

PAGE

policy analysis on growth and employment



Assessing the macroeconomic impacts of the financing options for renewable energy policy in Nigeria: Insights from a CGE model

RESEARCH PROPOSAL

Presented to

Partnership for Economic Policy (PEP)

By

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NIGERIA

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Before you begin

Please make sure to carefully review and understand the following

- [Webpage](#) – especially with regards to the PAGE priority themes and
- [Guidelines](#) – for designing a research project proposal (in scientific terms)
- [PEP requirements and strategy](#) for policy engagement and research communication

Please note that :

- This template is mandatory for proposals of projects submitted under the [PMMA](#) and [MPIA](#) groups, i.e. that do not involve data collection
- Plagiarism is strictly forbidden – see note on “references and plagiarism” at the end of this document/template. PEP will be using a software program to detect cases of plagiarism.
- PEP encourages applicant research teams to submit proposals in English, but content (in text boxes below) may also be written in French or Spanish (and will be accepted given proper justification of language barrier).

There are three main areas/dimensions to all PEP-supported projects: capacity building, research and policy engagement. Each dimension must be considered with due care and attention, as they will be assessed individually and concurrently to determine the overall quality of a proposal.

The PEP proposal template is structured in five sections, as follows:

- Project overview and objectives
- Capacity building – team composition and experience
- Research – literature review, method and data
- Policy relevance and engagement strategy
- Other considerations

SECTION I – PROJECT OVERVIEW & OBJECTIVES

1.1. Abstract (max 100 to 250 words)

The abstract should state the main research question, the context and its relevance in terms of policy issues/needs in relation to PAGE priority issues. Complete with a brief description of the method and data that will be used.

Climate change is a major challenge for the world today. Though its effects cut across all countries, developing countries are the most vulnerable. CO₂ emissions from the combustion of fossil fuel energy resources is the major cause of anthropogenic climate change, and the solution requires transitioning from conventional fossil fuel to clean and renewable energy sources in line with the Paris Climate Agreement and the United Nations' Sustainable

Development Goals (SDGs). As a result, several countries, including Nigeria, have formulated renewable energy and related environmental policies aimed at increasing the share of renewable energy in total energy use. Given that Nigeria is an oil and gas producing and exporting country and the electricity sector is currently dominated by hydro and natural gas power energy, it is important to understand how the renewable energy policy affects the macro-economy and other development outcomes. Thus, this study seeks to answer the question: What are the macroeconomic impacts of Nigeria's renewable energy policy? We will simulate the macroeconomic impacts of the policy, focusing on GDP, welfare, employment and other macroeconomic indicators. In terms of methodology, we will apply a CGE model to calibrate Nigeria's Social Accounting Matrix (SAM) in order to simulate the impact of the financing options for renewable energy. The results of this study will help the government in coordinating and harmonising its renewable energy policy options.

1.2. Main research questions and contributions(max 500 to 700 words)

Explain the focus (or key questions) of your research and its policy relevance. Explain why you think this is an interesting research question and what the potential usefulness and value added of your work might be - in terms of both (general) knowledge gaps and policy needs for evidence base.

The literature review shall be detailed under "Research" (section III), not in this section.

Climate change mitigation is a key global development agenda and requisite for the attainment of the United Nations' Sustainable Development Goals (SDGs), and a major part of this effort is the decarbonisation of the energy system. This entails shifting energy consumption from cheap emission-intensive fossil fuels such as coal, oil and gas to relatively expensive clean and renewable energy such as wind, solar, biomass and nuclear energy sources. Given the crucial relationship between energy consumption and the economy, various studies have been conducted on the economic impacts of renewable energy policies and adoption. Nigeria, on her own part, formulated the National Renewable Energy and Energy Efficiency Policy (NREEEP), and our research will be the first comprehensive analysis of the macroeconomic impacts of the policy, within a computable general equilibrium framework.

The broad research question in this study is: Will transitioning from fossil fuel to renewable energy have negative or positive effects on the macro-economy? The specific question is: Given the high cost of renewable energy relative to conventional fossil fuel, how would policies aimed at promoting renewable energy affect GDP, sectoral structure, employment, investment, income, trade and fiscal position?

Studies have been conducted on the impacts of renewable energy policy and adoption in different contexts. Majority of the existing CGE-related studies in the literature, such as Dai et al (2013), Bohringer et al (2012, 2013), Ge and Lei (2017) and Wianwiwat and Asafu-Adjaye (2013), focus on non-fossil fuel dependent countries and mostly on developed countries while studies on fossil-fuel dependent countries are rare. While these studies would provide an overview of the macroeconomic impacts of renewable energy policy, it will have differential effects within and between countries due to differences in the type and nature of renewable energy policy, structure of the economy, and technology advancement. Nigeria is a special case in this regard due to the heavy reliance of her economy on fossil fuel production. Therefore, it is crucial to examine the economy-wide impacts of renewable energy policies in Nigeria. This study will

contribute to the literature on renewable energy policy by analysing the policy instruments of the NREEEP.

Also, this study will mimic the electricity supply situation in Nigeria by considering own production of electricity from fossil-fuel based power generators. According to the World Bank's Enterprise Survey, about 60% of total electricity generation in Nigeria is self-generation and incorporating this into the model is important for describing the situation of electricity supply. Hence, unlike previous studies in the literature, our research will consider own production of electricity in the modelling and analysis.

