Low-Carbon Roadmap for the Egyptian Cement Industry

Project "Egypt: Technology and Policy Scoping for a Low-Carbon Egyptian Cement Industry"

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Foreword

Up until 2014, the Egyptian cement industry principally used state-subsidised natural gas and heavy fuel oil to fire their kilns. Due to the gradual phasing out of the subsidies and the scarcity of these fuels domestically, using natural gas and heavy fuel is no longer economically viable for the cement industry.

The enactment of amendments to the environmental law in April 2015 allows Egyptian cement companies to switch to using primarily high CO_2 intensive fuels such as coal and petcoke. This fuel switch will significantly increase CO_2 emissions from the Egyptian cement industry – up to 15% or to about 820 kg CO_2 per tonne cement.

In April 2016, Egypt signed the Paris Agreement to the United Nations Framework Convention on Climate Change (UNFCCC). This new global climate agreement commits countries to taking ambitious long-term measures to curb greenhouse gas emissions, with the ultimate aim of limiting the rise in global temperature to well below 2°C.

Since April 2015, the new Egyptian coal regulation requires that the revised operating permit of companies using solid fuels should include a plan of action on how the companies will limit the increase of CO_2 emissions resulting from the fuel switch.

Different technologies that can improve energy efficiency and reduce CO_2 emissions in the cement industry are already available. Their deployment will be most effective when such technologies are economically attractive and safeguard the licence to operate for the companies.

This will require supporting policies and decisive and collaborative action by several stakeholders, including cement companies, authorities at the national, governorate and local level, the related upstream and downstream industries and service providing companies, industry associations and environmental organisations.

Recognising the need to objectively assess the technologies available in the cement industry, their energy saving and CO_2 mitigation potential in Egypt, the required enabling policies and actions, as well as the financial and economic conditions necessary, the European Bank for Reconstruction and Development (EBRD), the Egyptian Environmental Affairs Agency (EEAA) and the Chamber of Building Materials Industries / Cement Industry Division (CBMI), in collaboration with the Egypt Ministry of Trade and Industry (MTI) and the Cement Sustainability Initiative (CSI) of the World Business Council for Sustainable Development (WBCSD), joined together to develop the "*Low-Carbon Roadmap for the Egyptian Cement Industry*". This Roadmap was developed under the EBRD-funded project "*Egypt: Technology and Policy Scoping for a Low-Carbon Egyptian Cement Industry*" from August 2015 to October 2016.

The effective implementation of the policy and technology recommendations described in this Roadmap will enable, by 2030, a complete reversal in the projected CO_2 emission increase from the fuel switch. By 2030, 2.2 million tonnes of coal will no longer have to be imported, saving about USD 200 million. A more ambitious scenario would further decrease specific CO_2 emissions to about 2% below the historic level prior to the fuel switch.

The Roadmap is realistic. The targeted improvements of the key performance indicators - on production volumes, energy efficiency, thermal substitution rate (alternative fuel use), clinker content, by-pass dust and CO_2 emissions – though ambitious, are achievable in the Egyptian context.

The improvements are attainable only with adequate policy, legislative and regulatory actions, appropriate financial resources and the preservation of the industry's competitiveness. The Roadmap outlines all of these.

The partners involved in this project look forward to continuing the productive collaboration to best facilitate the practical implementation of the recommendations in this Low-Carbon Roadmap.

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Key findings

Industry performance

The clinker kilns in Egypt are of the Best Available Technology (BAT) type (preheater or preheater + precalciner).

Nevertheless, the operational performance of the Egyptian cement industry compares unfavourably with the Best Available Practice (BAP) and with the industry average in most other regions worldwide:

- Almost as much as 5% of clinker volume, i.e. about 2 to 2.5 million tonnes annually, is discarded and landfilled as by-pass and cement kiln dust (BPD & CKD), resulting in energy losses and CO_2 emissions.
- Whereas about 50% of the Egyptian clinker kilns operate close to BAT thermal energy efficiency (taking into account dust disposal), the other 50% consume on average about 14% too much energy.
- Waste and biomass derived alternative fuels contribute less than 5% to thermal energy. This is 10% less than the global average and 25% less than good available practice.
- The 89% clinker content in cement is 15% more than the global average and within the highest 2% worldwide.
- Electric power consumption is slightly above the global average, but 15% above the Best Available Technology and Practice (BATP).

In the absence of this Low-Carbon Roadmap and implementation of its recommended mitigation measures, the fuel switch from mainly natural gas and fuel oil to solid fuels will increase specific CO_2 emissions by 15%, from 710 to 817 kg CO_2/tonne cement. Without the fuel switch, absolute CO_2 emissions from the Egyptian cement industry would reach 66-67 $MtCO_2$/year in 2030. After the fuel switch and without implementing the Low-Carbon Roadmap's measures, CO_2 emissions would reach around 76 $MtCO_2$/year in 2030 (as illustrated in Figure 1).

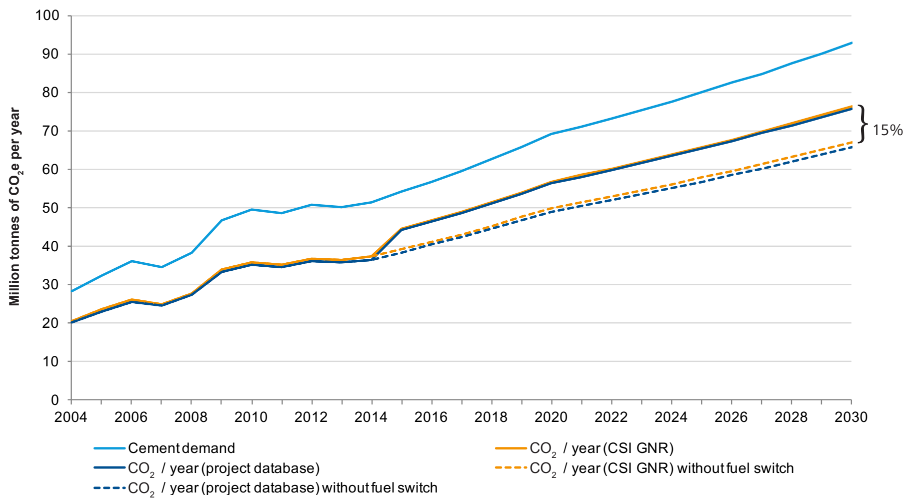
Consequently, Egyptian cement production would be within the 2% most CO_2 intensive worldwide.

Furthermore, the Egyptian cement sector's economic performance and competitiveness is below optimal:

- For the last five years the Egyptian cement industry has operated at about only 70% capacity utilisation. Such low capacity utilisation is unsustainable economically in the long-term. In particular, installed clinker production capacity is expected to be significantly higher than market demand for several years going forward.
- The whole Middle East and Mediterranean region suffers from significant excess cement production capacity.

With the Egyptian free on board (FOB) cement cost being 20 USD/tonne cement higher than the regional competition, the Egyptian cement sector is uncompetitive at the export market (except for some border markets accessible by trucks), with a very narrow competitive advantage on the Egyptian local market against importers.

Figure 1: Impact of the coal legislation on Egyptian cement sector's CO_2 emissions



Source: EBRD, 2016. Report D5

Main reasons for current industry status and emission performance

The main causes of the suboptimal performance of the Egyptian cement industry can be summarised in the following:

- The high chlorine content of Egyptian limestone deposits inevitably requires the extraction of BPD and CKD from the clinker and cement system. The existing technology used to treat and recover the dust uses a lot of water and has not yet been demonstrated to be technically and economically feasible at the required scale. Dust is therefore mostly landfilled.
- The excessively high specific thermal energy consumption of a large number of installations is probably caused by suboptimal operational management, process know-how and control, inadequate maintenance, as well as low capacity utilisation.
- The very low rate of alternative fuels and raw materials (AFR) is mainly caused by the underdevelopment of the upstream waste management value chain; severe shortcomings in waste management legislation and law enforcement; the absence of important principles such as "the polluter pays principle"; the absence of a proper waste management hierarchy and the responsibility and accountability of waste producers, collectors and haulers; the absence of any meaningful and professional waste management infrastructure; and the absence of any reliable information on waste production.

  As a consequence, the pricing of waste treatment service fees is futile, supply and quality are erratic and waste and biomass derived alternative fuels remain largely economically unattractive with respect to coal and petcoke.

  AFR process know-how at the Egyptian cement companies needs to be further developed as well.
- There are three main causes for the high clinker content in cement:
  1. Inadequate construction practices at the building sites with insufficient on-site quality control and testing by the formal, but especially by the informal, construction sector, may impede the integrity of constructions. As a consequence, whereas the Egyptian cement standard allows the production of many types of composite cements similar to the European cement standard, the construction codes prohibit certain cement types for reinforced concrete application. This means that most cement sold to the market is Ordinary Portland Cement (OPC).
  2. The limited availability of good-quality clinker substituting materials such as granulated slag, fly ash and pozzolana in Egypt limits clinker substitution with domestic products/materials.
  3. The excess clinker production capacity inhibits the economic incentive to substitute clinker with other constituents in cement.
- High clinker content, high dust disposal and low capacity utilisation all contribute to increased specific electric power consumption.
- Due to the very high excess supply on the regional international market (about 50 – 60 Mt/year), international clinker and cement market prices are very low, often just above the marginal production cost and below domestic prices. Combined with the comparatively high domestic production cost, Egyptian cement is uncompetitive on the international market.

Potential for emission reduction and energy performance improvement

The new coal regulation (April 2015) and this Low-Carbon Roadmap seek to set the pathway for the Egyptian cement industry to reduce its CO_2 emissions, so that the anticipated 15% CO_2 emission increase resulting from the fuel switch can be avoided.

Although a number of CO_2 mitigation measures exist, achieving this objective is technically and economically feasible in Egypt through four main levers:

1. Lowering the clinker content in cement;
2. Increasing the use of AFR substituting coal and petcoke;
3. Energy efficiency improvements;
4. Increasing the capacity utilisation factor (CUF) of the clinker production installations.

The Low-Carbon Roadmap suggests various mitigation scenarios. Under a **slow low-carbon scenario**, the desired 15% CO_2 emission mitigation can be achieved by 2030 by:

1. Lowering the sector average clinker content in cement from the current 89% to 80%;
2. Increasing the alternative fuel thermal substitution rate to 8% energy from alternative fuels (AF), of which 50% will come from biomass and 50% from fossil fuels;
3. All clinker installations achieving specific thermal energy consumption equal to or better than 3,620 MJ/tonne clinker (including energy loss due to discarding BPD and CKD).
4. The cement sector achieving at least 85% capacity utilisation. This requires that the pace of licensing new clinker and cement installations is such that it ensures a long-term balance between installed capacity, 80% clinker factor and domestic market demand.

Under a **rapid low-carbon scenario**, an additional 2% CO_2 reduction can be achieved by sourcing 15% thermal energy from AF (instead of 8%) and by lowering the sector average clinker content in cement from the current 89% to 80% by 2025 (instead of achieving this by 2030). Under this scenario, the desired 15% CO_2 emission mitigation can be achieved by 2025, instead of by 2030 (see Annex 2 for more details).

This more ambitious scenario would be more aligned with the UNFCCC's 2°C goal, but would however demand a higher level of commitment to the introduction of the Low-Carbon Roadmap's recommendations. Given that the rapid low-carbon scenario would result in emitting around 40 million tonnes of CO_2 less over a 15-year period, it should place Egypt in a better position to mobilise the support needed from the international community to help implement its recommendations.

