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A novelty design of GHG Emission Reduction Cost for the Province of Nusa Tenggara Timur, Indonesia: A quantitative-based scientific view

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Abstract. At present GHG emissions is a strategic issue in the effort to achieve SDGs. The Nusa Tenggara Timur (NTT) Provincial Government through its new leader in 2018 emphasizes the development of infrastructure in the field of renewable energy must be a top priority. This study aims to introduce a structured model of GHG emission reduction costs in NTT Province by referring to carbon tax considerations as exogenous factors. The results show that the average cost a reduction in the constraints between 14% and 16% are the most optimal would increase GDP to 20% compared to BAU conditions. The implications of this study will support the government's efforts in embracing a policy relating to the General Regional Energy Plan of NTT Province called in English Regional Energy General Plan which is being promoted.

1. Introduction

Currently, the livelihoods of community life at the NTT Province are still largely dependent on natural resources as one of the economic supporting commodities which situation is affected by geography and geology condition, so it is extremely prone to various natural disasters in addition lack of public awareness to maintain a sustainable environment which indirectly contribute to the risk level of the threat of climate change impacts. The province has been a victim the impacts of climate change. As new leader of this Province Mr. Victor Bungtilu Laiskodat has ambition as one of the prone provinces to be at the forefront in addressing the global problem of climate change by introduction the renewable energy system to improve electrification ratio for the last few years ahead. While the central government in Jakarta so far was conducted many efforts to tackle the climate change impacts by intervention the policy mitigation actions to become a national driving force to optimize its influential position internationally through bilateral and multilateral cooperation. so that, the climate change adaptation and mitigation action strategic issues will be integrated into the national and provincial development planning [1, 2, 3]. The NTT Province has potential to reduce greenhouse gases (GHG) emission by 2030 significantly such as various policies and technology applications and strategic
studies integrated to the regional economic development planning in line to achieve sustainable development goals (SDGs) while keep economy activities running well under GHG emission controlled.

2. Electricity and GHG emission profile of NTT Province.

Indonesia’s national energy policy (INEP) targets as much as 23% and 31% of the primary energy mix will supply from renewable energy by 2025 and 2050 [4]. Strengthening the national energy buffer through regional primary energy supply, instead of costly fossil fuel imports. Every year electricity subsidies increase 5% and data available show in 2010, fossil fuel subsidies in NTT Province was achieved 447.5 Billion IDR which make the present subsidies for electricity supply affordable for the population, cost the province over 661.1 Billion IDR per year which does not consider increases cost of diesel oil, while dependence on fossil fuel imports is steadily growing [2, 5, 6]. Although Indonesia made great advances in the electrification across the country, some provinces including NTT Province is still hard to reach great electrification until today [7]. NTT Province is covered into the Indonesian energy blueprint shown in Fig.1 to achieve objectives the development of an integrated network management power plant by 2020 to achieve GHG emission reduction

![Figure 1. Map of existing and planned integrated network management power plant [8]](image)

Current electricity in NTT Province is generated from Diesel Power Plants (DPP) that is operated by a state power company called “PLN NTT Branch.” PLN also serves as the administrator for distribution of electricity in the Province. Increased sustainable energy generation would benefit the NTT population, 5.12 million people and would help to support the population growth rate of 1.65%/year. The GDRP in 2015 was USD 3.8 Billion and GDRP per capita USD 742.2 and its growth rate 3.31% annually. However, the poverty rate was 22.19% which indirectly affects the good practice of sustainable use of renewable energy in achieving energy intensity of 1% or less [9, 10].

In order to pursue Indonesia GHG emission target 29% from BAU and 41% with foreign assistance [4], there was a series effort has been done by NTT province government through Regional Planning Agency (or BAPPEDA) as the institution is appointed for. As for economy of NTT province is lower compared among other therefore, a novelty model is necessary to overcome the challenge to support a General Regional Energy Plan which is being promoted. The certain amount of NTT Province’s GHG emission for the base year 2010 is 1.381Mt or around 0.047% for a global warming potential (GWP) 100 years and 1.454Mt or around 0.049% for a GWP 20 years both compared to total GHG emission
in Indonesia in 2010. This result is an adjustment from the previous results. Then verified use a linear program software and the result shown same percentage is 0.047% in comparison with total GHG emission in Indonesia by 2010 and 0.034% in comparison with the total GHG emission in Indonesia by 2020. These amounts are used as exogenous data to conduct for the model [4, 9, 11, 12].

3. Methodology

This research is done to integrate the design and statistical analysis to forecast economic growth trends and marginal GHG reduction cost. The methodology is used to estimate the costs and effectiveness of electricity produced by renewable energy technology (RET) sources and associated with carbon tax and reductions rate in GHG emissions in NTT Province for the period of 2014 as indicated in the hypotheses and explored the proof truth of the hypothesis. The economic I/O model has been adopted for this study which is investigated by Leontief showing relationship between economic sectors and environmental burden specifically it assesses consumption of energy final and environmental impacts of goods and services from a State by taking advantage of a country’s economic I/O matrix [11, 12, 13, 14, 15]. The I/O model also feasible to sum up the energy consumption and environmental impacts of each life-cycle phase [16]. In this study the NTT Province I/O [17] model is used coupled with an environmental perspective can support local government to monitor and controlled their emission, then will be able to evaluate the effectiveness of a proposed energy policy.

