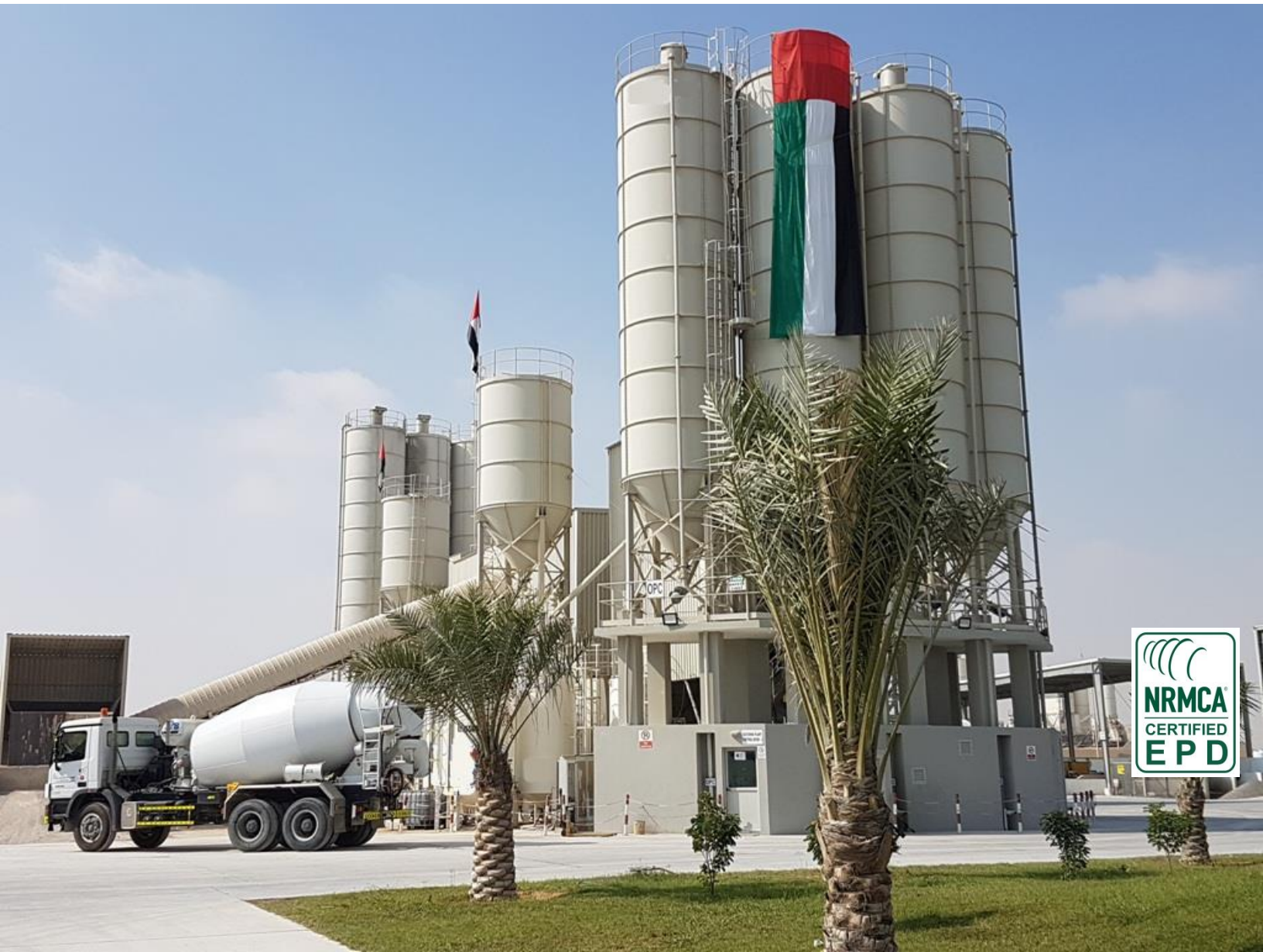
Environmental Product Declaration

بلدية دبي
DUBAI MUNICIPALITY

DUBAI READY-MIXED CONCRETE

EPD for concrete produced at eight ready-mixed concrete plants located in Dubai, United Arab Emirates



