International Aluminium Institute

In support of the G8 Plan of Action

Energy Efficiency and Greenhouse Gas Reduction Potentials in the Aluminium Industry

- A Workshop in the Framework of the G8 Dialogue on Climate Change, Clean Energy and Sustainable Development-

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This document contains the proceedings of the workshop on energy efficiency and greenhouse gas reduction potentials in the aluminium industry which took place on 24 May 2007 in Paris. This workshop is part of a series of collaborative IEA-Industry meetings in the framework of the G8 Plan of Action on Climate Change, Clean Energy and Sustainable Development.

The objective of the workshop was to bring together an advisory group of Aluminium industry experts and IEA energy and emission policy experts to discuss issues related to past trends and future action potentials in the aluminium sector. This document reflects the presentations and discussions of the participants at the workshop.

Robert Chase (IAI)

The aluminium industry is leading in sectoral agreements. It has been successful in breaking down international cooperation barriers in this area. The steel industry has indicated that it plans to follow the same approach of setting voluntary sectoral industry objectives. International Aluminium Institute (IAI) and International Iron and Steel Institute (IISI) have agreed to give a joint side-event at the next UNFCCC meeting in Bali. This may raise interest for sectoral agreements in other industries..

Noé van Hulst (IEA)

The concept of sectoral approaches can have several interpretations, which should be discussed further with industry. IEA is aiming for a strong cooperation with industry in this field.

At the Gleneagles meeting the G8 countries indicated their determination to reduce emissions jointly. The Gleneagles Plan of Action (GPA) reaches out to key developing countries – the +5 (Brazil, China, India, Mexico and South Africa) where CO_2 emissions continue to rise rapidly. This year, China will become the world's highest emitter.

In its G8 program of action, IEA was invited to come up with alternative energy scenarios and strategies for a clean energy future. Further, GPA requested IEA to "transform the way we use energy". The IEA's programme of work was presented with a focus on the industry task (assess energy efficiency performance, identify areas for further analysis of energy efficiency measures by industry, develop indicators to assess energy efficiency, and identify best policy practices).

The aim of this industry related work is to have close cooperation, and obtain feedback on IEA analysis. The benefit of IEA's engagement in G8 is to channel concrete policy recommendations to Sherpas that prepare the Japanese G8 meeting that is schedule for early July 2008. The G8 Sherpas will convene in March 2008.

Dolf Gielen (IEA)

The IEA has completed a new study *Tracking Industrial Energy Efficiency and CO_2 Emissions*. On a global scale, the aluminium sector represents about 2.8% of world electricity demand (1.7 EJ / year of electricity for smelters). Globally smelters show a narrow electric efficiency range, compared to variations in energy efficiency in other industries. Therefore the energy efficiency potential in primary smelters is limited. The average efficiency has improved by 0.4% per year between 1980 and 2005. Industry is the only source for comprehensive data on aluminium materials flows through the economy. An important characteristic of the aluminium cycle is that the stock of aluminium in use is still rising rapidly. This limits the recycling potential significantly. A key question is the remaining recycling potential, about 3.5 Mt of used aluminium is not accounted for in the present industry data.

Aluminium is a commodity with a single world market. Indirect emissions are very important because of the dominant share of electricity in the energy mix. As a commodity with a global market and high energy intensity, carbon leakage (due to industry relocation) may become an issue if certain countries adopt CO_2 policies. Competitiveness may also be affected. It is important that emission mitigation efforts focus not only on the production step, but also consider the full life cycle as, for example, aluminium can save energy in light-weight applications.

A number of cooperation avenues between the IEA and IAI were proposed: more detailed indicators on a country level, a review of technology options, scenarios and policies and measures including sectoral approaches.

Jerry Marks (IAI, PFC Consultant) Present progress and scope for further GHG emission reductions

Aluminium industry represents approximately 0.6% of world GHG emissions excluding electricity. If we include electricity emissions, it accounts for 1.4% of the total. This compares with 5% for iron and steel, and 4% for cement.

IAI covers 63% of world production in its energy survey, 69% if all Russian production is included (as planned). The key missing country is China, which accounts for 28% of world production. The average energy efficiency in China is estimated to be close to the world average.

