# Climate Value at Risk in Indonesia Oil & Gas Industry

Mirza Hedismarlina Yuneline*
Management Study Program, Sekolah Tinggi Ilmu Ekonomi (School of Business) Ekuitas, Indonesia

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**ABSTRACT**

Based on Pew Research Institute (2017) survey on 40 nations, 54% of the respondents believe that climate change is a top global threat. The United Nations Framework Convention on Climate Change (UNFCCC) built the convention for multilateral action to combat climate change and set out the framework to mitigate the dangerous impacts of climate change on ecosystems and humanity, in 2015 called Paris Agreement which agreed to limit the temperature under 2°C. In the case of a fossil-fuel company, the fossil fuel industry is estimated will lose revenues around USD 28 trillion in the $2^0$C scenario. But, running a business as usual (BAU) is also raising a stranded-assets risk. When investors have invested in these assets and it will become stranded assets due to climate change, these investors have a value at risks. This research estimates the climate value at risk (VaR) of in the case of Indonesia Oil & Gas Industry based on following assumptions; VaR is the probability distribution of present value losses on financial assets due to climate change and valuation model is using assets' discounted cash flow based on the future dividend. To estimate the impact of climate change, this research is using three functions of climate damage which are N-Damage, W-Damage, and DS-Damage. In the case of Indonesia Oil & Gas Industry, when the warming reaches 4°C, the economic damage is predicted support the DS-damage. That means the prevention of rising global temperatures is more financially attractive especially for risk-averse investors.

Keywords: Value at Risk; Financial Assets; Oil & Gas Industry

## 1. INTRODUCTION

Based on a survey that was held by the Pew Research Institute (Wike, 2017), climate change is seen as a top global threat. The polled that consists of 40 nations resulted that 54% believe that climate change is a very serious problem. Referring to Nurdiawansyah, et.al (2018), during September-October 2015, there had been 857 million tons of carbon emissions released into the atmosphere due to the worst forest fire event in Indonesia. Thus, referring to World Research Institute (WRI) Indonesia (2017), the impacts of climate change in Indonesia by 2050 and 2100 such as 2 meter sea-level rise by 2100; 42 million Indonesians could be at risk of regular flooding; 6.6 million hectares of Indonesia's land will be flooded; 1.5 thousands number of islands potentially drowned in 2050; and 2 times drought frequency that will threaten agriculture.

Furthermore, Pew Research Institute (Wike, 2017) also surveyed on the solution of climate change. 78% of respondents think changes in both policy and lifestyle will be necessary. Most of the respondents support their countries in joining the Paris Agreement to limit the greenhouse gas emissions while others think that major changes in lifestyle will combat climate change.

Under the terms of Paris Agreement on climate change, the world agreed to try keeping the temperature rise to well below $2^0$C with 195 countries joined and 187 countries shared their national climate plans, including Indonesia. Indonesia has prepared the Presidential Regulation for a National Action Plan for Reducing Gas Emissions called *Rencana Nasional Penurunan Emisi Gas*


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*Rumah Kaca (RAN-GRK)* which consists of Indonesia's emission reduction target which is 26% against Business as Usual (BAU) by 2020 and 29 - 41% against BAU by 2030 in Indonesia's Nationally Determined Contribution (NDC).

In a $2^0$C world, oil & gas industry will threaten by high-cost in losing the revenues. Eisenkopf and Knorr (2018) stated that the European Union (EU) climate policy has set the target on reducing greenhouse gas emissions by 80 – 95% in 2050. Thus, the EU also has a target on the transportation sector to reduce 60% of CO2 emissions in 2050. Lewis et.al, (2014) estimate that the fossil-fuel industry would lose USD 28 trillion of gross revenues in a $2^0$C world compared to business as usual. But by doing business as usual also raise the risk of a stranded asset such as unsustainable dynamics due to capital expenditures reductions and high oil prices that lead people to shift toward new clean energy.

Recently, Robins (2013) has already developed scenarios that showed major European oil and gas companies would be at risk due to reducing demand for oil and gas industry within 40 to 60 percent market capitalization in the $2^0$C world. It means that the climate-change ultimately affects the financial sector caused by the depreciation value of the financial assets. This research will examine the value at risk of the oil & gas industry in Indonesia by comparing stock valuation in BAU and $2^0$C condition.

