

MAINE STATE LEGISLATURE

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Energy in Maine

Margaret Chase Smith Policy Center

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February 2012

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February 14, 2012

Representative Ricky D. Long
Maine House of Representatives
2 State House Station
Augusta, ME 04333

Dear Representative Long,

The Margaret Chase Smith Policy Center is dedicated to improving and promoting the quality of public dialogue about state, regional, and national policy issues through applied policy research and projects that seek innovative solutions to practical problems. I am pleased to present you with a copy of the document *Energy in Maine*, which the Margaret Chase Smith Policy Center provides as part of its mission to provide nonpartisan, independent research to the State of Maine.

Energy policy is important to Maine as it looks for ways to modernize its industry, grow its economy, provide energy security to the state, and enhance the allure of Maine for its residents, businesses, and industries that are already here and those that are considering moving here. *Energy in Maine* is a foundational document identifying the current state of energy production and use in Maine, as well as identifying some considerations for energy policy in Maine.

It is our hope that this paper will be of assistance to you and the other legislators as you work to move Maine forward.

An electronic copy of this report and a brief can be found on the Margaret Chase Smith Policy Center website (<http://mcspolicycenter.umaine.edu/>). I'd be happy to speak with you about any questions you may have.

Thank you for your time.

Sincerely,

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Any errors in this paper are the author's alone.

The Margaret Chase Smith Policy Center

The Margaret Chase Smith Policy Center, established in 1989, is a nonpartisan, independent research and public service unit of the University of Maine. The Center is dedicated to improving and promoting the quality of public dialogue about state, regional and national policy issues through applied policy research and projects that seek innovative solutions to practical problems. Our research is interdisciplinary in that it cuts across departmental lines and brings together faculty and external policy experts to address issues confronting the state and nation.

The strength of our staff is our depth and range of substantive knowledge, our commitment to working collaboratively, and our ability to integrate our combined expertise.

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1. Introduction

Maine, like all other states, must rely on energy to fuel its industry, heat its homes and transport its goods. In 2009 (the most recent data available from the Energy Information Administration (EIA)) fossil fuels made up 55% of the energy used in the residential, commercial, industrial, and transportation sectors. The next largest energy source for Maine is biomass, at 15%.¹

Maine has no fossil fuel reserves nor any refining capacity [5], making Maine particularly sensitive to the fluctuations present in the worldwide market for fossil fuels. However, Maine does have significant potential to increase the diversity of current fossil fuels; enhance energy conservation and efficiencies; and produce alternative energy from Maine-sources including biomass, wind, solar and tides. All of these options could be used to reduce Maine's reliance on imported energy.

Energy policy is important to Maine as it looks for ways to modernize its industry, grow its economy, provide energy security to the state, and enhance the allure of Maine for its residents, businesses, and industries that are already here and those that are considering moving here. Current information regarding energy use is available at both the state and federal levels, through the Governor's Office of Energy Independence and Security (OEIS) and the U.S. Energy Information Administration (EIA). [6, 7] A full analysis of energy demands and supply (both actual and potential) is available at the federal level from EIA [8], while projections for state-level energy demands and supply are reliant upon individual reports. [9-12]

Energy in Maine presents a summary of the current state of energy production and use in Maine, and identifies some considerations for energy policy in Maine. The expectation is that this paper will provide a common foundation to assist policy makers as they work to move Maine forward. The intent of this work is to keep the focus on Maine and help inform decisions about what is best for the State of Maine.

2. Energy consumption and production in Maine

In order to best understand the different opportunities available regarding energy policy in Maine, it is important to have an understanding of where Maine currently stands with regards to energy consumption and production, including both traditional and alternative fuels and sources. The most recent data from EIA (2009) indicate that current energy use in Maine comes primarily from petroleum fuels (47%), biomass (15%), natural gas (8%), hydroelectricity (2%), with small amounts of on-shore wind (0.01%), geothermal (0.02%) and solar (0.05%) also in place.² Oftentimes, these energy sources are measured in different units: for example, gallons of heating oil or cubic feet of natural gas. In order to compare the different types of fuels and the energy they provide, it is necessary to use the same unit of measure. For this report, fuel (energy) comparisons are made in British Thermal Units (Btu), and the energy is "primary" energy – the energy in fuel that is consumed.

