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IMPROVING ENERGY EFFICIENCY IN THE IRON AND STEEL SECTOR: OPPORTUNITIES AND FINANCING CHALLENGES

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Improving energy efficiency in the steel industry is an important way to boost the viability and overall competitiveness of steel producers, particularly those that do not have mining assets or rely on costly raw material inputs. Greater energy efficiency, which can often be achieved at little cost, is also good for the industry's environmental performance. Some projects, however, are very expensive and often depend on financing mechanisms supported by government policies and measures. Past discussions of the Steel Committee on environmental issues have focussed largely on technology developments, with financing issues receiving less attention. For this reason, the Secretariat sought the expertise of the Institute for Industrial Productivity and requested the attached study that examines opportunities for improving energy efficiency in the steel industry and the types of financing mechanisms used by countries to implement energy efficiency projects. Delegates are invited to consider the effectiveness of existing energy efficiency policies and how to finance them

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1. Executive summary[1]

1. As the world moves to respond to the threat of climate change, energy efficiency is increasingly being seen as one of the most cost-effective solutions to cut growing greenhouse gas emissions.[2] In fact, energy efficiency – which means using less energy to provide the same service – could reduce industrial energy use by over 25 per cent (IEA, 2012). Industrial emissions currently account for a third of global emissions, more than any other sector of the economy.

2. In contrast to many other proposed solutions to mitigate climate change, both industry and policymakers stand to gain by improving industrial energy efficiency. Enterprises can save up to 10-30 per cent of their annual energy use – and therefore their energy budget – through better energy management (Reinaud et al. 2012). They can also increase operational efficiency and productivity and improve risk management. Energy efficiency brings a host of other benefits to human health and the environment.

3. In the context of the steel industry, energy efficiency, in most cases, reduces enterprises' environmental footprint and reduces local pollution. It is also good for the viability of the steel industry as energy efficiency increases industrial entities' overall competitiveness and profitability. However, although considerable improvements have been made in recent years, the iron and steel sector still has the technical potential to reduce energy consumption and CO_2 emissions by another 20 per cent, saving 5.4 EJ of energy and 400 Mt of CO_2 (IEA, 2012).

4. Some improvements in energy efficiency can be done at low cost, or even no-cost. While many low-cost solutions are available, some technologies (e.g. BF-Top Gas Recovery) are still quite expensive, which limits their broader uptake. A major shift in thinking will be essential to drive the uptake of energy efficiency measures and ensure that all companies implement the cost-effective measures. An important question is why some firms in the steel sector are not undertaking no-cost or low-cost investments which improve energy efficiency, and what this means for policymakers.

5. To increase energy efficiency in the iron and steel sector, governments across the world have generally developed policies that allow flexibility. This is mainly due to the fact that the sector spans a wide variety of sub-sectors, all with different energy consumption profiles (World Energy Council and

1 Julia Reinaud and Hannes MacNulty produced this paper on behalf of the Institute for Industrial Productivity (IIP) as part of its work to raise awareness about the value of industrial energy efficiency and drive the uptake of energy management measures by industry. Anthony de Carvalho, Laurent Daniel, Kassy Hayden and Murat Mirata reviewed the paper and provided valuable comments.

2 Energy and carbon efficiency are usually complementary objectives for many industries: the lower the energy consumed – usually burnt – the lower the carbon intensity. However, steel is different, as it uses its main source of energy to produce coke, not because of its thermal energy content, but as a reducing agent (Renda et al., 2013). Further, in most cases, GHG emission mitigation and energy efficiency efforts go hand in hand. One exception is carbon capture and storage, since use of this technology will increase the energy consumption levels of steel mills.

Ademe, 2013). Existing policies that target industrial energy efficiency typically aim to help industries identify which investments are the most cost effective as well as encourage them to make the investment in energy efficiency, either by reducing the payback time of these investments and measures (e.g. subsidies and loans), by mandating (e.g. energy-saving targets and emissions trading) or by encouraging implementation (e.g. voluntary agreements and differentiated electricity pricing).

6. The analysis that follows shows that, while each country has quite a different approach to industrial energy efficiency policy, in general all countries provide flexibility in how companies lower their energy consumption. This is especially true for *(i)* policies that rely on efforts from companies, *(ii)* those that mandate a maximum amount of energy per tonne of steel, *(iii)* those that require companies to identify energy efficiency opportunities, and *(iv)* those that reward overall energy performance improvement as opposed to targeting specific technologies and measures. However, within these flexible policies, there are often mandatory requirements within voluntary agreements (such as the adoption of energy management systems) and/or penalties for non-compliance.

7. The types of policies that are more restrictive are those that target maximum energy consumption for certain types of equipment or the installation of specific equipment, those that require companies to undergo energy audits, and those that mandate companies to close inefficient plants, as is discussed later in this report.

8. Government-led financing mechanisms have been developed by some countries to leverage and help unlock private sector financing for energy efficiency in industry. However, governments typically only have limited funds to support the widespread implementation of energy efficiency. Key issues for governments in this context have, therefore, revolved around the competitive advantages stemming from energy efficiency improvements and ensuring that financial mechanisms that leverage additional funds are in place.

9. However, good design of successful financial mechanisms can be difficult to achieve due to the many variables at play, particularly where energy efficiency projects are developed in an environment where traditional business models are primarily used. As a result, financial mechanisms need to be designed to address these specific key conditions, either in parallel or through separate initiatives. While awareness building and financial leveraging are the primary components of a successful financial mechanism, their design will also typically have to take into account a multitude of other classic project financing barriers. They will also have to address the specific characteristics of energy efficiency projects and be able to be adapted to the needs of industry and the market. Given the private financial benefits associated with energy efficiency improvements, it is important that government financial support mechanisms are designed correctly and adapted to market conditions in such a manner to avoid potential unintended consequences that can be associated with such incentives or subsidies.

2. The iron and steel sector: some key indicators

10. Iron and steel are key products for the global economy. Since 2000, global steel production has grown by 82%, reaching 1.546 billion tonnes of steel in 2012 (World Steel Association, 2012).

11. The sector is the largest industrial emitter of CO_2 (with direct emissions of 2.3 Gt in 2009), and the second-largest industrial energy user (consuming 26 EJ in 2009). The iron and steel industry also uses vast quantities of other resources, including iron ore, coking coal, water and chemicals.

12. Energy costs represent around 20-25% of the total input of steel producers. Lowering these costs has become one of the most important priorities for steel producers (Horvath, 2012). There is also a

broader trend towards reducing resource consumption, minimising greenhouse emissions and making operations eco-friendly, sustainable and more cost effective.

13. However, although considerable improvements have been made in recent years, the iron and steel sector still has the technical potential to reduce energy consumption and CO_2 emissions by another 20 per cent, saving 5.4 EJ of energy and 400 Mt of CO_2 (IEA, 2012).[3] While technological progress is needed to achieve some emission reductions, efficiency gains and the deployment of existing low-carbon energy account for most of the savings, according to IEA estimates (IEA, 2008).

3. The benefits of industrial energy efficiency

14. Energy efficiency offers one of the most cost-effective solutions to curb growing greenhouse gas emissions and tackle climate change. It also makes good business sense as it increases industrial entities' competitiveness and profitability. In the steel industry, energy efficiency is a key lever to maintain the viability of steelmakers that do not have mining assets as energy efficiency increases industrial entities' overall competitiveness and profitability.

15. In addition to saving energy costs, energy efficiency can also increase manufacturers' operational efficiency and productivity and improve risk management, as highlighted in the OneSteel case study below. The return on energy efficiency investments can be quite high. Examples from the past include Weirton Steel, which saved USD 17 million annually by investing in a new control system to improve plant efficiency and productivity. The project's USD 16 million cost was paid back in 11 months.[4] Bethlehem Steel Corporation also saved USD 3.3 million annually by improving the capacity and efficiency of its steam turbine generators at its Burns Harbour Facility in Indiana. The project's USD 3.4 million in costs paid for itself in just over one year.[5]

16. Energy efficiency improvements can also free up resources for investment in new machinery and further improvements in the production process – boosting competitiveness, productivity growth, employment and wages (UNIDO, 2011). In addition, energy efficiency so helps lower maintenance costs, increase production yield and provide safer working conditions. These improvements are collectively These improvements are collectively referred to as 'productivity benefits' or 'non-energy benefits' (NEBS).

Box 1. Case study: OneSteel

Mandated to conduct an in-depth energy assessment under the Australian Energy Efficiency Obligation scheme, OneSteel identified 15 energy-saving opportunities for its Newcastle Rod Mill. The 11 opportunities selected for adoption were expected to achieve annual energy savings of 68,000 gigajoules (GJ), or over six percent of total energy use. Other operational and business benefits were also achieved during implementation. For example:

- The installation of oxygen sensors in the reheat furnace, which are used to adjust the air to fuel mixture, increased yield by approximately 0.2 percent. This equates to savings of over D 300,000 per year.
- The installation of more efficient air compressors reduced operational risks because they were more reliable and easier to maintain than older models.

