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READINESS EVALUATION OF CARBON TAX IMPLEMENTATION BASED ON ERIA INDUSTRY 4.0 FOR THE CIRCULAR ECONOMY: A CASE STUDY AT PT XYZ

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ABSTRACT

The carbon tax is a new initiative that will be implemented in Indonesia. The implementation of the carbon tax will not be carried out simultaneously but depends on the readiness of each industrial sector. PT XYZ, one of the steel production businesses, may be one of the potential carbon tax objects in 2025. Previous research has resulted in an impact analysis of carbon tax implementation and low-carbon production technology, but none has comprehensively evaluated the industry's readiness to apply carbon tax. This study assessed company readiness based on eight determinants mentioned in the Economic Research Institute for ASEAN and East Asia (ERIA) Industry 4.0 Readiness Assessment for The Circular Economy. The method used in this research is a case study at PT XYZ through interview and documentation analysis. The finding assessed the level of readiness of PT XYZ on a scale of 'ready.' Based on the readiness assessment that has been carried out, recommendations were obtained and should be applied by the Company.

Keywords: Carbon tax, Circular economy, Impact, Readiness, Steel company.

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1. INTRODUCTION

The Indonesian government issues instrument policy to control climate change through fiscal policy. This fiscal policy is contained in Law of Republic of Indonesia No. 7 of 2021 concerning the Harmonisation of Tax Regulations (HPP Law) in Chapter VI regarding the carbon tax, hereinafter referred to as the carbon tax. This carbon tax will take effect on July 1, 2022, for the coal energy steam-electric power plant (PLTU) industry. It will then be applied to other sectors starting in 2025 by considering economic conditions and the readiness of the related industries. The issue of carbon taxes is also followed by the case of carbon trading, which is a mechanism flow for implementing a carbon tax.

In line with the above, PT XYZ, a company engaged in producing steel commodities, is aware of this issue and anticipates its implementation. However, there has been no comprehensive preparation from PT XYZ. Thorough preparations regarding implementing a carbon tax need to be carried out by PT XYZ because PT XYZ produces carbon dioxide emissions and uses raw materials and energy that produces carbon dioxide emissions from each supplier industry. This will lead to additional costs of raw materials, energy, and others, which gives a *multiplier effect* on the increase in production costs of PT XYZ. Evaluating this preparation is also in line with the importance of eco-efficiency, namely, using fewer inputs to produce the same output. According to the saying, preventing is cheaper than curing (Hansen and Mowen, 2018).

Based on the urgency of the above, the question in this research is how prepared PT XYZ is to face the implementation of the carbon tax, especially to reduce the negative impacts that will occur. This study evaluates the readiness to implement a carbon tax based on eight determinants of ERIA Industry 4.0 Readiness Assessment for The Circular Economy. This framework is used because it aligns with the carbon tax regulation implemented in Indonesia. The rule requires the Company to minimize the use of materials and energy because the carbon tax will be imposed on materials containing carbon. It requires companies to reduce emissions because the carbon tax will also be imposed on the carbon emissions emitted. Thus, this research provides recommendations that PT XYZ can apply regarding comprehensive preparations to reduce the negative impacts of implementing the carbon tax.

Since PT XYZ is a large steel commodity company in Indonesia and the implementation of the carbon tax is not carried out simultaneously but gradually by observing the readiness of each industrial sector, this research also provides information for the government on how prepared the steel commodity sector is to implement carbon tax regulations. This case study research also has an academic contribution considering that the previous studies only discussed the impact analysis after implementing the carbon tax and discussed low-carbon production process technology. This research explicitly examines the preparation before applying a carbon tax on the steel industry that has been carried out comprehensively and in-depth using the case study research method. For example, Alton et al. (2014) evaluate the impact of implementing a carbon tax in South Africa depending on how the government distributes carbon tax revenues. Khastar, Aslani, and Nejati (2020) analyzed the impact of implementing a carbon tax in Finland, which strongly influenced the carbon tax rate imposed. Chen et al. (2020) analyzed the impact of the cap-and-trade system and the carbon tax, which stimulated the industry to develop green innovations to reduce emissions. Dioha and Kumar (2020) Study of risk mitigation scenarios from carbon tax regulations in Nigeria, including mitigation scenarios for increasing renewable energy penetration, energy efficiency, and fuel switching.

The structure of this research is the first part describing the study's background. The second part reviews the literature on the ERIA Industry 4.0 Readiness Assessment for The Circular Economy framework to evaluate the readiness to implement a carbon tax, previous research, carbon tax regulations, and carbon trading regulations. The third part describes the research methods, data collection, and analysis techniques. The method used in this research is a case study at PT XYZ. Data were collected through interviews with 13 respondents from PT XYZ and related government institutions and document analysis of the Company's internal documents and associated regulations. The fourth part describes the organization’s profile. The following section describes the research results based on the data obtained. Then the discussion of the data is carried out on the concepts or theories used. This section is the core of the case study. The result shows that PT XYZ is ‘ready’ to implement the carbon tax. In the last section, this research is finalized with conclusions and suggestions that PT XYZ can apply to improve performance in reducing the negative impact of implementing the carbon tax.

