Methodological Approach to Regulating CO$_{2eq}$ Emissions from Major Energy Transition Projects in Sub-Saharan Africa: The Case of Hydroelectricity

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Abstract: The energy transition, validated by 194 countries at the end of CoP21 in Paris, requires new development design methods. This requirement, for the sub-Saharan African countries (SAC), could be an opportunity to finance their development. Following the mixed results of the Clean Development Mechanism (CDM), partly due to its rather restrictive selection criterion, the desire to implement carbon asset transfer mechanisms is proposed by many countries including Cameroon. However, the success of such a mechanism would be guaranteed by encouraging policies to regulate emissions. It is in this perspective that our work falls. It aims at proposing a regulation approach for major projects. We have dwelt on hydroelectric projects. To do this, we ordered considering their quantitative feature, 113 projects or visions proposed by 37 countries. Subsequently, a classification of projects according to compartments and trends was made. We finally pointed out 6 visions, including the mitigation in production, mitigation in distribution or service, adaptation in production, mitigation in transport, adaptation in distribution or service, and the adaptation in transport. The regulation methodology proposed for mitigation projects in the hydroelectric sector on a variable threshold hypothesis has led us to three trends in regulation.

Key words: Regulation, methodology, potential, emission, hydroelectricity.

1. Introduction

CoP 21, in Paris, demanded a plan to decarbonize the economies of 194 states, including sub-Saharan African Countries (SAC). Contributions structured in visions, projects and support needs, condensed in each Nationally Determined Contribution (NDC) or Intended Nationally Determined Contribution (INDC) are planned by many states. These allow us to understand the vision of the energy transition in the world that can help to improve the green financing mechanism.

However, various countries, including Cameroon [1], mention the implementation of the financing of these projects by a mechanism for the transfer of carbon assets. It is about the monetization of greenhouse gases avoided through the implementation of future projects.

Except that the Clean Development Mechanism, adopted by the Kyoto protocol and implemented in 2005, requires cumulative emissions of 20,000 t CO$_{2eq}$/year [2]. But this criterion seems to be incompatible with the expressed need, because the mitigation projects are mostly new infrastructures to be put in place and therefore do not record any emissions due to their activities. Proposing a methodology as part of a voluntary approach to regulating emissions, following the classification of Lehman [3], in order to incite a new vision of the carbon market constitutes one of the major tasks of our work. This methodology concerns hydroelectric projects.

The regulation requires a reference value (comparison). Concerning hydroelectric projects, the
emissive potential depends on several factors, namely, hydrology, the distance of supply, the amount of energy used for the works and others. Defining a fixed threshold without taking into account the capacity would thus be inappropriate. Hence the hypothesis of a variable threshold depends on the capacity of the structure.

2. Methodology

2.1 Analysis of NDCs or INDCs

The analysis of INDCs and NDCs makes it possible to quantitatively classify the trends in energy transition in sub-Saharan Africa. To achieve this, we proceeded as follows:

- Searching for the different NDCs and INDCs available information on the website of the United Nations Framework Convention on Climate Change (www4.unfccc.int).
- Data processing: we proceeded by classifying the information following the approaches (mitigation and adaptation) and according to the compartments (production, transport, and distribution or service).
- Evaluation of the percentages of each trend according to the compartments.

At the end of this first step, a classification of the energy transition trends will be made.

2.2 The Regulation

The incentive for a new market necessarily requires a threshold and management mechanisms different from the ideal case.

Since the notion of threshold needs to be adapted to the capacity of the infrastructure, we based our knowledge on the threshold on the hypothesis of a correlation between the capacity of the structure and its emissive potential. The validation of the correlation is done according to the following method:

- The search for basic data or correlation data: they will be obtained in the literature. This will be Life Cycle Assessment (LCA) work having an environmental impact on the climate change.
- Statistical research of the correlation: by analyzing the correlation coefficient (the correlation coefficient must be $\geq 0.4$).

3. Results and Discussions

The data analysis led us to obtain 37 NDCs and/or INDCs out of the 48 SAC.

