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Development of Low Carbon Cement Ecosystem in Indonesia Using Combine Stakeholder Analysis and Social Network Analysis: In a Perspective of Cement Company

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ABSTRACT: GHG emission remain the main issue for cement industry as well as global GHG emission record. GHG emission was still considered as the main contributor of global warming. Therefore, cement industry has an obligation to decarbonize its business. However, decarbonization is a complex process that need to be treated as an ecosystem. Low carbon cement is one of the objectives to decrease GHG emission in cement industry. The production of low carbon cement could be seen as an ecosystem that the stakeholders/actors within the ecosystem interacted each other. Stakeholder analysis and social network analysis could be used to evaluate the importance of the stakeholders/actors and the pattern of the interaction. By combining these two tools, there are 10 stakeholders/actors that should be put in main consideration. Eigenvector centrality and betweenness centrality were used to prioritize and evaluate the stakeholders. Construction company is the most popular stakeholder/actor and the most important intermediary actor due to its eigenvector centrality and betweenness centrality value of 0,347 and 35,610 respectively. Meanwhile construction company was also classified in a Player quadrant in power-interest matrix grid. In summary, cement company could prioritize its strategic initiative to engage with 10 most important and intermediaries' actors in low carbon cement ecosystem.

KEYWORDS: GHG emission, low carbon cement ecosystem, stakeholder analysis, social network analysis, eigenvector centrality, betweenness centrality

INTRODUCTION

According to World Economic Forum (WEF), 5 out of 10 global long-term risks are related to environmental issues. Extreme weather is the highest risk that human beings will be challenged in the next future. Climate change was the source of catastrophic reason behind extreme weather that happened in previous year. The US Global Change Research Program has released Climate Science Report regarding climate change events. According to the report, climate change was caused by natural climate driver and anthropogenic driver. Cracknell & Varostsos (2022) explained that the earth has had an atmosphere that for a long time ago had interacted to form weather and climate system. Due to human activities, these interactions have changed.

The Emission Gap Report by United Nations Environment Program (UNEP) in 2022 reveals the global average temperature in a level 1,8 C above pre-industrial levels. It was correlated with the spike of GHG emission level due to atmospheric concentrations of carbon-dioxide (CO_2). Meanwhile, according to McKinsey findings, cement industry was contributed 7% of global GHG emissions. This trend will increase in the future due to market demand. Gagg (2014) explained that concrete was the second most material that human consumed. Cement is the most important binding material in concrete. Moreover, Prakasan, et.al (2019) stated that cement is one the most largely materials used in construction industry.

According to Indonesian Cement Association, total cement production was 40-70 million ton from 2010 to 2021. This number will increase due to massive infrastructure development and increasing retail demand. In the same report, if cement industry could not implement initiatives, the GHG emission intensity will be 725,66 kgCO2/ton cementitious (see Figure I). PT Semen Indonesia (Persero) Tbk ("**SIG**") was the biggest cement producer in Indonesia. It is estimated 45% of capacity share was held by SIG. According to internal data, the increasing amount of cement production was related to GHG emission (see Figure II).

SIG needs to implement initiatives to transition into a low carbon product. However, most of construction projects still used high carbon cement especially Ordinary Portland Cement (OPC) whereas GHG emission intensity was 855 kgCO2/ton cementitious. It is relatively higher compared to other low carbon cement such PPC or PCC (Prakasan, et.al 2019). In regard to these issues, the

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production of low carbon cement is not dependent not only on the cement industry itself, but also its customer and its entire low carbon cement ecosystem.

