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Clean Coal Technology: Options and Viabilities – ESKOM, South Africa

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***Abstract*— Higher power generation efficiency and lower Green House Gas (GHG) emissions per kW of installed capacity are the global benefits of Clean Coal Technology (CCT), according to an in-depth literature review. There is however, no conclusive evidence that CCT is a cure-all for the problems linked to coal-fuelled power plants. Mayor world powers, including China, are confidently still commissioning new coal power plants to meet their substantial electricity needs. South Africa is facing an ethical dilemma - it signed an agreement to reduce its carbon emissions on one hand - yet, on the other hand, it faces the high cost of decommissioning and implementing CCT.**

The research problem explored is from an employee's perspective working for state power utility, Eskom, "of the effect of clean coal technology on Eskom and society". Data was collected from 125 respondents, working for Eskom, to address the research objectives drawn from the research problem. The data was collected from the employees, who answered a Google Forms questionnaire, adapted from Toliver (2013) & Weiner et al., (2017). To clarify the collected data, tables, charts and tables were used, and analysed with statistical tools (including descriptive statistics, correlation, regression and principal component analysis). The reliability of the collected data was tested using Cronbach's alpha score and was deemed largely reliable. This proved that the scale used was reliable. The validity of the questionnaire was not tested, as it was adapted from a pre-validated questionnaires from Toliver (2013) & Weiner et al., (2017).

CCT has a negligible relation with society and environment, but does have an effect on general health - the results suggest. It can then be argued that CCT and general health are correlated. The data also found that CCT and corporate governance, and CCT and social responsibility have a small /insignificant correlation.

Based on the findings of the research study and the literature reviewed, it is recommended that CCT is implementable, but its feasibility requires further comprehensive research to include other stakeholders and use a larger sample size. It is suggested to conduct a larger, more in-depth study using reliable indicators of the effects of CCT on Eskom. This should relate to society and the environment, general health, corporate governance, and social responsibility. The implementation of CCT will improve the general health of people affected by coal-fired power plants and support the South African government's commitment to lowering carbon emissions.

***Index Terms*—Clean Coal technology, ESKOM.**

I. INTRODUCTION

The South African energy sector is facing many challenges - including meeting the needs of ever-growing energy supply, ensuring an uninterrupted supply of electricity and stopping unwanted power outages. This is according to research done on South African coal fired power stations by Pretorius et al., (2015). Home use of energy dramatically increased (by 50%), during the period 1994 to 2007. This is due to the application of a Free Basic Electricity Policy in 2001. Now 50 kWh of electricity was supplied per household to poor households per month, free of charge (Inglesi and Pouris, 2010).

Eskom is the primary provider of electricity in South Africa. The parastatal must overcome the many challenges to meet the demand for electricity. The country generates 32% of the total energy on the African continent. The vertically integrated, state-owned power company is generating about 85% of the electricity used in the country and is providing most of the electricity in Africa (*South Africa - Energy*, 2020).

In January 2010, the country officially reported its climate change mitigation proposals with the United Nations Convention on Climate Change. These include a 34% reduction of emissions below 'Business as Usual' by 2020, and a 42% reduction by 2025. (Pretorius et al., 2015). This commitment has prompted studies and discussions on the topic - including the study on the use of clean coal technology. Solutions that deal with high CO_2-emitting sources, such as coal-fired thermal power plants are required for the integration of clean and sustainable energy technologies in South Africa (Banks, & Schäffler, 2010). The need is critical for the research and development (R&D) of clean coal technologies in the country. Coal-fired power stations to produce electricity are Eskom's primary source of power. These stations account for approximately 90% of the energy they produce.

Several of these power stations are reaching the end of their 50-year life cycle - the decommissioning stage (South Africa - Energy, 2020). As such, it is crucial to establish the impact of this decommissioning on the already stretched National Energy Grid, and to assess what is possible, in terms of future use of these plants. Undertaking a complete decommissioning exercise is a long and costly exercise and cause further financial strain for Eskom.

The Integrated Resource Plan (IRP) is an electricity infrastructure development plan and part of the National Development Plan (NDP). It is based on a least-cost electricity supply and demand balance, while trying to

minimize negative emissions and water usage, for supply security and the environment. The Minister of Mineral Resources and Energy signed the IRP in October 2019. The first plan was published in 2010, and IRP is supposed to be updated biannually. Unfortunately, due to delays and political interference, there has been much dithering about the generation mix - particularly the balance between the baseload –- such as nuclear power and coal – and renewables. (*South Africa - Energy*, 2020).