## 2. FRAMEWORK AND EMPIRICAL STUDIES

### 2.1.Climate Change and Indonesia's Policy

In the past seven years, World Economic Forum (2017) had released that environmental risks, such as climate change, the rising of greenhouse gas emissions, water supply crises, extreme weather events, failure of climate change mitigation and adaption, and major natural disasters, had already dominated the WEF's Global Risks Report. Climate change, water supply crises, and extreme weather events consistently existed in the top global risks over the past decade.

The United Nations Framework Convention on Climate Change (UNFCCC) established in 1992. The objectives the UNFCC (UNFCC, 2017) is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The UNFCC built the convention for multilateral action to combat climate change and set out the framework to mitigate the dangerous impacts of climate change on ecosystems and humanity. The multilateral negotiation that has been held under UNFCCC is the 1997 Kyoto Protocol and the latest 2015 Paris Agreement.

The Paris Agreement, which has been adopted by 195 countries, has its central objectives is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century below $2^0$C. It is the first agreement that brings all nations to undertake efforts to eradicate emissions altogether in order to avoid the impacts of climate change. Each country should submit their Nationally Determined Contribution (NDC) that consist of the emissions report and mitigation plan to reduce the emissions. Currently, more than 152 countries already ratified the Paris Agreement as evidence there is a global transition to a low carbon economy (UNFCC, 2017).

Since climate change has become a global threat, the Government of Indonesia continues to balance between future development and poverty reduction (Indonesia's NDC, 2016). In 2010, Indonesia committed to having 26% emissions reduction by its own efforts (41% with international support) against Business as Usual (BAU) scenarios by 2020 and set emissions reductions target of 29% - 40% by 2030. Furthermore, in Indonesia's NDC (2016), Indonesia has initiate policy for mixed energy use. Government Regulation No. 79/2014 focuses on re-directing energy resources from export to the domestic market (IEA, 2016). It sets out the supply of energy mix as follows:


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a. In 2025, the renewable resources at least 23%, the oil should be less than 25%, coal should be a minimum of 30%, and gas should be a minimum of 22%.
b. In 2050, the renewable resources raise at least 31%, the oil should be less than 20%, coal should be a minimum of 25%, and gas should be a minimum of 24%.

**2.2.The Financial Risk and Stranded Assets Risk from Climate Change**

The impact of climate change is raising awareness of investors and financial regulators. The financial sector is considered as an environmentally friendly industry but the changes in environmental bring risks the industry itself. Referring to Stern (2008) the climate change has a significant impact on economic development since the financial assets are ultimately backed by economic activities. The value of financial assets is derived by the expected return of the financial assets, such as dividends for stocks or coupon rate for bonds. Climate change can destroy the value of financial assets in two ways, for instance, it can directly depreciate the value of financial assets through extraordinary events such as extreme weather events. Secondly, it can reduce the output of the production process that can affect the expectations about future dividends.

In terms of fossil-fuel company, Lewis, et.al., (2014) estimated that the fossil fuel industry will lose revenues around USD 28 trillion by comparing the IEA's scenario and $2^0$C scenario. Within the policy of limiting the global temperature to no more $2^0$C, in both scenarios, the demand and the prices of fossil fuels would fall. It would reduce the revenues of the oil industry around USD 19.3 trillion, the gas industry around USD 4 trillion, and the coal industry around USD 4.9 trillion within the time frame of 2013 - 2035.

By doing business as usual (BAU) also raising questions on stranded-assets risk. Nelson, et.al., (2014) described that stranded assets are the phenomenon that certain assets like coal mines, oil fields, and forests would not be explored in order to keep the global temperature to no more $2^0$C. When investors or governments have invested in these assets or otherwise expected to benefit from them, these investors have a value at risk. When these assets are left unexploited or decline in value because of actions to reduce the threat of climate change, these unexploited assets are then deemed “stranded.” Stranded assets can include physical assets (such as power plants) or resources (such as oil).

As described, by doing BAU, the unsustainable dynamics, for instance in terms of Indonesia's oil industry, there is transition on cost recovery policy to gross split policy, will encourage the investment withdrawal for ongoing capital expenditures. The gross split policy will create higher revenues within the high oil price condition. But high oil price condition will lead to the shifting towards renewable energy. Means that the stranded-assets risk really exists on BAU conditions.