The key performance indicator values suggested under the rapid low-carbon scenario have already been realised and even exceeded in many other countries worldwide. They are thus realistically achievable. They may however be ambitious in the Egyptian context, especially with respect to difficulties related to construction practices and standards, the waste management framework and pricing, limited national availability of clinker substitution minerals and the high chlorine content of the limestone deposits.

Whereas the extraction of BPD from the kiln systems is technically unavoidable, eliminating its disposal could lead to an additional reduction in CO_2 emissions of around 4%.

However, the slow and rapid low-carbon scenarios only assume an insignificant reduction in BPD and CKD disposal because the only demonstrated technology for dust treatment and recycling in the clinker and cement systems currently consumes significant quantities of fresh water (1 tonne water per 1.5 tonne dust, or about 1.8 Mt water if all Egyptian BPD were to be treated and recycled), which may be problematic in the dry Egyptian environment.

Key policy actions in the next 5 to 10 years

For the cement companies to effectively implement the mitigation actions suggested in the Low-Carbon Roadmap and improve their energy and CO_2 performance, these actions must be economically attractive.

This is currently hardly the case or not at all the case in the present economic and policy context in Egypt. Decisive action by several governmental, public and business stakeholders is indispensable for creating the necessary enabling and economic conditions for improvement.

The proposed Low-Carbon Roadmap describes and explains the necessary policy actions, which can be concisely summarised as follows:

- Develop a cement sector monitoring, reporting and verification (MRV) system and database, compatible with the CSI international standard, collecting reliable factual information on all key performance indicators characterising energy and CO_2 emission performance of the industry. Good data is key for good decision making.
- Adapt the pace of licensing new clinker and cement installations with the purpose of balancing installed production capacity with long-term domestic cement market demand and taking into account a lower content of clinker in cement.
  No additional new clinker capacity needs to be built before 2025. Up until 2020, increasing market demand can be met by increasing existing capacity utilisation, and up until 2025 by lowering the clinker content in cement.
- Identify all measures that are necessary to improve the quality of construction and implement the resulting measures for improvement.
  Introduce a quality assurance certification scheme for ready-mix concrete installations and operations.
  Architects, engineers, and construction companies should undergo specific capacity building, learning and training for the use of composite cement in reinforced concrete and construction.
  Consequently, adapt the construction codes, enabling the gradual decrease of the content of clinker in cement, concrete and construction.
- Include measures requiring the fly ash to be of adequate quality for its use as a cement constituent and a minimum quota for its use as clinker substitution in the permits of new coal-fired power stations.
- The EEAA should classify fly ash as non-hazardous waste and allow import of foreign fly ash, slag and pozzolana.
- The key success factor for waste-to-energy and alternative fuels is to create market demand for environmental and legal waste treatment.
  It is essential that waste producers have a strict legal obligation to dispose of their waste in a safe, environmental and legal way and ensure that their waste disposal complies with the "waste hierarchy" and the "polluter pays principle".
  Adequate waste management legislation, regulation and law enforcement will generate market demand for environmental and legal waste treatment, a sound waste management market and infrastructure, and consequently a market price for waste treatment and disposal. This will help to create a business case for waste as a fuel in the cement industry.
- The cement company's operating permit should require that cement companies with a specific energy consumption higher than a benchmark are obliged to periodically execute an energy audit and financial-economic assessment of the energy efficiency improvement potential at their installations. Actions identified for energy efficiency improvements should then be implemented.
- Incentivise research and development for improving technology for BPD treatment and recycling, especially with respect to lowering water consumption and utilising solar energy in the process, lowering the investment and operational costs and recycling the recovered salts, and perhaps also for opportunities for mining of historic BPD landfills and export of the recoverable product.
- Strengthen the capacity of various stakeholders, which is a critical success factor for the detailed design and implementation of the mentioned policy measures that are needed to enable the widespread adoption of CO_2 mitigation actions in the cement sector in Egypt.

The authors recommend institutionalising regular consultations with the stakeholders involved in the implementation of such policy measures. This could be a regular roundtable or a steering committee.

A more detailed discussion of these policy actions, including identification of the key stakeholders that can or should take responsibility for the policy actions is provided below and in Annex 1 of this document.

1. Introduction

1.1. Objective of the Roadmap

The purpose of the Low-Carbon Roadmap for the Egyptian Cement Industry is to suggest a pathway for the sector detailing how to mitigate as far as possible the impact on greenhouse gas (mainly CO_2) emissions of the new fuel regulations in Egypt, which phase out the subsidies for natural gas and heavy fuel oil for cement plants, resulting in the use of more economically feasible solid fuels, such as coal or petcoke.

The Roadmap suggests the most suitable technological levers that can help the Egyptian cement industry improve its energy efficiency and reduce CO_2 emissions. It also recommends policy actions for the Egyptian Government that should provide effective incentives for the cement industry to implement low-carbon measures.

The depth and pace of implementation of the policy actions will have a direct impact on the pace of implementation of low-carbon technologies and the possibility for mobilisation of domestic and international climate finance, and consequently on the magnitude and timing of the CO_2 emission reductions that result from their adoption. The Roadmap is therefore structured around the main CO_2 mitigation levers that it is supposed to incentivise.

1.2. Approach and scope

The Low-Carbon Roadmap provides a set of policy recommendations, which if adopted should lead to the implementation of CO_2 mitigation activities (CO_2 mitigation projects and low-carbon practices) in the Egyptian cement industry. Two low-carbon development scenarios show how these recommendations can be implemented according to two different levels of ambition. A high level of ambition implies greater commitment from national authorities to implement policy recommendations, such as agreeing that a balance needs to be struck between clinker and cement production capacity and domestic market demand in the country, that an average sector clinker factor target must be set and that any new licences to produce clinker and cement that might be issued take such a target into account. Other recommended policy actions include systematically enforcing waste legislation, streamlining permits for alternative fuel and raw material (AFR) projects, specifying blended cement for reinforced concrete application in public sector infrastructure projects, among others. It also assumes that the international support needed to incentivise the uptake of low-carbon mitigation projects beyond the less ambitious, moderate scenario, becomes available. A higher level of ambition and sooner implementation of CO_2 mitigation activities will result in a higher reduction in CO_2 emissions by 2030, and mean that the CO_2 mitigation policy goal will be met sooner.

In order to design the Low-Carbon Roadmap, the authors undertook the following activities:

- Stakeholder consultations and workshops.
- Interviews with and data collection from 12 cement companies representing 87.3% of the total grey clinker capacity in Egypt.
- Assessment of confidential data received from the companies interviewed.
- Analysis of the current economic, policy, legislative and regulatory framework for low-carbon development of Egypt's cement sector and its comparison against international best practice.
- Analysis of gaps/barriers in the economic, policy, legislative and regulatory framework to achieving a sustainable low-carbon future of the cement sector in Egypt.
- Drafting policy gap closing actions and policy recommendations and discussion of these with stakeholders.
- Overall assessment of the impacts of different technological considerations/ drivers of GHG emissions of the existing production facilities in the Egyptian cement industry, such as:
  - production availability,
  - product portfolios (clinker factor),
  - energy consumption (thermal and electrical),
  - processing input substitution,
  - AFR.
- Evaluation of Egyptian cement production assets vs. European and global best practices.
- Low-carbon technological assessment for medium and large capacity integrated cement production facilities based on technology papers of the Cement Sustainability Initiative (CSI) and European Cement Research Academy (ECRA) and the authors' expertise, and evaluation of the future low-carbon development of the Egyptian cement industry as a whole.
- Assessment of Egyptian cement market competitiveness against countries located in the Mediterranean, the Red Sea, and the Gulf areas that have the potential to affect the situation in Egypt.
- Preparation of low-carbon technology/fuel scenarios.

2. Egyptian cement industry at a glance

In 2015, the Egyptian cement industry had a total installed production capacity of 62 million tonnes clinker, of which 60.3 million tonnes (97.3%) was grey cement clinker. At an average clinker content of 89%, this represents 68 million tonnes cement. This would however allow for the production of 80 million annual tonnes of grey cement in the case that Egypt meets the current world average clinker factor (75%). White cement, with 2.8 million annual tonnes clinker capacity, is a niche market.

In excess of 60% of capacity is produced by five multinational cement companies, with the remaining balance being produced either by state-owned or national and regional private entities.

With more than 50% of production capacity being built after 2000, the Egyptian cement industry can be considered as relatively young and up-to-date with respect to machinery and technology. Most of the integrated cement production facilities are equipped with four or five stage preheater or preheater/precalciner kilns, which is a BAT. After National Cement closed its two wet lines in 2015, all production lines in Egypt now exclusively utilise dry process technology.

What characterises the Egyptian cement industry is the rather large size of its production lines, with more than 60% being above 5,000 tonnes per day (tpd) clinker capacity, and four above 6,000 tpd clinker capacity.

During the last five years, the Egyptian cement industry has operated at about only 70% capacity utilisation. Such low capacity utilisation is unsustainable in the long-term. In particular, installed clinker production capacity is expected to be significantly higher than market demand for several years going forward.

The whole Middle East and Mediterranean region suffers from a significant excess cement production capacity.

An Egyptian FOB cement cost of 20 USD/tonne cement is higher than that of the regional competition, e.g. Turkey, and is therefore uncompetitive in the export market (except for some border markets accessible by trucks), and margins are narrow with competition from imports.

However, it is anticipated that demand will grow in the future as Egypt's economy and construction sector recover from the economic crisis. MTI predicts that cement consumption will be around 90 million tonnes by 2022, which means 81 million tonnes of clinker capacity at the current clinker factor. This is about a 75% increase from the 2012-2014 average production figure and will result in more than 1,000 kg cement production capacity per inhabitant per year.

Figure 2: Cement plants in Egypt

Plant Source: Cementis

Based on international experience, such large capacity expansion is economically unsustainable and is undesirable from a national energy and CO_2 emissions point of view. The Egyptian CBMI does not expect market demand to exceed 80 million tonnes cement by 2025, which is in line with the authors' estimation based on cement market expertise.

Until about 2013, the fuel mix was subsidised natural gas (60%) and heavy fuel oil (40%), which has changed to mainly coal and petcoke and less than 5% AFR since the phasing out of fuel subsidies. Specific thermal consumption is about 3,800 MJ/tonne clinker, with an average clinker content in cement of 89%.

The Egyptian cement industry contributes about 1.8% to national GDP and consumes about 5.3% of total energy in Egypt. In the scenario where the cement industry switches to 100% coal and petcoke, its sectoral CO_2 emissions (averaged over the 2009-2013 period) would go up from 35 to 40 Mt/year, increasing Egypt's national annual CO_2 emissions from 206 to 211 Mt, with the cement industry's share increasing from 14 to 16%.

3. CO_2 emission reduction levers and related policy recommendations

Traditionally, the three main levers to reduce *direct CO_2 emissions* from the cement industry are:

- Lowering the clinker content in cement and concrete;
- Improving thermal energy efficiency; and
- Substituting coal with AFR in the clinker manufacturing process.

In the Egyptian context, two other aspects may contribute significantly to reducing direct CO_2 emissions or limiting their growth:

- Balancing clinker and cement production capacity with long-term domestic market demand; and
- Reducing BPD and CKD disposal.