Total energy costs, consumption, production and imports for all six New England states are provided in Table 1; Table 2 compares New England energy consumption by sector; and Table 3

¹ Author calculations, based upon [1-4]; 2009 data.

² Author calculations, based upon [1-4]. Numbers do not add to 100% due to rounding, as well as not including electrical system energy losses.

provides a comparison of New England energy expenditures. For both Table 2 and Table 3, the residential and transportation energy numbers are provided per capita, since both sectors encompass the population of Maine.³ The commercial, industrial, and transportation sectors are compared using Gross State Product (GSP), a measurement of the economic output for the state, as these sectors incorporate the businesses of Maine. Providing energy consumption and expenditures in this way allows for a direct comparison of related sectors across New England.

Table 1: New England Energy: Total Cost, Consumption, Production and Imports

State	Cost (\$ billion)	Consumed (trillion Btu)	State Average Price (per MMBtu)	Produced (trillion Btu)	Percent of Energy Produced In-state	Percent of Energy Imported	Energy Imports (\$ billion)
Maine	\$5.66	430.5	\$13.14	139.7	32%	68%	\$3.82
Connecticut	\$13.35	788.4	\$16.93	200.3	25%	75%	\$9.96
Massachusetts	\$22.62	1426.0	\$15.86	98.5	7%	93%	\$21.05
New Hampshire	\$4.90	303.0	\$16.17	132.2	44%	56%	\$2.76
Rhode Island	\$3.43	219.3	\$15.63	2.7	1%	99%	\$3.39
Vermont	\$2.50	158.1	\$15.82	82.6	52%	48%	\$1.19

Data from [14-22] and author's calculations. Population numbers are from 2010 census; energy and dollar numbers are from 2009.

Table 2: New England Energy Consumption

State	Total (MMBtu per capita)	Residential (MMBtu per capita)	Transportation (MMBtu per capita)	Total (Btu per GSP)	Commercial (Btu per GSP)	Industrial (Btu per GSP)	Transportation (Btu per GSP)
Maine	324	70.76	92.97	86.03	14.65	27.92	24.68
Connecticut	221	73.41	68.51	34.65	8.68	3.67	10.76
Massachusetts	218	67.12	81.38	39.55	8.04	6.74	14.78
New Hampshire	230	36.19	98.47	51.28	14.02	7.92	21.28
Rhode Island	208	65.77	81.93	46.20	11.93	6.24	13.45
Vermont	253	45.92	89.87	64.20	12.92	9.91	21.74

Data from [1-4, 14-19, 22-43] and author's calculations. Population numbers are from 2010 census; energy and dollar numbers are from 2009.

³ EIA definitions for each sector:

“Residential: An energy-consuming sector that consists of living quarters for private households.

“Transportation: An energy-consuming sector that consists of all vehicles whose primary purpose is transporting people and/or goods from one physical location to another.

“Commercial: An energy-consuming sector that consists of service-providing facilities and equipment of: businesses; Federal, State, and local governments; and other private and public organizations, such as religious, social, or fraternal groups.

“Industrial: An energy-consuming sector that consists of all facilities and equipment used for producing, processing, or assembling goods.” [13]

Table 3: New England Energy Expenditures

State	Total (per capita)	Residential (per capita)	Transportation (per capita)	Total (per GSP)	Commercial (per GSP)	Industrial (per GSP)	Transportation (per GSP)
Maine	\$4,260	\$930	\$1,222	\$0.113	\$0.019	\$0.037	\$0.032
Connecticut	\$3,735	\$1,243	\$1,160	\$0.059	\$0.015	\$0.006	\$0.018
Massachusetts	\$3,454	\$1,065	\$1,099	\$0.063	\$0.013	\$0.011	\$0.020
New Hampshire	\$3,722	\$585	\$1,544	\$0.083	\$0.023	\$0.013	\$0.034
Rhode Island	\$3,257	\$1,028	\$948	\$0.072	\$0.019	\$0.010	\$0.021
Vermont	\$3,998	\$1,222	\$1,354	\$0.102	\$0.020	\$0.016	\$0.034

Data from [1-4, 14-19, 22-43] and author's calculations. Population numbers are from 2010 census; energy and dollar numbers are from 2009.

