The Risk of Disorderly Energy Transition to Indonesian Oil & Gas Sector

Yohanes Handoko Aryanto

{yohanes.handoko86@gmail.com}

Pertamina Energy Institute, Jakarta, Indonesia

Abstract. Oil & gas sector currently faces increasing global commitment and stakeholders' pressure for energy transition. However, oil demand is still increasing and is projected to surpass the pre-pandemic level. This situation, as part of disorderly transition, will pose many risks such as supply crunch and high energy price. Indonesia as net oil importer country is exposed to those risks especially in its net-zero roadmap. Moreover, Pertamina's current position in Indonesian oil & gas sector increases concentration risk. This paper will analyze the risks of disorderly transition to Indonesian oil & gas sector based on scenario analysis, literature review, and benchmarking. This paper identifies several Indonesian energy policies that should be strengthened to mitigate the risks of disorderly transition. This paper also demonstrates that scenario analysis can be utilized by the government to stress tests Indonesian net-zero roadmap as the risks of energy transition tend to be overlooked in the roadmap.

Keywords: Disorderly Transition, Strategic Risk, Scenario Planning, Energy Transition, Energy Security

1 Introduction

Energy transition has historically been a time-consuming process and has complex characteristics. The historical time-consuming process of previous energy transition described by several researches such as Solomon & Krishna (2011) 0 which shows that transition between major energy sources took few decades, or Fouquet (2016) which shows that the fastest historical sector-specific energy transition being observed was thirty yeas 0. Especially in low carbon transition, Buschmann and Oels (2019) explained that carbon lock-in and discourse are some of the causes of slow decarbonization in western industrialized countries 0. On the other hand, Luomi (2018) described one of the main characteristics of energy transition is the difficulty to predict the pace of energy transition, such as the direction of development and utilization of technology, the rate of growth of energy demand, government policies, and consumer preferences 0.

The time-consuming process, uncertainty, and difficulty of predicting the actions of each actor in the energy transition raises questions about how the energy transition to low carbon energy or Net-Zero transition will proceed in the future. Currently, there are many outlooks and scenarios regarding how the energy transition will proceed in the future. Newell et al., (2021)

ICONIC-RS 2022, March 31-April 01, DKI Jakarta, Indonesia
Copyright © 2022 EAI
DOI 10.4108/eai.31-3-2022.2320668

pointed out the differences of several currently available energy scenarios from different organizations such as BP Net Zero, BP Rapid Scenario, IRENA Transforming scenario, IEA Stated Policy, IEA Sustainable Development Scenario, IPCC IP 1 & IP 2. These outlooks and scenarios have its own assumptions and views about the future of energy system, resulting in different pathways and future trends. Based on Newell et al., (2021), for example in primary energy demand outlook, scenarios envision a wide range of potential future growth of global primary energy demand, even within scenario types 0. These scenarios also can be categorized into reference case; which assumes limited or no new policies, evolving policies scenarios; assuming that policies and technologies are developed according to recent trends and/or expert views of the team producing the outlook, and ambitious climate scenarios which are built around limiting global mean temperature rise to 2°C by 2100 0. These types of outlooks and scenarios are more about advocacy on how to achieve climate targets from reference case and what will happen if nothing change as in reference scenario.

Based on the speed and interaction between actors in the energy transition, there are two energy transition scenarios namely the orderly and disorderly energy transition. In an orderly energy transition scenario, the policy signal is clear, there is sufficient time to replace infrastructure and advance technology to keep energy costs within reasonable levels. In this scenario, the alignment of speed and phasing of the transition are the main key factors 0, therefore it has low transition risk. However, since energy sector is a complex system which consists of diverse supply sources, complex utilization and the involvement of multiple stakeholders, also influenced by various internal and external factors 0, it will be challenging to ensure that the energy transition will be conducted in orderly manner. Therefore, strategic planner and policy maker should stress test the energy transition roadmap and policies using a disorderly scenario to unravel uncertainty and energy transition risks.

In the oil & gas sector, we have seen the signal of a disorderly energy transition. Oil supply crunch and high prices are some of the characteristics of the disorderly energy transition 0. Supply crunch is driven by the increasing pressure of energy transition in the supply side of oil & gas while there is no significant change in the demand side. Particularly in Indonesia, various International Oil and gas Companies (IOCs) has left Indonesia's upstream oil and gas fields caused by increased competition for capital within global portfolios 0, leaving Indonesian National Oil & Gas Company "Pertamina" as the major player in the country[1]. This situation happened when Indonesia still requires oil & gas to support its economic growth and the Indonesian Government has a target to produce 1 mmbpd (million-barrel oil per day) and 12 mmscfd (million-standard cubic feet per day) of gas in 2030. Clearly that this situation increases risk for Indonesia oil & gas sector in term of investment dan funding required to maintain and develop the sector.

On the other side, the variable renewable energy (VRE) is vulnerable to climate disruptions. Several energy crises that happened in 2021 shows the vulnerability of energy transition (0, 0,

[1] In 2021, Pertamina contributes to 60% of Indonesian oil & gas production: https://www.pertamina.com/en/news-room/news-release/2021-transformation-pertamina-successfully-presents-idr-29.3-t-net-profit-and-creates-outstanding-achievements, accessed: 28 June 2022. In 2019, Pertamina contributes to 40% of Indonesian oil & gas production: https://www.pertamina.com/en/news-room/news-release/Pertamina-Strategy-to-Fulfill-Sustainable-Energy-to-Move-the-Economy, accessed: 28 June 2022.

0). With the increasing extreme weather and climate disaster, the energy transition will be facing more disruptions in the process, increasing the risks of disorderly energy transition.

Therefore, under the complexity nature of the energy system, the situations described above raises several questions that this paper seeks to answer:

1. What are the risks and uncertainties caused by the disorderly energy transitions to the Indonesian oil & gas sector?
2. How to ensure that Indonesian oil & gas sector is able to support the Indonesian energy transition under the disorderly energy transition scenario?

2 Literature review

2.1 Disorderly energy transition definition

In the context of energy transition scenario, the disorderly energy transition is one of scenarios that is being developed by the Network for Greening the Financial System (NGFS) – a group of 66 global central banks. NGFS scenarios is being recommended to test the climate risks in financial sectors. Based on NGFS definition, disorderly transition is a scenario that limits global warming to below 2ºC and assumes that climate actions are taken relatively late or divergently implemented globally, and results in the higher transition risk 0. In the context of NGFS scenario, the disorderly transition is about abrupt or divergent implementation of climate policies.

