DEVELOPMENT OF SUSTAINABLE CONSUMPTION AND PRODUCTION INDICATORS FOR INDUSTRIAL SECTOR ACCORDING TO CIRCULAR ECONOMY PRINCIPLES IN THAILAND

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ABSTRACT

Title of Dissertation DEVELOPMENT OF SUSTAINABLE CONSUMPTION AND PRODUCTION INDICATORS FOR INDUSTRIAL SECTOR ACCORDING TO CIRCULAR ECONOMY PRINCIPLES IN THAILAND

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The aim of this research is to (1) investigate sustainable consumption and production indicators for industries as well as examine the difficulties and limitations in using these indicators for the Eco-Factory program under the Federation of Thai Industries; and (2) develop sustainable consumption and production indicators for Thai industries based on the Sustainable Consumption and Production Roadmap 2017-2037 and circular economy principles which are part of Thailand's long-term strategic plan under the national industrial development goals based on the BCG (Bio-Circular-Green) Economy Model. At present, there appears to be no academic study of the Sustainable Consumption and Production (SCP) indicators for sustainable development at the micro level for industry in Thailand. This research focused on stakeholder involvement in developing indicators through surveys, in-depth interview, focus group meeting, seminar and workshop. The study results include a final version of SCP indicators (26 sets of indicators, 60 sub-indicators) consisting of 4 dimensions including environmental, social, economic and good governance dimensions. Recommendations for implementation of indicators are: (1) initiate pilot project to support practical implementation in the industrial sectors based on the industrial types including upstream, midstream, and downstream industries; (2) conduct a periodic review of the indicators, such as every 3 years, by entrepreneurs and other sectors, and there should be standards, evaluation and certification based on the circular economy standard of Thai Industrial Standard Institute (TISI); and (3) support information dissemination and workshops during as part of the first step to promote the readiness of industries interested in the implementation of and support for

sustainability reporting resulting from the indicator implementation, as well as create a collaborative network between industries.

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CHAPTER 1

INTRODUCTION

1.1 Statement and Significance of the Study

Thailand ratified Agenda 21 in the Rio Earth Summit in 1992 which was an important guideline for sustainable development in laying the groundwork for "Our Common Future" in 1986 of the World Commission on Environment and Development (WCED) defining that "it is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (Office of the National Economic and Social Development Board, 2008; United Nations Environment Programme, 2010). In the World Summit on Sustainable Development held in Johannesburg in 2002 that proposed national sustainable development strategy initiation and implementation (Office of the National Economic and Social Development Board, 2008) to different countries, Thailand, as a member country, has been developing national sustainable development strategies since 2008, and currently certifies them as the sustainable development goals.

In 1992, the result of announcing Agenda 21 entailed consumption and production movement. The Brundtland Commission of the United Nations defined Sustainable Consumption and Production (SCP) that "it is the consumption and production that continuously meets the needs of the present generation without creating restrictions on the needs of the next generations under the availability of nonrenewable natural resources which must be conserved as well as the consequences of environmental impacts." (The Office of the National Economic and Social Development Board, 2007; United Nations Environment Programme, 2012)

The SCP model is an application of integrating eco-friendly consumption and production and life cycle thinking in order to use resources efficiently. In other words, it is about fulfilling more and better goals with consuming less or concisely

refers to the concept of More and Better with Less which leads to sustainable development . Therefore, SCP is a policy tool and practical approach in improving environmental and social conditions as well as mobilizing the economic system to be in correspondence with development guidelines under the direction of green economy development.(United Nations Environment Programme, 2012)