Indirect CO_2 emissions[1] may be lowered by:

- Waste heat recovery (WHR);
- Improving electrical energy efficiency, and using electric power from renewable energy sources.

Other important measures with *indirect impact* on CO_2 emissions that have been included in the Roadmap are:

- Developing a monitoring, reporting and verification (MRV) system according to a harmonised sectoral standard to assess progress in CO_2 and energy performance;
- Introducing economic and financial incentives for CO_2 mitigation actions. Realistically, companies only implement low-carbon measures when they are forced to do so by law, regulation or operating permit or when such measures are economically attractive, i.e. when they allow improvement of the profit and loss statement. Policy actions should therefore include development of necessary economic and financial incentives that will stimulate the industry to invest in low-carbon technology options.
- Capacity building, awareness raising and improving dialogue among all stakeholders: government authorities, cement companies, upstream industries (e.g. producers of AFR or clinker substitutes), and consumers of cement products, for adoption and implementation of low-carbon measures.

In the following section each lever is described in more detail along with corresponding policy action recommendations.

3.1. Developing a monitoring, reporting and verification (MRV) system

Introduction of an MRV system for energy and CO_2 emissions in the cement sector according to a harmonised standard is crucial for an effective implementation of the Roadmap for a number of reasons:

- To monitor the key performance indicators (KPI) that define energy and CO_2 efficiency and manage energy and CO_2 emission performance at the plant and sector level;
- To comply with the environmental reporting requirement set out in the April 2015 fuel regulation. Environmental reporting should be of an international standard and include independent third-party verification. This will ensure a level playing field between cement companies;
- To compare performance and progress of different companies at the national and international level and to set realistically achievable performance benchmarks;
- To monitor policy implementation effectiveness and inform decision making;
- To use the results of the sectoral MRV in Egypt's national reporting to the UNFCCC.

It is recommended that the Government of Egypt and the CBMI take the following policy measures:

1. Establish an Egyptian cement sector energy and CO_2 MRV standard at the installation, company and sector level, which is compatible and comparable with the WBCSD CSI global MRV standard and the 'Getting the Numbers Right' (GNR) database. Such a standard should be developed through a consultative process between the CBMI, the Egyptian Organization for Standardization and Quality (EOS) and the EEAA. This will help form the basis of a comprehensive system in line and compatible with the UNFCCC requirements on transparency and international MRV systems.
2. The EEAA add the annual application of this MRV standard at the installation and company level, including independent third-party verification, into the technical regulation of the April 2015 coal law and in the operating permit of cement companies. Periodic environmental reporting, required by the April 2015 coal law, should be in accordance with this sectoral MRV standard.

[1] Carbon Capture and Storage or Use (CCS and CCU) are not proven or available technologies and thus not yet relevant in the Egyptian context.

3. Perform an inventory and annual assessment of the progress of KPIs at the sectoral level for cement, including national and international benchmarking, respecting each company's confidential information (e.g. data collection done by a reputed international auditing company).
4. Due attention should be paid to capacity building, training and learning of the relevant stakeholders. The CSI and its member companies can provide such capacity building.

Since the coal regulation entitles the EEAA to define the technical requirements for reporting and all tools, training materials and a helpdesk are available, these policy measures can be implemented in a very short period of time (approximately one year).

3.2. Lowering the clinker content in cement

Clinker production is the main source of CO_2 emissions in the cement industry, but clinker can be partially substituted by other mineral components (MIC) such as limestone, slag, fly ash or pozzolana, that cause little to no CO_2 emissions during production. Hence, lowering the amount of clinker in cement and in concrete is one of the main levers for reducing CO_2 emissions.

The main barriers for this mitigation measure are related to:
1. The limited availability of some clinker substituting materials in Egypt,
2. Inadequate construction practices at building sites,
3. Excess clinker production capacity.

Availability of clinker substituting minerals in Egypt

Ground granulated blast furnace slag (GGBFS or slag), fly ash, natural pozzolana and ground limestone can be other main constituents of cement, together with clinker. The Egyptian cement standard allows up to 35%[2] of each of these constituents in different blended and composite Portland cements. The properties of cements differ as a function of their composition and can be optimised depending on the construction application.

Their availability is however, with the exception of limestone, limited to non-existent types in Egypt.

Slag: the blast furnaces of the Egypt Iron and Steel Co., Hadisolb, can produce about 0.5 Mt of slag per year. Considering this limited quantity, clinker substitution by slag in Egypt is less than 1%[3].

Fly ash: since there is currently no coal-fired power generation in Egypt, there is no domestic fly ash production. This might change in the future as the Government of Egypt intends to license up to 12.5 GW of coal-fired power generation capacity by 2022. This will however lock-in very large additional volumes of CO_2 emissions for several decades, which is contradictory to the long-term goal of the UNFCCC Paris Agreement. As multinational financial institutions have decided not to finance new coal-fired power generation, the pace of future growth of Egyptian fly ash production remains quite uncertain.

Pozzolana: pozzolana deposits are available in countries around the Mediterranean Sea, such as Italy, Greece and Turkey; according to current information there are no such natural deposits in Egypt.

Limestone: limestone deposits are usually abundantly available and are the main raw material for clinker production.

The Egyptian cement industry cannot however count on limestone alone to sufficiently lower the clinker content in cement. For some applications limestone cement is not adequate and for other construction applications slag or fly ash cements are better options.

Whereas the limited regional availability of these MICs is a practical and economic hindrance to clinker substitution, it should not necessarily prevent it. Indeed – similarly to the long distance shipment of coal, clinker and cement – slag, fly ash and pozzolana can be (and are being) shipped over long distances. Whereas the bulk transport and port handling of granulated slag and pozzolana pose no particular problem, adequate measures must be taken to prevent dust emissions during the handling of fly ash (as with the measures to be taken for the handling of Egyptian domestic fly ash).

This Low-Carbon Roadmap assumes that the Egyptian cement sector can access clinker substitutes in the same way as cement companies do in many other countries around the world, taking into consideration health, safety and environmental issues associated with the handling of such materials.

Product qualities and construction practice and codes

Product and market differentiation is an important driver for better construction, for lowering the clinker content in cement, and as such for reducing energy consumption and CO_2 emissions.

The product labelling and technical guidelines for cement should provide all necessary information, advice and warnings to the customer. However, since in Egypt this advice is often not followed, cement companies are reluctant to offer differentiated products to the market. Hence, the cement industry's potential for lowering the clinker content in cement will in the first place depend on construction codes and practices, and training and quality control along the entire value chain from architects, engineers, ready-mix concrete and on-site concrete mixing to building contractors and authorities.

[2] For some cement types even up to 95%.

[3] In 2012, Egyptian cement contained on average 0.9% slag (based on the 13 installations in this EBRD project's database, five of which using slag).

Considering the above, the following policy measures are recommended:

1. The Ministry of Housing, Utilities and Urban Development (MoHUUD) organise consultations between the CBMI, the National Housing and Building Research Centre (HBRC), The Egyptian Organization for Standardization and Quality (EOS), the Egyptian Federation for Construction and Building Contractors (EFCBC), the Building Technical Inspection Agency (BTIA) and the Industrial Development Agency (IDA), with the objective to identify all measures necessary to improve the quality of construction and enable the gradual decrease of the content of clinker in cement, concrete and construction. This measure will also need to include improved education, learning and training of construction and supervisory staff.
2. Introduce a quality assurance certification scheme for ready-mix concrete installations and operations. A specific label should be granted to the ready-mix concrete producers verifying the application of specific requirements like modern test laboratory, BAT installations with automated weighing material and production process, and monitoring and reporting of good operational practice. Architects, engineers, and construction companies should follow specific capacity building, learning and training for the use of composite cement in reinforced concrete and construction, and be allowed to use concrete made of blended cement from the licensed ready-mix plants. Class A contractors should be sufficiently qualified and trained for applying composite cements. The correct application of such types of cement and concrete at the construction site should also be subject to adequate MRV.
3. Introduce design, engineering and construction standards and codes for differentiation of the cement product portfolio according to the characteristics of the specific construction application and encourage the use of blended and composite cement.
4. Permits for new coal-fired power stations in Egypt to include measures requiring fly ash to be of adequate quality for its use as a cement constituent and to impose a minimum quota for power companies to use fly ash as clinker substitute.
5. The EEAA to declassify fly ash from hazardous waste to non-hazardous waste or even to a by-product in cases where it can be used as a cement constituent.
6. The EEAA and MTI to allow import of foreign fly ash, slag and pozzolana.

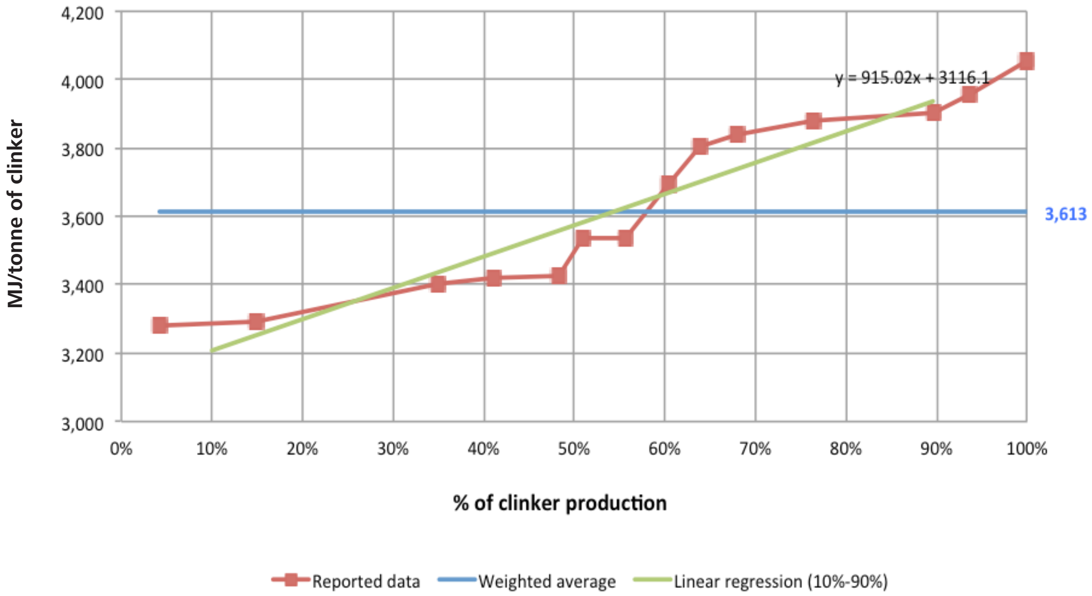
Implementation of these policy actions will take time and be a long-term step-by-step process, involving all stakeholders.

3.3. Improving thermal energy efficiency

Whereas about 50% of Egyptian clinker kilns operate close to BAT thermal energy efficiency (taking into account dust disposal), the other 50% consume on average an excess of about 14% energy.

Business decisions to improve thermal energy efficiency are almost always largely or entirely inspired by short- to medium-term financial

Figure 3: Hypothetical thermal energy efficiency of clinker production assuming no BPD & CKD disposal



Source: EBRD, 2016. Project database

assessment of alternative options. The energy cost consequently has an important bearing on the incentive to improve specific thermal energy consumption (STEC). Sourcing a high proportion of thermal energy from waste-derived fuels, especially of moist or coarse waste materials, can increase STEC. Whereas many countries apply a guiding STEC benchmark for permitting new installations, the achievement of a certain STEC is not usually mandatory but left to market forces. During the last decade, an increasing number of countries have introduced supplementary economic incentives (or are preparing to do so), such as an energy tax, carbon tax or emission trading system (ETS).