However, the term of disorderly energy transition has been described by several researches in the broader context. Battiston and Monasterolo (2021) defined the disorderly transition as a situation in which investors may not fully anticipate the policy impact on their business, which triggers an adjustment in asset prices, either positive or negative, respectively for low-carbon or high-carbon energy technologies 0. Meanwhile, Batten et al., (2016) explained that a disorderly transition is possible if, for example, the government's policy on carbon emission were to tighten abruptly – for example, due to a sudden change in popular attitude towards climate change, or a technological breakthrough in low-carbon energy generation 0. It is further explained that this transition has an impact on decreasing the value of fossil companies, increasing pressure on asset values, and having an aggregate impact on the economy through a negative supply shock (supply crisis) of fossil energy 0. Kapsarc (2018), explained that the interplay of increasingly complex dynamics, making it hard to predict future trajectories 0. The disorderly energy transition transition is marked by increased volatility in energy commodity prices. In the medium to long term, there is a risk of a disorderly energy transition caused by market disruptions and price volatility as companies and financial markets increase their risk preference in the hydrocarbon sector and delay the investment support needed to maintain hydrocarbon production capacity. Van der Ploeg & Rezai (2020) explains that the disorderly energy transition will increase the likelihood of stranded assets and legal claims. However, stranded assets and changes in market valuations will occur in disorderly energy transition if two conditions are met. First, there must be an unanticipated future change in conditions affecting the profitability of fossil-fuel assets. Second, it must be costly or impossible to shift around the underlying capital stocks in the carbon-intensive industries to productive use elsewhere after the energy transition 0.

Several researches suggests the impact of disorderly energy transition as follows:

- Market disruptions and price volatility 0
- Asset price volatility and financial instability 0
- Stranded assets and legal claims 0

Based on the previous researches, it could be implied that the disorderly energy transition is focusing on the negative impact of abrupt low carbon policies to fossil fuel industry. This paper view the disorderly energy transition from the perspective of supply-demand dynamics in the energy transition, where there is a mismatch in the speed of fossil energy phasing out and low carbon energy phasing in, and the dynamics of both could not support the energy demand in the process of energy transition. Therefore this situation will bring disruptions such as supply crunch, price volatility, and stranded assets.

Based on the several researches, the disorderly energy trasition could be caused by several factors as follows:

Table 1. Causes of Disorderly Energy Transition based on PESTEL Framework (compiled by author)

PESTEL	Examples of Causes
Political	• Unclear government low carbon policy signal • Abrupt government energy transition policy implementation • No alignment in energy transition roadmap between government and business entities
Economical	• Carbon lock-in in carbon based energy infrastructure • Low green technology cost efficiency • Slow reduction of fossil fuel subsidies • Reduction on fossil energy investment
Social	• Different perception on energy transition • Different preference on energy options
Technological	• Slow technological development • Unclear direction on technological research & development • Misalignment of tehcnology research & development and energy transition roadmap
Environmental	• Increasing carbon emission & global temperature • Increasing extreme weather and climate related disaster that disrupts energy system
Legal	• Increasing litigation issues related to fossil energy business

3 Methodology

This paper methodology is based on trend monitoring, case study benchmarking, and scenario analysis especially on the disorderly transition. The combination of qualitative case study and quantitative scenario analysis will be useful to triangulate the drivers, risks and uncertainties of the disorderly energy transition.

3.1 Case study approach

Case study is common and widely used in qualitative researches (0, 0, 0) and has been utilized by other researches in energy transition (0, 0, 0). The energy transition is a specific process for every country, the global energy landscape is heavily dependent on several key stakeholders, and in-depth case study analysis can help to examine existing approaches to energy transition implementation 0.

In this paper, case study is suited for exploring complex phenomena such as the disorderly energy transition. The primary objective of the case study in this paper is to examine the different cases and drivers of disorderly energy transition in oil and gas sector as a basis to evaluate the risks and uncertainty of the disorderly energy transition to oil and gas sector in developing country such as Indonesia. The sample was restricted by the event that shows the characteristics of disorderly energy transitions especially in global oil & gas sector that become the focus of this study. The focus of case study will be the occurence of the characteristics of the disorderly energy transition.

3.2 Scenario analysis approach

Scenario analysis approach is based on scenario planning. Several studies suggest that scenario planning is a strategic planning tool (0, 0, 0). Scenario analysis has been utilized in the energy transition researches (0, 0) and can be utilized to unravel the blindspots and uncertainties surrounding energy transitions. This method is more about strategic thinking than planning (0, 0), could become an early warning system (0, 0) and useful to identify critical future uncertainties 0 such in the disorderly energy transition.

There are normative and descriptive scenarios. The normative scenario is prepared by determining the desired future, then back-cast the future path to be taken. Example of normative scenario are scenarios targeting net-zero emissions in 2050 0. These type of scenarios are more about insight about how to achieve the energy transition using different pathway and therefore are less useful to identify risks and uncertainties surrounding the energy system and the energy transitions. Meanwhile, descriptive (exploratory) scenarios describe a diverse set of plausible future set and useful to test resiliency of various strategies to a wide range of future conditions 0. The descriptive scenarios that explore the wide range of future conditions will be useful to identify risks and uncertainties surrounding the energy transition.

The quantitative data of disorderly energy transition scenario in this study will be based on NGFS disorderly energy transition scenario and compared to NGFS orderly energy transition scenario. The NGFS is selected because the scenarios are well developed and provides robust model which comprises of 6 models, 27 scenarios, 1,759 variables, and cover 400 regions[2]. Several researches demonstrate the usefulness of the NGFS scenarios to explore the impact of disorderly energy transition to several aspects such as GDP, commodity price, or climate (0, 0, 0). This paper will analyze NGFS scenarios based on GCAM5.3 and REMIND-MAgPIE 2.1-4.2[3] models. Both models are selected because it provides oil price as scenario output and the result of the oil price timeseries are consistent to the described scenarios. However, there are differences between models as described by Bertram et al (2020) as follows 0. GCAM is a partial equilibrium model of the energy and land sector. It assumes that economic agents are

[2] https://data.ene.iiasa.ac.at/ngfs/#/docs, accessed: 20/03/2022
[3] The documentation of these models available at http://pure.iiasa.ac.at/id/eprint/17511/1/ngfs_climate_scenarios_technical_documentation__phase2_june2021.pdf, accessed: 20/03/2022

self-interested and myopic. Consequently, the model solves for the least-cost (or maximum profits) outcome in a particular period without consideration of how current decisions affect costs or profits in future periods. Meanwhile, REMIND-MagPIE combines a general equilibrium model on he energy sector and the macroeconomy under perfect foresight with a partial equilibrium model on the land sector. The majority of mitigation options reside in the energy sector which operates with perfect foresight. This implies that economy-energy nexus is constructed to maximize welfare for economic agents over the entire century.