The Aluminium for Future Generations is the global aluminium industry's sustainability initiative coordinated through the IAI.[1] At the heart of the initiative are a series of twelve specific sustainability objectives that have been set by the Institute's directors, each with its own indicators and monitoring method. Five of the eleven current objectives address the issues of reducing greenhouse gas (GHG) emissions and improving energy efficiency. The Institute also has an action plan to achieve these objectives. One of the most effective measures aimed at meeting improvement objectives is conducting regular surveys of member companies of performance in key areas that contribute to meeting the sustainability objectives. The survey results are analyzed and coded to maintain confidentiality and then reported to survey participants, including the CEOs and Presidents of member companies. These benchmark results allow the companies to assess their performance in the context of similar operations and contribute to setting meaningful improvement objectives.

Benchmarking is something the sector has been doing for a number of years.

- On electricity input, 15.3 MWh / t Al – IAI survey results show worldwide on average 5.4 t CO_2 / t primary aluminium of indirect emissions from electricity use. This estimate excludes results from China which does not participate in the survey. While no direct information is available on Chinese electrical sources, they are expected to be weighted toward coal as an energy source raising the global average indirect emissions per tonne aluminium when they are eventually included.
- There has been significant progress in perfluorocarbon (PFC) emission reductions: from 4.4 t CO_2 eq / t Al in 1990 to 0.96 t CO_2 eq / t Al today. PFC emissions contribute now approximately 31% of direct primary aluminium GHG emissions for production processes from mining bauxite, refining alumina, electrolysis and casting (not counting indirect emissions from power generation). Anode carbon accounts for approximately 1.6 t CO_2eq / t Al.

The production cycle of aluminium includes bauxite mining, alumina refining, smelting, casting, product fabrication, and recycling. The largest source of both direct and indirect GHG emissions in the production of aluminium comes from the primary smelting operations. Direct emissions from smelting result from the electrolysis reaction using carbon anodes that releases carbon dioxide and from time to time, when the process is out of balance, two perfluorinated carbon

[1] Available at http://www.world-aluminium.org/iai/publications/sustainable.html, June 2007.

compounds, CF_4 and C_2F_6. If we look at the sector's total direct emissions, smelting represents 50% of aluminium GHG emissions (80% if we include indirect emissions).

The IAI members are close to reaching the 2010 IAI PFC emissions objective of an 80% reduction in PFC emissions per tonne aluminium from the 1990 baseline. Current performance is a 78.6% reduction in PFC emissions per tonne of Al produced compared to 1990. The Industry has focused on improved work practices and process control to reduce PFC emissions. There has been a massive change in the overall technology mix worldwide as new smelters have come on-stream and old smelters have been phased out. The most efficient, lowest emitting technology has increased its share from 31% to 73% from 1990 to 2005 (PFPB Point Fed Prebake smelters). This estimate includes Chinese smelters. In absolute terms, CO_2 emissions have increased by 62% while PFC emissions have decreased by 64% over the same time period.

The Industry continues its efforts to reduce PFC emissions along with reduction in the electrical energy required to produce aluminium. The survey benchmark results show that there is still substantial improvement potential. PFC emissions could be reduced by still another one-third if all producers operating with emissions performance poorer than the IAI median could improve to median performance.

The largest proportion of GHGs from aluminium production is nowadays the indirect emissions associated with the production of electricity used in the smelting process. These indirect emissions can range from near zero for electricity produced with hydropower, to as high as about 20 t CO_2 per tonne primary aluminium when coal is used to generate electricity. Member survey returns show that about half of primary aluminium is produced using hydropower. Taking a holistic view of the mining, refining and smelting processes with today's production technology mix there appears to be GHG reduction potential of as much as 25 Mt CO_2-eq. These gains are, however, only part of the potential for aluminium. Modelling studies show that GHG savings from the use of aluminium as a light weighting material in transportation vehicles could result in GHG savings from improved fuel economy that would completely offset the GHGs from production of the metal in the future.

IAI has made a "what if scenario" for PFC emissions where every producer that performed poorer than the median were to improve to the median performance the global average could be improved to 0.63 t CO_2 eq / t Al from the 2005 result of 0.96 t CO_2 eq / t Al. The best smelters emit only 0.20 t CO_2 eq / t Al. However, bringing everyone to the benchmark level is not possible on the short term because not all have the same smelting technology.

