Greenhouse Gas Reductions or Greenwash?: The DOE's 1605b Program[*]

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Abstract

We assess why electric utilities participate in the Department of Energy's Voluntary Greenhouse Gas Registry, and the impact of participation on actual emissions performance. Aggregate statistics suggest participants are greenwashing: as a group, they increase emissions over time but report reductions, while non-participants decrease emissions over time. At the firm level, we find little evidence that political or public relations pressures affect participation. Rather, our results suggest participants are growing firms with high emissions that selectively report on successful reductions projects to obtain early reductions credits that would have economic value if the U.S. implements a cap-and-trade program. Participating in the 1605b program has no measurable effect on a firm's carbon intensity.

Keywords: greenwash, information disclosure, public voluntary programs, early reduction credits, greenhouse gas, electric utilities, the 1605b program

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1. Introduction

Environmental information disclosure programs have been hailed as the "Third Wave" of environmental regulation, following initial reliance on "command and control" policies such as Best Available Control Technology standards and a subsequent shift toward market-based policies such as tradable emissions permits. (Tietenberg 1998) A growing empirical literature suggests that mandatory disclosure programs do indeed lead to improved environmental performance, at least for firms that were initially weak performers. (Blackman, Afsah and Ratunanda 2004; Dasgupta, Wheeler and Wang 2007; Delmas and Shimshack 2007)

The effects of voluntary, as opposed to mandatory, environmental disclosures are more controversial. Non-governmental organizations (NGOs) often decry corporate environmental claims as mere greenwash, intended to unfairly bolster a dirty company's public image.[1] Furthermore, there is no academic consensus on whether voluntary environmental disclosures and environmental performance are even positively correlated. Economic models of disclosure imply a positive relationship, since firms with better performance will have more positive outcomes to disclose, and there exists some empirical literature to support this view.[2] In contrast, sociological "legitimacy theory" asserts that firms increase their disclosures after an accident or other negative event in order to bolster their tarnished reputations, and there exists empirical support for this view as well.[3] In light of these mixed findings, it is not surprising that many environmental advocates are distrustful of voluntary environmental disclosures and wary of greenwash.[4]

[1] Webster's New Millenium Dictionary of English defines greenwash as "The practice of promoting environmentally friendly programs to deflect attention from an organization's environmentally unfriendly or less savory activities."
[2] For theoretical models, see Milgrom (1981), Verecchia (1983), Shin (2003), and Sinclair-Desgagne and Gozlan (2003). For empirical support, see Al-Tuwaijri et al. (2004) and Clarkson et al (2006).
[3] For a discussion of the theory see Patten (1991); for empirical evidence see Patten (1992) and Deegan and Rankin (1996).
[4] Lyon and Maxwell (2008) present a theoretical model that combines a persuasion game with an NGO watchdog that punishes greenwash, thus reconciling the economic and sociological approaches.

In this paper, we compare firms' environmental disclosures against their actual emissions using a unique dataset created by section 1605b of the Energy Policy Act of 1992, which directed the Department of Energy to create a registry in which companies could record their voluntary reductions of greenhouse gas (GHG) emissions. For most industries, it is difficult to compare these disclosures against actual environment performance, since the U.S. currently has no federal regulation of GHG emissions. However, electric utilities must report detailed fuel use data to the Federal Energy Regulatory Commission (FERC), so we can compare their actual emissions performance against the disclosures they make through the DOE's Voluntary Greenhouse Gas Registry.

In the aggregate, there is a large gap between actual and reported aggregate emissions reductions over the period 1996-2003, as can be seen in Figure 1.[5] In fact, participants in the 1605b program reported significant reductions in tons of greenhouse gases emitted while actually increasing their emissions.[6] Ironically, firms that did *not* participate in the program actually reduced their emissions, as is shown in Figure II. From a high-level perspective, then, the program looks suspiciously like a government-supported opportunity for dirty firms to greenwash themselves.[7] Indeed, environmental groups have decried the 1605b program because it "encourages firms to make filings not on their entire corporate emissions profile, but on cherry-picked emission reduction projects."[8] This complaint is consistent with Lyon and Maxwell's (2008, p. 8) definition of greenwash as "selective disclosure of positive information about a company's environmental or social performance, without full disclosure of negative information on these dimensions, so as to create an overly positive corporate image."

[5] The reported reductions data are collected from the DOE's Voluntary Registry website. The actual reductions are calculated against the base year 1995 using data obtained from Platts, as described in section 5.
[6] When we compare reported and actual reductions at the firm level, we find that 68% of the reports to the 1605b program showed positive reductions while the firm's actual emissions rose.
[7] Firms might have reduced emissions compared to the 1605b benchmark years (1987-1990) but not compared to our benchmark year, 1995. For instance, this may be the case if firms increased renewable energy generation as a substitute for coal-based generation between the 1605b benchmark years and 1995.
[8] The quotes are taken from pages 3-4 of the comments on the 1605b program filed by a group of seven environmental groups led by the Natural Resources Defence Council on June 5, 2002, and available on the web at http://www.pi.energy.gov/enhancingGHGregistry/comments/documents/doniger.doc.

[Figure I about here]

[Figure II about here]

To explore firms' reporting behavior in more detail, we formulate and test a series of hypotheses regarding why firms participate in the 1605b program, and which types of firms are more likely to participate. There is a plausible economic benefit from participation, namely the hope of obtaining "early reduction credits" (ERCs) that would have value if the U.S. were to impose an emissions cap in the future.[9] We expect that firms with lower costs of emissions reductions were more likely to participate in order to pursue ERCs, so we include a variety of variables to capture this effect. In addition, firms might derive public relations benefits from participation, so we include a set of variables proxying for social and political pressures facing firms. Our empirical results suggest that economic motives drove participation in the program, and that public relations motives were less significant.

The remainder of the paper is organized as follows. Section 2 describes the 1605b program, and illustrates the sort of reports firms file with the Department of Energy. Section 3 surveys the relevant literature, and develops a set of testable hypotheses. Section 4 describes our econometric model, section 5 describes our data, and section 6 reports results. Section 7 describes recent modifications to the 1605b program, which provide further insight into the political economy of the program and reinforce our econometric results. Section 8 concludes.

2. The 1605b program

The voluntary registry program was established by section 1605b of the Energy Policy Act of 1992. The general features of the 1605b program align well with the proposals laid out in former President Bill Clinton and former Vice

[9] The value of such permits could be large indeed. According to the Carbon Trust (2006, p. 8), electric utilities in the U.K. made profits of over $1 billion in 2005 from carbon permits they were allocated under the E.U. Emission Trading Scheme.

President Al Gore's report titled, "Reinventing Environmental Regulation" (Clinton and Gore, 1995). One of the proposals is to take full advantage of the power of information. The 1605b program allows public electronic access, so the public as well as government and firms can access the program's database. The 1605b program also has a self-certification feature proposed in the report.

A critical aspect of the 1605b program is that there are no hard and fast rules about how to report reductions.[10] First of all, voluntary reporters can choose to report reductions at the "entity level" (entire firm) or at the "project level" (individual reduction project). Moreover, reporters can define the boundary of the entity or project.[11] Reporters are even allowed to report entity-level reductions just as the sum of project-level reductions. Second, voluntary reporters also have leeway in choosing baseline emissions against which to measure their reductions: historical or hypothetical. In the case of historical emissions, reporters can select any one year between 1987 and 1990 or use an average of any of those years. In the case of hypothetical emissions, reporters estimate what emissions would have been without entity- or project-level reductions. Third, reporters can report either reductions in absolute emissions or reductions in emissions intensity. Fourth, voluntary reporters can report indirect reductions or sequestration as well as direct reductions.[12]

In 2003, the latest year covered in this paper, the 1605b program received a total of 98 reports from the electric power sector and the reports provided information on 485 GHG emissions projects. The projects covered a wide range from reducing emissions at the electric power generation, transmission and distribution stages to demand-side management and carbon sequestration.

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[10] The unique features described here do not reflect the recently revised guidelines (effective date: June 1, 2006). This is because our analysis is based on the data firms reported to the 1605b program during 1995-2003, which is before the revised guidelines were introduced.

[11] This information is based on personal correspondence with EIA's 1605b project manager, Mr. Stephen E. Calopedis (October 18, 2005).

[12] Direct reductions refer to reductions from sources owned by the reporter. Indirect reductions refer to reductions from sources not owned by the reporter but somehow affected by reporter actions. An example of indirect reductions is a decrease in power plant emissions due to a decrease in end-use electricity consumption, which in turn is at least partly attributable to electric utilities' demand side management programs. Sequestration refers to the removal and storage of carbon from the atmosphere in carbon sinks such as trees, plants, or underground reservoirs. See *Voluntary reporting of Greenhouse Gases 2003*, EIA (2005).

Abatement strategies at the generation stage include fuel switching from high to low carbon fuel sources, improving plant availability at low-carbon generators such as nuclear and hydro, plant efficiency improvement, increases in low- or zero-emitting generation capacity, decreases in high-emitting capacity, and retirement of high-emitting plants. Reductions at the transmission and distribution stages involve reduced losses in the delivery of electricity from power plants to end use through the use of high-efficiency transformers, transmission line improvements, etc. Demand side management projects aim to improve end-use energy efficiency of both stationary and mobile sources in the industrial, commercial, residential, agricultural, and transportation sectors. Carbon sequestration projects report carbon fixing through afforestation, reforestation, etc. Projects on other GHGs such as methane are also reported to the 1605b program.

Three case studies in the appendix illustrate what kinds of projects are actually reported to the program. American Electric Power and Southern Company represent fossil fuel-oriented companies and Exelon Corporation a nuclear-oriented one. American Electric Power participates at the project level and most of its projects involve carbon sequestration. Southern Company participates both at the entity and the project level but the sum of the project level reduction is the same as the entity level reduction. Exelon Corporation participates at the project level and its projects include transportation-related ones. For all three companies generation at non-fossil fuel units such as nuclear or hydro accounts for the majority of their generation-related projects.