In terms of policy, the findings of this study will be important for policy making and planning. Unlike most previous research that examines the effect of renewable energy and environmental policies on climate-specific targets, this study specifically contributes to the understanding of the macroeconomic impacts of Nigeria's renewable energy policy. Nigeria, like many other developing countries, seeks to balance economic development and environmental goals and make substantial simultaneous progress on the SDGs. The study would provide more clarity on the "double dividend" hypothesis – positive effects on both the environment and economic development/livelihoods - of renewable energy policies. By understanding how this renewable energy policy will affect the macro-economy and other development outcomes, the Energy Commission of Nigeria, the Ministry of Power and other government agencies would be in a better position to formulate energy policy that supports the country's economic development goals. More so, the current renewable and environmental policies in Nigeria are not supported by enabling legislations. In enacting legislations to support Nigeria's efforts towards sustainable development, the findings of this study will also be handy for the National Assembly Committees on Power and Environment.

In addition, some developed countries and the international community have committed to providing financial and technical supports to developing countries to implement climate mitigation policies through instruments such as Global Climate Fund and bilateral support mechanisms. Understanding the economy-wide impacts of renewable energy policies and any potential trade-offs among development outcomes will aid domestic planning and provide a reference on the nature of domestic and external supports required to implement the policies. This study will provide evidence on the impact of renewable energy policy on Nigeria's economy and this would serve as a basis for how the international community will support Nigeria's transition.

SECTION II – CAPACITY BUILDING

2.1. Team composition and experience

For each research team member, please indicate (using the following tables – one per member):

1. **Age, sex, as well as relevant/prior training and experience** in the issues and research techniques involved (start with team/project leader).
 - Note that PEP favors gender-mixed teams, composed of a maximum of four (4) members, at least 50% female researchers, and at least two (2) junior researchers (aged under 30), all contributing substantively to the research project. PEP also seeks

gender balance in team leaders and thus positively encourages female-led research teams.

- Each listed member must post an up-to-date CV in their profile on the PEP website – refer to “How to submit a proposal” on the call’s [webpage](#).

2. Benchmark and expected capacity building:

- Describe the research capacities that each team member (and potentially her/his affiliated institutions) is expected to build through their participation in this project. This is an important aspect in the evaluation of proposals and should be presented in detail.
 - What techniques, literature, theories, tools, etc. will each team member and her/his institutions learn (acquire in practice) or deepen her/his knowledge of?
 - How will these skills help each team member in their career development?
 - What are the current state of knowledge of each team member in regard to the project you are proposing?

3. Task and contributions to project: Indicate the specific tasks each team member would carry out in executing the project.

- Note that one of the team members must be clearly identified as responsible for coordinating and reporting on the design/implementation of the projects’ policy engagement and communication strategy (see section III below). To achieve a more balanced task distribution, PEP advises to select a member other than the project leader.

Team leader

Name	Age	Sex (M, F)	Highest degree/diploma
Oluwasola Emmanuel Omoju	32	M	Ph.D. Economics (Energy Economics)
Training and experience	I am research fellow in the Department of Research and Training of the National Institute for Legislative and Democratic Studies (NILDS). I have a doctorate degree in applied economics with specialisation in energy economics from Xiamen University in China. My Ph.D. research focuses on the economic drivers of carbon emissions and renewable energy transition in developing and emerging countries. I am an experienced researcher with over seven years of research experience. I had visiting researcher positions in Austria and France, where I worked on energy systems modelling and computable general equilibrium (CGE) modelling. The findings of my research have been presented in international conferences and I have published over twenty papers in peer-reviewed journals. I am skilled in the subject matter and techniques/methodology of the proposed research.		
Expected capacity building	I am currently verse in both the subject matter and techniques of the proposed research. The project would enable me to improve my knowledge of CGE models and		

	<p>the application to my field of research. Working with a team comprising of a labour economist, development finance expert and a gender economist would broaden my knowledge of the link between my research field (energy economics) and other field of economics, facilitating multi-disciplinary competence. I will gain a broader theoretical and empirical understanding of how energy policies affect development outcomes, especially welfare, employment and gender. Participating in the project will have immediate impacts on my career and future research agenda as well as my capacity to influence policies in my current position. In the near future, I see myself as a tenured faculty member and policy researcher, sharing my passion for economic research both in the classroom and as part of an active research program. I hope to draw on my knowledge and experience during this project implementation, and also pass on those knowledge to others. While the details of my future career and research are likely to evolve over time, I am convinced the knowledge from the project would be valuable.</p>
Contribution to project	<p>This project is the idea of all the team members. However, I would be responsible for building the CGE model and executing the policy scenarios in GAMS.</p>

Team member #2

Name	Age	Sex (M, F)	Highest degree/diploma
Emily Ikhide	34	F	M.Sc. Economics; Ph.D Development Finance (in view).
Training and experience	<p>Emily is currently a research officer at the National Institute for Legislative and Democratic Studies and Ph.D. candidate in development finance at the University of Stellenbosch, South Africa. Before that, she bagged a Bachelor and Master's degree in Economics from the Universities of Namibia and Botswana. Her Ph.D. research focuses on development finance, with particular reference to the energy sector in sub-Saharan Africa. She has extensive research experience, including working as a researcher for the former Executive Governor of Ekiti State of Nigeria and current Minister of Mineral Resources.</p>		
Expected capacity building	<p>Emily's current research focuses on development finance, energy sector in sub-Saharan Africa, and rural development. Her methodological expertise is in econometric analysis. During her master's degree program, she took courses on advanced micro and macroeconomics and CGE modelling. Through this project, she will be able to apply her CGE knowledge to real life policy issues in the energy</p>		

	sector. This would enhance her capability in terms of her Ph.D. research, and she would pass the knowledge to colleagues and other graduate students in her program. As a result of the newly acquired knowledge and skills, she would be positioned to conduct further research in public policy analysis. In addition, the project would enhance her capacity to contribute more to her current position in the Public Finance and Macroeconomics Unit of the National Institute for Legislative and Democratic Studies. The CGE skills would enable her to analyse government fiscal policy and make recommendations to the parliament.
Contribution to project	Emily is versed in finance, econometrics, data analysis and gender issues. She will contribute extensively to the theoretical framework, literature review and discussion of the results of the project. Her vast experience in development finance would provide us with good background in development financing as it relates to renewable energy.

