CTCN
CLIMATE TECHNOLOGY CENTRE & NETWORK

CTCN Technical Assistance
Response Plan

Country	South Africa
Request ID#	2015000094
Title	Substantial GHG emissions reduction in the cement industry by using waste heat recovery combined with mineral carbon capture and utilization
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Summary of the CTCN technical assistance

The cement industry of South Africa is seeking to adopt innovative technologies to utilise alternative resources and provide safe carbon capture with a low marginal GHG abatement cost. The CTCN Technical Assistance will determine the technical feasibility of introducing a hybrid low-carbon system comprising waste heat recovery and mineral carbon capture and utilisation technology. In addition to establishing the technical feasibility, the CTCN Technical Assistance will determine the net marginal GHG abatement cost and propose a business plan. The CTCN activities and outputs will contribute to the further development of a bench-scale project and a full-scale demonstration project in South Africa.

Agreement:

(If possible, please use electronic signatures in Microsoft Word file format)

National Designated Entity to the UNFCCC Technology Mechanism for which the Climate Technology Centre and Network is the operative arm

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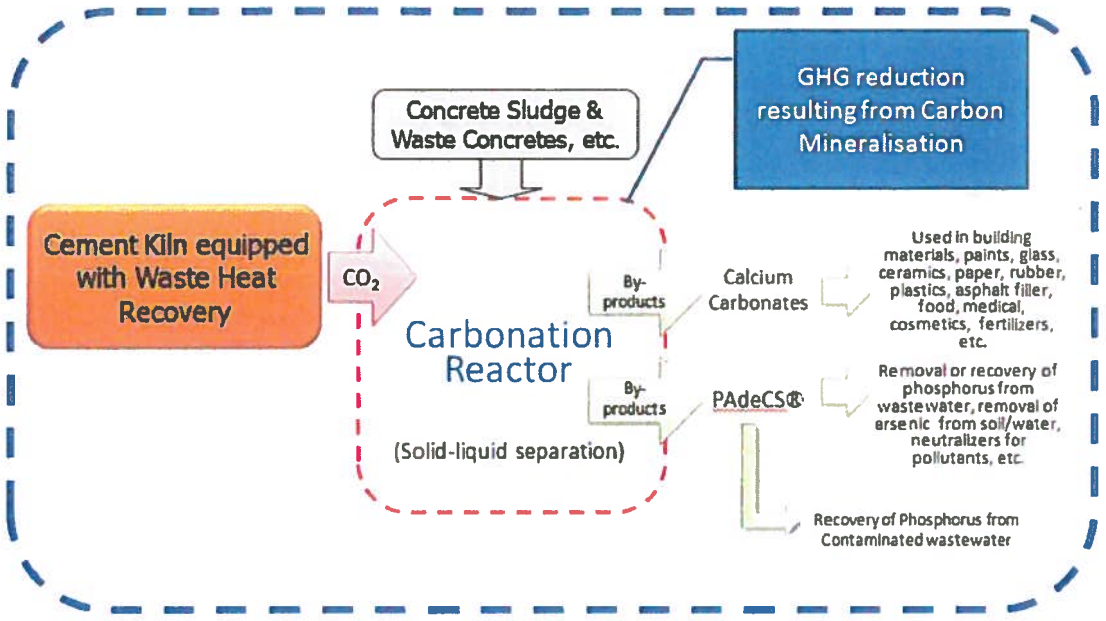
1. Overview of the CTCN technical assistance

1.1 Technology aspects

The proposed technology is a hybrid low carbon technology for the cement sector comprising waste heat recovery (WHR) and mineral carbon capture & utilization (MCC&U) technology (a safe CO_2 sequestration method) whilst utilizing specific industrial wastes and producing commercially useful by-products as illustrated in the diagram below.



The scope of the CTCN Technical Assistance (TA) focuses on a laboratory-scale feasibility assessment of the hybrid low carbon technology. The outputs from the technical assistance will establish the GHG reduction potential, marginal abatement costs and provide a business plan towards the establishment of a bench-scale project and demonstration project.

The waste heat recovery (WHR) component of the proposed technology is a well established and proven technology that has been deployed widely in the cement sector. It is an energy recovery heat exchanger that recovers heat from hot gas streams such as the kiln and cooler exhausts via a steam circuit and subsequent steam turbine to generate power. The MCC&U component of the hybrid technology is a system where CO_2 is chemically sequestered using industrial wastes such as concrete sludge and demolished concretes. There are several papers [2-6] published on the MCC&U technology and mineral carbonates generated from the process can be commercialized as environmental products. A concrete products manufacturer in Japan has already applied the technology [7].

The hybrid low carbon technology of WHR combined with MCC&U would be one of the promising options for the cement industry to realize safe and immediate reductions of significant quantities of CO_2 emissions. The technology is in line with the current mitigation potential analysis report published by the Department of Environment in the Republic of South Africa (RSA). Furthermore, this proposed project is in alignment with the RSA's Climate Change Technology Needs Asssessment dated 2007.