Environmental Product Declaration

NRMCA Certified Environmental Product Declaration

This environmental product declaration was conducted in accordance with ISO 14025:2006

Internal Verification External Verification X

Declared Product:	This Environmental Product Declaration (EPD) covers concrete mixes produced in the Emirate of Dubai, UAE.	
Declaration Owner:	**Dubai Municipality** P.O. Box: 67 Dubai, United Arab Emirates +971 4 2215555 http://www.dm.gov.ae/	بلدية دبي DUBAI MUNICIPALITY
Concrete Consultant:	**Grey Matters Consultancy** P.O. Box: 283079 Dubai Investment Park Dubai - UAE Tel: +971 4 8849525 Fax: +971 4 8849524 http://www.greymatters.ws/	Grey Matters Consultancy
Program Operator:	**National Ready Mix Concrete Association** 900 Spring St. Silver Spring, MD 20910 301-587-1400 www.nrmca.org/sustainability Lionel Lemay	NRMCA
LCA and EPD Developer:	**Athena Sustainable Materials Institute** 119 Ross Ave. #100 Ottawa, ON K1Y 0N6 613-729-9996 www.athenasmi.org James Salazar	Athena Sustainable Materials Institute
Product Category Rule:	The Carbon Leadership Forum PCR: Product Category Rules (PCR) for ISO 14025 Type III Environmental Product Declarations (EPDs) for Concrete Version 1.1 dated December 4, 2013, Serves as the PCR for this EPD. www.carbonleadershipforum.org.	
	PCR review was conducted by: Nicholas Santero, PE International; Holly Lahd, EL Analytics and Medgar Marceau, Morrison Hershfield; December 4, 2013	
Independent LCA Reviewer and EPD Verifier:	This EPD was independently verified by NSF International in accordance with ISO 14025 and ISO 21930. The life cycle assessment was independently reviewed in accordance ISO 14044 and the referenced PCR. Independent verification of the declaration, according to ISO 14025: 2006 ☐ Internal ☒ External	
	PRé Third Party Verifier Paula Bernstein, PRe Phone: 202-460-0280	
Date of Issue:	Issued March 15, 2017	
Period of Validity:	5 Years	
EPD Number	NRMCAEPD:10017	

NRMCA CERTIFIED EPD

Description of Company

The Dubai Municipality and Grey Matters coordinated 8 individual manufacturers participation in the study. The participating companies are listed in Table 1:

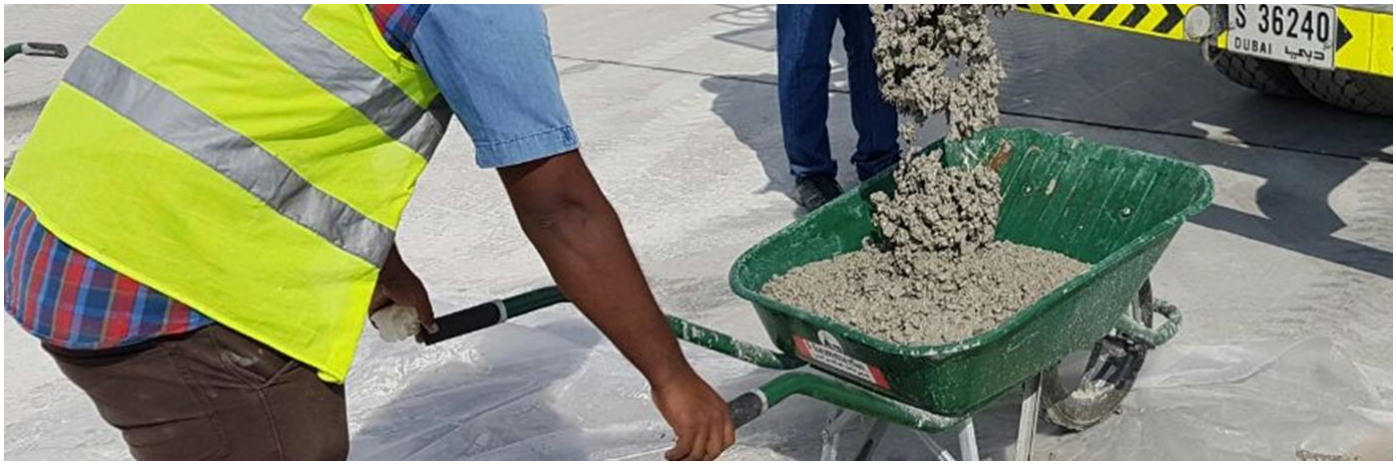
Table 1. Companies that Participated in EPD

