Energy Policy 123 (2018) 289–298

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Economic and environmental impacts of local utility-delivered industrial energy-efficiency rebate programs

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ARTICLE INFO

Keywords:
Industrial energy efficiency
Utility rebate programs
Input-output analysis

ABSTRACT

Manufacturing operations are constantly encouraged to include energy-efficient practices into their plant operations, including through rebate programs that provide monetary rewards for firms who purchase and employ energy-efficient equipment in their facilities. This article presents a novel methodology for analyzing the cascading economic and environmental effects of an electric utility company's industrial energy-efficiency rebate programs and applies it to the case of a local utility located in the U.S. state of Ohio. It examines the utility's industrial rebate programs for lighting, motor, and heating, ventilation, and air conditioning (HVAC) systems and estimates the economic and environmental impacts of the programs using an input-output modeling framework. All three rebate programs provided a modest economic boost not only to directly involved equipment manufacturers and marketing service providers, but also to other upstream industries responding to the direct impact and the final demand augmented by the associated increase in value added in the regional economy. Emissions avoided as a result of electricity savings were found to outweigh additional emissions generated from the production of the energy-efficiency equipment in the region throughout the program years. However, if the full equipment purchase data were made available, the amount of added CO_2 emissions would be larger.

1. Introduction

According to the U.S. Energy Information Administration, in 2017 the U.S. industrial sector consumed 8.3 quadrillion BTUs of petroleum, 9.8 quadrillion BTUs of natural gas, and 1.3 quadrillion BTUs of coal (U.S. Energy Information Administration, 2018). Globally, the industrial sector consumes 36% of global energy usage annually, which consequently also has a significant impact on the environment (International Energy Agency, 2017). In the U.S., several federal programs support the implementation of industrial energy-efficiency initiatives. For example, ISO 50001 energy management standard encourages manufacturing industries to create energy management plans to identify opportunities for improvements in energy efficiency (McKane, 2010). The U.S. Department of Energy's Superior Energy Performance (SEP) Program (Scheihing, 2014) offers a certification process to assist manufacturing industries in incorporating ISO 50001 and maintaining energy-efficient best practices in their operations. One study showed that manufacturing industries experienced greater energy-efficient paybacks within 2 years by combining ISO 50001 and SEP than through SEP alone (McKane, 2014). The Better Plants program further assists manufacturing industries wishing to adopt energy-efficiency strategies by providing free energy audits and software tools for analyzing energy-efficiency improvement opportunities (U.S. DOE, 2017). The world's largest energy audit program for SME is the Industrial Assessement Center (IAC) program supported by U.S. Department of Energy in which 18,000 no-cost energy audits have been provided to SMEs since 1990s (U.S. DOE, 2018). IACs typically identify more than $130,000 in potential annual savings opportunities for every manufacturer assessed, nearly $50,000 of which is implemented during the first year following the assessment. The IAC program utilize the straight pay back periods for each measure to facilitate the cost effectiveness of the program (Choi et al., 2013). In addition to these national energy-efficiency programs, each U.S. state has developed strategies for encouraging energy efficiency, and a majority have required local electric utility companies to offer rebate programs (Goldman, 2011). In 2009, utility companies in Ohio were required to offer rebate programs to reduce their annual electricity sales by at least 0.3% and to reach a 2% reduction by 2019 (Burr et al., 2013). In the EU, the Energy Efficiency Directive (2012/27/EU) introduced new energy efficiency policies in the member states. For industries, it is introduced under Article

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https://doi.org/10.1016/j.enpol.2018.08.066
Received 24 January 2018; Received in revised form 22 August 2018; Accepted 30 August 2018

7 (energy efficiency obligations and/or alternative measures), mandatory audits (Article 8) and new certification/qualification schemes. A swedish energy program has been operating the "Highlan"d program since 1990 to help improving industrial energy efficiency through audits which does not include investment assessments (Thollander et al., 2007). In the Australian enterprise energy audit program (EEAP), which offered energy audits including investment assessment with a 50% subsidy, around 80% of the recommended measures were implemented (Harris et al., 2000). Energy audits and energy management can be seen as important instruments to recognize and observe existing economic energy efficiency potentials by systematic procedures to gain knowledge and developing a strategy to achieve energy efficiency targets. Variety of methodologies are made to analyze the economic impacts of energy efficiency programs from policy instruments perspective, however, reviewing the plethora of policy instruments is not the scope of this research. There is a common misconception that customers who participate in the energy efficiency programs are the only beneficiaries. In fact, efficiency programs benefit the entire community and the ratepayers with cascading indirect and induced economic impacts. This paper presented a novel methodology which account some energy and non-energy benefit of the energy efficiency rebate program with a case study performed in a local region in the United States.

2. Background

Generally, benefit of energy efficiency program include but not limited to customer bill savings, avoided generation costs, avoided transmission and distribution costs, avoided cost of environmental compliance. It also can provide other program benefits with respects to utility, participants, and societal perspectives (Woolf et al., 2012). Cost of the energy efficiency program include but not limited to program administrator costs, EE measure cost (rebate to participants and participant contribution), lost revenues to the utility. There has been much debate about which is the most cost-effective energy efficiency program. Many states are not properly applying the cost effectiveness test and consequently, energy efficiency is being undervalued, and customers are paying more than necessary for electricity and gas services (Baatz, 2015).