In this paper, the quantitative results of the disorderly energy transition scenario based on NGFS will be combined with the result of qualitative case studies to evaluate the impact of the disorderly energy transition scenario to Indonesian oil & gas sector.

4 Analysis

The following section describes selected cases and brief characteristics of the disorderly energy transitions and the quantitative impact of disorderly energy transition based on energy transition scenarios. The analysis should give an idea of how the disorderly energy transition will impact the Indonesian oil & gas sector and how to ensure that the Indonesian oil & gas sector could support the energy transition.

4.1 Case study

The case study analysis will be based on the trend and phenomena that match to the definition and characteristics of disorderly energy transition explained in the chapter 2. Below are several events that matched to the characteristics of disorderly energy transition.

Table 2. Disorderly Transition

Characteristics	Description	Sources
Investor increased risk preference on oil & gas sector	• Trend of increasing hurdle rate in oil & gas investment. There is strong preference to concentrate oil & gas companies‘ conventional activities on harvesting phase and move away from exploration or appraisal phase.	0, 0, 0
Low oil & gas investment	• The world currently lack of oil & gas investment required to meet future demand. • There is an increasing global consensus around the need to curb fossil fuel production and place strict limits on the exploration of hydrocarbon reserves.	0 0
Increasing oil price caused by supply crunch	• European energy crisis caused by low power generation of wind turbine combined with low gas supply forced switching power generation to fuel oil.	
Increasing trend of oil consumption	• Uptrend of oil consumption & oil portion in primary energy consumption	Figure 1 [1] & 2 [2]
Litigation issue related to oil & gas business.	• There are increasing trend of climate related litigation issues.	0

	• Royal Dutch Shell faces major adverse decision from Dutch Courts to increase climate action, also ExxonMobil and Chevron faces shareholders pressure to increase climate action.	0

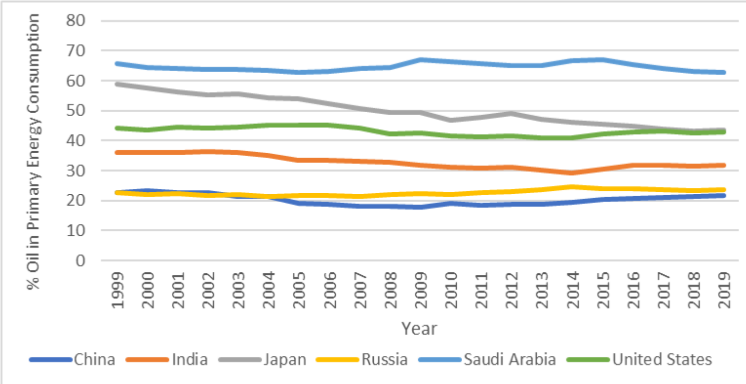

Fig. 1. Percentage of Oil in Primary Energy Consumption 00

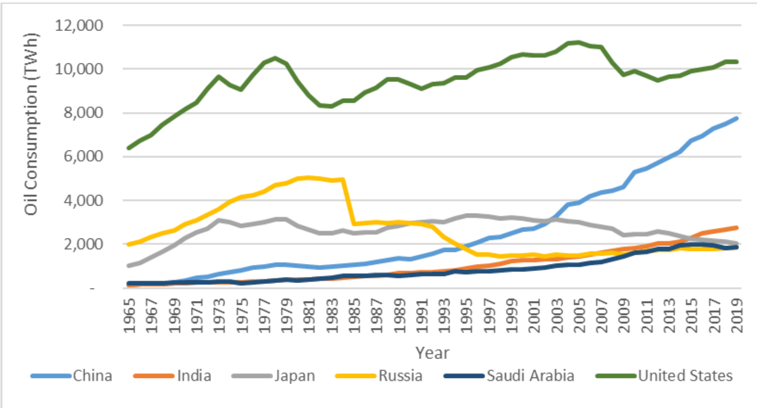

Fig. 2. Annual Oil Consumption Trend (in terawatt-hour) 0

Based on descriptions in table 2, the characteristics of disorderly energy transition has already occured. There is mismatch in the oil & gas supply and demand preference related to energy transition. In the supply side, several researches suggests that there are growing concern and preference that increase the pressure to oil & gas sector. Meanwhile, there are no significant change of oil & gas consumption especially for global top 6 oil consumers except Japan. Based on IEA, there are several factors that enable Japan to reduce its oil consumptions such as declining and aging population, high energy efficiency measures, and expanding fleet of hybrid and electric vehicle continue to reduce oil demand 0. The differencce in supply-demand preference could increase the risk of disorderly energy transition in the future.

Based on the recent study on oil & gas companies pathway to energy transition, there are different strategic preferences in the energy transition between European IOCs, American IOCs, and NOCs 0. The European IOCs such as BP, Shell, Equinor, ENI, Repsol, and Total Energies are having ambitious energy transition plan. The American IOCs such as ExxonMobil and Chevron are focusing on its core hydrocarbon exploration & production while investing in carbon capture technology to reduce emission. Meanwhile, National Oil Companies also embraces energy transition although its strategic direction still dependent to Government's policy.

From the perspective of government, the energy transition policies and energy transition commitments varies. For example, developing country such as Indonesia stated in the Nationally Determined Contribution (NDC) that the country requires global support to reduce emission up to 41% in 2030. There are also countries as China and India that requires high energy to support its economic growth and the high energy requirement currently supported by fossil energy 0. India sets its net zero target in 2070. Meanwhile, developed countries mostly has net zero target by 2050 and is supported by robust policies such as carbon price and well established emission trading system.

4.2 Energy transition scenarios

The energy transition model is using the NGFS scenario explorer provided by IIASA. The scenarios are as follows 0:

1. Orderly Transition
   a. Net Zero 2050 limits global warming to 1.5°C through stringent climate policies and innovation, reaching global net zero CO_2 emissions around 2050. Some jurisdictions such as the US, EU and Japan reach net zero for all GHGs.
   b. Below 2°C gradually increases the stringency of climate policies, giving a 67% chance of limiting global warming to below 2°C.
2. Disorderly Transition
   a. Divergent Net Zero reaches net zero around 2050 but with higher costs due to divergent policies introduced across sectors leading to a quicker phase out of oil usage with stringent policies in transportation and buildings sectors.
   b. Delayed transition assumes annual emissions do not decrease until 2030. Strong policies are needed to limit warming to below 2°C.