Company Name	Company Location
Ready Mix Beton	Al Quoz, Dubai, UAE
Austrian Arabian Ready Mix Concrete	Jebel Ali, Dubai, UAE
Cemex Topmix	Al Quoz, Dubai, UAE
Ready Mix Gulf (LafargeHolcim)	Al Quoz, Dubai, UAE
Transgulf Ready Mix Concrete Co.	Jebel Ali, Dubai, UAE
Technical Readymix Concrete Co. (Tremix)	Al Qusais, Dubai, UAE
Mills Bowley Concrete Products (MB Mix)	Dubai Investments Park, Dubai, UAE
Universal Concrete Products Ltd. Co. (Unimix)	Al Quoz, Dubai, UAE

Description of Product

Products covered by this EPD satisfy general purpose concrete as used in residential, commercial and public works applications in the Dubai, UAE. This EPD reports the impacts for different ready-mixed concrete products (listed in Table 2 on the following page) in accordance with the following:

- Dubai Municipality Circular 202: Use of Eco-friendly Cementitious Materials in Concrete
- ACI 211: Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
- ACI 318: Building Code Requirements for Structural Concrete
- ASTM C94: Standard Specification for Ready-Mixed Concrete
- CSI MasterFormat Division 03-30-00: Cast-in-Place Concrete
- UNSPSC Code 30111500: Ready Mix Concrete



NRMCA CERTIFIED EPD

Table 2. Declared Product Range Classification	
Product ID	**Compressive Strength (MPa @ 28 days)**
C30 - C35 (66%GGBS)	30-35 MPa
C40 (36%GGBS)	40 MPa
C40 (66%GGBS)	40 MPa
C45 (36%GGBS)	45 MPa
C45 (66%GGBS)	45 MPa
C50 (36%GGBS)	50 MPa
C55 (26%GGBS+5%MS)	55 MPa
C60 (26%GGBS+5%MS)	60 MPa
C65 (26%GGBS+6%MS)	65 MPa
C70 (26%GGBS+7%MS)	70 MPa
C75 (26%GGBS+7%MS)	75 MPa
C80 (26%GGBS+8%MS)	80 MPa
C90 (26%GGBS+8%MS)	90 MPa

This EPD is intended for use in Business to Business (B-to-B) communication. The scope of this EPD is cradle-to-gate and considers the following life cycle stages.

- **A1 - Raw Material Supply:** Includes all upstream processes related to extraction, handling, and processing of the raw materials and intermediate component products as well as fuels used in the production of concrete. Component products include cement, supplementary cementitious materials, aggregate (coarse and fine), water, admixtures and other materials or chemicals used in concrete mixtures.
- **A2 - Transportation:** Accounts for the transportation of all input materials and fuels from the supplier to the gate of the concrete plant.
- **A3 - Manufacturing (Core Processes):** Includes all core processes and the energy and water used to store, move, batch and mix the concrete and operate the concrete plant as well as the transportation and processing of wastes from these core processes.

