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Research paper

Inventory and classification of United States federal and state forest biomass electricity and heat policies

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ABSTRACT

As of September 2013, federal and state governments had nearly 500 policies to support production of electricity and heat from forest biomass. This research used a four-tier classification structure to categorize policy instruments used in these policies based on: approach (incentive, regulation, information), type (e.g. tax incentive), subcategory (e.g. tax exemption), and specification (e.g. sales tax exemption). More (113) of these policies were enacted in 2007 and 2008, more than in any other two-year period, and there was a significant increase in the number of forest bioenergy (46) and biomass specific (36) policies by 2013. Cluster analysis provided evidence that neighboring states adopted similar numbers and types of policies. Oregon (in cluster by itself) had the highest number of tax incentives and biomass-specific policies, while most Southern, Southeast, Southern Appalachia and Midwestern states (the most dissimilar cluster to Oregon) had a limited number of policies. Most states in remaining clusters offered a mix of integrated policies, rather than policies focused on regulations and technology improvement. Our findings provide guidance for policy development by enabling the transfer of policy approaches among different states and regions.

1. Introduction

Wood, a historically important source of heat, has also become a feedstock for production of electricity, combined heat and power (CHP), and biofuel production in the United States. Governments have enacted policies to improve the economic feasibility and technological reliability of bioenergy. This article examines forest biomass (defined as wood sourced from logging residues, forest industry by-products, forest thinnings, fuelwood, and urban wood residues) policies designed to encourage the generation of electricity and heat.

In 2013, the electricity generation sector was dominated by traditional energy sources, such as coal (39% of total generation), natural gas (27%), and nuclear (19%), while renewable sources accounted for approximately 14% of electricity production [1]. Hydropower (46%) and wind (29%), and different types of biomass (21%) were the most important renewable sources of electricity. Wood and wood-derived fuels accounted for 7%, or 39.9 TW-hours (TWh), of net generation from renewable energy sources. Industrial and independent power producers dominated the wood to electricity sector, jointly supplying more than 90% of output. Similarly, 95% of thermal energy production relied on fossil fuels such as natural gas, heating oil, and propane, while renewable sources (e.g. biomass, solar, geothermal) accounted for a small portion of the total [2]. Nevertheless, the International Energy Agency [3] estimated that total realizable generation potential for biomass electricity by 2020 will be 382 TWh – ten times greater its current size – and biomass CHP heat potential is 504 TWh. The 686 biomass CHP plants in the US in 2013 had a total installed capacity of 4118 MW, with California accounting for 703 MW of CHP capacity, followed by Maine (375 MW), Washington (332 MW), and South Carolina (315 MW) [4].

Potential forest biomass availability for energy production is estimated to be between 30 and 108 Mt of moisture-free biomass, depending on feedstock price range [5]. Fuelwood and milling industry residues (e.g. wood and bark residues) are currently used for energy generation and provide an estimated 35 and 29 Mt of moisture-free biomass per year, respectively [5]. With the further development of the bioenergy sector, other low-grade biomass resources can be employed. Potential bioenergy feedstocks are logging residues (62 Mt of moisture-free biomass) and other

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removals (23 Mt of moisture-free biomass), which represent nearly 30% of current wood removal volumes [5]. Forest thinnings can provide 72 Mt of moisture-free biomass per year, and residues from thinnings on other forestlands can provide an additional 2.9 to 5.8 Mt of moisture-free biomass – the volume depends on prices and whether federal forestlands are included in calculations [5]. Municipal solid wood waste, along with construction and demolition debris, can contribute an additional 29 Mt of moisture-free biomass annually [5].

Using forest-based biomass for energy provides socio-economic benefits. Markets for low-grade small-diameter trees and forest thinnings can: (1) enhance energy security and reduce dependence on imported energy [6], (2) promote local economic development through increased tax base and job creation [7], (3) decrease forest treatment costs [8], (4) reduce hazardous biomass build-up in wildfire-prone locations [9], and (5) prolong landfill lifetimes by eliminating woody material from waste streams [8]. Producing energy from forest biomass can also increase grid stability because biomass plants can provide base-load electricity production [10].

In addition to socio-economic benefits, development of the woody bioenergy sector produces ecological and environmental benefits. Utilization of low-grade material and forest thinnings can promote sustainable harvesting practices, reduce or remove invasive tree species, and decrease insect and disease outbreaks. Without markets for this material, it is often not harvested as part of ongoing forestry operations [11]. A number of analyses have found that forest bioenergy is a low carbon technology, because it generally releases significantly more biogenic carbon, rather than geologic carbon, into the atmosphere (e.g. Refs. [12,13]); however, other studies have found forest bioenergy has more significant carbon implications (e.g., [14]).