3.1 Construction of the simulation

The simulation is constructed of some main indicators among others comprehensive social costs as indicated for GHG reduction cost (average and marginal) and carbon tax model with an objective function in maximize the gross regional product (GRP). The variables are determined based on endogenous \((en)\) and exogenous \((ex)\). The exogenous variables are taken from existing data, while the endogenous variables are obtained from the results raised by the simulation model. The intended indicator model for maximize the GRP as follow:

\[
GRP = \sum v_v(i) \cdot X(i) + \sum v_v^{RT}(i) \cdot X^{RT}(i)
\]

where, GRP \((t)\) is the gross regional product in term \(t\) \((\text{time})\) \((en)\); \(X(i)\) is production vector of usual sectors \((en)\); \(X^{RT}(i)\) is production vector of RET sectors \((en)\); \(v_v(i)\) is \((\text{gross})\) added value ratio of usual sectors \((en)\); and \(v_v^{RT}(i)\) is \((\text{gross})\) added value ratio of RET sectors \((en)\). Subscripts \((i)\) are the industries in NTT Province. However, the GRP itself is determined endogenously and will not the main focus of this study due to the controlling is only focused on the social costs that need to be spent due to GHG emissions resulting from economic activities. With this type of economy structure, the GHG reduction cost has an important index. Generally, it is defined as follow:

\[
\varphi = (\text{Cost necessary for reducing GHG by } \Delta Z)/\Delta Z
\]

where, \(\varphi\) is average GHG reduction cost which is obtained through inverse comparisons between the main costs needed to reduce GHG emissions and difference amount of GHG emission as labeled \((\Delta Z)\). The \(\Delta Z\) is comparison between total amount of GHG emission and amount of GHG emission contributed by energy sector. With this simulation, the cost is measured in terms of reduction in GRP due to the GHG reduction constraint as indicated in formula below:

\[
\varphi^i(r) = \{(GRP^i(0) - GRP^i(r))/(\Delta Z(1- \frac{r}{100}))\}
\]
where, \( 
\phi^i(r) \) \( (en) \) is average GHG reduction cost in scenario of \( i \) and when the reduction rate of GHG emission \( (n) \) is \( r\% \) \( r = 0\% \) up to \( 20\% \) \((ex)\); \( GRP^i(r) \) is the GRP in scenario of \( i \) and when \( r\% \) \((en)\); \( ZZ \) is amount of GHG emission in NTT Province was emitted into the nature when the \( n \) is \( 0\% \) and the amount is 14.51977Mton CO\(_2\) \( (ex) \).

Note: scenario \( (i) \) means, which is no carbon tax and no-RET available when \( i = 0 \); scenario in which carbon tax is charged and no-RET available when \( i=1 \); and scenario where carbon tax is charged and RET system available when \( i=2 \). The carbon tax is exogenously determined.

While estimation the marginal GHG reduction cost is an important thing for decision makers to know how much society would want to spend on GHG emission reduction [jstor The Energy Journal]. In this study, it can be calculated as follow:

\[
\lambda^i(r) = \left\{ \frac{(GRP^i(r) - GRP^i(r + 1))}{14.51977} \right\} \quad (r = 0,2, \ldots ,19)
\]

where, \( \lambda^i (r) \) is a comprehensive social for marginal GHG reduction cost in scenario of \( i \) when the \( n \) is \( r \% \).

3.2 Hypotheses

The hypothesis is based on verification the effect between the trend amount of GHG reduction cost in a setting of reduction rate of the emissions, which is referred to the statement formula below:

- \( \phi^i(r) \) decrease drastically as scenario increases from \( i = 0 \) (no carbon tax, no RET) to \( i = 2 \) (with both carbon tax and RET available) with same \( r \) of any \( n \); and
- \( \lambda^2(r) \) increases as \( r \) increases with fixed \( i = 2 \).

4. Results and discussion

4.1 Results

The Marginal costs every region is different each other including the global marginal costs. For the case study in NTT Province the simulation results indicated in Figure 2.

![Figure 2. Average comprehensive social of GHG reduction cost](image)

The simulation shows the social costs having great influence on GHG emission reduction in the province of NTT with BAU scenario \( (\phi^0) \) (blue-line), for instance on the GHG constraints between
5% and 10%, the condition cost of averange GHG emission reduction quite spent the Province cost. The social costs continue to grow moving forward in line with efforts to reduce emissions between 10% and 18% and are able to stabilize in the constraint between 18% and 19% but these costs cannot exceed 20% reduction which will spent a lot of cost to burden the economy of NTT Province. This level shown the hypothesis is true. Further, on the conditions where there is no tax and RET is available ($\varphi^0$) (red-line), averange GHG reduction cost quite better than $\varphi^0$ especially for constraints between 5% and 12%, this results shows that the abatement cost of the NTT Province economic will be able to reduce GHG emissions between 5% and 10% if applying carbon tax without intervention of RET system application (this scenario, the carbon tax has been included as exogenous data in the model). However, after 10% of the contraints are apllied, the reduction cost increase drastically exactly on the constraints between 14% and 16% and flat up to 17%. This is reversed with the BAU conditions in the same constraint, and after 18% and above, the GHG will be uncontrollably large and not optimal, so that this level also shown the hypothesis is true.