Team member #3

Name	Age	Sex (M, F)	Highest degree/diploma
Stephen Kelechi Dimnwobi	28	M	M.Sc. Economics
Training and experience	Stephen is a trained economist. He holds bachelors and master's degrees in economics and will be commencing his PhD studies in the new academic year. His master's degree is in human resource economics while his PhD research interests are situated in the link between energy, labour, gender and rural development. Particularly, Stephen is motivated in conducting research that can inform policy on rural development, women and youth empowerment, good governance, energy and environmental sustainability. His research has been presented in academic conferences and he has published over ten papers in Nigerian and international journals. He is a skilled data analyst and proficient in the use of basic data analysis software.		
Expected capacity building	Working with the other team members will broaden Stephen's knowledge, skills and experience. The project will improve his capacity in literature preparation and presentation and data management. Stephen is a potential Ph.D. candidate with interests in the intersection of energy, labour, gender and rural development, and the subject matter of this project would serve as a solid foundation for his Ph.D. research. More importantly, he would be exposed to public policy analysis and CGE modelling. This would enhance his methodological competence and stand him in good stead to make significant progress in his research. Currently, there is no single expert in public policy analysis using CGE modelling at the Nnamdi Azikiwe University,		

	where Stephen is affiliated; thus, the skills and knowledge from the project would be passed on to other graduate students and faculty members in the university.
Contribution to project	Stephen will contribute to the project in a number of ways. First, he would be responsible for conducting an extensive literature review for the project. Second, as a versatile data analyst, he will also contribute to the project via collection and analysis of survey data for eventual use for the disaggregation of the SAM.

Team member #4

Name	Age	Sex (M, F)	Highest degree/diploma
Ms. Onogweshia Augustina Ehimare	26	F	B.Sc. Economics; MSc. Economics (in view)
Training and experience	Augustina holds a Bachelor of Science degree in Economics from Anambra State University (now Chukwuemeka Odumegwu Ojukwu University) in 2014. She graduated top of her class with a 1 st class honours. She is currently a graduate research student (Master's degree in economics) at the University of Nigeria, Nsukka. Her areas of research interest include international economics, gender and welfare economics. She had a brief stint as a personal assistant to the Head of Entrepreneurship and Business Studies Department of Federal University of Technology, Minna, Niger State.		
Expected capacity building	With no practical research experience, Augustina seeks to kick-start her academic development and research career with her participation in this project. She is eager to learn new economic tools, techniques and methodology. This project will get her acquainted with both the theoretical and practical aspects of public policy analysis and CGE modelling and she would also be inspired and benefit from PEP human capacity trainings and conferences, associated with the project.		
Contribution to project	Augustina has very good background in economic theory and econometrics and her skills would be instrumental to the success of this project. Specifically, she would contribute to the project in the area of survey data sourcing to be used for the disaggregation of the SAM, as well as in the literature search and review for the project.		

2.2. List of past, current or pending (non-PEP) projects in related areas involving team members, including resulting publications (If any)

Name funding institution, title of project and related publications, list of team members involved.

SECTION III – RESEARCH

3.1. Literature review (max 1000 to 1500 words)

Explain specific gaps in existing literature that your research aims to fill. You might want to explain whether or not this question has been addressed before in this context (including key references), and if so, what you wish to achieve (in addition) by examining the question again?

The economic implications of renewable energy policies are important research priorities, due to the crucial link between energy consumption and economic growth. The current studies examining the subject use methods ranging from reviews (Boluk, 2013), econometric analysis (Silva, et al., 2012; McKittrick, 2013; Hillebrand et al., 2006), primary data analysis (Sastresa et al., 2010) to macro-econometric modelling (IRENA, 2016; Ragwitz et al., 2009). While these studies are diverse in methodological approach and case study, the major limitation is that they narrowly focus on a single economic indicator such as GDP and employment and fails to capture economy-wide effects and sectoral interactions and changes. This shortcoming is noteworthy given Tavoni et al. (2015)'s assertion that environmental policies would cause changes in sectoral demand and composition. Also, most of the studies are based on developed countries analysis and may not be suitable for formulating policies for developing countries.

To overcome the key limitations mentioned above, CGE models are used to estimate the macroeconomic effects of renewable energy policies due to the economy-wide effects of energy policies. Dai, et al. (2016) analyse the economic impacts of large scale renewable energy development in China. Under the moderate scenario, non-fossil fuel and renewable energy sectors experience increased value added and job creation while fossil fuel and energy intensive sectors experience negative growth and job losses. There is a negative economic impact under the drastic growth scenarios as GDP and household consumption reduce by 0.3-1.5%. The study however has some key limitations, which our study on Nigeria will address. First, it fails to incorporate foreign trade of renewable energy technologies. This is particularly important given that China has the largest market and is a global player in the renewable energy technology market. Second, it only analyses the economic impact at the national level, ignoring that the policy might have different regional effects. Our study will capture trade in renewable energy technologies and investigate both national, regional and rural/urban impacts of renewable energy policy.

