TÉCNICO LISBOA

Carbon Pricing System in Africa as a solution to climate change: A case study of Nigeria's Oil and Gas sector

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Thesis to obtain the Master of Science Degree in

Energy Engineering and Management

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October 2020

Special acknowledgement

This thesis is based on the work conducted within the Innoenergy Master School, in the MSc program Clean Fossil and Alternative Fuels Energy. This program is supported financially by the Innoenergy. This author also received financial support from Innoenergy, which is gratefully acknowledged.

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MSc Clean Fossil and Alternative Fuels Energy is a collaboration of:

AGH University of Science and Technology, Krakow, Poland

SUT Silesian University of Technology, Katowice, Poland

IST Institute Superior Tecnico, Lisbon, Portugal

(The MSc thesis was prepared at IST Institute Superior Tecnico, Lisbon, Portugal)

Acknowledgements

I would like to thank my Supervisor dr inż Grzegorz Stefan Jodłowski of AGH University of Science and Technology, Krakow, Poland and co-supervisor Prof. Francisco Manuel da Silva Lemos of IST Lisbon, Portugal during the period of this thesis. I appreciate his support in the successful completion of this thesis.

I will like to also say thanks to the creators of the MACBETH software, Professor Carlos Bana e Costa as it helped in the smooth execution of my multi-criteria decision analysis for this thesis.

Special appreciation goes to my friends and family for their support during the period of my education and thesis.

Finally, thanks to InnoEnergy for giving me the support and opportunity to develop myself in my career.

Abstract (EN)

This thesis covered the case of the best and most practical carbon pricing approach in Africa with focus on the oil and gas industry in Nigeria.

The Main tool used in this study was the MACBETH multicriteria decision tool, developed by Jean-Marie De Corte, Jean-Claude Vansnick and Prof Carlos A. Bana e Costa. Another tool used was the E3 Carbon Tax calculator developed by RFF Carbon Pricing Initiative which helped in comparing 4 selected carbon pricing policies with a projection from now till 2034.

The objective was to determine the best choice between 4 options of carbon policy, The Climate Action rebate, The Market choice policy, The Carbon Cut policy and a Custom design from this study. This was done using 3 different criteria of Initial Tax ($), Tax growth rate and Revenue recycling.

Since this is a Multicriteria decision, The MACBETH tool was also used in making qualitative judgements that are based are on the difference in attractiveness between two items at a time, in order to produce numerical scores for the options in-category and to weigh the criteria.

The problem was structured by creating a value tree for the 3 criteria, the performance of each criteria was done by inserting a qualitative judgement of ‘’good’’ or ‘’neutral’’ based on the Decision Maker judgements. An Overall performance of the options was developed to see which was the best choice and a sensitivity analysis was done to see the effect of a change in the weight. The Decision Maker for this study was Basumoh Nigeria ltd, An oil and gas company in Nigeria.

The result of this study shows that using the Carbon Pricing tool by the Carbon pricing initiative and considering previous carbon policy experience in South Africa, our custom design was the better choice for Nigeria based on the decision maker’s judgement on if we were to develop a carbon price for the oil and gas sector that takes into account the Initial Tax rate and also Tax growth rate . The study also indicates that even though the Climate Rebate Act had the overall score for the options via qualitative judgment of the decision maker, our custom design was the better option when a sensitivity analysis was done by considering the intersection between the best and second-best options for the Initial Tax rate and Tax growth rate.

Keywords: Carbon, Multi-criteria, Pricing, MACBETH.

Resumo (PT)

Esta tese abordou a escolha da melhor e mais prática abordagem para os preços de carbono em África, com foco na indústria de petróleo e gás na Nigéria.

A principal ferramenta utilizada neste estudo foi a ferramenta de decisão multicritério MACBETH, desenvolvida por Jean-Marie De Corte, Jean-Claude Vansnick e Prof Carlos A. Bana e Costa. Outra ferramenta usada foi a calculadora E3 Carbon Tax, desenvolvida pela RFF Carbon Pricing Initiative, que ajudou a comparar 4 políticas de preços de carbono selecionadas com uma projeção a até 2034.

O objetivo foi determinar a melhor escolha entre 4 opções de política de carbono, desconto sobre a ação climática, política de escolha de mercado, política de corte de carbono e um design personalizado desenvolvido neste estudo. Foram utilizados três critérios diferentes: imposto inicial ($), taxa de crescimento fiscal e reciclagem de receita.

Por se tratar de uma decisão multicritério, a ferramenta MACBETH também foi usada para fazer escolhas qualitativas baseadas na diferença de atratividade entre dois itens de cada vez, de forma a produzir pontuações numéricas para as opções na categoria e ponderar os critérios .

O problema foi estruturado através da criação de uma árvore de valor para os três critérios, o desempenho de cada critério foi feito através da inserção de um julgamento qualitativo de "bom" ou "neutro" com base nos julgamentos do tomador de decisão. O desempenho geral das opções foi avaliado para ver qual era a melhor escolha e foi ainda feita uma análise de sensibilidade para avaliar o efeito de uma alteração nos pesos. Foi considerado que o tomador de decisão deste estudo era a Basumoh Nigeria ltd, uma empresa de petróleo e gás na Nigéria.

O resultado deste estudo mostra que, usando a ferramenta de Precificação de Carbono pela iniciativa de precificação de carbono e considerando a experiência anterior em termos de política de carbono na África do Sul, o design personalizado desenvolvido neste trabalho conduziu à melhor escolha para a Nigéria, caso desenvolvesse um preço de carbono para o setor de petróleo e gás. O estudo também indica que, embora o Climate Rebate Act tivesse a pontuação geral das opções por meio de julgamento qualitativo do tomador de decisão, nosso design personalizado foi a melhor opção quando uma análise de sensibilidade foi feita considerando a interseção entre as melhores e as segundas melhores opções para a taxa de imposto inicial e a taxa de crescimento de impostos.

Palavras-chave: Carbono, Multi-critérios, Preços, MACBETH.

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List of Abbreviations

DM**-** Decision Maker

MACBETH- Measuring Attractiveness by a Categorical Based Evaluation Technique

CSC- Carbon Social Cost

CGE- Computable general equilibrium

MCDA – Multi-Criteria decision Analysis

INDC - Intended Nationally Determined Contributions

1. Introduction

1.1 Framework and Objectives of Work

Developing countries in Africa are yet to fully subscribe to the idea of effective climate policies due to the large financial commitments it requires. Carbon Pricing is globally accepted as an effective and efficient economic tool to mitigate the social cost of emissions and also a tool to increase revenues to offset the distributional issues that come with Climate Policies.

The thesis seeks to recommend effective carbon pricing policies that help to reduce Nigeria's massive air pollution due to activities of the oil and gas industry while also encouraging the use of climate friendly technologies in the sector.

The thesis covers: Government reluctance to developing Lower Carbon Policies in Nigeria and Africa, Global Trends on Carbon Pricing, Best Approach for Carbon Pricing for Nigeria and Africa, The Price structure as it relates to carbon pricing in Nigeria and Africa, Sector that Carbon Pricing should cover, Re-routing carbon proceeds for effective development in Nigeria and Africa at large, Conclusions and Recommendations.

The study presents a multicriteria problem of making a choice between 4 different options of carbon pricing policies. The Decision Maker is considered to be an active company within the Oil and Gas industry in Nigeria. The four Policies are the Climate Rebate, Market choice, Cut Carbon and our custom design for the purpose of this study. These were based on 3 major criteria: Initial Tax, Growth Rate and Revenue Recycling

MACBETH software used in this multicriteria problem, The MACBETH tool was also used in making qualitative judgements that are based are on the difference in attractiveness between two items at a time, in order to produce numerical scores for the options in-category and to weigh the criteria.

The Carbon Pricing calculator developed by the Carbon pricing initiative was also used in analyzing the four different options based on the same 3 criteria listed above. This was done for a time period between 2020-2034.

The result from the two approaches to decision making seeks to highlight that the custom design presented in this study is the more feasible and practical option for imposing a carbon tax in the oil and gas sector in Nigeria.

1.2 Carbon Pricing

Carbon pricing is an environmental policy methodology that is used in a variety of countries and sub-national states and territories around the world. Carbon pricing operates by taxing issuers for the tonnes of carbon dioxide (CO2) emissions for which they are accountable (Marc 2019). CO2 is produced primarily through the burning of fossil fuels used in residential and commercial buildings for electricity generation, industrial production, transportation and energy usage.

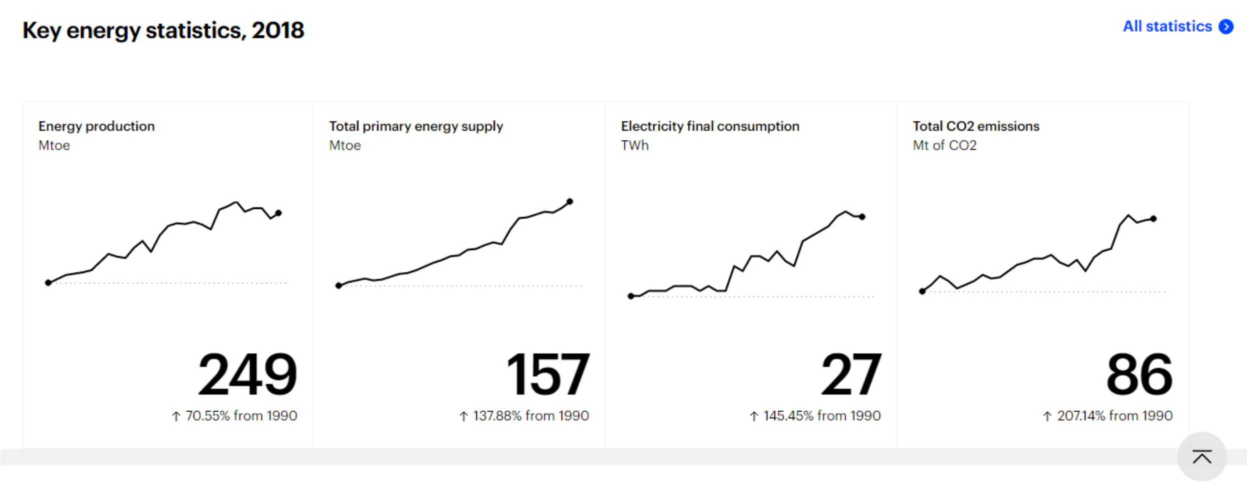

Figure 1 : Nigeria Key Energy Statistics (International Energy Agency)

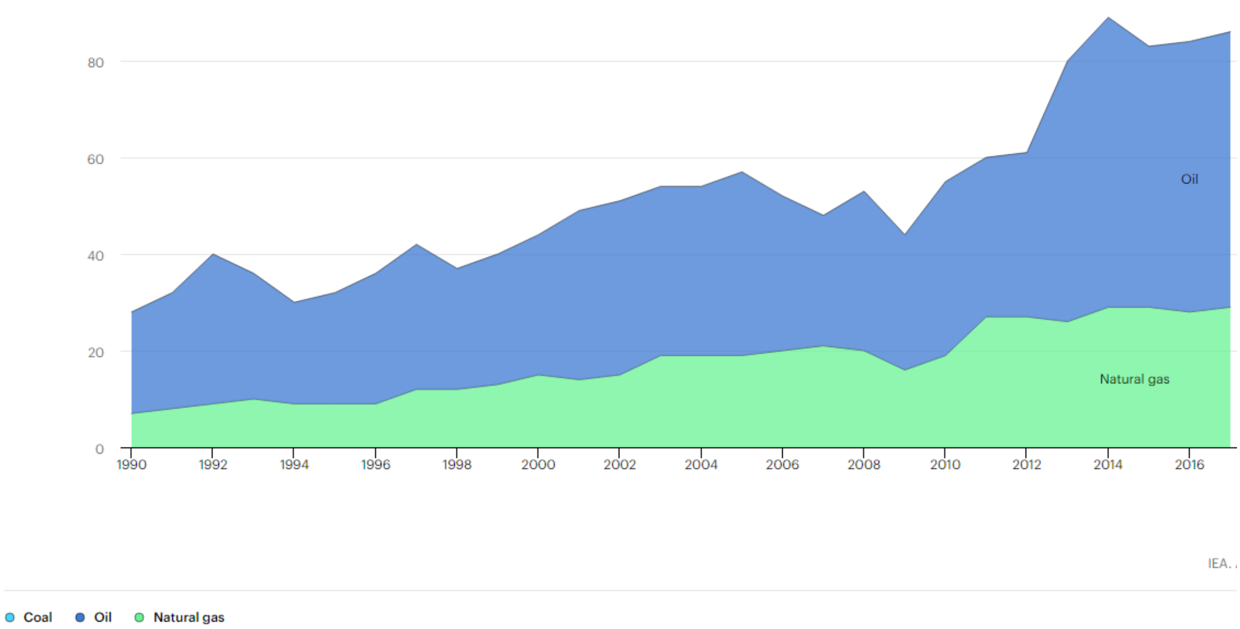

Figure 2: Nigeria CO2 Emission by energy source

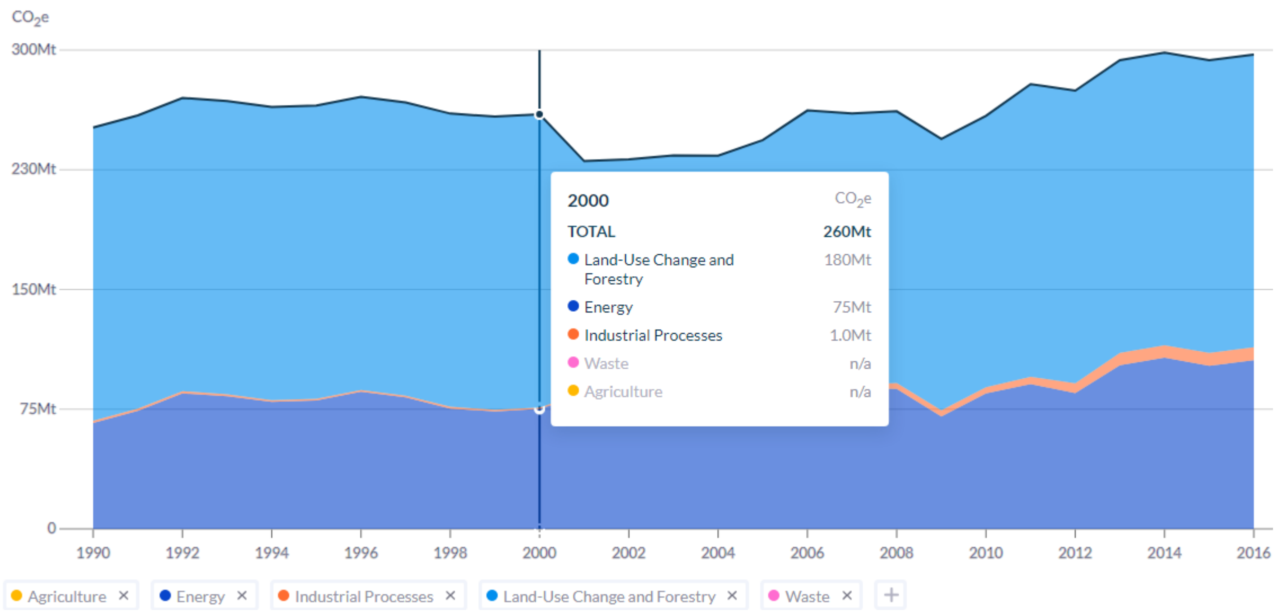

Figure 3 :Nigeria CO2 Emission by Sector (Climate Data Watch cait.wri.org)

1.2.1 Carbon Pricing Programs

Typically, **Carbon Pricing** programs take two forms: **Carbon taxes**, and **Cap-and-Trade schemes**.