Maine is not that different from other New England states when it comes to energy produced in-state, or energy imports. Maine has the lowest average price per million Btu (MMBtu) in New England, but also the highest per capita energy and Btu per GSP costs. Virtually all of this can be attributed to the amount of energy used in the industrial sector⁴.

Electricity in Maine is different than the other energy sources and fuels: electricity is a regional market and Maine is part of ISO-NE.⁵ ISO-NE is responsible for operating the New England power grid and wholesale electricity markets. [47] Maine is a net electricity exporter, and has the lowest electricity prices at the point of delivery from the power plant in New England [48-50]. Supply is only one of the two components that make up electricity expenses; delivery is the other.⁶ The delivery price is made up of transmission and distribution fees as set by the Maine Public Utilities Commission (MPUC) and the Federal Energy Regulatory Commission (FERC). [49, 52] MPUC has indicated that transmission costs will continue to increase, primarily due to investments in transmission by ISO-NE. [51]

3. Energy options for Maine

In order to evaluate Maine's energy options, it is necessary to have an understanding of where Maine currently stands and the alternatives available. An in-depth analysis of the different energy sources that are imported is not provided in this paper.

3.1. Current options

Existing energy sources and technologies could have significant impact on the feasibility of alternative energy sources taking hold in Maine. Foremost among these are natural gas, which is widely expected to be relatively inexpensive for some years to come, and conservation and efficiency programs that help reduce energy use into the future. Maine also has the option of continuing with current practices (status quo).

⁴ Maine is the only New England state in which industry is the largest energy-consuming sector. [44, 45]

⁵ ISO-NE is the acronym for Independent System Operators-New England, established in 1997. [46]

⁶ As explained by Maine Public Utilities Commission: "Delivery includes transmission, distribution and customer-related functions such as metering and billing, and supply includes the production and provision of electric energy and capacity." [51]

3.1.1. Status Quo

Fossil fuels account for 55% of the total energy used in Maine, with biomass next at 15%. The residential sector in Maine is heavily dependent upon heating oil: approximately 70% of households in Maine use Number 2 heating oil for their homes, the highest heating oil dependency in the U.S. [53] Electricity generation in Maine makes up 28% of the total energy used. One half of total electricity generation in Maine is accomplished with renewable energy sources, as follows: hydroelectric power (almost 26%), wood/wood waste (approximately 21%), and wind (about 2%). [54] Table 4 provides an overview of current energy use in Maine by both type of energy and sector.

Table 4: Overview of Energy Use in Maine: Total Percentage by Source/Type and Sector

	Natural Gas	Petroleum ¹	Hydroelectric	Biomass ²	Electricity ³
Percent of total energy⁴	8%	47%	2%	15%	28%⁵
Sector					
Residential	0%	9%	--	1%	11%
Commercial	1%	5%	0%	1%	10%
Industrial	6%	4%	2%	13%	7%
Transportation	0%	28%	--	--	--

Data from [1-4] and author's calculations. Energy numbers are from 2009.

Notes: 1: Petroleum includes aviation gasoline, distillate fuel oil, kerosene, jet fuel, liquefied petroleum gas (LPG), lubricants, motor gasoline, residual fuel oil, asphalt, and road oil.

2: For residential percentage, biomass includes wood only. For commercial and industrial percentages, biomass includes "Wood, wood-derived fuels, and biomass waste." [1-3]

3: This includes both retails sales and electrical system energy losses, which are "Incurred in the generation, transmission, and distribution of electricity plus plant use and unaccounted for electrical system energy losses." [1-4]

4: Coal, solar/PV, and geothermal are also used in Maine, and account for 0.19%, 0.05% and 0.02% respectively.