2. LITERATURE REVIEW

2.1 PREVIOUS RESEARCH

As a result of implementing the carbon tax regulation, the Company makes various preparations to reduce emissions. Generally, previous studies discuss the evaluation of the efforts done to reduce emissions after the implementation of the carbon tax, such as the analysis of low-carbon emissions technologies (Deng & Adams, 2020; Chen et al., 2020; Dioha & Kumar, 2020; Franks et al., 2017; Siagian et al., 2017; McCollum et al., 2018), as well as effort through sales strategy by revenue sharing and cost-sharing (Yang & Chen, 2018; Yang, Luo, & Wang, 2017). However, no previous research has discussed the in-depth and comprehensive preparations companies must carry out before implementing the carbon tax. This study evaluates the readiness to implement a carbon tax on one research object using the ERIA industry 4.0 readiness framework assessment for the circular economy, discussed next.

2.2 ERIA INDUSTRY 4.0 READINESS ASSESSMENT FOR THE CIRCULAR ECONOMY

The ERIA Industry 4.0 Readiness Assessment for The Circular Economy evaluates the readiness to implement a comprehensive carbon tax. ERIA developed this framework, an international organization established through a formal agreement between 16 countries in the East Asia region and ASEAN to conduct research activities and make policy recommendations to sustain economic integration in East Asia and ASEAN. This framework is used to assess the level of readiness in the *circular economy*. *The circular economy* is a restorative economy that minimizes the need for new material and energy inputs while reducing negative environmental impacts related to resource extraction, emissions, and waste. In a circular economy, waste is considered valuable because treatment allows the recovery of materials that can be reused as inputs or for the remanufacturing of industrial goods. The circular economy is a fundamental alternative to the take-make-use-throw linear economic model that currently dominates. This linear model assumes that natural resources are available, abundant, easy to obtain, and cheap to dispose of but are not sustainable (Steffen et al., 2015). Thus, natural resources must be managed efficiently and sustainably throughout their life cycle. With good

management in terms of *circular economy*, PT XYZ always adheres to regulations, one of which is the carbon tax regulation described in the next section. While also being able to maintain its business continuity and can create sustainability in its business.

Then, there is a framework called ERIA Industry 4.0 Readiness Assessment for The Circular Economy, a series of indicators to assess the Company's operational policies related to business readiness in implementing a circular economy. The framework is intended for policymakers and corporate managers responsible for identifying priority areas for change. There are eight determinants in assessing industry readiness within the framework, i.e., strategy and organization, plant and equipment, information technology systems, human resources, finance and investment, energy and resource management, quality management, and supply chain management. Each determinant describes the scoring criteria from levels 0 to 4 (see appendix 1).

2.3 Regulation on Carbon Trading and Carbon Taxes

The government has enacted the HPP Law in Chapter VI regarding the Carbon Tax, which will take effect from July 1, 2022, for the coal energy steam-electric power plant. For 2025 and beyond, the implementation of this carbon tax will extend to other sectors. According to the Minister of Finance, Sri Mulyani (Sembiring, 2021), the implementation of the carbon tax in different sectors will be carried out in stages according to the readiness of the relevant industry by taking into account the following things like economic conditions, the preparedness of businessperson, impact, and/or scale. Before being a subject to the carbon tax on carbon emissions, the entity can conduct carbon trading based on Presidential Regulation of Republic of Indonesia No. 98 of 2021 (Presidential Decree 98 of 2021) concerning the Implementation of Carbon Economic Values for Achieving Nationally Determined Contribution Targets and Control of Greenhouse Gas Emissions in National Development.

After the entity conducts carbon trading, the remaining emissions that cannot be reduced to the upper limit will be subject to a carbon tax. The tax rate is higher than or equal to the carbon price on the carbon market but at a minimum of IDR 30.00 per kilogram of carbon dioxide equivalent (CO_2e) or an equivalent unit under Chapter (9) of the HPP Law. The government policy to establish basic rules regarding the tax rate indicates that the government will set a low price for the

carbon tax rate and gradually increase it. This is in line with the research conducted by Ng (2019). One approach to setting the carbon price is to increase the carbon price gradually through legislation regulating from a low initial price. The gradually increasing carbon price will help the industry and the economy adapt to a market.

However, up until now, there has not been a directive procedure that regulates the provisions in Chapter 13 articles (14) and (15) of the HPP Law:

"The procedure for calculating, collecting, paying or depositing, reporting; the mechanism for imposing carbon taxes; and procedures for deducting carbon tax; carbon tax subject as referred to in article (5); and/or; revenue allocation from carbon tax for climate change control.".

3. RESEARCH METHOD

In this study, the authors use a descriptive case study research method using a single research object, namely PT XYZ. The data collection methods used are interviews and document analysis.

