [48]. Brock Evans of the Sierra Club wrote in *The Washington Post* that the "overcutting" of the country's forests was "one of the saddest parts of our recent history [49]." Ralph Nader was also critical of the Forest Service for opening the nation's forests "to excessive private timbercutting at the expense of wildlife, recreation, and reforestation [50]." These views were reflected in the landmark Monongahela decision in 1975, in which a federal judge ruled that the practice of clearcutting violated the Forest Service Organic Administration Act of 1897.

These attitudes toward forest harvesting practices were not unique to the US. By the 1970s, widespread criticism of timber harvesting had intensified in forested regions around the world, and people reported a growing aesthetic preference for untrammeled forested landscapes. This trend has continued into the twenty-first century. For example, a survey of Norwegians' landscape preferences found that wild and pristine forest environments near lakes were the most highly appreciated type of landscape; recently manipulated farm and forest scenes were among the least attractive [51]. In public statements against biomass, critics often focused on the aesthetic impacts that increased production would have on forests, and their narratives emphasized the non-productive value of forests.

To counter these concerns, forest professionals tried to convince the public that clearcutting was an ecologically sound practice and was sometimes necessary in order to regenerate certain early-successional tree species [52]. Kenneth Davis, President of the Society of American Foresters, argued that although clearcutting was "initially unattractive and conspicuous to the public," reforestation usually occurred quickly [53]. Although clearcutting was endorsed by the National Wildlife Federation, the American Forestry Association, and the Society of American Foresters, most members of the public remained unconvinced of the benefits of this harvesting practice. Narratives about how biomass energy would impact the aesthetic value of forests revealed that how one viewed silvicultural practices like clearcutting depended on one's level of education about forest succession and one's attitude towards natural resource management. In many countries and in the US in particular, interest in wild landscapes often superseded appreciation of working ones.

These different attitudes towards clearcutting reflected different ways in which groups valued forested landscapes. As with other types of renewable energy development, wind turbines in particular, conflict about the aesthetic impacts of new technologies have involved rural communities' appreciation of productive land versus urban populations' interest in recreational or scenic landscapes [54]. Navigating these different values posed challenges to renewable energy developers, especially as urban dwellers sprawled into the hinterlands towards the end of the twentieth century.

In addition to concerns about the aesthetic impacts of wood energy, a growing number of forest ecologists and environmentalists began to write about the ecological impacts of removing waste material at harvest sites—one of the primary sources of biomass fuel. Earl Stone, Professor of Forest Soils at Cornell University, pointed out that woody debris left after a harvest served many important ecological functions including wildlife habitat, soil nutrients, and watershed protection. He noted that the public was becoming more aware of the value of things once considered useless:

> For many forest owners, as well as vocal hunter, outdoor, and environmentalist groups, there are such things as den trees, cavity nesting birds, naturalism, diversity of habitats, species and size classes, to mention only a few. Certainly a vast quantity of 'waste' is available but by no means all unharvested growth is waste. Dead trees, weed trees, rotten trees, slash and brush are not devoid of on-site value at all times and places [55].

Stone criticized biomass enthusiasts for not considering environmental trade-offs, and for not anticipating the public's negative reaction to an accelerated use of biomass energy. For example, R. Metcalfe, Chairman of Canada's Forests for the Future, pointed out the biological limits of using biomass to meet the country's

energy needs. He stated that "if all Canadians started burning wood, our environment – land, air and water – would quickly be destroyed [56]." Metcalfe's and Stone's comments expressed the ideas of a growing number of ecologically-minded individuals who were concerned about repeating the wide-spread environmental destruction that occurred when wood provided the basis of Canada and the US's energy economies in the nineteenth century [57]. Narratives like those expressed by Metcalfe and Stone also revealed how concerns about the aesthetic and recreational value of forests were often closely aligned with certain ecological views of forests in the 1970s and 1980s.

In addition to concerns about the aesthetic and ecological impacts of wood energy, critics also complained about potential threats to public health. By 1981, several northern communities that had come to rely heavily on burning wood for heat began to report problems with particulates. Places like Missoula, Montana routinely had air quality alerts and residents expressed concern about the carcinogenic properties of particulates from wood [58]. Until the mid-1980s, however, most wood burning technologies remained relatively decentralized and concern about potential public health threats did not become a dominant part of public discourse against biomass energy until the late 1980s and 1990s, when several coal-fired electricity generating plants were converted to burn wood and new wood-fired power stations were proposed. Large, industrial-scale power plants that burned wood instead of coal presented a suite of issues that differed from those of smaller-scale technologies; not only did these power plants use wood fuel less efficiently, but they tended to concentrate public health problems in particular areas [59].