The CTCN TA will help to confirm the economic and technical viability of introducing MCC&U technology to RSA whilst utilizing concrete sludge from concrete product manufacturers and exhaust gas emitted from existing cement kilns. The proposed CTCN TA will target modern cement facilities

where the WHR and MCC technologies would be most relevant and feasible. It is designed to identify the potential CO_2 emission reduction benefits accrued from the MCC technology for a specific site as well as estimate the potential for the whole cement sector in the country. The TA will also contribute to determining the cost effectiveness of the hybrid system of WHR and MCC&U technologies, including estimation of the net marginal abatement cost of the GHG reductions. The final goal of the TA is to provide guidance for the hybrid technology deployment in the country.

1.2 Objectives (outcomes)

The objectives of the TA are to examine the technical and financial feasibility of the technology, determine the GHG emission reduction potential, assess the cost efficiency of the hybrid system, including net marginal abatement costs, and to design a business plan for the project implementation in RSA which will include a bench-scale project followed by a demonstration project.

The CTCN TA will demonstrate the technical and commercial feasibility of the hybrid system of WHR and MCC&U and the calculated net marginal abatement cost will allow comparison of the hybrid system with other possible clean energy and recycling technologies. Based on these outcomes being positive, the business plan will be implemented to establish bench-scale and full-scale demonstration projects in RSA and eventual roll-out of the hybrid system at suitable locations across the sector nationwide to realize significant GHG reductions and waste recycling. Furthermore the CTCN TA will contribute to the development of a market for innovative recycled by-products from concrete wastes such as environmental remediation agents, neutralizers and recovered materials such as phosphorus.

1.3 Results (outputs expected from CTCN assistance)

CTCN Technical Assistance will provide:

Output 1: An estimation of the potential by-products reacted through the MCC&U technology by analyzing the chemical components of exhaust gas from an existing cement kiln and analyzing the composition of concrete wastes such as concrete sludge. The estimation will consider any changes in the exhaust gas post WHR such as gas flow and temperature change and the effects on the MCC&U. The TA will also provide an assessment of the waste materials balance, including the by-products to be obtained through the MCC&U technology, and identification of waste stream sources;

Output 2: Information to select marketable by-product materials in RSA including compositions and recommendations for suitable and economical reactor operating conditions to produce the by-products;

Output 3: Estimation of the GHG emissions reduction potential of the hybrid low carbon technology for the sector by integrating the results of the TA with the outcomes on WHR arising from the 2012 feasibility study on low carbon technologies supported by the Ministry of Economy, Trade and Industry (METI), Japan [1]; and

Output 4: Development of a business plan for the deployment of the hybrid low carbon technology, including political and technical recommendations, international finance opportunities and calculation of the net marginal abatement cost.

Note: Within the competitive tendering process parties interested in delivering the TA should propose the most appropriate method of determining the net marginal abatement

cost (MAC). Consideration should be given to calculating the net MAC separately for the WHR and MCC&U elements of the hybrid system based on:

$$\text{Net Marginal Abatement Cost (\$/t GHG)} = \frac{\text{Total project cost- Total project savings}}{\text{Total GHG abated over X years}}$$

Where X is the life of the project OR other specified period of time

1.4 Expected use of outputs

Output 1 will enable the proponent to:

- specify and identify the wastes that can be utilized;
- identify the potential waste producers (including transportation and cost assessments);
- estimate the carbon capture potential resulting from the hybrid system;
- identify the potential by-products that can be produced.

Output 2 will enable the proponent to target the most valuable by-products to be produced based on the market needs in RSA;

Output 3 will enable the proponent to estimate the GHG emissions reduction potential for the cement sector in the RSA that can potentially be realized through the adoption of the hybrid technology;

Output 4, the Business Plan, will allow the proponent to demonstrate the financial and technical viability of implementing the hybrid low carbon technology in the RSA and to present the business plan to potential investors.

2. Description of the Assistance

2.1 Activities

As mandatory activities for all CTCN Response Plans, the Lead Implementer must produce the following: i) A detailed work plan of all activities, deliveries, outputs, deadlines and responsible persons/organizations and detailed budget to implement the Response Plan. The detailed work plan and budget must be based directly on this Response Plan; ii) Aligned with Annex II of this Response Plan, a monitoring and evaluation plan with specific, measurable, achievable, relevant, and time-bound indicators used to monitor and evaluate the timeliness and appropriateness of the implementation; iii) A two-page CTCN Impact Description (a template will be provided).

For the activities below, it is envisaged that some data will be collected by means of questionnaires to the selected cement plants and concrete producers via the ACMP in advance of the in-country visits by the TA Team.

Activity 1 – Identification and testing of the available alkali-rich industrial wastes and assessment of the MCC reaction

Analysis and evaluation of kiln exhaust gases from selected cement plants and identification of sources of alkali-rich industrial wastes including the collection of samples to determine the physical and chemical properties of the waste materials to be reacted in the MCC reactor. The methods of collection and transportation means of the concrete wastes and their costs, equipment procurement costs, etc. will also be assessed and any associated potential barriers for the project realization will be identified.

Activity 1.1 Assessment of physical and chemical properties of the concrete wastes and their transportation means

Survey local sites where concrete wastes containing Ca or Mg are continuously generated, collect samples and carry out an analysis of the samples to determine the potential MCC reaction. Make recommendations on waste collection methods from each identified site.