The evidence shows that clean coal technology (CCT) could be used as an alternative to the decommissioning of power plants. However, the question must be asked if CCT is feasible, appropriate, and accepted by Eskom employees? This needs to be explored. The impact of CCT on society also needs to be further analysed, as Eskom must make ethical and socially responsible decisions. The research study will uncover the employees' point of view about the use of clean coal technology (CCT) and then discuss the effect of CCT on Eskom and larger society.

II. REVIEW OF LITERATURE

A. Clean Coal Technology

The environment can be protected - if society shifts from fossil fuels to renewables. Global greenhouse gas (GHG) emissions are caused by the energy generated by coal-fired power plants. To combat climate change, the power sector must consider changing existing infrastructures, while remaining competitive. Global coal reserves are critical to energy sustainability. According to Pitso (2019), coal-generated power is still a primary source of energy worldwide, and coal-generated energy is expected to continue being a part of the global energy mix in future.

Coal combustion produces gasses - such as carbon dioxide (CO_2), nitrogen oxides, and sulphur oxides (respectively, NOx and SOx), (Pitso (2019). These gasses contaminate the environment. Researchers and scientists are developing technologies to reduce CO_2 and other gasses. Among these high efficiency, low emissions (HELE) technologies are supercritical (SC), ultra-supercritical (USC), and advanced ultra-supercritical (AUSC) technologies.

Nationally and internationally, definite plans for clean coal technologies are underway. In China, China's National Energy Administration (CNEA) has developed an 'Action Plan for Clean and Efficient Use of Coal (2015-2020)' to be the blueprint for China's clean coal policy (CNEA. China National Energy Strategy and Policy 2020 Subtitle 6: Energy, Environment and Its Public Health Impact, 2013), as cited by Pitso (2019). In South Africa, the National Development Plan (NDP) (2030) recognises the need to implement advanced clean coal technologies, and to reduce emissions while addressing climate change. For existing coal plants existing coal plants to continue to be in use, these must be retrofitted with CCS or other clean coal technologies (NDP, 2012).

In terms of finances, optimising old coal-fired power plants is seen as 'low-hanging fruit' in terms of utilising technologies, as it makes the best use of what is already available (Giglio, 2018).

With a population of 1.3 billion people, China needs a larger electricity system than many other countries. In the short to medium term, the electricity system is insufficient to replace coal. To close the gap, China is developing new technologies to drastically reduce local air pollution and climate emissions from the country's remaining coal plants (Bassett et al., 2017). The multi-power has gone that step to refurbish coal-fired power plants with cleaner technologies (CAP, 2017). The shift has gone from subcritical to supercritical, and is now ultra-supercritical. With these changes, China has demonstrated its commitment to reducing emissions and achieving greener coal power plants (Bassett et al., 2017)

B. Feasibility Of Clean Coal Technology In South Africa

Financial constraints are the primary obstacle to the adoption and implementation of Carbon Capture & Storage (CCS) technology. The cost of incorporating CCS into power systems can range from 30% to 70% - depending on the method of CO_2 capture used (Schacht & Jenkins, 2014; Beaubien et al., 2013).

Economic barriers are a challenge, as CCS is expensive and cannot be implemented by many developing countries, according to Maver, (2012 as cited by Yoro et al., 2016) states. South Africa is, however, a rapidly developing country with a good economic framework, and policies in place, to successfully implement CCS.

Of the scepticism expressed about the implementation of CCS technology in South Africa - it has been debated that implementation will jeopardise the country's efforts to develop renewable and sustainable energy resources, as these also require significant financial incentives from the government (Maver, 2012 as cited by Yoro et al., 2016).

Pollution and health risks are additional health risks caused by CO_2 emissions from the country's coal-fired thermal power plants. It is critical to establish regulatory frameworks in South Africa to oversee this technology (Voleno et al., 2014). Developing CCS financing mechanisms for CO_2-emitting industries, such as the Electricity Supply Commission (Eskom), could overcome economic barriers, and contribute to its financial development. Stakeholders could collaborate to help to speed up its implementation (Zhang et al., 2014).

In 2019, South African President Cyril Ramaphosa stated that Eskom is to be divided into three separate businesses, according to Naidoo (2019). The utility informed senior management that this could take between three to five years.

The government is providing a R128-billion bailout to Eskom over three years and appointed a chief reconstructing officer to oversee the company split. Adrian De Ruyter was appointed as the CEO in January 202 as the utility lacked a permanent chief executive officer. Rennings et al. (2013) has investigated the feasibility of new clean coal technologies. He determines that CCS technologies do not differ in

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uncertainties, and the overall process is primarily determined by the basic process.