Methodology of Underlying LCA

Declared Unit

The declared unit is 1 cubic meter of ready mixed concrete product. Key product variables include:

- ***28-day strength*** – Thirteen different specified compressive strengths were considered: 30-35 MPa, 40 MPa, 45 MPa, 50 MPa, 55 MPa, 60 MPa, 65 MPa, 70 MPa, 75 MPa, 80 MPa, and 90 MPa;
- ***Slag cement*** – Varies between 26% and 66% (lower for higher strength concrete);
- ***Silica fume*** – Varies between 0 and 8% (lower for lower strength concrete);
- ***Admixture use*** – The use of high range water reducing admixture varies between 4 and 9 liters per cubic meter;
- ***Aggregate use*** – The use of crushed coarse, crushed fine, and natural fine aggregates varies;

Product (mix design) components include: portland cement, slag cement, silica fume, natural and crushed aggregates, admixtures and batch water.

Scope of LCA

A summary of life cycle stages included in the EPD is as follows:

1. Raw Material Supply (upstream processes): Extraction, handling and processing of the raw materials used in the production of concrete: cement, supplementary cementitious materials, aggregate (coarse and fine), water, admixtures and other materials or chemicals used in concrete mixtures.
2. Transportation: Transportation of these materials from the supplier to the 'gate' of the concrete producer.
3. Manufacturing (core processes): The energy used to store, batch, mix and distribute the concrete and operate the facility (concrete plant)
4. Water use in mixing and distributing concrete.

A summary of life cycle stages excluded from the EPD is as follows:

1. Production, manufacture and construction of buildings capital goods and infrastructure
2. Production and manufacture of concrete production equipment, concrete delivery vehicles, earthmoving equipment, and laboratory equipment
3. Personnel---related activities (travel, furniture, office supplies).
4. Energy use related to company management and sales activities.

Building Life Cycle Information Modules															
Product stage			Construction Process stage		Use stage							End-of-life stage			
Raw Material supply	Transport	Manufacturing	Transport	Construction/Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	De-Construction/ Demolition	Transport	Waste processing	Disposal
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4

Figure 1. Life cycle stage schematic – alpha-numeric designations as per CLF PCR 2013(adapted from CEN 15978:2011)

Cut-off Rules

The cut-off criteria for all activity stage flows considered within the system boundary conform with ISO14044:2006 and section 3.3 of the CLF PCR 2013. Specifically, the cut-off criteria were applied as follows:

- All inputs and outputs for which data are available are included in the calculated effects and no collected core process data are excluded.
- A one percent cut-off is considered for renewable and non-renewable primary energy consumption and the total mass of inputs within a unit process. The sum of the total neglected flows does not exceed 5% of all energy consumption and mass of inputs.
- All flows known to contribute a significant impact or to uncertainty (e.g., portland cement and admixtures) are included.
- The cut-off rules are not applied to hazardous and toxic material flows – all of which are included in the life cycle inventory.

Allocation

The applied allocation procedures conform with ISO 14044:2006 clause 4.3.4.

Limitations

The limitations of this EPD include:

- This EPD does not report all of the environmental impacts due to manufacturing of the product, but rather reports the environmental impacts for those categories with established LCA-based methods to track and report. Unreported environmental impacts include (but are not limited to) factors attributable to human health, land use change, and habitat destruction.
- In order to assess the local impacts of product manufacturing, additional analysis is required.
- This EPD reports the results of an LCA or the 'cradle-to-gate' analysis. Thus, declarations themselves are not comparative assertions, defined as an environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function. An EPD does not make any statements that the product covered by the EPD is better or worse than any other product.
- The EPD participants may participate in other sustainability or environmental best practice programs. However, no such additional environmental claim or declaration is conveyed in this EPD.
- EPDs of concrete mixtures may not be comparable if they do not comply with this standard and data from this EPD. The data cannot be used to compare between concrete mixes, construction products or concrete mixtures used in different concrete products unless the data is integrated into a comprehensive LCA. For example, precast concrete, concrete masonry units and site cast concrete all have different manufacturing processes whose impacts are attributed to different LCA stages. This precludes direct comparison between mixtures used in these different products unless all lifecycle phases are included.
- Life cycle impact assessment (LCIA) results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.
- This EPD was created using industry average data for upstream materials. Variation can result from differences in supplier locations, manufacturing processes, manufacturing efficiency and fuel type used.