Source: www.ret.gov.au/energy/Documents/energyefficiencyopps/PDF/OneSteel%20Case%20Study.pdf

3 *Energy Technology Transitions for Industry.*

4 www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/weirtont.pdf

5 www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/betsteel.pdf

4. Removing the barriers to industrial energy efficiency

17. Despite the potential benefits, many industrial enterprises have been slow to adopt energy efficiency measures. There are a range of barriers that are slowing this uptake. One of the biggest roadblocks is a general lack of support from senior management. As a result of this organisation failure, plant managers tend to focus on meeting production targets rather than managing the use of energy. Other barriers include low or subsidised energy prices in some regions, perceived technical and operational risks associated with the implementation of energy efficient practices, and market failures such as limited knowledge of new energy-saving technologies and strategies or a lack of access to capital (UNIDO, 2011). In some cases, companies might also hesitate about investing in technologies that do not have a primary focus on increasing production capacity and revenue. This can result in a certain resistance to stand-alone energy efficiency investments.

18. Both governments and industry have been looking at potential solutions to the wide range of barriers – many of which can be overcome with the right approach, commitment and investment. To be effective, government-initiated energy efficiency policies and programs must have a combination of drivers, such as energy efficiency standards or targets, incentives and support mechanisms. Existing support mechanisms include capacity building for adopting corporate energy management systems (EnMS) and energy audits that help industries identify which investments are cost effective, as well as financial incentives (such as soft loans and grants) to reduce the payback time of these investments and measures and make them more attractive to industrial consumers. They also include recognition programs, or better access to information and technical tools. These address the specific barriers that enterprises face, such as a lack of capacity, finance or limited access to technical knowhow. [6]

19. Governments can also play an important role in establishing a framework to stimulate the uptake of energy efficiency by promoting the creation of new business opportunities associated with industrial energy efficiency, such as clean energy markets or energy efficiency professional services like technical assistance, and verification and certification bureaus. Governments can also help create a favourable framework by developing dedicated financial mechanisms that lower the inherent risks for the sponsors (such as the industrial end-user or the energy service company developing the energy efficiency project) and overcome project finance-related barriers.

5. Types of energy efficiency measures in industry

20. There are numerous opportunities for industrial enterprises to be more efficient and even to produce their own energy from industrial processes. Energy savings in industry can be achieved through better management as well as new investments. No-cost or low-cost improvements in energy management can often lead to significant savings even before any investment is needed.

6 There is inherent inertia in the energy efficiency process – e.g. the practice of delaying an upgrade to more efficient equipment if the existing equipment still operates. Businesses often do not make contemplated investment in energy and process efficiencies until capital equipment actually breaks down or is due for a scheduled upgrade or replacement. Getting businesses to accelerate investment decisions to capture energy and process efficiencies typically requires an external influence or education about the benefits. Given that capital investment is required to realise the energy and process efficiencies, access to investment and finance are integral components of the decision-making process.

Box 2. Payback period of specific energy efficiency projects in the iron and steel sector

In the iron and steel sector, many energy efficiency projects have a relatively short payback period (typically 3-4 years) without additional income (e.g. carbon income) or incentive mechanisms (IIP/Aquero 2012). An overview of the typical energy-saving potential identified in the steel sector in the United States with a value of over USD 100,000 is given in the table below with the relevant payback period.

Description	Savings (USD)	Cost (USD)	Payback (yrs)
Recycling casting sand	437,377	71,170	0.2
Use of most efficient type of electric motors	225,820	628,000	2.8
Turning off equipment when not in use	108,914	25,000	0.2
Using adjustable frequency drive to replace throttling system	200,411	425,00	2.1
Using adjustable frequency drive to replace motor-generator set	103,515	150,000	1.4
Reducing the pressure of compressed air to the minimum required	173,190	46,250	0.3
Using waste heat from hot flue gases to preheat combustion air	861,835	1,928,400	2.2
Recovering waste heat from equipment	2,641,138	12,550,416	4.8
Using or replacing with energy efficient substitutes	1,509,727	6,804,600	4.5
Using waste heat from hot flue gases to preheat combustion air	225,013	57,159	0.2

Source: http://iac.rutgers.edu/database/

21. Energy efficiency projects refer to investments in equipment, systems and services that result in reduced use of energy per unit of product or service generated (e.g. replacing an old boiler with a new boiler). Several types of activities increase the energy efficiency levels of companies:[7]

- refurbishment and replacement of inefficient technologies;
- procurement of best-performing equipment (boilers, electric motors);
- optimisation of industrial systems (steam and motor systems) that reduce energy system losses and improve system efficiency;

7 See ietd.iipnetwork.org for a comprehensive list of technologies and measures that reduce energy consumption in the iron and steel sector.

- bypassing certain production processes by installing new production concepts;
- recycling products and materials; and
- adopting energy management systems (EnMS).

22. Of all of these measures, an EnMS provides the most effective system for an industrial plant or facility to manage its energy use. An EnMS allows a company to identify and exploit cost-effective energy-saving opportunities by setting energy-saving targets and bringing top management on-board (see the case study below). According to the World Steel Association (Horvath, 2012), most iron and steel enterprises that implemented energy management reduced their average annual energy intensity by 0.6-4 per cent (direct energy).[8] Indirect energy savings reached a higher level, ranging from 5-10 per cent improvements per tonne of crude steel.

23. That said, not all technologies and measures that improve energy efficiency come at the same cost to industry in different regions and hence have the same payback time. This is the case, for example, with the coke dry quenching (CDQ) technology that is employed in five out of 128 coke batteries in Europe, accounting for approximately 10 per cent of the region's coke production.[9] The technology is more prevalent in Japan, Korea and China, where its implementation is driven by the scarcity of electricity, as well as in Russia, where the use of CDQ is driven by the expected low temperatures in wintertime (BCG, 2013).[10]

24. In Europe, industry estimates that, at best, a 15 per cent decrease in the overall CO_2 intensity of the sector could be achieved between 2010 and 2050 through the widespread dissemination of technologies that could reasonably become cost-effective in the future. In addition, some of the innovative technologies that could contribute to lowering energy consumption and GHG emissions are not yet available (Moya and Prado, 2013 sourcing Birat, 2011). Other technologies such as Direct Reduced Iron (DRI) have little prospect of taking root in some regions such as Europe due to a number of barriers, such as high prices for natural gas and high capital investment costs required for the new infrastructure (Moya and Prado, 2013 sourcing European Commission JRC-IET, 2010).

25. For those technologies that are already available, public policies may, however, help remove the barriers that prevent industry from making the investment. Recognising this, the next section describes policies that aim to widely spread the dissemination of technologies that are available today. It should be noted though that some technologies will have different payback periods, depending on the industry's region (e.g. CDQ), and therefore policies can vary between countries in terms of their approach in mandating or incentivising specific technology implementation.

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8 According to the average energy intensity of steel plants (18.2 GJ per ton of crude steel), direct energy saving is in the range of 0.12-0.7 GJ per ton of crude steel.

9 With CDQ, hot coke leaving the oven is cooled by nitrogen gas rather than the traditional method of using water. The nitrogen produces high-pressure steam for electricity or other purposes and as a result between 100 and 150 kWh per ton of coke can be recovered. Cost estimates for CDQ reach EUR 69 million for 1.5Mt product/year according to Moya and Prado (2013).

10 The recent study from BCG computed the economic feasibility of energy-recovery measures and the process-efficiency improvements within the steel sector by comparing the costs (CAPEX and OPEX) with the potential savings over an investment period of five years, depending on different price scenarios (high to low). A key outcome of the analysis was that while many technologies are feasible in any of the scenarios, widespread introduction of BOF gas recycling and CDQ only becomes feasible in a high-price scenario where input factor prices increased fivefold in real terms by 2050.

Box 3. EnMS in the ArcelorMittal factory, South Africa

By adopting energy management systems (EnMS), ArcelorMittal Saldanha Works in South Africa, which produces hot rolled coil, saved roughly USD 9 million in 2011 with a capital investment of just USD 500,800. This equated to a 5.3 per cent reduction in average energy demand (compared with 2010 baseline values). The company was able to offset its investment in less than four production days. In addition, even if no further investment to improve energy efficiency is undertaken and assuming that all assumptions are kept constant within the plant, the savings realised in 2011 (roughly ZAR 90 million) will amount to ZAR 362 million by 2016 (five years after the first investment).

