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Enterprise-level amount of energy saved targets in China: weaknesses and a way forward

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ABSTRACT

Recognizing the industrial sector's high energy use and vast potential for energy saving, many national governments have established voluntary or negotiated agreements that set quantitative energy-saving targets for individual industrial enterprises. The most commonly used energy-saving targets worldwide are volume and energy intensity targets. Since 2006, the Chinese government has set mandatory, enterprise-level energy-saving targets in terms of the “amount of energy saved”; this represents a unique category that differs from both volume and energy intensity targets. Based on first-hand data collected at ten case enterprises, this paper represents one of the first attempts to verify the reliability of the amount of energy saved data reported by the Chinese government and to rigorously and systematically investigate the inherent weaknesses of the amount of energy saved targets through a comparison with the mainstream categories of energy-saving targets. The ten case enterprises reported four different types of amount of energy saved. While all of the case enterprises claimed full achievement of their amount of energy saved targets, four enterprises exaggerated their performance by violating the National Standard for Calculating the Amount of Energy Saved of Enterprises. The paper thus hypothesizes that the National Top-1000 Enterprise Program's alleged achievement of performance 65% higher relative to its amount of energy saved target is likely an overestimation. Although amount of energy saved targets constitute an innovative energy-saving indicator, they do not represent a step forward from conventional volume and intensity targets because of the following four weaknesses: 1) amount of energy saved targets provide limited potential for comparison given the different types of amount of energy saved and the different calculation methods, 2) they generate uncertain environmental outcomes as it is possible to meet a portion of an amount of energy saved target through production volume expansion, 3) they are difficult to enforce due to the complexity of data verification on the part of local government agencies, and 4) they are poorly correlated with the national target for reducing energy intensity. Amount of energy saved targets should therefore be replaced with “double-control” targets that impose both volume and intensity targets on industrial enterprises.

1. Introduction

The industrial sector is responsible for one third of global primary energy use and two fifths of global energy-related carbon dioxide (CO_2) emissions (Price and McKane, 2008; Tanaka, 2011). Significant technical potential exists for industrial energy saving, representing approximately 20–23% of final energy consumption for eight energy-intensive industrial sectors[1] (ICF, 2015). Recognizing the industrial sector's high energy use and vast potential for energy saving, many national governments have established voluntary or negotiated agreements that set quantitative energy performance improvement targets for specific industrial sectors or individual industrial enterprises (Price et al., 2008). Target setting

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[1] The eight industrial sectors are pulp, paper and print; iron and steel; non-metallic mineral; chemical and pharmaceutical; non-ferrous metal; petroleum refineries; food and beverage; and machinery.

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creates measurable milestones that, if achieved, can lead to the success of these agreements and associated goals (Rao et al., 2013).

A review of voluntary or negotiated agreements worldwide suggests that energy performance improvement targets generally fall into three mainstream categories, namely, volume targets, energy intensity targets, and economic targets (Rietbergen and Blok, 2010). Among these three mainstream categories, energy intensity targets are the most frequently used, followed by volume targets. Energy intensity targets stipulate either a certain level of energy intensity to be achieved a fixed point in the future (an intensity improvement in absolute terms) or a certain level of improvement in energy intensity compared with a base year (an intensity improvement in relative terms). Energy intensity targets can be further divided into physical energy intensity targets and economic energy intensity targets, which set limits on energy use per unit of production output or per unit of output value, respectively. For example, in 2000, the U.K. government negotiated Climate Change Agreements with 44 energy intensive industrial sectors, of which 40 chose to commit to physical energy intensity targets. An example is the brewing industry, which committed to reducing its physical energy intensity by 11.6% from 66.44 kWh/hectoliter in 1999 to 56.94 kWh/hectoliter by 2010 (ETSU, 2001). In the first generation of “Long-term Agreements on Energy Efficiency” in the Netherlands, Philips Electronics pledged to reduce its economic energy intensity, defined as energy use per unit of output value, by 25% in the 1989–2000 period (Blok et al., 2004). Volume targets essentially require an enterprise to limit or reduce its energy use to a certain absolute level. For instance, in Japan's Keidanren Voluntary Action Plan on the Environment, 5 of the 35 industrial sectors committed to absolute energy use reduction targets, including the Japan Iron and Steel Federation, which aimed to reduce total energy consumption in the production process by 10% in the 2008–2012 period compared to the 1990 level (Wakabayashi and Arimura, 2016). Economic targets usually require that industrial facilities implement all energy-saving measures that meet a certain cost-effectiveness or profitability criterion. For instance, companies under Denmark's Energy Efficiency Agreements were required to implement all energy-saving projects with payback periods of up to four years, as identified in an energy audit or through internal investigations (Hansen, 2001). However, given that economic targets have not been used very frequently in energy policies, this paper does not go into detail about these targets.