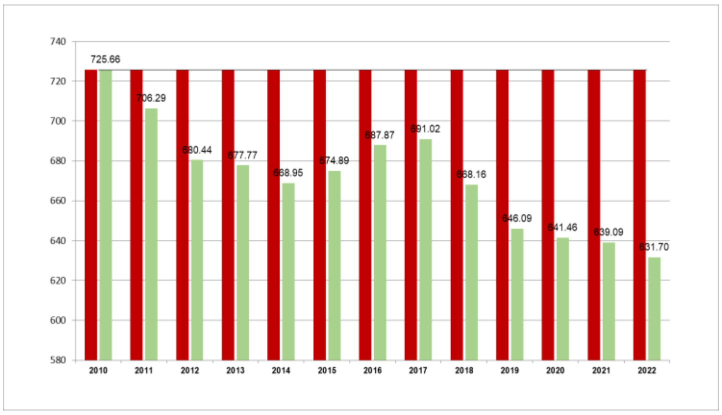

Figure I. GHG Emission Intensity in Cement Industry

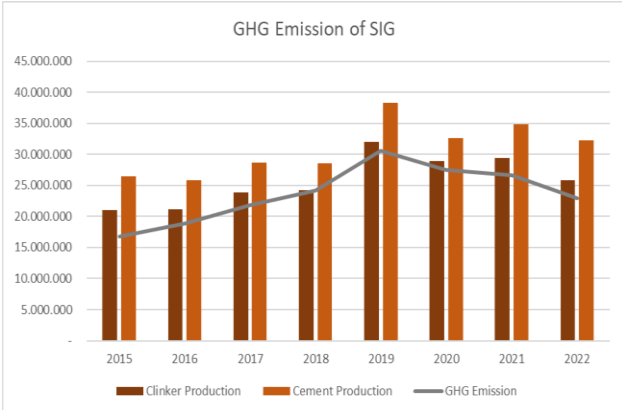

Figure II. The Relation of Clinker & Cement Production with GHG Emission

Based on the issue raise in previous section, cement industry will having important roles in decarbonization to tackle climate change issues. Meanwhile, this decarbonization effort needs a holistic approach as an ecosystem to produce low carbon cement. Therefore, the researcher found that it is important to raise 2 research questions:

1. How to identify the actor who contributes to the low carbon cement ecosystem?
2. Who is the most important actor regarding low carbon cement ecosystems?

THEORITICAL FOUNDATION

In this section, the theoretical foundation will first focus on GHG emission and cement production. Business ecosystem will be explained afterward due to its foundation to explore low carbon cement ecosystems. As important tools in this research, stakeholder analysis and social network analysis will be explained.

1. GHG Emission and Cement Production

Cement manufacturing process is typically using three-stage-manufacturing process: raw material preparation, clinker production, and clinker grinding. The most important process that directly contributes in GHG emission is clinker production. In this process, raw material that previously prepared (limestone and clay) is transformed into clinker. The transforming process use approximately 1.450 C in temperature. In this burning process, Calcium Carbonate ($CaCO_3$) is decomposed into CaO and CO_2 (calcination process). In the context of GHG emission, calcination process contributed approximately 70-80% of total GHG emission in cement industry. This GHG emission consists of GHG emission from calcination and fossil fuel burning.

In its Sustainability Report 2023, SIG has several initiatives to decarbonize its value chain. In GHG emission scope 1, SIG has successfully implemented some of the initiatives such increasing alternative raw material, producing low carbon cement whereas its GHG emission intensity per ton is lower than regular high carbon product as Ordinary Portland Cement (OPC), increasing Thermal Substitution Rate (TSR) by using alternative fuel, and redesigning the process to make it more efficient. Meanwhile, in GHG emission scope 2, SIG focuses on increasing renewable energy capacity by installing solar panels across the group.

2. Business Ecosystem

The term ecosystem came from biological event. It is explained that every creature interacted with each other to bring it into the integrated system. The term business ecosystem essentially explains that every actor in the ecosystem works together to be existed to ensure their objectives together (Moore, 1993). Moreover, Moores (1993) explained more detail that business ecosystem is consist of customers, market intermediaries (agents and channels), supplier, compliment products & services, and oneself. Due to the interaction of all the actros, business ecosystem will not reflect its traditional industry boundaries. It will go beyond boundaries that depend on one actor. It depends on the ecosystem's objectives.

To be specific, Moores (1993) business ecosystem will reflect these basic economic models:

1. There will be one or more core capabilities that can become the basis for providing value for end customers
2. A core product or service give a new capability for the entire ecosystem that is embodied within the system
3. A total experience is ultimately given to end customers not as a single product, but the entire products & services that is provided by the ecosystem
4. Business profit that is generated by the core products & services will be reinvested into the ecosystem to maintain its existence
5. Return from the core business will also be reinvested in alliance community development to support the leadership as well as the ecosystem itself.

Based on this explanation, the model of business ecosystem can be seen in Figure III as follows:

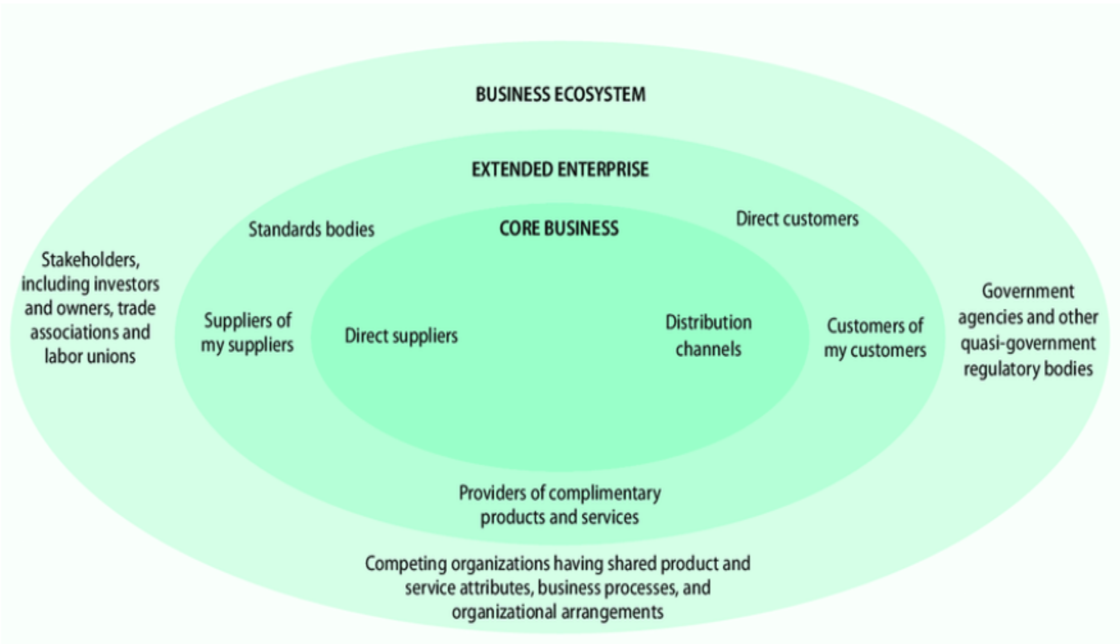

Figure III. Moore's Business Ecosystem Model

3. Stakeholder Analysis & Social Network Analysis

Every business has an actor, either organization or individual that will give impact or affected by the business itself due to decision making. Stakeholder analysis is social and natural events that is affected by the decision both individual and/or organization and then prioritize its involvement in decision making process (Reed, et. al 2009). Moreover, stakeholder analysis can be used to identify stakeholder's interest, influence and position regarding the issues (Grimble, 1998). In summary, stakeholder analysis can be applied to understand the whole system of the business by evaluating and defining who has a stake in accordance with the issues and prioritizing them in the decision-making process (Prell, et.al 2013).

The decision maker can classify every stakeholder/actor into a diagram. Ackerman and Eden (2010) explained stakeholders will be classified into 4 clusters in regards their position of power and interest. The stakeholder with a high interest regarding the issues will be classified into Subject and Player cluster. Meanwhile, if the stakeholder has low interest, they will be grouped into Crowd and Context Setter (Ackerman and Eden, 2010). The classification of the stakeholders/actors was called Power-Interest Matrix Grid than can be seen in Figure IV as follows:

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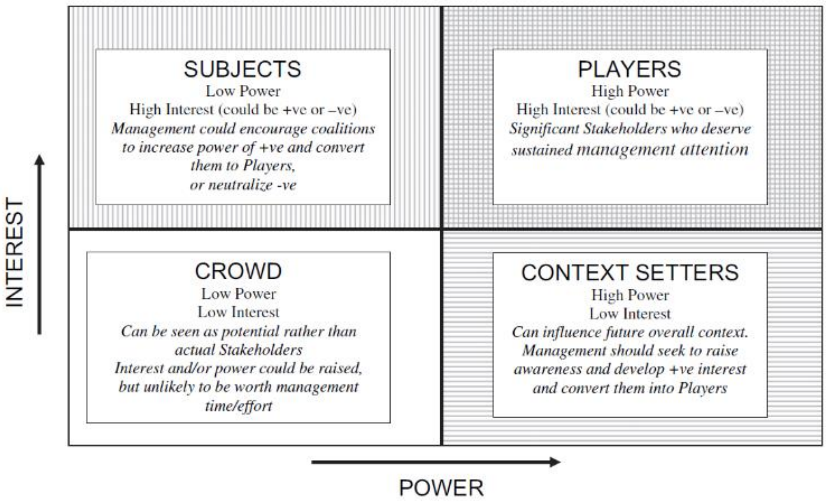

Figure IV. Power-Interest Matrix Grid

Ahmad, et. al (2019) stated that to examine the power and interest of each stakeholder/actor, arithmetic mean of all the expert answer was used. The equation (1) and (2) can be used to calculate power and interest:

$$Pi = \frac{\sum_{j=1}^{N} Pij}{N} \quad (1)$$

$$Ii = \frac{\sum_{j=1}^{N} Iij}{N} \quad (2)$$

Where: P_i and I_i are the i^{th} stakeholder's power and interest indices respectively; P_{ij} and I_{ij} are power and interest amount that j^{th} stakeholders assigned to i^{th} stakeholder evaluation from the expert; N is the total number of expert being asked.