The characteristics of each scenarios are described in table 3.

Table 3. NGFS Scenarios

Category	**Scenario**	**Policy Reaction**	**Technology Change**	**Carbon Dioxide Removal**	**Regional Policy Variation**
Orderly	Net Zero 2050	Immediate and smooth	Fast	Medium use	Medium
	Below 2 °C	Immediate and smooth	Moderate	Medium use	Low
Disorderly	Divergent Net Zero	Immediate but divergent	Fast	Low use	Medium

	Delayed Transition	Delayed	Slow/Fast	Low use	High

Figure 3 [3] illustrates the different emission reduction path between different scenarios. In the disorderly scenarios, divergent net zero and delayed transition has different emission reduction pathways. The pathways are in line with the descriptions and characteristics of each scenario described before. Divergent net zero has similar path with other scenarios within orderly transition category, this is because in this scenario, the policy introduced immediately but divergent in different jurisdictions. In delayed transition, emission will keep growing until 2030 then abrupt policies are being implemented to curb the pathway.

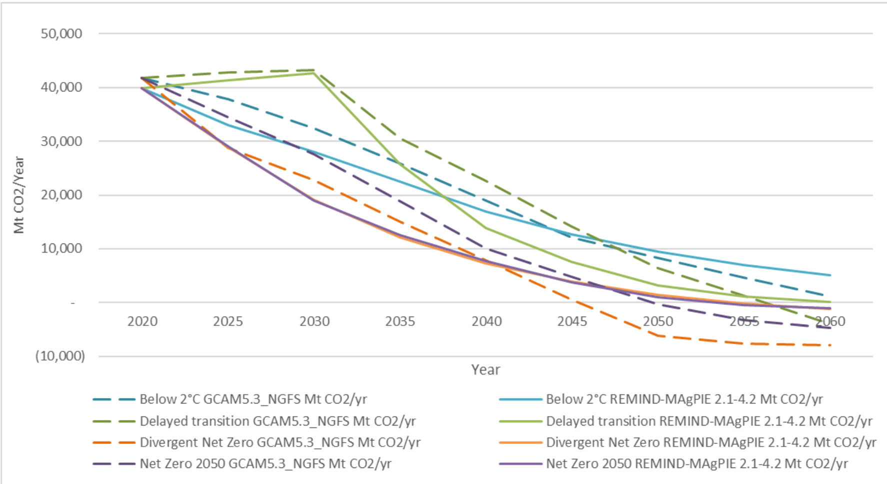

Fig. 3. CO_2 emission reduction pathway

For Indonesian oil & gas sector, global crude oil price plays an important role. Especially since Indonesia became net oil importer country with increasing consumption trend as seen in **Figure 4 [4]**. This is also related to Indonesian oil & gas balance of trade that has been on deficit since 2012 as seen in **Figure 5 [5]**. However, crude oil price has no short run or long run effects to Indonesian inflation 0, although if the price is above US$100 it will have low impact on inflation 0. Therefore, the issue on crude oil is more about energy security. Unlike oil price, gas price in Indonesia is mostly based on contract price as regulated in President Regulation No.121/2020 and Ministry of Energy & Mineral Resources Regulation No.8/2020, therefore it is less disrupted by global gas prices.

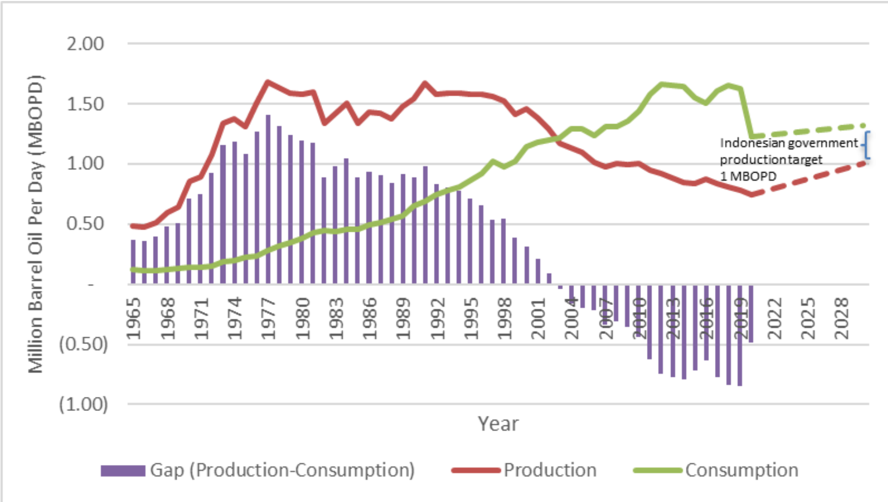

Fig. 4. Indonesian oil production and consumption (historical data adapted from BP 0)

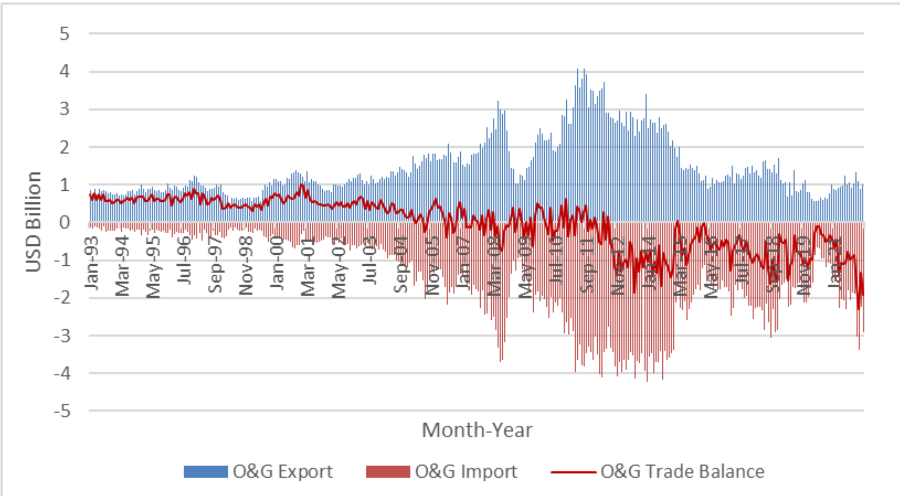

Fig. 5. Indonesian Oil & Gas Trade Balance in billion USD (adapted from BPS 0)

Since Indonesia is dependent on crude oil, and crude oil price has an impact on both Indonesian oil & gas trade balance and oilfield economic valuation, it is necessary to evaluate the impact of orderly and disorderly scenarios to oil price. The results of orderly and disorderly scenario groups based on the model that available in NGFS scenario explorer are presented in **figure 6 [6]**.

