REDUCING INDUSTRIAL AIR POLLUTION AND GREENHOUSE GAS EMISSIONS THROUGH TECHNOLOGY STANDARDS: COMPARING THE US, EU AND CHINA

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INTRODUCTION

Various jurisdictions around the world have experience using technology-based standards for emissions control and energy efficiency. China is experimenting now with sophisticated energy efficiency standards for key industries, which encourage cogeneration and waste-heat recovery. But China has not utilized the types of pollution control technology standards successfully employed in the US and other industrialized countries. The two approaches are in fact complementary and if used together in combination could provide a superior mechanism for reducing pollution and greenhouse gases. These two approaches are important components of the comprehensive suite of mutually reinforcing policies that is required to adequately address a full range of pollution emissions from the industrial sector.

- **Technology-based emissions standards.** The US has utilized various technology-based pollution emissions standards (BACT, LAER, RACT, MACT – described below) to drive significant reductions in pollutant emissions. China should consider development of such technology-based emissions standards, coupled with strong enforcement provisions to ensure that equipment is not installed and left unused. Technology-based standards should be performance-based rather than prescriptive, i.e., they should be expressed on the basis of a productive output, such as grams of pollutant per unit of product manufactured, rather than simply requiring that a particular control technology be employed. Output based emissions standards help to spur the development of improved air pollution control technology, as well as cleaner technology for the manufacturing process itself. While most US emissions standards fall short of being performance-based, it is widely recognized that this approach will also allow the emitter to reduce pollutant emissions in the most efficient and cost-effective manner possible.
- **Energy efficiency standards.** One shortcoming of technology-based emissions standards is their emphasis on end-of-pipe pollution reduction. Jurisdictions, including the EU and China, are experimenting with output-based, energy efficiency standards that can drive enterprises to reevaluate production processes and lead to more efficient systems of production. China has recently issued energy consumption standards for the production of 22 energy-intensive industrial products. Although they are designed to conserve energy, not control pollution, these standards will effectively reduce direct and indirect emissions

of greenhouse gases and criterion pollutants associated with the energy needed to fuel the production process. Though the implementation details are yet to be worked out, these energy consumption standards provide a strong policy foundation on which environmental regulators should build.

- **Combined approaches.** By jointly mandating high-efficiency technology and advanced pollution control technology, air regulators take an integrated approach to environmental and energy management. Such an approach takes advantage of synergies in management, enforcement and compliance, while driving advances in cleaner industrial technologies and controlling both direct and indirect emissions associated with industrial production.

This article will examine mechanisms employed in the US and EU for controlling industrial air pollution emissions vis-à-vis China's own evolving regulatory framework, and will conclude that China is well positioned to take advantage of the many years of experience in these jurisdictions and leapfrog directly to a combined approach.

US MECHANISMS

US Technology-based Requirements for Industrial Emitters

The US Clean Air Act employs two different and complementary means of reducing pollution. One approach starts with air quality standards, such as the National Ambient Air Quality Standards (NAAQS). Based on measurements of the concentration of pollutants in the air, air quality managers calculate back to the total emissions in the area that are consistent with achieving the desired air quality. The second approach begins with pollution control technology without regard to the existing air quality. Under this approach, the air regulator identifies how much emission reduction current technologies are capable of delivering. The Clean Air Act incorporates both these approaches.

The CAA includes five major types of technology standards. Two of them require EPA to adopt federal rules that apply directly to the emitters.

- ***New Source Performance Standards*** (NSPS) – These nationally-applicable standards are established by EPA rule for many categories of industrial emitters, such as coal-fired boilers or cement kilns. They are health-based standards that cover commonly-emitted substances (such as those subject to NAAQS) and apply only to major new industrial facilities. The NSPS are supposed to require the best technology currently available, taking into account cost and energy impact. These standards remain the same until changed through a new EPA rulemaking, so they are the same for every new emitter. In practice, the NSPS do not typically require the most advanced pollution control technology. This is because demanding requirements seldom emerge from the rulemaking process, and as time passes the standards become increasingly out-of-date. Still, the NSPS serves as a "floor" that prevents states from competing for new industry by offering lax pollution control requirements.

