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Impacts of a renewable portfolio generation standard on US energy markets

Andy S. Kydes*,[1]

Energy Information Administration, United States Department of Energy, USA

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Abstract

This paper analyzes the impacts of imposing a Federal 20 percent non-hydropower renewable generation portfolio standard (RPS) on US energy markets by 2020. The US currently has no RPS requirement although some state RPS regulations have been adopted but not uniformly enforced (see http://www.eia.doe.gov/oiaf/analysispaper/rps/index.html for a recent summary on RPSs in the US). The renewable portfolio standard (RPS) requires that 20 percent of the power sold must come from qualifying renewable facilities. The analysis of the 20 percent RPS was developed by using the December 2001 version of the National Energy Modeling System (NEMS) of the Energy Information Administration (EIA) and the assumptions and results of the *Annual Energy Outlook 2002 (AEO2002)* reference case.[2] A policy that requires a 20 percent non-hydro-electric RPS by 2020 appears to be effective in promoting the adoption of renewable generation technologies while also reducing emissions of nitrogen oxides by 6 percent, mercury by 4 percent and carbon dioxide by about 16.5 percent relative to the reference case in 2020. Electricity prices are expected to rise about 3 percent while the cost to the electric power industry could rise between 35 and 60 billion dollars (in year 2000 dollars in net present value terms).

Keywords: Renewable portfolio standard; Intermittent generation technologies; Technology learning

1. Introduction

Renewable technologies in the US, Europe and Japan have been supported for over 20 years with R&D investments and, for some technologies like wind and solar, with tax credits or other subsidies. Support for such programs have almost always been motivated by combinations of interest in reducing energy import dependence, reducing damaging environmental emissions, and saving some of the depletable high-quality resources like natural gas for future generations (inter-generational equity). Underlying these obvious goals has been the hope that by providing moderate-term subsidies, these technologies would eventually become economic and not require further government support. To date, such subsidies in the US have largely failed to produce economic grid-connected renewable generation technologies except in niche markets, even though the technologies have often met or exceeded their program goals, because the competing technologies have also improved and fuel prices have remained relatively low.

Concerns over the possibility that climate change may be caused by anthropogenic activities, particularly the combustion of fossil fuels, have raised interest in examining a series of policy options which may inhibit or reverse the growth of energy-related carbon emissions. A number of

*Tel.: +1 202 586 2222; fax: +1 202 586 3045.
E-mail address: akydes@eia.doe.gov.

[1]The author is an employee of the US Department of Energy, Energy Information Administration. However, the views contained herein are those of the author and do not necessarily represent the views or position of the US government or any agency thereof.

[2]The outlook for natural gas wellhead prices has changed considerably in the *Annual Energy Outlook 2006 (AEO2006)* (Energy Information Administration, 2006). Natural gas prices in the *AEO2004* are projected to remain well above $ 4.00 per mcf throughout the forecast, reaching $5.20 per mcf by 2025 in 2002 dollars. While higher natural gas prices are projected to make wind systems somewhat more attractive, the main impact of higher natural gas prices is to increase coal-fired capacity additions in the projection period. While the numerical results in the renewable portfolio analysis presented in this paper are expected to be somewhat different if *AEO2006* are used, the trends and general conclusions are unlikely to be affected by the choice of baseline.

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bills have been introduced by the US Congress that would simultaneously reduce emissions of nitrogen oxides (NO_x), sulfur dioxide (SO_2), mercury (Hg), and carbon dioxide (CO_2) from power generators. Two of the more recent policy proposals studied include Senate Bill 1766 and House Bill H.R. 4. Other related analyses have been performed at the request of the House Committee on Government Reform (Energy Information Administration, 2001a) and the Senate Committee on Environment and Public Works (Energy Information Administration, 2001b). These may be viewed or downloaded from the Energy Information website: http://www.eia.doe.gov/.