3.1 GAINING ACCESS

The first Authors submit interview access with the Fiscal Policy Agency (FPA) and the Directorate General of Taxation (DGT) through the official portal that has been provided. The authors then ask for access to data collection by contacting PT XYZ internally via email and telephone. The authors ask for full access to interviews with related departments, access to internal data, and direct observations in the PT XYZ area. On the other hand, direct observation in the area is not permitted given the restrictions on the number of workers who can enter the premises due to COVID-19. The authors submitted the entire list of questions and made a schedule for the interview. To maintain the confidentiality of participants and research objects in this study, the authors use anonymity for all participants and the organization of the research object.

3.2 DATA COLLECTION

After getting an interview schedule with each respondent, the authors interviewed with the questions that had been previously given. The interview questions are semi-structured. That means the interview question guidelines are prepared systematically and then combined with open-ended questions, which are expected to ease the way for digging deeper into information about the opinions and experiences of the informants on the activities that have been carried out (Wilkinson and Brimingham, 2003). Interviews were conducted with 13 interviewees consisting of 11 respondents from PT XYZ, one respondent from FPA, and one respondent from DGT (see table 1). Respondents from PT XYZ generally come from different departments and are selected based on the most suitable job descriptions to answer interview questions. Interviews with FPA and DGT were conducted due to limited information regarding the carbon tax regulations as described in section 2 above. The authors asked for internal company documents that could support their answers in the interview process.

Table 1. Detail Participant of Interview

No.	Interviewee Code	Position	Agency
1.	X1	Policy Analyst	FPA
2.	X2	Industrial VAT 3 Implementer	DGT
3.	X3	Head of Technology and Energy Development	PT XYZ
4.	X4	Head of Tax and Verification	PT XYZ
5.	X5	Industrial Engineering Analyst	PT XYZ
6.	X6	Health, Safety, and Environment Supervisor	PT XYZ
7.	X7	Energy & Utility Project Sales (Domestic) Manager	PT XYZ
8.	X8	Sales 5 (Export) Supervisor	PT XYZ
9.	X9	Head of Industrial Engineering	PT XYZ
10.	X10	Head of Hot Strip Mill	PT XYZ
11.	X11	Director of Human Resource	PT XYZ
12.	X12	Vice President of Research and Technology	PT XYZ
13.	X13	Head of Funding Strategy	PT XYZ

Source: the data has been processed by the authors

3.2 DATA ANALYSIS

The data that has been collected is processed using thematic analysis and content analysis. This case study research was initiated by data analysis on the interview results. Interviews have been conducted at three participating institutions, namely

PT XYZ, FPA and DGT. FPA and DGT received questions, including directions and technical rules if the carbon tax was imposed. Meanwhile, PT XYZ received questions regarding the readiness to implement the carbon tax. Analysis of interview results using thematic analysis techniques. The following are the steps carried out in thematic analysis:

- Results of the interviews in the form of recordings were played back to make a transcript of the interview.
- The results of interview transcripts are identified and grouped into similar themes based on eight determinants of the ERIA industry 4.0 readiness assessment for the circular economy framework.
- The information that has been grouped according to the theme is then evaluated on a 0-4 rating scale.

Next, content analysis was a substitute for activity records that the researcher could not observe directly (Stake, 1995). In this case study research, the document used as the data source is the Company's internal records related to the study of carbon tax regulations used at the Company's internal coordination meeting. The authors decided to do this because the data in the document is the most relevant data to answer related research questions and strengthen the results of existing interviews.

Then, the evaluation results of the readiness to implement the carbon tax are carried out by adding up the overall value for each determinant. The total score is categorised into 5 categories of readiness, namely, 0 - 10 = not ready; 11 - 20 = less ready; 21 - 30 = ready; 31 - 40 = very ready.

4. ORGANIZATION PROFILE

The author uses a single research object in this study, namely PT XYZ. PT XYZ is a holding company with dozens of subsidiaries and associated entities. Currently, PT XYZ has three thousand employees working. The current line of business is producing Hot Rolled Coil, Cold Rolled Coil or Sheet, Wire Rod, and other supporting businesses. PT XYZ has several plants, such as Coke Oven Plant, Blast Furnace Plant, Slab Steel Plant, and Hot Strip Mill Plant.

In addition to production scale and substantial carbon emission results, PT XYZ uses many materials and energy-containing carbon, i.e., Slab, coal, and natural gas. This makes PT XYZ a very interesting subject to study regarding the preparation

of the carbon tax application, which will have a large impact on the increase in PT XYZ's costs when applied.

5. RESULT AND DISCUSSION

To evaluate how well-prepared PT XYZ is in carbon tax implementation, this research uses the ERIA Industry 4.0 Readiness Assessment for The Circular Economy framework, with eight determinants used. Appendix 1 shows the worksheet results evaluating the readiness to implement the carbon tax at PT XYZ. Meanwhile, Table 2 briefly shows the calculation result of the assessment on readiness to implement the carbon tax at PT XYZ. With the efforts that have been made, PT XYZ gets a total evaluation value of the readiness to implement the carbon tax of 25 means that PT XYZ is in the 'ready' category for the implementation of the carbon tax.