- ***Hazardous Air Pollutant Standards*** (HAPS) – Maximum Available Control Technology (MACT) standards for HAPS are also established by nationally-applicable EPA rule on an industrial category-by-category basis. MACT standards are adopted for sources of "hazardous air pollutants," which are (1) more toxic than criteria pollutants in their effects on humans, and (2) usually emitted from a much smaller number of production facilities than the pollutants regulated under the NAAQS. The law with regard to HAPS is complex, but it can be simplified as follows.

- The CAA identifies almost 200 air pollutants that are considered hazardous and directs EPA to adopt MACT standards for each one.

- EPA establishes standards for each category based on the best performance of other facilities in that category. Any new production unit must have performance equal to the best existing unit; an existing production unit must upgrade performance to a MACT standard set by EPA at a performance level not worse than the average of the 12 percent best-performing existing units.

- If the application of the MACT standards is inadequate to reduce the risk to the exposed public, EPA is required to take any additional steps needed to bring the risk down to the one in one-million level for exposed individuals.

- States have the right to establish their own MACT standards, so long as they are at least as stringent as the federal MACT standard for the particular industrial category.

- As with NSPS, HAPS tend to lag behind the capabilities of advanced technology because they are established through a slow, drawn-out rulemaking process.

The other three types of technology standards are administered by the states, under the guidance of the federal EPA. These technology requirements also differ from the federal technology standards because they are applied through a case-by-case process that is designed to find the best and lowest cost technology at the time the new unit is constructed. These requirements also apply to "modified" industrial units, not just new ones.

- ***Best Available Control Technology*** (BACT) – When a new or modified unit is proposed for an area that attains the NAAQS – a "clean air area" – it must obtain a permit to construct. In order to obtain a permit, the owner must demonstrate the new or modified unit will install BACT. In order to determine what BACT is for the particular type of industrial unit, the state agency reviews all the information it can collect about available pollution control technology. EPA maintains a special "BACT/RACT/LAER Clearinghouse" where it keeps records of each state's past BACT determinations.[1] States may search the Clearinghouse to see what other states have required of industrial units similar to the one seeking a permit from them. But the states are not bound by the Clearinghouse. They may choose a technology, or combination of technologies, more stringent than any included in the Clearinghouse.

- ***Lowest Achievable Emission Rate*** (LAER) – When a new emitter is constructed or modified in a nonattainment area – a polluted area where NAAQS are not attained – it

1 See http://cfpub.epa.gov/RBLC/htm/bl02.cfm for the "RACT/BACT/LAER Clearinghouse" database.

must also obtain a permit. The emitter must demonstrate that it will be equipped with LAER pollution control technology. State LAER determinations, like BACT determinations, are recorded in the BACT/RACT/LAER Clearinghouse. Because LAER applies in areas where health standards (NAAQS) are not attained, the CAA intended for LAER decisions to give less importance to the cost and availability of pollution controls, and more importance to the need to protect public health, compared with BACT determinations which apply in areas where the air quality already attains NAAQS. In practice, however, there has been little difference in the BACT and LAER determinations.

- ***Reasonably Available Control Technology*** (RACT) – RACT, unlike BACT and LAER, applies to existing industrial emitters. SIPs for nonattainment areas are expected, at a minimum, to require installation of RACT on existing industrial emitters. The term "reasonably available" rather than "best available" is intended to indicated a greater flexibility for states to take into account factors that could increase the cost of installing a technology on an existing unit, as well as the remaining economic life of the unit, when determining the appropriate control technology. Consequently RACT requirements are usually less demanding than BACT or LAER. RACT determinations are sometimes made by states on a category-by-category basis, and sometimes on an emitter-by-emitter basis.