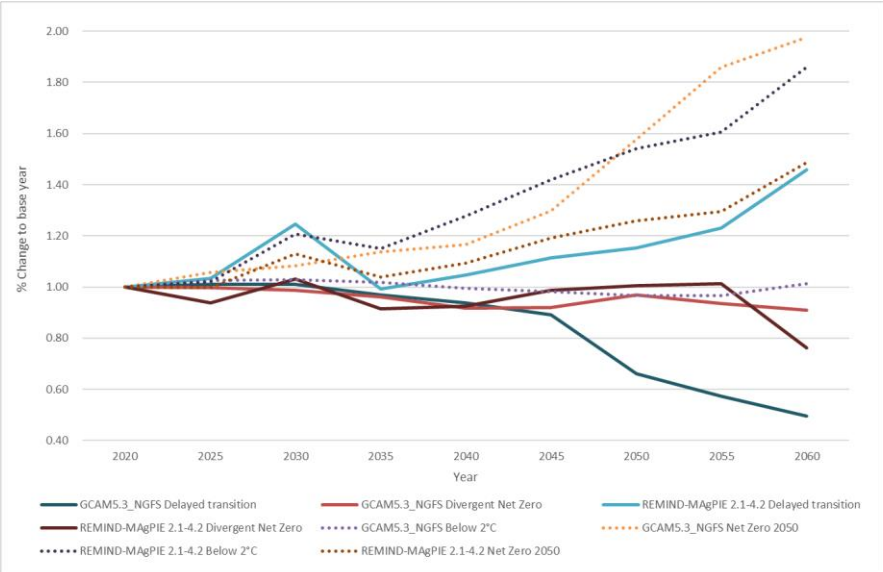

Fig. 6. Oil price % index change relative to base year

Table 4. Oil Price Fluctuations

Category	Model	Scenarios	(σ)
Disorderly Transition	GCAM5.3_NGFS	Delayed transition	0.09
		Divergent Net Zero	0.03
	REMIND-MAgPIE 2.1-4.2	Delayed transition	0.12
		Divergent Net Zero	0.11
Orderly Transition	GCAM5.3_NGFS	Below 2°C	0.02
		Net Zero 2050	0.07
	REMIND-MAgPIE 2.1-4.2	Below 2°C	0.07
		Net Zero 2050	0.07

Based on the result, the oil price is more fluctuated in disorderly transition compared to the orderly transition. Although, the delayed transition fluctuation is higher compared to divergent net-zero transition. In the orderly transition the oil price is relatively smooth and in an uptrend. However, oil price has a long history of fluctuation 0, even without energy transition. Furthermore, the oil price could be disrupted by physical climate risk especially from the production and logistics aspects as previously happened in Louisiana and Gulf of Mexico in 2021 0.

For strategic thinking purpose, the oil price outlook in the disorderly transition shows that the oil & gas sector should embrace the plausibility of oil price fluctuation and uncertainty of future trajectory (uptrend/downtrend). This situation is challenging for investment decision which require long payback.

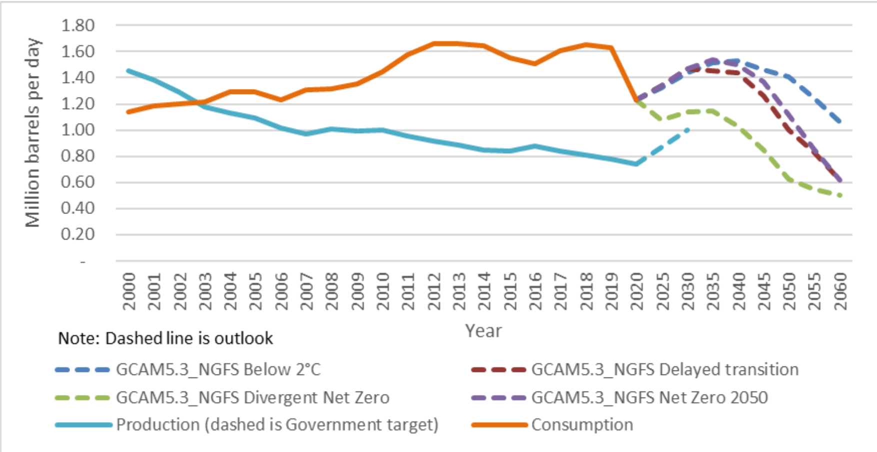

Fig. 7. Indonesian Oil Production - Consumption in Primary Energy Based on Scenarios

Based on the NGFS scenario as seen in **figure 7 [7]**, Indonesian oil consumption will not peaked until 2030s. However, the disorderly energy transition scenarios peak oil in Indonesia is faster than orderly scenarios. This is because in disorderly transition – delayed transition, climate policies being abruptly introduced to immediately curb the emission and divergent net-zero stringet policy in transportation and quicker phase out of oil being introduced. Compared to production, if Indonesian Government target of 1 million bopd oil production cannot be achieved and Indonesian future production folows historical trend, the gap of oil consumption and production will be widened until at least 2030.

4.3 Impact of disorderly energy transition to Indonesian oil & gas sector

Based on the case study and scenario analysis, the risks and uncertainty of disorderly energy transition can be described as in table 4. Degree of impact high if the impact directly affecting oil & gas value or sustainability and low if there are no direct impact to the sector.

Table 5. Disorderly Energy Transition Scenario Impact to Oil & Gas Sector

Sector Drivers	Risk/ Uncertainty	Description	Impact to Indonesian oil & gas sector	Degree of Impact
Oil Price	Risk	High oil price	Deficit on balance of trade, Pertamina financial risk, National energy security risk	High
		Low oil price	Stranded assets, low oil development & production activity, loss in oil assets value	High
	Uncertainty	Oil price fluctuation	Combination of above, low investment caused by cautious investor	High
Supply	Risk	Global oil supply shortage (supply crunch)	Energy security & higher oil price	High
Demand	Uncertainty	Magnitude of oil demand reduction caused by EV adoption	Faster EV adoption will increase the risk of stranded asset. Slower	High

			EV adoption require oil supply security.	
Hurdle Rate	Risk	Increasing hurdle rate caused by investor perception on energy transition 0	Increasing difficulties in investment decision on oil asset development.	High
Legal Issue	Uncertainty	Increasing litigation risk related to oil & gas sector development	Financial loss related to legal issue, supply crunch caused by abrupt reduction of oil investment.	High

Indonesia oil & gas sector current characteristics & attributes can be seen in table 6.