Policy measures[4] to improve thermal energy efficiency in Egypt's cement sector may include:

1. The Industrial Energy Efficiency Unit (IEEU) of the MTI and EEAA define BAT and energy efficiency benchmarks as a reference for existing installations and for the permitting of new installations (considering the influence of AFR use and BPD disposal).
2. Instead of mandatory achievement of the STEC benchmark, include the requirement in the operating permit that cement companies with higher STEC than the benchmark are obliged to periodically[5] execute an energy audit and financial-economic assessment of the energy efficiency improvement potential at their installations.
3. Arrange periodic accreditation of energy audit companies with proven experience.
4. Issue an operating permit along with the requirement that cement installations introduce energy management systems in line with ISO 15001, including adequate training of operating and maintenance personnel.

These policy measures could be implemented in a relatively short time period (about a year or so).

3.4. Using alternative fuels and raw materials (AFR)

The cement industry can offer an excellent and sustainable solution to several waste elimination problems and can substitute traditional fossil fuels with waste-derived fuels, provided this is economically attractive. There is one essential principle to be fulfilled to realise this potential: market demand for energy from waste must be satisfied by safe, environmentally sound and legal waste treatment solutions.

In Europe and North America, the market demand for safe, environmentally sound and legal waste treatment and waste co-processing was created by enactment of relevant waste management legislation and regulation.

Besides the overarching waste framework legislation, laws or regulations were introduced for specific waste products, such as industrial waste, domestic waste, waste oil and hazardous waste, and for specific disposal options such as landfilling, incineration and use in agriculture.

These policies and legislation have enabled the development of a sound waste management market with proper infrastructure and a price for waste treatment and disposal, which, in turn, encouraged the cement industry to use waste as a fuel[6].

To enable a similar development to take place in Egypt, it is necessary to develop and implement the legislative and regulatory framework at the national, regional and local level, ensuring that industrial, commercial, domestic and agricultural waste is properly dealt with along the entire value chain from waste generation through collection, transport to treatment and final disposal.

This requires implementation of the following policy actions:

1. Waste management legislation defines the roles and responsibilities of:
   - the waste management authorities at the national, regional and local levels;
   - the judiciary system, enabling the control and enforcement of waste legislation;
   - the waste producers, progressing towards extended producer responsibility;
   - the private sector operating in the waste value chain (from generation to final disposal).
2. The law and regulations contain provisions on:
   - the waste management hierarchy: when co-processing of waste (including by cement plants) should be the preferred route compared with the alternative waste disposal options (such as for instance landfilling, incineration, dumping and burning);
   - the "polluter pays principle", i.e. the party responsible for producing waste / pollution is responsible for paying for disposal / treatment;
   - a timeline for progressing with the gradual implementation of the above hierarchy and principle.
3. The regulations define the environmental, health, safety and technical criteria to be adhered to by the waste producers[7], collectors, transporters, and treatment and disposal companies;
4. The law and regulations require the waste producers[8], collectors, transporters, and treatment and disposal companies to monitor waste volumes, their origin and destination, and to report to an official database; define sectoral systems and IT tools for MRV of waste co-processing; and define control procedures and non-compliance penalties.

[4] All proposed policies may equally apply to all energy-intensive industries in Egypt.
[5] For instance, over a two- or five-year time period.
[6] A concise summary of key enabling success factors and utilisation of AFR in the European cement industry is given in the Report D5 'Policy Roadmap for the Low-Carbon Egyptian Cement Industry' under this project.
[7] Except for domestic waste producers.
[8] Except for domestic waste producers.

European Bank
for Reconstruction and Development

5. The law creates adequate budgetary, economic, financial and fiscal instruments that enable effective functioning of the waste management authorities and professional and sustainable waste management practices and defines penalties for non-compliance;
6. Adequate and continued communication and stakeholder engagement is sustained;
7. The judiciary system includes a section specialised in adequate, independent and impartial control and enforcement of waste management legislation[9];
8. The regulations and criteria ought to be tailored to the main waste categories (domestic, industrial, commercial, agricultural and medical waste), as well as to special waste streams;
9. A level playing field is ensured among formal and informal actors in the waste value chain.

This is a vast undertaking, which will have to be pursued gradually. These policy measures should apply equally to all companies active in waste management, whether state owned or private, formal or informal, waste service or cement companies.

The cement industry should comply with the relevant regulations, monitor and control the inputs, process, products and CO_2 emissions, and communicate results transparently. On the other hand, the waste management companies should meet the needs of the cement industry in terms of product quality and characteristics and sell waste with high calorific value, ideally at a certain discount compared with the cost of combustible fossil fuels.

Currently, the large majority of industrial and business waste generated in Egypt is uncontrolled; there are only a limited number of licensed landfills, and large parts of non-recyclable domestic waste are also spread across the environment. It is therefore suggested to develop a waste and AFR management system in a step-by-step sectoral approach, starting with the waste streams that involve a limited number of stakeholders, such as for industrial and business waste.

3.5. By-pass dust (BPD) and cement kiln dust (CKD) reduction

CKD is the dust that exits the top of the preheater with the exhaust gases and is captured by the flue gas filters before the flue gas is emitted through the stack. BPD is the dust that is drawn out of the kiln inlet when some kiln exit gases are extracted between the kiln and preheater to break the cycle of volatile species between the kiln and preheater. BPD is normally largely decalcined, while CKD is not[10].

In most countries[11] the vast majority of CKD is recycled in the kiln or in the cement mill, while BPD quantities are small to non-existent and are mainly caused by chlorine-containing AF.

However, due to the high chlorine content in limestone in Egypt (ranging between 0.07% and 0.4%, with an average of 0.17%[12]), the Egyptian cement companies have to extract BPD to prevent clogging of the kiln inlet system. The production of CKD cannot be avoided[13], and due to the specific Egyptian context BPD production can also not be completely eliminated.

On average, in Egypt around 38 kg BPD and 10 kg CKD are discarded per tonne clinker produced, causing about 180 MJ/tonne clinker or 5% more thermal energy consumption and 31 kg CO_2 per tonne clinker or 4% more CO_2. Whereas CKD and BPD production cannot be avoided, limiting their disposal could be an effective means of lowering energy consumption and CO_2 emissions.

Normally, the Egyptian cement companies take economically feasible measures to minimise the disposal of CKD and BPD because of the significant costs involved. Each tonne of dust disposed uses 1 to 1.6 tonnes of raw material and the corresponding energy cost.

CKD can be partially recycled in the clinker kiln and cement mill systems, BPD much less so. The permitted chlorine content in cement is the limiting factor. Nevertheless, due to the high chlorine content in Egypt's limestone and clay resources, large volumes of CKD and BPD remain that can technically not be recycled in cement or concrete.

There are possible uses for CKD and BPD in other applications, such as lower strength road foundations, soil and landfill stabilisation and agricultural soil improvement. However, the usable quantities are small compared to the volumes produced and such applications are inferior and do not improve the energy and CO_2 emission balance. The majority of CKD and BPD produced in Egypt is consequently landfilled.

Washing the unwanted water-soluble salts (mainly sodium and potassium chlorides and sulphates) out of the BPD and CKD with water and dewatering the remaining slurry that contains calcium carbonates and oxides, as well as silicium, iron and aluminium oxides, which can then be reintroduced into the kiln system, could theoretically completely eliminate the need to landfill CKD and BPD as well as the associated (but not entirely linked) CO_2 emissions and waste energy. However, this technology currently consumes significant quantities of fresh water (1 tonne water per 1.5 tonne dust, or about 1.8 Mt water if all Egyptian BPD were to be treated and recycled), which may be problematic in the dry Egyptian environment, and any solution depends on its economic feasibility.

[9] By enforcing current regulations, such as the ban on uncontrolled landfills, open air burning of tyres, etc., AFR usage could already be increased.
[10] As a result, BPD causes process CO_2 emissions (default is 525 kgCO_2/ tonne BPD). The CSI MRV CKD default calcination rate is zero (i.e. no emission of process CO_2 yet), but it is recommended to use a plant specific measured value.
[11] In addition to Egypt, the US cement industry also used to discard considerable amounts of CKD (about 15 to 30 kg CKD per tonne clinker sent to landfill).
[12] Project database.
[13] Otherwise CKD would be emitted as dust through the stack.

Hence, policy actions should aim to effectively incentivise research and development to develop a solution for the recycling of BPD (and perhaps CKD[14]). These include:

1. Cement companies should hold a dedicated permit to landfill CKD and BPD, specifying technical and occupational health and safety (OHS) criteria for landfilling and the obligation to register and report volumes and qualities.
2. Develop research and development (R&D) funds and execute research and development for improving the technology for BPD treatment and recycling, especially with respect to lowering water consumption and using solar energy for the process, lowering the investment and operational cost and recycling the recovered salts.
3. At a later stage, opportunities for mining the large volumes of landfilled BPD and export of recoverable product to countries with sufficient water availability and effective CO_2 price can be explored.

3.6. Balancing clinker and cement production capacity with long-term domestic market demand

To maintain the competitiveness of the industry and to enable the mitigation of CO_2 emissions and reduce traditional fossil fuel consumption, it is important to adequately balance domestic clinker and cement production capacity with domestic cement market demand, preventing systemic excess clinker production capacity and avoiding a clinker or cement export strategy.

The licensing of new clinker production and cement grinding capacities is a critical aspect in enabling such an adequate balance. Reducing the clinker factor from 89% to 75% (the world average is 74.7%) will increase cement capacity by 19% from 70 to 83 million tonnes at existing clinker capacity. This means there is no need for new clinker capacity before 2026, considering projected demand (see Figure 4).

Having over-capacity in a country not only discourages the reduction of clinker content in cement but also reduces margins to such an extent that the cement industry usually cannot afford to implement environmentally friendly measures. It is therefore important to hold an inclusive consultation between the Industrial Development Authority (IDA) of the MTI, CBMI, the Ministry of Investment (MoI) and other relevant stakeholders to:

1. Discuss medium- and long-term forecasts for domestic market demand and how that demand can be met with the existing clinker and cement capacity, clinker factor reduction and other measures; and
2. Decide on the optimal pace of licensing new clinker production and cement grinding capacities.

Such a consultation is very urgent in order to prevent the licensing and building of excess clinker capacity with all the associated negative consequences in terms of the cement sector's energy consumption, volume of coal that needs to be imported, CO_2 emissions, the country's foreign exchange reserves and the cement sector's profitability.

3.7. Waste heat recovery (WHR)

Energy and heat recovery is an indispensable measure applied by each and every cement plant. Even after heat recovery, the flue gases of the kiln and cooler stacks still contain a certain amount of energy. This can be partially recovered via a steam[15] boiler, with a subsequent steam turbine for the production of electric power. The relatively low temperature of this waste heat limits the thermal to electric energy conversion efficiency of WHR to about 20 to 25% or even less if heat has been maximally recovered in the cement plant.