While the terminology of these technology standards is confusing, the following table illustrates the conceptual distinctions relatively simply.

Consideration of Cost	**Federal Rule**	**State Case-by-Case**
Least	MACT	LAER
Middle	NSPS	BACT
Most		RACT

Despite the confusing terminology, it is apparent that these terms are intended to express policies that balance risk against cost. Where Congress concluded that the risks to public health are high (i.e., in areas where NAAQS are not attained, and in the vicinity of emissions of toxic pollutants) the CAA directs EPA and the states to give less consideration to the cost of reducing pollution. Where the dangers are lower (i.e., in areas where NAAQS are attained, or where EPA was directed to write a standard for the entire country, like the NSPS), or where pollution control costs can be expected to be higher (i.e., existing sources), Congress allowed EPA and the states to give greater consideration to cost.

In the US experience, NSPS has been broadened beyond technology, in the strict sense of the word, to include best operational practices that can be implemented to reduce emissions. The law provides that if an emissions standard is not feasible, then EPA may establish a design, equipment, work practices, operational standards or any combination of these. States are also encouraged to consider alternative production processes, as well as alternative fuels or combustion techniques in making a BACT determination.[2] The state and local permitting authority and the enterprise

2 The US Clean Air Act defines Best Available Control Technology as follows: " . . . an emission limitation based on the maximum degree of reduction of each pollutant subject to regulation . . . emitted from or which results from any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental and economic impacts and other costs,

ascertain what combination of measures constitutes the most stringent level that can be achieved cost-effectively for that particular facility. Generally, as it has been implemented, the regulation considers add-on technology controls that treat the end-of-process or end-of-pipe emissions, as opposed to addressing whole processes and plant systems.

EU TECHNOLOGY MEASURES

With the 2008 Integrated Pollution Prevention and Control (IPPC) Directive, the EU went considerably beyond the US approach by requiring major industries to apply Best Available Techniques (BAT).[3]

BATs represent the most effective techniques for achieving a high standard of pollution prevention and control. Like the US approach, the BAT mechanism is designed to provide flexibility to member states to balance technical and economic feasibility, and weigh the costs and benefits of different environmental protection measures. The IPPC Directive does not prescribe technologies, but it does require member states to take into account certain guidelines, called BAT Reference (BREF) documents, in determining appropriate regulations and permitting for industrial sources.

The BREF guidelines apply to specific industries. Currently there are 18 affected industries for which BREF guidelines have been finalized and adopted.[4] The guidelines specify the most effective techniques to achieve a high level of pollution prevention and control in an industrial process – this refers not just to technologies, but also to methods for optimal installation, operation (including energy consumption) and maintenance of an industrial facility.

Under the auspices of the European Commission, technical working groups are organized to devise and continuously update the BREF guidelines to incorporate new advances in technology. The working groups are comprised of a range of experts from the affected industries, member state government agencies, NGOs, research organizations and other institutes from across the European Union.

One major departure from the US system is that the EU BATs take an integrated approach to pollution control. The BATs consider an array of environmental impacts from industrial activity; not only those pertaining to air, for example, but also water and soil. In this way, the BAT approach seeks to effectively ensure that pollution does not get shifted from one environmental media, like air, to another, like water.

Importantly, the BAT approach also expressly requires industries and other affected sources to use energy efficiently, a requirement not found in the US BACT mechanism. Energy efficiency is incorporated in two ways: vertically within individual industrial sectors, and horizontally across

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determines is achievable for such facility through application of production processes and available methods, systems, techniques, including fuel cleaning, clean fuels, or treatment or innovative fuel combustion techniques for control of each pollutant" [42 USC Section 7479 (3); Clean Air Act Section 169(3)].