Activity 1.2 Assessment of chemical properties of the exhaust gas for MCC reaction

Analyze the chemical properties of exhaust gas from the cement kiln(s) and conduct laboratory tests to estimate the reaction volume of CO_2 in the MCC reactor and volume of by-products potentially generated from the reaction.

Activity 1.3 Identification of potential barriers envisaged for the project realization

Identify technical or legal barriers for collection and transportation of the wastes.

Activity 1 – Deliverables

Deliverables	Delivery date
Mandatory deliverables: i) Detailed work plan and budget, ii) a monitoring and evaluation plan, and iii) A two-page CTCN Impact Description	Month 1
1.1 Report identifying suitable waste production sites (waste sources) including an evaluation of their potential based on availability of materials, chemical analysis and potential MCC reactivity. The report will also address recommendations for waste collection and transportation.	Month 7
1.2 Report on the results of the cement kiln exhaust gas sampling and laboratory analysis including an estimation of the potential CO_2 capture in the MCC reactor and volume of by-products generated.	
1.3 Report on the technical or legal barriers related to collection and transportation of the concrete wastes.	Month 11

Activity 2 – Assessment of the domestic market for the by-products

Some of the carbonates generated by the MCC technology can be useful materials with potential commercial applications such as alternative raw materials or environmental remediation agents/absorbents. Therefore, the optimum conditions of the reaction process to generate such by-products which meet market needs in RSA will be explored. Also, the TA will identify the applications of the by-product and use the data to estimate the GHG net marginal abatement cost for the MCC technology.

Activity 2.1 Assessment of potential by-products

Examine laboratory test results from 1.2 to assess the applicability of by-products as environmental remediation agents for soil and water.

Activity 2.2 Selection of valuable by-products to meet market demands

Conduct a market survey and estimation of the by-products market value to identify marketable products in RSA among the by-products from the MCC reaction and determine the optimal reaction conditions for their generation.

Activity 2 – Deliverables

Deliverables	Delivery date
2.1 Report assessing the expected quality of by-products produced by the MCC reactor and their commercial suitability as remediation agents	Month 7
2.2 Report presenting the market survey results identifying the commercial by-products and specifying the optimal MCC reaction conditions for their production.	Month 11

Activity 3 – Estimation of the GHG emissions reduction potential of WHR and MCC&U for the cement sector

It is anticipated that data collection will be via questionnaires prepared by the TA experts to selected modern cement plants where the application of the hybrid system of WHR and MCC&U would be most relevant. Questionnaires would also be sent to concrete products manufacturers and ready mixed concrete plants in advance of site/plant visits. Data verification and further information will be collected during plant/site visits in order to estimate the GHG emissions reduction potential of the hybrid system of WHR and MCC reactor installation for the cement sector in RSA. The estimation will consider potential collaboration with other sectors if appropriate. Post TA, the mobile bench-scale reactor will be used to confirm the GHG reduction potential at selected cement plants prior to the roll-out of the full scale hybrid system of WHR and MCC&U.

Activity 3.1 Estimation of GHG emissions reduction by WHR

Estimate the annual GHG emissions reduction potential resulting from the installation of a WHR facility at the study target plant using existing GHG accounting methodology (e.g. WBCSD CSI protocol " CO_2 and Energy Accounting and Reporting Standard for the Cement Industry" : http://www.wbcsdcement.org/pdf/tf1_co2%20protocol%20v3.pdf).

Activity 3.2 Estimation of the GHG emissions reduction by MCC&U

Estimate annual GHG emissions reduction by introducing MCC&U technology at the study target plant by using a newly developed GHG accounting methodology for the MCC&U under this study.

Activity 3.3 Assessment of other concrete wastes and alternative waste sources for MCC reaction for further GHG emission reductions

Identify and survey possible sites generating other waste concretes and Alkali-rich wastes from other sectors around the potential hybrid system site and consider the collection measures for each waste to increase the collection volume.

Activity 3.4 Estimation of GHG emissions reduction potential for the cement sector in RSA

Estimate GHG emissions reduction potential for the cement sector in RSA by integrating above outcomes of Activity 3.1, 3.2 and 3.3.

Activity 3 – Deliverables

Deliverables	Delivery date
3.1 Calculation of GHG emissions reduction expected from the installation of a WHR facility at the study target cement plant (potential hybrid system site.)	Month 10
3.2 Statement of GHG emissions reduction expected from the installation of a MCC reactor at the study target cement plant (potential hybrid system site) including details of the newly developed GHG accounting methodology adopted for the purpose.	
3.3 Report identifying alternative waste sources from other sectors in the vicinity of the potential hybrid system site including an assessment of available volumes and recommendations for collection and transportation methods.	Month 12
3.4 Statement of GHG emissions reduction potential for the RSA cement sector resulting from the implementation of the hybrid system.	

Activity 4 –Development of a business plan and project implementation recommendations

Assess the financial viability of the hybrid system of WHR and MCC reactor installation and operation by estimating the net marginal abatement cost of GHG emissions reduction in the cement industry. The net cost will be calculated by subtracting the market price of by-products in the RSA from the hybrid system operating cost. The business plan will consider how to deploy the proposed MCC&U technology in the cement industry in the RSA and the envisaged resulting substantial GHG reduction in the country. The business plan should meet the standards for a large scale commercial investment proposal and should also consider potential financial support mechanisms for climate actions.