A **carbon tax** is a price per tonne of carbon or, more often than not, per tonne of CO2 emitted. Because the CO2 emissions from fossil fuel combustion are commensurate to the carbon content of the fuel, the carbon tax is really a CO2 levy. A tax of $1 per tonne of CO2 is equivalent to a tax of $3.7 per tonne of carbon, because carbon is about 3/11 of the CO2 mass. (Hafstead 2019)

A **Cap and Trade** policy restricts the total amount of CO2 that some facilities will produce. Within a cap-and-trade program. A limited number of emission allowances (also recognized as permits) are issued by the Government, each giving the holder the right to emit one tonne of CO2. (Marc 2019)

Allowances can be allocated in a variety of ways: they can be distributed directly to companies or facilities (a principle called free allowance allocation) or selling them via auction markets. The reduced, government-controlled supply of allowances "caps" the overall emissions level. Allowances can be sold, so permit sales and transactions (supply and demand) produce a market price for allowances — essentially one tonne of CO2 emissions. Many cap-and-trade policies contain arrangements for lending and allowances borrowing over time: Allowances granted in one year may be deposited to compensate for pollution in later years (bank), and permits provided and used in the current year (borrowing) for future years. (RFF 2019)

When banking and borrowing take place, emissions during a specific year may be greater or less than the number of allowances authorized in that year, but over time emissions and expenses are calculated and balanced. Banking and borrowing give companies’ greater versatility in regulatory strategies and compliance and lowers the cost of reaching a combined carbon goal. (RFF2019)

Carbon taxes and **Cap-and-Trade schemes** vary largely by the kind of assurance that they provide.

Carbon taxes offer pricing stability, because taxing companies recognize how much they will have to pay per tonne emitted but simply setting a tax rate does not ensure any particular emission reduction standard.

Economists see pollution as an externality that is harmful. Externalities apply to a condition in which other individuals bear the consequences of output or consumption but cannot be linked to the originator. The principal sign of an externality is the distinction between the individual concerned and the source. (Akinwande 2014)

Externality is not factored into the price of products and services. Therefore, goods and services are undervalued because total production costs (single and non-single) are not factored in the purchase price. This is a failure on the market which must be tackled by government intervention. In the case of a negative externality like emissions, the remedy should be to impose a tax per unit on emissions from a polluting operation.

The tax rate would be equivalent to the total external social damage caused by the last emission unit, when effectively allocated. Faced with this carbon levy, the externality would be "internalized" by businesses. By reducing their private costs, companies would at the same time reduce the costs to society as a whole. (Akinwande 2014)

The carbon tax system is based on the concept of Polluter Pays. The definition that Polluter Paying states: ‘’The polluter pays principle states that: national authorities should strive to encourage the understanding and acceptance of environmental costs and the use of economic tools, bearing in mind the approach that the polluter should, in theory, bear the emission costs, with proper consideration for the public interest and without altering foreign trade and investment’’ (Nicholas 2007)

A carbon tax is desirable because it provides a stable emissions price and a stable emission price is essential for companies that make long term decisions about investment and development in low-emission technologies. Carbon taxes easily transfer funds to the public revenue from emitting sectors. The revenue can be used to expand the revenue stream; to decrease the overall tax burden on the sector impacted by recycling revenues; to reduce taxes anywhere else in the economy. (Nicholas 2007)

Industry revenue recycling will allow emitters to minimize GHG emissions without increasing the overall tax burden on other parts of the economy. The benefit of this strategy is that it can ease the impact force of the scheme on those sectors that experience the greatest increase in spending and thus promote the transition to carbon tax. In the 1990s Norway introduced carbon tax like other Nordic countries.

The revenue from environmental taxes was designed to reduce labor taxes in the economy. At first, the tax covered 60% of all CO2 emissions from Norwegian energy. Norway's GDP grew by about 23 percent between 1990 and 1999, but emissions rose by only about 4 percent over the same period, suggesting a decoupling of emissions growth from economic growth. It was suggested that this tax helped to provide rewards for technological innovation. (IMF 2008)

Cap and trade schemes, on the other hand, set carbon limits and thus provide quantity stability, but price fluctuations under the framework of the trading market can provide a less solid foundation for business planning actions. Nonetheless, hybrid systems can be used to reduce confusion around costs or pollution. Cap-and-trade programs have proposed and used price floors and ceilings to prevent "too low" or "too high" prices. Carbon taxes may also be configured to change automatically if the real emissions bypass any specified emissions path. (Marc 2019)

(Jotzo 2011) posits that the two popular systems at work i.e. current emissions trading systems and carbon taxation have positive aspects but they also have downsides. The general idea of emission trading systems (ETS) is to mark an emission cap in order to result in a Carbon emission reduction. It is a cost-effective approach to reduce greenhouse gas pollution, in order to enable businesses to reduce their pollution, a government establishes a limit on the overall emission amount and generates licenses or allowances for each unit of pollutants permitted under the limit. it still best the question of uncertainty in terms of the exact price of carbon. (Baranzini 2016) argues that this uncertainty in the price does not bode well for future. (Wood 2011) though argues that price ceilings and floors can help to reduce the instability.

The other system commonly used is the concept of carbon taxation which solves the uncertainty in price but leads to difficulty in predicting the emission level and the impact on the environment. (Parry 2016) argued that this system leads a more cost-effective way to reduce the emissions. According to the (World Bank and Ecofys report 2016), it is reported that countries usually begin their carbon policy system with the concept of the carbon tax before transitioning to ETS.

Two major countries like Mexico and South Africa have implemented their carbon pricing in a way where carbon tax is introduced first and then ETS follows. Mexico has successfully implemented the tax in 2014 with an amount generated of one billion dollars which was to be followed by the introduction of ETS as of 2018. The recent carbon pricing system being adopted by South Africa comprises the carbon tax in relation to carbon emissions from fuel combustion and energy industries (Akanonu 2017). Sector specific carbon pricing systems have also been introduced across the world, Finland for example has adopted a tax for the oil and gas industry especially for coal and heavy oil.

The end goal is therefore to ensure the use of fuels with lower emissions. Considering the examples mentioned above, it is posited that Nigeria can also adopt the implementation of a carbon tax first and then introduce Cap and trade schemes after gaining some level of maturity. (Precious 2017).

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1.2.2 Benefits of Carbon Pricing

Carbon pricing measures include carbon taxes and cap-and trade schemes. They have several characteristics that tend to make them more effective or less disruptive than other future policies to reduce emissions of carbon dioxide (such as mandates for technology, direct regulations, zero-carbon energy subsidies etc.) (Marc 2019)

Flexibility

Carbon pricing encourages businesses to choose the most effective way of reducing (or not reducing) pollution in reaction to the carbon price. Under other laws, such as technological requirements, a regulator uses a single method for a diverse group of companies. These one-size-fits-all solutions will contribute to unnecessarily expensive cuts for some companies if there are alternative options for reducing emissions. (Marc 2019)

Equal Marginal Costs of Abatement

The affordable carbon price imposes a standardized premium on CO2 pollution regardless of the source. Consequently, the marginal cost of reducing emissions (the cost to firms of reducing their emissions by one unit) is evened up along all firms and sectors. (RFF 2019).This is really a necessary condition for lowering the cumulative cost of reducing pollution.

Regulations also indicate varying marginal cost of reducing emissions across industries and sectors: if one industry has a regulation with very strong marginal cost for reduction of emissions, removing this legislation and implementing more stringent regulations in sectors with lower marginal cost of reducing emissions may be more cost-effective. In fact, it would be very challenging for policymakers to do that, but carbon pricing is an inherent quality. (RFF 2019)

Encouraging Conservation

A carbon price allows people and businesses, more than traditional policies, to reduce their carbon emissions. A traditional control (such as a performance specification) establishes a strict emission limit per output unit, but does not provide inducements to reduce total demand.

Carbon pricing, on the other side, provides incentives to reduce emissions per unit of production but also pays a premium for each extra tonne of CO2 that is not lowered by increasing efficiency. The price of carbon-intensive goods (i.e. electricity or petrol) is therefore likely to be higher at a carbon price than under traditional regulations. That helps individuals and businesses to their production (as far as possible). A carbon price thus encourages more recycling than traditional legislation. (Marc 2019)

Revenue

A carbon price provides a new stream of revenues that can be utilized in a variety of ways. Revenue utilization can significantly impact a carbon pricing policy's economic costs and political feasibility.

1.3 Carbon Pricing Structure

According to (Rydge 2015) the price of carbon is generally varies between less than US$1 to about one hundred and thirty dollars for 1 tonne of CO2e but it is estimated that about 85% of the cases are less than 10 dollars per tonne of CO2e.

South Africa set the price of carbon at a rate of 8 dollars per tonne of CO2e with an estimated increase 10 percent (US$1) annually until 2019 in order to account for inflation and give business time to adjust Machingambi 2017).Another case study was the carbon pricing policy of British Columbia , Canada where the price of carbon was set at 7dollars per tonne, increasing by 3 dollars per tonne per year for a period of 4 years until it was fixed at 22 dollars (Ecofys 2016).

The concept of using a low rate at the beginning with a potential of gradual increase mitigated the adverse risk of political tension and served as an initiative for cleaner energy investments. (OECD 2015).

Achieving the goal of climate and financial advantages will require that **Nigeria** follows the trend of starting with a low carbon tax and increasing it by a certain percentage per year. It gives room for companies especially in the oil and gas industry to adjust to the new tax and also helps motivates them to support and implement cleaner technologies.

(Morris 2016) argues that starting with a higher carbon price will lead to a drastic increase in the price of fossil fuel and stretch the limit of the existing capital which will lead to reluctance both politically and industry wide.

An example can be seen in the Australia carbon pricing initiative, which was repealed in 2014 as a result of the agitations from the industry. The carbon tax was set at 23 dollars per tonne of CO2e with an increase of 2.5 per cent per year. As the price went up after the initial high tax there was a decline in the productivity and increase in unemployment which led to lots of political pressure until it was finally repealed. (Akanonu 2014).

Having established that the initial rate and the carbon price trajectory are pivotal to the outcomes of any carbon pricing policy, it is therefore important to derive the rate of change and also the carbon tax trajectory.

A first approach will be to make the carbon price equivalent to the current environmental damages for each extra ton of CO_2e that is emitted. It is called the **Carbon Social Cost**. The CSC simply estimates the current and future impact of carbon emissions on the economy. Therefore, if the carbon tax is marked at the CSC then it implies that the marginal cost will be equivalent to marginal damages which will help to soften the abatement costs. The marginal CSC is typically used to direct the trajectory of the tax. (Nordhaus 2017).

(Pindyck 2016) argues that the CSC value is greatly dependent on the discount rate and this rate is usually manipulated to obtain a wanted value. Another aspect of the estimation of CSC is that it involves high amount of uncertainties which rely on critical reasoning/bias like the advantages to the sector or industry it is to be implemented or a region/ country as a whole.

The average CSC has less pronounced uncertainties compared to the marginal CSC. The Average CSC Is a better option for carbon pricing as it is not as sensitive as marginal csc as it relates to the discount rate (Pindyck 2016). The average CSC refers to the flow of benefits in relation to the present value of emission reduction flows while the marginal CSC refers to the flow of benefits from a change per 1 ton in the current emission. The average CSC is less sensitive to discount rate as compared to the marginal CSC. The CSC approach has been implemented in many countries as it helps in defining the long-term sustainability goals and also defining the economic tools to achieve it in terms of taxes and charges.

The second approach to determine the initial price of carbon and the trajectory is to use formula for a gradual increment in tax rate which is usually dependent on a key economic indicator. The increments in tax rate can be related to an increase in inflation percentages, an example of this is the carbon pricing policy of South Africa. (Morris 2016) argues that it helps to provide a guide to long term investment in cleaner technologies.

The downside to this approach is the uncertainty in guaranteeing an emission outcome outside of an additional policy measure. Formulas tend to neglect other developmental factors such as national climate agreements which demand reviewing from time to time hence creating a level of uncertainty for business and industries in particular. (Morris 2016)

The third approach used in carbon pricing system is the concept of linking carbon price to other tax changes. It leads to fluctuations in the carbon price which affects investment decisions but it helps in keeping the carbon price as revenue neutral on the part of government. (Pindyck 2016).

Considering the approaches above, the initial rate and trajectory of the carbon pricing policy in Nigeria should be determined based on the rate of inflation thereby following the South Africa model. The Average CSC model is not yet suited for developing economies as a result of a limit in data availability.

The initial tax rate will be estimated to be 10 dollars per tonne of co2e with an increase per year. The low initial rate and gradual increase is best for the oil and gas sector in Nigeria in order to encourage investment in low carbon systems.

1.4 Environmental Tax Implementation: Lessons from Nigeria

Environmental taxation has been an integral part of Nigeria's gas flaring legal framework from the start, and is now one of the leading initiatives of their government in trying to reduce flaring. (Akinwande 2014)

In practice, Section 3 of the Associated Gas Reinjection Act prohibits gas flaring, but allows polluters to continue to flare at a fine's fee. The Section establishes as follows:

‘’Subject to subsection (2) of this section, no company engaged in the production of oil or gas shall after 1 January, 1984 flare gas produced in association with oil without the permission in writing of the Minister [1985 No.7.]’’

(2) Where the Minister is satisfied after 1 January 1984 that utilization or re-injection of the produced gas is not appropriate or feasible in a particular field or fields, he may issue a certificate in that respect to a company engaged in the production of oil or gas.

(a) Specifying such terms and conditions, as he may at his discretion choose to impose, for the continued flaring of gas in the particular field or fields; or

(b) Permitting the company to continue to flare gas in the particular field or fields if the company pays such sum as the Minister may from time to time prescribe for every 28.317 standard cubic metre (SCM) of gas flared:

Provided that, any payment due under this paragraph shall be made in the same manner and be subject to the same procedure as for the payment of royalties to the Federal Government by companies engaged in the production of oil.