Bohringer, et al. (2012) also employ a multi-sector and multi-region CGE model to evaluate the employment impacts of Ontario's feed-in-tariff program. The study concludes that there is an overall net employment loss, as positive effects on jobs in the renewable energy and manufacturing sectors are offset by job losses in other sectors of the economy. In another study, Bohringer, et al (2013) analyse the impact of renewable energy promotion on employment and welfare in Germany using CGE analysis. They simulate the impact of subsidized renewable energy electricity production and find that any positive effects on employment and welfare are limited and depends on the level of subsidy rates and financing mechanism; and there are negative welfare and employment impacts if renewable energy subsidies are financed by labour taxes. On the contrary, they find a minor positive effect if an electricity tax is imposed to finance renewables, but these positive effects becomes negative after the subsidy rates exceeds some threshold values. In a similar study to our proposed work on Nigeria, Ge and Lei

(2017) investigate the policy options for non-grain bioethanol in China using an economy-energy-environment CGE model. The study categorizes the policy incentives into five scenarios and compares the impact on the macroeconomy, energy consumption and CO₂ emissions. Another study that looks at a specific renewable energy source (Wianwivat and Asafu-Adjaye, 2013) examines the impacts of biofuel policy in Thailand using CGE model. They find that promoting biofuel leads to rapid increase in biofuel price and feedstock in the short run, but a slight increase in the long run. While Ge and Lei (2017) and Wianwivat and Asafu-Adjaye (2013) look at some of the questions we pose in this study, they only focus on biofuel policy. In the case of Nigeria, the government focuses on various types of renewable energy. Hence, our research will examine policies for the entire renewable energy sector, and not specific to a renewable energy type.

For Nigeria, studies on the economic impacts of renewable or environmental policies are rare. In IRENA (2016), Nigeria is one of the reference countries and the deployment of renewable energy has a negative effect on the GDP as a result of reduction in fossil fuel export. However, the deployment of renewable energy leads to increase in welfare by 0.5-1.1% depending on the scenario, coupled with a \$50 billion worth of fossil fuel import reduction. But this study estimates the welfare impact through changes in GDP. GDP is an inaccurate and inappropriate measure of welfare. Thus, in addition to estimating the impact of renewable energy policy on GDP, employment, trade, fiscal position and other macroeconomic indicators, our study will measure welfare changes from the effect on household income and consumption.

As seen in the literature, several studies have investigated the economic impacts of renewable energy and environmental policies. But there are still significant gaps in the literature. First, studies on the aggregate macroeconomic impacts of environmental and renewable energy policies in developing countries in general and Nigeria in particular are very rare. Since the formulation of renewable energy policies in Nigeria in 2003 up to the current National Renewable Energy and Energy Efficiency Policy initiated in 2015, there is no single study that has empirically investigated either its effectiveness or economic impacts. Most of the existing empirical studies in the literature focus considerably on developed countries such as OECD and EU countries, and their conclusions may not correspond to Nigeria or other developing countries. Nigeria depends on fossil fuel production and export for foreign exchange, government revenue and electricity generation; hence the macroeconomic and sectoral impacts of renewable energy policies will differ significantly from non-fossil fuel producing and exporting countries. Second, in the case of Nigeria and other developing countries, there is high level of own production of electricity from diesel and petrol-based generators (own production accounts for about 60% of electricity supply in Nigeria). But this is usually not considered by previous studies.

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- Boluk, G. (2013). Renewable energy: Policy issues and economic implications in Turkey. *International Journal of Energy Economics and Policy*, 3(2), 153-167.
- Dai, H., Xie, X., Xie, Y., Liu, J. and Masui, T. (2016). Green growth: The economic impacts of large-scale renewable energy development in China. *Applied Energy*, 162, 435-449.
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Ragwitz, M., Schade, W., Breitschopf, B., Walz, R., Helfrich, N., Rathmann, M., et al. (2009). The impact of renewable energy policy on economic growth and employment in the European Union. EmployRES Project report submitted to the European Commission.

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Silva, S., Soares, I. and Pinho, C. (2012). The impact of renewable energy sources on economic growth and CO₂ emissions - A SVAR approach. *European Research Studies*, 15, 133-144.

Wianwiwat, S. and Asafu-Adjaye, J. (2013). Is there a role for biofuels in promoting energy self-sufficiency and security? A CGE analysis of biofuel policy in Thailand. *Energy Policy*, 55, 543-555.

3.2. Methodology(max 1200 to 1600 words)

Presentation of the specific techniques that will be used to answer the research questions and how exactly they will be used to do so.

- Explain whether you will use a particular technique normally used in other contexts or whether you intend to extend a particular method and how you will do so.
- Explain if these methods have already been used in the context you are interested in (including key references).
- **For PMMA (microeconomic analysis) proposals only:** In case the proposed methodology aims to empirically estimate a causal relationship, explain potential sources of endogeneity in the context of your research, and how the proposed technique(s) would allow the identification of the relevant parameters.

The proposed method for achieving the objective of this study is the computable general equilibrium (CGE) modelling. CGE modelling uses a system of equations to model the economic behaviour of economic agents, and it has been increasingly employed to assess the macroeconomic, distributional and welfare impacts of energy policies (Kretschmer and Peterson, 2010). Since the aim of the study is to empirically investigate the overall macroeconomic impacts of Nigeria's renewable energy policy, this method is most appropriate because it is best for understanding the comprehensive economy-wide and distributional impacts of public policy (Nwafor et al., 2010). In addition to understanding the impacts of the policy instruments of the renewable energy policy, the CGE model will also show the direction and magnitude of the effects across all sectors, commodities, factors and agents. According to Tavoni et al (2015), emission-reduction expenditure costs are borne by the emission-reducing sectors, and they will lead to a reduction in output and international competitiveness of the sector via increase in production costs. On the other hand, the subsequent increase in the demand for emission-reduction goods will boost the output and competitiveness of the sectors producing them. Therefore, it is important to investigate the counteracting positive and negative

effects across sectors. The CGE model will estimate the effects of Nigeria's renewable energy policy on various macroeconomic and development indicators - macro, structural, price, trade, fiscal and labour market - simultaneously.

