



In support of the G8 Plan of Action

In collaboration with WBCSD



Energy Efficiency and CO₂ Emission Reduction Potentials and Policies in the Cement Industry: Towards a plan of action

This document contains the proceedings of the IEA/WBCSD Workshop on Energy Efficiency and CO₂ Emission Reduction Potentials and Policies in the Cement Industry, which took place on 4-5 September 2006, at the International Energy Agency in Paris. This workshop was organised as part of industrial sector activities in the G8 Gleneagles Plan of Action. The goal is to assess the efficiency performance and to identify areas where further analysis of energy-efficiency measures by industry sector could add value, across developed and interested developing countries. This document reflects the presentations and discussions of the participants at the workshop. The views expressed in this paper do not necessarily represent those of the IEA or IEA policy. A CD-ROM with the workshop presentations is available from the IEA Secretariat in Paris. All information is available at IEA WEB site: http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=266.

Key Messages

Data on energy efficiency and CO₂ emissions

- World cement production amounted to 2.3 billion metric tons (Gt) in 2005. About half of the production takes place in China. There are no accurate comprehensive statistics on energy use in the cement industry. It is estimated that total primary energy use for cement production amounted to 10-11 EJ (2-3% of total global primary energy use) and total CO₂ emissions (direct + indirect) were almost 1900 million tons of CO₂ (MtCO₂) in 2005 (almost 8% of total global CO₂ emissions), with more than 1400 MtCO₂ emitted from the kilns. The accuracy of these figures need further analysis, and for the time being they should be used with caution;

- Data on clinker production are essential for proper estimation of CO₂ emissions, but are not readily available. It seems that cement production data are often implicitly used as a proxy for clinker production;
- Alternative fuel use is included in the IEA energy statistics, but there seems to be underreporting in certain countries;
- Cement production will continue to grow in the coming decades, and CO₂ emissions will rise accordingly. The actual production growth rate is uncertain, especially as projections for China are uncertain;
- The regional and country average efficiencies and CO₂ emissions differ because of different use of clinker substitutes, alternative fuels, the kiln technology and fuel choice;
- Energy efficiency covers part of the emissions reduction potential: half to two-thirds of CO₂ emissions in Portland cement production originate from the clinker calcination reaction. The full scope of CO₂ reduction options hence spans beyond energy efficiency;
- There is an antitrust problem in data gathering on a plant level (from WBCSD experience);
- The quality of existing information/data regarding energy efficiency and CO₂ emissions is insufficient. Industry participants questioned the validity of the data that were presented at the workshop. It is imperative to improve the information and knowledge on energy and CO₂ performances;
- The technology characteristics of the capital stock may be used to generate estimates of the energy efficiency. Newly built kilns are generally large-scale rotary kilns with precalciner and 5 or 6-stage pre-heaters, which consume about 3 GJ fuel/t clinker. Wet kilns and vertical shaft kilns may use 4-5 GJ/t clinker. Operational factors such as seal leakages and the number of starts and stops can make a 10% difference. These cannot be identified through technology characterisation;
- Most electricity is used for grinding. Clinker substitutes increase energy needs for grinding;
- The clinker/cement ratio is a key factor that determines the energy and CO₂ intensity of cement;
- The use of alternative fuels varies widely and is a key factor that affects CO₂ emissions. The accounting of CO₂ emissions from alternative fuels of fossil origin poses a challenge. Cement kilns in Europe are without reason subject to stricter policies as waste incinerators are not part of the EU emissions trading scheme;
- Important new emerging energy efficiency/CO₂ reduction technologies are: reduction of clinker content in cement, clinker substitutes, add-on equipment that allows a higher share of alternative fuels, better waste heat recovery (from flue gases and from clinker), limestone feedstock substitution and CO₂ capture and storage.