In the early stages, social network analysis was introduced to explain social and behavior phenomena. However, social network analysis can be further used to explain relationship among social entities, its pattern, and implication due to its relation (Wasserman and Faust, 1994). The most fundamental and importance of social network analysis was identified by Wasserman and Faust (1994) as follows:

- Actor and their actions is interdependent rather than dependent
- Relational linkages among actors are channel for transfer and flow or resources (material and/or non-material)
- Network models focusing on individuals view in the network structural environment as providing opportunities for constraints and actions
- Network models conceptualize structure (social, economic, and political) as lasting pattern of actor's relationship

Due to its relational importance, social network analysis is an approach to focusing on how the relationship among stakeholders built a framework to a specific objective of analysis. According to Borgatti (2018), there are at least 2 different variables that should be identified, Node and Arch. Nodes were identified as an actor that make up the network. Meanwhile arch is the relationship itself among actors. To conceptualize the actors and their relation, adjacency matrix can be used to represent the system and transform it into mathematical matrix. An Adjacency matrix is a matrix in which each row and columns in the matrix represent nodes (actors) and entry in a matrix in row *i* and column *j* represent a relation from *i* to *j* (Borgatti 2018). A matrix was valued ($a_{ij} = 1$) if there is a relation between nodes (actors) and vice versa ($a_{ij} = 0$). In this research, the author uses directed graph due to the importance of direction.

Borgatti (2018) explained that to examine the contribution of a node (actor) in network, the researcher can use centrality. Centrality is an indicator that shows the structural importance of a node within the network. The researcher needs to find the right centrality indicator based on the objectives of the analysis. Borgatti (2018) added that there is some indicator that reflect the importance of intermediaries due to their roles on interconnecting two actor. Without these actors, the network will be disconnected. Moreover, there is also indicator that reflect the large number of relation whereas involving the specific stakeholder/actor.

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Due to the objective of this research, eigenvector centrality and betweenness centrality are used to evaluate the network. Borgatti (2018) explained that eigenvector centrality can be used to measure popularity of each node (which represents stakeholder/actor). The higher value of eigenvector centrality the more connected this node with the other nodes that themselves are also well connected. Eigenvector centrality can be expressed in question 3 as follows:

$$ei = \lambda \sum_j xij.ej \ (3)$$

Where e_i is eigenvector centrality score and λ (lambda) is a constant called eigenvalue.

Moreover, betweenness centrality is a measure a stakeholder/actor that act as intermediary within the network (Ahmad, et. al 2019). More specifically, it is calculated as the proportion of a node in all shortest path from one to other pass through the indicated node (Borgatti, 2018). Betweenness centrality can be calculated using equation 4 as follows:

$$Bi = \sum_{i<k} \frac{Gijk}{Gik} \ (4)$$

Where B_i is betweenness centrality indicator; G_{ijk} is the number of geodesic path that connecting i and k through j; and G_{ik} is the number of geodesic path connecting i and k.

CONCEPTUAL FRAMEWORK

In this research, the author's objective is to define interaction in low carbon cement ecosystem. The first step of evaluation is defining the stakeholder/actor related to low carbon cement ecosystem. Afterward, the interaction among stakeholders/actors was evaluated. As mentioned previously, eigenvector centrality and betweenness centrality will be used as indicators to answer the research questions. The conceptual framework of the research can be seen in Figure V as follows:

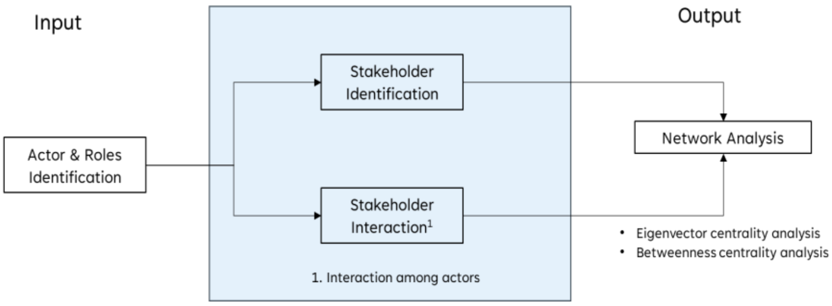

Figure V. Conceptual Framework

METHODOLOGY

A. Data Collection

The author divides data collection into 2 steps. The first phase was preliminary qualitative interview. The objective of this preliminary interview was to identify the context of low carbon cement ecosystem. Moreover, the relevant stakeholders/actors were also evaluated based on their involvement in the low carbon cement ecosystem. In Preliminary interview, the data collection will be structured in Table I as follows:

Table I. Preliminary Interview Data Collection Structure

Preliminary Interview		
Topics	Purpose	Data Collected
-	General Information	Name, Position, Experience
Low Carbon cement ecosystem	Exploring knowledge and experience interviewee regarding low carbon cement ecosystem	Insight on low carbon cement ecosystem based on knowledge and experience of interviewee

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Factor Analysis	Exploring factor affecting low carbon cement ecosystem	Insight on factor based on PESTEL Framework
Involvement	Perception on stakeholder's involvement	Insight on stakeholder's involvement regarding low carbon cement ecosystem

The result from the first phase will be used in the next process as an input. In the second phase, the interaction among stakeholders/actors will be analyzed. The expert's perspective on the interaction will be used to clarify the interaction based on their expertise and experience. In this research, the author will evaluate several clusters such cement company, direct supplier, distribution channel, customer of my customer, investor & association, and government agencies. The evaluation will be conducted as shown in Table II below:

Table II. Clustering Evaluator

Cluster	Evaluator
Direct Supplier	• Operation & Sustainability Function • Supply Chain Function
Distribution Channel	• Supply Chain Function
Direct Customer	• Marketing Function • Corporate Sales & Technical Sales Function
Customer of My Customer	• Marketing Function • Corporate Sales & Technical Sales Function
Investor & Association	• Investor Relation Function • Quality Assurance & Management System Function
Government Agencies	• All Function
Cement Company	• All Function

The expert will be asked to evaluate interaction from each stakeholder/actor in the cluster with the other stakeholders/actors. The expert will give a value "**1**" there is interaction and "**0**" if there is no interaction. In this phase, the data collection will be structured in Table III as follows:

Table III. Survey Questionnaire Data Collection Structure

Survey Questionnaire		
Topics	Purpose	Data Collected
Power Information	To collect power positioning of stakeholders/actors	The level of power addressing the ecosystem
Interest Information	To collect interest positioning of stakeholders/actors' ecosystem	The level of interest addressing the ecosystem
Relation	To evaluate stakeholder/actor's interaction	Interaction among stakeholders/actors

B. Data Analysis

In the first phase, the expert evaluates and filters the relevant stakeholders/actors in the context of low carbon cement ecosystem. Afterward, those relevant stakeholders/actors will be evaluated by expert following this step

1. Identify Power-interest
According to Ahmad et.al (2019), the power and interest of each stakeholders/actor were evaluated based on the category in Table IV as follows:

Table IV. Power-Interest Definition

Characteristic	Definition	Point Scale
Power	The capacity of stakeholders to influence low carbon cement ecosystem	• Having very low power (1) • Having low power (2) • Having moderate power (3) • Having high power (4) • Having very high power (5)
Interest	The level of influence in low carbon cement ecosystem	• Having very low interest (1) • Having low interest (2) • Having moderate interest (3) • Having high interest (4) • Having very high interest (5)

2. Identify interactions
The expert will evaluate the interactions based on their cluster in Table IV above. The structured of interactions are following the Table V below:

Table V. The Structure of Stakeholders/Actors Interaction

From/To	S1	S2	S3	S4	…	Sn
S1	1/0	1/0	1/0	1/0	…	1/0
S2	1/0	1/0	1/0	1/0	…	1/0
S3	1/0	1/0	1/0	1/0	…	1/0
S4	1/0	1/0	1/0	1/0	…	1/0
…	1/0	1/0	1/0	1/0	…	1/0
Sn	1/0	1/0	1/0	1/0	…	1/0

Afterward, the network diagram was drawn by using UCINET for Windows 6. By using the same tools, eigenvector centrality and betweenness centrality were determined. The author prioritizes the most popular and the most important intermediaries' stakeholders/actors based on the value of eigenvector centrality and betweenness centrality.

RESULT

In preliminary interview, the expert agreed that low carbon ecosystem is related to integrated and holistic system that consist of relevant stakeholders/actors (cement manufacturer, cement customer/users, and cement regulator) whereas the cement itself had a lower carbon footprint compared to regular cement product. Regarding the factors that contributed to low carbon cement ecosystem can be seen in Table VI as follows:

Table VI. Factor Regarding Low Carbon Cement Ecosystem

Factor	Factor
Politics/Legal	• Regulation and policy regarding low carbon cement both low carbon cement product standard and supporting regulation such carbon tax, CCUS, performance-based cement, and reward & punishment) • Advancement of regulation implementation and dissemination to related stakeholder
Economic	• Knowledge and awareness regarding cost efficiency benefit for both manufacturer and customer • Value being offered by low carbon cement (quality, price, etc)
Social	• Advocation for social awareness (economical and environmental consciousness)
Technology	• Advancement of cement manufacturing technology regarding alternative fuel and raw material, advance process control and carbon-captured utilization & storage • Advancement of cement application technology regarding minimizing cement consumption using software design
Environment	• Knowledge and awareness regarding environmental issues such global warming and GHG emission

Whereas according to expert's judgement, these are the relevant actors related to low carbon cement ecosystem:

Table VII. The Relevant Stakeholders/Actors in Low Carbon Cement Ecosystem

No	Actor	No	Actor
A	Cement company	L	Individual project owner
B	Chemical company	M	Indonesia Cement Association
C	Electrical energy provider	N	Banking
D	AFR Supplier	O	Green Building Council Indonesia (GBCI)
E	Building material retail shop	P	Green Product Council Indonesia (GPCI)
F	Logistic & distribution company	Q	Indonesia Construction Expert Community
G	Cement downstream product manufacturer	R	Investor
H	Construction consultant	S	The Audit Board of Republic Indonesia
I	Construction company	T	Ministry of Industry
J	Ready-mix company	U	Ministry of Education, Culture, Research, and Technology
K	Organization/institution project owner	V	Ministry of Public Work

In the second phase, the power and interest of each stakeholders/actor as shown in table xxx are evaluate and the result can be seen in Table VIII as follows:

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Table VIII. Power-Interest of Stakeholders/Actors

Code	Actor	Power	Interest	Cluster
A	Cement company	4,46	4,62	Player
B	Chemical company	2,31	3,00	Subject
C	Electrical energy provider	2,77	2,46	Crowd
D	AFR Supplier	2,69	3,85	Subject
E	Building material retail shop	2,62	2,00	Crowd
F	Logistic & distribution company	2,23	2,08	Crowd
G	Cement downstream product manufacturer	3,69	2,85	Context Setter
H	Construction consultant	3,54	2,54	Context Setter
I	Construction company	3,85	3,23	Player
J	Ready-mix company	4,08	3,00	Player
K	Organization/institution project owner	4,46	3,69	Player
L	Individual project owner	3,69	3,15	Player
M	Indonesia Cement Association	4,31	4,23	Player
N	Banking	3,54	3,54	Player
O	Green Building Council Indonesia (GBCI)	2,85	4,31	Subject
P	Green Product Council Indonesia (GPCI)	2,69	4,31	Subject
Q	Indonesia Construction Expert Community	3,08	3,00	Player
R	Investor	3,85	3,85	Player
S	The Audit Board of Republic Indonesia	3,00	1,85	Crowd
T	Ministry of Industry	4,54	4,23	Player
U	Ministry of Education, Culture, Research, and Technology	2,46	2,69	Crowd
V	Ministry of Public Work	4,23	4,23	Player

According to Table VIII above, the power-interest matrix grid will be shown in Figure VI below:

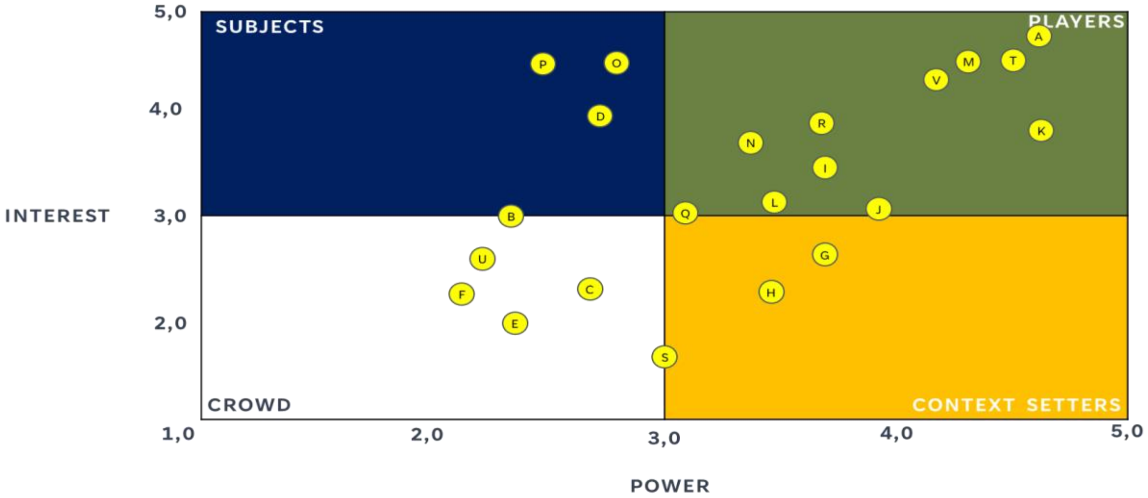

Figure VI. Power-Interest Matrix Grid

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In the second phase, the adjacency matrix was designed to evaluate the interaction that can be seen in Figure VII below:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
A	0	1	0	0	1	1	1	0	1	1	1	1	1	1	0	1	0	1	1	1	0	1
B	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
D	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
E	1	0	0	0	0	1	1	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0
F	1	0	0	1	1	0	1	0	1	1	0	0	0	1	0	0	0	1	0	0	0	0
G	1	0	0	0	1	1	0	1	1	0	1	1	0	1	1	1	1	0	0	1	0	0
H	1	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1
I	1	0	0	0	0	1	1	1	0	1	1	1	0	1	1	0	0	0	1	0	0	1
J	1	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	1	0	0	0	0	1
K	1	0	0	0	0	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	1
L	1	0	0	0	1	1	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0
M	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
N	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
P	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Q	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
R	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure VII. Adjacency Matrix Interaction of Stakeholders/Actors

According to figure VII, the network diagram was drawn by using UCINET for Windows 6 that can be seen in Figure VIII below:

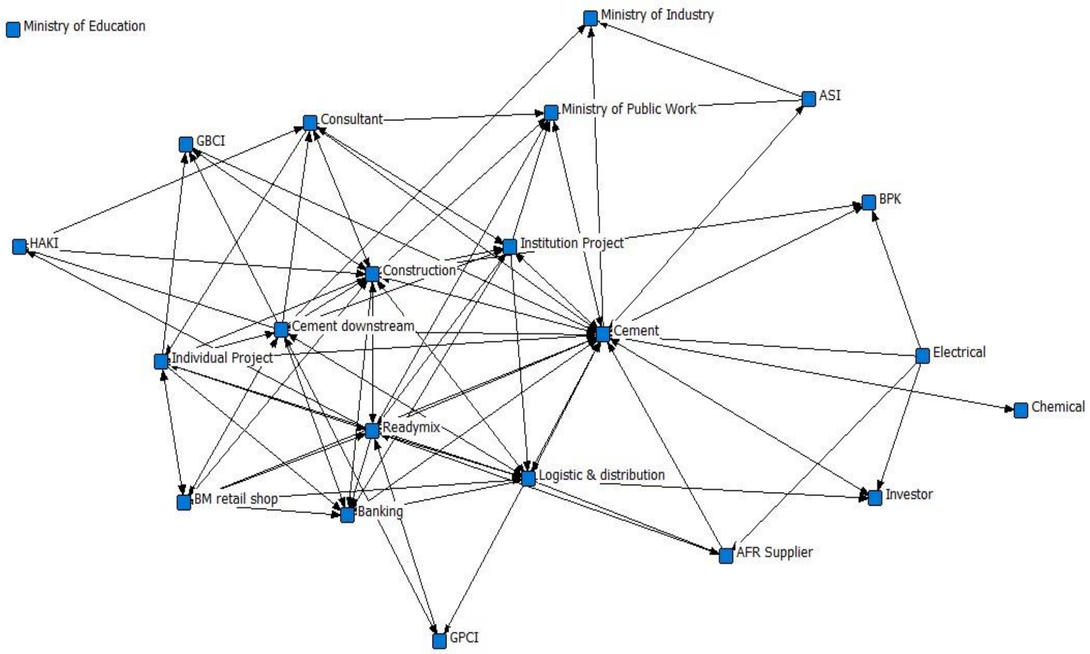

Figure VIII. Network Diagram of Low Carbon Cement's Stakeholders/Actros

To evaluate the most popular and important intermediaries' stakeholders/actors, the author uses eigenvector centrality and betweenness centrality as indicators. By using software UCINET for Windows 6, Tabel IX shown the result of these 2 indicators and their position in power-interest matrix grid as follows:

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Table IX. Eigenvector Centrality and Betweenness Centrality of All Stakeholders/Actors