WHR to power in the cement industry requires a relatively high investment (EUR 15 to 25 million for a 6,000 tpd installation), but has a low operational cost (EUR 0.3 to 1.2 per tonne clinker cost decrease). It is generally not economically feasible without additional financial support.

Hence, it is recommended to assess:

- All technical options to recover heat as thermal energy in the process (e.g. in the coal mill, in the cement mill for drying clinker substituting materials, for AFR treatment and drying or for BPD treatment and recycling);
- The remaining excess recoverable heat, as well as the potential and cost to produce electric power; and
- Policy and economic incentives encouraging the use of WHR as renewable energy without jeopardising thermal energy efficiency improvement measures that should come first.

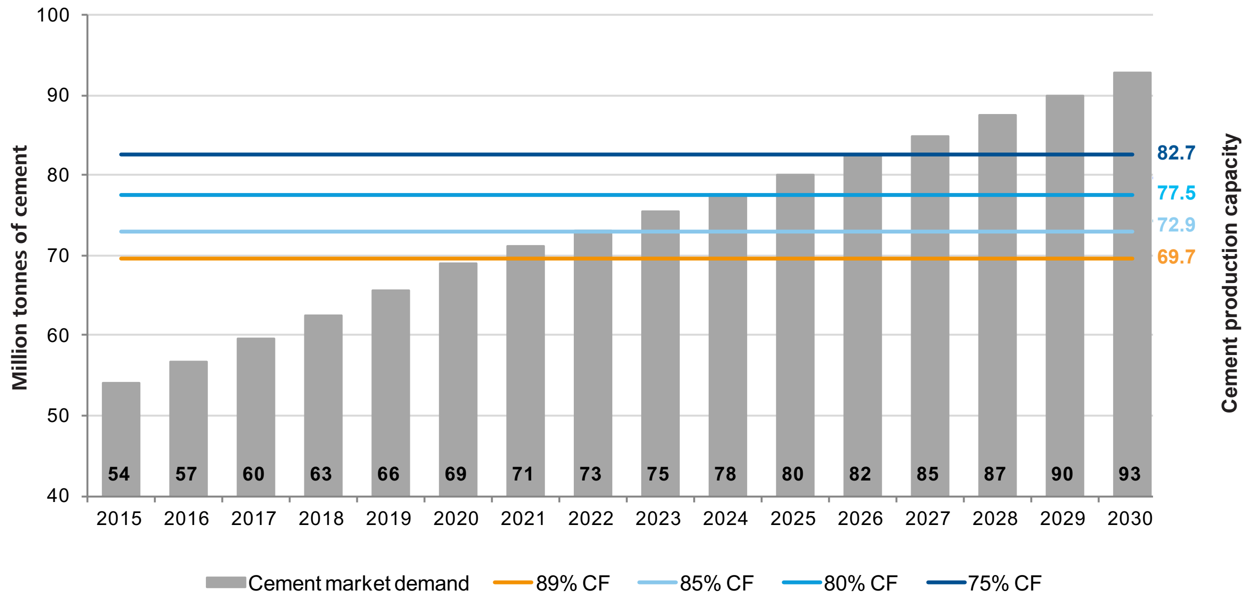
3.8. Introducing financial and market-based incentives

Energy and CO_2 emission improvement options will only materialise when they are economically and financially attractive. To the extent feasible they should be financed by the cash flow of companies, in principle either due to additional cost savings, additional revenues (for instance from AFR service fees) or passing on the cost of the measures in the cement sales prices to the customer.

Over the last 10 years, a number of countries have created such an additional economic incentive through ETSs or a carbon tax; and the 2015 Egyptian Intended Nationally Determined Contribution (INDC) to the UNFCCC suggests the option of establishing a national or regional carbon trading system. Such policies are intended to

[14] Since CKD production causes much less energy consumption and CO_2 emissions than BPD, its recycling is less effective for energy and CO_2 mitigation.
[15] Other fluids can be used in the so-called Organic Rankine Cycle if the flue gas temperatures are lower.

Figure 4: Cement production capacities at different clinker factor (CF) in cement with 2015 existing clinker capacity versus domestic cement market demand (in million tonnes)



Source: EBRD, 2016. Report D5

be "technology neutral", i.e. should incentivise any CO_2 mitigation technology starting with the least costly.

In Europe, a carbon cost of around EUR 15 per tonne CO_2 is needed to effectively mitigate CO_2 emissions from cement production.[16] It is unlikely that such carbon pricing will be reached in Egypt any time soon.

In any case, to be effective a carbon tax or ETS should be multi-sectoral, and not limited to just one industry sector. Building sufficient political support for a multi-sectoral carbon price, as well as for international climate finance, could be done under the framework of the Egyptian National Determined Contribution (NDC) to the UNFCCC Paris Agreement and is likely to take several years.

Whilst this process may take several years, it would be good to increase the level of understanding on GHG emissions across sectors, as this is relevant for the UNFCCC transparency framework, as well as valuable business information to direct investments and operations.

3.9. Building capacity and enhancing dialogue between stakeholders

Strengthening the capacity of various stakeholders will be a critical success factor in the detailed design and implementation of the mentioned policy measures that are needed to enable the widespread adoption of CO_2 mitigation actions in the cement sector in Egypt.

The financial means for this capacity development will have to be provided, for instance through the state budget, a levy or charge on fossil fuels and/or clinker, and/or the redirection of the (former) fuel subsidies or international climate finance (if the targets of the Roadmap are ambitiously contributing to Egypt's NDC under the Paris Agreement).

It is also recommended to institutionalise a regular consultation of the stakeholders involved with the implementation of relevant policy measures through, for instance, a regular roundtable or a steering committee that could guide the implementation of the Roadmap.

[16] Climate Strategies (2014).

4. Low-carbon technologies and reference plants for Egypt

CO_2 emission reduction levers are directly influenced by technical performance design levels (TPDL) and the corresponding structuring and implementation of these TPDL when upgrading existing facilities, as well as or building new plants.

The main drivers are the in- and output material streams in the overall cement manufacturing process. The primary cement manufacturing process consists of several intermediate production stages, and is in itself an integral part of the building material value chain, ranging from raw material exploitation through to delivery of the end product to the market place, i.e. building and structures.

The engagement and integration of the cement industry in upstream and downstream activities, in addition to the primary manufacturing process, is recommended as a means of minimising the carbon footprint of the entire value chain.

Therefore, a future low-carbon reference plant for Egypt should be designed to be capable of operating in an environment that stimulates low-carbon plant configuration and operation, and which factors in key low-carbon technologies and the corresponding TPDLs:

- **Clinker content reduction** – a reduction from the current levels of approximately 89% (average) clinker in cement to a sustainable 75% (approximate global average) or lower (several multi-national cement producers that are active in Egypt demonstrate lower values). This is in comparison with the global best practice of <50% clinker per tonne cement for some specialty blended cement types.
- **Specific thermal energy consumption (STEC)** – a reduction from a current average of 3,800 kJ/kg clinker[17] to a lower average level in line with global best practices; for existing plants a 3,000-3,200 kJ/kg clinker baseline (basis four to five stage preheater/precalciners) in the Egyptian context and for new builds a 2,800 kJ/kg clinker baseline (basis six stage preheater/precalciner); all to be adjusted upwards for the actual percentage kiln gasses bypassed (and BPD losses) in accordance with a pre-defined mechanism[18], e.g. a range of 2,900 kJ/kg clinker (six stage, ~10% kiln gas bypass) through 3,500 kJ/kg (four stage, ~30% kiln gas bypass). Allowance for AFR also to be made on a plant specific basis.
- In the Egyptian context, the negative influence on STEC of discarded BPD and CKD will have to be accounted for. Plants should be designed and operated to be able to tap into such waste thermal energy streams to: i) meet the manufacturing processes' thermal energy requirements for raw materials and fuel drying, and ii) generate electrical power through WHR. The latter is relevant to installations with excess thermal energy after thermal process energy needs are met.
- **Specific electrical energy consumption (SEEC)** – aim to reduce the SEEC per tonne of cement produced from the current level of 105 kWh/t cement to a sustainable target of 90 kWh/t cement or lower. Industry best practice would suggest even <80 kWh/t cement. Extensive production of blended cements and BAT machinery are the main drivers for achieving such a level of specific electrical energy consumption targets.
- **Alternative fuel (AF)** – plants are designed to be "AF-ready", so that they can accomplish a significant increase in the substitution of thermal energy provided through primary fossil fuels by alternative biomass or waste derived fuels. Future plants should be able to achieve a thermal substitution rate (TSR) of at least 30%. Industry best practice ranges from 80% up to 100% TSR.
- **Alternative raw material (AR) and mineral component (MIC)** – an increased use of AR and MIC – often waste streams from other industrial sectors – along with quality control and management of the supply chain of these materials.
- **Specific CO_2 emissions** – maintenance of current specific CO_2 emission levels below 800 kg CO_2/t clinker produced, considering a reduction of natural gas used (potentially to 0%) and a high degree of AF use - in excess of 30% TSR - as a primary thermal energy source.
- **Operational excellence** – future reference plants are designed, operated and maintained in a way that enables operating periods in excess of 90% of the total annual time at nominal or best demonstrated practice levels.
- **CKD/BPD and excellence in environmental performance (Environmental Management Systems or EMS)** – at present, approximately 5% of such materials are discarded. Re-introduction of CKD/BPD into the manufacturing process is highly dependent on changing the processing input, in particular, primary fuel, AF, AR and raw materials, and the acceptance in the Egyptian market of composite/blended cements (see above). This option has to be evaluated on a plant specific basis. Future reference plants should be able to maximise the amount of intermediate processing materials, i.e. CKD and BPD, that are reintroduced into the final cement products. CKD and BPD that cannot be reintroduced into the final cement product are used for alternative applications. The future reference plant is hence one that achieves 0% CKD/BPD disposal.

[17] Project database

[18] According to the CSI and ECRA technology papers, on average about 3,300-3,400 kJ/kg clinker baseline STEC should be achievable with four/five stage preheater/precalciner technology, which is predominant in Egypt; for a six stage preheater 2800 kJ/kg baseline STEC is achievable (the authors noted BAT baseline STEC's for modern preheater precalciner kilns: four-stage – 3,200kJ/kg, five-stage – 3000 kJ/kg clk, six-stage – 2,800 kJ/kg clinker. Each percentage bypass adding ~12kJ/kg clinker to the baseline).

The noted technological aspects of the process and corresponding TPDLs provide insight into the possibilities available to the Egyptian cement industry for its further low-carbon development. The following table details current market characteristics, performance in terms of KPIs and compares them against suggested TPDL.