Timing, flexibility, and policy perceptions

- Credible long-term CO₂ policy targets are needed to enable investments in long life capital stock in the cement industry, where a plant has a 30-year life span or more. Uncertainty on future climate policy therefore raises planning and investment problems for the industry. Ideally, short-term and medium term targets should be defined, and be in line with long term targets. The short and medium term targets should be formulated in a way that allows industry to respond in a flexible way. Specification of technologies and modes of operation should be avoided. Policy continuity and transparency are both imperative;

- Short-term actions are influenced by what is needed from an environmental perspective and by what is the technological and economic potential to reduce emissions;
- Energy efficiency targets should consider cost-effectiveness criteria;
- In all likelihood different CO₂ reduction and energy efficiency frameworks will be developed in different parts of the world. Whether and how such frameworks can enhance each other and not distort competition is an issue that warrants further research;
- Alternative fuel use should be encouraged. This will require a strong political push on the national level and approval from local authorities. Local public acceptance proves to be a challenge in certain regions, as shown by the case of Portugal and parts of the United States;
- Early action should be rewarded in every system, which is not the case today.

Technical matters in policy design

- As a starting point, an analytical methodology such as benchmarking is needed;
- System boundaries should be defined in a way that accounts for emission reduction benefits outside the cement sector (e.g. waste combustion in cement kilns reduces conventional waste incineration);
- The Cement Sustainability Initiative (CSI) has been developed under the WBCSD framework and is widely accepted and used by the industry. The consistency of the accounting of CO₂ emissions from alternative fuel use between different methodologies (EU ETS, CDM, AP6, IPCC...) should be aimed for. In the least, the collection of additional data under different methodologies should be avoided;
- IEA should urge governments to agree to disclose energy efficiency and emission data for the cement industry that are based on common measures;
- The cement industry notes problems with the EU emissions trading scheme, and its national allocation plans. Energy efficiency efforts are not properly valued when allowances are redistributed in the second phase of ETS, and use of waste fuels is not always fully credited as emissions reduction as there are no credits given for the use of waste synthetic organic products, despite reducing total CO₂ emissions.

International coordination

- The IEA G8 industry task should be coordinated with other international activities in the framework of the Asia Pacific Partnership on Clean Development and Climate, CSI and IPCC;
- Evidence in Europe suggests that grinding mills are being built that operate on imported clinker, which suggests that carbon leakage may occur. On the other hand, model-based analysis suggests that such leakage effects will be limited. There is no consensus on this issue;
- The CDM procedures are too bureaucratic, subjective and disconnected from business reality to make a significant impact on business decisions;
- A mechanism should be developed that allows an exchange of emission reduction credits between different national or regional emission reduction frameworks such as trading schemes, voluntary initiatives etc.;
- There is a need for broader participation first, before compliance instruments are fine-tuned;
- Benchmarking could be combined with a sectoral approach for the emissions reduction framework.

Summary of presentations

The IEA G8 Programme of Work

Robert Dixon, IEA, presented the IEA activities under the Plan of Action for the G8 Dialogue on Climate Change, Clean Energy and Sustainable Development. Goal is to deliver a final report to the G8 summit in Japan in 2008. The analysis of industrial energy efficiency and CO₂ emissions reduction potentials is part of this activity.

Dolf Gielen, IEA, presented the programme of work for the industry task. A number of workshops are planned with key industry sectors. Goal is to publish an analysis of Indicators for Industrial Energy Efficiency and CO₂ Emissions in April 2007 that builds on the outcome of these workshops. This publication will be submitted to the G8 summit in Germany. This is followed by an analysis of the potential of new technologies to reduce energy use and CO₂ emissions in the second half of 2007. This will feed into a scenario analysis of industrial emission reduction potentials. A dialogue with industry is a key part of this process.

Status and Global Trends

Three presentations were made on the topic of the status and global trends.

Arnaud Pinatel of Exane BNPParibas discussed the global market structure and demand trends. Looking at the trend from 1985-2005, cement consumption more than doubled. Demand in China and Asia accounted for 65% of the world total in 2005.

Consumption is projected to increase to 3.5 billion tones in 2020. The current cement market is balanced, which results in limited efforts to increase international trade. EUETS, other environmental legislation and rising fuel cost have affected the industry economics and industry strategy. Chinese equipment suppliers have recently been emerging as competitors in certain markets. Data suggest that plants are offered at half the price of other suppliers, but it is not clear if the figures are really comparable. A limited number of multinationals are now controlling 47% of the world capacity, and the 5 largest companies own 25% of the world capacity. However, only 14 % of all new capacity additions between 2001 and 2004 were carried out by multinationals. This is largely the effect of the important growth in the Chinese market, which is largely served by Chinese companies.