Rennings et al. (2013) compiled a figure comparing CCS technologies and this illustrates the associated risks and expected advantages of clean coal technologies. The following graph, figure 1 compares various CCS technologies - in terms of the benefits they are expected to provide and the risks they pose.

Investors face relatively low risks from both post-combustion and oxy-fuel combustion. In terms of continuous commercial operation, the use of IGCC in partnership with CCS, may present more challenges. However, such technologies may be more profitable than others. Power plant investors are risk-averse; this poses problems, as radical technologies are currently associated with greater uncertainties, instead of substantial improvements. Their large-scale establishment is only possible - if existing risks are greatly reduced, or there is a significant increase in expected profitability.

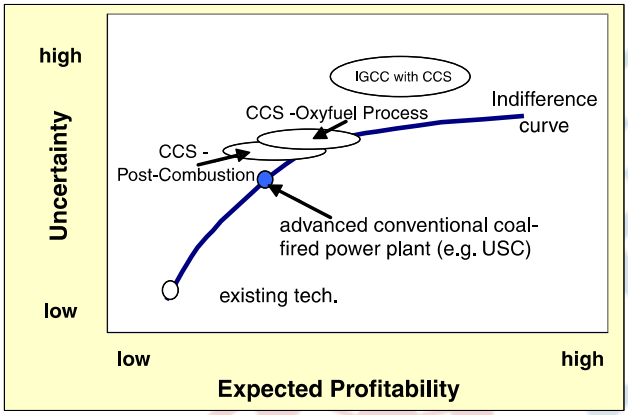

Fig 1. Clean Coal Technology
Source – Rennings et al. (2013)

C. Alterations of Coal-Fuelled Power Plants

Gatticchi (2020) suggests in a report on renewable energy in South Africa, that economic activity in four municipalities with a combined population of more than 2.3 million people may be jeopardised by the transition from traditional coal technologies to renewable energies. In the Emalahleni municipal area, coal-related activities account for 44 percent of the economy. The eastern province of Mpumalanga supplies most of the country's coal, which is mined in municipal areas.

Arguing on the topic of coal vs. renewable sources of energy, Gatticchi (2020) expands that coalmines and power plants need a larger work force than that used for renewable energy plants. He suggests that Mpumalanga will compete with other provinces for the location of solar power plants. The Northern Cape, which has a more arid climate with clear skies, is more suitable for solar energy.

Moving to a low-carbon economy will alter the economy's structure and have an impact on the working class," says Pulane Mafoea-Nkalai, as quoted by Gatticchi. Eskom has stated it intends to create alternative employment by repurposing power plants as part of its Just Energy Transition programme. The renewable energy sources are the way forward for a safer and cleaner environment. It is sustainable in the long-term, but may have a huge cost in the short-term. The capacity of renewable source of electricity has seen a steady growth since 2010, as is shown in figure 2 below

Capacity (MW)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
South Africa	993	997	1003	1500	2710	3429	4650	5587	6065	6167

Fig 2: Capacity of Renewable Source of Electricity Generation

The Integrated Resource Plan (IRP) plans to have the country's total electricity-production capacity increasing to 77,834 megawatts by 2030. Most of the increase will come from renewable sources - up from about 52,104 megawatts currently. An additional 14,400 megawatts of power will be produced from wind, 6,000 megawatts from solar plants, 3,000 megawatts from gas and diesel, 2,500 megawatts from hydropower, and 1,500 megawatts from coal by 2030. 59% of output by 2030 will be provided by coal, which will continue to play an important but diminishing role in electricity generation for the foreseeable future, (Bloomberg News Editors, 2020).

By 2040, it is estimated that at least 40% of the world's power will come from renewable sources (IEA, 2018), and by 2050, the planet could be powered by renewables (Wood, 2020). Renewable energy has a bright future, according to these statistics, but they also show that there has been a delay in the production and adoption of renewable energy on a global scale. Renewable energy sources (solar, wind, ocean waves, hydropower, hydrogen, biofuels, biomass, waste, and geothermal resources) is generally more credible than non-renewables (oil, natural gas, coal and petroleum). A debate about the credibility of renewable energy production is underway and related to the intermittent nature, unreliability, and variability in supply to meet demand (Delucchi and Jacobson, 2011).