Source: www.iee.csir.co.za/wp-content/uploads/2013/08/AM-Suldanah-Works-case-study-July-2013.pdf

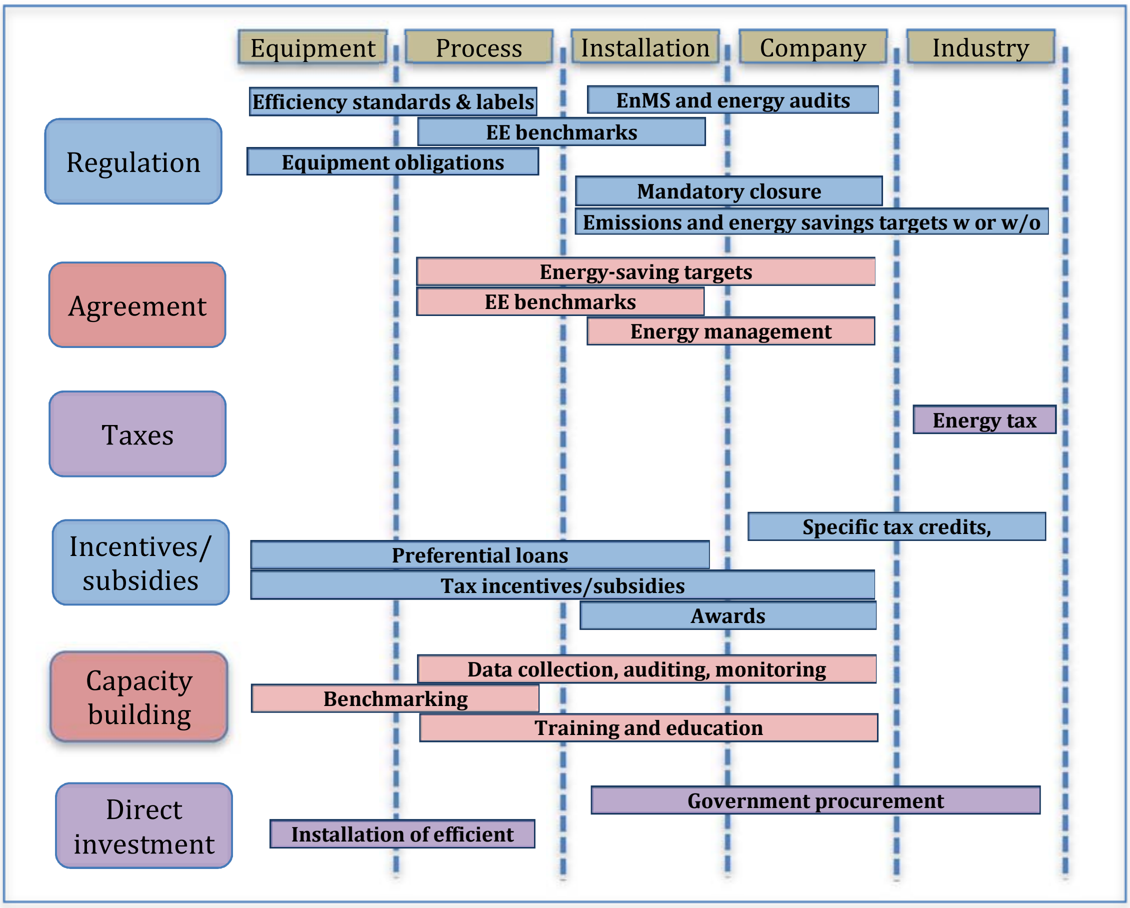
6. Energy efficiency policies and measures in the steel sector

26. Existing policies that target industrial energy efficiency typically aim to help companies identify which investments are cost effective and stimulate energy efficiency investments, either by reducing the payback time of these investments and measures (e.g. subsidies, loans and differentiated electricity pricing) or by mandating (e.g. energy-saving targets) or by encouraging implementation (e.g. voluntary agreements). [11] It should be noted that subsidies for energy efficiency improvements can be an area of contention due to the possible impacts they may have on the relative competitiveness of the steel industries that receive them.

27. Policies either target specific equipment and process improvements or the overall performance of an installation, a company or a sector. The section and Figure 1 below illustrate how specific policies can generate these energy efficiency improvements. The analysis shows that countries do not implement one policy in isolation. Rather, they design policy packages that address several energy improvement opportunities. Supporting measures that ensure that industry has the capacity and knowledge to achieve their energy efficiency goals are key to the success of many energy efficiency policies. To this end, most of the countries examined have implemented, or have started implementing, policies that focus on training and capacity building to ensure that industry has the awareness and skills to implement energy efficiency measures.

11 We recognise that several countries have also designed policies aimed at stimulating research, development and the deployment of technologies that help achieve higher energy efficiency levels in steel companies. These policies are not covered in this report, however.

Figure 1: Specific policies used by countries to improve industrial energy efficiency



7. Energy efficiency policies targeting the iron and steel sector

28. Each country has quite a different approach to dealing with industry and energy efficiency and, consequently, no one policy package is the same. Countries often try to avoid the application of stringent and costly measures that its major competitors are not subject to. As a result, in the steel sector, policies predominantly focus on energy-saving (or GHG emission reduction) agreements negotiated between industry and governments that are supported by fiscal incentives, or penalties in the case of non-compliance. As part of these agreements, companies must meet specific requirements, such as conducting energy audits, hiring energy managers and/or regularly reporting on their energy consumption.

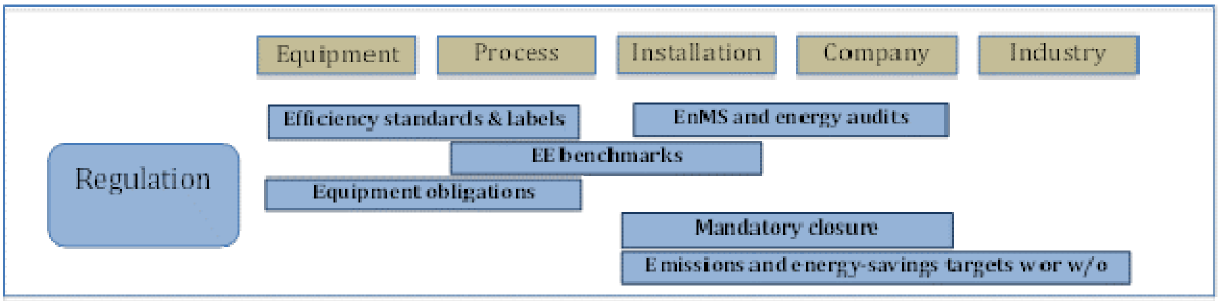
29. There are exceptions. This is the case in Europe, where the EU Emissions Trading Scheme mandates companies to reduce their greenhouse gas emissions.

30. The sections below focus on a range of policy types. Specific examples are provided to describe the ways in which they might be applied in different circumstances. Further details on these policies can be found on IIP's online policy database.[12]

[12] www.iipnetwork.org/databases/policy

8. Regulations for energy efficiency

31. Energy efficiency regulations in industry mainly cover equipment performance, with the aim of having companies implement the best-available technologies (BAT).[13] However, many countries have also begun to mandate industry to identify energy efficiency opportunities and, in some cases, disclose these to the public or to the companies' shareholders (as is the case in Australia). Further, several countries have required companies to invest in energy efficiency projects with a payback period that is below a defined threshold and/or adopt energy management activities.



8.1 Equipment

32. Regulations on the energy efficiency levels of equipment and processes generally target those that have the greatest energy reduction potential, either because they are extensively used in one industry and have a high total energy-saving potential or because they are used in a smaller industry and have a high overall impact. The most common examples of regulatory policies targeting industrial equipment in the iron and steel sector cover equipment types such as electric motors, variable speed drives for motor systems (VSD), boilers and process heaters, pumps and fans/blowers. These types of equipment are so-called cross-cutting technologies and are also found in the other industry sectors.

Energy efficiency standards and labels

33. Performance standards ensure that the least efficient technology (or process) within specified categories is simply no longer available on the market, while efficiency labelling requirements allow for greater transparency of products' suitability and performance.[14] Electric motors – for which national standards are progressively being superseded by standards established by the International Electro-technical Commission – are the most common equipment type subject to this type of policy.

34. Examples of countries that have introduced energy efficiency standards and labels are the United States, all EU countries, Canada, Brazil and Vietnam. For example:

13 There are several possible BATs available for the iron and steel industry: BATs for processes for the production of semis (coke plants, sinter plants, pellet plants, blast furnaces, BOFs, electric arc furnaces and bloom slabs, and billet mills) and for 'add on' or 'process intensification' types; and BATs that have different implementation methods, such as 'new technologies' that require the replacement of complete plants, 'process control' and 'maintenance'. See Moya et Pardo (2012).

14 Labels on electric motors are rarely implemented, except in Europe, while minimum energy-performance standards (MEPS) are implemented, on average, in two-thirds of surveyed countries (see WEC Ademe 2013 survey). MEPS on electric motors are implemented in half of surveyed countries, and 40 percent of countries have implemented labels on electric motors.

- In Canada, regulations require energy-using products to meet minimum energy-performance standards (MEPS) and enforce product energy efficiency labelling requirements.
- As part of the Clean Air Act, the US has recently introduced a GHG emission standard that requires industrial boilers and process heaters located at major sources to meet numeric emission limits.
- In Vietnam, mandatory MEPS for electric motors were introduced in July 2013.

Equipment obligations

35. In addition to energy efficiency performance standards being applied to specific equipment, some countries also have policies that place certain obligations on the use of specific equipment that reduces GHG emissions and saves energy.

36. India introduced equipment obligations that make it mandatory for all new steel production installations to employ coke dry quenching (CDQ) equipment that has to be either retrofitted in all coking plants in integrated steel plants or implemented at the design stage of all expansion projects.