New Chinese cement plants which are being exported are 'State of the art plants' with a high efficiency rate (close to BAT in terms of energy efficiency). On the other hand, a lot of the existing plants in China have a relatively low energy efficiency. Also only part of the new Chinese plants are state-of-the art in terms of overall efficiency.

Lynn Price, Lawrence Berkeley National Laboratory(LBNL), presented an analysis of global energy use, CO₂ emissions and the potential for reduction in the cement industry.

LBNL and Ecofys jointly estimated the energy use based on production data, clinker/cement ratios and average fuel consumption per ton of cement and converted to CO₂ emission using fuel emissions factors for the 27 largest cement producing countries. The

results suggest for these countries a total primary energy use from cement production of 10.8 EJ and total CO₂ emissions of 1888 Mt-CO₂. Technologies for reducing energy use were categorized into three processes: raw material, clinker making and finishing. There are many CO₂ reduction opportunities, and potentials vary by measure and region. The differences can be attributed to various factors, for example: the availability of alternative fuels and clinker substitutes, regulations/standards and market/public acceptance; and energy efficiency and capital stock characteristics. CO₂ emission reduction potentials were estimated at 8-28% by energy efficiency; 6-16% by alternative fuels; and 7-13% by blending. These potentials are not additive. The most effective strategy will depend on the local conditions.

Michael Taylor, International Energy Agency (IEA), presented an IEA paper “Energy Efficiency and CO₂ Emissions from the Global Cement Industry”. Country specific energy efficiency data suggests that global cement production consumes, on average, between 4 and 5 GJ per tonne of cement today. The industry uses 8 -10 EJ of final energy annually, while process emissions account for two-thirds of CO₂ emissions from the sector. The recent IEA publication "Energy Technology Perspectives 2006", presents a groundbreaking review of technologies across all sectors, which includes projections of global CO₂ emissions for 2050 under baseline (assuming no new energy and CO₂ policies) and global CO₂ emission stabilisation scenarios. Chinese cement production is assumed to decrease after peaking around 2015. Growing demand in other developing countries, particularly India, will allow global cement demand to continue growing; albeit at a slower rate than in the recent past. It is projected that total demand grows by 150% until 2050. In a scenario where total global CO₂ emissions are back to today's level by 2050 (ACT), direct CO₂ emissions in the cement industry are projected to grow to about 2700 Mt CO₂/yr¹ in 2050. If CO₂ capture and storage is economic in the cement industry at USD 25/t CO₂, then emissions in 2050 captured in the cement industry in 2050 might reach around 300 Mt CO₂ per year, reducing emissions from the industry to around 2400 Mt CO₂ in 2050. If China continues to replace its inefficient vertical shaft kilns and other countries replace their inefficient wet processes with dry process plants under a baseline scenario, the additional CO₂ mitigation opportunities in the global cement industry may be limited. There may also be limited potentials to substitute more clinker if cement demand continues to grow strongly.

Regional Perspectives

In this session, there were presentations on seven regions: Europe; US and Canada; Japan; China; Russia; India; and Latin America. A paper was also submitted that discussed market trends in the Middle East.

Claude Loréa, CEMBUREAU, presented on the European situation. The share of Europe in world cement production was 13.5% in 2005. Production in Turkey has increased substantially in recent years, while production in the EU15 was stable. Five countries represent 65% of production (Spain, Italy, Greece, Turkey, France). 44.3% of all cement is used for maintenance and modernisation, the remainder is used for new constructions. Cement (clinker) imports have increased, and European exports are decreasing because the industry has lost competitiveness under the EUETS.

¹ Cf. Current direct emission level was estimated about 1400 Mt-CO₂/yr in his presentation.

Apart from the EUETS, the rising prices of coal, petcoke, and electricity pose a challenge as energy cost represent 40% of total production costs. The cement industry cannot fully pass through CO₂ costs to customers. EU cement demand grows on average 1.25% per year, but clinker production decreases. When the production capacity expands, an allowance of EUETS should be granted for the additional capacity. If this is not the case, clinker imports from abroad pose a cheaper option.