The penalty for each 1,000 standard cubic feet (scf) of gas flared was originally fixed at 2 kobo (approximately equal to US$ 0.0009 in 1985) against the oil companies. The penalty was boosted in 1990, to 50 kobo/10,000 scf. In 1998 this was further elevated to 10 naira/1000 scf. The levy was increased in 2008 to US$ 3.50 (the value of today's 560 naira) for every 1,000 scf of gas flared. Nigeria also aims to increase the fine to the tax flared's global market value. (Petroleum Industry Bill 2012)

The Nigerian National Petroleum Corporation (NNPC) reported in 2012 that flare has dropped just 15 percent, which implies that 85 percent of Nigerian gas is still flared. After many years of introducing this tax system, the marginal rate of reduction in flaring in Nigeria leads to questions as to whether environmental taxes substantially lead to a reduction in emissions. It also leads to questions about the viability of the monitoring and reporting system designed to ensure the proactive disclosure and authentication of reduction rates. (Yusuf 2012)

The situation in Nigeria is relevant to the case in South Africa because the tax introduced in Nigeria followed the "soft ramp up" strategy, which is what South Africa's National Treasury intends to use. In a "soft ramp up" method, the tax is gradually introduced over time, beginning with a low initial rate or a small initial base and Then increase the rate or base to the pre announced timetable to reach the right system.

It is complicated to set the tax at the desired rate; this is evident in Nigeria's suggested plan to fix the flare penalty to the gas flared's international market value. The market value of gas varies by country and continents. Another component weakening Nigeria's flare sanctions regime is weak implementation and enforcement. Recently it was confirmed that none of Nigeria's oil companies paid the new gas flare penalty of $3.50 per standard cubic foot in 2012, because they objected with the penalty. (Yusuf 2012)

The Petroleum Resources Ministry, which was tasked with the responsibility of implementing the flare rule, failed to apply the penalty to oil companies. The estimated damage / penalty for gas flares by local and international oil companies between August 2011 and November 2012 is $3.9 billion. (Akinwande 2014)

In the Nigerian Extractive Industries Transparency Initiative report the following statement was made:

‘’We observed that the volume of Gas produced were not declared before flaring. The figures in this section are calculated by the company and forwarded to the DPR after the gas must have been flared. This is a serious control and monitoring weakness on the part of DPR whose responsibility is to ensure that JV companies provide it with accurate and reliable information. This should be addressed by the Federal Government to ensure that DPR is able to carry out its oversight function of monitoring the upstream sector of Oil and Gas industry in Nigeria.’’ (Petroleum Industry Bill 2012)

The Report summary indicates:

We recommend that greater control be exercised over Gas Flared Penalty calculation and payment. DPR officials should track an operator's daily output and quantity of Gas Flared and a certificate that is issued appropriately. It is evident from the above that the absence of a legal structure for reporting on greenhouse gases threatens Nigeria's tax regime.

Environmental transparency would be integrated into the tax regime if the companies are required to disclose GHG emissions and to check the data collected. What is truly going on under the tax regime in Nigeria is voluntary disclosure. The danger of voluntary reporting is reporting less and that means less income. Eventually, it will reduce the effect of the tax on inducing behavioral change. (Akinwande 2014)

1.5 Options for Carbon Pricing Design

In addition to deciding between a tax and a cap there are several policy options for how a carbon price could be implemented in the country, all of which have different impacts on overall costs, cuts in pollution, increased revenues and so on.

Price

As per economic theory, pollution pricing provides the highest net benefits (environmental, safety and other benefits less economic costs) when the carbon price is equivalent to the total damage caused by carbon emissions or the damage caused by introducing another tonne of carbon dioxide to the atmosphere. (Marc 2019)

This is accomplished either by putting the carbon tax equal to the marginal damage, or by capping emissions at a scale withing a cap-and-trade programmed that results in an emission allowance price equal to the marginal damage. The social cost of carbon is often called the Marginal Impact. (Marc 2019)

Stringency of policy is defined by the scale of the tax rate (under a carbon tax) or the level of the emission cap (under cap and trade) and how they evolve over time. A carbon tax of $50 is stronger than a carbon tax of$10: it will result in lower emissions and increased costs. Policymakers are confronted with a trade-off between sustainability targets and the costs of achieving certain objectives.

Coverage

Coverage of a carbon price programme specifies which sectors of the economy are affected by the carbon price and which forms of emission. For starters, The Cap and Trading scheme for the European Union's emissions trading framework includes CO_2, nitrous oxide(N_2O) and perfluorocarbons (PFCs) produced by 11,000 energy electrical and production concentrated facilities in 31 European countries. (RFF2019)

Overall, the plan contains some 45 percent of EU greenhouse gases. In contrast., the carbon tax of British Columbia refers to the purchasing and use of fossil fuels irrespective of the end use market, representing around 70 percent in regional greenhouse gas emissions. (RFF2019)

Point of Regulation

A carbon price control point specifies precisely who is expected to issue permits or submit the tax to the government. An upstream carbon tax would tax the carbon content (and therefore ultimate CO_2 emissions) of their products to fossil fuel producers. A midstream tax will charge the supply chain's first-time buyer of fossil fuels. A midstream fee, for example, will force a refinery to account for the carbon content of all the crude oil it buys.

The emitter is liable to a downstream tax: for example, coalfired plants, industrial consumers, or households and companies use oil in their cars, or natural gas in their homes and businesses.
The administrative cost of a carbon price may differ depending on the point of legislation but eventually a carbon price is passed on to consumers regardless of the regulatory level. (Marc 2019)

1.6 Carbon Pricing Policy and Sector

The activities of oil and gas companies both directly and indirectly contribute to the emission of greenhouse gases in Nigeria. The emissions come from the mining activities of coal, oil and gas. Several processes in the oil and gas industry lead to the emission of high amount of Nitrous oxide and also methane, processes like gasification, fuel combustion, storage and most importantly gas flaring. The graph below shows the Total GHG emissions in the Energy industry in Nigeria.

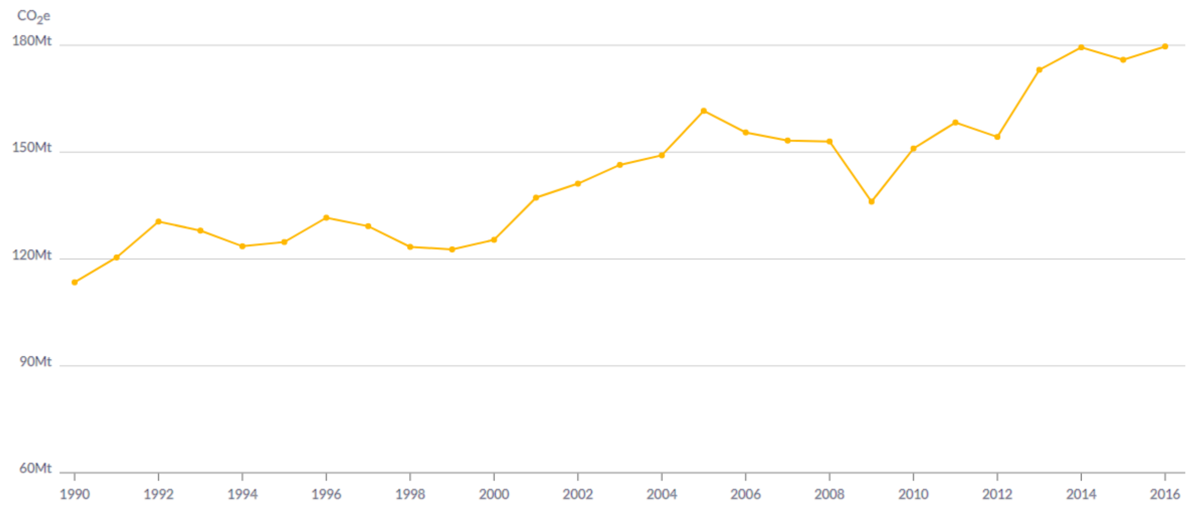


Figure 4 :Nigeria CO_2 Emission by Sector (CAIT Climate watch)

The Oil and gas industry accounts for over 70% of the GHG emissions in Nigeria, hence the need for implementing an effective carbon pricing policy.

There Is also the risk of lock-in for high carbon processes in the oil and gas industry, taking into account the high level of pollution intensity within the industry, it is worthy to note the while green retrofits might be ideal, there is a risk in terms of cost and available technical resources to foresee successful implementation. (Hogarth 2015)

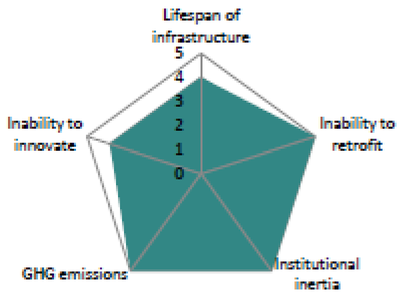


Figure 5 :Risk of lock-in to high carbon pathway (Hogarth 2015)

The suggested carbon tax will help in reducing gas flaring in Nigeria and serve as motivation of energy companies to conserve gas fuels for local distribution for the generation of power in the country. Hence the oil and gas industry can be a pilot for a larger scoped carbon pricing system in Nigeria.

1.6.1 Allocation of Carbon Tax proceeds

How can we reinvest the carbon dividend? What facilities, initiatives, or social services could be invested in to counter the climate policy's regressive effect? What infrastructures, initiatives, or social services should be invested in to counter such climate policy delivery effects? How to avoid future resistance?

Net energy-sector GHG emissions is about 162,73 tCO2e. With Nigeria's carbon tax pricing modestly beginning at $10/tCO2e, Nigeria will raise around $1.30 million of carbon revenue each year from the oil and gas sector11. It will provide almost 23% of the overall project funding expected to meet the INDC objectives of Nigeria. (Akanonu 2017)

Thus, the allocation of the carbon tax policy's vast future revenue is a vital decision: it has consequences for its electoral impact, distributional results, carbon emission results and the ultimate net benefits of the scheme. Governments have made various choices about whether their carbon tax strategies will recover revenues. The most common mechanisms for carbon dividend allocation include: tax reform, welfare services, and infrastructure improvements, as well as funding lower-carbon initiatives and technologies. (Andersen 2009)

Finland and Sweden, for example, introduce corporate tax cuts; the UK and Denmark reduce social insurance payments for employees; Switzerland directly gives households carbon dividend. British Columbia in Canada maintains a low-income climate change tax benefit scheme that offers tax breaks on low-income households 'family, industrial, and small business income taxes (Tietenberg, 2013).

Some carbon pricing schemes often use carbon dividend to encourage more emission decreases, lower emissions removal costs and reduce the effect of the policy on the domestic economy (Tietenberg, 2013). For example, in Denmark, 40 percent of carbon tax revenue is used for environmental incentives, while about 60 percent of the revenue is transferred to industry. Canada's Quebec invests its carbon tax income into a "climate bank" that funds programs that promote GHG cut. (Akanonu 2017)

For the carbon tax system proposed by South Africa, generated income will be invested into providing: tax incentives for energy-efficiency savings; enhanced basic free electricity / energy for minimal-income households; funding for the construction of solar water geysers; credit against Eskrom’s carbon tax liability for the clean energy premium incorporated into electricity tariffs; and enhancement of electricity levy. (Akanonu 2017)

Importantly, since state revenue in developed nations is sometimes inadequate to support basic services, one of the most successful methods of utilizing carbon dividends in developing countries is to invest in infrastructure that serves low-income households and decreases inequalities (Klenert, et al., 2017). Considering that carbon taxes are more difficult to circumvent than certain taxes (such as income tax), carbon taxes have been shown to improve tax regimes 'economic performance in countries with broad informal economies such as Nigeria. (Akanonu 2017)

In line with the SDGs, carbon dividends will make major impacts to ensuring equitable access to clean energy, power, sanitation, transportation network etc. Because low-income households have the least exposure to services, increased services coverage will help them more (Dorband, 2016).

A carbon pricing strategy may also have a distributional impact on capital away from its regressive effect on income. Provided that climate policies are slowly transforming fossil fuel reserves into "stranded resources," the income of fossil fuel asset owners is also impacted. It further highlights the challenge in enforcing climate change because owners in fossil fuel reserves are mostly wealthy people with political power. (Jakob & Hilaire, 2015). They may use their resources to organize opposition through staff, or directly lobby lawmakers. (Klener2017) proposes that nations might allow lump-sum payments to specific parties (such as foreign investors) to agree to their political resistance to climate policies, or leverage popular sentiment to claim the dominance of public interests over private interests. There are therefore different solutions.

The option of carbon income allocation by Nigeria in the light of the above is highlighted by this study. This study seeks to advise that a significant proportion of the carbon dividend would be injected back into the market to promote the productive usage of energy and the introduction of lower-carbon technology. The goal is to help eliminate obstacles, provide funding that encourages business to adapt to the price signal and increase the pace at which reduction opportunities are taken. In particular it will be necessary to promote access to long-term funding of initial capital costs for lower-carbon technologies.

Domestic businesses in the oil and gas industry will earn a portion of the initial capital expense for sustainable technology through long-term loans. This will resolve complaints regarding the effects of carbon tax on the industry's profitability, while resolving questions about the distributional influence on income and mitigating future political opposition most notably. (Akanonu 2017)

To counter the possible regressive impact of a carbon tax on the oil and gas industry in Nigeria, that a proportion of the carbon dividend can be used for: enhancing access to clean water (e.g. drilling boreholes), developing electricity / energy services (e.g. installing solar plants / panels for low-income households) and enhancing soil conditions to promote farming in the Niger Delta– the oil field. This will boost the region's deplorable living standards and placate the rage of rebels from the Niger Delta who are blamed for targeting Nigeria's oil installations – its primary source of income. (Akanonu 2017)

A small amount of carbon income should be directed to promote coverage on television channels and generate climate change activity and fuel consumer awareness and service demand. The initiative will emphasize its current and potential benefits to the Nigerian economy, fiscal efficiency, climate for competition, as well as citizens 'wellbeing. Preferably, the advertising initiative will be initiated one to two years before Parliament launches parliamentary negotiations on a carbon tax bill.

1.7 Carbon Pricing Programs around the Globe

The Carbon Pricing Dashboard of the World Bank outlines 52 carbon pricing policies initiated or expected to be introduced, with 46 Local and 24 sub-national regions protected by the measures.
These programmes will cover 11 gigatons of CO2 equivalent in 2018, representing 20 per cent of global emissions of greenhouse gas.

In fact, several global carbon markets take the shape of cap-and-trade systems, much of which can be seen in the European Union and California. Nonetheless, carbon taxes are becoming more common, and are now in place in the Us, several parts of Canada, Sweden, and more.