37. In Europe, under the EU Directive on industrial emissions, companies must show that they have systematically developed proposals to apply the "best available techniques" (BAT) and take into account energy efficiency performance and CO_2 emissions.

8.2. Process

38. Simply having energy efficient equipment and components in place will not guarantee that the entire system will be energy efficient – particularly if the system is not properly designed and operated. Poor design or operation in any one part of the system affects heat and material flows throughout the entire system. Evidence from national and international programs shows that, while efficient components may bring about gains in the range of 2-5 per cent, systems optimisation measures can attain average efficiency gains of 20-30 per cent with a payback period of less than two years. Misapplication of energy efficiency equipment, including high-efficiency motors and variable speed drives for motor systems, is common (Williams and McKane, 2013). Industrial energy systems applications are highly varied and optimisation cannot be achieved through component standards and labelling approaches alone.

39. To date, there are no mandatory measures for process/system improvements. Rather, government-led initiatives targeting an accelerated uptake of systems optimisation have been limited because they either focus only on individual items of equipment or are too broad in scope to deliver the change in management behaviour that is required to capture systems-level energy (see *Policies Promoting System Optimisation* below).

Box 4. Policies Promoting System Optimisation

Policies targeting systems improvement are generally in the form of financial incentives (as is the case in China), free systems assessments (as is the case in the US), policies that encourage the adoption of energy management systems (EnMS) (such as in Europe or the US) or capacity-building measures. Until recently, policies in the US, for example, had concentrated on educating industry about system energy efficiency opportunities rather than explicitly promoting the use of an energy management standard or offering financial incentives and/or penalties for meeting energy reduction targets.

Source: Williams and McKane, 2013

8.3 Installation, company and industry level

Energy audits

40. Energy audits assist industrial companies or facilities in understanding how they use and waste energy, and how they can improve their energy use. Energy audits are recognised as a crucial first step towards building energy efficiency awareness. To this end, policies that focus on energy audits are often supplemented by other policies that incentivise or mandate the implementation of identified energy efficiency opportunities, and they are often part of a larger policy mix. Energy audits, if they are not mandatory, are often supported by government subsidies (see the section below on government subsidies), especially for small and medium-sized enterprises (SMEs).

41. Examples of countries having introduced these types of policies are China, all EU countries, India, Japan, Russia, Thailand, the US, Tunisia, Turkey and the Republic of Korea:

- China introduced a mandatory measure in 2010 whereby new large industrial projects (fixed-asset investments) must undergo energy efficiency appraisals. All new investments must have both independent assessments and government reviews on whether they are energy-saving before being approved by regulators. Projects that pass are subject to government supervision and managers are required to submit energy reports (Xinhua, 2010). Additionally, as in China's Top-1,000 Program, energy auditing has become a requirement for all industrial enterprises in China's Top-10,000 Program.
- The Korean government has a mandatory energy audit programme for energy-intensive companies consuming more than 2 ktoe per year. It also provides subsidies that cover up to 90 per cent of the cost of energy audits for SMEs engaging in energy management.
- Under the European Energy Efficiency Directive (EED), large enterprises (including steelmakers) must undergo an independent energy audit. The energy audit must be carried out by December 2015 and at least every four years afterwards. Companies implementing an energy or environmental management system certified according to European or international standards would be exempted (provided equivalence). After 5 June 2014, the EED also requires that steelmakers refurbishing industrial installations which generate waste heat at a useful temperature level (a total thermal input >20MW) carry out a cost-benefit analysis to assess the option of introducing co-generation in heating.

Energy management systems

42. Companies must integrate energy efficiency into their management practices in order to develop a culture of continuous improvements and facilitate the efficient design and operation of their energy system. Governments and organisations promoting the rational use of energy have recognised the important role of energy management systems (EnMS) and are developing and implementing programmes to promote the use of EnMSs in industry (see *EnMS and IEE government programs* below).

Box 5. EnMS and IEE government programs

Government programs that encourage or mandate corporations to adopt energy management systems are generally embedded within target-setting policies, voluntary schemes or negotiated agreements to reduce energy demand or greenhouse gas emissions (Reinaud et al, 2012). Promotional aid and financial and regulatory incentives are often included to support EnMS adoption (McKane *et al.*, 2008). Government support for EnMS includes financial incentives (such as tax relief), reward programmes, ease of access to information (best practice, exchange and co-operation schemes, networking, implementation guidelines, etc.), and technical tools (support to carry out energy audits, development of technical energy profiles, benchmarking tools, etc.).

Source: Reinaud et al, 2012

43. Examples of countries having introduced these types of programs include Indonesia, Malaysia, Singapore, Thailand, over ten EU countries and Vietnam. A selection of these examples are described below:

- Factories in Thailand with an energy capacity of over 1,000 kilowatts (kW), or with an annual consumption exceeding 20 terajoules (TJ), are required to implement energy management systems and make progress reports available for external auditing. Thailand is currently considering energy management obligations for SMEs and buildings.
- In Singapore, energy-intensive companies are required to submit efficiency improvement plans. Energy management is mandatory for large businesses (consuming over 54 TJ/y).
- In Malaysia, energy management is mandatory for large energy-consuming businesses (> 3 million kWh per six months).
- Europe, Sweden, Denmark, Finland, Ireland, Germany and the Netherlands have successfully integrated energy management practices into energy-efficiency target-setting agreements.[15]
- In Australia, large energy-using businesses with an annual energy use above 0.5 PJ must undertake an energy efficiency assessment under the EEO Assessment Framework (similar to an energy management system framework) in order to identify cost-effective energy-saving opportunities (< 4 year payback). Implementation of the identified opportunities is not mandatory but the publication of the results of the assessment and the company's response is. Public pressure is intended to affect the extent to which companies implement the identified opportunities.
- In several countries – such as Japan, India, Turkey and China – companies that consume energy above a defined threshold are required to appoint an energy manager. Since 2007 in Turkey, the government has required industrial plants consuming at least 1,000 toe per year to nominate one of their employees as the energy manager. Plants consuming more than 50 ktoe per year, or those in specific industrial zones, must set up an energy management unit.

Energy efficiency benchmarks

44. While policies that set out energy efficiency standards typically focus on specific equipment or technology types, there is also the possibility of applying energy efficiency performance standards to industrial plants as a general energy user.

45. This occurred in China where industrial energy performance standards set minimum allowable energy efficiency values for products from existing plants and newly-constructed plants, taking into account different types of raw materials, fuels, and capacities (see the table 1 below). Aside from the mandatory minimum energy efficiency standards, a set of voluntary, more advanced "reach standards" have also been established.

15 Finland's energy efficiency agreements; the Netherlands' long-term agreements (LTAs); Ireland's Energy Agreements Programme (EAP); Denmark's Voluntary Agreement on Industrial Energy Efficiency (DAIEE); and Sweden's programme for Energy Efficiency in Energy Intensive Industries (PFE). See also the Institute for Industrial Productivity's energy efficiency programs database: www.iipnetwork.org/databases/programs

Table 1. China's minimum energy efficiency standards for the iron and steel sector (GB 21256-2007)

Process	Unit	Minimum existing	New plants minimum	Advanced minimum
BF-BOF	kgce/t	502	468	407
EAF	kgce/t	92	90	88

Source: General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ), and the Standardisation Administration of China (SAC): http://english.aqsiq.gov.cn

Mandatory energy consumption or GHG emission reduction targets, with or without trading

46. A number of countries have set up mandatory energy-saving or GHG emission reduction targets for industrial energy consumption and/or GHG emission reductions. Several of these countries have introduced a trading platform to ensure cost effectiveness, which allows companies that have excess GHG emission allowances or energy-saving certificates to sell them on the market.

47. Examples of countries that have introduced energy-saving or GHG emission reduction targets are India, Japan and the Republic of Korea. For example:

- Japan has implemented a specific energy efficiency benchmarking target for designated industry sectors, which must be met in the medium term (2015) and in the long term (2020).[16] These targets have been set at the energy efficiency level of the best-performing companies (top 10-20 per cent) within each industrial sub-sector. For the steel sector the targets are: integrated processes (19.07 GJ/tSteel); EAF processes for carbon steel (5.14 GJ/tSteel) and; EAF processes for specialty steel (12.93 GJ/tSteel). In addition, all businesses in Japan must improve their annual energy efficiency levels by 1%.
- Under Korea's national GHG and energy target management system, which was introduced in 2010, major industrial energy users are required to reduce their GHG emissions and energy use by taking comprehensive measures in accordance with agreed plans. The government reviews compliance and can recommend revisions to the plans. If energy users fail to achieve their targets, they have to revise their actions and their plan, and have it verified by third parties. If energy users do not follow these obligations, they are fined (Yun, 2011).

48. Examples of countries that have introduced trading schemes include India and the EU:

- The EU Emissions Trading System (EU ETS) sets a cap on total direct GHG emissions for its participants (mostly energy generation and heavy industry in participating countries). Allocation to energy-intensive industries is determined by using benchmarks, which are established per product.[17] Steel-making and casting of iron tubes, which risk carbon leakage, receive 100 per cent of their benchmark free allowances.