Data Sources and Data Quality Assessment

This EPD is based on foreground LCI data collected from the participating companies' production facilities. All upstream material, resource and energy carrier inputs have been sourced from various industry-average datasets and literature. Many of these data sets are defaulted to those specified for use in the CLF PCR 2013. Tables 3 to 5 describe each LCI data source for raw materials (A1), transportation by mode (A2), the RMC core manufacture process (A3), and descriptions of data quality for each data source.

Table 3. A1 - Raw Material Supply

Materials	LCI Data Source	Geography	Year	Data Quality Assessment
Cement (lbs)	Results for 1 kg Cement in United Arab Emirates as modeled in WBCSD-CSI tool for EPDs of concrete and cement. UAE-specific clinker factors and kiln fuels assumed in model.	UAE	2014-2015	• **Technology:** good Process represents average cement production in the UAE • **Time:** good Data is within 4 years • **Geography:** very good • **Completeness** good Data is based on an average of national production • **Reliability:** very good
Silica Fume (lbs)	None, no incoming burden, only inbound transport was considered	N/A	N/A	• **N/A** • **Recovered material**
Slag Cement (lbs)	Slag Cement Association N. America EPD Slag Cement, 2015	N. America	2013-2014	• **Technology:** good Process models ground granulated blast furnace slag • **Time:** good Data is within 3 years • **Geography:** fair • **Completeness** good • **Reliability:** very good, third-party verified EPD
Crushed Aggregates (lbs) *coarse and fine*	ecoinvent process: "Gravel, crushed, at mine" ecoinvent 3 Modified with UAE electricity	EU/UAE	2004	***CLF PCR 2013 Default Data*** • **Technology:** good Processes represent aggregate, with and without crushing. Dust emissions are estimated from limestone mining**.** • **Time:** fair Data Is twelve years old but technology remains consistent across the industry • **Geography:** good Swiss production (modified with UAE Electricity). • **Completeness:** very good • **Reliability:** very good Data is verified by ecoinvent.
Natural Aggregates (lbs) *fine*	ecoinvent process: "Gravel, round, at mine", ecoinvent 3 Modfied with UAE electricity	EU/UAE	2004	

NRMCA CERTIFIED EPD

Table 3. A1 - Raw Material Supply (Continued)				
Process	**LCI Data Source**	**Geography**	**Year**	**Data Quality Assessment**
Admixtures (lbs) High-range water reducing admixture (superplasticizer)	EFCA EcoProfile (325) CLF PCR 2013 Default	EU	2006	***CLF PCR 2013 Default Data*** • **Technology:** very good Processes represents admixture production for use in concrete • **Time:** fair Data is within eleven years • **Geography:** good • **Completeness:** good Data from a federation of European admixture producers • **Reliability:** good Profiles have undergone an independent review process. Compliance with ISO standards (unknown)

Table 4. A2 - Transportation				
Process	**LCI Data Source**	**Geography**	**Year**	**Data Quality Assessment**
Road (t*km)	ecoinvent 3 Transport, freight, lorry, unspecified {GLO}| market for | Alloc Def	Global	2015	• **Technology:** good Processes represents global average • **Time:** very good Data is within two years • **Geography:** fair • **Completeness:** good • **Reliability:** good • Data is from ecoinvent database
Ocean (t*km)	ecoinvent 3 Transport, freight, sea, transoceanic ship {GLO}| market for | Alloc Def	Global	2015	• **Technology:** good Processes represents global average • **Time:** very good Data is within two years • **Geography:** fair • **Completeness:** good • **Reliability:** good • Data is from ecoinvent database