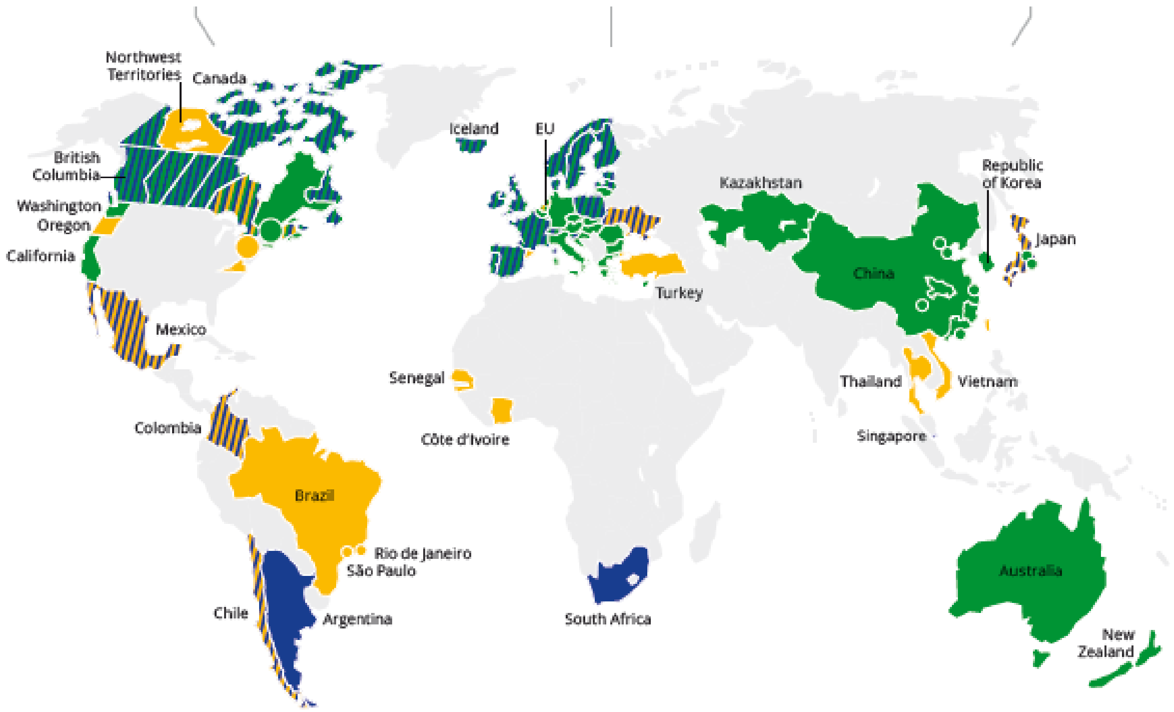


Figure 6: Summary map of regional, national and subnational carbon pricing initiatives

2. Methodology

2.1 Carbon Pricing Calculator

The tool was developed by the RFF carbon pricing initiative. The essence of using this tool was estimate the actual effect of different carbon pricing initiatives and help inform better decision making regarding the cost and benefit of this initiatives to the environment and economy. (RFF 2019)

The Impact is measured across emissions per year, the revenue per year, the actual carbon price, change in percentage of the consumer price and the cumulative emissions which relates to carbon dioxide emitted specifically by the energy industry. A carbon tax path was designed based on three criteria which are the

- Initial Tax per Ton,
- The growth for tax based on the inflation and
- How the revenue will be recycled.

The key aspects addressed in the tool takes into consideration the effect of carbon prices on the economy and environment based on the below:

- Carbon content of Fuel is what the price is based on
- The price is implemented for all combustion of fossil fuels
- Modelling of the impact of the price on strictly energy related Co2 emissions
- The price is implemented based on X dollar per ton with base year 2020 of the amount of Co2 emitted.
- The model does not take into consideration the impact of placing a tax on non-energy related CO2 emission with consideration also taking import and export of fossil fuels. (RFF 2019)

2.1.1 Goulder-Hafstead E3 model

To measure the impact of carbon-pricing policies, we use the Goulder-Hafstead Energy-Environment-Economy E3 CGE Model. The model is designed based on energy-related industries such as crude oil extraction, natural gas extraction, coal mining with focus on petroleum refining, and natural gas distribution. (Hafstead 2013)

The model is distinctive in its thorough analysis of the tax system, which requires correlations between environmental policy and pre-existing taxation on capital and labor; and its exposure to the complexities of capital which are essential for understanding how policies affect the economy over time.

Emission and GDP estimates under a carbon price scenario by comparing the percentage change of emission or GDP form the R3 model baseline to the AEO baseline. (Goulder 2013)

The E3 CGE model is a general equilibrium intertemporal mechanism of international trade.
The model blends a fairly realistic analysis of the tax system with a detailed picture of domestic energy supply and demand. The model is solved in yearly intervals beginning in a benchmark year.
The model works on both carbon tax and cap-and-trade scope of carbon emissions depending on the tax path. Carbon taxes and Cap-and-Trade Programs both integrate into the model a price on carbon. Based on the policy, the carbon prices are adopted identically into the model. (RFF 2019)

How the carbon price is introduced into the model is the difference between the carbon tax and the cap-and-trade program. Carbon taxes introduce this price through an exogenous price profile over time; cap-and-trade program set an exogenous limit, A, on the amount of carbon emissions in each period.
In addition, the price of fuel, Pc, will be the price so that total emissions, H, are equal to the total amount of allowances, A, in each cycle (provided there is no requirement for banking and borrowing). (Hafstead 2013)

In the model's energy policies are distinguished by an exogenous direction of commodity rates (carbon tax) or an exogenous path of limits of emission (cap and trade) by
(1) Point of Regulation,
(2) Industry Coverage,
(3) Tax Exemptions (carbon tax) or Allowance Allocation (cap and trade),
(4) Revenue Neutrality, and
(5) Special Cap and Trade Provisions. (Hafstead 2013)

2.1.1.1 Points of Regulation

Regulatory points constitute a key element in implementation for any carbon tax or cap-and-trade scheme. The control points under a completely upstream approach are the carbon entry points into the market, the coal mine mouth and the oil and gas wellhead, and the port of entry for imported fossil fuels. (Goulder 2013)

Here the carbon price is imposed as an export tax on manufacturers of products with a higher carbon content and a duty on the fossil fuels produced. The net producer price earned by suppliers of products with a positive carbon content (oil&gas, synfuels, and coal mining manufacturers of fossil fuel in practice) is:

$P_n^I = (1 - \tau_{xi})P_i - C_i P_c$ -------- Equation I

Where C_i is the carbon content of one unit of output. However, all duties on the supply of products from production or import will be raised by $C_i P_c$ $u$nder a completely upstream scheme where Pc is the price of carbon. Instead, the carbon regulation could be extended farther into the supply line at the gate of the industrial consumer. (Goulder 2013)

Industrial users face intermediate input taxes in a modified upstream carbon policy on their use of carbon-content goods (i.e. fossil fuels), regardless of source, domestic or foreign; the unit price paid by industry for domestic and foreign industries good. Since industrial consumers have to pay the intermediate import tax on foreign fossil fuels, in the changed upstream stage of regulatory policy no carbon tariff is enforced to stop double taxation on fossil fuels. (Goulder 2013)

2.1.1.2 Industry Coverage

Carbon policies can be defined by which sectors the policy covers. The model can examine policies restricting coverage to specific suppliers of fossil fuel (full upstream regulatory point) or to specific users of fossil fuel (modified upstream regulatory point)

To do this, equations (1) was modified to:

$P_n^I = (1 - \tau_{xi})P_i - C_i P_c U_i$ -------- Equation II

$P_{ij}^d = (1 + \tau_{xi})P_i - C_i P_c D_j$----------Equation III

Where Ui is a dummy variable equal to 1 where industry i is a completely upstream producer business and Dj is a dummy variable equal to one where industry j is a regulated industrial customer under the revised upstream legislation. (Goulder 2013)

2.1.1.3 Revenue Neutrality

A climate policy increases the government's tax base and tax revenues by focusing on economic output and employment. Furthermore, the government receives uses carbon tax / allowance payments as an indirect source of tax revenue. Depending on the policy and tax exemptions/allowance allocation, the net change in tax revenue could be positive or negative. The model allows for the option of imposing revenue-neutrality (net change in tax revenue of zero) through adjustments in marginal tax rates or lump-sum taxes. (Hafstead 2013)

2.2 Carbon Pricing Policies

2.2.1 Climate Action Rebate

The act highlights how climate reports make the implications apparent should we struggle to tackle climate change. Major economists believe a market-based method to reducing emissions is an effective and efficient strategy. There are high forecasts of extreme temperatures, rising sea levels and elevated storm and drought frequency and intensity. The act posits that Failure to act now will in future contribute to more serious costs for our climate and economy. (Feinstein 2019)

The 2019 Climate Action Rebate Act seeks to level the energy landscape by ensuring that businesses utilizing emission-intensive technology and fuels internalize the social and environmental impacts of those activities. Rectifying the market distortions already induced by the negative externality of pollutants would reduce greenhouse gas emissions effectively and create sustainable technologies. In turn, the revenue generated by the carbon fee is invested in projects that will reduce cost increases and hence help to rebuild our infrastructure and strengthen its durability, promote innovation in clean energy technologies and protect vulnerable employees and communities. The bill is aimed at reducing carbon emissions by 55 percent by 2030 and by 100 percent by 2050. (Panetta 2019)

Key Components

Carbon Fee

A gradually rising tax on fossil fuels and fluorinated gases, adjusted for their potential greenhouse gases. The price will be levied once, upstream and will start at $15 per metric ton of CO_2e. Exemptions and rebates are given for carbon capture, reuse and sequestration (CCUS); non-emissive applications such as the processing of chemical substances; and carbon sinks dependent on design. The fluorinated greenhouse gas tax is 20 percent of the oil charge. In fact, the cost is related to annual goals for reducing emissions and grows higher if those objectives are not achieved. (Panetta 2019)

Border Adjustment

Fossil fuels and carbon-intensive products incur border equalization taxes, while equivalent exported goods receive a refund.

Revenue Use

The bill rebates as a regular bonus 70 per cent of net income from the emissions tax. The rest of the revenue is spent on extra required investments in a cleaner energy future, including revamping our infrastructure, promoting energy innovation and funding to help companies move towards a cleaner energy economy (Feinstein 2019)

2.2.2 Cut Carbon Act

As of 2020, the Increase Wages, cut carbon Act imposes a premium of $40 per metric ton of carbon dioxide. The tax is levied "upstream," or at the point of extraction / production of coal, petroleum, natural gas, and fluorinated greenhouse gases. (Rooney 2019)

Revenue goes to a number of ends. Eighty-four per cent of the revenue is used to cover payroll taxes. The bill imposes taxes on (1) the producer or importer of coal (including lignite and peat), petroleum and petroleum products, and natural gas (not met $40 per ton in 2020, with an annual 2.5 percent increase in emission reduction targets); (2) any taxable imported product sold or used by its importer; and (3) fluorinated greenhouse gasses. (Lipinski 2019)

2.2.3 Market Choice Policy

The aims of the Market Choice Act are

1) to fund infrastructure projects by regulating and taxing GHG emissions
2) Spur major GHG emission reductions; and
3) Provide a business solution to increasing GHG regulations (FNCL 2018)

The 2019 act introduces a higher carbon tax rate, raising support for the atmosphere and projected revenue. It also allows more efficient carbon capture, recycling and use projects by study programs.

The Market Choice Act (MCA) is simply an act that seeks to impose a greenhouse gas (GHG) tax on emissions from fossil fuels, some large industrial facilities and certain industrial process goods. The GHG tax would launch at $35 per metric ton of CO2-equivalent emissions and rise at an average real pace of 5 per cent. Modeling estimates show that the MCA will reduce taxable GHG emissions by about 42 per cent in the first 10 years. (FNCL 2018)

The law also provides provisions for changing the carbon price to reach a range of emission goals, so that, if emission reductions fell behind requirements laid down in the legislation, the carbon tax rate would immediately rise. The expected emission reductions from the start of the tax are described as total emissions from taxable sources. If taxable emissions reach goal rates, then the carbon tax rate would grow. (Fitzpatrick 2018)

Fossil Fuels: The greater part of the tax base is on fossil fuel emissions. The MCA taxes the coal petroleum and natural gas. Coal is taxed at the mouth of the mine; oil products are taxed at the end of the refinery; and natural gas is taxed at the outlet from the gas processing plant.

Petrochemicals: MCA levies the same tax rate on facilities that generate GHGs when processing a specific product category like metals, petrochemicals, and cement. Such pollutants are imposed on facilities in each of those source groups that generate more than 25,000 tons of CO2e per year in the cycle. (Fitzpatrick 2018)

2.2.4 Custom Design

A custom carbon tax path was designed for this thesis based on three criteria which are the

- Initial Tax per Ton,
- The growth for tax based on the inflation and
- How the revenue will be recycled.

The initial Tax was pegged at $10 in accordance to concept of using a low rate at the beginning with a potential of gradual increase mitigated the adverse risk of political tension and served as an initiative for cleaner energy investments. (OECD 2015). It was chosen basing on the experience and lesson learnt South African Carbon tax path and also the minimum carbon price constraint by the Carbon price calculator. (Akanonu 2017)

Achieving the goal of climate and financial advantages will require that **Nigeria** follows the trend of starting with a low carbon tax and increasing it by a certain percentage per year. It gives room for companies especially in the oil and gas industry to adjust to the new tax and also helps motivates them to support and implement cleaner technologies. Hence the Tax grate in percentage was pegged at 3%.

The amount of revenue recycled was pegged at 23% based on the Net energy-sector GHG emissions is about 162,73 tCO2e. With Nigeria's carbon tax pricing modestly beginning at $10/tCO2e, Nigeria will raise around $1.30 million of carbon revenue each year from the oil and gas sector11. It will provide almost 23% of the overall project funding expected to meet the INDC (Intended Nationally Determined Contributions) objectives of Nigeria. (Akanonu 2017)

2.3 Macbeth Analysis

2.3.1 Introduction

Multi-Criteria Decision Analysis (MCDA) is a general method to help dynamic decision-making scenarios with various and sometimes contradictory priorities that are viewed differently by stakeholder group and/or decision maker. (G´omez-Baggethun 2014)

MCDA is a "definition concept to define a set of systematic strategies that aim to specifically take various factors into consideration when helping individuals or groups discuss specific decisions. This is grounded in institutional research and unified decision-assistance. Multi-Criteria Decision Analysis (MCDA) is a powerful method that we can extend on multiple specific decisions. It is most relevant to solving problems that are described as an option among alternatives. (Mendoza 2006)

It has all the attributes of a successful decision support method. It lets us concentrate on what is essential, is rational and clear, and is simple to use

MCDA issues consist of five elements:

• Purpose

• Decision-maker or party of decision-makers with views (preferences)

• Alternate choice

• Evaluation requirements (interests)

• Option / interest-related results or implications (Mendoza 2006)

2.3.2 Macbeth and differences among other methods

Measuring attractiveness by means of a categorical assessment methodology is the purpose of the MACBETH method developed by Professor Carlos Antonio Bana e Costa in collaboration with Professor Jean-Claude Vansnick and Dr. Jean- Marie De Corte, from the Universit´e de Mons. (Bana e Costa 2004)

MACBETH facilitates the comparison of alternatives against various requirements. The big disparity between MACBETH and other study of multiple-criteria decision (MCDA) is that only qualitative judgements are made on the difference in attractiveness between two items at a time, in order to produce numerical scores for the options in-category and to weigh the criteria.

The seven MACBETH categories are:

- No
- Very weak,
- Weak,
- Moderate,
- Strong,
- Very strong, and
- Extreme difference of attractiveness .

MACBETH has multiple uses in the sector: electricity, Carbon pricing (as in this case study), forestry, capital management, engineering, finance and IT among others. (Bana e Costa 2004)

2.3.3 Decision Maker

The Decision being analyzed is the choice regarding the best carbon pricing approach for the Oil and gas industry in Nigeria and Nigeria as a whole.

The Decision Maker is Basumoh Nigeria limited, a Trading, Storage, Marketing and Distribution of petroleum products such as Petroleum Motor Spirit (PMS), Automotive Gas Oil (AGO), Dual Purpose Kerosene (DPK), Liquefied Petroleum Gas (LPG) Storage and distribution and also Bitumen Products and also engages in upstream oil and gas activities.