Renewable energy is supported by the vast majority, but there is opposition from several interest groups and stakeholders. This is understandable - as renewable energy projects may have a negative impact on the communities where they are located (Gipe, 1995 as cited by Kaartemo & Gonzalez-Perez, 2020). Unintended displacements, deforestation, and engineering interventions can affect the quality of life - either temporarily or permanently, are among these negative effects. The opposition is known as the "not-in-my-backyard syndrome" (NIMBY) (Dear, 2007, as cited by Kaartemo & Gonzalez-Perez, 2020).

Scholars of international business (IB) should be aware of the pros and cons. IB researchers are encouraged to conduct additional research to understand our generation's most pressing issues better (Dörrenbächer and Michailova, 2019).

Given the international ties connected with the renewable energy industry, this is clear. Much of the technology and other resources, financing, and regulation is international, even though renewable energy production and consumption appears to be local, (Kaartemo, 2016 as cited by Kaartemo & Gonzalez-Perez, 2020). Several major multinational corporations (MNCs), such as AEON, Akso Nobel, H&M, Tata Motors, IKEA Group, and others have announced their intention to move to renewable energy sources (RE100, 2018, as cited by Kaartemo & Gonzalez-Perez, 2020).

International agreements have an impact on the global renewable energy market (such as the Paris Climate Change Agreement, signed by 194 nations in 2015). However, these agreements must be implemented locally, and countries have varying capacities and institutional regulatory environments for attracting (and sometimes distracting) renewable energy investments, and driving environmental innovation (Gonzalez-Perez, 2016).

There is little evidence, however, that these intergovernmental agreements have resulted in a satisfactory global greenhouse gas reduction (Aldy, 2015).

III. RESEARCH METHODOLOGY

A. Research Objectives

In addressing the research problem, the following objectives (from an employee perspective) formed the basis of this study:

1. Explore the effect of clean coal technology on the society and environment.
2. Explore the relationship between business ethics and the implementation of clean coal technology at Eskom.

1. Research Objective 1

Data was analysed by using the correlation between CCT and its effect on society. There are four dimensions of the "effect on society" construct. Each of these four dimensions was used. It determined the correlation between:

- CCT - General health;
- CCT - Business opportunities in the region;
- CCT - General infrastructure of the region; and
- CCT - Community development programmes was calculated.

2. .Research Objective 2

Data was analysed using correlation between CCT and the business ethics at Eskom. There are two major dimensions of the "business ethics" construct. Each of these two dimensions was used for correlation. The correlation between:

- CCT - Corporate governance; and
- CCT – Social responsibility was calculated.

The data analysis function of MS Excel was used for the descriptive statistical analysis and correlation of the data. The statistics were calculated and interpreted to conclude.

B. Research Design

An exploratory research design will be used for this research. Saunders et al. (2015) supports this argument and states that an exploratory study is a valuable means of finding out "what is happening; seeking new insights; asking questions and assessing phenomena in a new light." It is useful if you wish to clarify your understanding of a problem or are unsure of the precise nature of the problem.

C. Analysis of data

Analysis was done by using the appropriate statistical tools - including correlation, regression, and principal component analysis

Table 1. Research Design, Methodology, and Instrument

RESEARCH DESIGN, METHODOLOGY AND INSTRUMENT	STUDY
Philosophy	Critical Realism
Approach	Deductive
Strategy	Survey
Choice	Quantitative research
Time horizon	Cross-sectional
Population	Eskom employees
Samples	Mixed purposeful
Instrument	Structured questionnaire
Data Collection	Personal collection/ Google forms
Analysis	Statistical tools
Sample size	100-125 targeted

This research study used a non-probability method of sampling to collect the data. A sampling frame was technically available, but not accessible to the researcher. Respondents consisted of the employees, selected by a purposive sampling method. The first section of the questionnaire was designed to select respondents from across functional departments. The departments were divided into four sections:

- Section 1 - Administration, Management, Finance and Accounts, clerks, projects;
- Section 2 - Engineering, operations, supervision, quality assurance, controllers, coordinators, maintenance, production;
- Section 3 - Occupational safety, security;
- Section 4 - General workers and others.

D. Sample Size

The sample size calculator by raosoft.com determined the sample size. For a population of 4000, the calculator suggested a sample size of 351, with 95 % confidence level and 5 % margin of error. Due to time and resources constraints, this was deemed too large a sample size. Instead, a sample size of 125 was targeted, for valid statistical tests to

analyse the data. The questionnaire was sent to a total of 125 respondents via Google forms. The expectation was to receive at least 100 fully filled-in questionnaires that can be used to analyse the data.