16 Benchmarking targets are somewhat different from specific energy efficiency or GHG reduction targets in that they are based on less efficient sectors and/or energy users having to achieve the level of their best-performing peers – in effect bringing those with poor energy efficiency in line with a specified range of the top performers.

17 The average carbon-intensity of the top 10 percent of best performers represents the benchmark for allocating free emissions. Installations that meet the benchmark receive more allowances for free than those installations that do not, thus incentivising the latter to catch up to their best-performing peers. Free allocations are granted at the 80 percent level of the benchmark, a share that is set to decrease to 30 percent

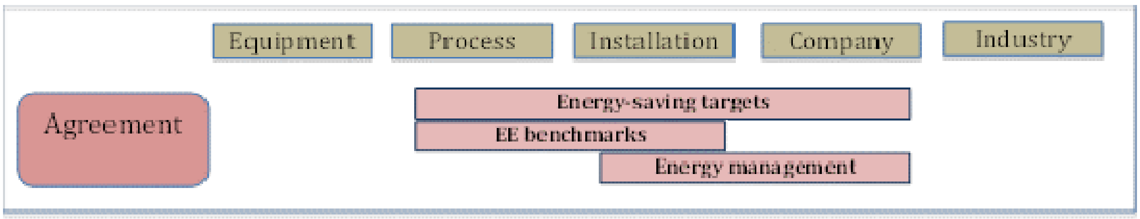
- India operates the Perform Achieve Trade (PAT) scheme, which imposes mandatory energy consumption reduction targets on specific facilities, with less energy efficient facilities having a greater reduction target than the more energy efficient ones. Facilities making greater reductions than their targets receive "energy-saving certificates", which can be traded or banked for future use.

Mandatory closure

49. While most policies typically incentivise or mandate industry to improve their energy efficiency, others remove poorly performing industry plants completely from the market. For example, since 2007, China has been closing small, inefficient plants and phasing out outdated capacity in 14 high energy-consumption industries. Compensation for 20-30 per cent of the value of the closed enterprises or production lines is available, but only in a minority of cases. The 12th Five Year Plan (2011-2015) specifically targets the iron and steel sector in order to phase out blast furnaces below 400 m^3 (excluding cast iron) and electric arc furnaces that produce less than 30 tons per day.

9. Voluntary and negotiated agreements

50. Voluntary or negotiated agreements (VA) between industry and governments are used as an alternative to mandate-based policies. Such agreements tend to work best with sectors that have a higher degree of organisation and structure as this assures a higher level of participation and industry associations are often engaged in the target negotiation. While VAs are, by nature, not compulsory for companies, to encourage participation some countries have chosen to apply a tax measure that is less preferable to the target group in case of non-compliance (in the event that EnMS adoption is a core element of the voluntary agreement) or non-participation in the voluntary/negotiated agreement. In most cases, a range of guidance materials, tools and technical assistance will also support a VA.



51. Examples of countries that have introduced negotiated and/or voluntary agreements are Denmark, Finland, Canada, China, Japan, Netherlands, South Africa, Sweden, UK and the US. Several examples are further described below:

- The US has a successful national partnership initiative in place that invites industrial companies to take a corporate-wide pledge to reduce the energy intensity of their industrial operations by 25 per cent or more within 10 years. By taking the pledge, companies are recognised as Better Plants Program Partners. Silver, gold or platinum designations are awarded according to the level of energy performance improvement and the maturity of the EnMS.

in 2020. However, this provision does not include sectors deemed to be exposed to the risk of carbon leakage, and which are listed in the Carbon Leakage Decision. These installations received 100 percent of their benchmark free allowances. Steel-making (NACE v.2 sector 24.10) and the casting of iron tubes (NACE v.2 sector 24.21) are included in the carbon leakage list. Although free allocation of allowances for electricity production is prohibited, an exception is provided for waste gas electricity (Art 10A.1 of the ETS Directive).

- To help South Africa achieve its target of 12 per cent energy savings by 2015 for all energy using sectors (relative to a business-as-usual baseline), the government introduced a voluntary agreement program to provide a platform for companies to establish and implement their own energy management plans, baselines and energy efficiency targets.

- In the UK, an industry agreement program was introduced to provide an incentive for different sectors to enter in climate change agreements (CCAs). Under the program, participating energy-intensive companies are granted a 65 per cent tax rebate (the climate change levy), provided that they meet specific targets set out in the agreement.

- In Germany, voluntary agreements with energy-intensive industry associations have existed since 1996. The 2013 agreement sets annual energy intensity reduction targets and pushes participating companies to implement energy management systems. Industries that comply with the targets set out in the voluntary agreements, as well as those that are EnMS certified (according to the German or ISO 50001 standard), can apply for rebates on energy taxes.

- China's negotiated energy conservation target-setting policy for large energy users was introduced in 2011. Known as the Top-10,000 Program, it is based on the Top-1,000 Program. One of the key requirements of the program is the establishment of an EnMS, among other obligations. The overall target of the program is an absolute energy-saving target of 250 million tonnes of coal equivalent (Mtce) by 2015.

10. Financial incentives and subsidies[18]

52. Typically, industrial energy efficiency financing policies and programs provide a range of interventions to address the different challenges that arise throughout the energy efficiency project development lifecycle. These challenges include the identification of energy-saving opportunities right through to the verification of the final energy savings of the implemented solution. Policies that focus on financial incentives can target specific energy efficiency technologies, broader processes, projects such as EnMS adoption, or incentives (typically tax related) that are awarded if a company meets specific energy-saving or GHG targets as part of broader negotiated agreements.

53. Energy efficiency financing mechanisms and programs range from tax incentives to direct subsidies and favourable credit mechanisms. Typical examples include:

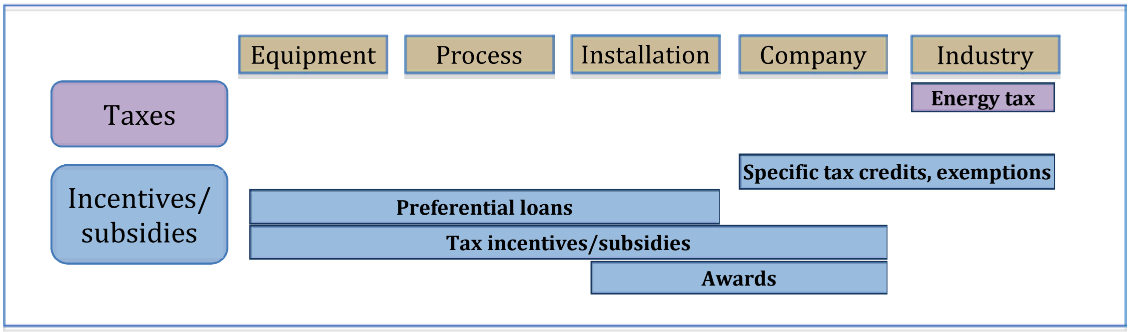
- Direct grants that defray costs, especially the up-front costs of project development activity (e.g. grants to support energy audits and the technical development of energy efficiency projects)

- Subsidies and rebates (e.g. direct subsidies for energy efficiency equipment)

[18] The provision of government financial support can take different forms, ranging from incentives that build upon existing tax or bank loan structures to the direct provision of financial aid or grants for specific types of EE projects or equipment. The type of financial support chosen will dictate the level of verification required to ensure the end user is not disproportionally advantaged, given the added financial benefit that can occur with EE improvements. In most cases building upon an existing structure such as a bank loan process will entail using similar verification methods as already in place, however for direct financial aid or grants a more customised verification process needs to be design for the particular situation. While a review of the type and design of financial supports is not the focus of this report, this is an area that requires further analyse to deliberately distinguish the various forms of financial support and the design of the verification process that may be required to ensure their successful implementation.

- Tax incentives such as credits, exemptions or improved depreciation conditions (e.g. on purchases of specified energy efficiency equipment)

- Reduced or low-interest rate loans.



10.1. Equipment

Tax incentives and subsidies

54. Both tax incentives and financial subsidies are used to motivate investment in energy efficiency technologies, either as a retrofit project or for a new installation. These are often specified through the use of eligible lists or BAT references. Countries tend to implement tax incentives (e.g. tax credits and tax deductions) and direct subsidies in quite different ways. For example, Canada has had a tax incentive for energy efficiency equipment investments in place since 1994. The Netherlands has also been operating a tax deduction scheme for similar investments since 1991. On the other hand, China has a number of direct financial subsidy schemes in place to encourage and accelerate targeted industrial energy efficiency investments as well as reward enterprises for energy savings achieved through technical renovation energy efficiency projects.