Table 6. Indonesian Oil & Gas Sector Attribute & Scenario Impact Analysis

Category	**Characteristics/ Attributes**	**Description**	**Scenario Impact**
Oil & Gas Sector Policy	Currently develop oil & gas law	Indonesia introduced Gross Split fiscal regime that has negative impact to oil & gas investment 0, although arguably has positive impact at low oil price scenario 0	High impact under both orderly and disorderly energy transition
Oil Supply Security	Depend on Indonesian NOC Pertamina	There is concentration risk caused by Indonesian oil supply that majority came from NOC Pertamina. Meanwhile, from inventory, Indonesian regulation stated that commercial reserves is minimum at 11 days and Indonesia currently does not have any strategic petroleum reserves or emergency inventory.	High impact under disorderly energy transition
	Depend on import	As seen in figure 4 [4], Indonesia currently oil net importer.	High impact under disorderly energy transition
Climate Policy	Introduction level as signal of government energy transition commitment	Indonesia has carbon cap & tax mechanism that will be broadly implemented in 2025, commitment to phase down coal. The Government also currently develop net-zero roadmap and has plan to utilize more renewable energy. Indonesian NDC stated that it will reduce 29% carbon emission on its own and 41% with international support.	Reducing policy uncertainty to the sector and wider stakeholders, reducing the potential of disorderly energy transition
Oil Sector Financial Security	Require external funding	Indonesia require external fund to develop its oil & gas sector.	High impact on disorderly energy transition scenario
Energy Transition Roadmap	Currently divergent and Net-zero roadmap under development	Government still develop the net-zero energy transition roadmap, although the high level of direction has been introduced in several occasions. However, Indonesia need energy transition roadmap alignment.	The allignment of energy transition roadmap will reduce policy uncertainty for the oil & gas sector and wider stakeholders.

Political	Not attractive	Investor perspective on Indonesian political risks is not attractive 0	High impact on any scenario
Technological	Conventional	Most of Indonesian oil & gas production are conventional. However, there are Government intentions to develop non-conventional production. Indonesia currently develop EV ecosystem.	High impact on disorderly energy transition. EV adoption is uncertain.
Legal	Medium climate litigation issues	Indonesia currently have medium climate litigation index, medium climate activism, extreme trend in climate litigation cases, and public awareness of climate change as major issue low 0.	Medium impact to energy transition, may potentially cause disorderly transition.

Based on the scenario impact analysis in table 5 and 6, the disorderly energy transition has medium-high impact to Indonesian oil & gas sector. Government has clear signal on the energy transition, although it requires international support to increase its climate action. Indonesian oil & gas sector relatively has lower public pressure to increase its climate action compared to the International Oil Companies. However, Indonesian oil & gas sector is exposed to the risk of oil price fluctuation. The energy transition has wide range of oil price scenarios and the disorderly energy transition could cause higher oil price fluctuation. Assuming low oil price in the future will reduce the economic valuation of oil sector and therefore will limit the range of oil sector investment. However, assuming high oil price will increase the risk of stranded assets and impairment loss in the future if the future oil price is lower. Moreover, Indonesia current situation as net oil importer will increase the nation risk to oil price fluctuation and energy security risk.

To reduce the impact of disorderly energy transition, this paper provides several recommendations as follows:

1. Revisit Indonesian petroleum fiscal regime with consideration on emission and future carbon pricing to attract investment.
2. Develop strategy to acquire oil supply from abroad.
3. Develop strategic petroleum reserves strategy as energy transition buffer to oil price fluctuations and supply shock.
4. Revisit its retail fuel price policy to be more flexible towards oil price fluctuation but resilience to reduce the economic impact.
5. Consider policy to curb demand in severe supply shock or high oil price situations such as implementing work from home policy to immediately reduce oil demand.
6. Create detailed energy transition roadmap with clear phases, with several scenarios as complement, to increase all stakeholders understanding on how the country will achieve its transition target. The energy transition roadmap should be holistically developed, such as considering the technology development path or human resource and natural resource management.
7. Create energy transition roadmap alignment with all energy sector stakeholders to ensure an orderly transition. The energy transition roadmap alignment will reduce the potential of divergent path and phase on the energy transition within the nation.

8. Increase collaboration to achieve energy transition target based on the roadmap, especially for Indonesian energy state owned enterprises such as PLN and Pertamina.
9. Develop policy to push the energy transition from the demand/consumer side. The increasing pressure on the supply side of oil should be balanced by the energy transition from consumer side especially on Small Medium Enterprises (SME) and household sector. Increasing energy efficiency from personal mobility and broadening public transportation could become solutions to reduce oil demand from household sector. Transition to hydrogen or electric based mobility as in Japan, has been proven to reduce oil demand, although it is currently costly.

5 Conclusion

Considering the complex nature of energy system, the energy transitions is less likely to be orderly, unless there are increasing global cooperation and alignment on the energy transition roadmap across actors within energy system. In the situation of disorderly energy transition, there are risks and uncertainty that mostly have medium to high impact to Indonesian oil & gas sector. Therefore, it will be useful for Indonesian government and oil & gas players to conduct stress testing on the Indonesian oil & gas sector strategy and capabilities based on energy transition scenarios.

Indonesian oil & gas sector is mostly vulnerable to disorderly energy transition scenario as a result of high and fluctuated price, and supply shock. Therefore, Indonesian Government should strengthen its current position, strategy, and capability to cope with the plausibility of the disorderly energy transition.

In this paper, oil price as key driver for oil & gas sector development have been analyzed. However, considering the limitation of the study, there are many other aspects that could be considered and evaluated in the context of scenarios. This paper only covers orderly and disorderly energy transition scenarios and emphasize on the transitional risk aspect of climate risk. For future study, it is recommended to explore another scenario and evaluate the physical risk aspect of climate risk.

References

[1] Solomon, B. D., & Krishna, K. The coming sustainable energy transition: History, strategies, and outlook. Energy Policy. 2011;39(11):7422-7431.

[2] Fouquet, R. Historical energy transitions: Speed, prices and system transformation. Energy Research & Social Science. 2016;22:7-12.