Activity 4.1 Calculation of investment costs for a WHR facility and GHG marginal abatement costs

Estimate the initial investment cost for installation of a commercial WHR facility and the associated GHG emissions reduction at the specific cement plant, and calculate the GHG marginal abatement cost (in net present value or a similar approach).

Activity 4.2 Calculation of investment costs for MCC&U and GHG marginal abatement costs

Estimate the investment and operating costs for the installation and operation of the MCC&U reactor and the net GHG marginal abatement cost (in net present value or a similar approach) by integrating existing data on MCC&U reactor operation in other countries with the output of Activities 1 and 2.

Activity 4.3 Identification of incentives and barriers (and recommendations on their removal)

Identify and integrate regulatory and socio-economic incentives and political/legal and financial barriers for implementing the proposed technology. The TA will propose measures for overcoming identified barriers, including those related to including the waste collection and consider possible opportunities for international support.

Activity 4.4 Business Plan Preparation

Preparation of a business plan based on results of the TA which will include proposals for a bench-scale mobile reactor followed by a demonstration project for the deployment of the hybrid low carbon

technology of WHR and MCC&U. The business plan should meet the standards of large scale investment proposal and should also consider potential climate finance into the business model.

Activity 4 – Deliverables

Deliverables	Delivery date
4.1 Financial viability assessment of the installation of a WHR facility at the study target cement plant and determination of the GHG marginal abatement cost.	Month 11
4.2 Financial viability assessment of the installation of a MCC reactor at the study target cement plant and determination of the GHG marginal abatement cost.	
4.3 Report on political, legal and financial incentives and barriers to the installation and operation of the hybrid technology, including the sourcing of waste materials, with proposals for measures to remove identified barriers. The report will also address possibilities for international support.	
4.4 The business plan based on results of TA	

Activity 5 Stakeholder meetings

Activity 5.1 A meeting with stakeholders is proposed to introduce and share the project (broad description of the technology and the objectives of the project). The meeting would also be used to prepare for the identification and testing of the available alkali-rich industrial wastes, the sampling and analysis of cement kiln exhaust gases and subsequent assessment of the MCC reaction.

Activity 5.2 A meeting with stakeholders is proposed to report on the findings of activities 1.1 and 1.2 and to prepare for activities 2 and 3.

Activity 5.3 A meeting with stakeholders is proposed to report on the results of activity 1.2 and provide an interim report on the results of activities 2.1, 2.2, 3.1 and 3.2.

Activity 5.4 A meeting with stakeholders is proposed to disseminate the findings of the business plan and the hybrid low carbon technology and receive feedback prior to submission of the final report.

Activity 5 – Deliverables

Deliverables	Delivery date
5.1 Stakeholder meeting - Project introduction and preparation	Month 1
5.2 Stakeholder meeting - Report on 1.1 & 1.2 and preparation for 2 & 3	Month 4
5.3 Stakeholder meeting - Report on 1.2 + interim report on 2.1, 2.2, 3.1 & 3.2	Month 7
5.4 Stakeholder meeting(s) to disseminate the findings of the business plan and hybrid low carbon technology and receive feedback prior to final publication	Month 10

2.2 Synergies and Baseline Setting

Related past and ongoing efforts are:

1) Past Efforts
In 2012 the Association of Cementitious Material Producers (ACMP) explored the investment and operation costs of introducing notable energy saving technologies for the cement industry and the associated potential GHG emissions reduction from the cement industry in RSA through a feasibility

study on clean energy technology diffusion [1]. The study also identified barriers to for their implementation.

2) Ongoing efforts

As identified in the request from the NDE, the 2012 study helped ACMP to estimate the GHG reduction potential of WHR. However, the association needs further assistance in progressing GHG emissions reduction towards meeting the sectoral target of a reduction of 34% by 2020 below the 1990 level. In addition the RSA INDC mitigation target is to reduce by 42% below business as usual the GHG emissions growth trajectory. To meet these targets the ACMP place high value on a number of initiatives and practices in the sector including promoting the use of alternative fuels and raw materials, introducing energy efficiency and conservation measures as well as carbon capture and storage. The introduction of the hybrid WHR and MCC&U technology is considered an innovative technology that would combine energy conservation, materials recycling and carbon capture.

2.3 Timeline

Activity	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Identification and testing of the available alkali-rich industrial wastes and assessment of the MCC reaction												
1.1												
1.2												
1.3												
Visit by TA Team												
Assessment of the domestic market for the by-products												
2.1												
2.2												
Visit by TA Team												
Estimation of the GHG emissions reduction potential of WHR and MCC &U for the cement sector												
3.1												
3.2												
3.3												
3.4												
Visit by TA Team												
Development of a business plan and project implementation recommendations												
4.1												
4.2												
4.3												
4.4												
Visit by TA Team												
Stakeholder meetings												
5.1	•											

5.2				•								
5.3								•				
5.4										•		

2.4 Expertise required and indicative estimated work days (important to note that final work days per Activity will be proposed by interested parties during the competitive bidding tendering process). It is anticipated that team members will have the following profiles:

Project Manager:	Experienced cement and concrete industry expert.
MCC Technical Expert:	Possessing technical knowledge and operating experience of an MCC&U reactor and academic expertise on mineralization and environmental remediation.
Cement Engineering Expert:	Technical knowledge and operating experience of both cement production and waste heat recovery.
Financial Expert:	Financial expert with knowledge and experience of determining MAC.