5: Coal is used to generate 12% of electricity generation in the ISO-NE region. [55]

3.1.2. Natural gas

Natural gas is a fossil fuel, with domestic supply expanding due to recent innovations in the technology used to mine natural gas. [56-58] The use of natural gas as a heating fuel is expanding for residential users in Maine [59, 60], and there is considerable interest from state leaders to expand the infrastructure (discussed in Section 4.2.2) to high energy-use industries, such as paper mills, that currently rely on heating oil. [61-65].

3.1.3. Conservation and/or efficiency programs

Energy efficiency and conservation programs work on the premise of reducing demand for energy by using it more efficiently. This could incorporate everything from peak and off-peak pricing and metering, equipment upgrades for efficient furnaces and boilers, the weatherization of homes, to lighting replacements. There are significant savings in both economic and energy costs that can be realized with the implementation of conservation and efficiency programs. [66-68]

Maine currently has statewide conservation and efficiency programs in place through Efficiency Maine and MaineHousing. Efficiency Maine Trust has programs targeting both homeowners and businesses, with rebates, low-cost loans, incentives, advice from experts on staff, and a listing of

private companies that can provide efficiency assistance. [69-72] MaineHousing programs target low-income households in the areas of weatherization, central heating improvements and appliance replacements, and have low cost energy loans available to qualified moderate-income households. [73]

Efficiency programs also are available through commercial entities. The only current program is a rebate available to commercial, industrial, institutional and multi-family residential customers of Unitil. [74]

3.2. Alternatives to fossil fuels for Maine

As noted in Section 3.1.1, Maine currently produces almost 50% of its electricity from renewable power: hydroelectric (26% of the 50%), wood and wood waste (21%), and wind (2%)⁷ [54]. The 50% more than meets the Renewable Portfolio Standards (RPS) Class II requirement that 30% of total electricity sales must come from existing renewable resources. Maine also must meet a RPS requirement for Class I (new renewables developed after 2005), of 10% by 2017 (a 1% annual increase that started in 2008). [75]

Current energy research throughout the world is addressing the need to reduce or eliminate continued reliance on fossil fuels, and Maine is no exception. In Maine there is active research at both public and private institutions in the areas of biofuels, biomass, off-shore wind, tidal energy and hydroelectric, as well the growing use of distributed solar generation for heat or electricity. These areas are discussed in further detail in the sections that follow.

3.2.1. Biofuels

First generation biofuels include biodiesel from waste fat and grease, and ethanol from sugar. Maine does not produce first-generation ethanol, but does have one biodiesel manufacturer [76] and quite a few companies that sell biodiesel blends.⁸ These companies provide biodiesel either as a blend for vehicles or in a mix with heating oil, primarily in southern and mid-coast Maine.

The development of second generation biofuels from sources such as algae and biomass (in the form of cellulosic biofuels) is currently in the research and development stage. [82-90] One of the challenges that biofuels faces is production technology that can produce these fuels at a cost competitive with market prices.⁹

3.2.2. Biomass

Biomass is used for both electricity generation and heating. Currently, there are residential, business, commercial, and governmental energy users of biomass throughout Maine. [92-97] There are four wood pellet manufacturers in Maine [98, 99] with one planned for 2013 [100], a different pellet manufacturer using mixed sources [101], and research and development in Maine using grass pellets for commercial boilers. [94]

Another use of biomass is being planned with a recent announcement by a Maine pulp mill to produce torrefied wood (also known as biocoal) by the end of November 2012. Torrefied wood is an energy source that can be used in place of coal. [102-107] The planned market for torrefied wood

⁷ Numbers do not add to 50% due to rounding, as well as not including the categories of “MSW Biogenic/Landfill Gas” and “Other Biomass.”

⁸ Companies include: Maritime Energy, Coastal Energy, Downeast Energy, Harvest Energy and Sprague Energy. [77-81]

⁹ A recent U.S. Naval contract for 450,000 gallons of advanced drop-in biofuel has an estimated price of \$7/gallon. [91]

is Europe and U.S. electricity producers who currently burn coal, with shipments out of Searsport. [106]

3.2.3. *Wind*

Wind has been used as an energy source starting with sailing ships, progressing to windmills on land for grinding grain and pumping water, and now to generate electricity and charge batteries. [108-110] The current use of wind for energy has focused on wind farms (utility-scale) that provide electricity to the grid.