**2.3.Climate Damage**

Referring to Covington and Thamotheram (2015), climate damage is defined as the fractional loss in annual economic output compared with the $2^0$C economy. Referring to the climate change policy, furthermore, Covington and Thamotheram (2015) assumed that the dividends will be reduced comparing with the $2^0$C economy. The assumptions are based on the effect of the world's GDP level on dividend distributions. The damage that caused by climate change will affect the future GDP level and its growth, that means it also will affect the future dividends and the value of stocks.

Covington and Thamotheram (2015) also defined the value at risk as to the fractional loss in the value of stocks compared with the $2^0$C economy. Furthermore, Covington and Thamotheram (2015) assumed that the loss of the value is equal with the expected present value of the changes in future dividends due to climate damage.


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Nordhaus (2013) already developed estimation of likely climate damage from the raising of temperature up to $3^0$C, called damage function N (N-damages). N-damages rise slowly to 4% at the warming of $4^0$C. It means the economic damage will increase by 4% when the temperature rising up to $4^0$C. Weitzman (2012) developed W-damages by modifying N-damages so that damage approaches 100% at 12°C and is approximately 50% at 6°C.

But then the World Bank (2012) released some serial reports as investigation result on the consequences of $4^0$C warming, for instance, there will be severe droughts, major floods, increasing the water scarcity, increasing risks on global and regional food production, and an irreversible loss in biodiversity. It was encouraged the development of DS-damages (Dietz and Stern, 2014) that modified W-damages that economic damages will increase by approximately 50% at 5°C.

## 3. METHODOLOGY AND DATA

The research is using a descriptive approach. It is based on empirical data on the case study and compares with previous literature study. The research aims to estimate the value at risk caused by climate change. Since the value at risk is the fractional loss from the value of the stock that determined by the changes in future dividends, the samples are 4 Indonesia's oil & gas and companies which had already distributed dividend in the last five years. The following are the research framework :

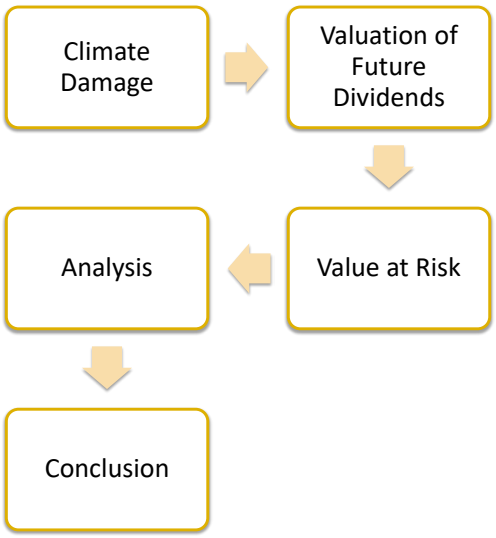


Figure 1. Research Framework

As described above, the high levels of warming might cause changes in the climate system, and climate change might damage the economic system. The analysis starts with the examination of climate damage, in the forms of N-damages, W-damages, and DS-damages, as follows:

$$Damage = 1 - \left(1 + \left(\frac{T}{18.8}\right)^2 + \gamma\left(\frac{T}{\beta}\right)^{6.754}\right)^{-1}$$

where: T = warming above pre-industrial

$\gamma$ = 0 for the N-damages (Nordhaus, 2013)

$\gamma$ = 1 and $\beta$ = 6.1 for the W-damages (Weitzman, 2012)

$\gamma$ = 1 and $\beta$ = 4.0 for the DS-damages (Dietz and Stern, 2014)


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Thus, the analysis continues with the valuation of stocks under the condition of $3^0$C warming, where the value of stocks in an economy without warming, as follows (Covington and Thamotheram, 2015):

$$V = \frac{d\,(1+g)}{k-g}$$

while the value of stocks with warming, as follows (Covington and Thamotheram, 2015) :

$$V = V1 + V2 = \frac{0.86d(1+g)\left(1-\left(\frac{1}{1+k-g}\right)^N\right)}{k-g} + \frac{0.5\,d}{k(1+k-g)^N}$$

where : d = dividends
k = cost of capital
g = expected growth rate
N = time frame