The policy considered in this paper is a 20 percent non-hydro electric renewable portfolio standard (RPS). A typical RPS requires that a share of the power sold must come from qualifying renewable facilities. Companies that generate power from qualifying renewable facilities are issued credits that they can hold for their own use or sell to others. To meet the RPS requirement, each individual electricity seller must hold credits—issued to qualifying renewable facilities or purchased from others—equal to the share required in each year. For example, a supplier of 10 TW h of retail electricity sales in a year with a 10-percent RPS requirement would have to hold 1 TW h of renewable credits. In a competitive market, the price of renewable credits would increase to the level needed to meet the RPS requirement. The RPS provides a subsidy to renewable generators (from nuclear, coal, natural gas, oil and hydro-electric generators) to make them competitive with other resource options while allowing the market to determine the most economical renewable options to develop.

2. Description of the modeling framework

This section provides a brief overview of the National Energy Modeling System (NEMS). NEMS is a large, technology-rich, regional, computer-based, energy-economy model of US energy markets for the midterm period through 2020. (The AEO 2006 version of NEMS projects through 2030.) Key features implemented in NEMS included: (a) regional outputs of energy, economic and environmental activity of the US economy; (b) use of a modular modeling structure to facilitate and enable the model builders to work with particular aspects of the model independently; (c) integration of engineering and economic approaches to represent actual producer and consumer behavior; (d) use of a projection period spanning 20–25 years; (e) incorporation of the broader energy analysis community and outside peer groups in the design and update of NEMS, and (f) endogenous technology learning (Energy Information Administration, 2000, 2003, 2002, 2006; Gabriel et al., 2001).

In accordance with the requirement that EIA remain policy-neutral, the *AEO* projections assume that all existing legislation, regulations, and policies remain unchanged. Further, these projections also depend on additional uncertain assumptions, including the estimated size of the economically recoverable resource base of fossil fuels, changes in world energy supply and demand, the rate at which new energy technologies are developed and the rate and extent of their adoption and penetration. Consequently, the *AEO* projections are not meant to be predictions about the future.

2.1. Purpose of NEMS

The primary purpose of NEMS is to analyze the energy-related consequences to the US of alternative energy policies or pertinent economic or energy market influences. The policy questions of interest have determined the level of detail required within the structure of NEMS. For example, environmental issues relating to energy production and consumption have taken on a new importance with the implementation of the Clean Air Act Amendments (CAAA) of 1990 and the proposed Kyoto agreement of December 1997 on greenhouse gases (Energy Information Administration, 1998). Accordingly, NEMS is designed to measure seven emissions (oxides of sulfur, oxides of nitrogen, carbon, carbon monoxide, carbon dioxide, volatile organic compounds and mercury) released in the use of energy products to generate electricity and, in the case of carbon (or carbon dioxide), constrain national emissions using a pricing mechanism. The technology representation in NEMS is particularly helpful in the analysis of national carbon mitigation policies and utility sector SO_x, NO_x, and mercury mitigation policies because of its explicit representation of vintaged (time-dependent) energy equipment and structures (e.g., building shells) and the careful tracking of vintaged capital stock turn-over rates. For similar reasons, NEMS contains sufficient detail in the transportation sector to project the use of alternative or reformulated fuels like compressed natural gas, ethanol, methanol, electric, etc. In addition to environmental concerns, NEMS is designed to account for existing and emerging government regulations (e.g., electricity restructuring), the potential for the development and use of new energy-related technologies, the increased use of renewable sources of energy (especially intermittent technologies), and the potential for demand side management, conservation, and increases in the efficiency of energy use. These topics reflect the expected scope of present and future government policy.

The NEMS' representation of energy markets focuses on four important interrelationships: (a) interactions among the energy supply, conversion and consumption sectors; (b) interactions between the domestic energy system and the general domestic economy; (c) interactions between the US energy system and world energy markets; and (d) the interaction between current production and consumption decisions and expectations about the future.

2.1.1. Domestic energy system/economy interactions

The general level of economic activity in sectoral and regional detail has traditionally been used as an