3 Full text of IPPC Directive 2008/1/EC is available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:024:0008:01:EN:HTML (as of January 20, 2010). A summary of the Directive is available at http://europa.eu/legislation_summaries/environment/waste_management/l28045_en.htm (as of January 20, 2010).

4 BAT reference (BREF) documents for all affected industries can be found online at http://circa.europa.eu/Public/irc/env/ippc_brefs/library and at http://eippcb.jrc.es/reference/ (as of January 20, 2010).

sectors. Firstly, BREF guidelines for a specific sector include energy-use specifications for industrial technologies and processes associated with that industry. These standards are typically established as output-based efficiency performance standards on the basis of a unit of product produced. Output-based standards for energy efficiency – like energy intensity targets – have the advantage of encouraging efficient production, as opposed to reduced fuel-use or reduced production. Examples of these standards include the following:

- The best available technique for the production of cement clinker is a dry process kiln with multistage preheating and precalcination with a heat balance of 3000MJ per ton of clinker produced.[5]
- For the ferrous metal industry, the energy BAT for the hot rolling process limits energy use to between 72-140 kilowatt hours per ton of material produced.
- The generation of steam for hydraulic acid pickling lines is limited to a specified number of gigajoules of BTUs per ton of material produced, depending on a range of processes and fuel input types.

Reinforcing the industry-specific energy efficiency guidelines, the EU system also includes a BREF dedicated explicitly to energy efficiency. It provides general energy efficiency techniques that are required to be considered horizontally across all industrial sectors covered under the IPPC Directive. For example, the generic BREF for energy efficiency includes recommendations for best available techniques related to heating and cooling, cogeneration, and lighting, as well as whole-system energy management and auditing. Because conditions vary substantially across industries and member states, the rules for the energy efficiency BAT lack specific terms and ultimately may prove too general to be consistently effective across implementation authorities. Having only been recently finalized in February 2009, the program is too new to judge.[6]

While the EU system clearly identifies energy efficiency as a means of pollution control and prevention, a theme continuous throughout the IPPC and BREF documents, these aspects of the regulation are not mandatory. The BATs are intended to serve as guidelines for the implementing authorities to apply to local conditions – environmental, climactic, economic, or otherwise – in the development and issuance of environmental permits.

Whereas in the case of pollution emissions, if a facility violates emissions or technology standards as prescribed in the IPPC Directives, the European Commission has authority to investigate complaints and file suit against the violator. After that, if the violator does not fall into compliance, daily fines will be applied. However, there is no penalty mechanism to reinforce compliance with the energy efficiency BATs. No comprehensive studies have yet been undertaken to evaluate how authorities have or have not incorporated the energy efficiency guidelines into the permitting process thus far. Additionally, for many the energy-intensive industries, BATs have not been adopted yet. Overall, it is too early in the course of the program to determine how the affected industries are in fact applying the BATs, including the energy efficiency specifications therein.

The primary approach taken to reduce air pollution emissions in the EU system is through advanced control technologies on processes – much like the focus of the US BACT system. But

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5 Reference Documents on Best Available Techniques in the Cement and Lime Manufacturing Industries (draft September 2007) is available online at http://ftp.jrc.es/eippcb/doc/clp_d1_0907.pdf (as of January 20, 2010).
6 The generic BAT for energy efficiency and associated reference guidelines, issued in February 2009, is available online at http://ftp.jrc.es/eippcb/doc/ENE_Adopted_02-2009.pdf (as of January 20, 2010).

the emphasis on energy efficiency in the EU – though the standards are neither mandatory nor appropriately specific – will likely lead to a program that is more effective at reducing emissions than the US BACT program. This is because additional regulatory focus on energy efficiency can drive an enterprise to make fundamental, early-stage changes in energy processes. In many cases, these energy-consuming processes are significant sources of emissions, particularly in energy-intensive industries, such as iron and steel, pulp and paper, textile and cement industries. Combined with the traditional pollution control technology standards, energy efficiency standards for industrial production can encourage fuel-switching, improved energy management systems, and improved fuel-use through technologies like combined heat-and-power (CHP), polygeneration, and waste-heat recovery – all of which lead to significant reductions in both the direct and indirect emissions of a facility.