Table 1: Technological performance indicators of current Egyptian cement industry, best practice and suggested Technical Process Design Levels (TPDL)

Technological aspects	Unit	Current best practice	Performance Indicators of Egyptian cement installations	
			Current	Suggested TPDL
Clinker substitution	% clinker/t cement	<50%	89%	<75%
Thermal energy consumption*	kJ/kg clinker	<2,800	3,425-4,171 (av. 3790 - project data)	<3,400 (kiln system/by-pass dependent)
Electrical energy consumption	kWh/t cement	<80	112 (GNR) 104 (project data)	<90
Alternative fuels (AF)**	% (thermal)	100%	low	min. 30%
Alternative raw materials (AR)**	% (kg/kg raw meal)	100% (small scale industrial)	low	min. 10%
CKD/BPD	% (of clinker)	0% (cement type dependent)	1.9-6.6% (4.8% in project database)	0% disposal
Specific CO_2 emissions	kg CO_2/t clinker	766 (EU ETS)	813 (GNR) 798 (project data)	<800
Specific CO_2 emissions	kg CO_2/t cement	CF dependent; 543 (global 10% best)	723 (GNR) 710 (project data)	<600
Carbon capture	-	pilot installation	minimal	initial investigations

* All possible mechanisms for thermal energy reutilisation to be employed
** Financial return and governmental policy largely determine this

Source: EBRD, 2016. Report D8-D9

5. Low-carbon scenarios up until 2030

Mitigating the CO_2 impact resulting from the introduction of the new April 2015 coal law relies largely on the extent of clinker content reduction and co-processing of waste (with an emphasis on agricultural waste and Solid Recovered Fuel (SRF)). These two levers are the ones that would provide the bulk of potential emission reductions and thus are crucial for achieving the Roadmap's objective by 2030. However, energy efficiency improvements are expected to deliver short-term gains in CO_2 performance and hence are where early emission reductions can be made. The implementation of a well-designed EMS should enable no-cost/low-cost energy saving opportunities to be implemented within one to two years of their introduction, through improvements in the way process equipment and utility systems are operated and maintained.

Projects and activities implemented to increase AF use and lower the clinker factor are also the ones that offer the largest impact in terms of hard currency savings and contribution to the achievement of other policy goals concerning waste management, energy security, industrial competitiveness, etc.

Two low-carbon development scenarios up until 2030 have been formulated for the implementation of the Roadmap: a moderately ambitious or *slow low-carbon development scenario* and a more ambitious or *rapid low-carbon development scenario* (for more details on the scenarios, please see the following sub-sections, as well as Annex 1 and Annex 2). The policy goal of mitigating the increased CO_2 emissions from potential coal usage can be met under both scenarios, but only if a balance is struck between clinker and cement production capacity and domestic market demand in the country. If such a balance is not found, the policy emission reduction goal will not be met.

5.1. Slow low-carbon development scenario

This scenario assumes that the Egyptian authorities are committed to implementing policy recommendations put forward in the Low-Carbon Roadmap. It also assumes that a structured, well-planned and sustained effort to strengthen and build capacities is pursued and that access to finance, particularly in the case of AF projects, is facilitated. To achieve the Roadmap's goal, it is key to reduce the sector's average clinker factor by 10% by 2030.

Hence, this scenario assumes that:

- The IDA maintains its recent proposal to issue 14 licenses for new clinker-cement installations, with a total capacity of 20 million tonnes cement/year at a 90% clinker factor (CF), aiming to increase the total installed capacity from the current 70 million tonnes to 90 million tonnes by 2020.
- However, as a consequence of the existing overcapacity, the difficult economic situation in the Egyptian cement industry, the uncertain investment climate in Egypt and limited investment capability of multinational cement companies, IDA succeeds in selling only half of the auctioned licenses. Only 10 million tonnes cement, 9 million tonnes clinker (instead of the planned 20 million tonnes) new capacity would come online.
- As a result, the total installed capacity will increase to 72 million tonnes clinker, 80 million tonnes cement (at 90% CF). This is sufficient to meet market demand until 2025 at a 90% CF. Further cement market demand growth can be met by decreasing the clinker content to 80% in 2030.

It is also assumed that no restrictions are imposed on the import of material that can be used to substitute clinker, should there at any point in time be insufficiently economical alternatives available in the country. The estimated demand for clinker substitute material by 2020 is approximately eight million tonnes.

Under this scenario, the Egyptian cement industry reaches a TSR of 8% through a fuel mix comprising 92% coal/petcoke, 4% SRF, 3% agricultural waste and approximately 1% dried sewage sludge (DSS), and reduces its clinker factor from 0.89 to 0.80 by the year 2030.

This scenario assumes that the international community provides technical assistance and support to the Egyptian authorities to put in place facilities and tools to reduce access to finance barriers, with a special emphasis on Small and Medium-Sized Enterprises (SMEs) seeking to invest in regionally located centralised agricultural waste storage and waste pre-processing facilities. An indicative level of capital expenditure needed to deploy the necessary waste pre-processing facilities, retrofitting the cement plants with the required co-processing equipment, and putting in place the necessary clinker substitute storage and handling facilities, is estimated to be in the order of EUR 90 million.

By the year 2030, this scenario assumes that the country has made some progress towards developing a well-functioning AF market and has significantly reduced the amount of clinker used to manufacture cement. As a result of such efforts, the cement sector would emit 10 $MtCO_2$/year less in 2030 than it would have otherwise.

The impact of the coal legislation on CO_2 emissions could be mitigated; the industry's coal imports would have been reduced by around 2.2 million tonnes per year by 2030. The aggregate hard currency savings by 2030 would be in the order of EUR 1.2 billion (assuming a price of coal of 86 EUR/tonne).

5.2. Rapid low-carbon development scenario

Under the more ambitious scenario, a 10% reduction in clinker factor (from 0.89 to 0.80) would already be achieved by 2025. This scenario is built on the following assumptions:

- The IDA changes its decision from late 2015 and decides not to issue new clinker-cement production licenses until at least 2020. This will avoid potential excess capacity of clinker production in the mid- and long-term as well as locking in corresponding CO_2 emissions.
- The current installed capacity is sufficient for meeting market demand at 89% CF until 2020.
- From 2020 to 2025 growing cement market demand but limited clinker production capacity will be an effective economic and market incentive to lower the clinker content in cement. Future cement demand is met by decreasing the clinker content to about 80%, potential sources of substitutes are limestone and partially, if available, fly ash from newly built Egyptian coal fired power plants.
- By 2020, the IDA and the CBMI will re-assess future cement market demand, available MIC and achievable clinker content in cement and decide on future additional clinker production and / or cement grinding capacity. It is assumed that the CF is maintained at 80% until 2030.

As under the slow scenario, there are no restrictions assumed on the import of material, which, if necessary, can be used to substitute clinker to meet the approximately seven million tonnes of substitute material needed by 2025. Under this scenario a TSR of 15% is achieved by 2030. By then, almost three million tonnes of coal imports to fire the cement industry's kilns could be avoided and the specific emission factor per tonne of cement could reach 694 tCO_2/tonne cement.

This scenario sees Egyptian stakeholders pursuing policy actions with much greater determination than under the moderately ambitious, slow low-carbon development scenario. For instance, waste legislation, such as the ban of uncontrolled burning of agricultural waste, is systematically enforced and the use of blended cement is extended to reinforced concrete applications in public sector projects through low-carbon purchase programmes, where such types of cement are specified to contractors. The country's willingness to increase stimulus to AF projects is also increased: fiscal and additional economic incentives (such as increased tipping fees) are introduced to incentivise greater use of AF and to extend the scope of low blended cement beyond the public sector and to include the private construction sector.

Such incremental efforts are funded jointly through domestic and international resources, and pursued as domestic and "supported" actions within the scope of the country's NDC to the UNFCCC Paris Agreement. Investments in pre- and co-processing, and clinker content reduction under this scenario, are assumed to total around EUR 150 million.

By the year 2030, this scenario assumes that the Egyptian cement sector emits around 11.5 $MtCO_2$/year less than it would have otherwise emitted in the absence of the Low-Carbon Roadmap, and needs to import around three million tonnes less coal per year. Aggregate hard currency savings resulting from coal that would no longer need to be imported would amount to roughly EUR 2 billion. Consequently, under the more ambitious, rapid low-carbon scenario, the Low-Carbon Roadmap's mitigation goal is achieved by 2025, five years ahead of 2030.

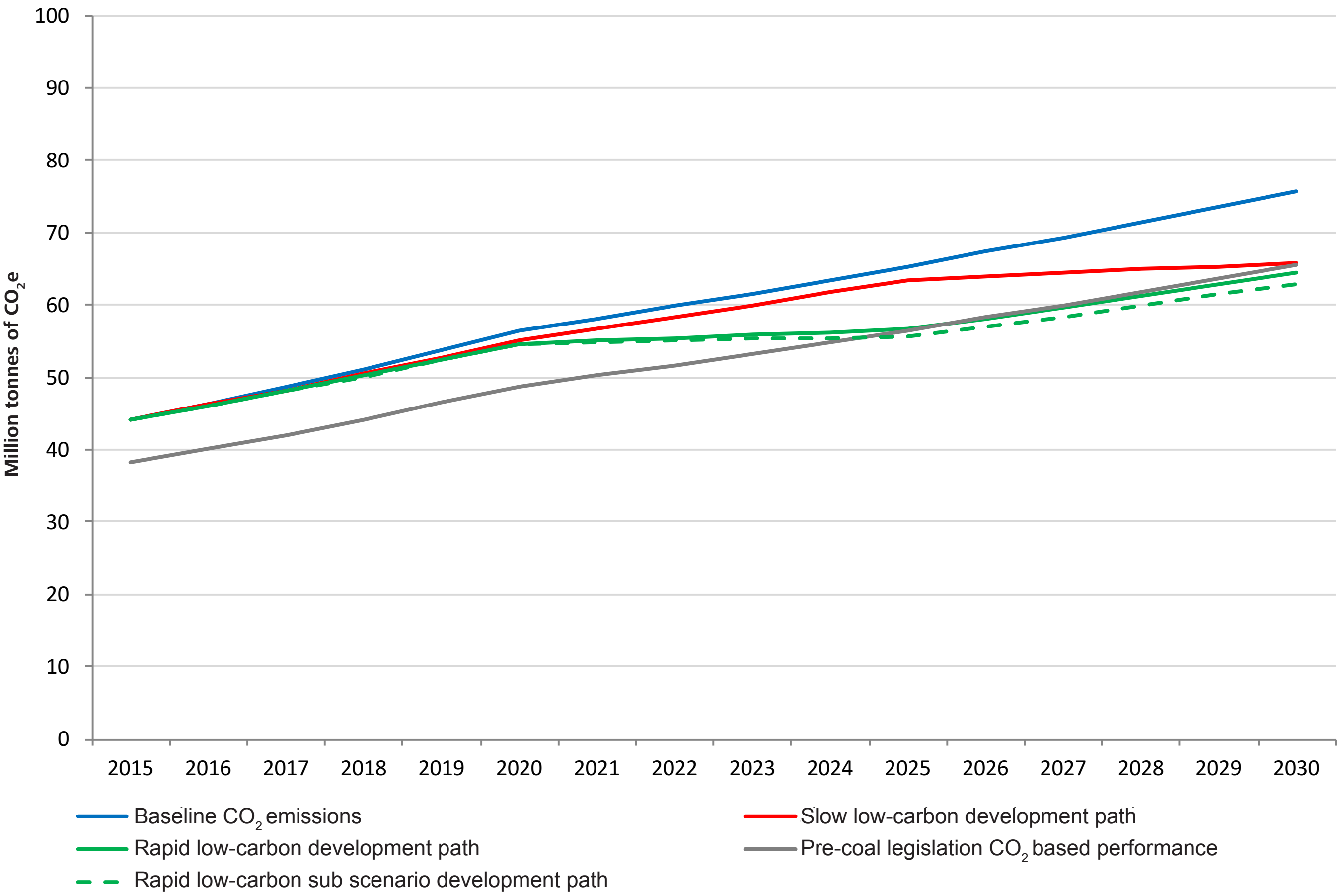
In fact, several international cement companies have set TSR targets in excess of 15%. Hence, a somewhat more ambitious rapid low-carbon sub-scenario sees the cement sector achieving a TSR rate of 15% by 2025, and of 22% by 2030.