The presentation about US and Canada was made by *Andy O'Hare, Portland Cement Association(PCA)*.

Production has been increasing while energy intensity (which is energy consumption per ton of production) has slightly improved. The net result has been a slight increase of CO₂ emissions since 1990 in both countries. In 2001 the U.S. cement industry adopted a voluntary agreement for reducing CO₂ emissions per ton of cement by 10% in 2020, compared to 1990 levels. In April 2006 more ambitious voluntary goals have been formulated with a 20% improvement in the energy intensity by 2020, compared to 1990. The US Climate Change Program is composed of three parts: i) effort in process including use of alternative fuel; ii) clinker substitution; and iii) consideration of cement energy benefits in the product use phase (e.g. in buildings or the transportation sector).

Toshio Hosoya, Japan Cement Association (JCA), showed that cement production in Japan has decreased by 28% during the last decade and discussed the structural change of energy supply. First from oil to coal in the early 80's, followed by an increased use of alternative fuels such as waste tires. Almost 1.3 Mt of alternative fuels (including tires) were used in 2005, representing about 35 PJ of alternative fuel, which equals approximately 20% of total fuel use. The use of wastes for alternative fuels and materials was driven by Japanese government policies aimed at reduced landfilling. About 10% of the electricity that is consumed is generated from waste heat from the cement kilns. This is cost-effective due to high electricity prices in Japan.

The NSP kiln (New Suspension Preheater kiln, a precalciner kiln with multi-stage preheaters) is dominant, accounting for 95% of total clinker production. Electricity use per tonne of cement has risen in recent years as more clinker substitutes are being used that require more electricity for grinding. The energy efficiency has been more or less constant during the past years because most facilities had installed efficient technology in the 1990s which limits the potential for further improvement. Japanese average fuel use is about 3 GJ/t clinker, the lowest level of all countries that have been analysed. The use of alternative fuels has increased, resulting in a reduction of total Japanese CO₂ emissions. However the Japanese share of alternative fuel use is still lower than in certain European countries such as Germany.

Cui Yuansheng, Institute for Technical Information of the Building Materials Industry of China, discussed Chinese cement production, its energy efficiency and CO₂ reduction potential.

Primary energy use for cement production in China was around 157 Mtce (4.5 EJ) in 2005, 74% of which is fuel for the kilns. CO₂ emissions amounted to 0.8 Gt. It is estimated that cement output will peak at 1.3 billion tons within the next 5 years. This will imply a massive shutdown of outdated equipment. The capital stock is quickly changing as vertical kilns are being replaced by energy efficient NSP kilns. Cement from vertical kilns is of lesser quality and only suited for rural use. Policies are aimed to phase-out vertical kilns. By means of process and equipment improvement, it will be possible to achieve CO₂ emissions reduction of 160-200 Mt in 5 years and savings may double in 10 years. The clinker/cement

ratio is 0.7-0.75, which is low. Further improvement will require new technologies for fly-ash treatment and other waste derived feedstock types. Also increased use of wood building materials as a substitute for concrete is being considered as a long-term strategy. It is estimated that one fifth to a quarter of all coal used for cement production could be replaced with alternative fuels derived from municipal solid waste, yielding a CO₂ emission reduction of 0.2 billion tonnes. The Eleventh Five-Year Plan includes a target of 20% for energy efficiency improvements by 2010 for all industrial plants, including cement kilns.

Two regions, India and Latin America, were addressed by *Ken Rumph, SBS*. He summarized the production volumes, energy use and CO₂ emissions; the emission reduction potentials such as use of alternative fuels and raw materials; and policy/ barriers and carbon leakage issues.

India has a 6% share of total world cement production. About 7 % of all cement (10 Mt/yr) is exported to neighbouring countries and the Middle East. Data availability poses a challenge, as different sources give quite different energy efficiency estimates. In a decade, the clinker factor has decreased from 0.89 to 0.76, but a further reduction is limited by the shortage of alternative feedstocks. Today 96% of all fuel is coal. Alternative fuels are being considered but their availability is limited. The kilns have limited heat recovery. Use of waste heat for power generation is being considered, but there are regulatory barriers for auto-production.