3. Literature Review and Testable Hypotheses

As of this writing, the U.S. has not imposed mandatory federal restrictions on GHG emissions. Instead, it has relied on an array of "public voluntary programs" (PVPs) that encourage, but do not require, firms to reduce emissions. As described by Lyon and Maxwell (2007), PVPs--- such as Climate Leaders, Climate Challenge, Motor Challenge, and Sustainable Slopes---typically invite firms to set reduction targets and share information about their efforts with regulators and other firms. In return, they may receive technical assistance and/or favorable publicity from the government; there are no penalties for failing to meet stated targets and no attempts to assess the accuracy of reported information. The DOE's Voluntary Greenhouse Gas Registry is part of the broad array of voluntary climate programs, but it is somewhat unusual in that it does not ask participants to set goals. Instead, it simply invites firms to disclose GHG reductions and emissions, and to describe actions they took to achieve reductions. Thus, the program resembles both a standard PVP and also a straightforward information disclosure program. In developing testable hypotheses, then, we draw upon both the literature on PVPs and the literature on environmental information disclosure.

The literature on public voluntary programs has found a number of empirical regularities that we might expect to hold here as well. (Lyon and Maxwell 2004, 2007) The benefits of participating in public voluntary programs are typically thought to include favorable publicity, improved relationships with regulators, information exchange with other participating firms, and technical assistance from environmental specialists. According to the DOE's Voluntary Registry website:

> "The voluntary reporting program provides an opportunity for you to gain recognition for the good effects of your actions---recognition from your customers, your shareholders, public officials, and the Federal government. Reporting the results of your actions adds to the public groundswell of efforts to deal with the threat of climate change. Reporting can show that you are part of various initiatives under the President's Climate Change Action Plan. Your reports can also record a baseline from which to measure your future actions. Finally, your reports, along with others, can contribute to the growing body of information on cost-effective actions for controlling greenhouse gases."[13]

This statement of the benefits of participation suggests that they are primarily in the form of publicity and improved relationships with regulators, though it also hints obliquely at ERCs in its reference to establishing a baseline for measurement. The empirical literature on PVPs examines the factors affecting the decision to participate and how effective voluntary programs are as regulatory tools.[14] Research generally finds that

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[13] http://www.eia.doe.gov/oiaf/1605/1605b.html

[14] The program that has received the most attention is the EPA's "33/50" program, which encouraged firms to reduce their emissions of seventeen key toxic chemicals, relative to a 1988 baseline, by 33 percent by

firm size, poor environmental performance and greater external pressure have consistently significant and positive effects on voluntary program participation. The effect of firm size suggests that larger firms face greater pressure from environmental or citizens' groups to take action, enjoy economies of scale in compliance, or have better access to capital markets and hence lower costs of new investments.[15] Dirtier firms are more likely to participate, perhaps because they face greater media scrutiny and pressure from environmental or citizens' groups.[16] The effect of greater external pressure suggests that firms are more likely to participate when they face greater external pressure from environmental groups, communities, state politicians, or industry associations.[17] In particular, Sam and Innes (2005) find that the density of state-level Sierra Club membership has a significant and positive effect on joining the 33/50 program, as does being in an industry that experienced a contemporaneous consumer boycott. In the case of GHG emissions, Rabe (2004) discusses the relative significance of state-level pressures.

Evidence on the effect of economic growth rates on participation is more limited. Videras and Alberini (2000) find that the firm-specific growth rate is in general not a significant determinant of participation in Green Lights, WasteWi$e or 33/50. However, DeCanio and Watkins (1998) find that the industry-specific growth rate had a positive and significant effect on the probability of participating in the Green Lights program.

In the case of GHG related programs, another important factor to consider is firms' fuel mix. Firms that rely heavily on GHG emitting fuels (fossil fuels) may be subject to greater external pressure to reduce emissions, and hence more likely to join

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1992 and 50 percent by 1995. Other programs studied include the DOE's Climate Challenge program and EPA's WasteWise program and Green Lights program. See Lyon and Maxwell (2007) for further details.

[15] Large firms were more likely to participate in the EPA's 33/50 program (Arora and Cason, 1995; 1996; Khanna and Damon, 1999; Videras and Alberini, 2000; Sam and Innes, 2005), the EPA's Green Lights program (DeCanio and Watkins, 1998; Videras and Alberini, 2000), the EPA's WasteWi$e program (Videras and Alberini, 2000), the DOE's Climate Challenge program (Karamanos, 1999; Welch, Mazur, and Bretschneider, 2000), and the Sustainable Slopes Program (Rivera and de Leon, 2004).
[16] Dirtier firms were found to be more likely to participate in the 33/50 program (Arora and Cason, 1995; 1996; Khanna and Damon, 1999; Videras and Alberini, 2000; Sam and Innes, 2005), the Green Lights program (Videras and Alberini, 2000), the Sustainable Slopes Program (Rivera and de Leon, 2004) and the WasteWi$e program (Videras and Alberini, 2000).
[17] Firms facing more pressure from environmental groups were more likely to participate in the 33/50 Program (Khanna and Damon, 1999, Sam and Innes, 2005) and the Sustainable Slopes Program (Rivera and de Leon, 2004).

voluntary programs. Karamanos (1999) examines this hypothesis for the Climate Challenge program, using a fraction of electricity generated from fossil fuels. He finds a significant positive effect of fossil fuel use on participation.

Combining these insights from the empirical literature on PVPs, we have:

Hypothesis 1: A firm is more likely to participate in the 1605b program to obtain favorable publicity and improve regulatory relationships if it: a) is large, b) emits more greenhouse gases, or c) faces greater external pressure from environmental groups, local communities, state politicians or industry associations.

Research on voluntary environmental disclosures can be found in both the economics and accounting literatures (Patten 1991, Patten 1992, Sinclair-Desgagne and Gozlan 2003, Al-Tuwaijri et al 2004, Clarkson et al 2006). As mentioned in the Introduction, however, there is no empirical consensus on the sign of the correlation between environmental performance and disclosures. Nor is there agreement on the theoretical factors that cause that sign to be either positive or negative. In our view, this reflects a need for careful attention to the circumstances surrounding a particular disclosure, including the potential positive responses from investors and the potential negative responses from NGOs concerned about greenwash.

The most conspicuous economic benefit from participating in the 1605b program was the possibility that participants would receive early reduction credits (ERCs), which might have significant value if the U.S. eventually creates a tradable permits scheme for GHG emissions. (Michaelowa and Rolfe 2001, Kennedy 2002, Parry and Toman 2002) In particular, participants would benefit if the government adopted an allocation scheme for permits that would award them free permits for reductions in GHG emissions made prior to the beginning of the trading scheme. In fact, just such a proposal was introduced by Senators John Chafee (R-RI) and Joseph Lieberman (D-CT) in the 105th and 106th Congresses.[18] Despite the failure of both bills to pass, these proposals made industry (and investors) keenly aware that ERCs might be awarded at some point in the future.[19]

[18] In the 105th Congress, Senator Lieberman, along with Senators John Chafee (R-RI) and Connie Mack (R-FL) introduced S. 2617, the "Credit for Early Voluntary Action Act." In the 106th Congress, Senators

Which firms are more likely to register GHG reductions in an attempt to garner ERCs depends upon the benefits and costs of participation. The value of a tradable GHG permit is set by market forces independent of any given firm's identity, while the cost of GHG reductions is firm-specific. Hence, we expect firms with low-cost reduction opportunities to be most active in pursuing ERCs. In particular, *large firms* are more likely to have enough potential ERCs to outweigh the cost of participating in a voluntary registry. Firms with *low-cost opportunities* to reduce emissions are also more likely to participate. This would include firms with inefficient older coal-burning plants that could benefit from a retrofit (proxied for by a high heat rate, or heat input per unit of electricity generated), and firms with nuclear or hydroelectric plants that are currently operating at low capacity factors. This category would also include firms with high-cost oil-burning plants that could be displaced by cheaper, cleaner, gas-fired generating units.[20] (We create a variable called "fuel switch saving" that measures the difference between the cost per kwh of the firm's most expensive fuel source and the cost per kwh of natural gas.) Utilities with *growing demand* can increase their capacity factors, operating more efficiently and reducing their carbon intensity, that is, their emissions per unit of generation. Growing firms can also justify building new plants, which during our sample period tended to be relatively low-emission gas-fired plants; adding new, clean capacity also reduces a firm's overall carbon intensity. To summarize, we have

Hypothesis 2: A firm is more likely to participate in the 1605b program in pursuit of early reduction credits if it: a) is large, b) has a high heat rate, c) has a low capacity factor, d) has a large potential fuel switch saving, or e) faces growing demand.

Chafee, Lieberman, Mack, Warner (R-VA), Moynihan (D-NY), Reid (D-NV), Jeffords (R-VI), Wyden (D-OR), Biden (D-DE), Collins (R-ME), Baucus (D-MT), and Voinovich (R-OH) introduced S. 547, the "Credit for Voluntary Reductions Act."

[19] To the best of our knowledge, there has been no prior empirical research on firms' pursuit of ERCs.

[20] During most of our sample period, natural gas was the fuel of choice for new generating units because it was both clean and cheap. As of September 2002, the Energy Information Administration reported that the average wellhead price of natural gas remained below $3.00 per thousand cubic feet (MCF). Since that time, prices have risen sharply, with the price in December 2005 over $10 per MCF. Utilities now face much more difficult choices when they expand capacity than they did during our sample period.

The hypotheses developed so far relate to why firms participate in the 1605b program. We now turn to hypotheses regarding what types of firms have better environmental performance, i.e., lower CO_2 emissions intensity, CO_2 emissions per net generation (lbs/MWh).[21] First of all, firms with a higher fraction of generation from hydroelectric or nuclear power, which emit zero carbon, should have lower CO_2 emissions intensity than otherwise. Second, firms with growing demand are likely to have lower CO_2 emissions intensity. During most of our sample period, natural gas was the fuel of choice for new generating units because it was both clean and cheap, so growing firms building gas units could lower their average emissions intensity. Growing firms could also increase their capacity factors, operating more efficiently and thereby reducing their carbon intensity. Third, firms with higher capacity factors, all other things equal, should have lower emissions intensity.

Hypothesis 3: A firm has better environmental performance, i.e., lower CO_2 emissions intensity, if it: a) has higher fraction of hydro or nuke, b) faces growing demand, or c) has a higher capacity factor.

Finally, we turn to the expected effects of participation in the voluntary 1605b program on environmental performance, which we measure using carbon emissions intensity. As noted by Lyon and Maxwell (2007), the literature that has conducted empirically rigorous assessments of PVPs has generally concluded that they have little or no impact on environmental performance; this includes such well-known programs as the EPA's 33/50 Program, Climate Challenge, Climate Wise, and Sustainable Slopes. Having no reason to expect the 1605b program to perform better than other programs in this regard, we have:

Hypothesis 4: Participation in the 1605b program has no impact on a firm's carbon intensity.