This research also analize the valuation of stocks under condition of $4^0$C warming, using the following formula (Covington and Thamotheram, 2015)
:

$$V(N) = \frac{d\,(1+g)^N}{(1+k)^N}$$

After that, we estimate the value at risk and percentage of value at risk, as follows (Dietz, et.al., 2016) :

$$VaR = d\sum_{t=0}^{T}\left[\prod_{s=1}^{t}\frac{(1+gt)}{(1+kt)} - \prod_{s=1}^{t}\frac{(1+gc)}{(1+kc)}\right]$$

where: $g_t$ = growth rate in condition with no warming
$g_c$ = growth rate in condition with changes in climate damage

Relative to present value of assets with no changes on climate damage, the climate VaR as follows (Dietz, et.al., 2016) :

$$\%VaR = \frac{\sum_{t=0}^{T}\left[\prod_{s=1}^{t}\frac{(1+gt)}{(1+kt)} - \prod_{s=1}^{t}\frac{(1+gc)}{(1+kc)}\right]}{\sum_{t=0}^{T}\left[\prod_{s=1}^{t}\frac{(1+gt)}{(1+kt)}\right]}$$

## 4. FINDINGS, ANALYSIS, AND DISCUSSION ON EMPIRICAL RESULTS

### 4.1. Climate Damage


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Based on the framework, the initial stage is to project the economic damage caused by climate change by using three damage functions. The following are an illustration of climate damage function :

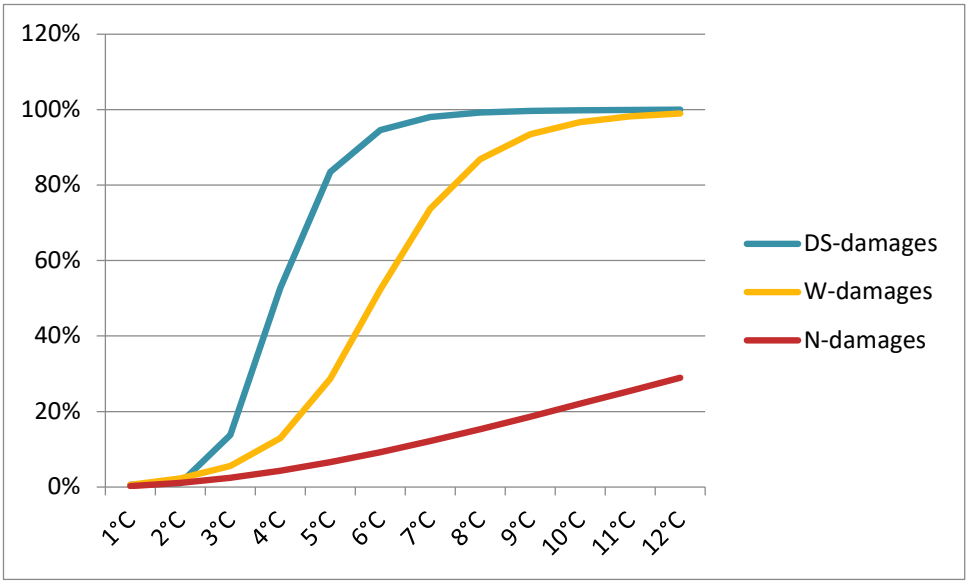


Figure 2. Climate Damage

When the temperature raising in the small amounts of warming, all the climate damage function show that there would be economy reduction by 1% - 2%. But when warming raise into 3°C, DS-damages function shows the economy damage by 14%, while W-damages shows 6%. It means, in terms of economic damage, we can still accept the risk when warming is raising under 2°C, but the warming of 3°C and beyond is unacceptable. DS-damages function shows that the economic damage reached 53% within 4°C warming and 100% within 9°C. N-damages shows that in 6°C warming economy damage would be 52% and will reach 100% within 12°C. Different from the other function, N-damages shown a slow increase in economic damage. Covington and Thamotheram (2015) indicated that N-damages function as a robust condition of economy response to warming while DS-damages is indicated as vulnerable.