For Latin America, data availability on a country level is limited. More information is available at a company level. New capacity is only added at a low rate because growth is limited. Recent data from Holcim Brazil suggests an 80% share of alternative fuels, mainly biomass.

Arnaud Pinatel, Exane BNPParibas, delivered a presentation about Russia. Russian cement demand was 150kg per capita in 2005, lower than 1990 levels. Average annual demand growth was 7% in the last 5 years. The average kiln is 50 years old and 85% of the capacity is based on the energy inefficient wet process. For decades, the industry had no incentive to invest in upgrading technology because of low profitability, and low energy prices compared to other regions. The main fuel is natural gas. The clinker factor is high.

Russia represents 3% of the world cement industry CO₂ emissions, which counts for about 60Mt of CO₂ in 2005 (BNP estimation) and this level is assumed to grow by 60% by 2010 (assuming 0.82 tonnes of CO₂ emissions per ton cement and no change in current practices). To meet projected demand growth, 25 to 30Mt of new production capacity are scheduled, equivalent to 40% to 50% of the existing operational capacity. This offers an opportunity for efficiency improvement.

Energy Efficiency and CO₂ Reduction Technology Potentials

The session included four speakers who provided perspectives on technologies and practices used around the globe to improve energy efficiency in the cement industry. Some speakers focused on globally used technologies, while others highlighted practices used in Japan and China, and methodological aspects for counting potentials.

Palle Grydgaard, FL Smidth, opened the session with a presentation on various technologies that are being used to reduce energy intensity and CO₂ emissions in the global cement industry. He began by highlighting certain key trends that reduce CO₂ emissions, including the shift from wet process to dry process; the shift to larger (> 5000 t/d to 12000 t/d) and more efficient units (< 90 kWh/t cement; < 3 GJ fuel/t clinker); the increased use of alternative fuels and feedstocks; increased automation for quality; and generally an increased focus and concern about the environmental impact of cement production. He proceeded to discuss various practices and technologies that are used to improve energy efficiency, including maximizing kiln loads, faster kiln rotation, mechanical flow regulators, and the use of seals to trap in heat. This was followed by a discussion of the increased use of waste fuels -- tires, plastics, wood, trash, etc.. New burners allow a higher share of alternative fuels in the rotary kiln, where about half the fuel is burned. Depending on the alternative fuel type, between a few percent and half of the fossil fuel can be substituted. A new supplemental unit has been developed (named "hot disk") that can be added specifically to the calciner unit to burn tires and other waste materials. About half the fuel is burned in the calciner, and 80-90% alternative fuel use seems feasible. The economics and availability of waste fuels varies. Also a new technology for heat recovery from the hot sintered clinker has been developed.

Lynn Price, LBNL, focused on energy efficiency and low-CO₂ technologies and practices in China. In the past vertical shaft kiln technology dominated, which has a low efficiency and has higher environmental impact than the alternative rotary shaft kilns. Government policy stipulates that no new vertical shaft kilns should be built or renovated. In the past few years a rapid shift from vertical shaft to rotary shaft kilns has occurred, as part of the government's effort to increase energy efficiency and for cement quality reasons. The speaker provided detailed information on the many cement kiln types found in China and discussed her estimates of CO₂ emissions from Chinese cement production which indicate primary energy use of 5.5 EJ and CO₂ emissions of 974 MtCO₂ in 2004. The speaker also provided information on energy efficiency improvement opportunities and the use of waste-derived fuels, including case studies from China.

In 2005, China announced that energy use per unit of GDP must decline by 20% between 2005 and 2010. One key program for realization of this target is the Top 1000 Enterprise Energy Efficiency Program in which energy consumption targets are set for 2010 for the participating enterprises and both the government and the enterprises work toward achievement of the goals, with the government providing supporting policies and programs and the enterprise implementing energy efficiency technologies and measures. This program includes 85 cement companies.