Activity 1	**Identification and testing of the available alkali-rich industrial wastes and assessment of the MCC reaction**
	Visits to the cement plant(s) and concrete manufacturer(s) to determine current operations and obtain the samples.
TA Expert 1	Project manager (Cement sector expert) : One person - 25 man days
TA Expert 2	MCC technical experts : 3 persons - total 61 man days
TA Expert 3	Cement engineering expert : One person - 25 man days
Other	Plant manager and the plant staff will be required to support/attend to the MCC technical experts.
Activity 2	**Assessment of the domestic market for the by-products**
TA Expert 1	Project manager: one person - 25 man days
TA Expert 2	MCC technical experts: 3 persons -total 61 man days
Other	Deploy local consultant/institute to survey the market for by-products
Materials	Brochure on the various potential by-products to be provided to the participants (TA output)
Activity 3	**Estimation of the GHG emissions reduction potential of WHR and MCC &U for the cement sector**
TA Expert 1	Project manager: one person - 25 man days
TA Expert 2	MCC technical expert: one person - 12 man days
TA Expert 3	Cement engineering expert: one person - 18 man days
TA Expert 4	Financial Expert : one person 25 man days
Other	Cement plant staff will be required to support/attend to the MCC technical experts.
Materials	Interim report on Activity 2 and Activity 3
Activity 4	**Development of a business plan and project implementation**

	recommendations
TA Expert 1	Project manager: One person - 25 man days
TA Expert 2	MCC technical expert: 2 persons – total 19 man days
TA Expert 3	Financial Expert: one person - 7 days
Materials	Business plan for the hybrid low carbon technology (TA output)
Activity 5	**Stakeholder meetings**
TA Experts	Sector / stakeholder meetings to be held during the visits of the TA experts to the RSA within Activities 1 to 4.
Participants	ACMP members, Concrete Product Manufacturers, Ready mixed concrete companies, RSA Government, financial sector, local engineering companies, local distributor of chemical products and consultants specializing in climate and resource management.
Materials	TA Outputs – presentation documents and interim reports

2.5 Main partners

Stakeholder	**Role to support the implementation of the CTCN assistance**
Association of Cementitious Material Producer (ACMP)	Provision of information on the collection of local waste concretes and supporting the TA in market research surveys relating to commercial by-products.
Department of Environmental Affairs (Chemical and Waste Branch / Climate Change branch)	Provide legal and policy direction on the collection of waste concretes, GHG emissions reduction and soil decontamination in the RSA.
South Africa National Energy Department Institute (SANEDI)	Provision of information and data relating to CCS in the RSA
Local cement plant(s)	Support in the selection of the site where a demonstration project could be established including production information and further information such as site conditions, site layout and other necessary construction information in relation to the future installation of a pilot hybrid facility. Plant manager and the plant staff will be required to support/attend to the MCC technical experts.
Local concrete product producers and ready mixed concrete manufacturers	Provide information on waste concretes such as concrete sludge from their activities and feeding them continuously to the carbonation reactor

2.6 Indicative budget (important to note that the below overall estimate is an indicative budget estimate only. The final costing per Activity will be proposed by interested parties during the competitive bidding tendering process).

Activities	**Estimated Budget (USD)**
Activity 1: Identification and testing of the available alkali-rich industrial wastes and assessment of the MCC reaction	*US$ 61,500*

Activity 2: Assessment of the domestic market for the by-products	*US$ 65,000*
Activity 3: Estimation of the GHG emissions reduction potential of WHR and MCC &U for the cement sector	*US$ 58,000*
Activity 4: Development of a business plan and project implementation recommendations	*US$ 43,500*
Activity 5: Stakeholder meetings	*US$ 11,000*
Measurement, evaluation and learning	Recommended to be 5-8% of the overall budget
Total	Maximum up to US$ 250 000

The implementation of this Response Plan will be led by the Climate Technology Centre (including selection, contracting, supervision and monitoring of implementation partners) in close coordination with the corresponding National Designated Entity and relevant national actors. Implementation will be led by an International Consortium or Network Partner of CTCN.

2.7 Gender considerations

The proposed Technical Assistance is not gender specific and will be conducted by appropriate experts regardless of gender. Parties interested in delivering the proposed TA will demonstrate their commitment to gender mainstreaming within their proposal as part of the tendering process.