Table 5. A3 - Manufacturing				
Process	**LCI Data Source**	**Geography**	**Year**	**Data Quality Assessment**
Electricity (kWh)	Energy source breakdown: International Energy Agency electricity statistics for 2014 UAE electricity generation[1] Electricity generation processes: ecoivent V3	UAE/Global	2014/ 2015	• **Technology:** very good Process represents production of electricity in the UAE in 2014. (See % contribution by source below) • **Time:** very good Electricity production data and breakdown is within two years • **Geography:** very good • **Completeness:** good Data is representative of UAE production • **Reliability:** good ecoinvent has verified the data
Diesel and Gasoline (liters)	ecoinvent 3 Heat, central or small-scale, other than natural gas {RoW}| heat production, light fuel oil, at boiler 10kW condensing, non-modulating | Alloc Def	Global	2015	• **Technology:** very good Process represents combustion of fuel oil in a condensing boiler. • **Time:** very good Data is within two years • **Geography:** fair • **Completeness:** good Data is representative of US conditions • **Reliability:** good Data is from ecoinvent database *Gasoline represents a small portion of the weighted average energy mix (<1%)
Hazardous Solid Waste, (lbs)	ecoinvent 3, Hazardous waste, for incineration {GLO}| treatment of hazardous waste, hazardous waste incineration | Alloc Def, U	Global	2008	• **Technology:** good • **Time:** fair Data is within ten years. • **Geography:** fair Processes model Swiss production (no US process in USLCI database). • **Completeness:** very good • **Reliability:** very good Data is verified by ecoinvent.

[1] UAE electricity statistics: http://www.iea.org/statistics/statisticssearch/report/?year=2014&country=UAE&product=ElectricityandHeat

Table 5. A3 - Manufacturing				
Process	**LCI Data Source**	**Geography**	**Year**	**Data Quality Assessment**
Non-Hazardous Solid Waste, (lbs)	ecoinvent 3, Waste concrete {GLO}| treatment of, inert material landfill | Alloc Def, U	Global	2008	• **Technology:** good • **Time:** fair Data is within ten years. • **Geography:** fair Processes model Swiss production (no US process in USLCI database). • **Completeness:** very good • **Reliability:** very good Data is verified by ecoinvent.

UAE Purchased Electricity source grid mix	**LCI Data Set**	**kWh production per kWh at user**
Oil	Electricity, high voltage {RoW}| electricity production, oil | Alloc Def, S	0.0144
Natural Gas	Electricity, high voltage {RoW}| electricity production, natural gas, at conventional power plant | Alloc Def, S	1.0545
Solar	Electricity, low voltage {RoW}| electricity production, photovoltaic, 570kWp open ground installation, multi-Si | Alloc Def, S	0.0029
Total		**1.0718**

Data Quality

Data quality/variability requirements, as specified in the CLF PCR 2013 sections 3.5 and 3.6, are applied. This section describes the achieved data quality relative to the ISO 14044:2006 requirements. Data quality is judged on the basis of its precision (measured, calculated or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied within a study serving as a data source) and representativeness (geographical, temporal, and technological).

Completeness: All relevant specific processes, including inputs (raw materials, energy and ancillary materials) and outputs (emissions and production volume) were considered and modeled to represent the specified and declared RMC products. The relevant background materials and processes were taken from ecoinvent v 3 LCI databases and were modified with UAE-specific electricity inputs before they were modeled in SimaPro software v.8.0.1, 2014.

Reproducibility: Internal reproducibility is possible since the data and the models are stored and available in a SimaPro database for all background processes, and in Athena's proprietary concrete LCA calculator* for all production facility and mix-specific calculations. A considerable level of transparency is provided throughout the LCA report as the specifications and material quantity make-up for the declared RMC products are presented and key primary and secondary LCI data sources are summarized. The provision of more detailed data to allow full external reproducibility was not possible due to reasons of confidentiality. * *Athena has developed a proprietary tool that allows the calculation of PCR-compliant LCA results for ready-mixed concrete product mix designs. The tool scales results for base-unit technosphere inputs (i.e. 1 kg portland cement, 1 kWh electricity, etc.) to replicate the reference flow conversions that take place in SimaPro.*

Representativeness: The representativeness of the data is summarized as follows.