E. Research Instruments

A survey was conducted with questionnaires to collect the data from the respondents. The questionnaire was adapted from Toliver (2013) & Weiner et al., (2017) and was based on a Likert scale. Five sections divided the questionnaire. Section 1 targeted the demographic information of the respondents. Section 2 to 5 focussed on the Research Objectives, Number 1 to 4. Section 2 of the questionnaire was adapted from the scale, developed by Weiner et al., (2017).

The Acceptability of Intervention Measure (AIM), Intervention Appropriateness Measure (IAM), and Feasibility of Intervention Measure (FIM), developed the scale in the study. The scale was developed by Weiner et al. (2017), and tested for reliability and validity. Cronbach's alpha Likert scale for the 4-item scales were 0.85 for acceptability, 0.91 for appropriateness, and 0.89 for feasibility. The Cronbach's alphas for the scales from the test-retest reliability survey were 0.83 for acceptability, 0.87 for appropriateness, and 0.88 for feasibility. The validity was tested using Confirmatory factor analysis (CFA). The factor loadings for the 3-factor CFA ranged from 0.75 to 0.89, and fit for the three-factor CFA model. This was deemed acceptable.

	CCT	*Improving the general health of the community*
CCT	1	
Improving the general health of the community	0.55	1

The measures could be used separately or together, and the items could be customised to specify a reference organisation, situation, or population. These measures were adapted for this research study and considered as a suitable measure. The original scale developed is attached as an appendix.

Section 3 to Section 5 was adapted from the scale developed by Toliver (2013). He conducted a study to develop and validate a measure of corporate social responsibility and states that Item Response Theory (IRT) and discrimination analysis should be used to validate a study. A nomological network was developed to further establish the construct validity of the scale. Additional information about the employee's perception of the company's CSR practices can be provided by the proposed scale and as a general measure of employee engagement (Toliver, 2013).

The research study examines the employees' perceptions, and the objectives include the effects of CCT on Eskom, society and environment and business ethics. The scale developed by Toliver, (2013) was adapted to develop the research instrument (in this case, a questionnaire) for the research study.

F. Research Instruments

Sources of Information and Sampling Methods

Employees of Eskom provided the data that was collected. Data was collected with a non-probability method of sampling. This data will be triangulated for a critical discussion and analysis.

Data was gathered electronically using Google forms, due to time constraints and the Covid-19 pandemic. A total of 125 questionnaires were forwarded to employees of Eskom's Head Office. Respondents from different functional departments were considered and forwarded the questionnaire. It was expected that there would be a response rate of at least 80-85 %, which resulted in more than 100 fully filled-in responses. Access to the respondents from different functional departments proved to be a challenge. Personal assistance from senior management helped in reaching out to the respondents electronically. Members of senior management were contacted personally.

IV. DATA ANALYSIS

The collected data was analysed by using descriptive statistics including – mean, and standard deviation, and correlation analysis. The Google forms data was organised in an Excel spreadsheet.

The first research objective is to explore the effect of clean coal technology on society and the environment. The data analysis pack of MS Excel conducted the correlation analysis to analyse the relationship between Clean Coal Technology (CCT), and its effect on society and the environment. There are four dimensions of *effect on society* construct. Each of these four dimensions will be used to calculate the correlation value.

A. CCT - General health

A correlation of above ± .29 is considered significant. This indicates a significant relationship between CCT and *Improving the general health of the community.* The correlation value as per the data analysis lies between ± 0.50 and ± 1, which indicates a strong correlation. This shows that if the use of CCT increases, it may help to improve the general health of the community.

B. CCT - Business opportunities in the region

	CCT	*Business opportunities in the region*
CCT	1	
Business opportunities in the region	0.0416 771.32	1

A correlation of below ± .29 is considered as insignificant and small, and hence there seems to be no

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relationship between CCT and business opportunities in the region. The correlation value as per the data analysis near .29, which indicates a small correlation, and since it is almost 0, it can be interpreted that there is no relationship between these two variables – CCT and business opportunities in the region.

This indicates that if the use of CCT increases, it will have no effect on the business opportunities in the region, and it will remain the same.

C. CCT - General infrastructure of the region

A correlation of below ± .29 is considered as insignificant and small and hence there seems to be no relationship between CCT and general infrastructure of the region. The correlation value as per the data analysis lies below ± .29, which indicates a small correlation. We can thus interpret that there is no relationship between these two variables – CCT & general infrastructure of the region.

	CCT	*community development programmes*
CCT	1	
Community development programmes	0.102239577	1

This indicates that if the use of CCT increases, it will have no effect on the general infrastructure of the region, and it will remain the same.