3.2.3.1. *On-shore wind*

Maine currently has seven utility scale wind farms in operation, totaling 325.5 MW and generating 939.9 million kWh per year, and two more under construction. [111-119] As of December 2011, approximately “1,350 MW of proposed resources in Maine (primarily wind) have entered the ISO queue, representing 27% of the proposals in New England.”¹⁰ [75]

3.2.3.2. *Deepwater off-shore wind*

Off-shore wind facilities are wind turbine facilities located in coastal waters. While near shore off-shore wind energy has a long history in Europe [122], there are no floating deepwater¹¹ offshore wind farms operating in the world. Research is currently underway in the Gulf of Maine to determine how to build, capture and transport 5 gigawatts of wind energy from deepwater sources. [9, 50] Deepwater offshore wind will require both updates of the electricity transmission system in Maine and up-front investments by ISO New England (ISO-NE).¹² [123]

3.2.4. *Tidal energy*

The use of tidal action to generate power goes back to at least 900 C.E. [124] There are some commercial-scale tidal projects world-wide but none in the United States. [12] In 2008 electricity was generated from the Bay of Fundy currents, and a commercial power system will be installed in Cobscook Bay in 2012. [125, 126] A different feasibility study is underway in Passamaquoddy Bay, with construction expected to begin in 2013. [127]

3.2.5. *Hydroelectric*

Hydroelectric power has been used to produce electricity in U.S since the early 1900’s. [128] As noted in Section 3.2, hydroelectric power generation is the largest source of renewable electricity generation in Maine. [54] Current research and development is exploring ways to minimize the environmental impacts of existing hydroelectric facilities, especially with regard to fish species and dam removals. [129] One project in particular, the Penobscot River Restoration Project, is a collaborative effort¹³ to remove some dams and upgrade existing facilities, with the intent to

¹⁰ This does not include additional proposals outside of the ISO-NE region in northern Maine, which is served by the Northern Maine Independent System Administrator, Inc. [120, 121]

¹¹ Deepwater offshore wind refers to ocean floor depths of greater than 60m (197 feet).

¹² As a member of ISO-NE, Maine’s needed transmission upgrades rely on the investment provided by ISO-NE, and electricity generated in Maine is added to the entire ISO-NE grid

¹³ The Penobscot River Restoration Project is made up of made up of PPL Corporation, Black Bear Hydro LLC, Penobscot Indian Nation, American Rivers, Atlantic Salmon Federation, Maine Audubon, Natural Resources Council of Maine, Trout Unlimited, U.S. Department of Interior (Bureaus of Fish and Wildlife; Indian Affairs; National Park Service), and the State of Maine (State Planning Office; Department of Natural Resources; Department of Inland Fisheries and Wildlife; and Atlantic Salmon Commission). [130]

maintain at least the same amount of electricity generation and increase the amount of fish habitat. [130, 131]

3.2.6. Distributed Generation Solar (DGS)

Distributed generation solar systems are small-scale solar systems located where the energy is used (on-site) [132], such as solar hot water heaters and photovoltaic rooftop systems that generate electricity. Maine currently has 50 companies that are involved in solar space heating, solar water heating and/or photovoltaic system installation. [133, 134] The largest impediment to DGS is the upfront cost of purchasing and installing the system. [135] Currently there are no Maine-specific data identifying either the range of unit costs or the payback periods for residents and businesses to adopt the one of the available DGS systems. There also is no existing research on the optimal DGS technologies for use in Maine. This is now being researched by an economist at the University of Maine, along with analysis of the types of subsidies and education that may encourage DGS adoption. [133]

4. Maine's strengths and needs

4.1. Knowledge

The alternative energy sources being developed in Maine will require many of the same occupations that are in demand now: electricians, welders, builders, engineers, scientists, designers, and mechanics, to name a few. There also is a need to develop new educational programs and training for up-and-coming areas, with current examples being the wind power technology program at Northern Maine Community College, [136] and energy auditor training courses. [137]