Dr Patrick Atkins (IAI Consultant): energy efficiency

Energy management is an important issue for the worldwide aluminium industry. Improvement of energy efficiency is a challenging problem and an important issue. Efforts to reduce energy use have been underway since the industry began 120 years ago. It is in the industries best interest as a way to reduce cost and significant efforts have been aimed at achieving this goal. Considerable progress has been made, but many of the major process operations are still less than 50% efficient due in large part to the process requirements of heat balance, limitations on heat exchanger capabilities, materials of construction requirements to deal with the aggressive process environments, sensor limitations and management complexities for large integrated process operations.

Energy conservation approaches cover:

- Process improvements through monitoring and controlling innovations
- Process system and equipment innovations (designing and building more efficiently)
- Process and system management would reduce energy use
- Waste heat recovery and reuse could also reduce energy use. This is the "holy grail" of the industry but there are many challenges.

Three focus areas for energy use reduction are:

- Refining process (or alumina production): a series of heat exchangers are applied in alumina production. Still 60% of energy input into the calcinations process is lost or 100 MW per calciner.
- Smelting cell operation: (40% of energy input is lost); 150 MW per smelter energy use
- Melting, holding and casting operations in the ingot production plants: 60% of the energy input into the molten metal furnaces can be lost. Typical energy needs are 15 MW per large furnace.

IAI routinely collects data on the refining and smelting energy use from the global industry and provides the data to the industry as a means to help establish energy use benchmarks for various processes. The following benchmarks have been defined

- Refining: Average 10.5GJ/t Benchmark: 6.5
- Smelting: Average 15.3 MWh/t: Benchmark: 13.3
- Remelting: Average 4.5GJ/t: Benchmark 2.1
- Casting: 0.5GJ/t: Benchmark: 0.3

Since the industry continues to grow rapidly, the addition of modern refining, smelting and ingot casting plants will help reduce the energy average usage for the industry. As process sensor technology and control systems improve, additional energy reductions will result as they are applied to existing as well as new facilities.

Energy use reductions will be complicated by the long capital turnover of the industry where plants can operate for 50 years or more. The current limitations on process sensors and the difficulties of managing complex interconnected processes to eliminate excess energy use will limit future reductions.

Discussions

Q: Are you trying to track indirect emissions from electricity use? How does secondary aluminium affect the overall picture? Is biomass an option at all in the anode?

A: There is no serious effort to use biomass for anodes. There are limited sources of materials to which the industry has access to for the anode.

Regarding indirect emissions, the IAI tracks annually emissions from electricity and these are available on the IAI website. Some data are based on national grids, but in some countries, there are no national grids (e.g., US, Russia, China). There can also be regional or provincial differences such as in Canada. It is important to use appropriate data.

China is not included in IAI data. This would be a good sector for an international sectoral agreement because China is already relatively efficient due to the young age of the plants in operation.

Q: Does the IEA have detailed information on Chinese power generation?

A: As part of the G8 Plan of Action the IEA Clean Coal Centre (CCC) is preparing an inventory of the efficiency of all coal fired power plants in the world, including China. This will be a public database, available via the CCC website.

Q: The IAI sustainability initiatives in PFC involved teams training other smelters on how to reduce emissions. While PFC reduction is not a competition issue, the situation may be different for energy efficiency as it may enhance the competitiveness of competitors?

A: Indeed the issue of PFCs reductions has no competitiveness consequences. For a given smelter and technology type, the actual performance depends on how well companies implement the training. Some other technology areas are important for the competitiveness. The industry is very careful when dealing with these technologies because of the potential legal consequences of information sharing. For example regarding waste heat recovery, the industry is very open on what it is trying to achieve, but when it comes to technology details, information is not shared.

It is recommended that continues to IEA use established IAI energy efficiency performance data in order to avoid confusion.

Uwe Remme (IEA)

Uwe presented the ETP scenario results for power generation: baseline scenario, ACT accelerated technology scenarios (+6% CO_2 emissions in 2050, compared to 2003) and TECH Plus scenarios (more optimistic scenario for energy efficiency improvements and costs, -16% CO_2 emissions).