D. CCT - Community development programmes

A correlation of below ± .29 is considered as insignificant and small. There seems to be no relationship between CCT and community development programmes. The correlation value as per the data analysis lies below ± .29, which indicates a small correlation. We can thus interpret that there is no relationship between these two variables – CCT and community development programmes.

This indicates that if the use of CCT increases, it will have no effect on the community development programmes of Eskom, and it will remain the same. The section above analysed the effect of CCT on society and environment. There were four dimensions of society and environment that were analysed. The first dimension of effect of CCT on general health of the community indicated a positive high correlation value. According to the views of the respondents, CCT will have a positive effect on the health of society members.

However, the other three dimensions of business opportunities in the region, general infrastructure of the region, and community development programmes indicated a low degree of correlation. The outcomes here state that CCT may have no effect on business opportunities in the region, to the general infrastructure of the region and on community development programmes by Eskom.

The analysis was done based on the views of respondents.

	CCT	*general infrastructure of the region*
CCT	1	
general infrastructure of the region	0.154336862	1

The second research objective is to explore the relationship between business ethics and the implementation of clean coal technology at Eskom. Data is analysed using correlation between CCT and business ethics at Eskom. There are two major dimensions of the *business ethics* construct. Each of these 2 dimensions will be used for correlation. The correlation between:

- CCT - Corporate governance; and
- CCT – Social responsibility, is calculated.

E. CCT - Corporate governance

This examines the correlation between CCT and corporate governance.

Table 2.: Correlation between CCT - 14 Dimensions of Corporate Governance

	CCT
CCT	1
1. Plays by the rules	0.09
2. Acts responsibly in its decision making	0.08
3. Makes honest decisions	0.08
4. Encourages me to abide by a Code of Conduct	0.09
5. Works by business ethics	0.14
6. Rewards ethical work behaviour	0.21
7. Works by honest business practices	0.13
8. Conducts business in an honest manner	0.15
9. Does business in a fair manner	0.12
10. Works by ethical standards	0.06
11. Holds employees accountable for their actions	0.16
12. Is committed to doing the right thing	0.14
13. Represents itself honestly	0.14
14. Believes in having the courage to do the right thing	0.22

A correlation of below ± .29 is considered as insignificant and small, and hence there seems to be no relationship between CCT and corporate governance. The correlation value as per the data analysis lies below ± .29 (0.08 to .22 for all the 14 constructs), which indicates a small /insignificant

correlation. We can thus interpret that there is no relationship between these two variables – CCT and corporate governance. The use of CCT will not affect the corporate governance status of Eskom. However, the above analysis was dependent on the respondents' views. To test the statistical significance of the correlation, P-value was calculated, and the results are presented in Table 4 below

The P-value for all the 14 –dimensions is more than 0.05, hence the correlation between CCT and the 14 dimensions is statistically insignificant. We can thus not rely on the correlation found earlier by analysing the respondents' views.

F. CCT - Social responsibility

A correlation of below ± .29 is considered as insignificant and small, hence there seems to be no relationship between CCT and social responsibility

Table 3: Correlation between CCT and Social Responsibility

	CCT
CCT	1
Encourages to volunteer	0.05
Active in the community	0.06
Has a recycling programme	0.07
Workplace is safe for all employees	0.09
Supports the community	0.09
Concerned about human rights	0.11
Environmentally friendly	0.20
Community service projects	0.12
Good neighbour in the community	0.07
Minimizing the environmental impacts of our business	0.20
Committed to conducting business in a sustainable manner	0.13

Table 4. Significance Test for Correlation between CCT and 14 dimensions of corporate governance

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.346096728							
R Square	0.119782945							
Adjusted R Square	-0.023508203							
Standard Error	1.189399321							
Observations	101							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	14	16.556	1.183	0.835	0.628			
Residual	86	121.662	1.415					
Total	100	138.218						
	Coefficients	*Standard Error*	*t Stat*	***P-value***	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.820	0.404	6.979	**0.000**	2.017	3.624	2.017	3.624
1. Plays by the rules	-0.031	0.259	-0.119	**0.905**	-0.545	0.484	-0.545	0.484
2. Acts responsibly in its decision making	-0.084	0.248	-0.339	**0.736**	-0.578	0.409	-0.578	0.409