A more ambitious scenario would be more aligned with the UNFCCC's 2°C goal, though such a low-carbon pathway would demand a higher level of commitment to the introduction of the Roadmap's policy recommendations. It would also put Egypt in a better position to mobilise the support needed from the international community to implement the Roadmap, as well as other mitigation efforts under its NDC. It is important to note that the otherwise anticipated 15% CO_2 emission increase in the absence of the Roadmap is averted by 2025 under the rapid low-carbon scenario, instead of by 2030 (under the slow low-carbon scenario). This in turn results in around 40 million tonnes of CO_2 less being emitted over the next 15 years.

Although achieving the Low-Carbon Roadmap's goal by 2030 depends mainly on ability to reduce clinker content and increase the use of AF, a number of additional CO_2 mitigation measures should be addressed. Most of these are energy efficiency measures that result in indirect CO_2 reductions, such as variable speed drive (VSD), energy efficient motors, etc. Though the uptake of such mitigation measures should be encouraged through policy incentives (and through broader, cross-industrial energy efficiency initiatives), their contribution to achieving the goal of mitigating the 10 $MtCO_2$/year emissions increase by 2030 expected from the cement industry's switch to coal/petcoke is limited. Nevertheless, a number of technological solutions exist, which have considerable technical mitigation potential, such as BPD reuse and WHR to power, but whose economic viability at scale is at present uncertain. Hence, these measures have not been considered for the purpose of the scenario analysis, however, they are presented as potential mitigation levers in the Low-Carbon Roadmap.

A total of 545 kg CO_2 are emitted for each tonne of BPD generated. Based on 2012 figures for instance, the additional amount of CO_2 that is associated with the BPD generated that year was almost

Figure 5: Egyptian cement sector CO_2 emission projections under different scenarios*



*Emission estimation for slow, rapid scenarios and rapid sub scenario for low-carbon development of the Egyptian cement industry compared with a business-as-usual and hypothetical scenario without natural gas subsidy removal (prior to the introduction of the coal legislation).

Source: EBRD, 2016. Report D7

0.7 $MtCO_2$. If such a rate of BDP disposal is not lowered, then by 2030 around three million tonnes of BPD alone will be landfilled each year. Additionally, the total indicative WHR to power technical potential in the cement sector in Egypt is considerable and estimated to be in the range of 200-250 MWe. If such potential were to be realised, it could result in emission reductions in the range of 0.8 – 1 $MtCO_2$/year. The viability of BPD reuse and WHR to power should be investigated in the Egyptian context and means of overcoming barriers to their implementation established.

Annex I provides a proposed action plan, summarising the policy recommendations mentioned above under each scenario, including identification of the key stakeholders that can or should take responsibility for the policy actions. The action plan proposed for each of the two scenarios, if followed, should result in mitigating the impact of the coal legislation on CO_2 emissions by 2030 or even earlier.

Annexes

Annex 1: Action plan for the low-carbon Egyptian cement sector

Rapid low-carbon development scenario description – Alternative fuels

<table>
<tr><th></th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th><th>2026</th><th>2027</th><th>2028</th><th>2029</th><th>2030</th></tr>
<tr><td rowspan="13">Agricultural waste</td><td></td><td colspan="5">AF awareness raising and capacity building programme aimed at the agricultural sector, waste management sector and other key stakeholders.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="10">Technical assistance programme launched to support waste suppliers, aggregators and end users in setting up and operating pre-processing and co-processing installations.</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="10">Feasibility studies are undertaken to determine the potential to create agricultural waste aggregators or intermediary bodies.</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="10">Where government incentives exist for the safe disposal of agricultural waste, waste aggregators are allowed to bid for the waste so that it can be used as alternative fuel to coal and petcoke.</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Guidelines for safe storage of agricultural waste are developed.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="3">Legislation to allow for the safe storage of agricultural waste is introduced.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Studies are undertaken to identify efficient agricultural waste collection models.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="4">Pilot projects to demonstrate applications and business models</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="10">Ban on uncontrolled burning of agricultural waste is systematically enforced.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="10">International funding becomes available to “top up” incentives to encourage the use of agricultural waste as fuel where necessary.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="10">Results-based financing (RBF) scheme implemented to support otherwise unviable projects (within NDC framework and through international support).</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="10">Agricultural waste collection models are introduced, long-term agricultural waste supply agreements between the agricultural waste suppliers and the aggregators (waste management companies) are put in place.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="10">Offtake agreements between waste management companies and cement companies to secure predefined volumes of pre-processed agricultural waste of a predetermined quality and price/pricing mechanisms are put in place.</td></tr>
</table>

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	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Solid recovered fuel (SRF)		Awareness raising and capacity building programme targeted at municipalities, waste management companies and other key stakeholders covering the technical, health, safety and environment, financial aspects is designed and rolled out.													
		Long-term municipal solid waste (MSW) supply contracts between the municipalities and waste management companies to secure the annual supply of predetermined volumes of MSW at a predefined tipping fee to the waste management company are in effect.													
		Long-term SRF offtake contracts between the waste management companies and the cement companies are in effect.													
		Pilot projects and programme (e.g. Nationally Appropriate Mitigation Actions or NAMAs, RBF scheme) designed and implemented													
		Tipping fees are introduced in the governorates.													
						Tax exemptions introduced on projects that are otherwise not viable.									
						International support becomes available to “top up” tipping fees in order to narrow the gap between the existing fee and what is needed to make co-processing viable.									
						Waste pre-sorting introduced at waste source.									
		Waste collection of MSW is made systematically across the country and MSW is brought to the official sorting facilities.													
				Waste pickers are assigned formal jobs in the pre-processing operations and trained accordingly.											
		MSW pre-processing installations are built and investment made in co-processing installations in cement plants.													
				“One stop shop” for permitting waste management operations is introduced to reduce transaction costs.											
				Waste collection efficiency improves.											
				Ban on uncontrolled landfilling introduced.											
				Technical assistance programme to support new entrants and existing operators in increasing AF pre-processing capacity.											

<table>
<tr><th></th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th><th>2026</th><th>2027</th><th>2028</th><th>2029</th><th>2030</th></tr>
<tr><td rowspan="6">Tyres</td><td></td><td colspan="2">Studies are undertaken to determine efficient tyre waste collection models. undertaken to determine efficient tyre waste collection models.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Eco tax is introduced.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="9">Ban on landfilling tyres implemented.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="9">Ban on open air burning of tyres implemented.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="9">Ban on the use of tyres as fuel in combustion systems not adequately equipped.</td></tr>
<tr><td></td><td></td><td colspan="6">"One stop shop" for permitting tyre waste management operations is implemented.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="8">Dried Sewage Sludge (DSS)</td><td></td><td colspan="3">Public awareness programme on safe usage of sludge.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="3">HSE guidelines for handling and transportation of sludge issued.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="4">Low cost solar sludge drying feasibility studies undertaken.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="12">Solar based sludge drying facilities are designed and built. Demonstration projects carried out.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="9">Sewage sludge containing heavy metals is no longer used for agricultural purposes.</td></tr>
<tr><td></td><td colspan="14">New wastewater treatment plant designs assess the production of DSS for use as fuel.</td></tr>
<tr><td></td><td colspan="14">"One stop shop" for permitting DSS waste management operations introduced.</td></tr>
<tr><td></td><td colspan="14">Co-processing facilities are built/upgraded to enable DSS to be used as fuel.</td></tr>
</table>

Source: authors' elaboration, in consultation with key stakeholders

Rapid low-carbon path development scenario description – Clinker content reduction

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Clinker content reduction					Cement market demand growth will be met by decreasing the clinker content to 80% by 2025.										
		Awareness and training programmes are introduced to improve the level of understanding of blended cement.													
		Resource mapping to identify sources of clinker substitute material in the country.													
		Egyptian codes and standards are revised to enable the use of blended cement.													
						Egyptian codes and standards revised to enable Portland Limestone Cement (PLC) to be used in reinforced concrete.									
		Programme is designed to gradually introduce blended cement in the construction sector, including training programme and certification scheme.													
			Quality assurance certification scheme for ready-mix concrete installations and operations is introduced.												
		Government introduces low-carbon cement procurement policy for public sector projects.													
									Capacity building for architects, engineers, and construction companies on the use of composite cement in reinforced concrete.						
				Incentive schemes for blended cement use in the private sector introduced and enhanced through international support.											
						Blended cement utilisation programme is scaled up to introduce blended cement in the formal private construction sector (for commercial and residential building projects).									
		The EEAA classifies foreign fly ash as non-hazardous waste and allows it to be imported.													
				Coal fired power plants develop ash disposal programmes in conjunction with the cement industry.											
					Blended cement awareness and capacity building programme for the informal building sector is piloted and launched.										
		Blended cement NAMA designed and its implementation catalyses the above actions. NAMA becomes platform for clinker factor reduction actions.													

Source: authors' elaboration, in consultation with key stakeholders

Annex 2: Egypt’s cement sector KPIs under different development scenarios

KPIs	Historical reference	Baseline	Slow scenario			Rapid scenario			Rapid sub scenario		
			2020	2025	2030	2020	2025	2030	2020	2025	2030
TSR, %			4	6	8	4	9	15	7	15	22
Clinker factor	89	89	89	89	80	89	80	80	89	80	80
SEC_{th}, MJ/t clinker	3790	3790	3710	3621	3621	3621	3621	3621	3619	3619	3619
Fuel CO_2 intensity, kg CO_2/GJ	61.6	94.4	93.0	91.5	89.9	93.0	89.2	84.6	90.7	84.6	79.3
Fuel CO_2 emissions per tonne clinker, kg CO_2/t clinker	234	358	345	331	326	338	323	306	328	306	287
Direct CO_2 emissions per tonne clinker, kg CO_2/t clinker	794	918	405	891	886	898	883	866	888	866	847
Total direct CO_2 emissions per tonne cement, kg CO_2/t cement	706	817	805	793	709	799	707	694	791	694	679
Direct CO_2 emissions, million tCO_2/year*	65.5	75.8	55.6	63.5	65.8	55.1	56.6	64.4	54.6	55.5	62.9
Aggregated CO_2 emission reduction compared to baseline, million tCO_2	n/a	n/a	2.2	9.4	42.1	3.7	31.8	83.3	5.1	37.3	95.2

*Historical reference and baseline values estimated assuming historical reference period and baseline CO_2 performance in 2030

Source: EBRD, 2016. Report D7

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Annex 3: Abbreviations and acronyms