Although energy efficiency is widely considered key to reducing greenhouse gas emissions, the literature has identified several structural and behavioral barriers to the adoption of energy-efficiency improvements (Allcott and Greenstone, 2012; Cagno and Trianni, 2014; Cagno et al., 2013; Gillingham et al., 2009; Hirst and Brown, 1990; Stadelmann, 2017). Among the identified risk factors in energy-efficiency investments are uncertainty regarding electricity supply, market prices, and government policies; difficulty obtaining financing; lack of information; and misplaced incentives. The state of Ohio, for example, has been pursuing energy-efficiency investments under its Clean Energy Law passed in 2008. The law mandated that Ohio's major utilities reduce 22% of their sales volume and peak demand by 1% in 2009 and by 0.75% per year from 2010 through 2018 through energy-efficiency and demand-side management. Although the law was overturned in 2014 by the state legislature, which placed a two-year freeze on energy-efficiency requirements, many utilities continued to advance their energy-efficiency programs by securing sizeable funding through various measures and incorporating energy efficiency into their integrated resource planning processes. This continuity was made possible because Ohio is one of 19 U.S. states with either lost-revenue adjustments or revenue decoupling mechanisms that help counter utilities' disincentives to advance energy efficiency by mitigating the impact of utility-delivered energy-efficiency programs on sales (ACEEE, 2013). Among those utilities is Dayton Power & Light (DP&L), which offers prescriptive rebate programs called Rapid Rebates Programs for Lighting, HVAC, Motors, Drives and Compressed Air, and a complementary program, Custom Rebates, that covers energy-saving initiatives outside of the Rapid Rebates Program. To be eligible for receiving monetary rebates under these programs, each equipment type must meet certain criteria, as explained in the case study section.

Numerous previous studies have examined the economic impact of energy-efficiency improvements on GDP (Greening et al., 2000), employment (Scott et al., 2008; Wei et al., 2010), and health (Ürge-Vorsatz et al., 2009) on a state or a national economy level. Among several analytical approaches available to study such improvements (Laitner et al., 1998; Mirasgedis et al., 2014; Yushchenko and Patel, 2016), input-output analysis has often been employed for its ability to capture potential direct and indirect impacts of energy efficiency (ACEEE, 2012; Angelou Economics, 2011; Cellura et al., 2013; Lester, 2013; Lutz et al., 2012; Paul et al., 2010). Yet the input-output approach has rarely been applied to energy-efficiency programs delivered by local utilities, which are one of the most widely implemented types of programs for improving local energy efficiency, which means that most extant studies have underestimated those programs' economic impact by ignoring their indirect or induced impacts on the community. Energy efficiency program can provide other program impacts to include the impacts that are not part of the costs, or the avoided costs, of the energy provided by the utility. Other program impact include non-energy benefits and non-energy costs. Among many aspects of the other program impacts, our study focus on estimating the community wide indirect and induced economic and environmental impacts of the electricity utility's energy efficiency program. This article argues that utility-based rebate programs can boost the local economy not only by distributing the utilities' investment dollars within the community, but also through the direct energy savings achieved by implementing energy-efficiency measures, and therefore both effects should be considered as part of the economic impact of these programs.

3. Methodology

Fig. 1 illustrates this study's methodology for analyzing the cascading economic and environmental impacts of a utility-based rebate program. As it shows, the first step is gathering information on the performance of the rebate program offered to the utility's industrial customers located in its service territory. The second step is calculating the total investments and marketing costs incurred by the utility company for the rebate program and the resulting energy savings of the industrial customers. The third step is allocating the monetary value of these rebates to individual upstream supplier sectors. The fourth step is to assess the direct, indirect, and induced economic impacts of the rebate program through an economic input-output framework. The fifth step is estimating the program's environmental impacts through estimating both economy-wide emissions added by the increased production activities of direct and indirect goods and services and emissions avoided by the industrial electricity savings achieved from the rebate program. These five steps are elaborated in turn below.

The first step is to collect detailed information on the rebate program itself. Energy-efficiency rebate programs are offered for residential, commercial, and industrial customers in about 50% of the states for their commercial and industrial (C&I) customers in the U.S (U.S. Department of Energy, 2017). The eligibility of customers for the utility rebate programs relies on whether they are geographically located in the utility's service territory, which typically consists of neighboring counties within a specific state and is monitored at a zip-code level. The records kept by utility companies often include their customers' rebate program enrollment, dollar amounts received from the rebate programs in return for implementing particular energy-efficiency measures, self-reported estimates of energy or demand savings resulting from installing the measures, and zip codes of the location where the installation occurred. The same detailed information is also kept with regard to vendors participating in the rebate programs, who may also offer their services to customers outside the utility's service area. This information is also utilized for calculating the utility's investments in rebate programs. We have received C&I program data