While for scenario ($\varphi^2$) (green-line), the conditions of the carbon tax and RET are equally available. The simulation shown that the average GHG reduction cost are very small and do not burden the current economic conditions in the Province. A very drastic comparison between the scenario $\varphi^0$ and $\varphi^1$. This optimal scenario shows that the emissions constraint after 18% raises the trend of social costs slightly compared to the previous cost trend and flatly after constraint 19%. So the government is strongly encouraged to choose the condition of the scenario, where both rhe carbon tax and RET system are available. This level of simulation is meet the hypothesis mentioned that the average GHG reduction cost decrease drastically as scenario increases. The average cost of GHG reduction from the sample $n=14\%$ and 20% are 40.8 Billion IDR to 88.4 Billion IDR; 25.8 Billion IDR to 63.3 Billion IDR; and 3.01 Billion IDR to 12.5 Billion IDR compared among scenarios $\varphi^0$, $\varphi^1$ and $\varphi^2$ respectively.

The Marginal GHG reduction cost in the NTT Province is meet the hypothesis as indicated in Figure 3.

![Figure 3. Marginal GHG reduction cost of carbon tax and RET are available](image-url)

An example of marginal GHG reduction cost to answer hypothesis 2, for constrains between 15% and 17% are not so high between 16 Billion IDR and 48.7 Billion IDR, however raised drastically on the GHG constraint 18% and so on is 519.7 Billion IDR and above.

4.2 Discussion
The marginal costs are effectively rise by such amount referred to the sum of impacts into countries accounts associated with inequalities in income distribution or for risk aversion [18] at the condition of average GHG emission cost is introduced where no carbon tax and no RET system in available, with continued efforts in reducing emission in a sustainable way does not guarantee rapid acceleration of NTT emissions reduction without sacrifice the current economy. At this BAU level, conservation efforts through adaptation actions are consolidated and coordinated can still continue to be carried out. However, the GHG emission mitigation actions that necessary indicate financing cannot be applied after 20% constraints without conflict among stakeholders in term of economy perspective and emission control. Strictly, the emission reduction policy carried out at this level remains optimal, which can be done only under the constraints of 14% to 16%. Further, if we compared the average cost among scenarios by introduction a carbon tax mechanism without RET system and/ or if at the same time introduce both the carbon tax mechanism and RET system available will become more optimal especially the last scenario has mentioned as labelled $\phi^2$. If this policy is implemented, definitely will attract special attention or it can become a dynamic for modern society and industry, but government authority is a good opportunity at the level of this scenario. Nevertheless, many studies have done mentioned that the total costs of climate change are small in the future and this definitely meet our two three scenario case studies present the sanguine view that seemingly expensive investments today result in lower costs in the future [19] in this sense, we could recommended the carbon taxes system must be introduced and implemented by consider any exogenous values that are not considered in the current model to make the results more strong and reliable.

The uncertainty about the marginal costs is large and exceed the costs that have been suggested by the policies and many assumption-based studies have been carried out with uncertainty [20] Similarly, studies that use equity weighing, have higher estimates and larger uncertainties [21, 22]. In our study found the marginal of GHG emission reduction cost is strongly correlated through introduction of RET and carbon tax mechanism, however this must be done for further research as mentioned by [23] said reliable of policy simulations in term of Marginal costs (abatement and welfare) for GHG emission reduction are differ from the conditions under which the marginal abatement costs were simulated.

5. Conclusions

Half important structure of economy in terms of the impact caused by introduction of a carbon tax and environmentally friendly subsidy to promote RET under GHG emission constraints, then analyze value of proposed scenarios are considered in this study. A mechanism and/or policy about carbon tax as special tax and subsidy distribution should become a concern for the government. This model can be optimized the NTT Province economy and flexible may applied to any other developing region which has the same economic characteristics to achieve the SDGs especially goals 7 said ensure access to affordable, reliable, sustainable and modern energy for all and the same time meet the provincial government mission to emphasize the development of infrastructure in the field of renewable energy as a top priority. However, deeply research regarding the carbon tax itself and contribute to tackle GHG emission and GRP improvement need to be further research in addition to count the efficiencies indexes to get more comprehensive social cost-benefit analysis of RET while GRP is strictly considered. The implication of this study will equip the Nusa Tenggara Timur government trust in adopt a proper method in deciding a mechanism for environmental policy and to set technical steps for Indonesia government to overcome targets to reduce GHG emission in the level of national and regional by 2030 and become a strong reference to prepare General Regional Energy Plan and achieve SDGs in regional level match to the current government leader vision.

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