## 4.2. Valuation of Future Dividends

In order to estimate the climate value at risk, we need to estimate the impact of climate change on financial assets. The financial assets - in this term is stocks - valued by its discounted cash flow. In the long run, the stocks are worthy if its dividend paid regularly. In this case, we have 4 company that paid the dividend, as follows :

Table 1. Sample's Current Data

| No | Company | Code | Dividend per Share | Cost of Equity | Growth Rate |
|---|---|---|---|---|---|
| 1 | PT. Benakat Integra, Tbk. | BIPI | 1.00 | 10.13% | 4.81% |
| 2 | PT. Elnusa, Tbk. | ELSA | 10.2861 | 15.45% | 11.39% |
| 3 | PT. Medco Energi Internasional, Tbk. | MEDC | 16.38851 | 11.62% | 1.52% |


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| | | | | | |
|---|---|---|---|---|---|
| 4 | PT. Radiant Utama Internsco, Tbk. | RUIS | 7.50 | 5.70% | 5.11% |

Referring to Finance Research Institute Indonesia (2017) Indonesia's equity risk premium is 7.08%, and the risk-free rate is 5.30%. The company's growth rate is determined by multiply the company's return on assets and the plow back ratio.

Regarding the time frame, referring to the Intergovernmental Panel on Climate Change (2013), the global mean surface temperature showed the trend for 15-years rate of warming. Furthermore, IPCC (2013) has considered when the world's government do not implement the emissions reduction pledged and doing BAU, the warming is estimated in the range 2.6°C to 4.8°C by 2081 - 2100. Considering the 15-years rate of warming, Covington and Thamotheram (2015) assumed that there is 20% probability that warming would reach 4°C in 2070, 40% probability in 2085, and 40% probability in 2100. Thus, Covington and Thamotheram (2015) also had a scenario that warming would be estimated reach 3°C in 2030.

The valuation of future dividend will be estimated in the two conditions. First, the company is running without any consideration to reduce emission called BAU. Second, when the company is being risk-averse by mitigating to limit warming under 2°C. In the first condition, the valuation of future dividend is estimated by the current growth rate and cost of equity. But regarding the second condition, we have arguments in two stages.

First, in the long run, corporate earning is a roughly constant share of Gross Domestic Product (GDP). It means the corporate earnings should grow roughly at the same rate as GDP. The data of Indonesia's long-term GDP is taken from the Organisation for Economic Co-operation and Development data (OECD, 2017). About the discount rate, Dietz, et.al. (2014) assumed that the discount rate is 7%. It is estimated by in the real terms is 4.07% and pegged to GDP growth rate estimated by DICE. The DICE puts at 3.71%, while the discount rate is 36% above the GDP growth.

The valuation of BIPI, ELSA, and MEDC shows that the valuation under scenario mitigating to limit the emission reduction under 2°C is higher than BAU. The high-cost capital expenditure makes the cost of equity is higher and has an impact the company put in higher risk having BAU than stay under 2°C. RUIS is the only company that shows by doing BAU, its valuation is higher than the mitigation.

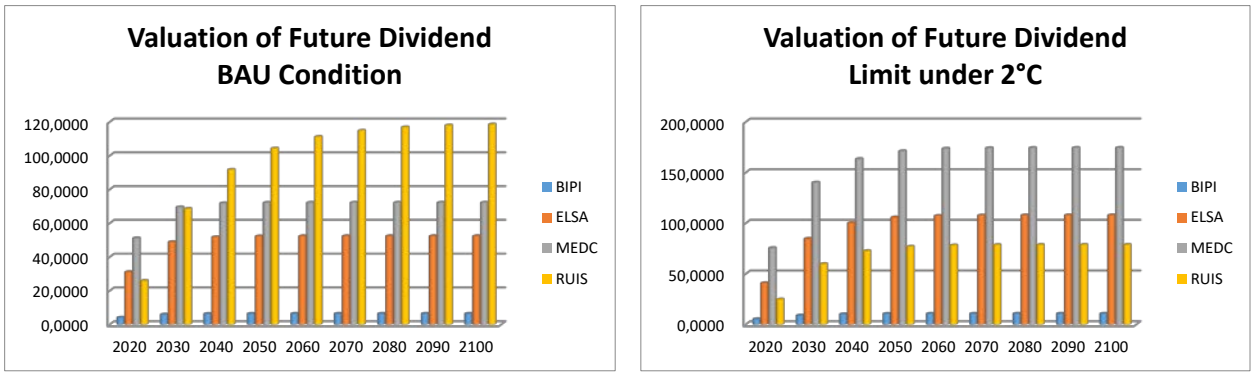


Figure 3. Valuation of Future Dividend

## 4.3. Value at Risk

In this part, we examined the impact of climate change on economic damage when warming reaches 3°C. As mentioned above, Covington and Thamotheram (2015) had a scenario that


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warming would be estimated reach 3°C in 2030. According to DS-damages that shown in table 2, at 3°C, there will be 14% economy damage caused by climate change. The future dividend will be cut by 14% along with climate change. When warming reaches 4°C, the total reduction of dividend will be 53%.