[21] We use the intensity measure as our environmental performance indicator since the main product of the electric utilities is electricity, which is more or less a homogeneous good.

Section 5 discusses the precise variables we use to test these hypotheses. Before we turn to that discussion, however, we present the econometric models we use for estimation.

4. Econometric Models

We use a random utility model to analyze the factors that lead electric utilities to participate in the 1605b program (Domencich and McFadden, 1975). In the model, a firm, the decision maker, has complete information and makes a rational choice based on the information, i.e., the firm chooses the alternative with the highest utility. Unlike the firm, we, the analysts, have incomplete information and thus need to take uncertainty into account. The sources of uncertainty include unobserved alternative attributes, unobserved individual attributes, and measurement errors. To reflect this uncertainty, we model the firm's utility as a random variable, which has a deterministic part and a stochastic part. Different assumptions about the stochastic part lead to different models. We assume a normal distribution, and use a Probit model. In this model, let *i* denote the firm and *j* denote the choice to participate in the program (*j*=1) or not (*j*=0). Let

D_{it} = 1 if firm *i* makes choice 1 in period *t*

D_{it} = 0 if firm *i* makes choice 0 in period *t*

The firm's utility is

$$V_{ijt} = \mathbf{X_{ijt}\beta} + \varepsilon_{ijt} \qquad (1)$$

We observe

$$y_{it} = 1 \textit{ iff } V_{i1t} > V_{iot}$$

This is equivalent to

$$\mathbf{X_{i1t}\beta} + \varepsilon_{i1t} > \mathbf{X_{i0t}\beta} + \varepsilon_{i0t}$$

or

$$\varepsilon_{i0t} - \varepsilon_{i1t} < \mathbf{(X_{i1t} - X_{i0t})\beta}$$

Then the probability of participation is

$$\begin{aligned} \mathrm{P}_{it} &= Prob\ (y_{it}=1 \mid \mathbf{X_{it}}) \\ &= Prob\ (\varepsilon_{i0t} - \varepsilon_{i1t} < \mathbf{(X_{i1t} - X_{i0t})\beta}) \\ &= F[\mathbf{(X_{i1t} - X_{i0t})\beta}] \end{aligned}$$

where F is cdf of $\varepsilon_{i0t} - \varepsilon_{i1t}$. If ε_{i0t} and ε_{i1t} are normally distributed with mean 0 such that $\varepsilon_{i0t} - \varepsilon_{i1t} \sim N(0, \sigma^2)$, then

$$P_{it} = \Phi(\mathbf{Z_{it}\gamma}) \qquad (2)$$

where Φ is the standard normal cdf and $\mathbf{Z_{it}\gamma = (X_{i1t} - X_{i0t})\beta}$

We assume that firms participate in the 1605b program if the net benefit with participation is greater than the net benefit without participation. Thus, we include the variables that affect the benefit and cost of 1605b participation as regressors in our Probit models.

To estimate the impact of a firm's 1605b participation on our outcome variable of interest, CO_2 emissions intensity (CO_2 emissions per net generation (lbs/MWh)), we make use of a treatment effects model that takes into account selection on unobservables.[22] The analysis has two stages, participation and outcome. Equation (3) and equation (4) are the second-stage outcome equations for the participants and non-participants, respectively. Equation (5) is the first stage probit model.[23]

$$y_{1it} = \alpha_1 + \mathbf{X_{it}\beta} + \mu_{it} \qquad (3)$$

$$y_{0it} = \alpha_0 + \mathbf{X_{it}\beta} + \mu_{it} \qquad (4)$$

$$D_{it}^* = \mathbf{Z_{it}\gamma} + \varepsilon_{it} \qquad (5)$$

$D_{it} = 1$ if $D_{it}^* > 0$ and $D_{it} = 0$ otherwise,

In these specifications, y_{1it} and y_{0it} are CO_2 emissions intensity in the second stage for the 1605b participants and non-participants, respectively. $\mathbf{X_{it}}$ is independent variables that affect CO_2 emissions intensity. D_{it} is a participation dummy and D_{it}^* is a latent variable for participation. $\mathbf{Z_{it}}$ is independent variables that affect firms' participation decision.[24]

[22] We follow Cameron and Trivedi (2005). Both in the first and the second stages, the coefficients of the independent variables are assumed to be the same for the participants and non-participants. They are also exposed to a common unobservable shock. The approach is fully parametric and the model is estimated by maximum likelihood.

[23] The variables in **Z** may overlap with those in **X**, but it is assumed that there exist at least one component of **X** that is a nontrivial determinant of the participation dummy and not a part of **Z**, that is, significantly correlated with the endogenous participation variable, but uncorrelated with the outcome variable, except through the participation dummy.

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We allow for the possibility of correlation between the error terms in the first and the second stage. The nonzero correlation coefficient, ρ, reflects the endogeneity of the participation variable. We assume $\mu_{it} \sim N(0, \sigma)$, $\varepsilon_{it} \sim N(0, 1)$ and $corr(\mu_{it}, \varepsilon_{it}) = \rho$.

Using the participation dummy, the two outcome equations, equation (3) and equation (4), can be written in one equation.

$$
\begin{aligned}
y_{it} &= D_{it}y_{1it} + (1-D_{it})y_{0it} \\
&= D_{it}(\alpha_1 + \mathbf{X_{it}\beta} + \mu_{it}) + (1-D_{it})(\alpha_0 + \mathbf{X_{it}\beta} + \mu_{it}) \\
&= \alpha_0 + \mathbf{X_{it}\beta} + \eta D_{it} + \mu_{it} \qquad (6)
\end{aligned}
$$

where $\eta = \alpha_1 - \alpha_0$.

The coefficient of the participation dummy variable in equation (6), η, represents the effect of participation on outcome upon random selection.

The expected difference in outcome conditional on participation, that is, the expected difference in CO_2 emissions intensity between the 1605b participants and non-participants, needs to take into account the selection effect. This requires estimating the expected value of μ_{it} conditional on participation, i.e., $E(\mu_{it} \mid \varepsilon_{it} > -\mathbf{Z_{it}\gamma})$ and $E(\mu_{it} \mid \varepsilon_{it} \leq -\mathbf{Z_{it}\gamma})$. To estimate this, we assume that μ_{it} and ε_{it} has a joint normal distribution. Under this assumption, the expected values of μ_{it} for the participants and non-participants are represented by:

$$E(\mu_{it} \mid \varepsilon_{it} > -\mathbf{Z_{it}\gamma}) = f(\mathbf{Z_{it}}\hat{\gamma})/F(\mathbf{Z_{it}}\hat{\gamma}) \qquad \text{if } D_i=1 \qquad (7)$$

$$E(\mu_{it} \mid \varepsilon_{it} \leq -\mathbf{Z_{it}\gamma}) = -f(\mathbf{Z_{it}}\hat{\gamma})/[1-F(\mathbf{Z_{it}}\hat{\gamma})] \qquad \text{if } D_i=0 \qquad (8)$$

where f is the standard normal pdf and F is the standard normal cdf. The expected difference in outcome conditional on participation can then be calculated as follows.

$$
\begin{aligned}
&E(y_{it} \mid D_{it}=1) - E(y_{it} \mid D_{it}=0) \\
&= \{\alpha_1 + \mathbf{X_{it}\beta} + E(\mu_{it} \mid \varepsilon_{it} > -\mathbf{Z_{it}\gamma})\} - \{\alpha_0 + \mathbf{X_{it}\beta} + E(\mu_{it} \mid \varepsilon_{it} \leq -\mathbf{Z_{it}\gamma})\} \\
&= \eta + E(\mu_{it} \mid \varepsilon_{it} > -\mathbf{Z_{it}\gamma}) - E(\mu_{it} \mid \varepsilon_{it} \leq -\mathbf{Z_{it}\gamma}) \qquad (9)
\end{aligned}
$$

Thus, the unconditional and conditional expected differences in CO_2 emissions intensity between the 1605b participants and non-participants can be estimated using equations (6) and (9), respectively. If ρ, the correlation coefficient between μ_{it} and ε_{it}, is significantly different from zero, estimating the conditional expected difference between the 1605b participants and non-participants can provide additional insight into the impact of the 1605b program.

5. Data

The models are estimated using a pooled database of 83 investor-owned electric utilities (IOUs) over the period 1996-2003.[25] The total number of observations in the sample is 596, and thus a firm is in the sample on average for 7 years. The 1605b participation data were collected from the DOE's Voluntary Registry website.[26] Financial, operational and environmental performance-related data were obtained from Platts, a company specializing in energy industry data.[27] Table I provides a list of explanatory variables used in this paper and their definitions. Some of the variables are lagged by one year to avoid endogeneity concerns.

Hypothesis 1 in section 3 proposes that firms are more likely to participate in the 1605b program if they are larger, have higher greenhouse gas emissions, or face greater external pressure. We measure firm size using electric operating revenues. Greenhouse gas emissions are calculated based on fuel consumption. We take this approach rather than using direct observations from the continuous emissions monitoring system (CEMS) for several reasons. First, the Natural Resources Defense Council (NRDC) reported that turbulent flow in the emissions stack could bias the CEMS estimates upward by 10-30 percent.[28] Second, NRDC also found cases where the CEMS data deviate from the EIA and FERC estimates when the latter two agreed for the most part. In these cases of discrepancies, NRDC used the FERC-based estimates. Third, we were able to obtain a more complete dataset using the fuel consumption data than would have been possible using the CEMS data alone. In cases where fuel consumption data were not available, we

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[25] The reason for pooling is discussed later in the section.
[26] http://www.eia.doe.gov/oiaf/1605/frntvrgg.html
[27] Collecting financial and operational data for electric operating companies has become more difficult since the mid-1990s when the Energy Information Administration (EIA), the statistical agency of DOE, stopped organizing in a convenient format the raw data that electric operating companies report to FERC. More recently EPA has made publicly available an integrated database, eGRID, which provides emissions and generation data, but it has a number of drawbacks. First, there is a considerable time lag involved; for example, the database now available only covers the period from 1996 to 2000. Second, eGRID provides no financial information.
[28] www.nrdc.org/air/energy/rbr/append.asp.

supplemented our fuel consumption-based estimates with adjusted CEMS estimates to increase the number of observations.[29] We also conducted estimations using CO_2 emissions intensity as our measure of greenhouse gas emissions, which we compute by taking CO_2 emissions divided by net generation in megawatt-hours (MWh).