One important option to mitigate emissions from fossil fuelled power plants is CO_2 capture and storage (CCS). The CCS data in the ETP model have been revised. 3 CCS options have been considered for natural gas and coal plants: oxyfueling, chemical absorption, and IGCC with pre-combustion capture, and the latest CCS cost data were presented. The latest model runs assume higher CCS cost for industrial processes and show higher CO_2 emissions at USD 25/t CO_2 than the ACT Map scenario.

Baseline power generation is dominated by coal. In the MAP scenario CCS plays an important role. The greatest CO_2 reductions for power generation arise from efficiency gains in electricity end-use.

The scenarios project that:

- CCS can become a key abatement option; renewables can increase by a factor of 4.
- Aluminium production accounts for 3% of global electricity demand in 2050 as aluminium production triples by 2050.
- CCS adds USD 10-20 / MWh to power generation cost, which equals USD 150-300 / t Al

In December IEA will release a new study on *Prospects for Industrial Energy Use and CO_2 Emissions* as part of its G8 Plan of Action. This will include a discussion of energy efficiency and CO_2 reduction potentials for aluminium, including new technologies. A first workshop for discussion of DRAFT scenario results will be held 1-2 October in Paris at the IEA headquarters. IAI will be invited to participate.

The ETP2008 publication will be input for the 2008 G8 summit. The IPCC 4th assessment report indicated that emissions should be reduced by 50-60% compared to 2050. IEA may therefore analyse more ambitious emission reduction scenarios in ETP2008.

Ken Martchek (Alcoa)

This presentation highlighted the development and utilisation of global and regional mass flow models and related GHG emissions by the aluminium industry. Past and current mass flows and emissions intensities are based on statistics reported to global and regional aluminium associations by industry members, producers, and suppliers.

Future mass flows and emissions projections are based on estimates of: 1) future market demands, 2) recycle metal returning to the industry from customers, 3) recycled metal products that have reached the end of their useful lifetimes, and 4) anticipated trends in efficiency and technology improvements. The models have been useful to quantify various future scenarios such as the potential of reaching voluntary objectives, achievable benchmark performance and the promise of future efficiency and technology advancements.

In 2006, total recycling of scrap exceeded primary aluminium production. Data on trade flows are available for Europe in 2004, but not for all regions. GHG emission intensity of primary aluminium operations is modelled. Data covers 65% of the world 2006 primary aluminium production. The share of the industry's total metal supply from post-consumer and customer (new) scrap has risen from 15% in 1980 to 30% in 2006.

Jürg Gerber (WBCSD)

It is important to consider the full lifecycle of aluminium and not only the production process. A policy message for the G8 could be that behaviour needs to be changed and adapted in order to enhance recycling. Without recycling, the industry would not be able to satisfy demand, nor be as sustainable (95% energy savings compared to primary smelting production). Recycling is important in North America, Europe and Asia. The number of recycling plants is much bigger than the number of smelters. Collecting recycling companies are often not the same companies as remelting companies and primary aluminium producers.

The term recycled aluminium has a more positive connotation than secondary aluminium and is therefore preferred.

Discussion

Q: How did you quantify strictness of regulation? A: Regulation strictness was based on a very qualitative scale.

Q: How can the gap between actual and needed clean investments be bridged? A: New policy signals are needed such as standards, CO_2 mitigation policies, etc.

Q: Is USD 25 really sufficient to achieve substantial emission reductions?

A: Probably not. The USD 25 / t CO_2 for CCS reflect the cost of this option. This does not imply that this is the incentive that would allow CCS development on a global scale. The cost in the coming decades will be substantially higher, but they are projected to decline in the coming decades as the technology matures.

Recyclers: IAI membership includes 30% of recyclers. There is a link between European refiners (they have cleaner inputs and may be able to produce other final products) and remelters (they receive all types of scrap). There is a strong competition for scrap – mostly all is exported to China today.

NB: Recyclers use mainly natural gas to melt and not electricity. There is a huge competition for the scrap metal. Alloys price quotations exist based on different qualities of the alloy. Generally scrap prices are linked to primary aluminium prices.