- Time related coverage of the manufacturing processes' primary collected data: 2015 (12 months).
- Upstream (background) LCI data was either the CLF PCR 2013 specified default or more appropriate LCI datasets as found in the UAE-adjusted ecoinvent v 3 database.
- Geographical coverage for the cement and RMC plant operations is United Arab Emirates; other upstream and background processes are based on global average data.
- Technological coverage is typical or average – specific to the participating facilities for all primary data.

Reliability: *The degree to which the sources, data collection methods and verification procedures used to obtain the data are dependable*. For core manufacturing processes the reliability of the information and data is deemed to be very good as these were derived from primary data from ready-mixed concrete producers and subsequently reviewed by Athena for plausability. All other LCI data have been incorporated in accordance with the default CLF PCR 2013 requirements or derived from ecoinvent databases, which have been verified by ecoinvent.

Life Cycle Assessment Results

Environmental Indicators and Inventory Metrics

This EPD supports 15 life cycle impact assessment indicators and inventory metrics as listed in Table 5. As specified in the CLF PCR 2013, Section 8., the US EPA Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI), version 2.1, 2012 impact categories were used to calculate mandatory category indicators.

Table 5. Life Cycle Category Indicators and Inventory Metrics

#	LCIA Indicators	Abbreviations	Units
1	Global Warming Potential (climate change)	**GWP**	kg CO2-eq
2	Ozone Depletion Potential	**ODP**	kg CFC-11-eq
3	Acidification Potential	**AP**	kg SO2-eq
4	Eutrophication Potential	**EP**	kg N-eq
5	Photochemical Ozone Creation/Smog Potential	**POCP**	kg O3-eq
	Inventory Metrics		
6	Total primary energy consumption	**PEC**	MJ (HHV)
7	Depletion of non-renewable energy resources	**NRE**	MJ (HHV)
8	Use of renewable primary energy	**RE**	MJ (HHV)
9	Depletion of non-renewable material resources	**NRM**	kg
10	Use of renewable material resources	**RM**	kg
11	Concrete batching water consumption	**CBW**	m3
12	Concrete washing water consumption	**CWW**	m3
13	Total water consumption	**TW**	m3
14	Concrete hazardous waste	**CHW**	kg
15	Concrete non-hazardous waste	**CNHW**	kg