We include a number of variables to proxy for external pressures faced by firms in our sample. These include the number of subscribers to *Sierra* magazine in a given state. This variable proxies for the strength of environmental groups in the state, and has been found significant in previous empirical work by Maxwell, Lyon and Hackett (2000). Following these authors, we also include an interaction term between Sierra subscriptions and lagged SO_2 emissions, since NGOs may target their pressure toward the dirtiest firms. In addition, we include League of Conservation Voters ratings for the U.S. House and Senate delegations in each state, along with a measure of the stringency of Renewable Portfolio Standards (RPS) in each state that has passed one. We also include a measure of how many other firms in the industry participated in the 1605b program in the previous year, to allow for the possibility that external pressure to participate grew as participation became more common.

We include several variables designed to capture the presence of low-cost opportunities for emissions reductions. These include heatrate (the ratio of heat input to electricity generated), which is a direct measure of combustion inefficiency; capacity factor (ratio of energy generated to capacity), a measure of how well capacity is used; and lagged fuel switch saving (a measure of how much money a firm could save by switching from oil to natural gas). In addition, we include growth in generation over the previous three years, on the view that generation growth allows firms to add new generating units with the latest and cleanest technologies.

Finally, in assessing whether 1605b participation affected carbon intensity, we include a measure of the fraction of a firm's power that is derived from carbon-free hydroelectric and nuclear sources, a variable we expect to have strong explanatory power.

[Table I about here]

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[29] Although we ultimately chose not to use the CEMS data as our primary data source, we did run our estimations using this data as a robustness check. Results were qualitatively similar to what we obtained from the fuel consumption data.

To investigate firms' participation decisions in the 1605b program and their effect on CO_2 emissions intensity, we pool our dataset across years. There are two reasons for this. First, the 1605b program does not require that the IOUs make any short- or long-term commitment. This implies that every year they can opt out or opt in, providing theoretical support for pooling. Second, Hausman test results demonstrate that we cannot reject the null hypothesis that the firm-specific effects are uncorrelated with the independent variables. In other words, we do not find evidence that fixed effects are present.[30] This finding further supports pooled analyses (Cameron and Trivedi, 2005). We use panel-corrected standard errors and t-statistics for statistical inference.[31]

Table II provides summary statistics for the explanatory variables used in our analysis, both in the aggregate and by participation category. Out of 596 firm-year observations, 52% have a participation dummy which equals 1. Thus, approximately 44 out of 83 firms participated in the program. On average, 1605b participation is associated with larger and dirtier firms, as represented by higher revenue and higher lagged CO_2 and SO_2 emissions, respectively. Participants also have higher CO_2 emissions intensity. In addition, 1605b participation is associated with greater external pressure, as measured by larger numbers of Sierra magazine subscriptions and higher LCV scores for the House and Senate. The interaction term between lagged SO_2 emissions and Sierra magazine subscription, and the RPS index, however, are higher for the non-participants.

The 1605b participants appear to have more low-cost abatement opportunities, as proxied by lower capacity factor (higher excess capacity), and higher savings possibilities from switching to natural gas. Participation in 1605b is also associated with a higher fraction of hydroelectric and nuclear power in overall firm generation, perhaps reflecting opportunities to reduce emissions by improving nuclear available rates. Three-year

[30] We note two qualifications in this statement. First, only three firms in our sample show variation in participation status during 1996-2003. Accordingly, fixed effect estimates are based only on these three firms, whereas random effect estimates are based on our full sample. Second, due to convergence problems, we could conduct the Hausman test using a model with at most three independent variables deemed most important in making participation decisions (lagged CO_2 emissions, electric operating revenue, and Sierra magazine subscription). We obtain $\chi^2(2)=2.12$ and p-value of 0.346.

[31] We assume observations are independent across firms but not necessarily independent within firms, so use clustered standard errors. For details see Wooldridge (2002).

lagged growth rates are higher for participants, although one-year and two-year growth rates are lower.

[Table II about here]

Table III presents the correlations between each of the variables. Most correlations are relatively low. However, not surprisingly, there are significant correlations between operating revenues, CO_2 emissions and SO_2 emissions; between House and Senate LCV scores; and, negatively, between heatrate and fraction hydroelectric and nuclear capacity.

[Table III about here]

6. Results

In this section, we report our empirical results. We begin with estimates of the factors driving participation in the 1605b program, which test our Hypotheses 1 and 2, and then turn to treatment effects estimates of the effect of participation on carbon emissions intensity, which test our Hypotheses 3 and 4. Following that, we explore whether our basic estimates are robust to the inclusion of measures of indirect emissions reduction and sequestration.

Participation

We estimate four alternative probit specifications to analyze what factors motivate firms to participate in the 1605b program. These specifications utilize different measures of greenhouse gas emissions, and also explore the role of the interaction between Sierra membership and SO_2 emissions. The results are presented in Table IV.

[Table IV about here]

The estimated coefficients of the participation probit equation provide support for portions of our Hypotheses 1 and 2. To begin with, we find strong support for Hypotheses 1a and 1b, namely that larger firms and firms with larger CO_2 emissions are more likely to participate. The coefficient on electric operating revenue is consistently positive and significant in all four specifications. Higher CO_2 emissions, whether measured as total tons of lagged emissions or lagged carbon intensity, are also consistently associated with a significantly greater likelihood of participation. In Model 3, which includes both measures, only CO_2 intensity is statistically significant.

We find little support for Hypothesis 1c, which predicts that firms facing greater external pressure are more likely to participate. League of Conservation Voters scores are never significant in any of the Models, nor is the number of Sierra subscriptions. Model 4 shows that the interaction term between Sierra subscriptions and SO_2 emissions, however, is positive and significant at the 10% level, suggesting that external pressure is not entirely irrelevant. In addition, we find that firms are less likely to participate in states with an RPS, and that participation is less likely the stronger is the RPS. This is consistent with the notion that firms may participate in 1605b in an attempt to preempt a state RPS. Once the RPS is passed, however, preemption is no longer possible, and participation in 1605b flags.

Hypothesis 2 garners moderate support in our estimations, suggesting that opportunities for low-cost abatement played a role in participation decisions. As noted above, large firms are significantly more likely to participate, which may reflect the role of scale economies in making participation cost-effective. Inefficient firms with high heatrates are more likely to participate, although the effect is not statistically significant. Firms with low capacity factors are also more likely to participate, although this effect is only statistically significant in Model 2. Greater opportunities for savings from fuel switching were not a significant determinant of participation. However, Hypothesis 2e receives strong support. Firms with growth in net generation three periods earlier were significantly more likely to participate in 1605b.

Overall, we find strong evidence that large firms with high carbon emissions are more likely to participate in the DOE's Voluntary Greenhouse Gas Regsitry, consistent with prior work on public voluntary programs. In addition, we find strong evidence that firms with growing generation are more likely to participate, and somewhat weaker evidence that firms with low capacity factors are more likely to participate; both of these results are consistent with the notion that firms with low-cost abatement opportunities were pursuing early reduction credits. Finally, there is some evidence that participation is more likely for firms with high SO_2 emissions in states with strong environmental group membership, and in states that had not yet passed RPS legislation; both of these results are consistent with the notion that external pressures played some role in influencing participation decisions.

Treatment Effects

Table V presents the estimation results of three alternative treatment effect models. The exclusion restriction is satisfied via the electric operating revenue variable. It has a significant effect on the participation decision, but not on CO_2 emissions intensity, which is already adjusted for the amount of net generation.[32] The three models differ in terms of which other variables are excluded from the second stage estimation, with Model 2 excluding growth in net generation and Model 3 also excluding lagged fuel switch savings. The first stage specifications of the treatment effect models do not include lagged CO_2 emissions. This is because CO_2 emissions intensity, our dependent variable in the second stage, is calculated by dividing the current CO_2 emissions level by net generation and the current and lagged CO_2 emissions are highly correlated with each other, and hence including the CO_2 emissions variable is likely to create an endogeneity problem.

[Table V about here]

Consistent with our results from the stand-alone probit model, Table V provides support for Hypotheses 1a, 2a, 2c, and 2e; that is, firms are more likely to participate in the 1605b program if they have high revenues, low capacity factors, and growth in lagged net generation. Indeed, the statistical significance of capacity factor is at the 1% level across all three models, higher than in the stand-alone probits.

[32] We tested that the electric operating revenue variable does not affect the 2nd stage outcome variable, CO_2 emissions intensity.

The second-stage estimations of all three Models in Table V also support Hypothesis 3: firms with a higher fraction of power from hydroelectric or nuclear sources, growing demand, and high capacity factors have lower CO_2 emissions intensities. It would be surprising indeed if low-carbon fuel sources such as hydroelectric and nuclear did not reduce emissions intensity; we find the effect is highly significant. Growing demand allows a firm to exploit a broader array of emissions-reducing techniques, and a high capacity factor suggests that a firm has already taken advantage of relatively low-cost abatement opportunities such as expanding effective capacity through improvement in operating efficiency. Both effects reduce firm-level CO_2 emissions intensity.

Finally, we also find support for Hypothesis 4: 1605b participation has a positive but insignificant effect on CO_2 emissions intensity.[33]

<u>Regressions after adjusting for indirect reductions and sequestration</u>

We next explore the role of indirect emissions reductions and sequestration. The CO_2 emissions and emissions intensity variables as used in the participation probit and the treatment effect models are based on fuel consumption data and hence do not reflect the indirect reductions and sequestration reported to the 1605b program. Thus, it is potentially important to investigate the role of indirect reductions and sequestration, which would reduce emissions relative to what would be expected from fuel consumption alone.

We are particularly interested in whether the opportunity to report indirect reductions and sequestration provides firms with added or possibly different incentives to participate in the 1605b program than does reporting direct reductions alone. This question arises because, as described in the Introduction, firms are required to file their operational and financial performance to FERC including their fossil fuel consumption. This fossil fuel consumption data, which is publicly available, implicitly reveals firms'

[33] The correlation coefficient between the first and second stage equations, ρ, is consistently positive across alternative model specifications. This indicates that we would overestimate the impact of the 1605b program, if we do not control for selection on unobservables. Yet, the chi-square test statistic shows that we cannot reject the hypothesis that ρ is not significantly different from zero. This in turn tells us that the degree of overestimation due to selection on unobservables, if any, is insignificant.