The knowledge base for energy issues in Maine encompasses public and private education through the Maine Community College System and the United Technology Center; the University of Maine and the University of Maine System; Maine Maritime Academy; private universities in the state; privately run training institutes such as the Cianbro Institute and Northeast Technical Institute; and Efficiency Maine Trust through their Qualified Partner program and Building Operator Certification program. [138-144]

4.2. Infrastructure

Maine's current energy use relies on an established infrastructure of truck transport, oil and natural gas pipelines, and electric transmission lines.

4.2.1. Transportation and facility infrastructure

Much of Maine's current energy delivery relies almost entirely upon the use of trucks, a delivery model that is used not just for oil, but also wood pellets [145, 146] and biodiesel [76-81, 147], and could be used for biofuels as they reach commercialization. Maine also has an active network of rail lines, connected to many industrial energy users in the state, as well as cargo ports in Portland, Searsport, and Eastport, Bangor, and Bucksport. [148] The infrastructure needed for developing off-shore wind and tidal energy, such as ports, facilities and equipment, and companies with in-house knowledge is already in place. [50]

4.2.2. *Oil and natural gas pipelines*

Portland-Montreal Pipe Line (PMPL) provides oil pipeline service in Maine. PMPL has two tank farms, one at each end of the pipeline: South Portland, Maine and Montreal, Quebec. [149] Portland Harbor is “one of the largest oil receiving terminals on the East Coast” [150], and “the only oil port on the U.S. East Coast that is linked to an inland pipeline.” [151]

There are two major natural gas pipelines serving Maine: the Portland Natural Gas Transmission System (PNGTS) and the Maritimes and Northeast Pipeline, with the natural gas supplied from the southeast U.S., and Canada. [152] Natural gas service pipelines are being laid throughout the state, in both urban areas of the state (Portland, Bangor), as well as major industrial users such as Lincoln Paper & Tissue, Woodland Pulp LLC, and Great Northern Paper in Millinocket. [61-65]

4.2.3. *Electric transmission lines*

Maine is currently an “export-constrained load zone” in ISO-NE, meaning that there are parts of Maine where electricity demand is met but the excess generated electricity cannot be exported due to a lack of transmission capabilities. [55] Existing electric transmission lines in Maine are in need of an upgrade to meet both current reliability and transmission needs [153], as well as accommodating the installation of smart grids and any new electricity generation from wind, hydropower, or tidal energy. [11, 12, 154]

4.3. *Regulatory requirements and programs*

Government is a multi-layered endeavor, from the direct democracy of town meetings, to the representative government of city councils, county commissioners¹⁴, the state legislature, and the federal government. As a result, there is fragmented power and responsibility that affect energy related actions and opportunities throughout the state. Most often, the regulatory requirements of one level of government have to build upon the requirements of another level.

Although a comprehensive overview of the regulatory requirements for each level of government in Maine is beyond the scope of this paper, what follows is a summary of those that have the greatest influence on Maine’s current system and options for the future with regards to energy.

At the local level the major regulatory mechanism impacting energy policy is zoning, which affects primarily electricity transmission lines, wind energy systems and natural gas pipelines. While local approval has long been needed for transmission lines, ordinances for wind energy systems are a fairly new local issue. A significant number of local ordinances have been put in place in recent years, with over 25 local governments having implemented wind energy ordinances, most covering grid-scale systems. [156-180]

A summary of the state programs, codes, agencies and one regional program is provided in Table 5; federal agencies and departments are listed in Table 6.