Notwithstanding the potential benefits of forest bioenergy, there are a number of non-technical challenges that hinder the expansion of bioenergy markets [15,16]. Supply can be disrupted by weather and market fluctuations, such as those caused by price changes in competing energy industries such as coal and natural gas. Unless it is processed, woody biomass is a low-density feedstock with high harvesting and transportation costs, which generally makes it uneconomical to transport more than 80 km [17]. Complex permitting procedures for utilization of biomass for energy can also negatively impact investors' confidence prior to building a facility. When supplies are limited, using wood as an energy feedstock can increase competition for the material between bioenergy sector and pulp and paper industry. In addition, the positive environmental attributes of renewable energy are only marginally monetized through markets for ecosystem services and air pollution offsets, though to some extent renewable energy credits (RECs) and carbon credits account for these attributes [8]. On the other hand, there is a concern that burning biomass could reduce air quality by releasing particulate matter [14].

National, state, and local governments have introduced policies to improve the economic attractiveness and technological reliability of forest bioenergy [18]. Building on previous policy classification efforts, this article develops a more in-depth classification framework for federal and state bioenergy policies that includes analysis at the policy subcategory and specification level. This framework allows policymakers, stakeholders, and the public to better understand the mechanisms that legislators are currently using to support forest bioenergy. In addition, the article provides an update on the changing bioenergy policy landscape, distinguishes policies according to their focus on forest bioenergy, and utilizes cluster analysis to establish regional policy diffusion. In contrast to research on forest biomass-based liquid biofuel policies (e.g. Refs. [19,20]), this study focuses on forest biomass energy policies targeted towards the generation of electricity and heat.

1.1. Forest biomass energy policy analysis

A variation of an 'infant industry' argument is often used to justify government intervention into the renewable energy sector. An infant industry, such as the forest biomass energy industry, often incurs high entry costs, including research and development, negotiation, contracting, and contract enforcement costs [15]. In this initial stage, policymakers often enact legislation that protects the infant industry and reduces these costs. As the industry continues to grow, the production costs are expected to decline through learning-by-doing and economies of scale. In theory, at some point the infant industry should no longer require governmental support and become independent.

Governments adopt policy instruments with different characteristics to stimulate growth in the bioenergy industry, and several attempts have been made to classify policy approaches. Generally these, studies have identified numerous policies promoting renewable energy, but have found few policies specifically targeting forest bioenergy [21,22].

One approach introduced seven policy categories, three of which were aimed at lowering project capital costs (tax credits, renewable energy grant programs, and loan guarantees; tax credit for residential biomass energy; and government bonds), three others represented government mandates (renewable energy mandates; voluntary or mandatory renewable portfolio standards (RPS); and federal green power purchasing goal); and one category addressed rural energy grants and feasibility studies [21].

Another survey of wood-to-energy policy instruments [23] classified policies into three mutually exclusive categories: rules and regulations (e.g. RPS, green building requirements), public service programs (e.g. technical assistance, research, and education), and financial incentives (including a variety of policies that promote sustained feedstocks, reduce capital and start-up costs, and offer production subsidies). The study identified 272 state policies in effect as of September 2008 applicable to the forest bioenergy sector. Only four states had policies specifically aimed at promoting the use of forest biomass for energy. These included Alabama's wood-burning heating system deduction, Arizona's qualifying wood stove deduction, Maryland's wood heating fuel exemption, and Missouri's wood energy production credit.

In another review of state bioenergy policies, the policies were analyzed based on their effects at different stages of the supply chain (harvesting, transportation, manufacturing, and consumer markets) and included building codes and biofuel policies [22]. The policies were divided into six categories: tax incentives, cost-share programs and grants, rules and regulations, financing, procurement, and technical assistance. The majority of biomass policies were aimed at manufacturing and consumer markets, and only a few policies addressed transportation.

States differ with respect to their rate of adoption of forest bioenergy policies. As of 2008, Massachusetts, Wisconsin, North Carolina, California, and Washington had enacted 13 or more policies to support bioenergy projects, while Wyoming, Indiana, Nebraska, West Virginia, and Mississippi adopted only two policies [22]. States with stronger forest bioenergy policies tended to have better environmental health as measured by a 'Green Index' [18,24]. However, states' per capita gross domestic products and greenhouse gas emissions were not correlated with the strength of forest biomass legislation, and no regional associations were detected [18].

2. Material and methods

We compiled a list of federal and state forest bioenergy policies affecting the generation of electricity and heat in effect as of September 2013 using three primary sources: online data-mining,