CO_2 emissions.[34] Thus, even if a utility does not participate in 1605b, its overall carbon footprint can still be verified. When indirect reductions and sequestration are taken into account, however, firms have an additional incentive to participate in the program, so as to report indirect reductions and sequestration that would not be obvious from FERC data. Examining the role of indirect reductions and sequestration also allows us to examine whether 1605b participation does indeed make a difference in CO_2 emissions intensity if all types of reductions reported to the program, including direct and indirect reductions and sequestration, are taken into account.

We examine the impact of indirect reductions and sequestration by re-running the same participation probit and treatment effect models as before, but with two new variables: adjusted CO_2 emissions and adjusted CO_2 emissions intensity. The adjusted CO_2 emissions variable is created by subtracting the sum of indirect reductions and sequestration as reported to the 1605b program from the fuel consumption-based CO_2 emissions estimates.[35] The adjusted CO_2 emissions intensity variable is obtained by dividing the adjusted CO_2 emissions by net generation.

Tables VI and VII show the regression results for the probit and treatment effect models, respectively. They are virtually identical to those reported in Table IV and Table V in terms of the significance of the coefficients and their signs. This suggests that the opportunity to report indirect and sequestration projects did not provide much in the way of added or different incentives to participate in the program. However, we do find that with the adjusted CO_2 emissions and intensity variables, 1605b participation now has a negative effect on CO_2 emissions intensity in two out of three model specifications; nevertheless, its effect is still not statistically significant.[36]

[Table VI about here]

[Table VII about here]

[34] Fossil fuel consumption broken down by fuel types reveals CO_2 emissions level because there is no commercialized end-of-pipe CO_2 removal technology yet.
[35] Reductions reported to the 1605b program include greenhouse gases other than CO_2. The DOE's Voluntary Registry website reports total reductions in terms of CO_2 equivalents.
[36] We also examined whether 1605b participation had any measurable effect on reductions in CO_2 emissions intensity over the period 1995-2003. We did not find any significant effect of 1605b participation.

7. Recent Revisions to the 1605b Program

The 1605b program has recently been substantially revised. In this section, we offer further insight into the motives of firms participating in the 1605b program, drawing upon the comments filed by various interested parties in the revision process. On April 15, 2002, the Department of Energy (DOE) issued a Notice of Inquiry requesting public comments on the 1605b program, with a goal to "enhance measurement accuracy, reliability and verifiability, working with and taking into account emerging domestic and international approaches."[37] Over one hundred sets of written comments were filed,[38] and six public workshops were held to discuss the program. After soliciting public comments, the DOE on April 21, 2006, published in the Federal Register the final revised General Guidelines governing the Voluntary Reporting of Greenhouse Gases (1605b).[39]

Perhaps the most significant change in the 1605b program is that the revised guidelines place greater emphasis on entity-wide reporting. Large emitters interested in not just "reporting" reductions, but also formally "registering" them must submit entity-wide emission inventories and will be recognized only for net reductions in their entity-wide emissions.[40] To the extent that "registered" reductions are more likely to be granted early reduction credits (ERCs),[41] this change in reporting rules discourages companies from the selective reporting of good news.

Electric utility companies fought hard against requiring entity-wide inventories for registering reductions. The Edison Electric Institute (EEI), the trade association of investor-owned electric utility companies, argued that firms have many motives for

[37] U.S. Department of Energy, "Voluntary Reporting of Greenhouse Gas Emissions, Reductions, and Carbon Sequestration," Federal Register: May 6, 2002 (Volume 67, Number 87), pp. 30370-30373.
[38] The comments can be found at http://www.pi.energy.gov/enhancingGHGregistry/commentsspring2002.html.
[39] The revised General Guidelines referenced Technical Guidelines dated March 2006 that were made available on the internet.
[40] DOE, Guidelines for Voluntary Greenhouse Gas Reporting, General Guidelines Finalized 04/21/06.
[41] Free market advocates such as Competitive Enterprise Institute (CEI) oppose the idea of ERCs, arguing that the introduction of ERCs effectively facilitates the adoption of a mandatory Kyoto-style cap-and-trade program. Companies with ERCs will lobby for such a program, since ERCs are valuable only under such circumstances. CEI further states that early action crediting was the centerpiece of a Clinton-Gore strategy to divide and conquer business opponents of the Kyoto Protocol. CEI, Public comments on DOE's notice of inquiry on ways to enhance the existing greenhouse gas registry, spring 2002. http://www.pi.energy.gov/enhancingGHGregistry/commentsspring2002.html

participating, including (p. 7) "the recordation of transferable credit, baseline protection and credit for past actions" and "public relations material and releases and annual reports." The bulk of the EEI comments are oriented towards transferable credits, though, and EEI reluctantly admits that (p. 7) "If the purpose is to obtain transferable credits…the reporting under the revised guidelines may need to be more rigorous in the criteria to be applied…" Even then, however, it maintains that (p. 7) "these criteria should not, and need not, be dependent on entity-wide reporting."

The EEI gives a hypothetical example (pp. 4-5) that crystallizes its views. It posits a predominantly nuclear-fueled utility whose sales grow over a decade from 32.6 terawatthours (TWH) to 35.7 TWH, and whose carbon emissions increase from 12.3 to 13.6 million tons. The utility meets the new demand with natural gas, and undertakes two other "projects": an increase in the heat rate of a coal plant, and a demand-side management program to reduce peak demand; its overall carbon intensity is unchanged. The firm's aggregate GHG emissions have risen by about 10%, however. The EEI complains that "Under an approach where transferable credits could only be earned for absolute reductions in entity-wide emissions, this utility would receive no credits…However, in examining this utility's actions more closely, one sees that it provided real emissions reductions. As a result, it would need to be able to report at a project level in order to receive credit for the two actions that do make such contributions."

The EEI example perfectly mirrors our empirical results. The firm faces increasing demand, and increases its aggregate carbon emissions over time. Nevertheless, it wants to obtain early reduction credits, so it participates in 1605b in order to highlight two individual projects, while electing not to report on the 1.3 million ton increase in its overall GHG emissions.

In opposition to EEI, the Natural Resources Defense Council (NRDC), an environmental NGO, condemned project-level reporting, arguing that it allows companies to "cherry pick" the projects they want to report:

> "Without full and transparent entity-wide emissions accounting, project-based reporting weakens the system and undermines the value of real reductions by providing opportunities for gaming the system and claiming hypothetical reductions while emissions are actually increasing. While companies report their

> entity-wide emissions, there is no reason to continue providing for a separate registry on a project basis, since any legitimate project-based activity is automatically incorporated in company-wide totals and will show up as part of the firm's changes in total emissions from year to year." (NRDC, p.4)[3]

After considering both points of view, DOE voiced a similar rationale for why it finally decided to require entity-wide reporting under the revised guidelines:

> "…Because most large companies and institutions regularly take actions that have as one of their effects the reduction of greenhouse gas emissions, there are always many candidates for project-based emission reductions. But the net effect of such project-based reductions on an entity's total emissions is often questioned, because large entities may be taking actions that reduce emissions, while simultaneously taking other actions that increase emissions. Furthermore, it is impossible to evaluate the significance of a particular entity's actions to reduce emissions unless the total emissions of that entity are known." (DOE, p.19)[42]

In the end, the utilities lost in their bid to retain the extraordinary flexibility of the original reporting system. The resolution to this heated debate---entity-wide reporting for registering reductions---makes it much more difficult for 1605b participants to obtain early reduction credits while increasing their overall GHG emissions.

8. Conclusions

We have presented what is to our knowledge the first empirical analysis of the factors that lead electric utilities to participate in the Department of Energy's Voluntary Greenhouse Gas Registry, and the impact of participation on their actual emissions performance. We are able to provide an unusually sharp comparison of firms' environmental disclosures with their actual environmental performance, because utilities are regulated and must file detailed fuel-use data with the Federal Energy Regulatory Commission.

We find that in the aggregate, participants in the Voluntary Registry increase emissions over time but report reductions, while non-participants decrease emissions over time. At the firm level, participants tend to have high carbon dioxide emissions, and high carbon intensity. Thus, our results demonstrate a negative relationship between

[42] DOE, Guidelines for Voluntary Greenhouse Gas Reporting, General Guidelines Finalized 04/21/06.

environmental performance and environmental disclosures. Furthermore, we find that participating in the program had no measurable effect on a firm's carbon intensity.

Our results clearly demonstrate that participants in the 1605b program engaged in selective disclosure of positive environmental results. However, we find little evidence that political or public relations factors played important roles in firms' disclosure behavior; in particular, neither House nor Senate attitudes on environmental issues have measurable effects on participation, nor does a higher number of environmental group members in a given state. Instead, our results suggest the primary driver for participation in the program is the possibility of obtaining early reduction credits. Indeed, the public comments of the utility trade association make it clear that companies are keenly interested in obtaining tradable credits in the event the U.S. adopts an emissions trading program for greenhouse gases.

Is it appropriate to label participation in the 1605b program a form of greenwash? The selective disclosure we document here comports with the notion of greenwash put forward by Lyon and Maxwell (2008): "selective disclosure of positive information about a company's environmental or social performance, without full disclosure of negative information on these dimensions, so as to create an overly positive corporate image." The only point which one might argue is whether 1605b disclosures create an "overly positive corporate image." When asked about the views of a critic of the 1605b program, Pat Hemlepp, director of corporate media relations at American Electric Power, retorted: "The funny thing is, he makes this seem like this is something companies are pointing to. The only time I've ever mentioned this is when I'm talking about this to a reporter who is asking about it."[43] Hemlepp's perspective seems to be that selective disclosure only counts as greenwash when used as a public relations tool. We view this as an interesting position, and hope that our results will both stimulate further discussion of what constitutes greenwash, and spur further empirical research into the phenomenon.

[43] Quoted in T. Weiss (2007).

APPENDIX

In this appendix we present three case studies (American Electric Power, Southern Company, and Exelon Corporation) on projects reported to the 1605b program.

American Electric Power

American Electric Power (AEP) participates at the project level and reported a total of 100 projects in 2003. 15 of them are about electricity generation, transmission, and distribution, 4 about energy end use, and 77 about carbon sequestration. AEP also reported 1 halogenated substance and 4 other emission reduction projects.