55. Examples of countries that have introduced tax incentives or subsidies to increase investment in energy efficiency equipment and projects are Australia, China, Canada, Netherlands, Germany, India, Japan, South Africa, Thailand, UK, Brazil, Chile, the Republic of Korea and Tunisia. For example:

- Chinese enterprises that can demonstrate energy savings from qualified projects (e.g. equipment retrofit and/or energy systems optimisation projects) of over 10,000 tons of coal equivalent (tce) are eligible for a financial reward of the equivalent of USD 12 to USD 15 per ton of CO_2 emissions reduced. Eligible energy efficiency technologies and processes include: coke dry quenching (CDQ), top-pressure recovery turbines (TRT), recovery of heat from converter gas, continuous casting, slab hot charging and hot delivery, coal moisture control (CMC), recycling waste heat from sintering, combined heat and power (CHP) and energy systems optimisation.

- The Canadian government provides an opportunity for enterprises investing in eligible energy efficiency equipment to immediately write off 50 per cent of the cost of the equipment against their taxes. This is significantly higher than the maximum write-off of 20 per cent for the cost of non-eligible equipment.

- The Netherlands offers industry either a tax deduction of a share of an eligible environmentally-friendly investment cost or a flexible depreciation on the same investment.

- In 2011, Russia introduced a new law that promotes investment in R&D and energy efficient equipment through property and income tax credits, and accelerated depreciation.

10.2. Process

Tax incentives and subsidies

56. Many policies provide incentives to enterprises investing in specific types of energy efficiency process improvements. Part of the incentive or subsidy may also cover the cost of implementation of the project. As is the case for specific energy efficiency equipment investments, the form of financial incentive can be tax based, a direct subsidy or a preferential loan and credit facilitation. Typical examples in the iron and steel sector include incentives for delivering lower emission energy sources and/or energy systems optimisation. The intention in such cases is to focus on reducing GHG emissions through a change in energy source type, reducing waste and/or reducing energy consumption.

57. Examples of countries that have introduced incentives for the implementation of energy efficiency processes and/or systems are Germany, Netherlands, Norway, Sweden, Thailand, UK, US, China and Korea. A selection of these examples is described below:

- In the Netherlands, a subsidy scheme pays parties that deliver energy to the grid produced by renewable sources (or combined heat and power (CHP)). The subsidy equals the difference between the production costs from conventional sources and the higher production costs from renewables (or CHP).

- The US government provides a tax credit incentive for the development and deployment of renewable energy technologies and CHP. The scheme reduces federal income taxes for qualified tax-paying owners based on eligible capital investments placed in service during a specific period. The US also provides an additional tax incentive where businesses may recover investments in certain property – such as renewable energy, biomass and CHP – through enhanced depreciation deductions.

- Although free allocation of allowances for electricity production is prohibited in the EU ETS scheme, an exception is provided for waste gas electricity, as in the case of BOF steelmakers when they generate electricity through the recycling of waste gases.

Preferential (or low-interest) loans

58. In addition to direct financial subsidies or tax incentives, some supporting policies develop a structure of financial support through specific financial institutions. This type of financial mechanism, which includes preferential loans or a loan guarantee scheme, is discussed later in this report.

10.3. Installations

59. Many governments introduce financial schemes to directly incentivise companies to engage in energy efficiency activities rather than only focus on equipment or process-related incentives. These can range from subsidies or incentives targeted at specific energy efficiency awareness activities (such as energy audits and the adoption of energy management systems) to financial incentives that reward the overall achievement of energy savings negotiated through voluntary agreements between government and industry. The form of financial support can vary from specific grant types to tax exemptions or incentives.

Subsidies for energy audits

60. In a number of countries, energy audits are partially subsidised or even totally free as they can leverage a much larger investment in energy efficiency solutions.

61. Denmark, Finland, France, India, Ireland, Japan, Korea, Sweden, Switzerland, the United Kingdom and the US subsidise energy audits. For example:

- In the US, small and medium-sized enterprises (SME) with annual energy costs of between USD 100,000 and USD 2.5 million are offered system energy assessments by energy experts from the Department of Energy (DOE) who work with plant energy teams to identify opportunities for improving the energy use associated with steam, process heating, pumps or compressed air systems (see the case study on industrial assessment centres below).

- Finland has maintained an energy audit grant scheme since 1992. It provides a 40-50 per cent subsidy to companies wanting to carry out an audit. By the end of 2011, virtually all energy use by industry had been audited at least once.

- In Sweden, financial support for energy audits is available for companies consuming more than 500 MWh of energy per year.

Box 6. Case study: industrial assessment centres in the US

The US Department of Energy (DOE) supports the university-based industrial assessment centers (IACs). The IACs provide free energy, waste and productivity assessments for SMEs with annual energy costs of USD 100,000-2.5 million. Each manufacturer typically identifies about USD 55,000 in potential annual savings. Over 15,000 IAC assessments have been conducted to date.

Out of the 58 assessments in blast furnace and steel mills, energy management was recorded as having the potential to deliver on average USD 45,499 worth of savings with an average payback of 1.3 years.

Subsidies for energy management

62. In several countries, energy management adoption is partially subsidised, especially for the first companies piloting EnMS adoption under the international standard ISO 50001. For example, the Canadian government offers cost-shared assistance to industrial companies to perform EnMS implementation pilots according to ISO 50001 as well as energy-related assessments. A financial incentive of up to 50 per cent of study costs (to a maximum of CAD 25,000) for ISO 50001 implementation pilots is provided.

Tax exemptions

63. Participation in, and compliance with, voluntary or negotiated energy-savings agreements exempts participants from other policies or taxes. Both are tied to meeting specific energy-saving targets and implementing EnMS or energy audits.

64. In Germany, industries that comply with the energy-saving targets set out in the voluntary agreements and that are EnMS certified (according to the German or ISO 50001 standard) can apply for rebates on energy taxes.

65. Similarly, in Denmark, enterprises must obtain an energy management certification (EN16001 standard), make a number of special investigations that include an evaluation of the profitability of energy

efficiency projects, and implement all projects with a simple payback horizon of less than four years. If the company does not comply with these requirements, the agreement is cancelled and the company must pay back the energy tax rebate.

66. Another interesting example of a policy that encourages energy efficient performance in companies can be found in China. The Chinese government has established a policy permitting differential electricity pricing for high energy-consuming industries. Electricity prices are set based on the energy intensity level of each enterprise – the less energy efficient a company is, the higher its electricity price.

11. External recognition for achievements

67. Reward programmes and external recognition for energy efficient performance or EnMS adoption can enable companies to showcase their performance to customers, peers and other stakeholders. They can also serve as an important incentive for implementing an EnMS.

68. Several countries recognise and reward companies that show energy performance improvement. For example:

- In India, an award programme promotes energy efficiency and the adoption of clean and innovative technologies by industry and other sectors. The programme has been in place since 1991, and has historically played an important role in India's policy package in the absence of mandatory measures.

- To promote best practices for energy conservation, the Japanese government has established the Energy Conservation Grand Prize.

- The Korean government has held the Energy Conservation Promotion Convention every year since 1979 and awards prizes to companies and persons who have carried out energy conservation best practices.

- In the US, the CHP Partnership, which is a voluntary program, seeks to reduce the environmental impact of power generation by promoting the use of CHP through outreach and support measures. By becoming members of the partnership, the companies and organisations involved in the partnership have access to a variety of tools and services. The partnership also provides a variety of recognition opportunities for partners, including awards and certificates.

12. Financing of energy efficiency investments

69. Energy savings can be considered as an asset, but they are quite difficult to measure. This can hinder the promotion of investment in, and external financing of, industrial energy efficiency as stakeholders (in particular, end-users and financiers) do not always grasp the concept and the value of energy savings since it is an intangible asset. Energy efficiency/conservation investments often result in additional cash flow – not from a new source of revenue, but because of a reduction in costs. Cash inflows for energy efficiency investment projects are calculated on estimated savings that are based on actual energy usage measurements, historical energy usage records, and validated and warranted equipment performance. Consequent reductions in maintenance and labour costs increase the ability of the company to repay a loan. Unlike power projects that generate a stream of additional revenue, energy efficiency projects generate a stream of savings.

70. The financial situation of a company determines to a large extent the company's investment decisions regarding energy efficiency. Key considerations when making financial decisions about energy-savings investments include the following:

- the type and level of governmental support;
- internal sources of funding;
- access to finance (borrowing from a bank and the institution's willingness to lend for these investments);
- the financial viability of the energy efficiency projects (and other identified benefits, such as improved product quality, process efficiency and productivity);
- the priority of the energy efficient investment over other projects/investments that are competing for the company's financial resources;
- the amount of investment necessary and whether it can be financed from the operating budget or as a capital expense;
- the availability of utility financing programs with repayment of the investment through end-user utility bills (see box below), or third party financing agreements such as through an energy service company (ESCO) service level agreement.[19]

Box 7. Utility/third party financing programs

Utility or third party financing programs typically provide energy efficiency solutions for their customers that are paid for through the end-users utility bill on the basis of the energy savings achieved – i.e. energy costs are reduced for the end-user through the energy efficiency solution but their utility bill might remain at the same level as before until the investment cost is paid off. Utilities or third parties offering such services may also fund additional program offerings, such as free energy audits or subsidised energy efficiency solutions by imposing a general rate on their energy tariffs for all customers.

For more information see iipnetwork.org/database/programs or Taylor et al (2012).