In China, the industrial sector consumed more than 70% of total energy and accounted for 68% of total carbon emissions in 2012 (NBS, 2011, 2012). As a result, the Chinese government has long recognized the urgency of launching industrial programs that set enterprise-level energy performance improvement targets (Cao et al., 2016; Lo et al., 2015; Liu et al., 2012). The most representative programs are the National Top-1000 Enterprise Program from the 11th Five-Year-Plan (FYP) period (2005–2010) and its replacement, the National Top-10,000 Enterprise Program from the 12th FYP period (2010–2015). Both programs set mandatory, enterprise-level energy-saving targets in terms of “amount of energy saved” (AES, *jienengliang*), which refers to a reduction in energy consumption while meeting the same energy demand, typically measured in units of tons of coal equivalent (tce) according to the National Standard for Calculating the Amount of Energy Saved of Enterprises (GB/T 13234-2009), hereinafter referred to as the National Standard[2] (AQSIQ, 2009) (see the five main types of AES in Table 1). Many provincial and municipal governments followed suit by launching provincial and municipal equivalents of the National Top-1000 and Top-10,000 Enterprise Programs and setting mandatory AES targets for industrial enterprises within their respective jurisdictions. Taking the National Top-1000 Enterprise Program as an example, this program aimed to achieve a total AES target of 100 Mtce by 2010 (NDRC, 2006). This target was allocated across the 1008 most energy-intensive enterprises in the 9 major energy-consuming industries, each of which consumed at least 180,000 tce annually.[3] The AES target comprises two components: a cumulative AES target that each enterprise must achieve by the end of a FYP period and an annual target for each year of the period. Industrial enterprises subject to AES targets are evaluated by local Energy Saving Offices (ESOs) each year, and this evaluation is primarily based on the enterprises' self-reported AES target performance (Li et al., 2013).[4]

A closer look at the Chinese enterprise-level AES targets reveals that they represent a unique category of energy target that does not fall into any of the three mainstream categories commonly used in

Table 1
Five types of AES and the corresponding calculation methods.

Type of AES[a]	Calculation methods
AES of production output[b]	$\Delta E_{\mathrm{p}} = \sum_{i=1}^{n}(e_{\mathrm{p}i\_b} - e_{\mathrm{p}i\_r})\cdot M_{i\_r}$ (1)
AES of output value[c]	$\Delta E_{\mathrm{ov}} = (e_{\mathrm{ov}\_b} - e_{\mathrm{ov}\_r})\cdot G_r = \Delta e_{\mathrm{ov}}\cdot G_r$ (2)
AES of technique	$\Delta E_{\mathrm{t}} = \sum_{i=1}^{m}\Delta E_{\mathrm{t}i} = \sum_{i=1}^{m}(e_{\mathrm{t}a} - e_{\mathrm{t}b})\cdot P_{\mathrm{t}a}$ (3)
AES of product mix variety	$\Delta E_{\mathrm{pm}} = G_r\cdot\sum_{i=1}^{n}(K_{i\_b} - K_{i\_r})\cdot e_{\mathrm{ov}i\_r}$ (4)
AES by energy type (energy type method)	$\Delta E_{\mathrm{cn}} = \sum_{i=1}^{n}(e_{\mathrm{c}i\_b} - e_{\mathrm{c}i\_r})\cdot M_{i\_r}$ (5)

[a] Among the five types of AES, the most common are the AES of production output and the AES of output value. Notations for Eq. (1) and Eq. (2) are given in notes 2 and 3. For the notations for the other equations, please refer to AQSIQ (2009).

[b] In Eq. (1), ΔE_{p} is the AES of production output (tce); $e_{\mathrm{p}i\_b}$ is the physical energy intensity of product *i*, defined as energy consumption per unit of production (E_i/M_i) in base year *b* (tce/product); $e_{\mathrm{p}i\_r}$ is the physical energy intensity of product *i* in reporting year *r* (tce/product); M_{i_r} is the production output of product *i* in reporting year *r*; and *n* is the number of product types produced in reporting year *r*.

[c] In Eq. (2), ΔE_{ov} is the AES of output value (tce); e_{ov_b} is the economic energy intensity, defined as energy consumption per unit of output value (*E*/*G*), in base year *b* (tce/10^4 Yuan); e_{ov_r} is the economic energy intensity in reporting year *r* (tce/10^4 Yuan);G_r is the output value (constant price) of the enterprise in reporting year *r* (10^4 Yuan); Δe_{ov} is the reduction in economic energy intensity (tce/10^4 Yuan).

[2] Specifically, for industrial enterprises, AES reflects the difference between an enterprise's actual level of energy consumption and the anticipated level of energy consumption for the business-as-usual scenario within an accounting period.

[3] AES target setting is primarily based on each enterprise's share of energy consumption among all of the enterprises under scrutiny, adjusted for the enterprise's potential for technological progress. For example, if Enterprise A accounts for 0.5% of the total energy consumption for all National Top-1000 Enterprises, then the AES target assigned to Enterprise A will be approximately 0.5% of the AES target for all National Top-1000 Enterprises (i.e., 100 Mtce). Therefore, the AES target for Enterprise A would be 0.5% × 100 = 0.5 Mtce. However, if the efficiency level of Enterprise A is already quite high and if the potential for a further increase in efficiency is limited, then the resulting target will be lowered accordingly.

[4] During the 11th FYP period, Chinese enterprises were evaluated each year by local Energy Saving Offices (ESOs) based on their cumulative AES relative to the base year levels (Li et al., 2013). For example, if Enterprise A was required to meet the AES target of 500 tce by 2010 relative to the 2005 level, then it was expected to have achieved 20% of the 500 tce target (i.e., AES equal to 100 tce) by the end of 2006 and 40% of the 500 tce target (i.e., AES equal to 200 tce) by the end of 2007. Starting in the 12th FYP period (2011–2015), local ESOs required enterprises to report their incremental AES relative to the previous year in addition to their cumulative AES since the beginning of the FYP period (PESO, 2013). Enterprises calculate their AES based on the National Standard and submit self-examination reports to the municipal and provincial ESOs on a yearly basis. The ESOs review these reports and organize an assessment group comprising experts from a variety of energy-relevant agencies and research institutes to conduct an on-site inspection of the enterprises before they make a final assessment. However, because the assessment experts are not full-time inspectors and because they are able to commit only a few hours to an enterprise each year, the final assessment is largely based on the enterprises' self-examination reports.