For the purpose of this thesis and vying on their industry experience, they have the responsibility to choose between 4 Carbon Pricing Policies or approaches.

- Market choice act 2019
- Carbon act of 2019
- Climate action rebate act
- Custom design

Table 1: Criteria and options of the projects

Policy	Initial Tax (Per metric Ton)	Tax Growth Rate (%)	Revenue Recycling (%)
Custom Design	10	3	23
Climate Action Rebate	15	2.25	40
Cut Carbon Act	40	2.5	84
Market Choice Act	35	5	70

3 Result and Discussion

Figure 7:Climate Action Rebate Vs Custom Design

Year	Custom Carbon Pricing Design	Climate Action Rebate Act (Coons-Feinstein)
2020	10	15
2021	10.30	30
2022	10.61	45
2023	10.93	60
2024	11.26	75
2025	11.59	90
2026	11.94	105
2027	12.30	120
2028	12.67	135
2029	13.05	150
2030	13.44	165

2031	13.84	180
2032	14.26	195
2033	14.69	210
2034	15.13	225
2035	15.58	240

Figure 8:Climate Action Rebate Vs Custom Design

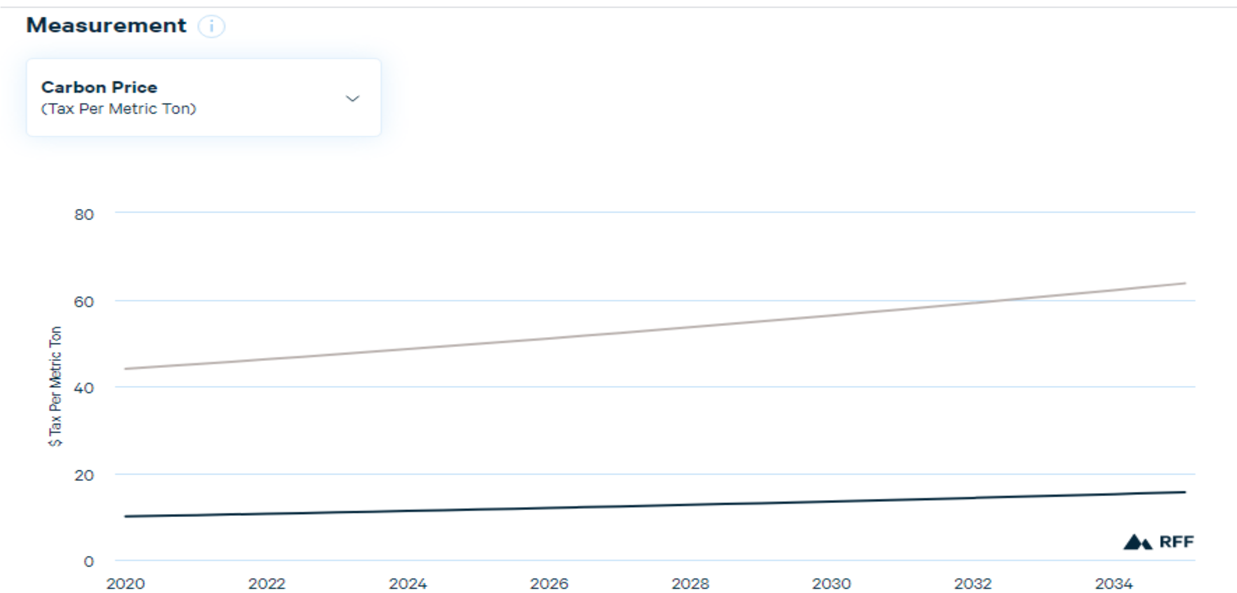


Figure 9:Cut Carbon Act Vs Custom Design

Custom Carbon Pricing Design

Initial Tax Per Metric Ton	Tax Growth Rate	Revenue Recycling
$10	3%	Corporate Income Tax Cuts

Year	Custom Carbon Pricing Design	Raise Wages	Cut Carbon Act (Lipinski)
2020	10	44	
2021	10.30	45.10	
2022	10.61	46.23	
2023	10.93	47.38	
2024	11.26	48.57	
2025	11.59	49.78	
2026	11.94	51.03	
2027	12.30	52.30	
2028	12.67	53.61	
2029	13.05	54.95	
2030	13.44	56.32	
2031	13.84	57.73	
2032	14.26	59.18	
2033	14.69	60.65	
2034	15.13	62.17	
2035	15.58	63.73	

Figure 10: Cut Carbon Act Vs Custom Design

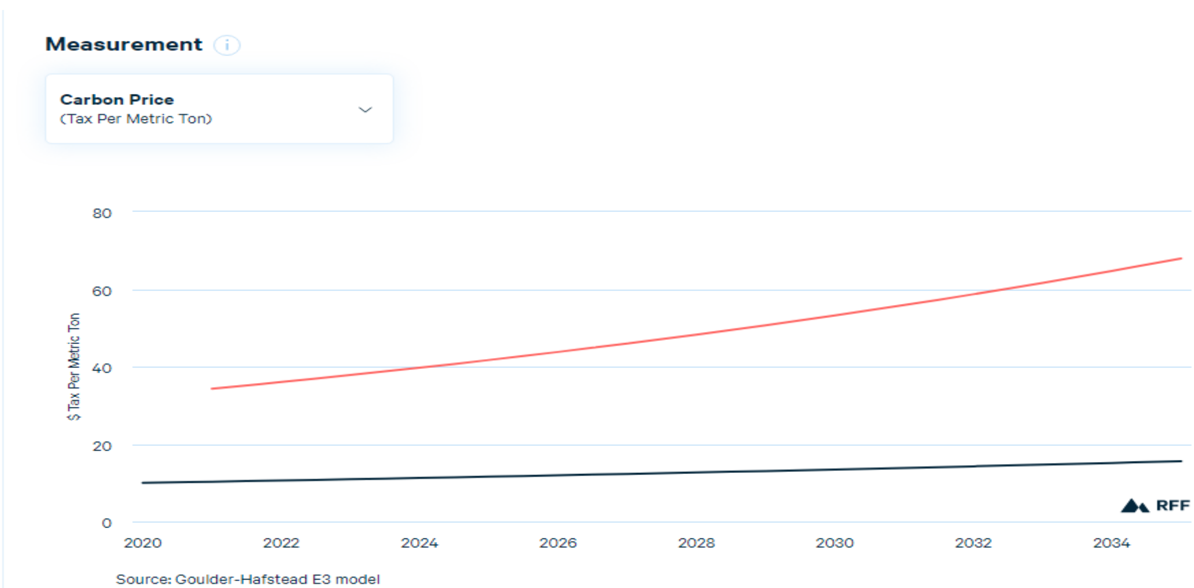


Figure 11: Market choice Vs Custom Design

Year	Custom Carbon Pricing Design	MARKET CHOICE Act (Fitzpatrick)
2020	10	
2021	10.30	34.31
2022	10.61	36.03
2023	10.93	37.83
2024	11.26	39.72
2025	11.59	41.71
2026	11.94	43.79
2027	12.30	45.98
2028	12.67	48.28
2029	13.05	50.70
2030	13.44	53.23
2031	13.84	55.89
2032	14.26	58.69
2033	14.69	61.62
2034	15.13	64.70
2035	15.58	67.94

Figure 12: Market choice Vs Custom Design

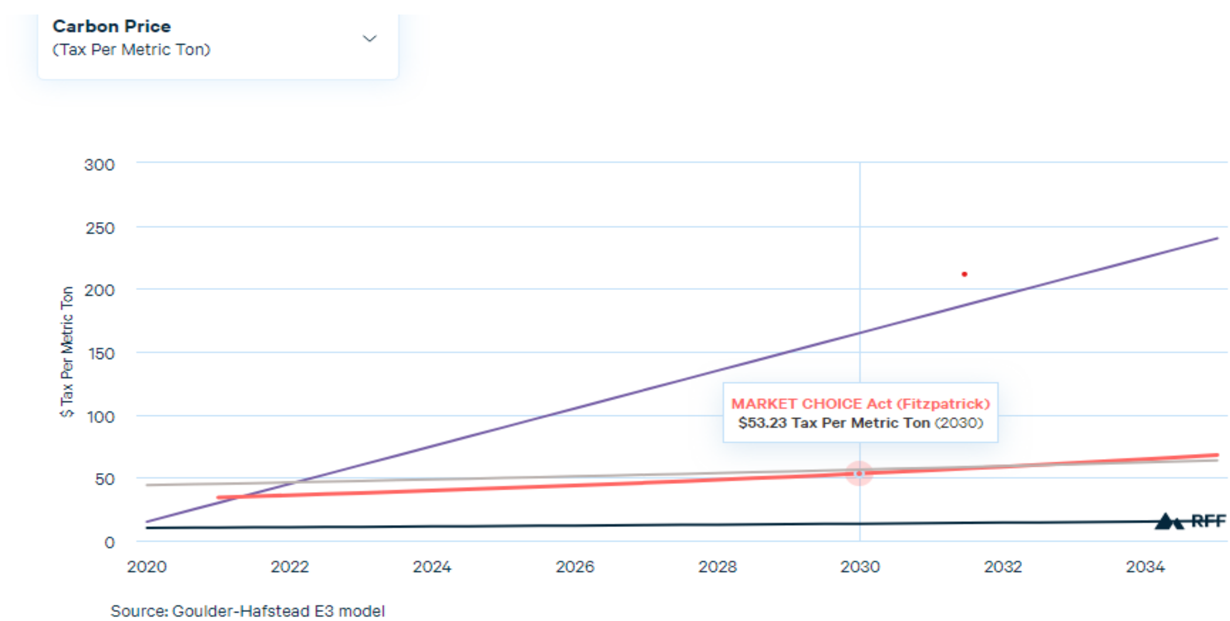


Figure 13: Comparison of all policies

3.1 STRUCTURING THE PROBLEM AND MODEL

Problem structuring involves specifying the potential alternative (means) for achieving the end result within the limits of each constraints that each option can pose and how its consequences on the desired outcome are. The fundamental principle is to promote and solve complex problems by decomposing them in multiple sections.

Upon consulting with the Decision Maker, we settled on a Bottom-Up strategy on which the opinions were described as seen below. Then, the 3 criterion nodes were aggregated into 1 parent node with significant non-criteria.

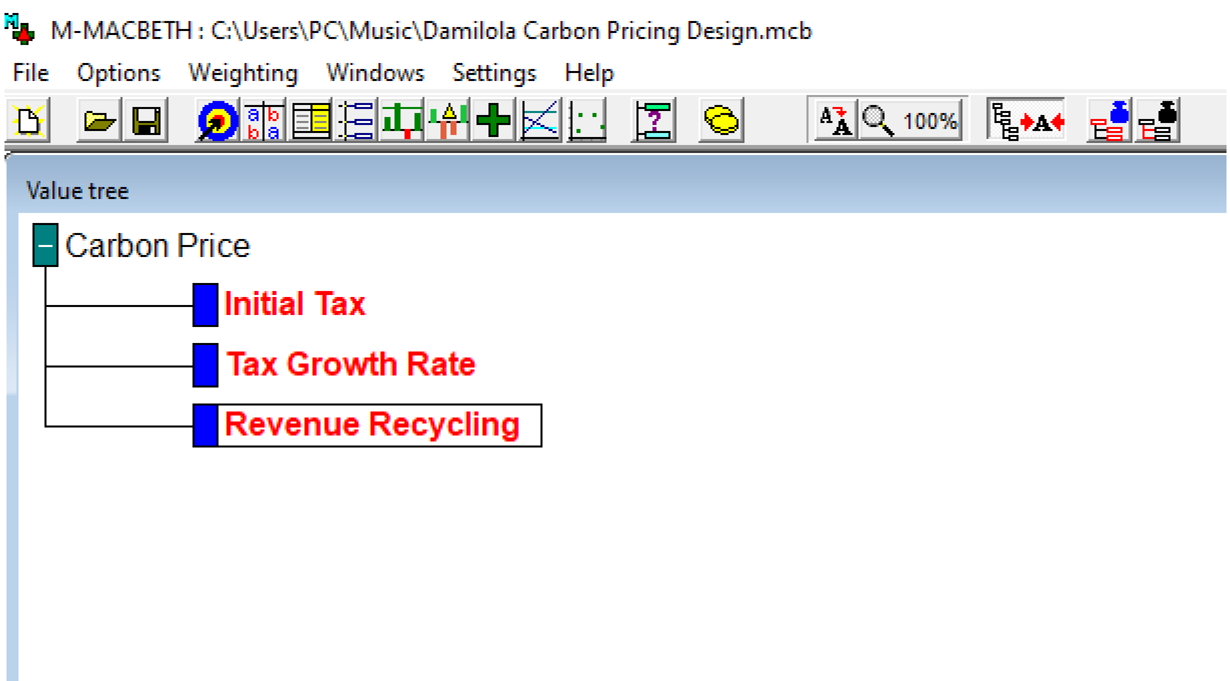


Figure 14: Value Tree

3.2. DESCRIPTORS OF PERFORMANCE

3.2.1 Initial Tax (Per Metric Ton):

Tax is charged on all fossil resources (coal, petroleum, and natural gas) combusted in Nigeria. The tax is focused on such fuel's carbon content. The tax is levied at $X per ton of CO2 generated by combustion.