3. Makes honest decisions	-0.144	0.262	-0.548	**0.585**	-0.666	0.378	-0.666	0.378
4. Encourages me to abide by a Code of Conduct	-0.060	0.194	-0.308	**0.759**	-0.446	0.327	-0.446	0.327
5. Works by business ethics	-0.197	0.290	-0.679	**0.499**	-0.774	0.380	-0.774	0.380
6. Rewards ethical work behaviour	0.394	0.257	1.532	**0.129**	-0.117	0.904	-0.117	0.904
SUMMARY OUTPUT								
7. Works by honest business practices	-0.357	0.316	-1.129	**0.262**	-0.986	0.272	-0.986	0.272
8. Conducts business in an honest manner	0.383	0.348	1.099	**0.275**	-0.310	1.075	-0.310	1.075
9. Does business in a fair manner	0.134	0.219	0.609	**0.544**	-0.302	0.570	-0.302	0.570
10. Works by ethical standards	-0.242	0.194	-1.251	**0.214**	-0.628	0.143	-0.628	0.143
11. Holds employees accountable for their actions	0.063	0.243	0.261	**0.795**	-0.420	0.547	-0.420	0.547
12. Is committed to doing the right thing	0.156	0.265	0.587	**0.559**	-0.371	0.682	-0.371	0.682
13. Represents itself honestly	-0.126	0.312	-0.404	**0.687**	-0.745	0.493	-0.745	0.493
14. Believes in having the courage to do the right thing	0.311	0.208	1.496	**0.138**	-0.102	0.725	-0.102	0.725

The correlation value as per the data analysis lies below ± .29 (0.05 to .20) (for all the 11 constructs), which indicates a small /insignificant correlation. We can thus interpret that there is no relationship between these two variables – CCT and social responsibility. The use of CCT will not affect the social responsibility status of Eskom. Validating the construct entails ensuring that it measures what the researcher intends it to measure, which is much easier to assess with the help of Principal Component Analysis (PCA). A PCA assists the researcher in determining the principal components by extracting the underlying factors from the questions, or any other type of data. This, in turn, assists the researcher in converting large amounts of data into smaller, easier-to-digest sets that can be analysed more quickly and easily.

PCA can help the researcher strip away unnecessary components of the data, so it's reduced to its basic, or principal, components. The researcher has used a PCA, so that the components of the data for the construct are reduced to its principal components.

Table 5. Principal Component Analysis

Principal Component Analysis:						
Eigenvalues:						
	F1	F2	F3	F4	F5	F6
Eigenvalue	4.512	2.531	0.944	0.621	0.553	0.495
Variability (%)	41.017	23.007	8.583	5.642	5.031	4.504
Cumulative %	41.017	64.024	72.606	78.248	83.279	87.782

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Table 6. Principal Component Analysis

Principal Component Analysis:					
Eigenvalues:					
	F7	F8	F9	F10	F11
Eigenvalue	0.405	0.324	0.275	0.226	0.114
Variability (%)	3.679	2.944	2.501	2.057	1.036
Cumulative %	91.462	94.406	96.907	98.964	100.000

The PCA and the scree plot above indicate that the maximum variation (91.46 %), in the data comes from F1 to F7 However, the Eigenvalue of more than 1 is considered as significant and only F1, F2 and F3 can be considered as significant or the principal components of the study

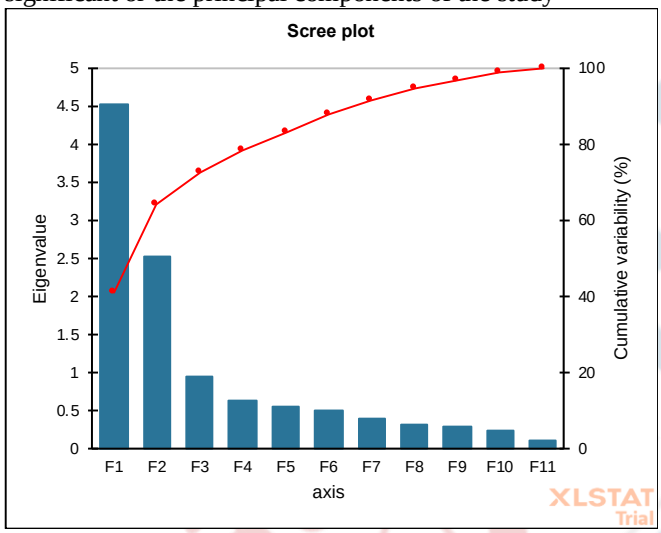

Fig 3: The PCA and Spree Plot

It can be concluded that out of 11 components/ dimensions used in the survey questionnaire related to CCT & corporate social responsibility, there are 3 principal components – *Encourages to volunteer, active in the community*, and *has a recycling programme*, that cause significant variation in the study. The remaining 8 components - *workplace is safe for all employees, supports the community, concerned about human rights and environmentally friendly, community service projects, good neighbour in the community, minimizing the environmental impacts of our business, committed to conducting business in a sustainable manner* do not cause a significant variation in the study.