Toshio Hosoya, JCA, briefly summarized the Japanese cement industry's electric consumption and technology trends. Finish grinding process counts for 39% of total electricity consumption at a plant in Japan, milling and crushing raw material process 28% and pre-heater and kiln process (fan and coal mill) 30%. He highlighted the growth in the use of alternative fuels in the cement process, including some data on the breakdown of energy use between the major phases of cement production. The power purchases from the grid have declined substantially in favor of own power generation from fossil fuels. The share of autogeneration from fossil fuels increased from about 25% in 1990 to 60% in 2005. The share of power generation from waste heat has decline dfrom about 15% in 1990 to 10% in 2005. He then listed some energy efficiency measures that are in use at plants in Japan, and closed with the cost of power generation from waste heat at a Japanese plant (investment cost about USD 2000/kW for a production of 35-40 kWh/t clinker).

Kanako Tanaka, IEA, made a presentation on conceptual issues of methodology using diffusion ratios of energy efficient technologies/processes for estimation of energy efficiency/CO₂ reduction potentials. This approach avoids detailed assessment of the energy efficiency of the whole facility, as it focuses on specific technology options. Barriers of social/economic/market nature reduce the technical potential further. Economic cost of reduction is relatively straightforward. The approach allows the identification of specific projects and measures that can be a basis for country cooperation.

Alternative fuels, feedstocks & processes

Patrick Verhagen, Holcim presented potential and opportunities for increased waste use. The word "co-processing" is referring to the use of waste materials in industrial processes. Alternative fuels use in cement kilns should be recognized and encouraged as a solution for hazardous waste treatment, CO₂ emission reductions on a global perspective, and reduced fossil fuels dependency. About 32% of European waste can be co-processed in cement kilns. This would avoid the use of incinerators. Waste co-processing needs to be stimulated by policies which stimulate treatment / recycling / source separation.

More specifically, as one of the uses of waste, the application of municipal solid waste (MSW) in cement kilns in Japan was introduced by *John Saunders, Taiheiyo Cement*. Most MSW is incinerated in Japan to reduce the volume, but the ash generated still remains a burden (38Mt/yr MSW to 6.1 Mt of ash) and has to be disposed of in landfill sites. However, the installation of pre-treatment facilities to wash the incineration ash enables its use as a cement raw material. MSW can also be delivered directly to a cement plant without having been pre-sorted or incinerated. In this case, the MSW passes through a bio-digester (converted from a redundant cement kiln) after which it is easily sorted and separated and used as cement raw material and fuel.

Claude Loréa, CEMBUREAU, addressed general and technical information as well as the European situation in the use of alternative materials and fuel use for clinker production. The cement industry offers a unique opportunity to co-process wastes, thereby saving natural resources. The chemical composition of clinker limits the use of alternative feedstocks. Pre-treatment may be needed in order to achieve consistent material characteristics. In general, no significant impact on the environment has been recorded when co-processing selected waste streams as alternative fuel/material.

John Davison, IEA GHG R&D Programme talked about the high potential for CO₂ capture using chemical absorption systems. Post-combustion capture or oxy-combustion seem the best solutions for cement kilns, as pre-combustion capture would not capture the bulk of the CO₂ resulting from the calcination reaction. Flue gas from kilns has a much higher concentration of CO₂ than exhausted gas from power plants. Costs are expected to be broadly similar to capture cost for power plants.

In the final presentation, *Ellis Gartner, Lafarge*, introduced the option of low CO₂ cement. Such cement types would have a different composition that requires less or no calcium oxide, which would avoid process emissions. The production of alternative cement

such as “BCSAF”² clinkers emits about 25% less CO₂ than conventional cement, for roughly equivalent performance. These clinkers can be made in existing plants. Development of such clinker substitutes requires a good understanding of “cement science”. Further development of this option will require a “scientific” approach by the whole industry, including the concrete industry, better performance-based cement & concrete norms and education of end users.

Barriers and Opportunities: Policy and other Market Mechanisms

A key issue for all regulatory and voluntary approaches is the data collection and verification, both as input for negotiations and for measurement of compliance.

More abstract discussion considered the final goal of sectoral compliance with emissions reductions, relative to targets according to federal jurisdiction. Participants debated how such units of compliance could level the playing field for concrete installations, otherwise operating within an international competitive market distorted by national carbon constraints of variant stringency.