Robert Chase (IAI)

The International Aluminium Institute's Board of Directors is made up of the CEOs of the Member companies, which together produce 75% of the world's primary production aluminium and a third of the world's recycled aluminium. In 1980, Europe and US produced 51% of the world's aluminium, but this had fallen to 24% in 2006. In contrast China's production had risen from 2% in 1980 to 26% in 2006. The primary aluminium industry has been growing fastest in Non OECD countries. The aluminium industry needed therefore to adopt a global approach to climate change as less than 40% of aluminium production was covered by the limits of the Kyoto Protocol. Aluminium is truly a global industry and this poses a challenge for climate policies as 63% of the production takes place in countries that are outside the Kyoto framework. About 75% of the global production uses modern technology, and about 25% is based on old technology. This old technology is responsible for 60% of PFC emissions.

The IAI has developed the 'Aluminium for Future Generations' Sustainability Programme, which sets 12 demanding voluntary objectives backed by a set of 22 performance indicators which are designed to make the metal more sustainable. Four of these voluntary objectives form the basis of the IAI global strategy for addressing Climate Change: 1) an 80% reduction in perfluorocarbons (PFCs) per tonne of production by 2010 as compared to 1990; 2) a 10%

reduction in smelting energy per tonne by 2010; 3) a further improvement in recycling performance; and 4) a further contribution to the reduction of GHG emissions from transport through increased use of aluminium for light weighting.

The IAI's emissions reduction programme includes annual surveys, benchmark graphs and an expert with measuring equipment, who advises on how to improve performance. The industry also has common measurement and calculation tools. According to the survey results for 2005, there has been a 78% reduction in PFCs against the 80% target and a 64% reduction in global PFC emissions since 1990. PFC emissions have fallen from 86 million in 1990 to 31 million tonnes in 2005, despite a 64% increase in aluminium production.

The IAI global surveys now include PFC emissions from the Krasnoyarsk smelter in Russia (1 Mt aluminium / year) and will progressively include all Russian production. Russia has been reporting energy consumption to IAI for some time. Rusal is currently building a 3 GW hydroelectricity power station and a new 600 kt smelter in Siberia. The company is aiming for vertical integration to reduce the risk of climate policy exposure, based on the large remaining hydropower potential in Russia. The Chinese industry has designated two pilot plants, Pingguo and Qingtongxiao that will report their PFC emissions for 2006.

The successful reduction in global PFC emissions is due to heavy investment in the latest technology (which now represents 75% of smelting capacity), the phasing out of older technology and the adoption of best operating practices. The performance of Non OECD smelters currently participating in the IAI Annual PFC Surveys is comparable to those of the OECD due to the industry's success in transmitting best practice and the latest technology globally.

There is still however scope for improvement as the average variation between best and worst performers for all technologies is a factor of five. 20% of the smelting capacity is responsible for the remaining 65% of the global PFC emissions. Indirect emissions from electricity is now the major challenge and the industry is seeking to improve the energy efficiency of all its production processes. So far the industry has achieved 5% reduction in energy used for smelters per tonne of aluminium and a 10% reduction has been achieved for alumina production in the period 1990 to 2005. Recycling aluminium conserves energy and reduces GHG emissions. Currently recycled metal meets one third of the global demand and has already avoided 1 billion tonnes of emissions. Overall the results of the IAI Aluminium for Future Generations initiative show that voluntary agreements can work effectively in reducing GHG emissions.

Richard Baron (IEA)

There is growing interest in sectoral approaches to GHG mitigation as a means to both broaden the scope of GHG reduction policies beyond existing countries and activities, and address rising competitiveness concerns in trade-exposed energy and GHG-intensive industries (including iron and steel, cement and aluminium). The IEA is analysing the issue from an intergovernmental perspective – recognizing that there are efforts taken unilaterally by industry as well. The expertise inside sectors could, at least, provide useful information to guide future climate policy at country or regional level (e.g. inside the EU). Turning to developing countries, some may take commitments on the basis of given sectors, as a first step towards a broader contribution to GHG mitigation. In developed countries, views differ on the possible role of international sectoral approaches – differences explained by the existing GHG policy culture in these countries.