Table 2. Calculation Results of Evaluation of Readiness of Carbon Tax Implementation at PT XYZ Based on ERIA Industry 4.0 Framework Readiness Assessment for The Circular Economy

Determinant (Criteria)	**Level**
Strategy and Organization	3
Plant and Equipment	4
Information Technology Systems	2
Human Resource	2
Financial and Investment	
Financial Availability	1
Investment Allocation	1
Resource Consumption and Energy Management	4
Quality Management	
Zero Defect Programs	2
Quality Traceability	3
Supply Chain Management	3
Total Score	**25**

Source: the data has been processed by the authors

An assessment of the carbon tax implementation readiness evaluation has been carried out. It will be described in the following discussion below based on the eight determinants of the ERIA Industry 4.0 Readiness Assessment for The Circular Economy.

1. Strategy and Organisation

PT XYZ's organizational strategy in considering the principles of eco-innovation is at level 3. Namely, there are principles and beliefs that eco-innovation is a priority and positively contributes to the Company's profitability. X12 said:

"*So, after we make a roadmap [a decarbonization strategy through innovation], everyone must be aware of that direction. [. . .] So, it will not be possible to realize decarbonization without steel. Steel is a very, very environmentally friendly material. It never runs out because it will be able to recycle endlessly."*

In addition, the form of eco-innovation carried out by PT XYZ is more than just complying with applicable regulations (level 2). Still, not all forms of innovation are explicitly required to apply the principles of eco-innovation and show a positive contribution to the environment (level 4). This is evidenced by the environmental regulations that have been fully complied with based on the compliance status on the Ministry of Environment's reporting portal. Other eco-innovation principles are also applied to production and sales activities. For example, an online sales platform for PT XYZ is created to increase sales for PT XYZ and the Group of Companies because it sells products from associated companies and subsidiaries. This is also done to improve service to consumers. Consumers can easily find steel products from online searches, and when ordering, consumers can also track the delivery of the ordered goods. Innovation from production activities is also carried out by applying new renewable energy, such as installing solar panels for electricity in company buildings. Furthermore, PT XYZ also optimizes the utilization of Cook Oven Gas for Reheating Furnace at Hot Strip Mill Plant and Boiler at Cold Rolling Mill Plant and has carbon capture technology. However, several facilities in the upstream Blast Furnace Plant and Direct Reduction Plant were temporarily shut down due to intense price competition, so it is cheaper to manage semi-finished products such as Slab and Billet than to manufacture from raw materials Iron Ore and Flux. Thus, because some facilities are turned off, not all innovations have been carried out explicitly by applying the eco-innovation principle.

2. Plant and Equipment

The evaluation of PT XYZ's plant and equipment is at level 4 because all facilities in the manufacturing process can adopt the principles of repair, refurbishment, and remanufacturing. Repairment is the process of repairing damaged equipment so that it can be reused. At the same time, refurbishment returns the function of used equipment to like-new (Zacharaki et al., 2021). Remanufacturing is the highest level in the circular economy, the same as refurbishment, but remanufacturing is carried out thoroughly and increases its functional capacity. X10 said:

"So, we do maintenance planning from upstream to downstream [factories]. So, maintenance includes repairs. Repair means that the damage is repaired. [...] Then, we also categorize that the repair can be done by ourselves or must require the third party. PT XYZ brought out the third one for repairs... For example, if there is still after-sales service, we will use it first."

Furthermore, based on interviews with X10 refurbishment conducted at PT XYZ, they made their new tools from damaged ones by remaking them through technical drawings, which are then realized internally or using workshop services. Based on interviews with X10, the principle of remanufacturing (or what they call revitalization) that PT XYZ does is to restore the functional capacity of equipment and factories as before or even increase their operational capacity. Remanufacturing is carried out periodically depending on the condition of the factory and the tool itself. However, in principle, remanufacturing of equipment and factory facilities must be carried out considering the ancient age of the factory and equipment. Then, of the seven factories PT XYZ owned, they have adopted the remanufacturing principle.

"The major revitalization was carried out in ninety-three [1993] and 2010. The major revitalization was to restore it to its original capacity and increase the capacity from 1,8 million tons to increase its production capacity to 2,4 million tons. [. . .] PT XYZ has been operating for a very long time. So, each factory has its characteristics and has its revitalization timeline. So, everything has been revitalized."

3. Information Technology Systems

In the third determinant evaluation, the information technology system implemented by PT XYZ is at level 2; namely, the consumption of resources and energy is monitored in real-time to take corrective action if necessary. X10 said:

"We have sensors or measuring instruments related to electricity and gas consumption. Second, we have just installed CEMS (Continuous Emission Monitoring Systems). [...] For now, the [tools] that have been installed are real-time."

The monitoring system does not touch level 3 because the monitoring system does not generate notifications that signal the need for action from the user. The X10 also explains:

"So, it's only reading [sign], and the control will be in the human [...] But that's right now. So that doesn't mean it will be like that in the future. So maybe later, we will have alerts or warnings given related to excessive consumption of fossil energy. It might be like that in the future."