Government support

71. Governments typically only have limited funds to support the widespread implementation of energy efficiency. Therefore, decision makers have typically considered whether energy efficiency is competitively advantageous and how to deliver financial mechanisms that leverage additional funds.

72. As a result, financial mechanisms need to be designed to address these specific key conditions, sometimes in parallel or through separate initiatives. While awareness building and financial leveraging are the primary components of a successful financial mechanism, their design will also typically have to take into account a multitude of other classic project financing barriers, such as those given below:

- the small size of energy efficiency projects;
- difficulties with project aggregation;

19 The US National Energy Service Company Association (NAESCO) describes an ESCO as a business that "develops, installs and arranges financing for projects designed to improve the energy efficiency and maintenance costs for facilities".

- lack of knowledge and awareness on the part of banks and financial institutions;
- high project development and transaction costs ("soft" costs);
- limited creditworthiness of many potential borrowers;
- difficulty in collateralising or securitising project assets;
- limited experience with ESCO-type project implementation;
- risk perceptions; and
- the monitoring and measurement of energy savings.

The typical types of financial vehicles

73. The industrial market is extremely sensitive to its rate of return on investment but is probably less affected by ideological drivers or marketing actions. Consequently, private sector involvement is critical for the success of industrial energy efficiency policy programs.

74. The primary financing options available for companies to finance energy efficiency projects are typically:[20]

- *Internal funding through the company's operating and capital budgets*. This is rare for major capital-intensive projects in many private companies due to internal hurdle rates, which require significant returns on investment. It is not uncommon for smaller projects, however.
- *Bank loans based on the company's credit history and borrowing capacity*. This allows the bank to have full recourse for loan repayment as an on-balance sheet transaction.
- Leasing from a third party.
- *Shared and guaranteed savings structures offered by energy services companies* (ESCOs) with a guarantee of cash flow for the company. These types of transactions are common in the United States and increasingly in China.

75. In the case of external energy efficiency project financing through a bank loan, a number of government-led programs focus on providing guarantees or similar risk-sharing schemes to the financial institutions. In return, financial institutions are able to provide preferential loans to companies investing in specific or qualifying energy efficiency equipment, or to ESCOs in the case of third party financing. The principle of such programs is to leverage additional funds from the private sector to enable a larger uptake of industrial energy efficiency projects, especially where a government's direct funding ability is limited. In some cases, the participating financial institutions will also receive support to improve their technical expertise and understanding of energy efficiency projects for the purposes of evaluating the perceived risk of investments more effectively.

76. The way in which these financial vehicles are made available to the end user can vary, but three typical models will often be applied (IIP-Aquero, 2012):

a) The end-user can be the direct borrower and engage a solution provider as required.

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[20] To estimate which sources of funding will be used the solvency ratio is often used. Another criteria that will determine the extent to which companies will use equity to finance their investment is the return on equity (ROE). For more information, see Reinaud et al, 2011.

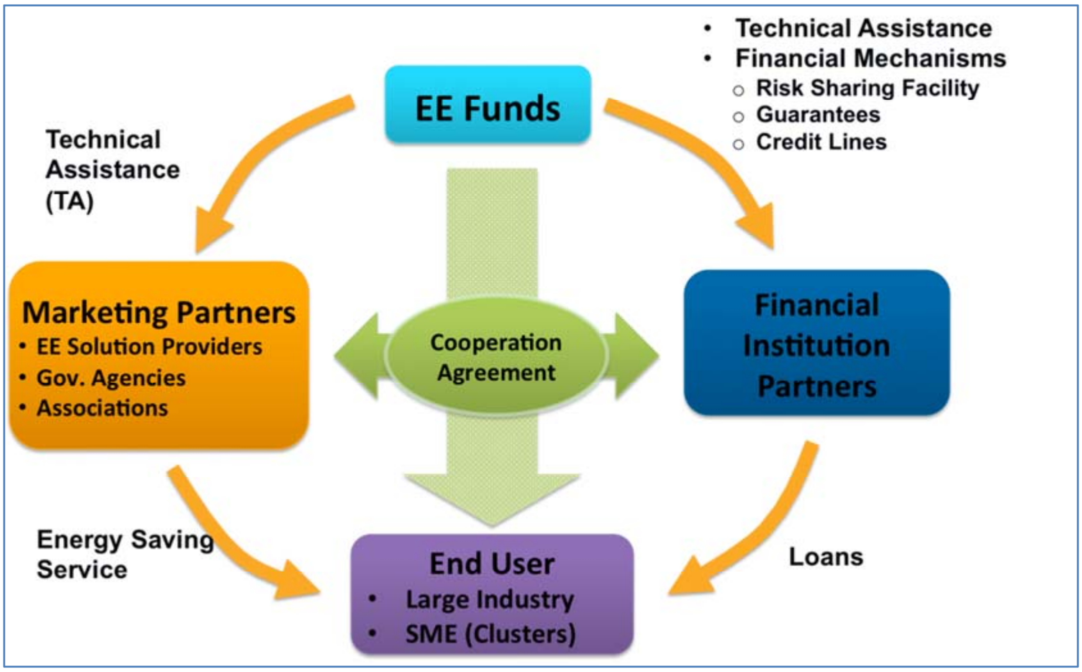
b) A solution provider, such as an energy service company (ESCO), can be the borrower and provide the end-user with a shared energy savings plan.

c) Financial institutions become directly involved in providing financial and technical services under the more unique model for integrated industrial energy efficiency banking solutions, as is the case with the European Bank for Reconstruction and Development.

Financing with the end-user as borrower

77. Solution providers (such as equipment suppliers, government agencies, etc.) can be connected to a financial institute to ensure the best integration of technical assistance and financial support. A primary fund source (such as a dedicated credit line, government guarantee or risk-sharing mechanism) provides technical assistance (awareness building, opportunity identification, solution provision, etc.) and financial support (e.g. preferential loan rates) that an end user can use to both identify energy-saving opportunities and implement energy efficiency projects.

Figure 2: Overview of integrated technical assistance and financial support model for end-users



Source: IIP-Aquero, 2012

78. India, Korea and Thailand have similar policies. For example:

- India has introduced a partial guarantee fund scheme, which offers a risk-sharing mechanism that provides commercial banks with partial coverage of risk exposure against loans issued for energy efficiency projects.

- Korea operates an energy conservation fund, which facilitates long-term, low interest rate loans in addition to a 10 per cent tax deduction option, for investments in energy efficiency and conservation facilities in industry and buildings.

- In Thailand, commercial banks have been engaged to develop and streamline procedures for appraising and financing energy efficiency projects. The government provides dedicated credit lines to lower the banks risks, which makes the energy savings and financial paybacks "tangible" to the commercial banks.

Financing with the energy efficiency solution provider as borrower

79. If an energy efficiency solution provider acts as the borrower for an energy efficiency project, a shared savings model between the solution provider (typically an ESCO) and the end-user is normally applied. This involves the end user contracting a specified level of energy savings on an annual basis for an agreed period.

80. The different stages of a shared savings model include the following (IIP-Aquero, 2012):

1. The solution provider provides or arranges for financing.
2. The performance contract specifies the sharing of the cost savings between the solution provider and customer.
3. The performance contracts may typically be 3-7 years in duration.
4. Payments are structured so that the solution provider recovers its implementation costs and obtains the desired return on its investment within the specified time period.
5. The customer generally makes no investment in the project.
6. The customer gets a share of the savings during the contract period and 100 per cent of the savings afterwards.

Box 8. Case study: Metrus Energy

Founded in 2009, Metrus Energy (ME) is a US-based company that develops finances, owns and operates large energy efficiency (EE) projects for commercial and industrial clients in the US.

The company invests its own capital as equity participation in EE projects and partners with third party debt providers to raise debt finance, which enables industrial customers to finance EE projects off balance sheets with no capital outlay by the host entity.

In order to facilitate the financing of the projects, ME signs an efficiency services agreement (ESA) with clients, eliminating their upfront investment cost barriers. ME funds 100 percent of project costs, and repayments by the client are based on avoided energy use and reduced OPEX. ME has ownership of the EE equipment and pays for selected maintenance costs. A typical ESA between the client and ME lasts 5-10 years but includes periodic buy-out windows.

Source: www.iipnetwork.org/delivery-mechanisms-financing-industrial-energy-efficiency

Integrated industrial energy efficiency banking

81. Financial institutions do not generally understand the benefits of energy efficiency and, in turn, accept an element of risk sharing or similar in providing leveraged funds on a widespread basis to industry. The European Bank for Reconstruction and Development (EBRD) has successfully mainstreamed energy efficiency finance in its organisation and has made it an intrinsic and an increasingly important part of its core banking business.