As industrial use of biomass-based electrical power increased in the 1990s, concerns about environmental injustice arose. Because existing power plants that converted fuel sources from coal to wood were typically located in low-income communities, often with large racial minority populations, environmental justice activists argued that this new renewable fuel simply perpetuated the injustices inherent in fossil fuel-based energy systems. A report by the NAACP found that African Americans who lived near power plants fueled either by wood or coal were more likely to suffer a variety of health effects than other Americans [60]. In 1994, when Michigan's Department of Environmental Quality approved a proposal to build the Genesse Power Station, a biomass plant located near a low-income, predominantly African American neighborhood in Flint, Michigan, activists argued it was an act of environmental racism, and they filed a complaint with the Environmental Protection Agency (EPA) stating that the agency had violated Title VI of the Civil Rights Act of 1964 [61]. The protesters maintained that the state had "engaged in a pattern and practice of race discrimination by siting incinerators almost exclusively in predominately minority communities [62]." They argued that historically disenfranchised populations should not be further marginalized in order to meet the state's renewable energy portfolio standards. Despite the complaint, the Genesee Power Station was built and has continued to operate for twenty years.

Concerns that arose over the biomass plant in Flint reveal that renewable energy technologies were not exempt from concerns about environmental injustice and racial discrimination. Although many people assumed renewable energy technologies would produce fewer public health burdens than energy systems based on fossil fuels, all energy sources produce benefits and burdens. In the case of biofuels, those benefits and burdens were not always distributed in an equitable manner [63]. The concerns raised by protesters in Flint demonstrate how different social groups have worked to shape the production of renewable energy systems, and illustrate the range of motivations for participating in decision-making about new technologies.

Civil rights violations and environmental justice concerns were also themes employed by biomass critics in countries around the world. Underlying these themes were different ideas about appropriate scales of governance and the extent to which those affected by new energy technologies should be involved in decision-making processes [64]. In a study of biomass development in the UK, Bishnu Raj Upreti found that mistrust in decision-making was among the major sources of conflict [65]. Another study in England found that residents in the city of Winkleigh strongly opposed a new proposed 21.5MWe biomass plant because they felt developers failed to incorporate authentic two-way interactions between decision-makers and the public in the decision-making process [66]. The protests of activists in Flint, Michigan and the surveys of English residents suggest the importance of process – and the power of proper procedure – in the transition to renewable energy technologies.

Narratives of opposition frequently came from those who would be affected by new biomass technologies; those sources of opposition included not only residents living near large industrial wood-burning power plants, but also representatives from the forest products industry. While many supported the development of new fuelwood markets, others feared that demand for wood energy would interfere with traditional forest product markets. For example, in Sweden, representatives of the pulp industry argued that demand for woodchips would decrease the availability of material for pulp and would drive prices up [67]. Similar arguments were made in the US where leaders of the forest products industry expressed concern that a major increase in the use of forests for fuel might negatively affect available supplies of raw material for other uses [68]. These concerns reflected a kind of narrative inconsistency among the forest products industry: some felt that the burgeoning fuelwood market could help bolster other forest products, while others believed that traditional forest product markets might be threatened if the demand for forest fuels increased significantly.

Narrative inconsistency within stakeholder groups and conflict between them had long-term consequences for biomass development, and may have contributed to the instability of financial investment in wood-burning technologies. One reason for the lack of financial investment in biomass was political. Commenting on the lack of federal policy and its relationship to private investment, one biomass advocate noted: "If the manufacturing and distributing of wood were controlled by a handful of giant corporations as nuclear, coal and oil [are], perhaps industry would take a serious interest [69]." Another reason for this lack of investment was the perception of risk that came from competing public narratives about renewable energy technologies like biomass. Why would national governments – or private investors – want to put money towards something that may create more social and environmental problems than it could potentially solve, especially when the total amount of energy produced by biomass would never be equivalent to the massive amount of energy stored in fossil fuels?

Compared to the oil industry, which had been heavily subsidized by the US government since the early twentieth century, federal investment in wood energy had taken a back seat by the mid-twentieth century [70]. Even though President Carter's 1977 National Energy Plan focused on energy conservation and sought to remove price controls on oil and natural gas in order to help level the playing field for other forms of energy, his plan emphasized domestic coal and nuclear power. Renewable energy advocates had high hopes when Congress passed the Public Utilities Regulatory Policy Act (PURPA) in 1978. PURPA helped to restructure the power of energy utilities by guaranteeing a market for "qualifying facilities" – cogeneration plants and new types of small independent power facilities – the kinds of facilities for which biomass was well-suited [71]. Yet despite creating incentives for nontraditional energy generation, without sustained investment in research and development, biomass technologies failed to gain widespread

entrance into the marketplace. The US was not alone in this respect; other forest-rich countries like Canada had invested little to no funding towards the research and development of biomass energy technologies by the late 1970s [72]. This lack of sustained federal investment in renewable energy like biomass had cascading effects—it made private investors less inclined to invest.