Impact Assessment Results

Table 6. Summary Results (A1-A3): United Arab Emirates average concrete, per cubic meter															
Indicator/LCI Metric	**GWP**	**ODP**	**AP**	**EP**	**POCP**	**PEC**	**NRE**	**RE**	**NRM**	**RM**	**CBW**	**CWW**	**TW**	**CHW**	**CNHW**
MIX ID	**kg CO2**	**kg CFC-11**	**kg SO2**	**kg N**	**kg O3**	**MJ**	**MJ**	**MJ**	**kg**	**kg**	**m3**	**m3**	**m3**	**kg**	**kg**
C30 - C35 (66%GGBS)	222.14	2.80E-05	6.62	0.60	79.32	2660.84	2624.88	35.96	2171.82	1.81	0.16	0.12	1.43	4.87E-03	87.17
C40 (36%GGBS)	328.30	3.52E-05	7.71	0.81	92.10	3321.78	3286.84	34.94	2400.42	2.56	0.14	0.12	2.32	2.88E-03	87.15
C40 (66%GGBS)	234.99	2.91E-05	7.67	0.68	90.98	2792.55	2754.43	38.12	2186.56	1.94	0.15	0.12	1.49	5.27E-03	87.17
C45 (36%GGBS)	334.08	3.56E-05	7.73	0.81	92.40	3367.17	3331.67	35.50	2388.95	2.62	0.14	0.12	2.37	2.96E-03	87.15
C45 (66%GGBS)	242.79	2.97E-05	7.71	0.70	91.54	2863.43	2824.04	39.39	2158.71	2.03	0.15	0.12	1.54	5.53E-03	87.18
C50 (36%GGBS)	340.80	3.60E-05	8.73	0.88	103.33	3421.07	3385.05	36.02	2377.83	2.67	0.15	0.12	2.43	3.02E-03	87.16
C55 (26%GGBS+5%MS)	367.86	3.78E-05	8.76	0.92	103.85	3571.09	3535.93	35.15	2394.41	2.85	0.15	0.12	2.68	2.28E-03	87.15
C60 (26%GGBS+5%MS)	373.87	3.82E-05	8.78	0.93	104.18	3620.30	3584.59	35.71	2396.71	2.90	0.15	0.12	2.72	2.34E-03	87.15
C65 (26%GGBS+6%MS)	370.68	3.81E-05	8.78	0.92	104.14	3600.94	3565.32	35.62	2403.73	2.87	0.14	0.12	2.68	2.34E-03	87.15
C70 (26%GGBS+7%MS)	372.96	3.84E-05	5.39	0.71	67.23	3617.10	3580.99	36.11	2418.34	2.90	0.14	0.12	2.69	2.40E-03	87.15
C75 (26%GGBS+7%MS)	379.77	3.89E-05	5.41	0.72	67.57	3671.07	3634.43	36.64	2423.11	2.96	0.14	0.12	2.73	2.44E-03	87.15
C80 (26%GGBS+8%MS)	384.36	3.93E-05	6.41	0.79	78.56	3714.68	3677.44	37.24	2411.99	3.00	0.14	0.12	2.76	2.52E-03	87.15
C90 (26%GGBS+8%MS)	394.97	4.01E-05	6.45	0.81	79.08	3798.09	3760.00	38.09	2414.05	3.09	0.13	0.12	2.84	2.60E-03	87.16

References

American Concrete Institute (ACI) 211: Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete

American Concrete Institute (ACI) 318: Building Code Requirements for Structural Concrete

ASTM International (ASTM) C94: Standard Specification for Ready-Mixed Concrete

Athena Sustainable Materials Institute: A Cradle-to-Gate Life Cycle Assessment of Ready-Mixed Concrete Manufactured in the United Arab Emirates Version 1.0; Prepared by the Athena Sustainable Materials Institute for Grey Matters: November 2016.

Carbon Leadership Forum (December 4, 2013). Product Category Rules (PCR) for ISO 14025 Type III Environmental Product Declarations (EPDs) of Concrete v1.1.

Carbon Leadership Forum Clarification #1 (April 10, 2014), Clarification #2 (July 17, 2014) and Clarification #3 (June 1, 2015) to: PCR for ISO 14025 Type III Environmental Product Declarations (EPDs) of Concrete v1.1.

Construction Specifications Institute (CSI) MasterFormat Division 03-30-00 Cast-in-Place Concrete

EN 15804:2012 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products.

European Federation of Concrete Admixture Associations (2006). EFCA Environmental Declarations for Admixtures. http://www.efca.info/publications.html

ISO 21930: 2007 Building construction – Sustainability in building construction – Environmental declaration of building products.

ISO 14025: 2006 Environmental labeling and declarations - Type III environmental declarations - Principles and procedures.

ISO 14044: 2006 Environmental management - Life cycle assessment - Requirements and guidelines.

ISO 14040: 2006 Environmental management - Life cycle assessment - Principles and framework.

National Ready Mixed Concrete Association 2013. Program Operator Instructions for Environmental Product Declarations v1.2.

National Renewable Energy Laboratory 2014. U.S. Life Cycle Inventory Database. https://www.lcacommons.gov/nrel/search.