4. Human Resources

PT XYZ's evaluation of the fourth determinant is at level 2. The Company's employees, suppliers, distributors, and retailers are aware of environmental issues and have adopted new ways of working to support the Company's initiatives in adopting an environment-based approach (ERIA, 2020, p. 94). X12 explains awareness of environmental issues and new ways of working to support the Company's initiatives in adopting an environment-based approach carried out by employees of PT XYZ and electricity supplier (it's subsidiary). Efforts made by employees are to involve relevant departments by creating teams to carry out energy conservation which is part of the energy efficiency work program to achieve net-zero carbon. Meanwhile, to all employees in general, awareness and efforts towards environmental issues are carried out by doing simple things to save electricity and water consumption by all employees of PT XYZ. X12 said:

"So, there are several pillars that we are doing. The first is energy efficiency, and then the second is using renewable energy. Alhamdulillah, we have just inaugurated the use of solar panels in the technology building, which is being carried out by a subsidiary of PT XYZ [supplier] [...] At that time, we carried out energy conservation as a part of the pillars of energy management, so like it or not, we [Research and Technology Division] involved the energy users. These energy users are friends in the [Directorate] of production [...] Directorate of production as well of course there are other friends, supporting supply chain and logistics. [. . .] Actually, with the use of lights, water, and so on, there are

many writings in the hallway, such as energy-saving notes. That is our effort to spread the word to all. All must be aware of it. "

Furthermore, X5 also explains how awareness and new ways of working are being carried out by electricity suppliers (PLN) in supporting PT XYZ's initiative to take an environment-based approach. X5 said:

"As far as I know, PLN now has a program called REC (Renewable Energy Certificate). So, they sell electricity a little more expensively because it uses renewable energy. But compared to being taxed on carbon, it's cheaper."

The evaluation score on this determinant does not reach level 3 because not all suppliers have environmental awareness and work methods. There is no initiative from PT XYZ to convince and inform customers regarding maintenance and repair services and environmental impacts. Based on X5, the selection of raw material suppliers continues to use the old supplier based on the desired quality and available budget. Meanwhile, based on X7 and X8, consumers, both retailers and end consumers, have not paid much attention to environmental impacts, so PT XYZ's initiative has not yet been seen convincing and informing customers, especially regarding environmental impacts.

5. Finance and Investment

The fifth determinant is finance and investment, with two criteria evaluated. They are financial availability and allocation of funds in investment for eco-innovation. The evaluation of the criteria for the availability of funds is at level 1; namely, the Company currently has a large amount of debt and cannot invest in the long term, including implementing a circular economy on environmental aspects. This is supported by data in the annual report ending December 31, 2021, that PT XYZ's Debt to Equity Ratio was recorded at six times, which means it has exceeded the management policy limit on the capital structure. In addition, based on interviews conducted with X13, companies are not allowed to carry out activities that cause capital expenditure, especially expansion activities and new investments. X13 said:

"Now we are under a restructuring agreement. We have a financial resolution. We are not allowed to have financial covenants. PT XYZ is not allowed to carry out CAPEX [capital expenditure] activities specifically related to expansion or new investments."

Evaluation of the criteria for allocation of funds in the context of investment for eco-innovation is at level 1, in which funds are allocated selectively and in stages

when requested by the department. This is based on an interview conducted with X13, in line with X13's initial statement, which stated that investment could not be made. Still, before financial restructuring was carried out, PT XYZ allocated investment for eco-innovation when it was only done when asked, considering its feasibility study. Then the allocation is done selectively, considering the limited availability of the budget. X13 said:

> "From what project needs, what is the feasibility study like, then we will find the source of the funds."

As explained by X3 and X12, examples of investment allocations that have been made before financial restructuring are the replacement of transparent roofs in the logistics warehouse area and the replacement of conventional lamps with LED lamps.

6. Resource Consumption and Energy Management

The sixth determinant is energy management and resource consumption with evaluated criteria, namely the extent to which technology approaches and applications in the production process, including the mechanism for converting and utilizing waste into energy. Evaluation on this criterion, PT XYZ is at level 4, a comprehensive approach used throughout the supply chain based on a thorough understanding of the waste generated by the supply chain. Waste is not only used for internal company processes, such as hot steam waste, to increase the heat capacity of the furnace. However, waste can also be utilized along the supply chain, such as selling defective goods into shreds, selling by-products in ferrite sand to the asphalt and magnet industry, and selling CO2 gas to the soft drink industry. X10 expresses this:

> "So, at HSM, if the product fails. It's usually in the form of steel. We sell it in chopped form. Those small workshops also need small ones like plates. [...] There are also by-products. For example, if steel is heated continuously. When exposed to air, it will oxidize. So later, there will be a layer of Fe_2O_3, Ferro oxide sand, or crust. So, we are selling it. It can still be used again for one of them for mixing asphalt or magnetic raw materials. [...] There is also waste, for example, hot steam emission. So, from combustion, it produces hot steam. Then we rotate the hot steam again through a recuperator tool to heat the combustion chamber. So, we throw away the temperature is still 400^o Celsius. So, we rotate it again to

enter it again into the furnace. So, it will increase the heat capacity of the furnace. "

In addition, the waste generated from the production process at the Blast Furnace Plant, Slab Steel Plant, and Billet Steel Plant in the form of Slag can also be used for carbon capture utilization and storage. However, this is still in the research stage, which is being developed with BRIN as described by X12. X12 said:

"Then carbon capture utilization and storage, we also have research in collaboration with BRIN concerning the use of Slag. Slag is waste from steel factories and then used to capture carbon."