Here are the different NDC and INDC proposals:

- **Benin**: they intend to develop the production of electrical energy from natural gas and renewable energy sources and expand household access to electric lighting as a replacement for kerosene lighting [4].
- **Burkina Faso**: the transition to the electricity sector will focus on the diversification of energy sources (solar, wind, biogas) and on the promotion of energy saving technologies in industries and buildings [5].
- **Cameroon**: they engage to improve access to electricity for populations and industries by quadrupling production capacity by 2035, in the use of renewable energies in the production of electricity for areas that are difficult to connect, and finally to promote energy efficiency [1].
- **The Comoros**: hydraulics and solar have been favoured instead of hydrocarbons without eliminating wind energy, while geothermal energy has been taken into consideration by 2030. A development in renewable energies has been expected during the period 2010-2030 from around 3% to almost 43%, with however geothermal production accounting for 16% if the operation is carried out. The other measures concern the control of energy during transformation and transmission, and energy efficiency through improved stoves, improvements in carbonization and stills among others. Minimize losses on the electricity distribution network (currently losses on the distribution network according to the report Development of a National Energy Sector Strategy in the Comoros reach 30%, the rehabilitation of the network will enable to reduce this loss to 15%). Rehabilitate power plants, hydrocarbon electricity
generators are poorly maintained due to lack of human resources and capacities. This is one of the other measures that would benefit from being implemented diligently with immediate results. Currently the loss during transformation in power plants is estimated at 8% and a decrease to 6% is possible [6].

- **Congo** has a significant hydroelectric potential estimated at around 14,000 MW, of which barely 228 MW (1.6%) is exploited. The Republic of Congo wishes the share of hydroelectricity in its energy mix, to reach around 4,000 GWh consumed by 2025 [7].

- **Ivory Coast** aims at increasing the use of renewable energies in the production of electricity [8].

- **Gabon** is focusing its carbon project on the development of carbon-free means of production and on improving energy efficiency [9].

- **Djibouti**: installation of 60 MW on-shore wind turbines in Goubet. They are expected to be effective as from 2025. A very high voltage line with a capacity of 50 MW was constructed whose aim is to import electricity from Ethiopia to Djibouti. In total 90% of Ethiopia’s electricity is produced from hydroelectricity. This project was completed in 2011. Installation of three solar power plants in Petit Bara, Ali-Sabieh and Goubet with photovoltaic potential estimated at 250 MW. The project is expected to be completed in 2025. Exploit geothermal energy, whose potential is estimated at 1,200 MW in the regions of Lake Assal, Lake Abbé and North Goubet. Those energy plants will be effective as from 2030. The energy efficiency project for 10 buildings, this 2-year project aims at enabling the Djiboutian Agency for the Control of Energy (ADME) to study the energy consumed by 10 buildings, which will lead to a reduction of the energy supply of public buildings. The two-year project also aims to improve the energy efficiency of the former “Cité Ministerielle” building before installing a photovoltaic solar park on the building’s roof. The photovoltaic system will be connected to the national energy network. To significantly reduce the state’s electricity bill, “ADME” will continue to extend the project to all public buildings in the next years. Awareness will be raised on the use of energy-efficient lighting equipment (low-consumption lamps) in residential areas. Carry out diagnosis of lighting and air conditioning systems in the various administrative buildings [10].

- **Ethiopia** intends to develop the production of electricity from geothermal, wind and solar sources to minimize the adverse effects of droughts mainly in the hydroelectricity sector [11].

- **Eritrea**: the energy sector emphasizes on the introduction and the use of renewable energy sources such as solar, wind and geothermal energy to replace efficiently and take concrete measures to limit the dependence on fossil fuels. Quantitatively, it is almost 70% of fossil fuels based energy production that will be replaced by the use of renewable energy sources. Finally, at least a 50% reduction in losses in transport and distribution is envisaged [12].