¹⁴ According to the U.S. Census Bureau (based upon 2007 data): there are 850 local governments in the State of Maine. [155]

Table 5: Maine and Regional Programs with Regulatory Oversight in Energy Areas

Agency or Program	Summary
Efficiency Maine Trust	Specific energy efficiency targets in electricity, natural gas and heating fuel consumption, as well as weatherization. Accomplished through work done by Efficiency Maine Trust. [69, 181-185]
Maine Building Codes	Statewide building codes and statewide energy code, required for municipalities with more than 4,000 residents; municipalities with less than 4,000 residents may chose to adopt this code or have no code. [186-188]
Maine Department of Conservation - Land Use Regulation Commission	LURC is responsible for planning, zoning and subdivision control the unorganized and deorganized townships of the state [189], including energy generation and transmission projects. [190]
Maine Department of Environmental Project	Air emission; erosion and sedimentation control; hydropower and dams; mining, natural resources protection, shoreland zoning; site location and wind projects [191, 192]
Maine Department of Marine Resources	Aquaculture, marine patrol, protected resources, resource management, and sea-run fisheries & habitat. [193]
Maine Department of Inland Fisheries and Wildlife – Bureau of Resource Management	Management and preservation of wildlife resources and inland fisheries. [194]
Maine Public Utilities Commission	Utilities: electric, natural gas, telecommunications, and water; and ferries. [195] Programs include: Renewables Portfolio Standard (RPS) [196]; certification program [197]; net metering [198]; energy conservation loan program through the Finance Authority of Maine (FAME) [199];
Maine State Historic Preservation Commission	Review of any projects that may impact an archeological site or National Register of Historic Places site. [200]
Maine State Planning Office	Hydroelectric licensing, renewable ocean energy, and uniform building and energy codes. [201]
Regional Greenhouse Gas Initiative	Market-based regulatory program to reduce carbon dioxide emissions by power plants. Ten northeast and mid-Atlantic states are participating. [202]

Table 6: Federal Programs with Regulatory Oversight in Energy Areas

US Agency or Program	Summary
Army Corps of Engineers	Any work and/or structures located in, under or over navigable waters; the discharge of dredged or fill material into waters; and the transportation of dredged material for ocean disposal. [203]
Bureau of Ocean Energy Management	Renewable energy production on the Outer Continental Shelf (OCS), including leases, right-of-way (ROW) grants, and right-of-use and easement (RUE) grants; and RUEs for the alternate use of OCS facilities for energy or marine-related purposes. [204]
Bureau of Safety and Environmental Enforcement	Outer Continental Shelf: oil, gas and sulphur operations; geologically and geophysical explorations; prospecting and operations for other minerals. Oil spill response requirements for facilities seaward of the coastline. [205]
Department of Energy	Oversight of electric energy transmission and natural gas importation and exportation. [206]
Federal Energy Regulatory Commission (FERC)	Interstate transmission of electricity, natural gas, and oil; review proposals for liquefied natural gas terminals and interstate natural gas pipelines; license hydropower projects. [207]
Federal Aviation Administration	Height of objects in airspace [208]
Fish and Wildlife Service	Bald and Golden Eagle Protection Act, Endangered Species Act, Marine Mammal Protection Act, Migratory Bird Treaty Act. [209]
National Marine Fisheries Service	Endangered Species and Marine Mammal permits. [210]
Coast Guard	Fisheries law enforcement, marine environmental protection, and navigational aids. [211]

4.4. Environmental impacts

Any new fuels or energy approaches in Maine will undoubtedly have some type of environmental impact. The environmental impacts of current energy use have been studied fairly extensively, and won't be discussed in this paper.¹⁵ Rather, a brief overview of some emissions and environmental impacts resulting from energy alternatives is provided.

The use of alternative fuels discussed in this report results in either lower air emissions than the fossil fuels they replace or emissions that are not measurably different. For wind, tidal energy or hydroelectric, the full environmental impact is dependent on the site, and those specific impacts will have to be addressed on a site-by-site basis.

4.5. Economic development

Energy development in Maine can be an opportunity for economic development because it offers the opportunity to substitute state-based energy for imported energy. There is no universally accepted definition of economic development, and the number of definitions is almost unlimited. [212-219] However, there are some characteristics found in many definitions of economic development that can be helpful, including:

¹⁵ Similarly, an analysis of the environmental impacts from the manufacture and delivery of each potential alternative energy source is beyond the scope of this paper.