Like wind and solar, biomass was poised to benefit from PURPA's policy incentives for smaller renewable projects. But like other renewables, biomass skeptics pointed out problems associated with intermittency. Although for wind, trouble with intermittency usually meant lack of blowing wind, for biomass, it had more to do with the many moving parts in the system—the difficulty in coordinating the logging, chipping, trucking, storing, and burning of woody material. Like skeptics of solar and wind, those who questioned the viability of biomass energy pointed out the lack of infrastructure to facilitate the widespread adoption of such technologies, and the problems that lack of infrastructure posed for commercialization. Like other renewable energies, biomass critics noted that the economies of scale would also be hurdle; no singular fuel source would be able to compete with the massive amount of energy produced by fossil fuels. Skeptics also noted that renewable fuels like biomass or wind remained utterly dependent on fossil fuels for production and distribution. These concerns about intermittency, lack of infrastructure, and economies of scale were real limiting factors not only for biomass, but for other forms of renewable energy as well. Yet it is important to note that the *perception* of these technological and economic limitations also contributed to public hesitancy to support renewable fuels. In this way, cultural beliefs compounded the material problems associated with technology and economics.

An examination of different forms of opposition toward biomass reveals that one of the barriers to decentralizing energy has been cultural anxiety about the ecological and public health impacts of local energy. Public opposition based on these important public concerns helped to perpetuate the sense that like other renewables, biomass technologies were a relatively risky investment. This uncertainty may have deterred potential investors and policy makers from taking a more proactive approach to support this form of renewable fuel. In this sense, public discourse worked to limit – or at least to slow – biomass development. In doing so, narrative conflict helped to inadvertently reinforce the path of centralized, fossil-fuel based energy systems.

2.3. Conclusion: the paradox of local power

The history of public discourse about biomass development illustrates a core paradox of local power: distributing power away from the centralized systems of production that brought unprecedented amounts of energy to American consumers in the twentieth century required local communities to accept the ecological and public health risks of their consumption. It forced energy users to confront the consequences of their consumption—a sight that that many preferred to be left unseen [73]. Decentralizing energy systems also required navigating local conflicts over land use, civil rights, and resource management that rivaled national debates in terms of their complexity. Despite the promise of local power, these hidden risks and complicated political dynamics were things most communities were not willing to accept or able to work through. Thus, while decentralized sources of renewable energy like biomass have had the potential to help shift the economy away from fossil fuels, we have not been equipped to deal with the consequences. Although there have been many technological and scientific challenges to developing distributed energy systems like biomass, those factors have often been overshadowed by more fundamental cultural ideas and complex socio-political dynamics.

Those who have advocated for decentralized energy systems have had to navigate a complex boundary between maintaining local control over decision-making while also taking advantage of national policy tools and structures. In Sweden, the successful development of biomass has largely occurred as a result of favorable national tax policies bolstered by widespread public support for domestic sources of renewable energy. In the US, biomass development has been limited not only because of fewer federal incentives, but also because of social and environmental concerns. The more recent quest to reduce carbon emissions has spurred the development of renewable energy technologies like solar panels, wind turbines, and biomass facilities, but like all technologies, these renewable energy systems have frequently created unintended consequences on ecosystems and human communities. People have responded to those consequences in very different ways. Navigating current tensions between renewable energy advocacy, environmental concerns, and social justice requires close attention to how and why different understandings arose, and how they have played out in public discourse.

Narratives produced by those who promoted biomass and those who protested it reveal different visions of how a transition to biomass could affect political power. Because of the inherently local, decentralized nature of biomass systems, forest fuels had the potential to reform the political power systems associated with conventional energy technologies. Yet unlike solar advocates in the mid-twentieth century who explicitly sought radical change through the development of decentralized energy technologies, biomass advocates took a more pragmatic approach. Although advocates of wood energy were part of a larger chorus of voices in the 1970s that promoted the idea that local control of energy production and distribution was increasingly necessary, they did not seek to subvert dominant political paradigms. In cases where coal-fired plants were being converted to biomass, and where large industrial-scale biomass plants were proposed, wood energy advocates relied on existing energy infrastructure and the political dynamics that controlled those systems. In some cases, like the Genesee Power Station in Flint, Michigan, biomass advocates may have inadvertently perpetuated entrenched systems of inequality. Many acknowledged the dependence of wood energy on fossil fuels for harvesting and transportation, and held fast to the conservative political views that historically characterized business leaders within the forest products industry. So while in some ways biomass was touted as a domestic source of renewable energy that could help alleviate dependence on unstable political regimes in the Middle East, its development was limited not only by the distributed nature of forest resources, but also by the ideas of those who promoted it and those who opposed it.

Understanding history does not allow us to predict the future. But as historians Richard E. Neustadt and Ernest R. May have demonstrated, history does allow us to view events as part of a time-stream, where we can imagine the future to be when it becomes the past with "some intelligible continuity but richly complex and able to surprise [74]." In the context of energy transitions, historical perspectives allow us to better understand the cultural and political struggles that renewable energy leaders have faced—the nontechnical factors that often get buried in the tomes of work on energy written by economists and technicians. By examining the nuances of narratives constructed by those who promoted and those who opposed renewable energies like biomass, we gain a more complex view of the dynamic interaction between cultural ideas about nature, power, and the implementation of new technology. An exploration of conflicting narratives can help us to understand – and therefore better address – the underlying barriers to public support for energy transitions. In the case of biomass development, narratives explored here reveal that the challenges to developing more sustainable energy systems are not just technical

problems, but are also based on the complexity of diverse human experiences and perceptions.

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