- **The Gambia**: the transition will be through the installation of solar photovoltaic, wind and hydroelectric plants. New modernization works on the national distribution line will enable to reduce losses during the transmission. Substitute incandescent light bulbs and raise awareness in the residential sector and the adoption of energy efficient appliances. Increase the capacities of the production sector through additional capacities of solar, wind and hydroelectric plants. Reduce the fuel consumption through efficiency standards [13].

- **Ghana** envisages a 10% insertion of renewable energies by 2030, aims to promote clean lighting for rural households, to double the energy/efficiency improvement to 20% in electricity plants [14].

- **Guinea** will produce 30% of its energy (excluding wood energy) by renewable sources. It aims to improve the efficiency of electricity production by 50% compared to the baseline (2011) [15].

- **Guinea Bissau**: 80% renewable energy in the national energy mix by 2030. Efficiency reduces energy losses by up to 10% over the 2030 period. There
will be 80% of universal access to electricity by 2030. Promote an electrical energy production system from renewable energies (hydraulic, photovoltaic and wind) [16].

- **Mauritius** is considering the development of solar, wind and biomass energy production as well as the modernization of the national electricity grid through the use of smart technologies [17].

- **Kenya** will choose to increase the resilience of current and future energy systems. Expand the solar and wind geothermal energy production, or other renewable and clean energy options. Improve the energy and resource efficiency in different sectors [18].

- **Lesotho:** promote an energy mix that distances populations from biomass. Build storage dams for hydroelectricity production. Improve energy efficiency by 20% by 2020. Increase access to clean energy by 35% in 2015, 40% in 2020 and 50% by 2030. With the increase in rural electricity supply, paraffin consumption is expected to drop from 30,434 kiloliters (2014) to 25,000 kiloliters (2020) and 20,000 kiloliters (2030). Reduce transmission and distribution losses from 12% in 2015 to 7.5% by 2030 (i.e. 0.5% reduction per year) [19].

- **Liberia:** protection of water catchments around hydroelectric sources such as the basin of the St. Paul River. Strengthen transmission and distribution infrastructure for public services to ensure climate resilience (example: floods). Improve energy efficiency by at least 20% by 2030. Increase the share of renewables to at least 30% of total electricity production and 10% of overall energy consumption by 2030 [20].

- **Madagascar:** facilitate access to energy, stabilize the energy existing situation and develop new alternatives, such as renewable and alternative energies; energy production (rehabilitation of the network and energy plants); development of renewable energy (increase in the contribution of hydroelectricity and solar power from 35% (current) to 79%); improvement of energy efficiency [21].

- **Mali** aims to speed up the inclusion of renewable energies in the energy mix. Its service sub-sector will focus on the application of energy efficiency combining the rational use of energy, saving and controlling energy [22].

- **Malawi** intends to promote the energy mix in order to move populations away from biomass. They also plan to build storage dams for hydroelectricity production. They also promote the use of solar photovoltaic energy and energy efficient light bulbs. Finally, they aim at increasing the production of renewable energy [23].

- **Namibia** aims at increasing the share of renewable energies in electricity production from 33% to 70%. They will also implement the energy efficiency program to reduce consumption of around 10% by 2030, the implementation of efficiency and the demand side management (DSM). [24]

- **Niger** intends to develop its electricity supply network to allow its populations to have access to electricity [25]. They are planning to improve the energy efficiency of various sectors and the promotion of photovoltaic solar energy for pumping and electrification, as well as the exploitation of renewable energies (solar, wind, nuclear and hydroelectricity) that aims at reducing the impact of its electricity production. Likewise energy efficiency will be adopted.

- **Uganda:** they are promoting the use of renewable energies and other sources of energy. They also intend to increase efficiency in the modern energy sector, mainly electricity, and ensure the best use of hydroelectricity through rigorous management of water resources. Investments will be made in the protection against climate change that may affect the electricity sector. Infrastructures favorable to the development of the electricity sector will be constructed, including power lines. They expect to achieve at least 3,200 MW of renewable electricity generation capacity by 2030, unlike the 729 MW in 2013. Take nationwide appropriate mitigation actions for integrated sustainable energy solutions for schools.
in off-grid areas. The promotion and wider adoption of solar power systems, as well as the development and enforcement of building codes for energy are among the measures taken [26].