- Governmental or community-based organizations using policies to create and retain jobs, wealth, and improving the quality of life. The policies put in place can encompass virtually any area. Some examples include taxes, education, the environment and zoning.
- Using labor, capital, and technologies together to improve the economy.
- Expanding or maintaining business activities and/or employment.

Along with the many definitions of economic development, there are also myriad ways to determine the impact of economic development programs. Some of the most common measurements include employment growth, income growth, and indicators of firm location. [220] When measuring energy related economic development, some of the impacts that can be evaluated include: the actual cost of energy to businesses and residents; how energy costs effect other areas of the economy (food, education, training, employing more people), and opportunities for economic growth in the energy industry itself. [221]

4.6. Economics

The final consideration in identifying viable alternative energy sources in Maine is the one that will almost certainly drive energy option decisions: the economic costs and benefits, and how these compare to current energy sources. As noted in Table 1, in 2009 Maine spent \$5.66 billion dollars on energy, with \$3.82 billion of that sent out of the state. One incentive to ongoing research and development in Maine is to provide an opportunity for some of those energy dollars to remain in the state.

Changes to the current energy mix in Maine will require investments in education, training, and infrastructure. These costs exist whether the change involves going from one fossil fuel to another (for example heating oil to natural gas), or to full-scale implementation of alternatives (such as a deepwater offshore wind farm in the Gulf of Maine, or the switchover of homes from oil heat to wood pellets). Direct comparisons of economic costs and benefits are complex, with careful consideration needed on both the types and sources of data used, as well as the methods used for any projections.

5. Trade-offs

Virtually all decisions require trade-offs, whether determining what product to buy, how much time to invest in a project, or what energy policy is best for Maine. Trade-offs can include issues at the national, regional and local levels. In simplest terms, a trade-off involves paying a cost to receive a benefit; if there is more benefit than cost, the trade-off is worthwhile. Energy policy trade-offs are not necessarily easy to quantify either in a monetary sense or in other quantifiable ways.

When determining the best route for Maine, there are many different things to consider. For example, changes in fuels can cause changes in distribution systems and infrastructure, which then can change the numbers and types of employment. Some of the more specific trade-offs may include:

- Local economic development: where will development occur, and how will it impact the state and the particular region?
- Jobs: what jobs will be created and what jobs may be eliminated (and where) based upon the policy chosen?

- Emissions reductions: will emissions increase or decrease, and where?
- Energy security: will Maine's energy security be increased by switching fuel sources?
- Cost to ratepayers: will a change result in a cost increase or decrease to Mainers? How much will the cost increase or decrease be?

Trade-off evaluation often requires a great deal of information, some of which may not be readily available. Effective decisions should determine the trade-offs for a specific project while considering overall policy implications. It should be pointed out that an important component of any project's cost is the opportunity cost of not spending that money on other projects.

6. Summary

There are extensive energy options available to Maine, all of which can have an impact not only in the type of energy used, but also in other areas including: building a knowledge-base throughout the state, enhancing infrastructure, and providing economic development. There are always trade-offs to consider, with policy makers having to rely heavily on the economics, and the recognition that what was best for the present and near-term may not be true five-to-ten years down the road. All policy decisions require trade-offs and considering as many as possible helps ensure decisions reflect what's best for Maine.

Part of the considerations when determining energy policy and the best course of action for Maine begin with defining Maine as it pertains to energy needs: Is it industry? Is it the retail sector, including tourism? Is it the residents? There are other considerations well: who is Maine competing with for economic development and how does the cost and types of energy come into play? Is a comparison to the rest of New England valid? Or is an assessment relative to other states with similar industries and per capita income the best approach? Should Maine compare itself to states with similar populations and levels of education? All of these areas are intertwined, and understanding how best to address each area individually and as a whole will help provide the framework needed to make energy decisions that are best for Maine.

While *Energy in Maine* is intended as a foundational brief, it provides (at best) an incomplete analysis of the energy options for Maine. Further research and analysis on each topic area (including a more detailed comparison of different energy options and a realistic time-frame for their implementation) will begin to provide more comprehensive guidance for determining the energy decisions that are best for Maine.

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