[3] Buschmann, P., & Oels, A. The overlooked role of discourse in breaking carbon lock-in: The case of the German energy transition. Wiley Interdisciplinary Reviews: Climate Change. 2019;10(3):574.

[4] Luomi, M. The Foreign Relations of Energy Transition–Framing the Issue for the UAE: EDA Insight; 2018. 9 p.

[5] Newell, R., Raimi, D., Villanueva, S., & Prest, B. Global energy outlook 2021: pathways from Paris. Resources for the Future Report; 2021. p. 11-21.

[6] NGFS. NGFS Climate Scenarios for central banks and supervisors; 2020 June. Available from: https://www.ngfs.net/sites/default/files/medias/documents/820184_ngfs_scenarios_final_version_v6.pdf

[7] Laimon, M., Mai, T., Goh, S., & Yusaf, T. Energy sector development: System dynamics analysis. Applied Sciences. 2019;10(1):134.

[8] Battiston, S., Dafermos, Y., & Monasterolo, I.: Climate risks and financial stability. Journal of Financial Stability. 2021;54:100-867.

[9] Wood Mackenzie. Indonesia upstream summary; 2021 August. Avalable from: https://my.woodmac.com/document/761975

[10] Federal Energy Regulatory Commission, North American Electric Reliability Corporation, & Regional Entities. The February 2021 Cold Weather Outages in Texas and the South Central United States | FERC, NERC and Regional Entity Staff Report. Federal Energy Regulatory Commission; 2021 November. Available from: https://www.ferc.gov/media/february-2021-cold-weather-outages-texas-and-south-central-united-states-ferc-nerc-and

[11] California ISO. Summer Market Performance Report June 2021; 2021 July. Available from: http://www.caiso.com/Documents/SummerMarketPerformanceReportforJune2021.pdf

[12] ESOTC 2021 | EUROPE | IMPACT Low winds. (n.d.). Copernicus Climate Change Service; April 4, 2022. Available from https://climate.copernicus.eu/esotc/2021/low-winds

[13] Batten, S., Sowerbutts, R., & Tanaka, M. Let's talk about the weather: the impact of climate change on central banks; 2016.

[14] KAPSARC. Understanding the Energy Transition; 2018 April. Available from: https://doi.org/10.30573/KS--2018-WB16

[15] Van der Ploeg, F., & Rezai, A. Stranded assets in the transition to a carbon-free economy. Annual review of resource economics. 2020;12:281-298.

[16] Oxford Economics. What if the move to net-zero emissions is disorderly?; 2021 May. Available from: http://blog.oxfordeconomics.com/content/what-if-the-move-to-net-zero-is-disorderly

[17] World Economic Forum. Global Risks 2022: The "disorderly" net-zero transition is here and it's time to embrace it. World Economic Forum. Retrieved January 23, 2022. Available from https://www.weforum.org/agenda/2022/01/global-risks-2022-disorderly-net-zero-transition/

[18] McKinsey & Company. The economic transformation: What would change in the net-zero transition; 2022 January. Available from: https://www.mckinsey.com/business-functions/sustainability/our-insights/the-economic-transformation-what-would-change-in-the-net-zero-transition

[19]Verisk Maplecroft. Environmental Risk Outlook 2021. [Cited 2021 May]. Available from: https://www.maplecroft.com/insights/analysis/environmental-risk-outlook-2021/
[20] Climate Action Tracker. CAT Climate Target Update Tracker; 2022 January 23. Available from: https://climateactiontracker.org/climate-target-update-tracker/
[21] ECIU. Net Zero Scorecard. Energy & Climate Intelligence Unit; 2022 [cited 2022 January 23]. Available from: https://eciu.net/netzerotracker
[22] World Bank. Carbon Pricing Dashboard. The World Bank; 2022 [cited 2022 January 23] Available from: https://carbonpricingdashboard.worldbank.org/
[23] SBTi. Target Dashboard. Science Based Target; 2022 March 17 [cited 2022 March 20] Available from: https://sciencebasedtargets.org/companies-taking-action
[24] BP. Statistical Review of World Energy; 2021 July [cited 2022 January 23] Available from https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html
[25] IEA. Energy subsidies – Topics; 2020 [cited 2022 March 20] Available from https://www.iea.org/topics/energy-subsidies
[26] Njie, B., & Asimiran, S. Case study as a choice in qualitative methodology. Journal of Research & Method in Education. 2014;4(3):35-40.
[27] Baskarada, S. Qualitative case study guidelines. The Qualitative Report. 2014;19(40):1-25.
[28] Gammelgaard, B.: The qualitative case study. The International Journal of Logistics Management; 2017.
[29] Gribkova, D., & Milshina, Y. Energy Transition as a Response to Energy Challenges in Post-Pandemic Reality. Energies. 2022;15(3):812.
[30] Ahl, A., Yarime, M., Goto, M., Chopra, S. S., Kumar, N. M., Tanaka, K., & Sagawa, D. Exploring blockchain for the energy transition: Opportunities and challenges based on a case study in Japan. Renewable and Sustainable Energy Reviews, 2020. 117 p. 109488.
[31] Laes, E., Gorissen, L., & Nevens, F. A comparison of energy transition governance in Germany, the Netherlands and the United Kingdom. Sustainability. 2014;6(3):1129-1152.
[32] Schoemaker, P.J., Scenario planning: a tool for strategic thinking. Vol. 36, no. 2, pp. 25-50. Sloan management review; 1995.
[33] Godet, M., The art of scenarios and strategic planning: tools and pitfalls. Technological forecasting and social change. 2000;65(1):3-22.
[34] Peterson, G.D., Cumming, G.S. and Carpenter, S.R. Scenario planning: a tool for conservation in an uncertain world. Conservation biology. 2003;17(2):358-366
[35] Alshammari, Y. M. Scenario analysis for energy transition in the chemical industry: An industrial case study in Saudi Arabia. Energy Policy, 2021. 150 p. 112128.
[36] Bazilian, M., Bradshaw, M., Gabriel, J., Goldthau, A., & Westphal, K. Four scenarios of the energy transition: Drivers, consequences, and implications for geopolitics. Wiley Interdisciplinary Reviews: Climate Change. 2020;11(2):e625.
[37] Grant, R.M. Strategic planning in a turbulent environment: Evidence from the oil majors. Strategic management journal. 2003;24(6):491-517.
[38] Meissner, P. and Wulf, T. Cognitive benefits of scenario planning: Its impact on biases and decision quality. Technological Forecasting and Social Change. 2013;80(4):801-814.
[39] Ramírez, R., Österman, R. and Grönquist, D. Scenarios and early warnings as dynamic capabilities to frame managerial attention. Technological Forecasting and Social Change. 2013;80(4):825-838.