The decision maker was questioned about his comparative framework and he decided that we are going to use a Quantitative one with comparisons named" good and" neutral" where

Good = $10

Neutral = $45

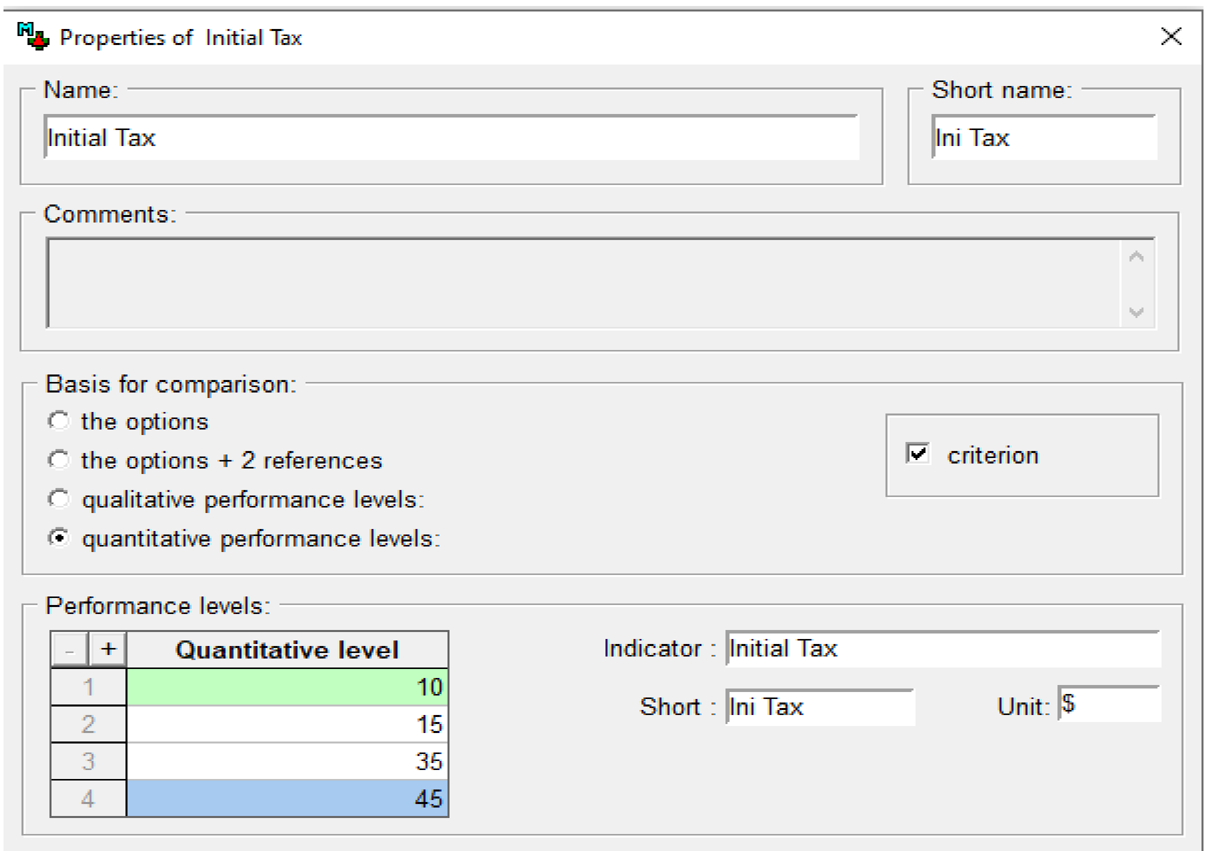


Figure 15: Properties of Initial Tax

3.2.2 Tax Growth Rate (%):

Refers to the percentage increase in the tax levied per year

The decision maker was questioned about his comparative framework and he decided that we are going to use a Quantitative one with comparisons named" good and" neutral" where

Good = 2.25%

Neutral = 5%

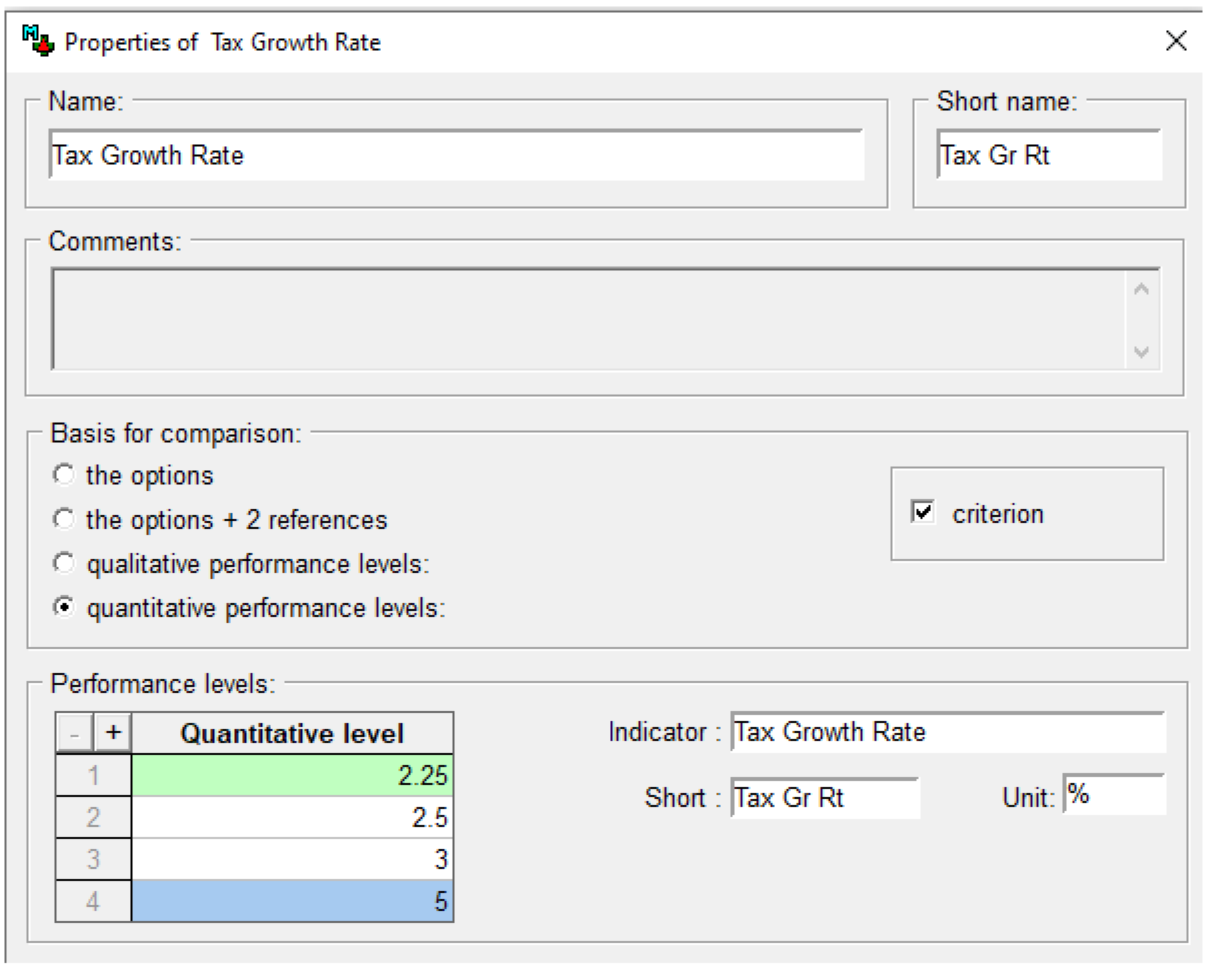


Figure 16: Properties of Tax Growth Rate

3.2.3 Revenue Recycling (%):

It refers to the percentage of revenue gotten from the Carbon Tax proceeds to be utilized in enhancing the economy and developing infrastructure and clean energy initiatives and technology.

The decision maker was questioned about his comparative framework and he decided that we are going to use a Quantitative one with comparisons named" good and" neutral" where

Good = 84%

Neutral = 23%

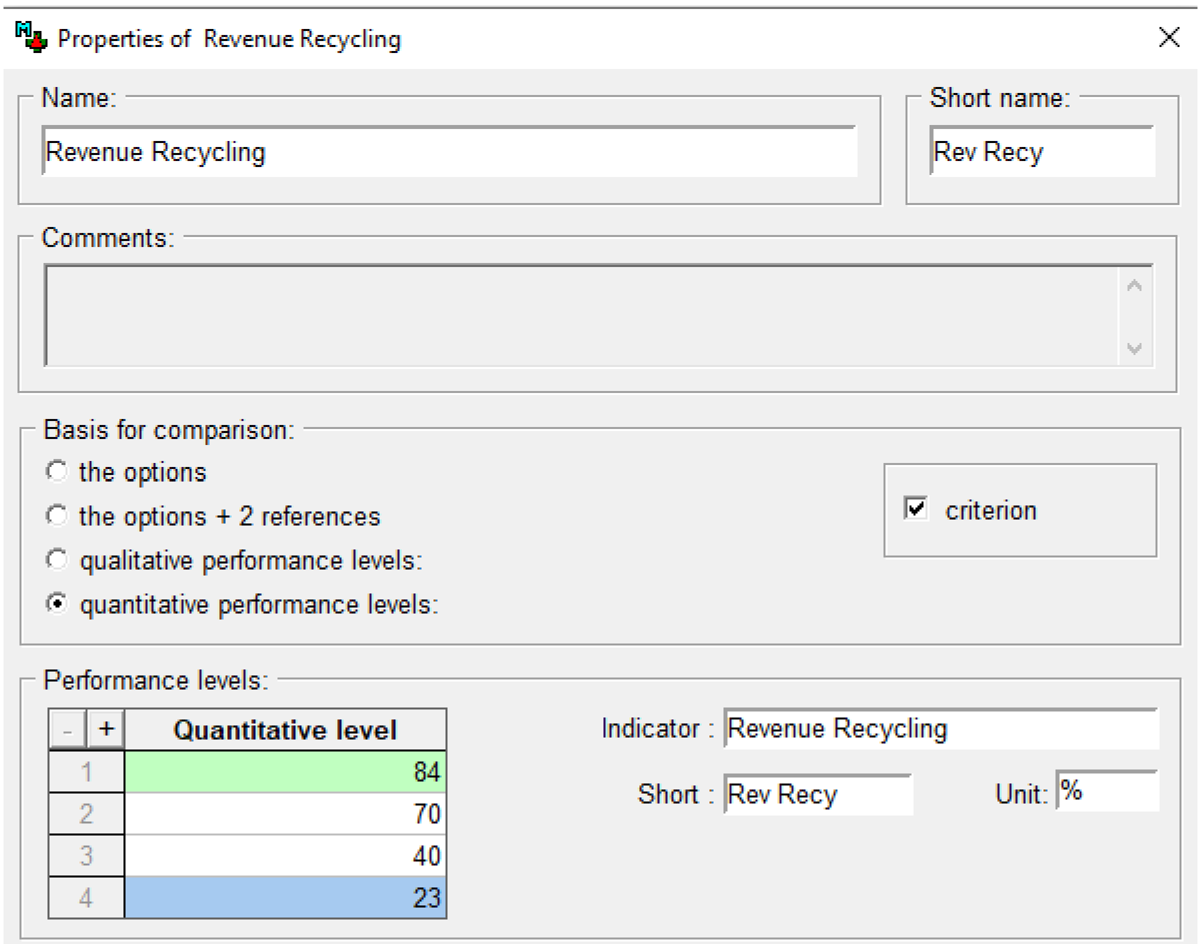


Figure 17: Properties of Revenue Recycling

Table of Performance

Table of performances

Options	Ini Tax	Tax Gr Rt	Rev Recy
Mar choice	35	5	70
Rev Wages	40	2.5	84
Clim Reb	15	2.25	40
Cus Des	10	3	23

Figure 18: Table of Performance

3.3 ADDITIVE VALUE MODEL

3.3.1 Attractiveness Judgements

To translate performance into value function M-MACBETH sets 2 reference point i.e. upper reference labeled good and lower reference designated neutral.

Our DM was asked to define good and neutral reference level to the performances in each criterion. The process to get the value function for Performances on each criterion required that Our DM makes qualitative judgments in quality judgment matrix in order to account or measure the difference of attractiveness between options. This is indicated in the pictures below:

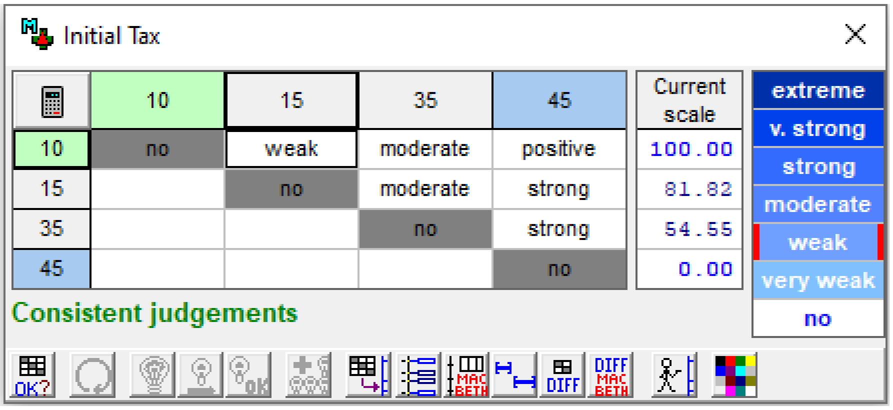
Tax Growth Rate

	2.25	2.5	3	5	Current scale
2.25	no	weak	moderate	strong	100.00
2.5		no	weak	positive	77.78
3			no	strong	55.56
5				no	0.00

extreme
v. strong
strong
moderate
weak
very weak
no

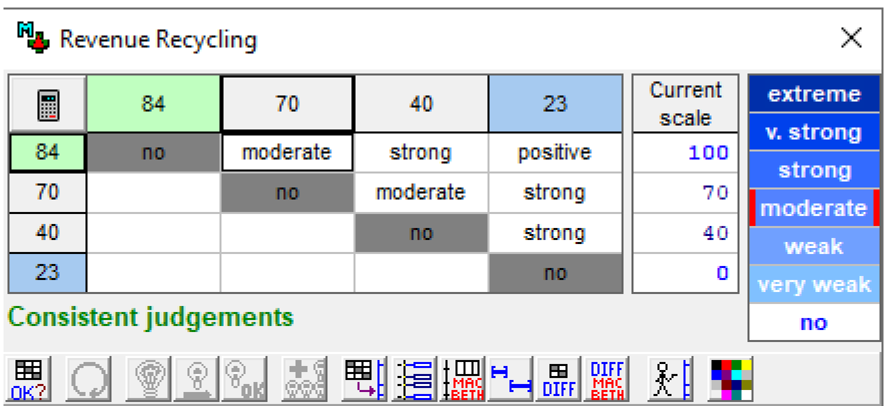
Consistent judgements

Figure 19: Judgement on Tax Growth Rate



	10	15	35	45	Current scale
10	no	weak	moderate	positive	100.00
15		no	moderate	strong	81.82
35			no	strong	54.55
45				no	0.00

Figure 20: Judgement on Initial Tax



	84	70	40	23	Current scale
84	no	moderate	strong	positive	100
70		no	moderate	strong	70
40			no	strong	40
23				no	0

Figure 21: Judgement on Revenue Recycling

3.4 VALUE SCALE

After generating the judgment matrix as above, M-MACBETH was used to develop a value function/scale for every criterion as indicated below.