Box 9. Mainstreaming energy efficiency finance

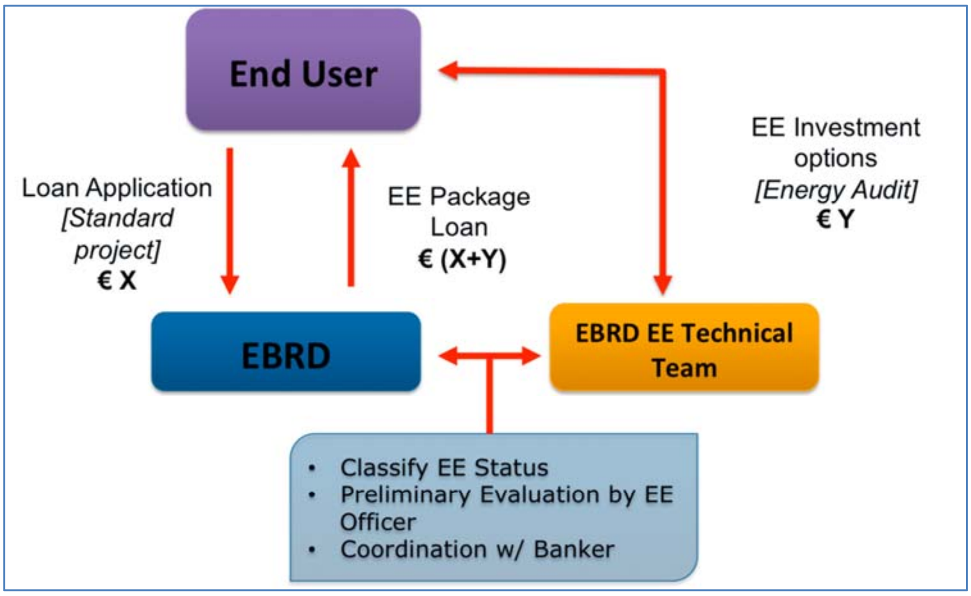
Mainstreaming energy efficiency finance involves bringing energy efficiency considerations into banks' standard industrial lending practices – through procedural, personnel and organisational changes. The goal is to efficiently integrate technical and financial advisory services that are relevant to industrial energy efficiency into the lending process for plant expansions and improvements, as well as for dedicated energy efficiency projects.

82. The integrated banking process that EBRD uses is based on the synchronised integration of relevant technical and financial advisory services into their standard industrial lending, whether that lending is sought for plant expansion, improvement or for energy efficiency itself. An overview of this process is documented and illustrated in the figure below:

1. Incoming industrial/commercial loan applications are automatically assessed for their energy efficiency potential along with all other criteria.
2. If energy efficiency potential is identified, an energy efficiency questionnaire is sent to the applicant.
3. Based on the returned information, a full-day meeting with the applicant will be requested by EBRD to discuss energy efficiency opportunities and conduct a plant tour.
4. If the applicant is interested in pursuing additional energy efficiency investments, EBRD will offer free services (such as a complete energy audit of the plant) to identify energy efficiency investment opportunities that could be added to the original loan request.
5. Based on the outcome of the energy audit or other review services, recommendations are made to the applicant for possible energy efficiency investments and, if accepted, these are then added to the overall loan conditions.

83. While the energy efficiency assessment is a standard part of EBRD's evaluation of loan applications, clients are not required to implement the industrial energy efficiency investments identified. Nevertheless, more than 60 per cent do so voluntarily, according to EBRD estimates.

Figure 3: The EBRD example of an integrated IEE banking solution



Source: D'Addario, 2012

13. Conclusion

84. There is significant potential to improve energy efficiency in the iron and steel sector and many governments are developing policies to this effect. That said, not all energy efficiency measures come at the same cost and hence payback period. Further, barriers might impede companies to invest in these types of investments and measures. In this regard, government support is often provided.

85. Unfortunately there is no "one-size-fits-all" policy package. Each country must tailor their policies and programs to market conditions and its relative size. This is consistent with the analysis presented here, which shows that while each country has quite a different approach to industrial energy efficiency policy, in general all countries provide flexibility in how companies lower their energy consumption.

86. This is especially true for policies that rely on efforts from companies, mandate a maximum amount of energy per tonne of steel, require companies to identify energy efficiency opportunities, and those that reward overall improvement. However, within these flexible policies, there are often requirements within voluntary agreements (such as the adoption of energy management systems) and/or penalties for non-compliance.

87. The types of policies that are more restrictive are those that target maximum energy consumption for certain types of equipment or the installation of specific equipment, require companies to undergo energy audits, and those that mandate companies to close inefficient plants.

88. Government-led financing mechanisms have also been developed by some countries to leverage private sector financing. However, good design of successful financial mechanisms can be difficult to achieve due to the many variables at play, particularly where energy efficiency projects are developed in an environment where traditional business models are primarily used.

89. Overall, the paper finds that government-led finance programs are structured in different ways to address specific aspects of the project within the context of the market circumstances. These can be categorised into six principal financing categories:

- financing of technical development (e.g. energy audits);
- on-lending programs;
- risk sharing programs;
- interest subsidy structures;
- loans and co-finance facilities; and
- capital cost rebates/buy-down.

90. In summary, despite the variation in industrial energy efficiency financing mechanisms analysed, some fundamental best practice characteristics were identified. While awareness building and financial leveraging are the primary components of a successful financial mechanism, their design will also typically have to take into account a multitude of other classic project financing barriers. They will also have to address the specific characteristics of energy efficiency projects and be able to be adapted to the needs of the industry and the market.

REFERENCES

Birat J.P. (2011), CO_2-lean Steelmaking: ULCOS, Other International Programs and Emerging Concepts. 1stEECR Steel Congress, Düsseldorf, 2011.

European Commission (2010), Final Report of the Set-Plan Workshop on Technology Innovations for Energy Efficiency and Greenhouse Gas (GHG) Emissions Reduction in the Iron and Steel Industries in the EU-27 up to 2030.

Horvath L. (2012), "World Steel Association – Steel Industry & EnMS", IIP EnMS Shandong workshop, retrieved November 13, 2013 from: http://d15mx5mqz9twln.cloudfront.net/sites/iipnetwork.org/files/file_attachments/resources/EnMS_WSA_2012.pdf

Industrial Assessment Centres (IAC), US Department of Energy: http://www1.eere.energy.gov/manufacturing/tech_assistance/iacs.html

International Energy Agency (2012), Energy Technology Transitions for Industry.

International Energy Agency, (2008), Energy Technology Perspectives 2008, Scenarios and Strategies to 2050.

Institute for Industrial Productivity, Aequero (2012), Delivery Mechanisms for Financing of Industrial Energy Efficiency – A Collection of Best Practices.

McKane, A., L. Price, and S. de la Rue du Can (2008), Policies for Promoting Industrial Energy Efficiency in Developing Countries and Transition Economies, United Nations Industrial Development Organization, Vienna, Austria.

Mey, J. (2011), "How Can We Facilitate the Introduction of Energy Management Systems (EnMS)?", Paper presented to the ECEEE (European Council for an Energy Efficient Economy) Summer Study, June 2011.

Moya J.A., Pardo N. (2013), The Potential for Improvements in Energy Efficiency and CO_2 emissions in the EU27 Iron and Steel Industry under Different Payback Periods. Journal of Cleaner Production.

Newman, J. (2012) Energy Efficiency Policy and the Iron and Steel Industry – 2012. DSTI/SU/SC(2012)17, OECD

Pardo N., J.A. Moya, K. Vatopoulos (2012) Prospective Scenarios on Energy Efficiency and CO_2 Emissions in the EU Iron & Steel Industry, Joint Research Centre.

Reinaud J., A. Goldberg, V. Rozite (2012), Energy Management Programmes for Industry, Gaining Through Saving, The IEA policy pathway series.

Reinaud J. and A. Goldberg (2011), The Boardroom Perspective: How Does Energy Efficiency Policy Influence Decision Making in Industry?, The IEA energy efficiency series.

Renda et al (2013), Assessment of Cumulative Cost impact for the Steel Industry, Centre for European policy studies.

UNIDO (2011), Industrial Energy Efficiency for Sustainable Wealth Creation, Industrial Development Report 2011.

Williams R. and A. McKane (2013), "Global Overview—The Systems Approach to Energy Efficiency in Industry", WIREs Energy Environ 2013, 2: 363–373 doi: 10.1002/wene.72.

World Energy Council and Ademe (2013), World Energy Perspective – Energy Efficiency Policies – What Works and What Does Not.

World Steel Association (2012), World Steel in Figures 2012.

Worrell E. J. A. Laitner, M. Ruth and H Finman, (2001), Productivity Benefits of Industrial Energy Efficiency Measures, Lawrence Berkeley National Laboratory.

Worrell E. J. A. Laitner, M. Ruth and H Finman, (2003), Productivity Benefits of Industrial Energy Efficiency Measures, Energy 28 (2003) 1081–1098 1089, Lawrence Berkeley National Laboratory

Xinhua (2010), "China Orders Compulsory Energy-Saving Assessments of New Fixed Asset Investments", 21 September 2010. Retrieved November 13, 2013 from: http://www.globaltimes.cn/content/576312.shtml

Yun, S. (2011), "Energy Management Programme in Korea", IEA-IIP Workshop on Energy Management Programme, Policy Pathway series, 30 September 2011, Paris, Retrieved 13 November, 2013, from: http://www.iea.org/media/workshops/2011/iip/15_Yun.pdf