Consensus emerged regarding the importance of learning-by-doing, of constructing and using reduction mechanisms of broad coverage, however imperfect. Participants emphasized the importance of policy instruments that reduced emissions leakage to less-stringent production sites and mentioned the merits of instruments built on eventual objectives, not on specific technological prescription. Many participants voiced support for objectives benchmarked on energy performance.

Bruno Vanderborcht, Holcim, presented the evaluation of the EUETS for the cement industry. The EUETS is a remarkable political and business achievement and has placed CO₂ emissions and reductions firmly on the cement industry’s business agenda. The EUETS national allocation plan (NAP) 2005-2007 do not reward the three key drivers for emissions reduction; notably the reduction of clinker content in cement, investment for cleaner facility and the use of waste as a fuel. It creates a competitive distortion within the EU and outside the EU. It creates an incentive for reduced activity.

The EUETS concept is acceptable, but the current NAP is not. Allocation discrepancy is due to industrial lobbying and to the decrease in production, relative to the reference period for allocation. Benchmarking (performance based) allocation should be used in the future. Trading on performance based allocation is compatible with WTO rules. Long-term converging differentiated benchmarking to seek predictability in 4 decades and to integrate international competition. For future setting of regional benchmarks, all manner of statistics would be required to construct a regional platform. Importance of inclusion of the developing countries was also stressed and some related ideas considered.

David Pockington, British Cement Association, addressed UK views on barriers and opportunities of market and other mechanisms especially on UK climate change levy (CCL), UKETS and EUETS. The UK scheme was innovative but flawed. Decision-making that involves plant investments must account for a realistic timeline of construction and deployment. Policy uncertainty plagued decision-making under the EUETS and the UKETS. Drawbacks of the CCL approach were discrepancies between individual sector contributions; an arbitrary basis for exemptions; incompatibility in methodology with EUETS; and different price of carbon in the CCL and the EUETS. The resulting policy redundancy has resulted in a lot of bureaucracy and inefficiency.

² Based on belite, calcium sulfoaluminate and calcium alumino-ferrite.

Andy O'Hare, PCA, explained US Energy Star scheme using the spreadsheet of the actual evaluation. In the US, two voluntary initiatives are operational: the Energy Performance Indicator and Energy Star. Both schemes evaluate the performance at the plant level. The Energy Performance Indicator is a benchmarking scheme with a rating from 0 – 100 within the US plant stock, where cement plants can gauge their efficiency relative to the past 30 years of datasets provided by the US Department of Commerce and the cement industry. The individual plant data, based on total primary energy, are not shared. As a marketing strategy, the Energy Star brand is granted for any plant achieving a 75 rating in terms of energy performance (i.e. any plant that is in the top 25% in terms of energy efficiency). The achievement is verified yearly, creating an annual incentive for performance improvements. Data are validated by comparing voluntarily-submitted data with data kept by the Department of Commerce. Energy Star is fuel-neutral, with no preference for plants burning biomass or alternative fuels.

The Japanese experiences with voluntary action were introduced by *Yoshito Izumi, Taiheiyo Cement*. The Nippon Keidanren (Japan Business Federation) voluntary agreement covers 45% of Japan's emissions at 1990 levels. Thirty five industry sectors are participating, including the transport and energy sectors. Each industry sector has an individual sectoral target and an action plan that is reviewed annually. The results are made public. The cement industry has a voluntary agreement, but there is no enforcement by the government. The cement industry has nearly met its 2010 reductions target (3% reduction of energy intensity compared to 1990 levels), and thus is considering a new, more stringent objective. The boundary for the cement industry is defined as follows: energy includes all input fossil fuels and purchased electricity (excluding alternative fuel), and cement includes exported clinker. Data collection is regulated by the JCA. Emissions reduction due to technology improvement has been almost saturated. Recent efforts have been focused on alternative fuel use.

Howard Klee, WBSCD addressed the views of several social and political issues on alternative fuel and materials use, such as public acceptance, regulation and standards. Though many merits were recognised, there are difficulties without the right framework. Main concerns are: public belief that alternative fuels may produce other emissions; communities' worries about health effects; alternative materials may require precautionary handling techniques for employee protection; potential for problems in transport and storage; and product standards based on composition rather than performance may restrict use. The application of wastes would need an enforcement with appropriate rules and systems such as: clear information to public with required reporting; management and monitoring systems with clearly documented facilities plans; and legislative and regulatory framework conditions.