The PEP 1-1 and PEP 1-t models developed by Decaluwe et al. (2013), will be used as the reference CGE model in this research project. The PEP 1-1 model is a single-country static model. Unlike other CGE models, it separates capital and labour into several categories, and takes into account a broader set of tax instruments (Decaluwe et al, 2013). The PEP 1-t model on the other hand is a single-country recursive dynamic model. It extends the PEP 1-1 model by incorporating time dimension into the model. Hence, the impacts of the policy can be assessed over time. Given that Nigeria's renewable energy policy is a long-term policy whose implementation and impact will spread over a long period of time, the dynamic model PEP 1-t model will also be applied in this project. The PEP 1.1 and PEP 1-t CGE models will then be used to calibrate the SAM. The model will be implemented with the use of the GAMS software.

The original PEP model is a general CGE model, as such energy is not modelled as a production factor in it. But according to Lin and Atsagli (2017), there is significant evidence of substitutability between electricity and capital and electricity and labour in Nigeria. The study uses ridge regression to estimate a translog production function to investigate the potential for substitutability among factors of production and fuel types. Therefore, we will extend the PEP models to incorporate energy factor, following the works of Ge and Lei (2017) and Wianwiwat and Asafu-Adjaye (2011). In addition, self-generated electricity will be modelled into the CGE framework. The structure of the potential CGE model that will be used in the proposed project is shown in the figure 1 below.

A Leontief function is used to decompose output into intermediate consumption (excluding electricity), and value added and electricity. A constant elasticity of substitution (CES) function is used to disaggregate the value-added and electricity into labour and capital-electricity composite. Similarly, a CES function is used to determine the decomposition of electricity and capital. Furthermore, electricity is decomposed into self-generated electricity and government/utility-supplied electricity energy using a CES function. When there is no supply of electricity from the utility, people generate electricity on their own. Electricity supply from utility could be from fossil-fuel electricity producer or renewable electricity producer, and this is modelled through a CES function. However, the utility will purchase electricity from fossil fuel and renewable producers at different prices and sell at an average price to consumers. But electricity prices differ across the three consumer categories (residential, industrial and commercial). Therefore, the price changes for each category of consumer may be a key policy instrument.

Normally, to achieve climate change mitigation, the share of renewable electricity generation is expected to increase while that of fossil-fuel is expected to reduce (Lin and Omoju, 2017). But in the case of Nigeria, and as stated by the NREEEP, the government aims to develop both fossil fuel and renewable electricity simultaneously.

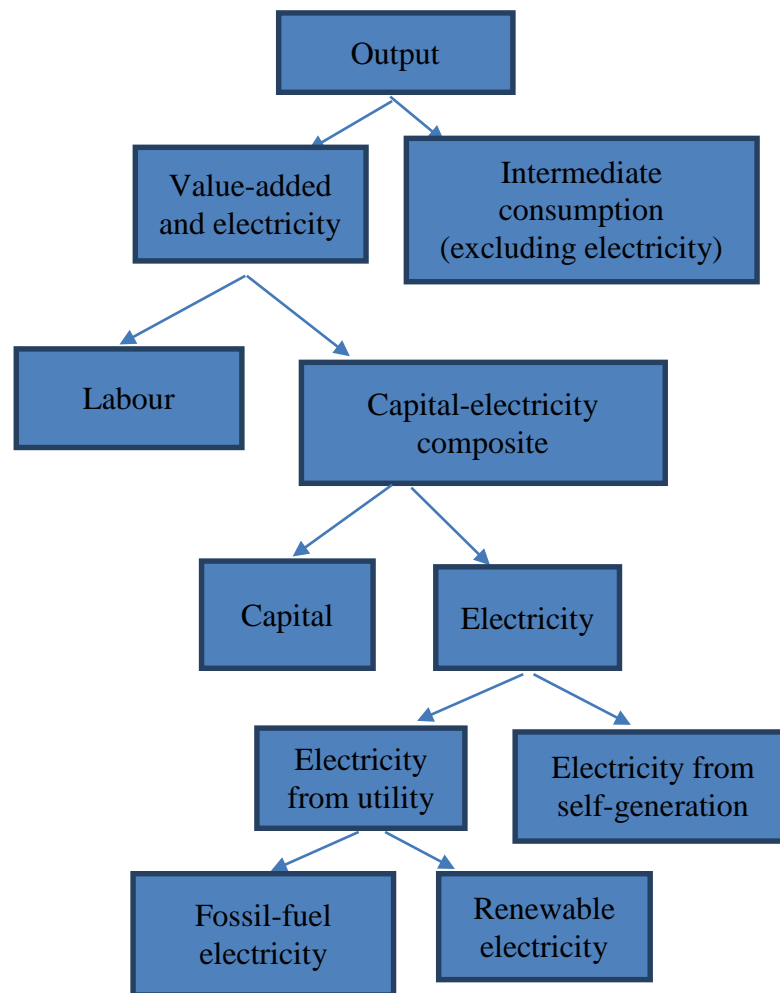


Fig. 1: Structure of the CGE model

Source: Ge and Lei (2017) and authors' extension

The Nigerian government's plan to promote renewable energy cut across all types of renewable energy and sets target for the medium (2020) and long term (2030). The summary of the renewable energy targets is shown in the table below.

Summary of renewable energy targets under the NREEEP

Renewable energy type	2012	2015	2020 (Medium term)	2030 (Long term)
Large Hydro	1938.00	2121.00	4549.00	4626.96
Small Hydro	60.18	140.00	1607.22	8173.81
Solar	15.00	117.00	1343.17	6830.97
Biomass	-	55.00	631.41	3211.14
Wind	10.00	50.00	57.40	291.92
Total	2023.18	2483.00	8188.20	23134.80
Share of RE in total (projected) electricity generation	23%	10%	18%	20%

The Nigerian government proposed numerous incentives and policy instruments to finance renewable energy. This include capital grants to renewable energy producers, tax holidays and rebates, subsidy for consumption of renewable energy, reduction of import/excise duties for import of the renewable energy sector, tax on fossil fuel producers, feed-in-tariff mechanism, financial support from international organisations and so on. The specific policy shocks that this research will simulate include:

- (i) increase in subsidy for the production and consumption of renewable electricity;
- (ii) increase in tax for fossil fuel electricity producer in the form of a carbon tax;
- (ii) Feed-in-tariff mechanism (simulation of increase in different categories of electricity prices and explore their effects on the economy).