More than half of the electricity generation, transmission and distribution projects relate to non-fossil fuel units, such as increases in solar and wind power capacity and availability, and efficiency improvement at nuclear and hydro units. For example, the nuclear projects improve availability by decreasing the length of refueling outages and reducing forced outage rates by enabling certain maintenance activities, which used to be performed only during outages, to be performed with the unit online. The hydro projects improve efficiency and extend the life of aging equipment through facility improvement. A few projects report activities related to coal-fired units: improving heatrate via non-routine activities such as operational changes, equipment replacement and load optimization, and adding gas capability to previously coal-fired units.

The energy end use projects encourage efficient energy use by providing incentives for homeowners, commercial and industrial customers to adopt more efficient equipment and to use lighting more efficiently. Of AEP's projects, 77% involve carbon sequestration, most of which is accomplished by afforestation and reforestation through tree planting. The halogenated substance project involves sulfur hexafluoride (SF_6) gas reduction. SF_6 is a GHG that has about 22,000 times higher global warming potential per unit than carbon dioxide (CO_2), the most abundant GHG (EIA, 2004). AEP achieved SF_6 reduction by replacing high-volume leaky circuit breakers with low-volume ones. Other emission reduction projects are fly ash utilization and Enviro Tech Investment funds. The fly ash program recycles fly ash (a coal combustion byproduct) as a substitute for

Portland cement in concrete production. This eliminates the need to dispose of the fly ash and at the same time reduces CO_2 emissions from manufacturing Portland cement. Enviro Tech Investment funds refer to funds that are exclusively used for investment in companies, both US and foreign, that perform R&D on products that reduce energy consumption.

Southern Company

Southern Company (SO) participates both at the entity and the project level, although the sum of the project level reductions is the same as the entity level reduction. In 2003 SO reported a total of 35 projects. Fifteen involve electricity generation, transmission, and distribution, 3 involve cogeneration and waste heat recovery, 1 affects energy end use, 2 are about transportation and off-road vehicles, and 12 about sequestration. SO also reported halogenated substance and “other” emissions reduction projects.

About half of the electricity generation, transmission and distribution projects are similar to those reported by AEP, but SO also reported seven “other” projects. They include nuclear capacity uprating, natural gas-based combustion turbine and combined cycle units, biomass and switchgrass projects. Nuclear capacity uprating refers to increasing the maximum power level at which nuclear power units operate, which requires NRC approval. Nuclear capacity uprating is equivalent to increasing low carbon emitting capacity. The increases in natural gas fired units (new combustion turbine and combined cycle units) represent CO_2 reductions compared to coal-fired generation. SO was also investigating the feasibility and profitability of co-firing biomass and switchgrass with coal. Two of its subsidiaries, Georgia Power and Mississippi Power, have co-fired biomass with coal. Cofiring with switchgrass is still at an experimental stage.

The cogeneration and waste heat recovery projects report the use of natural gas at cogeneration plants, that is, plants that produce both electricity and steam. CO_2 reduction is achieved in two ways. One is by using a low emitting fuel source, natural gas, instead of coal. The other is by utilizing heat that would otherwise have been discarded. Had the same amount of heat been generated separately, CO_2 emissions would have been greater no matter what fuel sources were used. The energy end-use project promotes energy efficiency in residential, commercial and industrial sectors. The transportation and off-road vehicles projects report how SO supports the operation of alternative fuel vehicles, and promotes carpooling and mass transit use for its employees. The projects on carbon sequestration, halogenated substances and other emissions reduction are similar to those reported by AEP.

Exelon Corporation

Exelon Corporation (EXC) participates at the project level and reported a total of 42 projects in 2003. Twenty six involve electricity generation, transmission, and distribution, 1 involve cogeneration and waste heat recovery, 4 affects energy end use, 2 are about transportation and off-road vehicles, 3 about waste treatment and disposal, 1 about oil and natural gas systems and coal mining, and 4 about carbon sequestration. EXC also reported one "other" emission reduction project.

All of the electricity generation, transmission and distribution projects are about non-fossil fuel units. Eleven projects reported nuclear uprating, 9 reported wind and solar energy-related efforts, 5 reported hydro facility overhauls, and 1 reported improvement in distribution efficiency. Wind and solar energy related projects cover a wide range of applications from installing new facilities to raising public awareness of alternative energy resources and renewable energy markets. EXC overhauled seven hydro units to improve unit efficiency and overall plant capacity.

The cogeneration and waste heat recovery project reported fuel switching from coal to natural gas and installing heat exchange equipment. In addition to typical efficiency improvement projects, the energy end-use projects include a load control program which provides incentives for large commercial and industrial customers to cut electric loads upon request during peak periods. Transportation and off-road vehicle projects report how widely EXC invests in alternative fuel vehicles and uses them in its facilities. The waste treatment and disposal projects are about using landfill gas to generate energy; this reduces emissions of methane, which has 23 times higher global warming potential than CO_2 (EIA, 2004). The project on oil and natural gas systems and coal mining reports improvement of the natural gas distribution system. Carbon sequestration was mostly done by tree planting but also by recycling some wood utility poles. Each pole reused represents a tree that was not cut down to manufacture a new utility pole. The "other" emission reduction project reported recycling of materials including paper and metals, which can reduce GHG emissions by displacing the production of these products from alternative sources, which may require more energy intensive production processes.

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Table I. Explanatory variables and their definitions

Variables (proxy for)	Definition (unit of measurement)
Lagged CO_2 emissions	Lagged (t-1) total carbon dioxide (CO_2) emissions (10^9 lbs) This is calculated based on fuel consumption data. First, total carbon input is calculated using carbon coefficients 25.97 for Coal, 14.47 for Natural Gas, 17.51 for Refinery Gas, 19.95 for Distillate fuel (Oil-L), 21.49 for Residual fuel (Oil-H) and 27.85 for Petroleum Coke (The units for carbon coefficients are Million Metric Tons per Quadrillion Btu).* These estimates are then converted to CO_2 emissions by multiplying by 3.7, the molecular weight of CO_2 relative to carbon,,. When carbon input data is missing but Platts' emission data are non-missing, Platts' emission data are used instead.**
CO_2 emissions intensity	CO_2 emissions per net generation (lbs/MWh). Net generation (MWh) is defined as the amount of gross generation less the electrical energy consumed at generating stations.
Sierra magazine subscription	Number of subscriptions to Sierra magazines at the state level in 2000 (thousands).
Electric operating revenue	Revenue from sales of electricity (10^9 \$).
Heatrate	The ratio of heat input to net energy generated (Btu/kWh).
Capacity factor	The ratio of energy generated to the maximum that could have been generated. It is calculated by dividing net generation (MWh) by (nameplate capacity (MW)×8760(hours)).
Fraction of hydro and nuclear	The ratio of energy generated from hydro and nuclear units to total energy generated.
LCV scores	The League of Conservation Voters (LCV)'s scorecards for U.S. Senate and House.
RPS index	State Renewable Portfolio Standard index. It is calculated by dividing % goal by the difference between the goal year and the enacted or effective year, whichever comes first.***
Lagged fuel switch saving	Lagged (t-1) low cost and low carbon fuel switching opportunity (10^6 \$). Estimated for the month with the highest generation for the year, this is calculated by ordering generators from lowest to highest cost, and multiplying the amount of oil-based generation times the difference in fuel costs between oil and natural gas if oil-based and natural gas-based generation are adjacent in the dispatch order and the cost of natural gas is lower.
Lagged SO_2 emissions	Lagged (t-1) sulfur dioxide (SO_2) emissions (10^9 lbs).
Lagged 1605b participation trend	Lagged (t-1) total number of 1605b participants in the electric power sector****
Growth in generation (t-1, t-2, and t-3)	Percentage growth relative to years t-1, t-2, and t-3.
Interaction between lagged SO_2 emissions and Sierra Subscription	This is obtained by multiplying the values for lagged SO_2 emissions (10^9 lbs) and Sierra Subscription (thousands).

* *Documentation for Emissions of Greenhouse Gases in the U.S. 2003*, EIA (2005), p. 189.

** An adjustment factor is calculated to convert Platts' CO_2 emissions data to fuel-based CO_2 estimates. The fuel-based estimates are regressed on Platts' reported emissions data and the inverse of the coefficient, 0.7527, is used as an adjustment factor. This aligns well with NRDC's report that continuous emissions monitoring data could be biased upward by 10-30 percent relative to fuel-based estimates. www.nrdc.org/air/energy/rbr/append.asp.

*** State Renewable Portfolio Standards data are obtained from www.dsireusa.org.

**** *Voluntary reporting of Greenhouse Gases 2003*, EIA (2005), p. 4.

Table II. Descriptive statistics for explanatory variables

Variable (unit)	Entire sample N=596	1605b Participants N=309	1605b Non-Participants N=287
Lagged CO_2 emissions (10^9 lbs)			
Mean	17.751	24.966	9.984
Standard Deviation	16.817	19.096	8.883
Min	0.006	0.130	0.006
Max	109.224	109.224	30.203
CO_2 emissions intensity (lbs/MWh)			
Mean	1172.405	1246.034	1093.133
Standard Deviation	690.168	740.465	623.171
Min	0.351	7.201	0.351
Max	4659.061	4659.061	3590.840
Sierra magazine subscription (thousands)			
Mean	4.598	5.364	3.774
Standard Deviation	2.504	2.663	2.023
Min	0.404	1.007	0.404
Max	10.767	10.767	10.767
Electric operating revenue (10^9 \$)			
Mean	1.431	2.158	0.649
Standard Deviation	1.596	1.874	0.576
Min	0.011	0.226	0.011
Max	8.906	8.906	3.626
Heatrate (Btu/kWh)			
Mean	9899.740	9900.724	9898.682
Standard Deviation	1801.146	1332.374	2199.402
Min	0	1103.420	0
Max	14379.810	11859.420	14379.810
Capacity Factor			
Mean	0.529	0.514	0.545
Standard Deviation	0.140	0.133	0.145
Min	0.065	0.154	0.065
Max	0.880	0.821	0.880
Fraction of Hydro and Nuclear			
Mean	0.141	0.174	0.105
Standard Deviation	0.273	0.270	0.272
Min	0	0	0
Max	1.392	1.392	1.000
LCV scores: Senate			
Mean	39.242	42.634	35.589
Standard Deviation	31.537	31.056	31.696
Min	0	0	0
Max	100	100	100
LCV scores: House			
Mean	39.773	42.922	36.383
Standard Deviation	19.628	18.148	20.604
Min	0	4	0
Max	100	94	100