- **Rwanda** is aiming for a low carbon energy mix, small-scale sustainable energy development according to the energy efficiency and demand management [27].

- **The Central African Republic**: they will opt for the promotion of low consumption lamps (LCL), the construction of dams and rural electrification [28].

- **Seychelles**: they opt for a more resilient energy base with greater innovation in renewable energies where possible. The energy policy that was proposed in 2010 set a target of 15% of energy supply from renewable energy sources by 2030 [29].

- **Sierra Leone**: they are considering expanding the use of clean energy (for example: solar, mini hydroelectric power station, LPG, biomass stoves, etc.) and developing agricultural and urban waste incineration programs for production of energy [30].

- **South Africa** plans to decarbonize its energy system by 2050 and promote the energy efficiency in lighting [31].

- **Somalia** is orienting its policy on the use of renewable energies, adopting solar energy for public lighting and the residential sector. It also plans to set up new solar stations [32].

- **Sao Tome and Principe**: the energy transition can be summed up in the establishment of an isolated mini power station (1 MW), a hydroelectric power station connected to the main network (9 MW), photovoltaic panels (12 MW) and a mini power station hydroelectric connected to the main network (4 MW) [33].

- **Sudan**: the projects for the integration of renewable energies in the electricity system concern: (a) wind energy (1,000 MW connected to the grid) that will be applicable in areas with strong wind power. (b) Solar energy (1,000 MW on and off grid), applicable in different states of Sudan. (c) Production of 2,300 MW from gas in different regions of the country. Solar technologies (100 MW, grid connected), are applicable especially in northern Sudan. (d) The use of waste (80 MW connected to the grid), for example in the sugar industry. (e) The geothermal potential (300 MW) that will be exploited in various states of Sudan. Small hydropower plants (50 MW connected to the grid), in particular in combination with irrigation sites. Rural solar electrification through 1.1 million solar home stations (SHSs) until 2030. Energy efficiency projects include: reduction of losses in transmission and distribution networks; the rehabilitation of the hydropower plant cooling system; increase in preparation of the matrix turbine plant; reducing the costs of electricity production and consumption of thermal power plant auxiliaries; improvement of the specific fuel consumption of thermal power stations. The replacement of incandescent lamps by compact fluorescent light (CFL) and LED lamps in the residential areas; the establishment of the labeling system for electrical appliances [34].

- **Tanzania** plans to explore and invest in an energy diversification system; promotes the use of energy efficient technologies and behaviors; aims to improve integrated watershed and upstream land management for hydroelectric sources; also intends to improve the use of renewable energy potential across the country (hydro, solar, wind, biomass and geothermal energy). The country also intends to explore and invest in the diversification system to ensure overall energy security for economic development by improving financial affordability and rehabilitation while contributing to the reduction of emissions over time. They are working on the promotion of clean technologies for the production of electricity and the use of various renewable sources such as biomass, geothermal, wind, solar and renewable; promote energy efficient technologies for transmission/transport of supply and demand as well as behavior change in energy consumption; promote rural electrification [35].

- **Chad**: interconnection of the Chad-Cameroon power grids to supply Chad with 500 GWh hydroelectric powers; solar energy production up to 200 GWh/year.
that will be about 140 MW/year; wind energy production up to 50 GWh/year; construction of the 225 kv national line to interconnect all towns; cross-border electrification (between neighboring towns) [36].

- **Togo** plans to develop renewable energies and mini grids for rural electrification. An electric energy saving strategy will be implemented [37].

- **Zambia** aims to develop solar and wind power in rural areas without electricity, and to extend the electricity network to non-electrified rural areas [38].

- **Zimbabwe** intends to implement management practices that improve power generation capacity in situations of limited water availability due to reduced rainfall, the improvement in energy efficiency, to increase hydropower in our energy mix, to develop off-grid solar and renovation and electrification of the rail network [39].