7. Quality Management

The seventh determinant is quality management with two evaluated criteria: the Company's ability to track quality in the supply chain and the extent to which a zero-defect approach is used to reduce or even eliminate waste. Evaluation of the first criterion is the Company's ability to track quality in the supply chain. The result PT XYZ is at level 2, in which quality issues can be traced to certain batches based on product parameters and production processes. There are several stages to conducting quality searches, from purchased materials to products to consumers. In general, quality tracking conducted by PT XYZ is on a production batch scale, although there is one stage of quality tracking carried out at the unit level. Based on interviews conducted with X5, it was stated that quality tracking was carried out starting when buying materials such as Slab. Slab quality is checked twice at the port and the factory, but both processes are carried out by sampling. Furthermore, quality tracking is also carried out during the production process, where samples are taken and tested for their chemical and mechanical properties, such as tenacity, strength, and brittleness. Furthermore, sample checking is carried out again on the final product sent to the customer. This is confirmed by statement X9, which states that quality checks are carried out on each batch. X9 said:

"Yes, we do have testing from this coil number. For example, today, I produce 6 thousand tons. For example, 1 coil has 20 [tons] which means 300 [number]. Coil numbers 1-15 will be taken in one sample. One sample in one batch, of which 16 to 30 are retaken 1 sample. So, it's every 1 batch."

One of the quality tracking processes carried out at the unit level is thickness quality tracking using an ultraviolet sensor. X5 explains:

"We use ultraviolet to check the thickness. How can you tell the difference between 2 mm and 1 mm? It's impossible to measure [manually]."

Then on the evaluation of the second criterion, namely the extent to which a zero-defect (ZD) approach is used to reduce or even eliminate waste, PT XYZ is at level 3; namely, formal programs related to ZD have been started comprehensively within the Company with continuous monitoring and improvement. Based on the interview, X9 said:

"Our [PT XYZ] zero defects related to mechanics, dimensions, and chemicals are guaranteed. We already have SNI standards. We also adjust them with orders because we sell customized goods. If there are problems related to dimensions, for example, a little bumpy, we will repair them on the machine. It's called skin pass for re-leveling."

8. Supply Chain Management

The eighth determinant is supply chain management, with the evaluated criteria being the level of advancement in reverse logistics system from a circular economy perspective and environmental aspects. Reverse logistics is moving an item from downstream to upstream of the supply chain to repurpose the used goods or because the goods are damaged or did not meet the order specification. Evaluation of PT XYZ on this criterion is at level 3, in which the Company collaborates with several critical supply chain partners both upstream and downstream and has implemented collection, sorting, repair, and remanufacturing mechanisms to bring used or defective materials and products to relevant critical entities upstream in the supply chain as the interview conducted with X9 explained that there is already a reverse logistics mechanism listed in the contract. If the goods sent are defective or do not match the order's specifications, they will be returned through a third party who has cooperated. However, this is limited to suppliers in areas near the factory. For suppliers outside the island or abroad, there is no reverse logistics mechanism, only a compensation fee in the form of a deduction for the remaining unpaid bills. X9 explains how the reverse logistics mechanism is being done from PT XYZ to suppliers. X9 said:

" Those suppliers close to the factory are told to pick up [defective goods or deemed unfit to the specifications ordered]. After taking them, they are given new ones [...] Another example, I ordered goods from Australia, for example, the contract was 10 billion. Then [PT XYZ] filed a purchase complaint worth 2 billion [and] it was agreed that an error occurred from the supplier side. That means it's reduced to 2 billion. So, 8 billion we pay. "

A reverse logistics mechanism is also carried out by PT XYZ and customers who are close, for example, customers from Java and Sumatra. For customers outside Java and Sumatra and even abroad, the mechanism used is cost compensation. According to X5, if the goods ordered are defective or do not match the purchase specifications, then PT XYZ investigates to determine the cause of the damage to the goods. If PT XYZ causes the error, PT XYZ will take it when sending the following order while bringing new replacement goods. Then the goods are returned to the warehouse in Jakarta and then to the factory or directly to the PT XYZ factory, depending on the customer's location. This mechanism applies to customers who have long-term purchase contracts. However, the reverse logistics mechanism used for the customer of outright sell is generally the same, except that the damaged goods are taken back with no waiting for the next purchase.

