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Analysis

The job generation impacts of expanding industrial cogeneration

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ABSTRACT

Sustainable economic development requires the efficient production and use of energy. Combined heat and power (CHP) offers a promising technological approach to achieving both goals. While a recent U.S. executive order set a national goal of 40 GW of new industrial CHP by 2020, the deployment of CHP is challenged by financial, regulatory, and workforce barriers. Discrepancies between private and public interests can be minimized by policies promoting energy-based economic development. In this context, a great deal of rhetoric has addressed the ambiguous goal of growing "green jobs." Our research provides a systematic evaluation of the job impacts of an investment tax credit that would subsidize industrial CHP deployment. We introduce a hybrid analysis approach combining simulations using the National Energy Modeling System with Input–output modeling. NEMS simulates general-equilibrium effects including supply- and demand-side resources. We identify first-order employment impacts by creating "bill of goods" expenditures for the installation and operation of industrial CHP systems. Second-order impacts are then estimated based on the redirection of energy-bill savings accruing to consumers; these include jobs across the economy created by the lower electricity prices that would result from increased reliance on energy-efficient CHP systems. On a jobs-per-GWh basis, we find that the second-order impacts are approximately twice as large as the first-order impacts.

1. Introduction

Many economic, environmental and political factors are driving a growing emphasis on the efficient and environmentally sustainable production and use of energy (Brown and Sovacool, 2011; Pollin et al., 2008). From climate change to foreign exchange, our current patterns of energy use in the United States and worldwide are severely stressing natural and social systems (Diamond, 2005; Rockstrom et al., 2009). U.S. energy demand is projected to continue to grow,[1] and concerns about the security and affordability of energy supply are literally front-page news.

Conflicts about the policy drivers of economic growth and job creation and anxieties about persistent structural under-employment are feeding debates over infrastructure investments and environmental policy. Regulatory policies that are feared to lead to the loss of jobs are easy political targets, uniting business owners and workers, even when health and other social benefits are large in comparison. Alternatively, regulatory or fiscal policies that can be shown to produce net job growth tend to be politically attractive.

Recent studies of "green jobs" have shown positive contributions of clean energy policy legislation to job creation and sustainable economic development (Laitner and McKinney, 2008; Pollin et al., 2008). However, these studies shed little light on the relationship between clean energy investments, energy market dynamics, and macroeconomic effects including both direct and indirect employment development. For example, analysis to date has not fully evaluated the second-order employment effects from the redirection of energy-bill savings accruing to participants in energy-efficiency programs (although in a different context, these expenditures have been considered by analysts of the "rebound effect" (e.g., Sorrell et al., 2009)).

In addition, the literature has rarely examined the impact of lower energy prices economy-wide that could result from the lower energy use that occurs following energy-efficiency investments. With large-scale energy efficiency, competitive markets would see lower clearing prices for energy and price-regulated markets would experience lower marginal dispatch costs — in both cases, prices would benefit from decreasing reliance on the most expensive marginal generating equipment (Kim et al., 2013; Kramer and Reed, 2012; Steinhurst and Sabodash, 2011). This "demand reduction induced price effect" (DRIPE) suggests that increased energy efficiency could reduce energy prices for all customer classes, generating jobs across the economy as the resulting savings are spent on goods and services that are more job-intensive than the capital-intensive industries associated with energy production. Two studies which have addressed these effects quantitatively include Laitner (2009) and Laitner et al. (2010). The results are not precisely

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[1] The U.S. Energy Information Administration (2012) forecasted that U.S. total energy consumption would grow by 0.3% per year from 2010 to 2035.

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comparable because these papers model end-use efficiency improvements in all sectors, whereas our research addresses direct efficiency improvements in the industrial sector and calculates second-order impacts based only on price reductions in the commercial and residential sectors, but the job-creation impacts from energy-bill savings are similar. In another similar study, Rhodium Group (2013) looked at economy-wide impacts of major efforts to improve "energy productivity," and found a net increase of 1.3 million jobs in 2030 derived from net energy bill savings of $494 billion, $151 billion of which was attributed to the reduction in energy prices driven by reduced demand.

This study assesses the employment impacts and energy market dynamics of a sizeable increase in the deployment of one key energy efficient technology – combined heat and power (CHP) systems – driven by a federal investment tax credit (ITC). CHP technology is often regarded as a transformational technology with potential for significantly improving energy efficiency by productively reusing waste heat (Shipley et al., 2008); indeed, a recent executive order has set a national goal of 40 GW of new industrial CHP by 2020, targeting a broad set of stakeholders including states, manufacturers, and utilities (The White House, 2012). Our analysis recognizes that subsidies can produce changes in energy consumption, production, and prices across the economy, including the industrial, residential, and commercial sectors. By combining an Input–output (I–O) model with the projections of an energy systems model (the National Energy Modeling System (NEMS)), we develop a hybrid analytical tool to generate plausible estimates of the consequences of various policy, price, and technology scenarios.