RPS index			
Mean	0.085	0.082	0.088
Standard Deviation	0.270	0.268	0.271
Min	0	0	0
Max	1.833	1.833	1.429
Lagged fuel Switch Saving (10^6 $)			
Mean	0.020	0.028	0.010
Standard Deviation	0.088	0.099	0.073
Min	0	0	0
Max	1.205	0.815	1.205
Lagged SO_2 emissions (10^9 lbs)			
Mean	0.137	0.195	0.075
Standard Deviation	0.178	0.221	0.078
Min	0	0	0
Max	1.148	1.148	0.466
Lagged 1605b participation trend			
Mean	106.292	106.220	106.369
Standard Deviation	5.226	5.192	5.271
Min	99	99	99
Max	115	115	115
Growth in net generation (t-1)			
Mean	0.023	0.007	0.040
Standard Deviation	0.206	0.157	0.248
Min	-0.933	-0.933	-0.317
Max	3.207	1.067	3.207
Growth in net generation (t-2)			
Mean	0.053	0.027	0.082
Standard Deviation	0.289	0.205	0.357
Min	-0.930	-0.930	-0.412
Max	3.628	1.233	3.628
Growth in net generation (t-3)			
Mean	0.528	0.887	0.141
Standard Deviation	10.653	14.789	0.513
Min	-0.917	-0.917	-0.452
Max	259.973	259.973	4.423
Interaction between lagged SO_2 Emissions and Sierra subscription ((10^9 lbs)× (thousands))			
Mean	0.733	1.137	0.298
Standard Deviation	1.121	1.393	0.396
Min	0	0	0
Max	7.954	7.954	1.809

Table III. Variable Correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1)																
(2)	0.153															
(3)	0.131	-0.0944														
(4)	0.5034	-0.1936	0.4209													
(5)	0.1543	0.2869	-0.167	-0.1288												
(6)	0.0594	-0.2104	0.0921	-0.0068	0.0644											
(7)	-0.1291	-0.3506	0.1296	0.3588	-0.679	-0.1841										
(8)	-0.1508	-0.0582	0.3098	0.139	-0.1211	-0.096	0.1799									
(9)	-0.1079	-0.0351	0.4395	0.1409	-0.2019	-0.0486	0.1593	0.6624								
(10)	-0.0607	-0.0079	0.2142	0.1517	-0.0024	-0.0244	0.0379	0.0685	0.1208							
(11)	0.0953	-0.0123	0.0949	0.1545	-0.0201	-0.0325	0.0521	0.0604	0.0405	0.1284						
(12)	0.7395	-0.0218	0.2313	0.3656	0.0524	0.1656	-0.1183	-0.1208	-0.0678	-0.1442	0.058					
(13)	-0.0776	-0.0465	0.0019	-0.0503	0.0056	-0.013	-0.0047	0.0648	0.0401	-0.2183	-0.0627	0.0124				
(14)	-0.0524	-0.0997	-0.1027	-0.1031	-0.0171	0.0945	0.0105	-0.0535	-0.06	-0.0568	0.0031	0.0123	0.0506			
(15)	-0.0681	-0.1002	-0.1461	-0.1368	-0.0458	0.0488	0.0598	-0.0474	-0.0286	-0.0793	-0.0184	0.0039	0.0954	0.5757		
(16)	0.0005	0.0127	-0.0306	-0.0224	0.012	-0.0651	-0.0181	-0.0491	-0.0255	-0.0164	-0.0095	0.0139	-0.0292	-0.0126	0.0357	
(17)	0.658	-0.0183	0.4246	0.3636	0.026	0.1794	-0.0965	-0.0419	0.0268	-0.0877	0.0216	0.9402	0.015	-0.0044	-0.0162	0.6045

(1) Lagged CO_2 emissions (2) CO_2 emissions intensity (3) Sierra magazine subscription (4) Electric operating revenue (5) Heatrate (6) Capacity factor (7) Fraction of Hydro and Nuclear (8) LCV scores: Senate (9) LCV scores: House (10) RPS index (11) Lagged fuel switch saving (12) Lagged SO_2 emissions (13) Lagged 1605b participation trend (14) Growth in net generation (t-1) (15) Growth in net generation (t-2) (16)) Growth in net generation (t-3) (17) Interaction between lagged SO_2 emissions and Sierra subscription

Table IV
1605b Participation Probit

Variable	Model 1	Model 2	Model 3	Model 4
Lag CO_2 Emissions	4.013e-02* (2.226e-02)		2.61e-02 (2.368e-02)	
Lag CO_2 Emissions Intensity		4.702e-04** (1.827e-04)	3.741e-04** (1.872e-04)	
Sierra Subscription	0.133 (8.764e-02)	0.130 (8.626e-02)	0.137 (8.898e-02)	-2.64e-02 (0.112)
Electric Operating Revenue	0.631* (0.358)	0.982*** (0.328)	0.771* (0.396)	0.945*** (0.323)
Heatrate	1.05e-04 (1.269e-04)	1.21e-04 (1.317e-04)	1.09e-04 (1.314e-04)	1.30e-04 (1.260e-04)
Capacity factor	-1.880 (1.170)	-1.36 (1.076)	-1.39 (1.102)	-2.055* (1.141)
Fraction of hydro & nuclear	0.439 (0.933)	0.608 (0.986)	0.682 (0.972)	0.312 (0.929)
LCV score: Senate	3.17e-03 (5.257e-03)	3.15e-03 (5.157e-03)	3.49e-03 (5.204e-03)	7.64e-04 (5.383e-03)
LCV score: House	8.59e-03 (9.240e-03)	4.59e-03 (9.048e-03)	6.59e-03 (9.287e-03)	8.80e-03 (8.442e-03)
RPS index	-0.799 (0.493)	-0.822* (0.498)	-0.822* (0.485)	-0.860 (0.531)
Lag Fuel Switch Saving	-7.40e-03 (0.933)	0.344 (1.016)	7.92e-02 (0.960)	1.290 (1.084)
Lag SO_2 Emissions	-6.14e-02 (1.371)	1.40 (1.616)	0.440 (1.445)	-5.390 (4.153)
Lag 1605b reporting Trend	2.81e-03 (8.383e-03)	8.68e-04 (7.795e-03)	3.52e-03 (8.304e-03)	-5.40e-04 (7.293e-03)
Growth in net generation (t-1)	-6.44e-02 (0.184)	-0.122 (0.211)	-9.12e-02 (0.223)	-0.149 (0.168)
Growth in net generation (t-2)	-8.96e-02 (0.192)	-5.48e-02 (0.174)	-6.36e-02 (0.177)	-0.135 (0.186)
Growth in net generation (t-3)	1.008e-02*** (2.453e-03)	1.022e-02*** (2.376e-03)	1.027e-02*** (2.354e-03)	1.048e-02** (2.503e-03)
Interaction between Lag SO_2 Emissions and Sierra subscription				1.438* (0.841)
Constant	-2.66 (1.630)	-3.227* (1.773)	-3.454* (1.773)	-1.58 (1.609)
Observations	596	596	596	596
Count R^2	0.800	0.817	0.807	0.797
Adjusted Count R^2	0.585	0.620	0.599	0.578
Log Likelihood	-261.856	-258.799	-255.979	-261.003
χ^2[15]	77.24 {0}	78.91 {0}	80.10 {0}	73.67 {0}

Table V
Treatment Effect Models

Variable	Model 1: 2nd stage: CO_2 Intensity	Model 1: 1st stage: 1605b Participation	Model 2: 2nd stage: CO_2 Intensity	Model 2: 1st stage: 1605b Participation	Model 3: 2nd stage: CO_2 Intensity	Model 3: 1st stage: 1605b Participation
Sierra Subscription	-9.618	0.121	-6.943	0.122	-7.248	0.121
	(33.72)	(0.082)	(33.03)	(0.083)	(32.87)	(0.082)
Heatrate	0.024	1.274e-04	0.023	1.271e-04	0.025	1.280e-04
	(0.032)	(1.284e-04)	(0.031)	(1.284e-04)	(0.031)	(1.286e-04)
Capacity factor	-1.320e+03***	-1.918*	-1.344e+03***	-1.936*	-1.375e+03***	-1.933*
	(4.455e+02)	(1.102)	(4.301e+02)	(1.101)	(4.255e+02)	(1.097)
Fraction of hydro & nuclear	-9.011e+02***	0.178	-9.230e+02***	0.170	-9.002e+02***	0.177
	(2.320e+02)	(0.942)	(2.206e+02)	(0.945)	(2.153e+02)	(0.944)
LCV score: Senate	-1.162	2.486e-03	-1.089	2.504e-03	-1.037	2.549e-03
	(1.773)	(5.216e-03)	(1.776)	(5.225e-03)	(1.778)	(5.204e-03)
LCV score: House	2.227	5.497e-03	2.058	5.495e-03	2.232	5.437e-03
	(4.125)	(8.757e-03)	(3.958)	(8.753e-03)	(3.833)	(8.753e-03)
RPS index	-17.440	-0.802	-7.655	-0.800	0.630	-0.791
	(1.768e+02)	(0.501)	(1.771e+02)	(0.501)	(1.727e+02)	(0.499)
Lag Fuel Switch Saving	19.340	0.349	6.458	0.351		0.333
	(1.845e+02)	(0.963)	(1.811e+02)	(0.972)		(0.978)
Growth in net generation (t-1)	-1.627e+02	-0.182		-0.111		-0.116
	(1.368e+02)	(0.199)		(0.198)		(0.205)
Growth in net Generation (t-2)	-93.19	-0.095		-0.058		-0.053
	(1.244e+02)	(0.186)		(0.170)		(0.169)
Growth in net generation (t-3)	-0.877*	9.503e-03***		9.902e-03***		9.834e-03***
	(0.504)	(2.357e-03)		(2.322e-03)		(2.299e-03)
Lag SO_2 Emissions	-89.60	1.313	-119.90	1.312		1.343
	(2.370e+02)	(1.559)	(2.226e+02)	(1.568)		(1.556)
1605b Participation	24.62		46.05		6.319	
	(1.765e+02)		(1.725e+02)		(1.600e+02)	
Electric Operating Revenue		0.947***		0.949***		0.944***
		(0.316)		(0.317)		(0.317)
Lag 1605b reporting Trend		6.813e-04		5.433e-04		7.950e-04
		(7.600e-03)		(7.560e-03)		(7.413e-03)
Constant	1.774e+03***	-2.283	1.772e+03***	-2.267	1.758e+03***	-2.302
	(4.217e+02)	(1.649)	(4.068e+02)	(1.646)	(4.069e+02)	(1.644)
Observations	596	596	596	596	596	596
Log likelihood	-4929.054		-4931.330		-4931.541	
$\chi^2[13]$	203.410 {0}					
$\chi^2[10]$			63.060 {0}			
$\chi^2[8]$					60.670 {0}	
Ρ	0.256		0.238		0.272	
	(0.130)		(0.132)		(0.143)	
$\chi^2[1]$, ρ=0	3.52 {0.06}		3.02 {0.08}		3.27 {0.07}	

Robust standard errors are in parenthesis. Degrees of freedom are in square brackets. P values are in curly brackets. χ^2 is a chi-square test of the assumption that all coefficients are jointly equal to zero. ρ is the correlation coefficient between the error terms of the first-stage participation and the second-stage outcome equations. $\chi^2[1]$, ρ=0 tests the independence of the two equations.