The discussion touched on whether the aluminium industry needed any government involvement to go further, in light of its current achievements under the aegis of the IAI sustainability objectives, and of a probably slow process if UNFCCC Parties where to adopt such a sectoral approach. The latter was not seen as a likely outcome.

Comment: APP has a broader scope than just aluminium (it has a clean energy task force). There is a concern that in fact "some countries will not take on targets" should be "the majority of countries will not take on targets". The UNFCCC process seems very slow and time consuming. The aluminium industry should not wait for the outcome of this process. China is the main challenge for a bilateral or multilateral approach. Rusal has already committed to a reduction of 50% by 2015 of its GHG emissions. This has been done on a voluntary basis, with the electricity price as driver for energy efficiency. Rusal would not want UNFCCC administration to slow down the efficiency of the voluntary agreement approach and company-led incentive system which is working well already. Industry players consider a further complication of the system as a potential deterrent (e.g., how would you allocate the target?).

Jane Ellis (OECD)

In 2006, transactions of carbon credits on the market were worth USD 30 billion. The Clean Development Mechanism (CDM) was worth USD 0.5 billion. Most of the monetary volume was in the EU ETS.

The Annex 1 countries accounted in 2000 for little over half of the world's GHG emissions. CDM is a project -by-project mechanism. It "should" also lead to a technology transfer, but there is no specific oversight if this really happens.

In January 2006, five countries accounted for 2/3 of expected credits. In April 2007, among these 5 countries, China represents more than half of the 327 Mt CO_2 / year expected credits. On a sectoral distribution, a large proportion is on end-of-pipe applications: HFCs and N_2O. Some sectors are not represented: the aluminium sector represents less than 0.1% in the total share of credits expected from the projects. Three projects deal with the aluminium sector: one for PFCs, one for a wind turbine, and one on fuel switching. This is three out of a total of 1900 projects.

It is remarkable that there are many CDM projects with a low CER return on investments projects such as in the field of renewable energy. This may be explained by the fact that there are other reasons for adopting renewables. For example China claims CDM credits for all its wind investments, a diversification policy.

CDM "programmes" are allowed since the Montreal negotiations. Projects need to be voluntary (as opposed to mandatory programmes). Under discussion are CDM projects for coal power plants.

In conclusion most CDM credits are expected from low-cost, low-risk, high volume, non-CO_2 projects. The price of CDM depends on who bears the risk of acceptance of the credits, and when you agree on the contract (e.g., before the methodology is approved, after the credit is issued, etc.).

Ken Martcheck (Alcoa)

75% of energy use in cars is related to mass. Therefore light-weighting is a major fuel saving option. More than $1/4^{th}$ of aluminium is used in the transport sector.

IAI has campaigned to say that light-weighting is an important component in GHG emission reductions from transport. The big opportunity is that the US fuel efficiency regulation (CAFÉ) is being revised. Light-weighting can contribute to fuel savings whatever material is used (e.g., high strength steel or aluminium).

Aluminium industry modelling has been extended to quantify the energy and emissions effects of customer, and ultimately, consumer usage and recycling of aluminium products. The high strength to mass ratio, durability, recyclability and other performance characteristics of aluminium contributes positively to the energy efficiency of transportation, packaging, and building products. The life cycle effect of the use of aluminium products in transportation and other applications has the potential to avoid emissions in excess of the emissions of aluminium production by and after 2020.

Peter Taylor (IEA) explained possible future cooperation between IEA and IAI, after providing a brief summary of other energy indicators work (work with the +5 countries and Russia, additional work on industry and China and indicators for power generation).

The potential cooperation was described as twofold: energy and emissions performance indicators, and IAI participation in analysis of the potential for sectoral approaches to GHG reductions (understanding the regional nuances and national circumstances).

Discussion

Comment: The focus should be on energy efficiency, and sectoral approaches not necessarily weighted too much. On the data, integrity of IAI data is based on the anonymous regional data. In certain cases it will be difficult to obtain country data (e.g., only one producer left in Russia).

The industry is committed to the IAI voluntary agreements. This is a sectoral approach, but not a sectoral agreement. APP follows the same approach and works closely with IAI.