2.8 Risk identification and risk mitigation

Risk	Consequence	Probability	Mitigation measure
Availability of appropriate Technical Assistance experts	Non-fulfillment of the TA	Very low	Pre-identification of suitable experts
Public security	Difficulty for experts to visit to RSA due to unexpected incident (i.e. terror attack, strike etc)	Low to Medium	Extension of time schedule
TA cost exceeding CTCN budget	Non-fulfilment or incomplete TA	Low to Medium	Co-finance by other climate funds

3. Long-term impacts of the assistance

3.1 Expected climate change-related benefits

	CTCN climate technology impact	Anticipated contribution from CTCN assistance

1	Climate technologies adapted to national context are identified and prioritized to enable their deployment and/or transfer in the requesting countries	The applicability of the hybrid low carbon technology to the cement sector and the net marginal GHG abatement cost will be demonstrated by the CTCN Technical Assistance. The business plan will form the basis to scale up the deployment via a bench-scale project towards a demonstration project and ultimately further installations in the cement sector. Furthermore, the utilization of wastes from concrete products manufacturers and other concrete wastes will deliver benefits in terms of waste management and resource utilization. The technology could also be applied to other sectors which generate alkali-rich industrial wastes such as coal-fired power generation, paper and iron & steel to deliver further significant GHG emission reductions in RSA.
2	New national Technology Needs Assessment (TNA) and Technology Action Plan (TAP) as a result of the response	
3	Progress made against mitigation objectives (i.e. energy and carbon intensity reduction) as a result of the response	MCC technology can lead to very significant GHG reductions. The TA will assess the performance indicators for absolute emissions reduction or carbon intensity reduction resulting from the hybrid low carbon technology.
4	Progress made against adaptation or resilience objectives (e.g. climate vulnerability index improvement) as a result of the response	
5	New mitigation or adaptation technology projects/initiatives implemented as a result of the response	MCC is a very safe carbon capture technology. The TA will assess how it would be introduced to RSA together with resource recycling and utilization and thereby contribute to the establishment of a sustainable society
6	New or strengthened policies/ laws developed, approved and enacted as a result of the response	The response will not directly impact on policies or laws but successful implementation of a demonstration project could influence policies or laws relating to resource recycling in the future.
7	New policies/laws where climate change was mainstreamed as a result of the response	The response will not directly impact on policies or laws mainstreaming climate change but successful implementation of a demonstration project could influence policies or laws relating to GHG reduction in the future.
8	Country integrating climate change mitigation and/or adaptation issues into its planning and policies as a result of the response	
9	New or strengthened Public-Private Partnerships (PPP) created directly as a result of the response	
10	New or strengthened twinning	

	arrangement created as a result of the response	
11	Capacities to access and attract public and private finance increase to enable financing of technology deployment	The net abatement cost of the proposed hybrid low carbon technology will be determined and the anticipated short payback period should encourage various sources of investment.
12	Post-response intervention funding attributable to the response.	International finance opportunities would be explored once the net abatement cost has been determined.
13	Framework and analysis of local production developed to enable deployment of national production of climate technologies	It may be possible to establish a national carbon capture network with other sectors which generate alkali-rich industrial wastes from coal-fired power, paper and iron & steel.

3.2 Co-benefits

	Sustainable Development Goal	**Contribution from CTCN assistance**
1	End poverty in all its forms everywhere	No contribution
2	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture	No contribution
3	Ensure healthy lives and promote well-being for all at all ages	No contribution
4	Ensure inclusive and equitable quality education and promote life-long learning opportunities for all	No contribution
5	Achieve gender equality and empower all women and girls	No contribution
6	Ensure availability and sustainable management of water and sanitation for all	Minimal contribution - Concrete sludge as an industrial waste is recycled in the MCC reactor and waste water is not discharged into sewers.
7	Ensure access to affordable, reliable, sustainable, and modern energy for all	Negligible contribution - Electrical power will be generated through the WHR facility using waste heat from kiln exhaust gas but the project will not directly improve access to or availability of modern energy for all.
8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Provide best practice with regards to the management of the concrete waste streams identified in the project. The current challenges facing implementation of the national waste management strategy will be addressed by the project both in terms of waste management and in terms of job creation.
9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	MCC is a very safe carbon capture technology.
10	Reduce inequality within and among countries	No contribution
11	Make cities and human settlements inclusive, safe, resilient and sustainable	No contribution

12	Ensure sustainable consumption and production patterns	Contribution to resource recycling. Namely, industrial wastes such as concrete sludge generated from concrete product manufacturers and ready mixed concrete plants, and demolished concretes are used for MCC. In addition, some of the by-products generated during the process would be utilized as alternative raw materials or environmental decontamination agents/absorbents.
13	Take urgent action to combat climate change and its impacts	Significant contribution – the hybrid low carbon technology has significant potential in terms of CO2 emissions reduction from the cement industry.
14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development	No contribution
15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	Depends on current practise for the disposal of concrete sludge identified during the TA.
16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	No contribution
17	Strengthen the means of implementation and revitalize the global partnership for sustainable development	Sector action (low carbon partnership initiative led by WBCSD) would help to deploy this hybrid low carbon technology

3.3. Post-assistance plans and actions

Post CTCN TA there is a need to undertake a bench-scale project investigating the MCC technology. This is to be followed by a full-scale demonstration project for the hybrid technology including WHR. In order to undertake these two aspects a single proposal should be submitted to either the Green Climate Fund or the Global Environment Facility fund. RSA has accredited evaluation bodies for both these funds. Based on the successful completion of the demonstration project the proposal will be to implement the roll-out plan provided the demonstration shows the potential for mitigation tied to economic development through the sale of value-add products emanating from the process.