Referring to the OECD forecast (2017), Indonesia's GDP growth is 4.78% in 2030. We assume that the dividend growth is the same as GDP growth in the 2°C world. The formula shown above represent the DS-damages function, $V_1$ is a present value of stream dividend, where the dividend, which already cut by 14%, growth for N years. And the $V_2$ is the present value of a stream of the dividend when it doesn't grow anymore.

Apparently, all of the sample risks have resulted from the value at risk below 14%. the RUIS value at risk actually supports the N-damages function. It is shown has a 1.75% dividend reduction when warming reaches 3°C. The highest value at risk is MEDC, that shown 12.86%. The following are the value at risk of the samples in 3°C warming:

Table 2. Value at Risk in 3°C Warming

| No | Code | Value at Risk | Climate Damage |
|---|---|---|---|
| 1 | BIPI | 4.23% | W-Damage |
| 2 | ELSA | 12.15% | DS-Damage |
| 3 | MEDC | 12.86% | DS-Damage |
| 4 | RUIS | 1.75% | N-Damage |

Previously, IPCC (2013) had already estimated that 4°C warming by 2081 - 2100. Thus, Covington and Thamotheram (2015) assumed that the probability of 4°C warming is 20% will reach in 2070 and each 40% in 2085 - 2100. The value at risk in 4°C warming shows all above 40% in 2070, 2085, and 2100. The result itself support the DS-damages function. The following are the value at risk in 4°C warming:

Table 3. Value at Risk in 4°C Warming

| No | Code | Value at Risk | Climate Damage |
|---|---|---|---|
| 1 | BIPI | 40.19% | DS-Damage |
| 2 | ELSA | 51.44% | DS-Damage |
| 3 | MEDC | 58.62% | DS-Damage |
| 4 | RUIS | 48.05% | DS-Damage |


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Based on the calculation above, we can see that warming at 3°C might have less impact on certain stocks. But when the warming reaches 4°C warming, the economic damage will be unbearable and it actually may impact all the stocks.

## 5. CONCLUSION

Even though the financial sector is considered as an environmentally friendly industry but the changes in environmental bring risks to the industry itself. In order to examine the economic damage caused by climate change, we can use three function climate damage, which are DS-Damages, W-Damages, and N-Damages. And to estimate the value at risk, we need to estimate the valuation of future dividend. The valuation of four samples, which are BIPI, ELSA, MEDC, and RUIS shows that the valuation of BIPI, ELSA, and MEDC under scenario mitigating to limit the emission reduction under 2°C is higher than BAU. That means by running the company in the term of limiting the emission reduction is more profitable than BAU. It is caused by the high-cost capital expenditure that makes the company is riskier.

The estimation of value at risk in 3°C warming under the assumption that it will reach by 2030, shows less impact certain stocks, which is RUIS has the same characteristics with N-Damages. But in the 4°C, warming that will reach by 2070 (20% probability), 2085 (40%), and 2100 (40%) shows that all stocks have the same characters with DS-Damages. That means, when the warming reaches 4°C, the economic damage will be unbearable. By keeping the temperature under 2°C is a better idea than doing business as usual to avoid economic damages.

## 6. LIMITATIONS

The research has some limitations which do not include Indonesia's policy on the fossil-fuel company. Currently, Indonesia is in the transition to change the cost recovery policy to gross split policy. The cost recovery policy is considered to make benefit to the fossil-fuel company but burden the government budget. The gross split policy, in the other way, can make benefit to the fossil-fuel company when the oil prices are going high. In this research, the fluctuations of oil prices also do not consider.

## 7. RECOMMENDATION

This research can be used to raise awareness of the investors regarding the climate change risk. The investors should aware of climate change because the economic damage that caused, would be a tremendous impact. The government, on the other side, should balance between the policy that supports the emission reduction but also find the right solution to the fossil-fuel company without burden the budget. For the next research, it can be added to some scenarios regarding government policy and climate risk. The verification methods may be needed to estimate which assumptions would be taken to analyze climate risk and its impact.

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