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- Wianwiwat, A. and Asafu-Adjaye, J. (2013). Is there a role for biofuel in promoting energy self sufficiency and security? A CGE analysis of biofuel policy in Thailand. *Energy Policy*, 55, 543-555.

3.3. Data requirements and sources(max 400 to 700 words)

This is a critical part of the proposal. The key issue is to explain the reason for the choice of your particular databases. You must establish that they are ideal for the question you wish to address and that you have or will have access to these data before your project begins. Please consult the "[Guide for designing a research project proposals](#)" for more detail.

The proposed project aims to investigate the economy-wide effects of Nigeria's renewable energy policy using a computable general equilibrium (CGE) model. The baseline data for the modelling is the Social Accounting Matrix (SAM) of Nigeria. The Social Accounting Matrix describes the interrelations among all the economic agents, sectors of the economy and factors of production. It shows the circular flow of inflow (income) and outflow (expenses) of economic agents (Breisinger et al., 2009), and describes how agents allocate factors of production to sectors and how sectoral outputs are distributed among the economic agents. The main economic agents in a Social Accounting Matrix are households, firms, government

and the rest of the world. In effect, it shows the overall picture of the allocation of economic resources and activities among all these agents in an economy.

The latest Social Accounting Matrix for Nigeria was published in 2010 based on 2006 national accounts data (Nwafor et al., 2010). According to Nwafor et al. (2010), the data for constructing the matrix were obtained from various publications of key government agencies such as the Central Bank of Nigeria, National Bureau of Statistics and Ministry of Agriculture and Water Resources. The main modules of the matrix include activities/sectors, commodities, factors of production, transaction costs, households, firms, government, taxes, savings and investment and rest of the world. The rest of the world and some parts of the taxes cover the international trade aspect of Nigeria's economic activities in 2006.

There are three types of production factor reported in the SAM, and they include land, labour and capital. The households are sub-divided based on the six geo-political zones and rural/urban divides. In all, there are twelve categories of households (South-South rural, South South urban, South East rural, South East urban, South West rural, South West urban, North Central rural, North Central urban, North East rural, North East urban, North West rural, North West urban). There are also four categories of taxes – direct/income tax paid by household and firms to the government, indirect/sales taxes paid on commodities, activity tax paid by firms to the government, and import tax. A total of sixty-one (61) economic activities/sectors are represented in the original SAM, covering such activities as rice, potatoes, beans, maize, beef, goat meat, poultry meat, transport, finance, health, NGOs, etc. However, we will aggregate all the agriculture-related activities into four major sectors/activities, consisting of crop production, fisheries, livestock and forestry. Other sectors/activities will be as they are in the original matrix. Similarly, there are sixty-two (62) commodities in the original SAM, but all the agriculture-related commodities will be aggregated into four main commodities (crops, fisheries, livestock and forestry commodities). The reason for the aggregation of the agriculture-related commodities and sectors is that there are no economic or theoretical reasons to believe that renewable energy policies will affect different crops like rice, potatoes, beans, etc in different ways, except for bio-fuel policies which may affect bio-fuel crops differently from other crops.

Because our interest is in renewable electricity policy, the utility sector/activity and commodity in the original matrix will be disaggregated into water and electricity sectors and commodities, based on their proportions in the 2006 national account data, published by the Central Bank of Nigeria (CBN, 2017). The electricity sector and commodity will be further disaggregated into self-generation and utility-generated electricity. The data for disaggregating the electricity sector in this respect is from the World Bank's enterprise surveys and available to the team. Utility-generated electricity will be further disaggregated to determine the respective shares of conventional and renewable electricity sectors and commodities, based on Nigeria's electricity generation data obtained from the online database of the United States Energy Information Administration (EIA). After all the modifications, the revised SAM will contain twenty-nine (29) activities and thirty (30) commodities. The SAM has already been modified to the PEP format.

In addition, between 2006 when the SAM was developed and now, the Nigerian economy has changed significantly in size and structure. Thus, the SAM will be updated to reflect the current structure of the Nigerian economy. The SAMBAL methodology developed by Lemelin, Fofana and Cockburn (2013) will be used for this purpose.

In terms of the availability of the data to be used for this study, the SAM is already available and has been formatted to PEP standard. The Central Bank of Nigeria's data to be used to disaggregate the utility sector in the macro SAM to water and electricity sectors has also been obtained. The data on self-generated electricity is available in the World Bank's Enterprise Surveys and has been obtained by the team.

References

Breisinger, C., Thomas, M. and Thurlow, J. (2009). Social accounting matrices and multiplier analysis: An introduction with exercises. Food security in Practice Technical Guide 5. Washington, D.C.: International Food Policy Research Institute. Available at <http://www.ifpri.org/publication/social-accounting-matrices-and-multiplier-analysis>.
CBN (2017). 2016 Statistical Bulletin: Domestic production, consumption and prices (stabull-2016-004), Central Bank of Nigeria, Abuja. Available at <http://www.cbn.gov.ng/documents/Statbulletin.asp>
Lemelin, A., Fofana, I., & Cockburn, J. (2013). Balancing a social accounting matrix: Theory and application. Available at <https://ssrn.com/abstract=2439868>
Nwafor, M., Diao, X. and Alpuerto, V. (2010). A 2006 Social Accounting Matrix for Nigeria: Methodology and Results. Nigeria Strategy Support Program Report No. NSSP007, International Food Policy Research Institute, Abuja, Nigeria.