AF	Alternative fuels
AR	Alternative raw material
AFR	Alternative fuels and raw materials
BAP	Best Available Practice
BAT	Best Available Technologies
BATP	Best Available Technologies and Practices
BPD	By-pass dust
BTIA	Building Technical Inspection Agency
CBMI	Chamber of Building Materials Industries/Cement Industry Division
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Use
CF	Clinker Factor
CKD	Cement kiln dust
CO_2	Carbon dioxide
CSI	Cement Sustainability Initiative
CUF	Capacity utilisation factor
DSS	Dried sewage sludge
EBRD	European Bank for Reconstruction and Development
ECBM	Export Council for Building Materials
ECRA	European Cement Research Academy
EEAA	Egyptian Environmental Affairs Agency
EFCBC	Egyptian Federation for Construction and Building Contractors
EMS	Environmental Management System
ENCPC	Egypt National Cleaner Production Centre
ESWA	Egyptian Solid Waste Management Agency
ETS	Emission Trading System
EOS	Egyptian Organization for Standardization and Quality
EU	European Union
EUR	Euro
FOB	Free on board
GDP	Gross domestic product
GGBFS	Ground granulated blast furnace slag
GHG	Greenhouse gas
GJ	Gigajoule (10^9 joules)
GNR	Getting the Numbers Right database
GW	Gigawatt (10^9 Watt)
HBRC	Housing and Building Research Centre
IDA	Industrial Development Authority
IEA	International Energy Agency
IEEU	Industrial Energy Efficiency Unit of MTI
IFC	International Finance Corporation
INDC	Intended Nationally Determined Contribution
kg	Kilogram
KPI	Key performance indicator
LCTPi	Low Carbon Technology Partnerships Initiative
LECB	Low Emission Capacity Building
MALR	Ministry of Agriculture and Land Reclamation
MHP	Ministry of Health and Population
MIC	Mineral components
MJ	Megajoule (10^6 joules)
MoF	Ministry of Finance
MoHUUD	Ministry of Housing, Utilities and Urban Development
MoI	Ministry of Investment
MoLD	Ministry of State for Local Development
MRV	Measurement/Monitoring, reporting and verification
MSEA	Ministry of State for Environmental Affairs
MSW	Municipal solid waste
Mt	Million tonne
MTI	Ministry of Trade and Industry
MWe	Megawatt electrical
MWRI	Ministry of Water Resources and Irrigation
NAMA	Nationally Appropriate Mitigation Actions
NDC	Nationally Determined Contribution
OHS	Occupational health and safety
OPC	Ordinary Portland Cement
PJ	Petajoule (10^{15} joules)
PLC	Portland Limestone Cement
RBF	Results-based financing
RDF	Refuse-derived fuel
R&D	Research and development
SEEC	Specific electrical energy consumption
SME	Small and Medium-Sized Enterprise
SRF	Solid recovered fuel
SRI	Sustainable Resource Initiative
STEC	Specific thermal energy consumption
SWM	Solid waste management
Tpd	Tonnes per day
TPDL	Technical performance design levels
TSR	Thermal substitution rate
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
WBCSD	World Business Council for Sustainable Development
WHR	Waste heat recovery
WRI	World Resource Institute

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Annex 5: Roadmap partners

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European Bank for Reconstruction and Development (EBRD)

The EBRD is investing in changing people's lives and environments in more than 30 countries that stretch from central Europe to Central Asia, the Western Balkans and the southern and eastern Mediterranean and more recently Cyprus and Greece. With an emphasis on working together with the private sector, we invest in projects, engage in policy dialogue and provide technical advice that fosters innovation and builds sustainable and open-market economies.

The EBRD is the largest single investor in many of the countries where it operates. The Bank's investments also mobilise significant foreign direct investment into its countries of operations. It invests mainly in private enterprises, usually together with commercial partners. It provides project financing for the financial sector and the real economy, both new ventures and investments in existing companies. It also works with publicly-owned companies to support privatisation, the restructuring of state-owned firms and improvement of municipal services.

The EBRD is owned by 65 countries and two intergovernmental institutions (the European Union and the European Investment Bank). It maintains a close political dialogue with governments, authorities and representatives of civil society to promote its goals. It also works in cooperation with international organisations such as the OECD, the IMF, the World Bank and UN specialised agencies.

Green Economy Transition (GET)

The EBRD launched the Green Economy Transition (GET) approach in 2015 to put investments that bring environmental benefits at the heart of our mandate. Preserving and improving the environment are central features of a modern, well-functioning market economy and therefore key goals of the transition process that the EBRD was set up to promote. Building on a decade of successful green investments, the GET approach seeks to increase the volume of green financing from an average of 24 % of EBRD annual business investment in the 10 years up to 2016 to 40 % by 2020. The EBRD has invested to date in Egypt cumulatively EUR 1.9 billion in 36 projects, of which 15 projects representing EUR 695 million are within the GET mandate. The Bank's areas of investment include the financial sector, agribusiness, manufacturing and services, as well as infrastructure projects such as power, municipal water and wastewater services and contributions to the upgrade of transport services.

http://www.ebrd.com/egypt.html

Cement Sustainability Initiative

World Business Council for Sustainable Development (WBCSD) / Cement Sustainability Initiative (CSI)

The CSI is a global effort by 24 major cement producers with operations in more than 100 countries who believe there is a strong business case for the pursuit of sustainable development. Collectively these companies account for about one-third of the world's cement production and range in size from very large multinationals to smaller local producers.

The members of the CSI – a voluntary business initiative from around the world – have been addressing climate change issues for more than a decade. The CSI is currently working to understand the impact of cement's whole life cycle, i.e. from quarrying limestone or obtaining alternative raw materials from other industries, to the end product as concrete and recycled aggregates. To date, the CSI remains one of the largest global sustainability programs ever undertaken by a single industry sector.

www.wbcsdcement.org

Ministry of Environment, Egyptian Environmental Affairs Agency (EEAA), Environmental Pollution Abatement Program (EPAP)

The Ministry of Environment focuses, in close collaboration with the national and international development partners, on defining environmental policies, setting priorities and implementing initiatives within a context of sustainable development. According to the Law 4/1994 for the Protection of the Environment, the Egyptian Environmental Affairs Agency (EEAA) was restructured with the new mandate to substitute the institution initially established in 1982. At the central level, EEAA represents the executive arm of the Ministry.

The EEAA offers incentives to institutions and individuals engaged in activities and projects directed to environmental protection purposes.

The Environmental Pollution Abatement Program (EPAP) promoted by EEAA has been supporting industrial establishments in pollution abatement projects to reach compliance through subsidized loans or direct grants. The program has started in 1990 and is on-going. A new phase, EPAPIII, will extend over the next 5 years.

www.eeaa.gov.eg

The Egypt National Cleaner Production Center (ENCPC) at the Ministry of Trade and Industry (MTI)

The Egypt National Cleaner Production Center (ENCPC) was established in 2005 by the United Nations Industrial Development Organisation (UNIDO) in close cooperation with the Ministry of Trade and Industry (MTI) as a service provider to Egyptian industry on Green Industries & Resource Efficiency and Cleaner Production. The ENCPC is as an integral part of the national programme for "Industrial Council for Technology and Innovation" (ICTI) of the MTI, which includes 13 technology and innovation centers (e.g. food, agricultural products, plastic, engineering, tanning). The ENCPC acts as a cross-cutting centre and cooperates with the other relevant technology centers. The ENCPC is also a part of the UNIDO/UNEP global network of National Cleaner Production Centers and Programmes (NCPCs/NCPPs), which includes 51 NCPCs/ NCPPs.

www.encpc.org

Chamber of Building Materials Industries / Cement Industry Division (CBMI)

The Cement Industry Division is one of the divisions of the Chamber of Building Materials Industries and is affiliated to the Federation of Egyptian Industries (FEI).

The main objectives of the Division are to: 1) support the development of the cement industry and the cementitious products in Egypt; 2) support the cement and clinker industry companies in maintaining a fair competitive environment for manufacturing cement, clinker and cementitious products as compared to other building materials and to other countries; 3) represent the cement industry before any governmental or non-governmental authorities and update the companies on policy developments on technical, environmental, promotional and energy issues; 4) participate actively in the definition and the evolution of the national standards for cement, clinker and cementitious products (including concrete) in Egypt; and 5) participate in disseminating any technical advances that support the development of the cement's industry and products.

www.fei.org.eg

South Pole Group

South Pole Group is a global provider of sustainability solutions, with a proven track record in low-carbon development, policy advisory, capacity building, and facilitating cooperation between multiple stakeholders.

South Pole Group has supported public and private clients in developing strategies for GHG emission reductions in various economic sectors, including the cement industry. A large share of these activities is related to the development of Nationally Appropriate Mitigation Actions (NAMAs), Low-Emission and Low-Carbon Development Strategies (LEDS/LCDS), roadmaps, GHG abatement plans and corporate strategies to reduce climate impacts.

Within the cement sector, South Pole Group has been involved in several projects in various countries including China, Ecuador, Indonesia, Mexico, Peru, Sri Lanka, Thailand and Vietnam, and has provided consulting services for the WBCSD/CSI on developing standardised baselines at the global scale.

South Pole Group was the lead partner of the consortium of consultants who successfully prepared the Low-Carbon Roadmap for the Egyptian Cement Industry. Drawing on its international experience, the company's experts were able to ensure the adaptation and implementation of global best practices that best fit the national context and the requirements of the Egyptian cement industry.

This entailed effective oversight of project coordination and communication with key stakeholders in Egypt. South Pole Group's consultants were additionally in charge of assessing the current energy and CO_2 emission performance data of the industry, preparing a CO_2 emission baseline study and low-carbon development scenarios, as well as providing technological and policy recommendations for the Egyptian cement industry.

www.thesouthpolegroup.com

Cementis

Cementis is an international, Swiss-based team of cement industry ex-executives offering a range of services to enable companies to pursue business in an increasingly carbon constrained world.

Cementis advises its clients - cement companies, waste producers and waste management companies, development banks, large financial organizations, government authorities in the related sectors and environmental agencies – on how to formulate a vision, design a strategy, set long-term goals, and develop a roadmap to reach the set goals. Cementis facilitates the introduction of necessary decision-making processes and provides management with the tools needed to tackle key business issues and to achieve the long-term sustainable development vision.

Cementis experts have decades of experience in working successfully in the cement industry, drawing on industry insights from over the five continents including MENA countries, India, Russia, Peru and Mexico, among many others.

For this Low-Carbon Roadmap, Cementis' experts were key in engaging the cement industry stakeholders in Egypt, collecting data from the cement plants, designing the future low-carbon cement plants and analysing international competition. Moreover, the company provided comprehensive advice to the project team on low-carbon technologies selection and policy recommendations in the Egyptian context, particularly for AFR co-processing.

www.cementis.com

EcoConServ

Since its foundation in 1999 (as a S.A.E under the Egyptian Law No. 157 of 1981), EcoConServ Environmental Solutions, Egypt (EcoConServ) has provided state-of-the-art environmental technical assistance to a wide spectrum of clients, including bilateral and multilateral development and financial institutions, governorates, municipalities, as well as companies and organizations in several sectors. EcoConServ has undertaken projects locally in Egypt and regionally in Palestine, Syria, Jordan, Lebanon, Tunisia, Algeria, Libya, Sudan, Yemen, Saudi Arabia, Iran, Pakistan, Ethiopia, Nigeria, and Malawi.

As the local team of the consortium, EcoConServ's contribution to the Low-Carbon Roadmap for the Egyptian Cement Industry included collection and analysis of information pertinent to technical, legal, socio-economic, and political factors affecting the Egyptian cement industry and market. The information included current and planned national policies, regulations and strategies in Egypt related to the cement, energy, waste management sectors, as well as climate change mitigation and environment protection. EcoConServ provided recommendations to the international consultants on the applicability of the recommended policy actions in the local context. EcoConServ was also actively involved on the ground in the organization of the final stakeholder consultations meetings and workshops in Cairo.

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