Code	Actor	Cluster	Eigenvector	Betweeness
A	Cement Company	Player	0,394	197,226
B	Chemical Company	Crowd	0,044	0,000
C	Electrical Energy Provider	Crowd	0,077	0,000
D	AFR Supplier	Subject	0,118	0,833
E	Building Material Retail Shop	Crowd	0,245	0,510
F	Logistic & Distribution Company	Crowd	0,291	20,893
G	Cement Downstream Product Manufacturer	Context Setter	0,311	30,017
H	Construction Consultant (Planning Consultant, Construction Management Consultant, Quantity Surveyor)	Context Setter	0,212	4,783
I	Construction Company (SOE Construction Company & Private Construction Company)	Player	0,347	35,610
J	Ready-mix Company	Player	0,293	16,967
K	Institutional Project Owner (Government)	Player	0,257	5,976
L	Individual Project Owner (Developer)	Player	0,281	8,376
M	ASI (Indonesian Cement Association)	Player	0,074	0,000
N	Banking	Player	0,271	0,000
O	GBCI (Green Building Council Indonesia)	Subject	0,149	0,167
P	GPCI (Green Product Council Indonesia)	Subject	0,112	0,143
Q	Indonesia Construction Expert Community	Player	0,130	0,500
R	Investor	Player	0,085	0,000
S	BPK	Crowd	0,092	0,000
T	Ministry of Industry	Player	0,087	0,000
U	Ministry of Education, Culture, Research & Technology	Crowd	0,000	0,000
V	Ministry of Public Work	Player	0,176	0,000

According to Table IX above, the author excludes cement companies due to the objective of this research. In a perspective of cement company, the most popular stakeholders/actors can be identified in Table X based on the eigenvector centrality value (the author prioritize top ten of these stakeholders/actors)

Table X. 10 Most Popular Stakeholders/Actors in Low Carbon Cement Ecosystem

Code	Actor	Eigenvector	Cluster
A	Cement Company	0,394	Player
I	Construction Company (SOE Construction Company & Private Construction Company)	0,347	Player
G	Cement Downstream Product Manufacturer	0,311	Context Setter
J	Ready-mix Company	0,293	Player
F	Logistic & Distribution Company	0,291	Crowd
L	Individual Project Owner (Developer)	0,281	Player
N	Banking	0,271	Player
K	Institutional Project Owner (Government)	0,257	Player
E	Building Material Retail Shop	0,245	Crowd
H	Construction Consultant (Planning Consultant, Construction Management Consultant, Quantity Surveyor)	0,212	Context Setter

Meanwhile, the most important intermediaries' stakeholders/actors can be evaluated by their betweenness centrality value as shown in Table XI below:

Table XI. 10 Most Important Intermediaries Stakeholders/Actors in Low Carbon Cement Ecosystem

Code	Actor	Betweenness	Cluster
A	Cement Industry	197,22	Player
I	Construction Company (SOE Construction Company & Private Construction Company)	35,610	Player
G	Cement Downstream Product Manufacturer	30,017	Context Setter
F	Logistic & Distribution Company	20,893	Crowd
J	Ready-mix Company	16,967	Player
L	Individual Project Owner (Developer)	8,367	Player
K	Institutional Project Owner (Government)	5,976	Player
H	Construction Consultant (Planning Consultant, Construction Management Consultant, Quantity Surveyor)	4,783	Context Setter
D	AFR Supplier	0,833	Subject
E	Building Material Retail Shop	0,510	Crowd

In a perspective of cement company, there are 10 important stakeholders/actors that need to be engaged: *construction company, cement downstream product manufacturer, logistics and distribution company, ready-mix company, individual project owner, institutional project owner, construction consultant, building material retail shop, banking, and AFR supplier.* Implication of these findings are cement company can focus its engagement strategy in order to achieve decarbonization targets. Although there are 21 stakeholders/actors related to low carbon cement ecosystem, cement company only need to engage and focus with 10 stakeholders/actors due to their popularity and important on intermediary's role within the network of low carbon cement ecosystem.

CONCLUSION AND RECOMMENDATION

The result of the research is essential to find the best way to prioritize to whom engagement should be taken. From this research, the authors conclude that:

1. Social network analysis could be used to complement to evaluate to whom cement company need to focus its engagement initiatives. By using eigenvector centrality and betweenness centrality, it can be evaluated the most popular and important stakeholders/actors in low carbon cement ecosystem. Combining social network analysis and stakeholder analysis will be useful to design differentiation strategies in engaging relevant stakeholders.
2. According to the research, cement company need to engage with these stakeholders/actors: construction company, cement downstream product manufacturer, logistics and distribution company, ready-mix company, individual project owner, institutional project owner, construction consultant, building material retail shop, banking, and AFR supplier

By conducting this research, the authors recommend several opportunities to be explored in the next future. In summary, the recommendation is:

1. To make the evaluation of low carbon cement ecosystem more comprehensive, the analysis could be wider into others cluster of business ecosystem according to Moore's theory.
2. By focusing on several important stakeholders, cement companies hopefully can accelerate their initiative on decarbonization strategy.
3. The research could be used as a baseline for developing climate-related policy for the management of cement company

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