6. CONCLUSION AND RECOMMENDATION

This case study aims to examine how PT XYZ's readiness to implement the carbon tax is prepared. This research is essential because PT XYZ does not only produce CO_2 emissions but uses materials and energy that contain CO_2, which will affect the increase in costs due to carbon taxes, causing a multiplier effect on the rise in production costs of PT XYZ. Thus, this research contributes to PT XYZ to provide comprehensive preparations for the implementation of the carbon tax, as well as contributing to the government in providing information regarding the readiness to implement the carbon tax in the steel industry. The evaluation was carried out using eight determinants of the ERIA Industry 4.0 Readiness Assessment for The Circular Economy. This framework is used because it is most in line with the concept and purpose of implementing the carbon tax in Indonesia by reducing CO_2 emissions produced and reducing the use of materials and energy used.

PT XYZ received an evaluation score of 25, indicating that PT XYZ is at the 'ready' level to implement the carbon tax. This readiness level is supported by the highest evaluation scores on the determinants of plant and equipment and resource consumption, and energy management. PT XYZ is at level 3 on evaluation of these three determinants, which are strategy and organization, quality management - Zero Defect, and supply chain management. To accomplish a higher readiness level of those three determinants, there are several things to be done for each determinant.

First, the organization's strategy regarding the principles of eco-innovation can be improved more by creating environmental cost and benefits reports so that the Company has all the data related to costs incurred for ecological interests and benefits obtained from time to time. Second, applying the ZD program to the entire supply chain. Third, collaborating with all supply chain partners to create a mechanism for collecting scrap metal or scrap steel, which the Company then purchases to mix with other materials to produce steel.

Then, the evaluation of the determinants of information technology systems, human resources, and quality management - quality tracking is at level 2. The readiness level of those determinants can be enhanced by these following recommendations. Firstly, PT XYZ should use a monitoring system to provide alerts for something not working as usual. Secondly, PT XYZ can do massive marketing through online sales platforms and company websites to brand that PT XYZ's products are environmentally friendly. PT XYZ can also put an ecologically friendly sign on each product so that customers are more aware of PT XYZ's sustainable products. Thirdly, preferably PT. XYZ searches for quality issues in each unit. Then the sample parts in each unit can be sold to manufacturers who need steel in small sizes. The lowest evaluation value determines the availability of funds and investment allocation at level 1. What needs to be done to improve PT XYZ's financial performance is improving efficiency and continuing to carry out debt restructuring. For example, efficiency can be achieved by replacing building lights that use sensors.

The drawback of this study was that it did not use the observation method due to the limitation of the number of people in the office and factory to prevent the transmission of COVID-19. The observation method will be beneficial in understanding the business process of the object of research to provide a more in-depth analysis. The use of the observation method is highly recommended for further study.

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APPENDIX

Appendix 1. PT XYZ ERIA Industry 4.0 Readiness Assessment for the Circular Economy

Determinant 1: Strategy and Organization					
Assessment Criteria	**Readiness Level**				
	Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Consideration of extent emphasis on eco-innovation principles, including the design of products for longer life, enabling reuse, use of non-toxic natural materials, and dematerialization, such as the use of the Internet and reduced packaging. (ERIA, 2020, p. 91 & 280)	There's no consideration of eco-innovation and design for environmental principles. The focus is on cost reduction and improved performance, even if this means sacrificing the circularity principles of sustainability.	Incidental incorporation of eco-innovation aspects, such as the use of modular parts or reduced packaging, are due to reasons for cost reduction.	Explicitly incorporated eco-innovations aspects and designs are only to meet regulatory requirements.	Eco-innovation is a priority within a principle and conviction that it can make positive contributions to profitability.	All innovation is explicitly required to incorporate eco-innovation principles and demonstrate positive contributions toward a circular economy.
Determinant 2: Plant and Equipment					
Assessment Criteria	**Readiness Level**				
	Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Adoption of the principle of 'repair, refurbishment, and remanufacturing' within the capability of plant and equipment and facilities layout. (ERIA, 2020, p. 92 & 281)	Adoption of the repair, refurbishment, and remanufacturing principles will not be possible with the current facilities layout and production processes.	Conversion of some sections of the production process to adopt repair, refurbishment, and remanufacturing, but the organization has not initiated the move.	Adoption of repair, refurbishment, and remanufacturing principles to the sections of the production process that can be converted are being suitably redesigned and renovated.	Adoption of repair, refurbishment, and remanufacturing principles in several sections of the production process.	Adoption of repair, remanufacturing, and refurbishment principles within the entire manufacturing facility.
Determinant 3: Information Technology Systems					
Assessment Criteria	**Readiness Level**				
	Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Energy consumption, resource use, and emissions monitoring system. (ERIA, 2020, p. 93 & 276)	The service provider provides resource use and energy consumption information.	Recording of energy and resource consumption for later review and developing emission reduction and energy-saving measures by using sensors.	Real-time monitoring of resource and energy consumption to take corrective action where needed.	An alarm generation to enable prompt action to be taken based on consumption comparison and disturbing patterns.	Automated systems to monitor resource and energy consumption as well as carbon emissions, identify inefficiencies, and propose corrective action.