A total of 113 projects have been identified, and the distribution according to various compartments and trends is given in the following table (Table 1).

| Trends             | Compartment | Adaptation | Mitigation |
|--------------------|-------------|------------|------------|
| Production         | 17          | 47         |
| Transport          | 03          | 10         |
| Distribution/service | 09         | 27         |

The Fig. 1 is about carbon projects distribution according to compartments.

![Fig. 1 Carbon projects evaluation according to NDCs/INDCs.](image)

Depending on the compartments, we have:

- Production (56.64% of total projects): 73.44% is dominated by mitigation projects targeting projects for integrating renewable energies into the electricity system;

- In transport (11.50% of the total of projects): the vision is driven by the extension of networks in order to increase the electrification rate;

- **Distribution/service** (31.86% of total projects): distribution is focused on the application of energy efficiency, particularly in reducing line losses. We also have services, like the establishment of DSM, and the promotion of SHS.

Thus, depending on the compartments and the trends, we can classify the energy transition of the electricity sector in sub-Saharan Africa as follows:
• mitigation in production;
• mitigation in distribution or service;
• adaptation in production;
• mitigation in transport;
• adaptation in distribution or service;
• adaptation in transport.

The regulation of the emissive potential of hydroelectric projects in the mitigation trend can be done according to the following diagram on the figure 2.

The implementation of these carbon projects depends in part on external financing. Some states refer to an accounting system for issues allowing a transfer of assets to finance them. This approach gives rise to the carbon market.

Step 1: LCA of the new system: from the data from the project studies, the decision-maker would have to carry out an LCA study according to the simplified, parameterized models, EIO_LCA, while defining the criteria.

Step 2: selection of the correlation systems: by referring to a database of LCA studies existing in the literature, select the projects according to the proximity of the energy, and by observing the minimum value of the correlation coefficient.

Step 3: analyze the linearity of the systems: this step consists of studying the hypothesis of the linearity between the systems and the emissions.

At the end of this step, 3 possibilities arise:

1) The emissions of the new system are below the correlation line (under linearity); repeat the test by choosing new correlation elements;

2) Perfect linearity between the new system and those of the database;

3) Emissions from the new system are above the correlation line (on linearity). In this case, there is the existence of emissions potential to be absorbed.

![Fig. 2 Regulation mechanism in mitigation.](image)
Emission clipping will consist on eliminating emissions through a transfer mechanism. Indeed, the amount of emissions identified will be transferred for elimination, in favor of CO₂ catching projects. The principle is summarized in Fig. 3.

The regulation proposed in our work aims to incentivize the carbon market for mitigation projects. It is based on the assumption of linearity between the emissive potential and the capacity of the structure. However, certain factors could impact this assumption, including the date of the study considered in the correlation model. Indeed, technological change has an impact on the emission potential because industries are increasingly required to comply with emission quotas and they need to optimize processes. Thus previous studies could have an impact on the correlation on one hand. On the other hand, according to Auididilìo [40], few LCA studies are carried out in Africa and therefore in sub-Saharan Africa. The choice of an inventory model existing in databases such as ecoinvent, GaBi could lead to erroneous evaluations, either by overestimating or underestimating the potential. Thus the choice of studies for the correlation model must be made by observing the same database or even the same characterization approach.

4. Conclusion

This work focuses on a methodological approach to regulating greenhouse gas emissions from majority projects, in the electric energy sector, defined within the framework of the energy transition. It was circumscribed for developing countries located in sub-Saharan Africa, in order to conciliate carbon projects linked to the development of new infrastructures and the constraints of limiting emissions required by the Paris agreement of 2015. The method articulates in two points, firstly the search for the threshold of durability through the databases of LCA studies. This makes it possible to determine the coefficient of linear correlation between the various infrastructures constituting our database. Then proceed with the analysis of the environmental sustainability of our new infrastructure. This step concerns the analysis of the position of the new energy infrastructure emissive potential in relation to the threshold admitted in the first step. We have illustrated the method for the hydroelectric sector, three trends have emerged, under linearity, perfect linearity and on linearity. Under linearity is obtained when the emissive potential of our infrastructure is below the durability threshold required for the capacity of this infrastructure, perfect linearity is obtained when the potential is the same as that of the required threshold and finally on linearity is obtained when the potential exceeds the required threshold. In order to define a new carbon market, the last configuration threshold is subject to potential clipping. This operation will consist of eliminating the potential exceeding the threshold value by valuing it through carbon capture projects.
References