CHINA'S INDUSTRIAL ENERGY EFFICIENCY STANDARDS

In contrast to the approaches by the US and the EU, China has recently developed and issued comprehensive energy efficiency standards on an output basis for 22 energy-intensive industrial products.[7] Though yet to be implemented, these standards apply to specific production and system processes within a facility – which in the case of steel, for example, may cumulatively account for as much as 85 percent of a facility's total energy consumption associated with the production of a unit product.

In the case of cement, the rule sets minimum efficiency standards per unit of product for both existing and new facilities. The quotas are organized by plant size (tons produced per day), type (clinker production, cement production or cement grinding plants), and by fuel and/or electricity consumption (kgce/ton and kWh/ton). (See Tables 1 and 2 below.) There are mandatory threshold levels of energy consumption, while the standards also recommend incremental energy efficiency targets to help facilities make the necessary transition and upgrades (as well as possible fiscal incentives, depending on the technology).

Table 1. Mandatory threshold levels of energy consumption per unit product for existing cement plants

Categories	Comparable comprehensive standard coal consumption of clinker (kgce/ton)	Comparable comprehensive electricity consumption of clinker* (kWh/ton)	Comparable comprehensive electricity consumption of cement** (kWh/ton)	Comparable comprehensive energy consumption of clinker (kgce/ton)	Comparable comprehensive energy consumption of cement (kgce/ton)
≥ 4,000 ton/day	≤120	≤68	≤105	≤128	≤105
2,000~4,000 ton/day	≤125	≤73	≤110	≤134	≤109
1,000~2,000 ton/day	≤130	≤76	≤115	≤139	≤114
<1,000 ton/day	≤135	≤78	≤120	≤145	≤118
Cement Grinding Plants	—	—	≤45	—	—

7 The 22 industrial products are cement, steel, caustic soda, ferroalloy, coke, calcium carbide, architecture and sanitary ceramics, yellow phosphorous, carbon materials, synthetic ammonia, flat glass, electrolyzed aluminum, wrought aluminum alloy for architecture, copper and copper-alloy tube, coal-fired power, and the metallurgy of copper, zinc, lead, nickel, magnesium, antimony, and tin.

*Only applies to clinker production plants. ** Applies to cement production plants, including cement grinding plants.

Table 2. Mandatory threshold levels of energy consumption per unit product for new cement plants[8,9]

Categories	Comparable comprehensive standard coal consumption of clinker (kgce/ton)	Comparable comprehensive electricity consumption of clinker* (kWh/ton)	Comparable comprehensive electricity consumption of cement** (kWh/ton)	Comparable comprehensive energy consumption of clinker (kgce/ton)	Comparable comprehensive energy consumption of cement (kgce/ton)
≥ 4,000 ton/day	≤110	≤62	≤90	≤118	≤96
2,000~4,000 ton/day	≤115	≤65	≤93	≤123	≤100
Cement Grinding Plants	—	—	≤38	—	—
*Only applies to clinker production plants. ** Applies to cement production plants, including cement grinding plants.					

A complementary set of standards for the cement industry provides detailed specifications for production processes in new and expanded facilities.[10] These include information and guidance on energy management, specific requirements for motors, fans, pumps, and transformers, and energy consumption and heat standards for all key processes and systems in cement production. The standards recommend specific processes and systems while prohibiting others, and require new and expanded plants to incorporate waste-heat recovery or ensure built-in capacity for future installation.

Assuming the same pollution controls are in place, a high-efficiency industrial plant will be cleaner than a less efficient one. Industrial standards for energy consumption can bring about significant reductions in criteria and other hazardous pollution emissions and reduce carbon dioxide and other greenhouse gases. If the energy efficiency standards are implemented and enforced successfully, the affected industries in many cases will have to shift their energy use to cleaner fuels and cleaner production processes, including CHP, polygeneration and waste-heat recovery. China's current industrial energy consumption standards, consequently, directly serve the interest of environmental regulators.