V. PRESENTATION OF FINDINGS

Currently, a variety of solutions for mitigating climate change are being discussed around the world, including carbon capture and storage technologies (CCS), as cited by Yoro et al (2016). CCS technologies will help to reduce carbon emissions, enabling coal-dependent electricity markets like South Africa to continue to operate. Pitso (2019) further argues that all must adapt and developing clean coal technology will not be the only approach to saving the environment. But, as the world moves toward a sustainable energy transformation, the substantial analysis shows that coal will not withdraw from the energy mix, however - it is possible to push towards the rollout of clean coal technologies to allow for required pollution reductions.

According to one study, the environmental benefits of CCT are obvious. Reduced SO2 and NOx emissions reduce acid rain, which in turn, reduces lake acidification and eutrophication, and damage to forests and other vegetation. It also reduces damage to steel, limestone, concrete, and other structures. CCTs have helped to reduce the amount of pollution emitted by fossil-fuel-fired power plants. (*Clean Coal Technology - an Overview | ScienceDirect Topics*, 2015).

As a result, it can be concluded that the literature reviewed suggests considerable benefits of CCT for environment and human health. It also suggests benefits in terms of bringing down the carbon emissions. The WFGD system, a CCT ensures that people can breathe clean air.

Climate change is unavoidable, according to evidence, unless greenhouse gas emissions from fossil fuels are drastically reduced. However, there are numerous market failures related to greenhouse gasses, and limiting greenhouse gas emissions is still heavily reliant on good intentions (Covert et al., 2016). Regrettably, the era of oil and fossil fuels is far from over (IEA, 2018). In 2015, fossil fuel subsidies totalled US$5.3 trillion, or 6.5 percent of global GDP (Coady et al., 2017).

The Kyoto Protocol to the United Nations Framework Convention on Climate Change, according to (DNA | Department: Energy | Republic of South Africa, 2012), aims to reduce air pollution, which is blamed for global warming. However, the commitment by various countries in bringing down the carbon emissions is to be fully implemented with good intentions. Hence, it can be reasonably argued that the literature reviewed agrees that the greenhouse emissions are far from over and despite commitments, the good intentions of various countries are still not evident.

VI. DISCUSSION OF THE FINDINGS OF THE STUDY

The findings of the study are consistent with the findings of the reviewed literature in terms of societal/ community health. The literature suggests that CCT has a plethora of environmental and human health benefits, which will ultimately save countries billions of dollars. The analysis of primary data also suggests that CCT will help to improve the overall health of the community. Both indicate that CCT will benefit society/ community members' health. The findings of the primary data analysed also indicate that the region's business opportunities and general infrastructure structure will remain unchanged, and thus the lives of community members will remain unchanged. The research findings also indicate that Eskom's community development programmes will remain unchanged, following the implementation of the CCT. These additional findings are not contradictory to the findings of the reviewed literature but are the result of the study's specific research objectives.

The study's findings do not agree with the findings of the reviewed literature. This could be because the research study found the corporate governance and social responsibility status of Eskom was a result of CCT implementation, whereas the literature reviewed was more generic in nature and suggested that various countries have yet to become serious about reducing carbon emissions. Since the study's research population was limited to Eskom employees, the findings may not be consistent with the literature reviewed.

VII. CONCLUSION

The use of CCT will aid in the improvement of the community's overall health. However, it will have no effect on the region's business opportunities or general infrastructure, which will remain unchanged. Furthermore, the data analysis findings indicate that the use of CCT will have no effect on Eskom's community development programmes. They will remain unchanged, and thus society and community will be largely unaffected using CCT. The correlation between CCT and corporate governance was analysed by using 14 dimensions of corporate governance and the correlation found that the use of CCT would have no effect on Eskom's corporate governance status. However, the correlation of CCT with all the 14 dimensions of corporate governance was found to be statistically insignificant - indicating the correlation by chance, which cannot be relied upon.

Similarly, the correlation between CCT and social responsibility of Eskom was analysed using 11 dimensions of social responsibility and the correlation found that the use of CCT would have no effect on Eskom's social responsibility status. However, a principal component analysis was done to reduce the number of dimensions of social responsibility.

The analysis concluded that out of 11 components/dimensions used in the survey questionnaire related to CCT and corporate social responsibility, there are only 7 principal components relevant for the study. As a result, it can be suggested that there is no link between CCT and seven dimensions of social responsibility of Eskom. Eskom's use and implementation of CCT may not change its corporate social responsibility status.

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