3.4 Monitoring and Reporting of technical assistance results and impacts

Performance indicators of CTCN Assistance				
Response output *(linking to sec 1.2)*	**How output will be used to ensure creation of result**	**Expected result**	**Expected outcome of result** *(linking to sec 1.1)*	**Anticipated impact that outcome will produce** *(linking to section 3)*
An assessment of the waste materials balance including the by-products to be obtained through the MCC&U technology and identification of the waste stream source.	The output will be used to determine the technical feasibility of the hybrid low carbon technology in RSA	Identification of waste streams (waste concrete) and assessment of potential by-product from the MCC reactor	The results will be used in the assessment of the economic and technical feasibility including determination of the net marginal abatement cost	The recycling of wastes from the concrete sector will result in improved resource efficiency. Industrial wastes from the concrete sectors where cement is used as a raw material, such as concrete sludge generated from ready mixed concrete plants and concrete product manufacturers, will be utilized within the MCC&U. Aggregates from the waste will be separated and reused/recycled.
Technical aspects of MCC (e.g. Concrete wastes information and generation of by-products) Selection of valuable by-products to meet market needs in RSA.	Carbon captured Amount: Analysis of concrete wastes Quantify available volume of concrete wastes to be collected GHG emissions from other sources: Quantity of concrete wastes and transport options By-product information: Chemical analysis of exhaust kiln gas and the waste Results of laboratory test using the by-product	An assessment of the waste materials balance including the by-products to be obtained through the MCC&U technology and identification of the waste stream source.		
Estimation of GHG emissions reduction potential for the cement sector	Quantification of net GHG reduction potential*. (* =Amount of Carbon captured – (GHG emissions from transportation and power consumed by the reactor))	Existing GHG accounting methodology will be adopted to estimate the emissions reduction potential.		Reduction of GHG emissions in the host country.

		Any variables affecting the calculation should be identified and quantified.		
Development of a business plan to deploy the hybrid low carbon technology (9-12 months after Phase 1, 2 &3)	Financial information a. Estimate annual sales amount and a net marginal abatement cost** (** = (Cost for MCC operation – Sales amount of by-product)/Net GHG reduction) b. Feasibility of the project realization and the possible next step for implementing the project are identified Recommendations and way forward a. To be informed by NDE with the co-operation of the relevant government waste managers based on the Phase 1 and 2.		Enable the NDE to progress to bench scale project followed by deployment of the hybrid low carbon technology	

References:

1) http://www.meti.go.jp/meti_lib/report/2013fy/E003499.pdf "Feasibility Study Report on Bilateral Offset Credit Mechanism Project for Clean Energy Technology Diffusion in Cement Sector in the Republic of South Africa (March 2013)"
2) A. Iizuka, et al. "Development of a New CO_2 Sequestration Process Utilizing the Carbonation of Waste Cement" Ind. Eng. Chem. Res. 43, 7880-7887 (2004)
3) Y. Katsuyama & A. Iizuka, et al. "Development of a Process for Producing High-Purity Calcium Carbonate CaCO3) from Waste Cement Using Pressurized CO_2" Environmental Progress Vol.24, No.2, 162 (July 2005)
4) A. Iizuka et al. "Bench-Scale Operation of Concrete Sludge Recycling Plant Utilizing Carbon Dioxide," Ind. Eng. Chem. Res., 51, 6099–6104 (2012)
5) A. Iizuka et al. Cost Evaluation for a Carbon Dioxide Sequestration Process by Aqueous Mineral Carbonation of Waste Concrete", J. of Chemical Engineering of Japan, Vol. 46, No. 4, pp. 326–334 (2013)
6) Y. Abea & A. Iizuka et al. "Dissolution rates of alkaline rocks by carbonic acid: Influence of solid/liquid ratio, temperature, and CO_2 pressure" chemical engineering research and design 9 1 933–941(2013)
7) PAdeCS Consortium (PAdeCS brochure)

4. Signatures

Signatures of the requesting country

NDE	Request Proponent
Name: HENRY RUMAIN	Name: DHIRAJLAL B K RAMA
Title: NDE - KSA	Title: EXECUTIVE DIRECTOR : ACMP
Date: 03-10-2016	Date: 04-10-2016
Signature:	Signature:

Signatures of the CTCN

CTCN Director	Climate Technology Manager
Name: JUKKA UOSUKAINEN	Name: RAJIV GARG
Title: DIRECTOR - CTCN	Title: TECHNOLOGY MANAGER (ai)
Date: 06/10/2016	Date: 06/10/2016
Signature:	Signature:

Annex 1: Response Long frame

Activity *(link to sec 2)*	**Description of sub-activities conducted by the CTCN**	**Output/ Deliverable** *(link to sec 1.3)*	**Expected Outcome** *(link to sec 3)*	**Main national partners involved**	**Objectively Verifiable Indicator** *(see Annex 2 for guidance)*	**Means of Verification** (data source, method of collection, responsibility and periodicity)
Activity 1	Assessment of physical and chemical properties of the concrete wastes and their transportation means	An assessment of the waste materials balance including the by-products to be obtained through the MCC&U technology and identification of the waste stream sources.	Assessment of the MCC reaction.	ACMP members, Concrete product manufacturers, Ready mixed concrete companies South Africa National Energy Department Institute (SANEDI)	Report identifying and evaluating suitable waste production sites including recommendations for waste collection and transportation.	Report submitted (month 7)
	Assessment of chemical properties of the exhaust gas for MCC reaction				Report on the results of the cement kiln exhaust gas sampling and laboratory analysis and an estimation of the potential CO_2 capture and volume of by-products generated	Report submitted (month 7)
	Identification of potential barriers envisaged for the project realization		Any technical or political barriers are identified		Report	Report submitted (month 11)
Activity 2	Assessment of potential by-products	Report on potential by-products	By-products identified and assessed		Report	Report submitted (month 7)
	Market survey to select valuable by-products that meet market demands	Market report		Local consultant	Report	Report submitted (month 11)
Activity 3	Estimation of GHG emissions reduction by WHR	Quantitative estimate		ACMP members, Department of Environmental Affairs (Chemical and Waste Branch / Climate Change branch)	Statement of expected GHG emissions reduction at target cement plant site	Presented at stakeholder meeting (month 7)
	Estimation of GHG emissions reduction by MCC&U	Quantitative estimate				

	Assessment of other concrete wastes and alternative waste sources that can be utilised in the MCC reactor	Qualitative estimate		South Africa National Energy Department Institute (SANEDI)	Report	Report submitted (month 12)
	Statement of the potential GHG emissions reduction in the RSA cement sector from implementation of the hybrid low carbon system	Statement of the potential GHG emissions reduction				
Activity 4	Calculation of investment costs for WHR and associated GHG marginal abatement costs	Financial viability assessment		ACMP members Department of Environmental Affairs (Chemical and Waste Branch / Climate Change branch) South Africa National Energy Department Institute (SANEDI)	Business Plan	Report submitted (month 12)
	Calculation of investment costs for MCC&U and associated GHG marginal abatement costs	Financial viability assessment				
	Identification of barriers and recommendations for their removal	Report on findings				
	Development of a business plan and project implementation recommendations	Business plan	Assessment of the financial viability of the hybrid system			
	Stakeholder meeting	Business Plan			Event took place (month 10)	Event minutes and list of attendees
Activity 5	Stakeholder meeting	Introduction to the project (broad description of the technology and the objectives of the project). Preparation for		ACMP members, Concrete product manufacturers, Ready mixed concrete companies	Event took place (month 1)	Event minutes and list of attendees

		identification, sampling and testing of industrial wastes and analysis of cement kiln exhaust gases.		South Africa National Energy Department Institute (SANEDI)		
	Stakeholder meeting	Presentation of findings of activities 1.1 and 1.2		ACMP, Local cement plant(s)	Event took place (month 4)	Event minutes and list of attendees
	Stakeholder meeting	Presentation of results of activity 1.2 and interim report on the results of activities 2.1, 2.2, 3.1 & 3.2		ACMP members,Department of Environmental Affairs (Chemical and Waste Branch / Climate Change branch) South Africa National Energy Department Institute (SANEDI)	Event took place (month 7)	Event minutes and list of attendees
	Stakeholder meeting	Business Plan		ACMP members, Concrete Product Manufacturers, Ready mixed concrete companies, RSA Government, financial sector, local engineering companies, local distributor of chemical products and consultants specializing in climate and resource management.	Event took place (month 10)	Event minutes and list of attendees

Annex 2: Indicative list of performance indicators

Overall Activity	**Specific Activity**	**Indicator**
Capacity Building	▪ Development and delivery of workshops ▪ Development and delivery of trainings (e.g. webinars, e-learning, ad-hoc) ▪ Development and delivery of toolkits	Number of participants trained or training days received; Post training evaluation and feedback (and minutes); CTCN Knowledge Management System (KMS) users; Webinar content/minutes/feedback; e-learning content/feedback
Advisory	▪ Development of needs assessment/ studies/ reports/ etc. ▪ Establishment/development of recommendations	Diversity of sources used; Response Implementer efforts days; Recommendations; Scope of dissemination; Level of detail used; Feedback; Uptake of recommendations
Policy development	▪ Development of strategy ▪ Drafting of implementation plan ▪ Formulation inputs to policy/ law	Strategy available and adapted to local context and national priorities; Number of interview/events conducted to developed the strategy/ plan; Strategy/Plan dissemination; Number of technologies recommended in the strategy/plan; Scope of changes recommended by the strategy/plan.
Project implementation	Mitigation ▪ Energy supply ▪ Energy use ▪ Industry ▪ Transport ▪ Agriculture ▪ Waste management ▪ Forestry Adaptation ▪ Water ▪ Infrastructure, transport and urban design ▪ Early warning and environmental assessment ▪ Coastal zones	Outputs available and adapted to local context and national priorities; Level of private sector participation; Planning/Outputs distributed to decision makers with feedbacks; Integration of outputs/outcomes into planning of host country; implementation of outputs/outcomes by host country or other multi/bi-lateral organisation; Level of cooperation between Response Implementer, NDE and Response Proponent(s).

Overall Activity	**Specific Activity**	**Indicator**
	▪ Agriculture and forestry ▪ Human health ▪ Marine and fisheries	
Development of a new partnership or strengthening of an existing one	▪ Development/ Establishment of basis for Twinning ▪ Development/ Establishment of basis for PPP ▪ Development/ Establishment of basis for knowledge partnership	