Indeed, viewed from an environmental perspective, the energy efficiency standards are comparable to output-based CO_2 emission standards, which consider cogeneration and waste heat recovery. China's efficiency standards for industrial products are a powerful mechanism that, if implemented and enforced, and combined with strong BACT technology standards to include other pollutants, could hold the promise of being significantly more effective than either the US BACT or the EU BAT approaches. The policy mechanism would represent a climate-friendly air

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8 The source of both Tables 1 and 2 is GB 16780-200x: The Norm of Energy Consumption per Unit Products of Cement, available for purchase in Chinese at http://www.spc.net.cn/produce/showonebook.asp?strid=33233 (as of April 28, 2009). 8 GB 50443-2007: Code for the Design of Energy Conservation in Cement Plants.
9 By comparison, the EU BAT for cement states "for new and major upgrade the BAT for the production of cement clinker is considered to be a dry process kiln with multistage preheating and precalcination. The associated BAT heat balance value is 3000 MJ/ tonner clinker." The value of 3000 MJ/t clinker is equal to 102 kgce/t clinker and should be compared to the first column in Tables 1 and 2. See http://ftp.jrc.es/eippcb/doc/clp_d1_0907.pdf.

quality management tool of the sort that air and power regulators will increasingly need to rely on to ensure that reductions in conventional pollutants are not achieved at the expense of carbon emissions, and vise versa.

COORDINATING ENERGY AND ENVIRONMENTAL REGULATION

China has a strong track record of recognizing the intrinsic links between energy and environmental management. China's current industrial energy consumption standards provide a valuable regulatory framework on which environment controls can be built. Stricter energy efficiency standards can effect pollution reductions, and so these standards provide an effective lever for the environmental regulator. By jointly mandating high-efficiency technology and advanced pollution control technology, environmental regulators could take advantage of synergies in management, enforcement and compliance. By jointly regulating air pollution and energy efficiency, as the EU has begun to do through the 2008 IPPC Directive, China can put forth a more comprehensive, integrated, and effective industrial technology policy, which will affect both reductions in criterion pollutants and CO2 emissions.

As China considers the US BACT and EU BAT models for driving advanced pollution control technology in the industrial sector, it should not overlook the strong foundation it already has in place with its energy consumption standards for industrial products. And as China moves to adopt implementation and enforcement rules for the industrial standards, environmental regulators should be brought to the table to evaluate consequences and opportunities to coordinate environmental objectives. Additionally, China should be mindful of the lessons learned from international experience, which include:

- Devise a system for periodic, transparent and scientific review and tightening of the standards. Such a system should include special consideration for tightening power sector emission standards if and when existing generation pricing reflects market pricing.
- Design the regulations to reward performance beyond the threshold standards and drive innovation, as has been done in some provinces already.
- Implement the standards effectively. This will include linking the standards to the permitting process, and ensuring that the industries are well-informed about the applicable standards. Industries will also be educated on how to meet the standards, including assistance with identifying opportunities to improve production processes and utilize combined heat and power, cogeneration and polygeneration opportunities.
- Build on the EU IPPC's treatment of energy efficiency. The generic BAT for energy efficiency offers important guidance, in particular, on the development and implementation of formal and systematic energy management systems.
- Approach policies for advance pollution control technology on a multi-pollutant basis and evaluate impacts on climate change emissions and the potential co-benefits of controls. China's energy efficiency standards for industrial products are analogous to output-based CO_2 standards. Integrating high-efficiency technology and advanced pollution control requirements such as BACT, while considering the full range of pollutants simultaneously, will give industry the signals it needs to make long-term planning decisions that favor cleaner processes and technologies.