[1] Republic of Cameroon. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Cameroon.

[2] African Development Bank. 2012. Manual for the Clean Development Mechanism’s Programs of Activities in Africa: Practical Recommendations for Successful Implementation.

[3] Lehmann, A., et al. 2015. “Policy Options for Life Cycle Assessment in Deployment in Législation.” Life Cycle Management, 213-24. doi: 10.1007/978-94-017-7221-1_15.

[4] Republic of Benin. 2017. Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Benin.

[5] Republic of Burkina Faso. 2016. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Burkinafaso.

[6] Union of Comoros. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Comoros.

[7] Republic of Congo. 2017. Intended Nationally determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Congo.

[8] Republic of Ivory Coast. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Côted'Ivoire.

[9] Republic of Gabon. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Gabon.

[10] Republic of Djibouti. 2016. Intended Nationally determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Djibouti.

[11] Federal Democratic Republic of Ethiopia. 2017. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Ethiopia.

[12] The State of Eritrea. 2018. Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Eritrea.

[13] Republic of Gambia. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Gambia.

[14] Republic of Ghana. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Ghana.

[15] Republic of Guinea. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Guinea.

[16] Republic of Guinea –Bissau. 2018. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/GuineaBissau.

[17] Republic of Mauritius. 2016. Intended nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Mauritius.

[18] Republic of Kenya. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Kenya.

[19] Republic of Lesotho. 2018. Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Lesotho.

[20] Republic of Liberia. 2018. Intended Nationally determined contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Liberia.

[21] Republic of Madagascar. 2016. Intended nationally determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Madagascar.

[22] Republic of Mali. 2016. Nationally Determined contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Mali.

[23] Republic of Malawi. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Malawi.

[24] Republic of Namibia. 2016. Intended Nationally determined contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Namibia.

[25] Republic of Niger. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Niger.

[26] Republic of Uganda. 2016. Intended Nationally Determined Contribution Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Uganda.

[27] Republic of Rwanda. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Rwanda.

[28] Central Africa Republic. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/CentralAfrica Republic.

[29] Republic of Seychelles. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Seychelles.

[30] Republic of Sierra Leone. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/SierraLeone.

[31] Republic of South Africa. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/SouthAfrica.

[32] Republic of Somalia. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Somalia.

[33] Republic of Sao Tome and Principe. 2016. Intended Nationally Determined Contribution. Accessed on April 2020.
Methodological Approach to Regulating CO$_{2eq}$ Emissions from Major Energy Transition Projects in Sub-Saharan Africa: The Case of Hydroelectricity

www4.unfccc.int/sites/NDCStaging/Pages/SaoTomeandPrincipe.

[34] Republic of Sudan. 2016. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Sudan.

[35] United Republic of Tanzania. 2018. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Tanzania.

[36] Republic of Chad. 2017. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Chad.

[37] Republic of Togo. 2017. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Togo.

[38] Republic of Zambia. 2016. Intended Nationally determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Zambia.

[39] Republic of Zimbabwe. 2017. Intended Nationally Determined Contribution. Accessed on April 2020. www4.unfccc.int/sites/NDCStaging/Pages/Zimbabwe.

[40] Astudillo, M. F. 2017. “Life Cycle Inventories of Electricity Supply through the Lens of Data Quality: Exploring Challenges and Opportunities.” International Journal of Life Cycle Assess. doi: 10.1007/s11367-016-1163-0s.