[40] Bodwell, W. and Chermack, T.J. Organizational ambidexterity: Integrating deliberate and emergent strategy with scenario planning. Technological Forecasting and Social Change. 2010;77(2):193-202.
[41] Kahane, A. Scenarios for changing the world. The Dance of Change. A Fieldbook for Sustaining Momentum in a Learning Organization. New York, NY: Currency Doubleday; 1999.
[42] TCFD. Guidance on Scenario Analysis for Non-Financial Companies; 2020 October. Available from: https://assets.bbhub.io/company/sites/60/2020/09/2020-TCFD_Guidance-Scenario-Analysis-Guidance.pdf
[43] Lindgren, M., & Bandhold, H. Scenario planning. London: Palgrave; 2003.
[44] Allen, T., Dees, S., Caicedo Graciano, C. M., Chouard, V., Clerc, L., de Gaye, A., ... & Vernet, L. Climate-related scenarios for financial stability assessment: An application to France; 2020.
[45] Kemp, J., McCowage, M., & Wang, F. Towards Net Zero: Implications for Australia of Energy Policies in East Asia. RBA Bulletin; 2021 September.
[46] Gambhir, A., George, M., McJeon, H., Arnell, N. W., Bernie, D., Mittal, S., ... & Monteith, S. Near-term transition and longer-term physical climate risks of greenhouse gas emissions pathways. Nature Climate Change. 2022;12(1):88-96.
[47] Bertram, C., Hilaire, J., Kriegler, E., Beck, T., Bresch, D. N., Clarke, L., ... & Yu, S. NGFS Climate Scenarios Database: Technical Documentation; 2020.
[48] Zhou, Xiaoyan., Wilson, Christian., & Caldecott, B. The energy transition and changing financing costs; 2021.
[49] Fattouh, B. Energy transition, uncertainty, and the implications of change in the risk preferences of fossil fuels investors; 2019.
[50] Fattouh, B., & Sen, A. Economic diversification in Arab Oil-exporting countries in the context of peak Oil and the energy transition. In When Can Oil Economies Be Deemed Sustainable?: Palgrave Macmillan, Singapore; 2021. 73-97 p.
[51] IEF & IHS Markit. Oil and Gas Investment Outlook. International Energy Forum; 2021 December. Available from: https://www.ief.org/investment-report-2021/download
[52] Setzer, J., Higham, C., Jackson, A., & Solana, J. Climate change litigation and central banks. European Central Bank Legal Working Paper Series; 2021.
[53] Blackmon, D. A Day That May Live In Infamy For Big Oil. Forbes. 2021 May 27 [cited 2022 March 20]. Available from: https://www.forbes.com/sites/davidblackmon/2021/05/27/may-26-2021-a-day-that-may-live-in-infamy-for-big-oil/?sh=4ae8db1675d9
[54] Share of direct primary energy consumption by source.: Our World in Data; 2020 [cited 2022 March 20]. Available from: https://ourworldindata.org/grapher/share-of-primary-energy-consumption-by-source?country=%7EOWID_WRL
[55] Oil consumption.: Our World in Data; 2021 [cited 2022 March 20]. Available from: https://ourworldindata.org/grapher/oil-consumption-by-country?tab=chart
[56] EIA. International - U.S. Energy Information Administration (EIA). EIA Independent Statistics & Analysis; 2020 November 2 [cited 2022 March 20]. Available from: https://www.eia.gov/international/analysis/country/jpn#:%7E:text=10-,Structural%20factors%20such%20as%20a%20declining%20and%20aging%20population%2C%20high,continue%20to%20reduce%20oil%20demand.
[57] Asmelash, E., & Gorini, R.: International oil companies and the energy transition. International Renewable Energy Agency: Abu Dhabi, United Arab Emirates; 2021.

[58] NGFS. (2021, June). NGFS Climate Scenarios for central banks and supervisors. https://www.ngfs.net/sites/default/files/media/2021/08/27/ngfs_climate_scenarios_phase2_june2021.pdf

[59] Rostin, R., Adam, P., Nur, M., Saenong, Z., & Baso, J. N.: The effect of crude oil prices on inflation, interest rates and economic growth in Indonesia. Vol. 9, no. 5, pp. 14. International Journal of Energy Economics and Policy, (2019)

[60] Darmawan, I., Siregar, H., Hakim, D. B., & Manurung, A. H.: World Oil Price Changes and Inflation in Indonesia: A Nonparametric Regression Approach. Signifikan: Vol. 10, no. 1, pp. 161-176. Jurnal Ilmu Ekonomi, (2021)

[61] BP.: Statistical Review of World Energy. BP Statistical Review of World Energy Download. (2021). Retrieved March 20, 2022, from https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/xlsx/energy-economics/statistical-review/bp-stats-review-2021-all-data.xlsx

[62] BPS.: Badan Pusat Statistik. (2022). Retrieved March 20, 2022, from https://www.bps.go.id/subject/8/ekspor-impor.html#subjekViewTab3

[63] Baumeister, C., & Kilian, L.: Forty years of oil price fluctuations: Why the price of oil may still surprise us. Vol. 30, no. 1, pp. 139-60. Journal of Economic Perspectives, (2016)

[64] EIA. (2021, September 16). Hurricane Ida disrupted crude oil production and refining activity. Today in Energy - U.S. Energy Information Administration (EIA). Retrieved March 20, 2022, from https://www.eia.gov/todayinenergy/detail.php?id=49576

[65] Yun, P., Jia, L., Xin, Y. J., Du Fen, S., Wen, C. Y., Wei, L. H., & Feng, G.: Indonesia's New Petroleum Fiscal Regime: Fiscal Changes, Impacts and Future Trends. In IOP Conference Series: Earth and Environmental Science. Vol. 446, no. 5, p. 052078. IOP Publishing, (2020)

[66] Pandey, P., & Chopra, P.: Gross Split PSC a Game Changer in Lower for Longer Scenario. (2019)

[67] Riswan, K., Cahyandito, M. F., Herwany, A., & Anwar, M.: The Investors' Perspective on Investment Attractiveness of Oil and Gas Exploration Industry in Indonesia. Vol. 7, no. 4 .15, pp. 409-412. International Journal of Engineering & Technology, (2018)