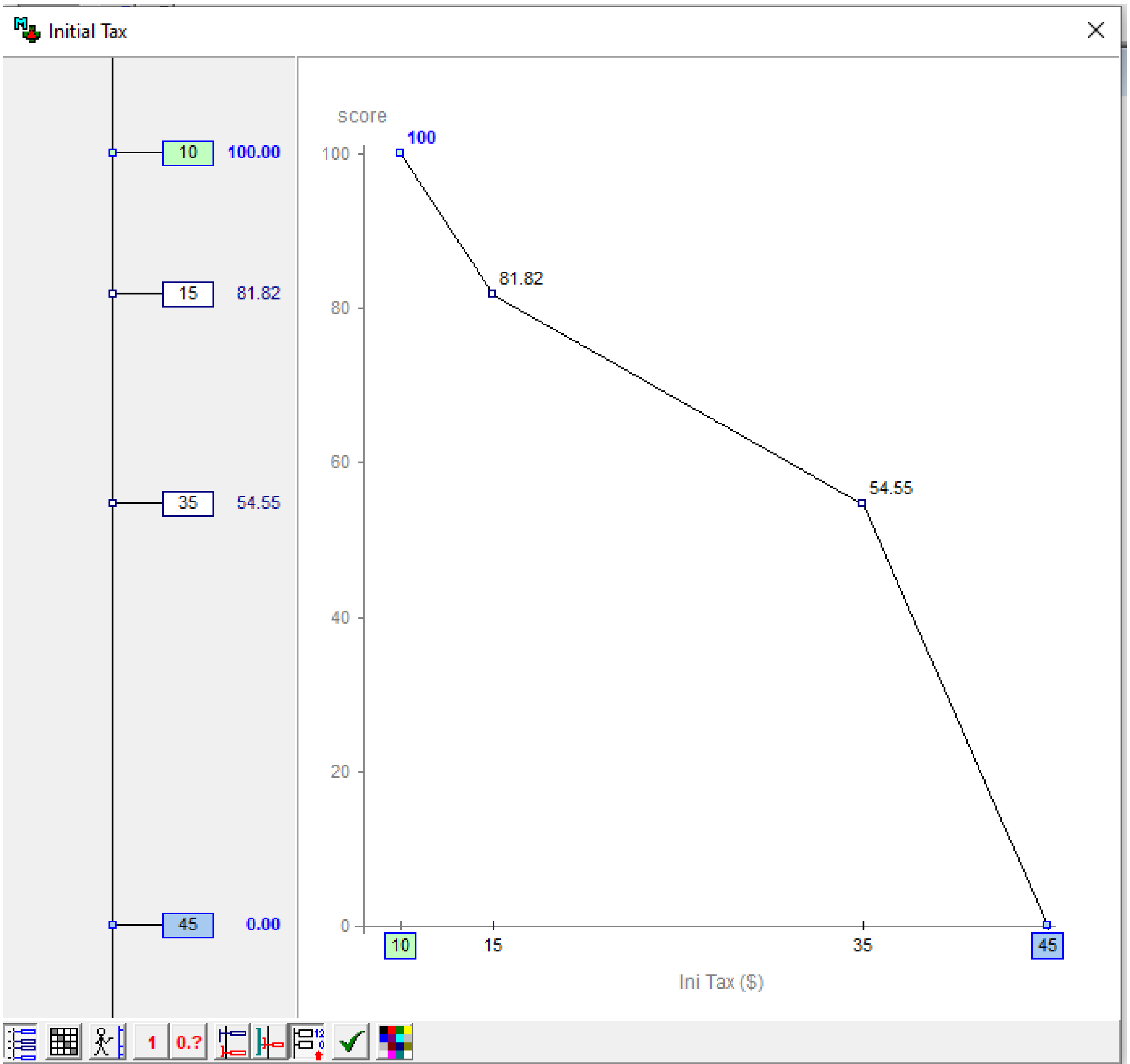


Figure 22: Value Function on Investment cost

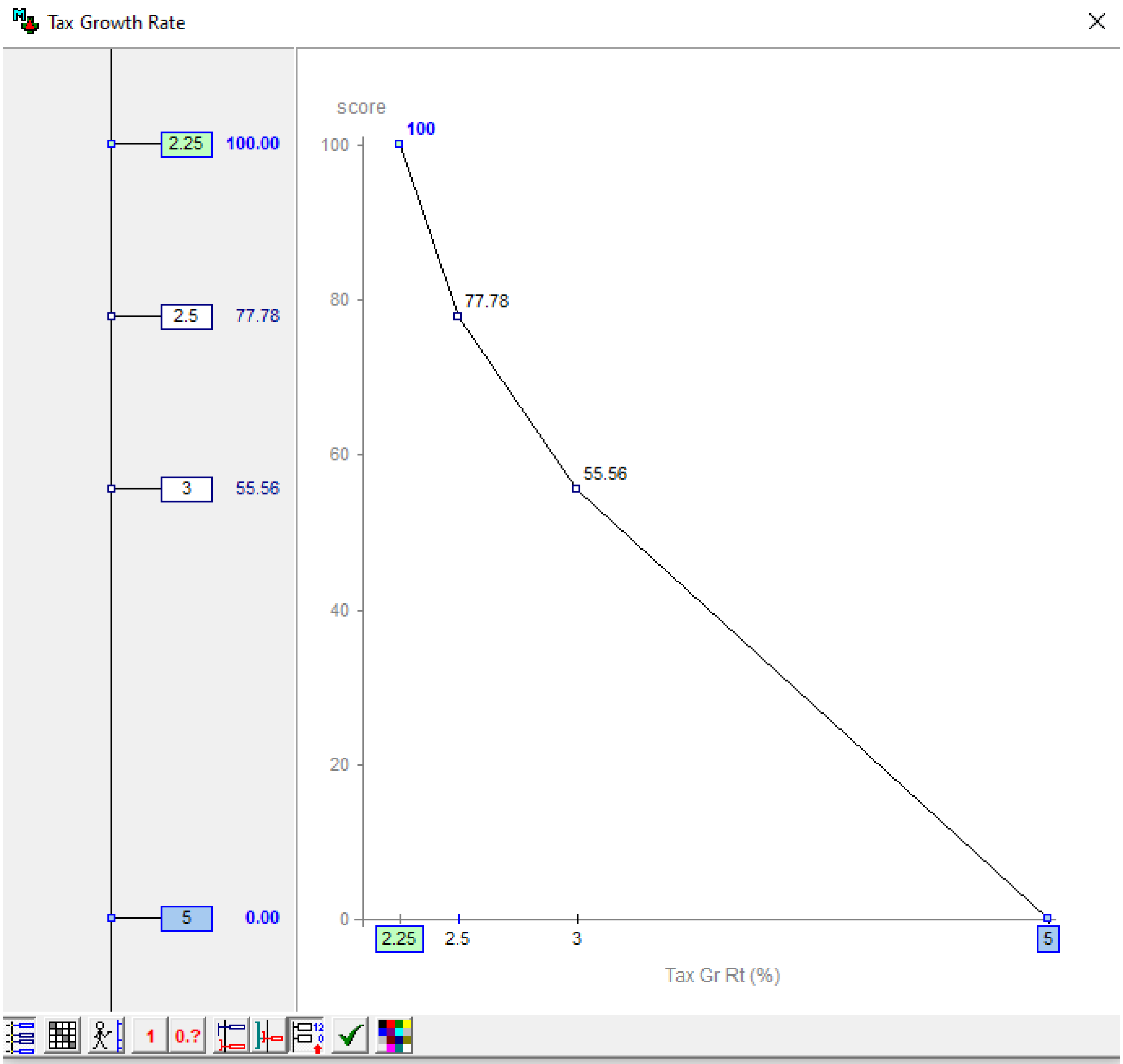


Figure 23: Value Function on Tax Growth Rate

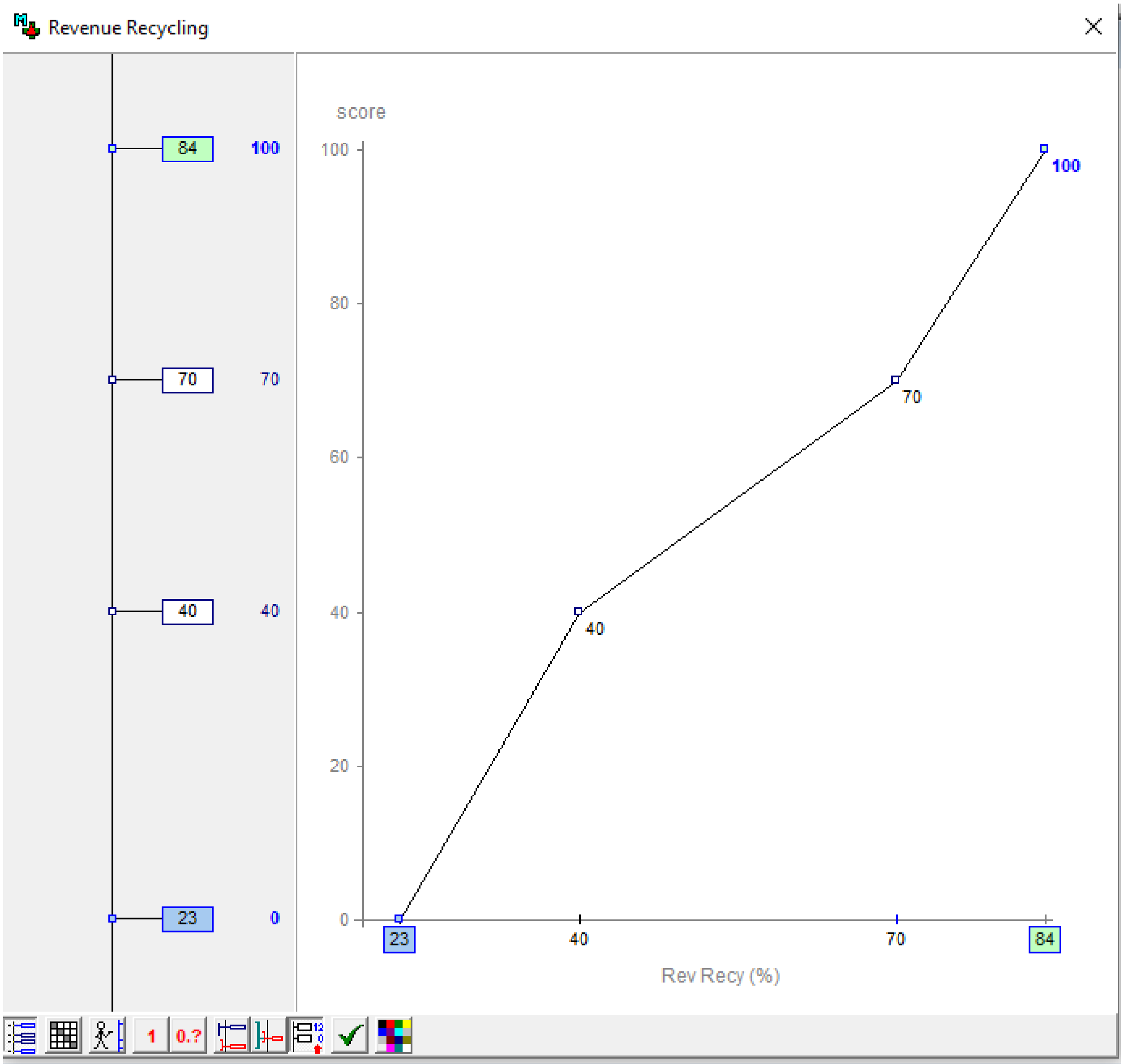


Figure 24: Value Function on Revenue Recycling

3.5 WEIGHTING COEFFICIENT

The DM ordered his points of view in terms of a descending importance of swing from lower reference level to high reference level and then made qualitative judgement of attractiveness.

MACBETH determined the weights of the criteria while the DM made a qualitative judgment input so as to measure the difference of attractive between each pair of criteria.

Once the quality judgments matrix is done, the consistent weight of criteria is done by MACBETH and Cross checked with the decision maker. It is of importance that the calculation based on the representation sum of all criteria weight should sum up to 100.

The judgment matrix and the weights calculated are indicated below:

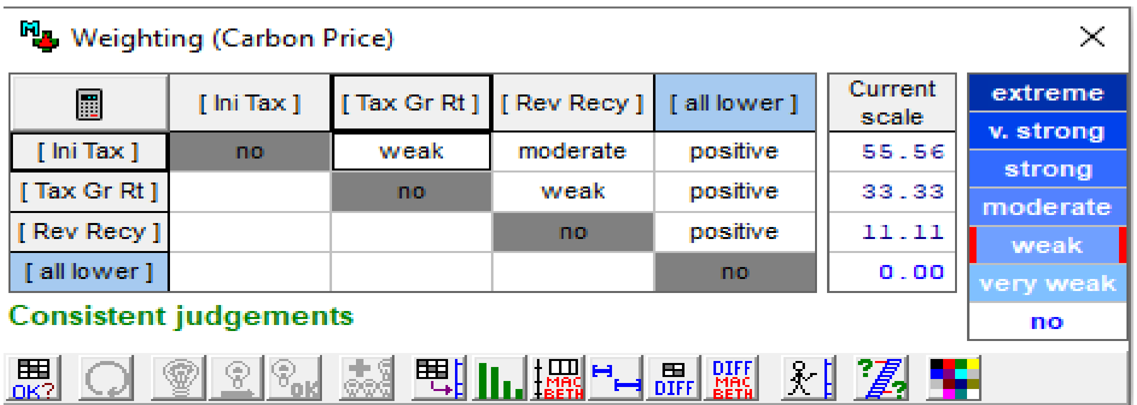


Figure 25: Weighting of Options

M-MACBETH indicated weights for criteria, the decision-maker cross-checked and final weights is shown below and also the overall performance of options.

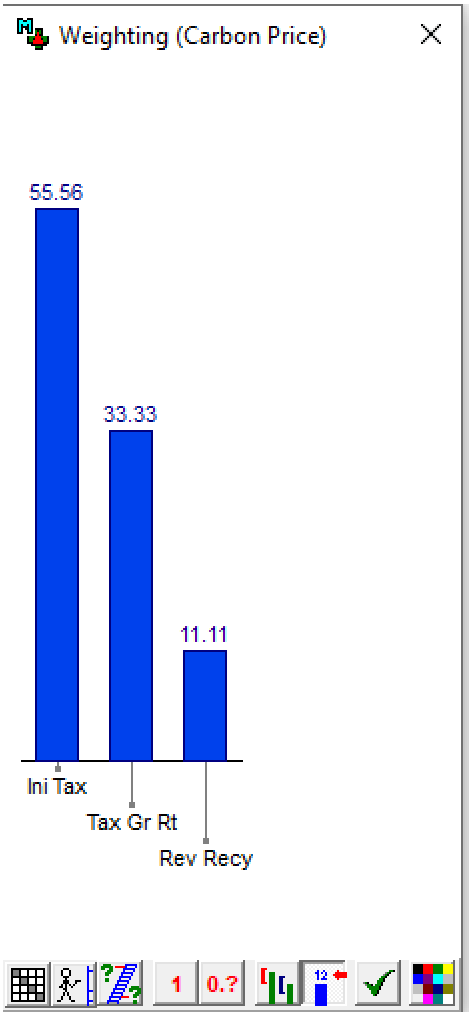


Figure 26: Validation of Weights

3.6 Overall Performance of Options

The figure indicated below highlights the overall value score of the model. M-MACBETH calculates the overall score of the options via an additive model i.e. overall summation of the multiplication of partial value scores of options on each criteria and weight of the criteria

Table of scores

Options	Overall	Ini Tax	Tax Gr Rt	Rev Recy
Mar choice	38.08	54.55	0.00	70.00
Rev Wages	52.19	27.28	77.78	100.00
Clim Reb	83.23	81.82	100.00	40.00
Cus Des	74.08	100.00	55.56	0.00
[all upper]	100.00	100.00	100.00	100.00
[all lower]	0.00	0.00	0.00	0.00
Weights :		0.5556	0.3333	0.1111

Figure 27: Table of Scores

The row ''All Lower'' refers to the overall reference whose performances on all criteria are equal to their lower references. The ''All upper'' indicates the overall performance whose performances on all criteria are equal to the upper reference. They are both benchmarks of intrinsic overall attractiveness (Carlos A. Bana e Costa 2005).