Determinant 4: Human Resources					
Assessment Criteria	**Readiness Level**				
	Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Degree of Circular Economy value networks that have been built amongst employees, stakeholders, and buyers. (ERIA, 2020, p. 94)	No explicit efforts have been made.	Employees are aware of the Circular Economy imperative and have adopted new ways of working to support the firm's initiatives in adopting Circular Economy-based approaches.	Employees, critical suppliers, distributors, and retailers are aware of the Circular Economy imperative and have adopted new ways of working to support the firm's initiatives in adopting Circular Economy-based approaches.	Employees, all suppliers, distributors, retailers are aware of the Circular Economy imperative and have adopted new ways of working to adopt Circular Economy -based approaches through the entire supply chain, initiatives are underway to convince and inform customers about maintenance and repair services, environmental impacts, materials that have been put in place to foster a circular economy	Employees, all suppliers, distributors, retailers are aware of the Circular Economy imperative and have adopted new ways of working to adopt Circular Economy-based approaches through the entire supply chain, consumers reinforce the Circular Economy-based approaches by demanding sustainable products, commodities, and services.
Determinant 5: Finance and Investment					
Assessment Criteria	**Readiness Level**				
	Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Financial availability. (ERIA, 2020, 189)	Significant difficulty in financial availability.	High level of debt and cannot invest in long-term innovation regarding the circular economy.	A limited amount of funds can be invested in innovative projects.	Recognized as a sound firm in its financial availability.	For the development of a circular economy, financial availability is not a concern at all.
Critical allocation of funds for circular economy investment. (ERIA, 2020, 80)	Has not been considered.	Funds are allocated selectively, incrementally, and only when requested by a department	Basic level allocation of seed funding.	In selected areas, investments have been made.	Enterprise-wide investments have been made.
Determinant 6: Energy and Resources Consumption Management					
Assessment Criteria	**Readiness Level**				
	Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Degree of 'waste-to-energy' approaches, such as thermochemical conversion (gasification, combustion, refuse-derived fuel, and pyrolysis), physicochemical conversion (transesterification), and biochemical conversion (fermentation and anaerobic digestion), are used as a	None used.	Ad-hoc usage of thermochemical conversion approaches such as combustion (hot gases) and refuse-derived fuel.	Consistent and regular usage of thermochemical conversion approaches, such as combustion (hot gases) and refuse-derived fuel, and plans	A sophisticated understanding of the nature of wastes generated by the firm leads to extensive usage of the waste-to-energy approach.	A sophisticated understanding of the nature of wastes generated by the supply chain leads to extensive usage across the supply chain.

secondary resource to reduce the carbon footprint. (ERIA, 2020, p. 96)			are underway to examine the feasibility of adopting other approaches.		
Determinant 7: Quality Management					
Assessment Criteria	**Readiness Level**				
	Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Supply chain quality traceability. (ERIA, 2020, p. 277)	The causes of problems cannot be traced. Accepting rejects and providing replacements in response to quality issues.	Quality issues are traceable down to the batch based on product parameters.	Quality issues are traceable down to the batch based on product and production process parameters.	Achieving zero defects by using advanced control systems (e.g., artificial vision) and machine learning systems and automatic adjustment of machine parameters.	Product value arises from the protected intellectual property used and extensive digital features.
The degree of the 'zero-defect' (ZD) approach is used to eliminate waste. (ERIA, 2020, p. 96)	The emphasis is on reducing the extent, and defects are regarded as inevitable.	There is interest, and plans are being made to move towards a ZD target.	Initiation of formal ZD programs within the firm, and some are being piloted.	Comprehensive initiation of formal ZD programs within the firm with continuous monitoring and improvement.	Comprehensive initiation of formal ZD programs within the firm and with all key partners in the supply chain.
Determinant 8: Supply Chain Management					
Assessment Criteria	**Readiness Level**				
	Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**
The sophistication level of the reverse logistics system from a circular economy perspective. (ERIA, 2020, p. 97)	Any collection from the downstream end of the supply chain is done on a need basis. No formal reverse logistics capability.	The firm is planning/developing arrangements to develop a mechanism of collection, sorting, refurbishment, and remanufacturing to bring materials and used products only up to the firm, with its downstream supply chain partners.	The firm, in collaboration with its downstream supply chain partners, has put in place a mechanism of collection, sorting, refurbishment, and remanufacturing to bring materials and used products only up to the firm.	The firm, in collaboration with some of its critical supply chain partners (both upstream and downstream), has put in place a mechanism of collection, sorting, refurbishment, and remanufacturing to bring materials and used products upstream to the relevant entities in the supply chain.	The firm, in collaboration with all its supply chain partners (both upstream and downstream), has put in place a mechanism of collection, sorting, refurbishment, and remanufacturing to bring materials and used products upstream to the relevant nodes in the supply chain.