The final presentation in this session was by *Philippe Quirion, CIRED*, on competitiveness issues including carbon leakage in the cement industry under CO₂ tax scheme and EUETS. He introduced the model-based study. Under the hypothesis that a 15 €/t CO₂ tax scheme is implemented in Annex B countries without either revenue recycling or border-tax adjustment. Significant CO₂ leakage (25% in 2010, 13% in 2020) would be expected, but the bulk of abatement remains (75% to 87%). The picture differs under the EUETS since emission allowances are re-allocated every five years (updating). If updating is based on emissions during the previous period, CO₂ abatement is roughly halved compared to an allocation without updating and the leakage ratio is similar. If updating is based on cement production during the previous period, CO₂ abatement in the EU is slightly reduced, but since

the leakage ratio is halved, world emissions are similar to an allocation without updating. In both cases, there would be no relocation. Leakage is due to overcapacities, not to new plants devoted to exports. Sensitivity analysis of the CO₂ price has not been carried out, but there may be a threshold value above which relocation would occur. Participants raised the importance of using appropriate values for assessment on the issue of carbon prices.

Existing and planned activities and the need for coordination

Howard Klee, WBCSD, introduced the WBCSD Cement Sustainability Initiative (CSI), which was led by member companies of WBCSD aimed at sustainable development. Regarding CO₂ and energy efficiency, current activities are aimed at updating and improvement of CO₂ accounting and reporting; development of guidelines for the responsible use of fuels and materials in cement kilns; and preparation of a protocol for emissions monitoring and reporting. The focus is now in development and implementation of specific projects aimed at 2020. They have established key performance indicators and defined good/best practice guidelines and measurement tools. No group target is set but individually set and signed by company CEO (on GHG, NO_x and SO_x). CEOs have agreed to external auditors to provide certification / verification starting from 2007.

Asia-Pacific Partnership (APP) on Clean Development and Climate. *Yoshito Izumi, Taiheyo Cement*, introduced the cement sector project in which Japan is taking the role of chair. As a first step the cement sector is conducting a survey on data such as production forecasts, CO₂ emissions, energy consumption and alternative fuel and resources, which will be published in 2006. They focus on the six APP countries: Australia, China, India, Japan, Korea and the USA. They also started to develop performance indicators aligned with the CSI guidelines and the G8 action plan, which include energy efficiency indicators and alternative fuel use factors. Goal is to estimate reduction potential of emissions in the cement industry of APP countries after developing a database of all cement kilns over the next 2 years and then to diffuse best available technologies.

Richard Baron, IEA offered an introduction to possible sectoral approaches to greenhouse gas mitigation, considering basic questions: which sectors/entities could participate in such an international approach? What would the approach consist of (benchmarking, rate of diffusion of technologies, a crediting mechanism...)? How would it function in light of the different parties involved (governments, in the intergovernmental climate change context, industry, in both domestic and international environments)? How would a sectoral approach address competitiveness concerns that prevail now, as the result of different levels of climate constraints across the globe? At the very least, a sectoral approach could provide a realistic look at key industry sectors, from the standpoint of mitigation technology, market growth and competitive pressures. Based on WBCSD experience, some participants noted that there may be an antitrust problem related to the gathering of energy use and CO₂ emissions data for an industry on a plant scale. Also not all forms of international, sector-based, cooperation may be allowed. It was noted that the Asia Pacific Partnership on Clean Development and Climate (APP) should help gather missing data from China, and provide an instrument for information sharing on energy efficiency.

More practical attempts to express energy efficiency based on benchmarking were summarized by *Ernst Worrell, Ecofys*. Benchmarking provides a tool for a fair comparison of performance and addresses the specific product and feedstock mix. Benchmarking efforts

are ongoing worldwide where methodologies vary and transparency would be necessary for broader acceptance. Many kinds of primary information, such as publicly available statistical data and more confidential data possessed by private companies, are used for setting benchmarks. Data collection and data accuracy would be difficult for some countries such as China. In UK, the national allocation plan for the EUETS relies on benchmarking data.

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