SECTION IV – POLICY ENGAGEMENT

4.1. Policy relevance

4.1.1. Describe policy context and needs

Describe the specific policy issues or needs that your research aims to address; how your potential outcomes and findings may be used in policy making? Please be as precise as possible, indicating specific current or prospective policies and the specific contributions your research would make.

Also, justify timing of your research in terms of policy and socioeconomic needs and context – e.g. reference to existing, planned or potential policies at the national, regional or local level; specific political context; international examples of similar policy problems or solutions, etc.

Nigeria is one of the largest producers of fossil fuel primary energy sources in the world. It also has one of the largest reserves of crude oil and gas globally. Despite this abundance of primary energy sources, electricity access in Nigeria is less than 60%, and is characterised by incessant and regular power failure. Electricity generation is based on hydro and natural gas. Most of the crude oil produced in Nigeria are exported while a smaller proportion is refined locally. Majority of refined oil are imported due to inadequate local refining capacity. The supply of natural gas, which is the major fuel for non-hydro electricity generation, is inadequate because of the high competition between domestic supply and export. Export of natural gas commands higher prices than domestic supply, and producers prefer to export rather than sell in the local market, including to electricity plants. This constitutes a major challenge for electricity access in Nigeria and has resulted in self-generation. Over 95% of households in Nigeria has diesel or petrol-based power generators which often substitute for power supply from the utility. According to the

current World Bank's Enterprise Survey, self-generation constitutes about 60% of electricity generation in Nigeria. The limitations and challenges of the existing electricity generation structure and environmental consideration motivate the need to diversify the electricity generation sources, including towards renewables.

Nigeria first formulated a renewable energy policy in 2003 and the recent renewable energy policy is the National Renewable Energy and Energy Efficiency Policy (NREEEP) of 2015. Nigeria also submitted its Nationally Determined Contributions (NDCs) as part of its commitment to the Paris Climate Agreement. Both the NREEEP and NDCs are currently the basis for achieving the government's renewable energy and climate mitigation targets. Meanwhile, the Sustainable Development Goals (SDGs) of the United Nations also recognises the importance of clean energy and environmental protection, among many other goals and targets.

But will the implementation of these renewable energy and climate change policies not undermine the achievement of other SDG goals? For example, increasing the share of renewable energy in total energy consumption may affect economic growth because of the relatively high cost of renewable energy. Therefore, this study seeks to understand the overall economy-wide impacts of Nigeria's renewable energy policy. In other words, this study looks at the plausibility of simultaneously attaining the targets of the SDGs or the validity of the double-dividend hypothesis of climate and renewable energy policy, where renewable energy policy leads to both environmental and economic gains.

The findings of this study would provide a reference for the economic impacts of renewable and related climate policies in Nigeria. The Nationally Determined Contributions (NDCs) of the Paris climate agreement is non-binding, and the National Renewable Energy and Energy Efficiency Policy is subject to review. While significant changes have been made to Nigeria's renewable energy policy in recent years, understanding how it affect other macroeconomic variables and development indicators would be relevant for policy makers in reviewing existing policies and formulating new ones.

The Nigerian National Assembly (Parliament) Committees on Power, Climate Change and SDGs are considering enacting environmental legislations to support Nigeria's transition to clean energy and climate change mitigation. Given the strong affiliation of the experienced researchers (in this study) with the National Parliament of Nigeria, the findings of this research will be handy for the parliament in developing evidence-based legislation and policy that would enhance renewable energy and equally promote inclusive and sustainable development. Similarly, some environmental right organisations in Nigeria are pushing the government to consider "specialised" funding for renewable energy in the annual national budget. But there is no empirical evidence on the appropriate financing mechanism for renewable energy in Nigeria. The findings of this study will also contribute to this debate and provide science-based evidence on renewable energy financing. Importantly, this study will provide some policy guidance on how the renewable energy policy will affect other development outcomes, within the framework of a CGE model. For example, if the adoption of a biofuel policy in Nigeria has a negative impact on the output of agriculture sector, it could indicate a negative impact on SDG 1 & 2 (to eliminate hunger and poverty). This will help Nigeria's SDGs office on the best way to allocate SDG budget.

Lastly, the international community committed to supporting developing countries to switch from fossil fuel energy resources to renewable energy. Individual countries like China has also promised financial support to developing countries under the framework of South-South Cooperation. Developed countries, through various support frameworks such as the Global Environment/Climate Fund, also promised to support developing countries in the mitigation and adaptation to climate change. However, it is important to understand how the transition to renewable energy will affect developing countries, in order to know the nature of financial and economic supports needed to implement the policy. The results of this project will provide policy guidance on how the international community can support Nigeria's transition to clean energy.

4.1.2. Consultations to date

List the consultations that you have had with potential research users (e.g. policy makers or stakeholders) and that have helped define your research question, and/or informed you of the specific policy context described above.

For each institution consulted, please:

- List key (individual) representatives who participated in the consultation
- Describe the main outcome(s) of the consultation (feedback, inputs, etc.)

Name of institution/organization #1	Senate Committee on Privatisation, National Assembly, Nigeria
List the key representative involved in consultations (names and titles/positions)	
- Barrister Chidi W Nwachukwu, Senior Legislative Aide to the Committee Chairman	
Describe main outcomes of consultation – feedback or inputs received	
The Chairman of the Committee wrote to the National Institute for Legislative Studies requesting for research to develop some subject matters into a legislative bill. One of the key subject matters was introduction of electric vehicles by 2035, within the context of Nigeria’s overall renewable energy and climate policies. The proposed research was discussed and have integrated the main ideas of the committee.	