2. Industrial CHP and ITC Policy

Also known as cogeneration, CHP is the production of electricity together with economically useful heat, for use in industrial processes and for heating and cooling buildings. By capturing energy that would otherwise be wasted, the efficiency of conversion can be increased from 45% in typical thermal power plants to as much as 70% in efficient natural gas CHP facilities (U.S. Environmental Protection Agency Combined Heat and Power Partnership, 2008). In addition, while the main fuel of CHP systems is natural gas,[2] CHP can often be fueled with industrial waste products or with biomass, further reducing fossil fuel consumption and carbon dioxide emissions.

CHP is also a form of distributed generation, as CHP technologies allow end-users to generate electricity on site. The primary CHP technologies (so-called "prime movers") include gas turbines, reciprocating engines, and boiler/steam turbine combinations, which are combined into systems with electrical generators and heat recovery equipment. Such systems are tailored to available fuels, plant operating costs, the difference between electricity price and fuel costs,[3] and the on-site need for electrical power versus thermal energy (Sentech Inc., 2010). Deployment of CHP systems reduces electricity purchased through the grid from central utility stations and usually produces power to sell back to the grid. This onsite generation avoids energy losses from electricity transmission, and it can increase overall system resilience, as has been shown in the development of locational marginal pricing for distributed generation of all types (Lewis, 2010). These characteristics make CHP especially attractive for industrial users who want to enjoy the benefits of site-specific, strategic energy production to supply their electricity and thermal energy needs.

The industrial sector is the largest consumer of energy in the U.S., accounting for 31% of total energy consumption in 2010 (U.S. EIA, 2012). According to the *Annual Energy Outlook 2012*, industrial energy consumption is also expected to show the largest increase of any sector over the next 25 years. Therefore, improving energy efficiency in the industrial sector is a critical agenda item for policy-makers.

Despite the economic and environmental attractiveness of CHP, decision-makers in the industrial sector face financial, regulatory, information, and workforce barriers to what are generally considered to be cost-saving investments. Many studies have documented a gap between optimal and actual energy efficiency (Dietz, 2010; Hirst and Brown, 1990; Jaffe and Stavins, 1994). First of all, the economic challenges of CHP investments are the greatest barrier to viability (Chittum and Kaufman, 2011); although CHP promises long-term energy-bill savings, companies often feel a greater financial risk because CHP installations have high upfront costs and long payback periods compared to traditional equipment. The current economic downturn in the U.S. has caused companies to become increasingly conservative, with even greater aversion to longer payback periods compounded by difficulties securing financing (Chittum and Kaufman, 2011).

Second, utility monopoly power and utility rate structures also distort CHP economics. Many utilities discourage CHP facilities from acting as independent distributed generators who can sell excess power to nearby customers at retail or negotiated rates. In some states, utilities own and manage the transmission and distribution infrastructure and they discourage CHP users from selling their excess power back to the grid at a wholesale rate. Furthermore, utilities impose additional charges for private wire usage and for standby or back-up service (Chittum and Kaufman, 2011; Sciortino et al., 2011). These electricity rate structures reduce the money-saving potential of on-site generation.

Third, the enforcement of interconnection standards and environmental regulations can be substantial barriers to CHP investments, especially for smaller CHP projects. Although many states have developed interconnection standards that ensure stable utility service, the lack of uniformity in application processes has caused unnecessary project delays and has generated high transaction costs (Shipley et al., 2008; U.S. EPA, 2012). In addition to the costs of dealing with interconnection standards, various permits and regulations—such as input-based emission standards—can also increase upfront project costs. Satisfying the conventional emission regulations based on heat input (lb/MMBtu) or exhaust concentration (parts per million) can be challenging to CHP deployment at the beginning of a project's lifespan. CHP generally increases the emissions onsite, but due to its high efficiency, reduces the overall emissions of all pollutants in a given region as well as overall fuel consumption (Chittum and Kaufman, 2011). Many CHP studies argue that the transformation from current input-based emission standards to output-based standards can capture the total regional emissions benefits of CHP development (Shipley et al., 2008; Cox et al., 2011; Sciortino et al., 2011).

Lastly, as CHP has been utilized in quite varied sectors, the difficulty of effectively sharing lessons and information across industries can impede the process of diffusion and modernization of CHP projects (The Committee on Climate Change Science and Technology Integration (CCCSTI), 2009). Given the uncertainties about the benefits and risks of CHP technology over a project's whole lifespan, the information incompleteness can be a substantial barrier to expensive capital investments. Subsidies that encourage the market penetration of CHP systems and continuing technology development may mitigate these information barriers.

CHP users, manufacturers, and service providers have advocated for expanding CHP-friendly tax credits to reduce market barriers to the expansion of CHP (ICF International, 2010). The federal government has established a 10 percent ITC for qualified CHP systems through 2016. The eligible system size is capped at 50 MW that exceeds 60% energy efficiency on a lower heating value basis.[4] Several states are beginning to tackle current regulatory barriers. Legislative proposals have suggested

[2] Approximately two-thirds of industrial CHP systems in the U.S. are fueled by natural gas (ICF International, 2011).

[3] The difference between the price received by a generator for the electricity it produced and the cost of the natural gas needed to produce that electricity is called the "spark spread." Spark spread (in $/MWh) is calculated as Price of Electricity − [(Price of Natural Gas) ∗ (Heat Rate)] = $/MWh − [($/MMBtu) ∗ (MMBtu/MWh)].

[4] The Database of State Incentives for Renewable Energy, www.dsireusa.org/.