The model results of the table of scores can be comprehensively explained by using a difference profile which helps to explain the differences in the scores of any two of options. If we do a comparison between two options, we can identity a positive difference (Indicated in green) which shows the criteria for which the first option outperformed the second option. Alternatively, a negative contribution indicated by the red bar below highlights the criterion for which the second of the selected option outperformed the first.

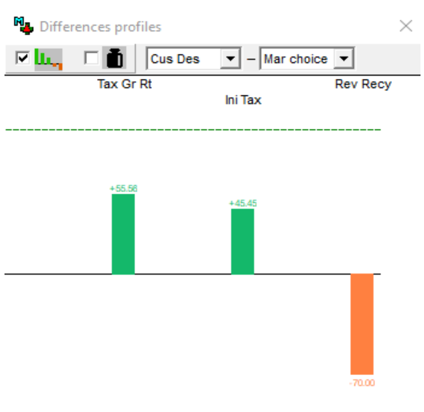
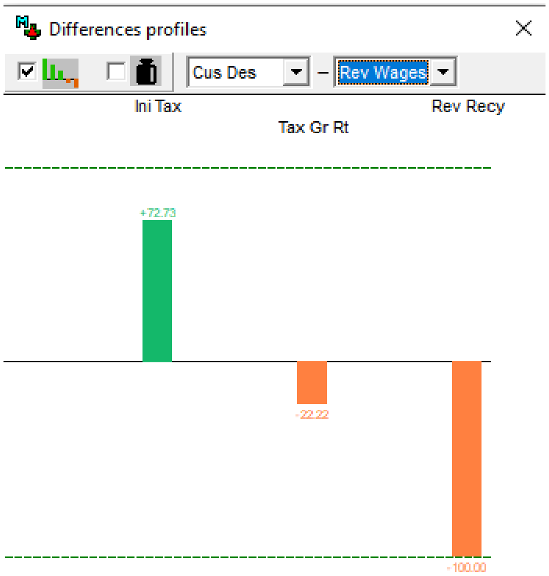


Figure 28 Custom design vs Market Choice

In the above figure for example, comparing the custom design and the Market choice, we can see that the custom design outperformed on the Tax growth rate and Initial Tax criteria but not in the Revenue recycling.



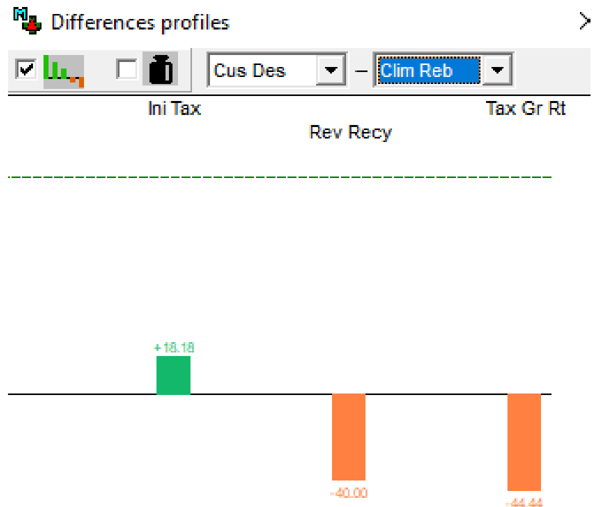


Figure 29: Custom Design vs *Rev Wages*

Figure 30 Custom Design vs Climate Rebate

Comparing the Custom design and the revenue wages, we can see that the revenue wages act outperformed custom design for Tax growth rate and Revenue recycling criteria and also same when we compare custom design and climate rebate act. One thing is constant, the Custom design outperforms all options in terms of the Initial Tax rate which leads to the next phase of performing a sensitivity analysis.

3.7 SENSITIVITY ANALYSIS

A sensitivity analysis is done in order to see if there Is a difference in the ranking order of the overall performance of the options when there is a change in the weight.

The analysis takes into consideration moments where the maker of the decision has some form of reservation or uncertainty regarding the judgment verdict given on the criteria. Hence, sensitivity is done on the best and second-best options

The Figure below indicates the sensitivity analysis on Initial Tax

We can see a slight imprecision will not ultimately affect the best option as the current weight indicated is 55.56. However, when the weight is 70.4, there occurs a change and at this point the best option will the custom design.

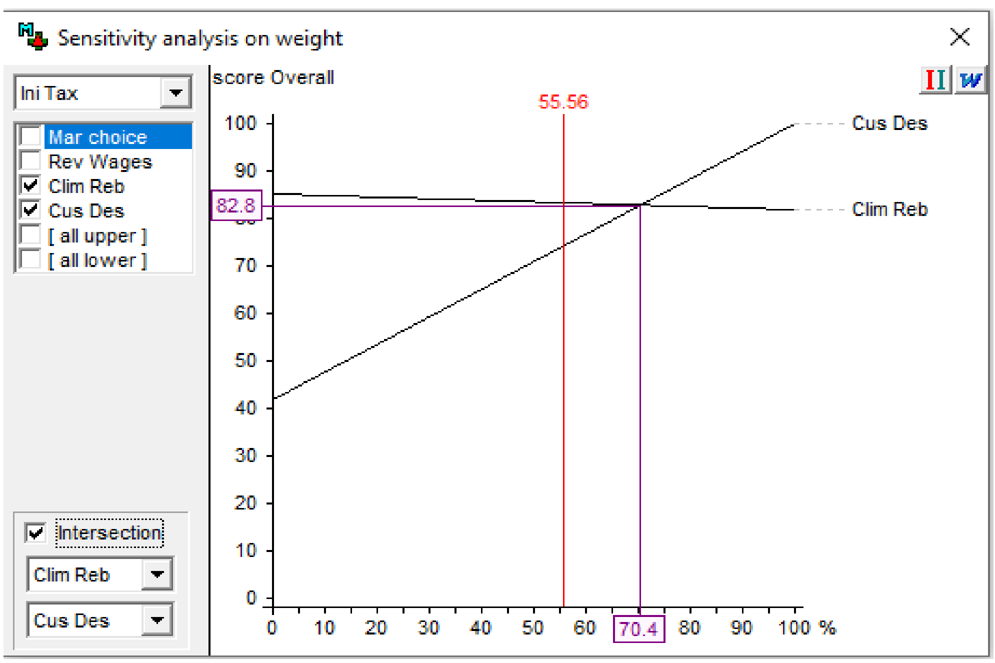


Figure 31 Sensitivity Analysis on Initial Tax

The sensitivity analysis on the Tax Growth Rate, we can see a slight imprecision will not ultimately affect the best option as the current weight indicated is 33.33. However, when the weight is 16.0, there occurs a change and at this point the best option will the Custom Design.

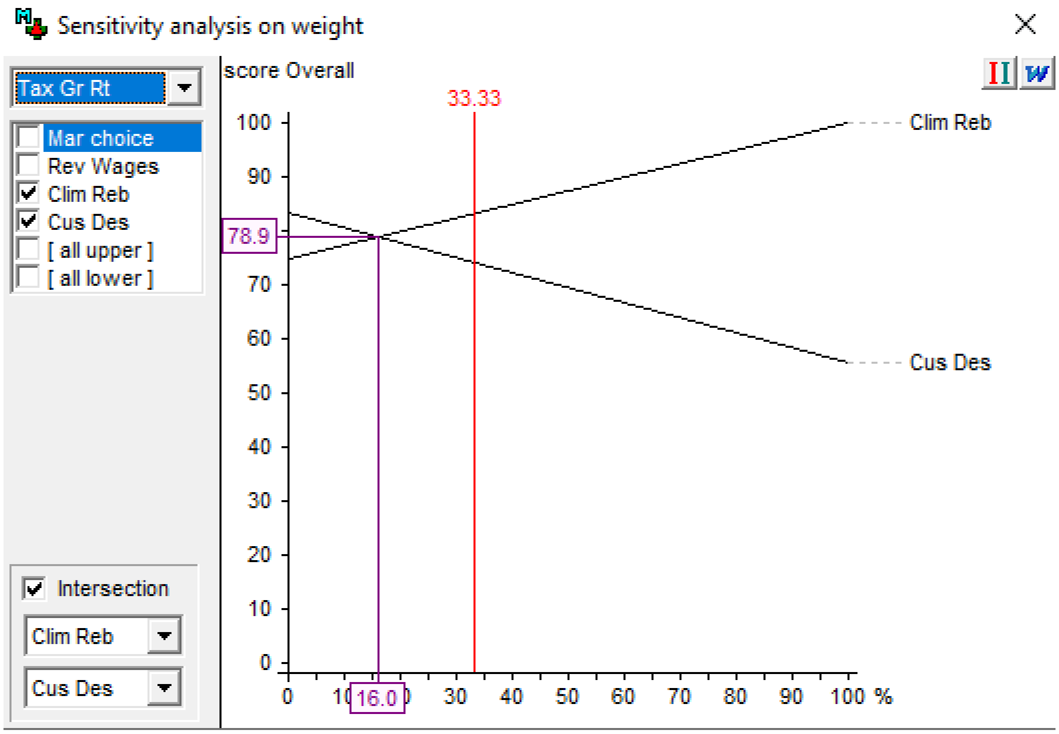


Figure 32 Sensitivity Analysis on Tax Growth Rate

The sensitivity analysis on the Revenue recycling, we can notice that option Climate Rebate does not intersect with the Custom design no matter the weight of the criterion which is indicated in the figure below. It can then be said, that the option Climate Rebate dominates the Custom design.

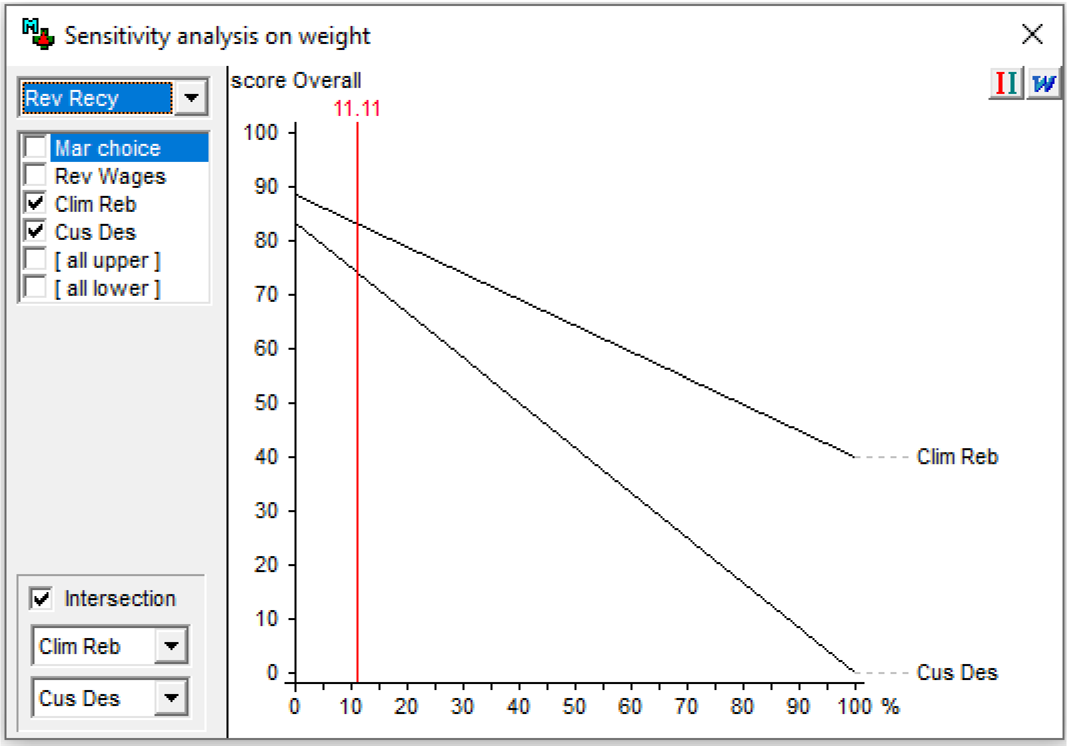


Figure 33 Sensitivity Analysis on Revenue Recycling

4. Recommendation and Conclusion

To summarize this study, 4 Carbon pricing policies were studied, The cut carbon, Market choice, Climate Rebate and Custom design approach. The main objective was to study which policy works best for the oil and gas industry in Nigeria considering no prior carbon pricing policy has been fully developed in Nigeria.

The tools used were the Carbon pricing calculator developed by the Carbon Pricing initiative, which enabled us compare the projection of each policy in terms of Initial Tax, Tax growth rate and revenue recycling for a period of 2020 to 2034. The other tool used was the Multicriteria decision analysis tool MACBETH developed by Professor Carlos Antonio Bana e Costa in collaboration with Professor Jean-Claude Vansnick and Dr. Jean- Marie De Corte, from the Universit´e de Mons. The used helped the decision maker (Basumoh Nig Ltd, and oil and gas company in Nigeria) to make qualitative and quantitative judgement about the 4 different policy options based on the same criteria used in results for the carbon pricing calculator projections initially developed.

From the result using the Carbon Pricing calculator, we observed that the long term projection of the custom design is better considering especially as it relates to the initial tax required for the beginning of the process and also to encourage players in the industry to develop more carbon efficient technologies and innovate within that space. Achieving the goal of climate and financial advantages will require that **Nigeria** follows the trend of starting with a low carbon tax and increasing it by a certain percentage per year.

It gives room for companies especially in the oil and gas industry to adjust to the new tax and also helps motivates them to support and implement cleaner technologies. (Morris 2016) argues that starting with a higher carbon price will lead to a drastic increase in the price of fossil fuel and stretch the limit of the existing capital which will lead to reluctance both politically and industry wide.

Using the MACBETH approach, even though the climate rebate policy had the best overall score in terms of options , we observe that by doing a sensitivity analysis on the best two options with the overall score(Climate Rebate and Custom design) we observe that a slight change in the weight shows that the custom design is also a better choice.

From the results of the difference table, we can see that the initial tax criteria outperformed all other criteria for the difference option and this was raised by the Decision Maker. Hence from the result of the sensitivity analysis which addresses and visualizes the extent of the result of the model will change as a result of the criterion weight.

From the result of the sensitivity analysis, comparing the two options with the best scores (Climate rebate act and Custom design) for criteria ''Initial Tax Rate'' when the weight shifts from 55.56 to 70.4, there occurs a change and at this point the best option will the custom design. The sensitivity analysis on the Tax Growth

Rate indicates that a shift 33.33 from 16.0, there occurs a change and at this point the best option will the Custom Design.

It is therefore recommended that in order for Nigeria to play a leading role in enforcing carbon efficiency and investing in carbon efficient technologies, it is necessary to enforce and adopt the right energy prices as the prices of the conventional energy used today is not a correct reflection of the production cost and also does not take into consideration the cost on the environment.

It is also important to ensure that revenue gotten from the energy carbon pricing adopted should be used in investing in renewable energy technologies such as increase in use of solar energy technology as also helping to reduce tariffs on such renewable technologies

It is also highly recommended that more awareness is done for enlightening the communities, private companies and the civil society on the need to adopt correct carbon prices, technologies and holding energy companies accountable for ensuring that we reduce our carbon emission levels as a country.

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