* Significant at 10%; ** Significant at 5%; *** Significant at 1% (all two-tailed tests).

Table VI

1605b Participation Probit after Adjusting for Indirect Reduction and Sequestration

Variable	Model 1	Model 2	Model 3	Model 4
Adjusted Lag CO_2 Emissions	3.810e-02* (2.231e-02)		2.48e-02 (2.367e-02)	
Adjusted Lag CO_2 Intensity		4.406e-04** (1.813e-04)	3.483e-04* (1.865e-04)	
Sierra Subscription	0.133 (8.729e-02)	0.130 (8.598e-02)	0.137 (8.846e-02)	-2.64e-02 (0.112)
Electric Operating Revenue	0.652* (0.358)	0.984*** (0.329)	0.787** (0.395)	0.945*** (0.323)
Heatrate	1.01e-04 (1.264e-04)	1.17e-04 (1.307e-04)	1.03e-04 (1.304e-04)	1.30e-04 (1.260e-04)
Capacity factor	-1.89 (1.166)	-1.41 (1.076)	-1.44 (1.101)	-2.055* (1.141)
Fraction of hydro & nuclear	0.386 (0.928)	0.550 (0.980)	0.597 (0.963)	0.312 (0.929)
LCV score: Senate	3.09e-03 (5.258e-03)	3.04e-03 (5.166e-03)	3.35e-03 (5.208e-03)	7.64e-04 (5.383e-03)
LCV score: House	8.47e-03 (9.219e-03)	4.79e-03 (9.034e-03)	6.69e-03 (9.264e-03)	8.80e-03 (8.442e-03)
RPS index	-0.805 (0.491)	-0.829* (0.498)	-0.831* (0.485)	-0.860 (0.531)
Lag Fuel Switch Saving	1.19e-02 (0.940)	0.342 (1.017)	8.97e-02 (0.964)	1.29 (1.084)
Lag SO_2 Emissions	2.22e-03 (1.380)	1.37 (1.609)	0.460 (1.444)	-5.39 (4.153)
Lag 1605b reporting Trend	2.41e-03 (8.291e-03)	6.40e-04 (7.744e-03)	3.04e-03 (8.203e-03)	-5.40e-04 (7.293e-03)
Growth in net generation (t-1)	-5.96e-02 (0.178)	-0.119 (0.206)	-8.37e-02 (0.214)	-0.149 (0.168)
Growth in net generation (t-2)	-8.78e-02 (0.191)	-5.90e-02 (0.174)	-6.60e-02 (0.177)	-0.135 (0.186)
Growth in net generation (t-3)	1.010e-02*** (2.460e-03)	1.020e-02*** (2.379e-03)	1.025e-02*** (2.358e-03)	1.048e-02*** (2.503e-03)
Interaction between Lag SO_2 Emissions and Sierra subscription				1.438* (0.841)
Constant	-2.55 (1.611)	-3.089* (1.748)	-3.260* (1.736)	-1.58 (1.609)
Observations	594	594	594	594
Count R^2	0.800	0.813	0.805	0.796
Adjusted Count R^2	0.585	0.613	0.596	0.578
Log Likelihood	-262.641	-260.055	-257.501	-261.003
$\chi^2[15]$	77.56 {0}	78.53 {0}	79.78 {0}	73.67 {0}

Table VII

Treatment Effect Models after Adjusting for Indirect Reductions and Sequestration

Variable	Model 1 2nd stage: Adjusted CO_2 intensity	Model 1 1st stage: 1605b Participation	Model 2 2nd stage: Adjusted CO_2 intensity	Model 2 1st stage: 1605b Participation	Model 3 2nd stage: Adjusted CO_2 intensity	Model 3 1st stage: 1605b Participation
Sierra Subscription	-8.754	0.121	-6.269	0.123	-6.449	0.122
	(33.85)	(0.082)	(33.26)	(0.082)	(33.04)	(0.082)
Heatrate	0.030	1.257e-04	0.030	1.256e-04	0.031	1.259e-04
	(0.031)	(1.276e-04)	(0.030)	(1.278e-04)	(0.031)	(1.279e-04)
Capacity factor	-1.330e+03***	-1.924*	-1.356e+03***	-1.942*	-1.373e+03***	-1.941*
	(4.480e+02)	(1.100)	(4.330e+02)	(1.099)	(4.250e+02)	(1.096)
Fraction of hydro &	-8.534e+02***	0.167	-8.772e+02***	0.159	-8.655e+02***	0.162
nuclear	(2.306e+02)	(0.942)	(2.209e+02)	(0.945)	(2.156e+02)	(0.944)
LCV score: Senate	-1.005	2.513e-03	-0.944	2.526e-03	-0.926	2.548e-03
	(1.775)	(5.216e-03)	(1.780)	(5.225e-03)	(1.774)	(5.212e-03)
LCV score: House	2.066	5.482e-03	1.921	5.487e-03	2.026	5.458e-03
	(4.140)	(8.754e-03)	(3.986)	(8.750e-03)	(3.866)	(8.752e-03)
RPS index	-21.85	-0.808	-11.28	-0.806	-8.233	-0.802
	(1.795e+02)	(0.501)	(1.799e+02)	(0.501)	(1.744e+02)	(0.499)
Lag Fuel Switch Saving	-16.01	0.321	-28.78	0.324		0.327
	(1.960e+02)	(0.958)	(1.913e+02)	(0.966)		(0.980)
Growth in net	-166.7	-0.188		-0.113		-0.116
generation (t-1)	(1.369e+02)	(0.204)		(0.202)		(0.205)
Growth in net	-92.52	-0.096		-0.058		-0.056
Generation (t-2)	(1.256e+02)	(0.186)		(0.169)		(0.169)
Growth in net	-0.821	9.474e-03***		9.866e-03***		9.826e-03***
generation (t-3)	(0.508)	(2.353e-03)		(2.315e-03)		(2.299e-03)
Lag SO_2 Emissions	-34.75	1.306	-63.30	1.305		1.320
	(2.472e+02)	(1.550)	(2.341e+02)	(1.559)		(1.555)
1605b Participation	-6.348		14.790		-7.734	
	(1.805e+02)		(1.768e+02)		(1.613e+02)	
Electric Operating		0.949***		0.951***		0.948***
Revenue		(0.316)		(0.317)		(0.316)
Lag 1605b reporting		6.551e-04		5.278e-04		6.631e-04
Trend		(7.596e-03)		(7.559e-03)		(7.411e-03)
Constant	1.705e+03***	-2.261	1.703e+03***	-2.248	1.696e+03***	-2.265
	(4.148e+02)	(1.640)	(4.019e+02)	(1.638)	(4.033e+02)	(1.635)
Observations	594	594	594	594	594	594
Log likelihood	-4915.772		-4918.052		-4918.114	
$\chi^2[13]$	197.150					
$\chi^2[10]$			58.830			
$\chi^2[8]$					56.920	
ρ	0.266		0.249		0.268	
	(0.132)		(0.134)		(0.143)	
$\chi^2[1]$, ρ=0	3.67 {0.06}		3.17 {0.07}		3.17 {0.07}	

Robust standard errors are in parenthesis. Degrees of freedom are in square brackets. P values are in curly brackets. χ^2 is a chi-square test of the assumption that all coefficients are jointly equal to zero. ρ is the correlation coefficient between the error terms of the first-stage participation and the second-stage outcome equations. $\chi^2[1]$, ρ=0 tests the independence of the two equations.

* Significant at 10%; ** Significant at 5%; *** Significant at 1% (all two-tailed tests).

Figure I. 1605b Reported Reductions (IOUs) vs. Actual Reductions (IOUs)

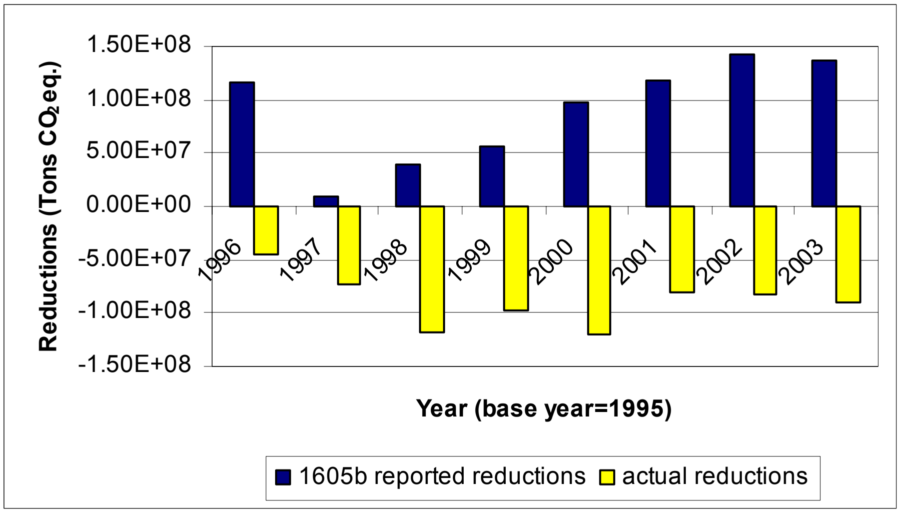

Figure II. Actual Reductions: IOU Participants vs. IOU Non-Participants