Name of institution/organization #2	Central Bank of Nigeria (CBN)
List the key representative involved in consultations (names and titles/positions)	
- Harrison O. Okafor, Ph.D., Assistant Manager	
Describe main outcomes of consultation – feedback or inputs received	
Given the important role of the CBN in supporting government policies and providing funds for development initiatives, key persons in the bank have been consulted to get their ideas of the financing mechanism available for renewable energy in Nigeria. Their ideas have been incorporated into the project. One of the key policy scenarios that will be implemented in this project will be based on the financing mechanism discussed with the bank’s representative.	

Name of institution/organization #3	Name of instit./org.
List the key representative involved in consultations (names and titles/positions)	
- Professor I. J. Dioha, Director of Renewable Energy Department, Energy Commission of Nigeria (ECN)	
Describe main outcomes of consultation – feedback or inputs received	
The Energy Commission of Nigeria (ECN) is responsible for initiating and drafting Nigeria’s energy policy. The Commission was at the forefront of the formulation of the Nigerian Renewable Energy and Energy Efficiency Policy (NREEEP), which this study is evaluating. The Director has been contacted about the proposed research and is keen to support and follow-up on the research progress. The findings of the research would be an essential input in the review of the policy by the Commission.	

4.2. Engagement strategy

4.2.1. Identify target audiences

Identify potential users of your research findings – institutions/organizations that may use your findings to inform, advice or influence policy or other relevant decision-making processes. Please explain why you believe these institutions/organizations are the most important potential users of your research, to inform relevant development/policy decisions.

Name of institution/organization #1	Various Committees of the National Assembly (Committees on power, environment, SDGs, climate change, privatisation, labour and employment, women affairs, etc)
Explain relevance of this user to inform key decisions	
The National Institute for Legislative Studies where the two experienced researchers are affiliated is a think-tank arm of Nigeria’s national parliament. The parliament and its various committees always request for research to develop specific subject matters into legislative bills and laws. The findings of this research will be useful for the parliamentarians and the committees to create evidence-based legislation that support the country’s renewable energy and development policies. They will also be equipped with scientific evidence to engage the executive arms of the government (Ministries, Departments and Agencies) in their oversight and supervisory functions.	

Name of institution/organization #2	Central Bank of Nigeria, Abuja
Explain relevance of this user to inform key decisions	
The Central Bank of Nigeria is tasked with ensuring financing for major government projects and initiatives and advising the government on economic policies. This project looks at the economic impacts of the various financing and policy options for renewable energy in Nigeria. The results of the research will provide a reference for the bank in determining the optimal financing policy options, and therefore aid economic policy. This is in line with the bank’s effort to enhance development and infrastructure financing in Nigeria.	

Name of institution/organization #3	Energy Commission of Nigeria Abuja
Explain relevance of this user to inform key decisions	
Insert your text here – max 100 words The Commission is saddled with the responsibility for formulating and drafting national energy policy. The results of this project would provide the Commission with a scientific evaluation of the impact of the policy, and aid review and future policy formulation.	

4.2.2. Define outreach and engagement strategy

How, from proposal design to the dissemination of your research results, will you consult and communicate with these users to both gather their inputs and keep them informed of your project, in order to increase chances of research uptake?

The Committees of the National assembly usually conduct public hearings on matters that is under consideration for legislation in the parliament. We will submit periodic reports to the relevant committees and also present the ideas of the projects in public hearings that are relevant to the subject matter of the project. Meanwhile, members of the parliaments and their aides are usually invited to attend internal seminar presentations on matters and issues that are relevant to them and their respective committees. The relevant committees of the parliament would be carried along on the project through these channels. Similarly, regular discussions will be conducted with the representative of the Central Bank of Nigeria. We will also seek to publish a brief idea of the project in the Central Bank of Nigeria's Development Finance newsletter to stir debate and attract comments.

4.2.3. Outline your preliminary dissemination strategy

Outline your preliminary dissemination strategy (channels, tools, events, audiences, etc.).

Note that PEP expects grantees to disseminate information about their research work and (expected) outcomes throughout the project cycle, and not only after publication.

As noted earlier, the work-in-progress of this project will be presented at a public hearing of the National Assembly, and the project idea will also be published in the Central Bank of Nigeria's publications. A public lecture will also be organised alongside the Energy Commission of Nigeria to disseminate the ideas of the project. The proposal was presented at the 2018 conference of the Nigeria/International Association for Energy Economics (NAEE) in April 2018 and generated lots of interest. The progress of the research will be presented in other relevant conferences. The final output will be published in an energy-oriented peer-review journal such as Energy Policy or Energy Economics, and a summary published in energy-oriented blogs and online forums. A policy brief will also be extracted and submitted to the National Assembly for deliberation and to serve as an input in the review of existing energy policies and enacting a comprehensive renewable energy law.

SECTION V – OTHER CONSIDERATIONS

5.1. Describe any ethical, social, gender or environmental issues or risks that should be noted in relation to your proposed research project.

There are no known ethical, social, gender and environmental risks with respect to this research project.

5.2. References and plagiarism:

Applicants should be very careful to avoid any appearance of plagiarism. Any text of five or more consecutive words that is borrowed from another source should be carefully contained between

quotation marks with a reference to the source (including page number) immediately following the quotation. It is essential that we be able to distinguish what you have written yourself from what you have borrowed from elsewhere.

Note also that copying large extracts (such as several paragraphs) from other texts is not a good practice, and is usually unacceptable. For a fuller description of plagiarism, please refer, for example, to the following website:

- <http://writing.yalecollege.yale.edu/advice-students/using-sources/understanding-and-avoiding-plagiarism>

PEP will be using a software program to detect cases of plagiarism.