Based on the policy development over the past decade, Thailand has strongly emphasized SCP due to the limitation of natural capital in Thailand nowadays as well as the ecological footprint which is lower than the existing ecosystem capital. Hence, the national sustainable development mechanism adopting the green growth strategy needs to be cooperated by all relevant sectors, especially entrepreneurs in industrial, service and public sectors which play important roles in mobilizing the economy. For the industrial sector, manufacture exploits resources and simultaneously creates an environmental impact from its production activities. The service sector in Thailand after participating in the United Nations Conference on Environment and Development in 1992 develops various plans and strategies which progress beyond other countries in the ASEAN Community, especially the 11th National Economic and Social Development Plan (2012-2016) to the 12th National Economic and Social Development Plan (2017-2021) proposed by the Office of the National Economic and Social Development Council (NESDC) that meet the green growth or green economy.(National Economic and Social Development Board, 2016; Office of the National Economic and Social Development Board, 2017) Additionally, in 2019, the government promoted the New Sustainable Growth Engine or BCG model which consists of developing bioeconomy, circular economy and green economy concurrently in order to develop the economy of the country which corresponds to the Sustainable Development Goals as well as sufficiency economy that creates a base for SCP operations(National Science and Technology Development Agency, n.d.). The Office of Natural Resources and Environmental Policy and Planning (ONEP) identified strategies, adjusted consumption and production bases to be eco-friendly, and developed the 20-year Sustainable Consumption and Production Roadmap 2017-2036 by specifying consumption and production goals based on 3 main strategies comprising of lifting Thai society to meet sustainable consumption strategy, lifting Thai society to meet the sustainable production strategy and lifting Thai society to

apply supported factors for sustainability strategy. (Office of Natural Resource and Environmental Policy and Planning (ONEP), 2017)

Therefore, SCP Roadmap of the manufacturing strategy proposes the goal that "Thai industry has been intended to be sustainable manufacturing industry in a socially responsible and environmental-friendly way as well as emphasize manufacturing process development, Green Industry certification and integrated industrial waste management".(Office of Natural Resource and Environmental Policy and Planning (ONEP), 2017) It specifies indicators, such as numbers of the factory that obtain Certificate of the Green Industry within 2021 with 2,000 additional green factories each year and numbers of industrial estates that are certified as Eco Industrial Town which annually increase not less than 4 estates.(Office of Natural Resource and Environmental Policy and Planning (ONEP), 2017)

Moreover, performance reports and sustainability indicators of companies listed on the stock exchange within 2021 and other related indicators, such as industry resource efficiency, power consumption, green label products, industrial waste management and recycle (Office of Natural Resource and Environmental Policy and Planning (ONEP), 2017). However, SCP Roadmap was revised in 2019 which goals and objectives for industry sectors are more specifics and correspond to SDG12. There are 19 SCP indicators with targets required for industry sectors to achieves by 2037.(Office of Natural Resource and Environmental Policy and Planning (ONEP), 2020)

Although Thai manufacturing sector grows rapidly and becomes an important sector that generates income for the country, its manufacturing process is inappropriate and negatively impacts the environment. Therefore, it is necessary to execute to create sustainable production for the industrial sector in order to compete in the world market. The government sector, especially the Ministry of Industry, as the main sector, has continuously supported the enhancement and development of industries in Thailand to have a sustainable production by developing concrete projects for relevant sectors, such as the Green Industry Project of the Ministry of Industry, Eco-Labeling Promotion, Green Public Procurement and Environmentally-friendly Services of the Pollution Control Department of Ministry of Natural Resources and Environment, Providing SCP Information to General Public,

Promoting Renewable Energy and Energy Efficiency of the Ministry of Energy, Carbon Reduction Labelling Promotion, Carbon Footprint of Products of the Greenhouse Gas Management Organization (Public Organization).(Department of Industrial Works, 2019b)

Conforming to the Sustainable Industrial Development Policy 2015 presented by the government sector, the Federation of Thai Industries and the Industrial Estate Authority from the private sector collaborate to develop eco-factory criteria for entrepreneurs in manufacturing sectors, and the entrepreneurs who are certified can equate to achieving the Green Industry Level 4 or settling in Green Culture level. (Federation of Thai Industries and Industrial Estate Authority of Thailand, 2018) It is showed that there are 5 levels of Green Industry including Level 1 Green Commitment, Level 2 Green Activity, Level 3 Green System, Level 4 Green Culture and Level 5 Green Network. (Department of Industrial Works, 2019a) From 2011 to 2018, there were 32,272 entrepreneurs in manufacturing sectors who received the Green Industry Mark; however, only 285 and 36 entrepreneurs could achieve Level 4 and Level 5 certification respectively. (Department of Industrial Works, 2019a) Additionally, for the eco industry, there were 209 entrepreneurs in manufacturing sectors achieved the certificate (in December 2019). The criteria of assessing eco industry are based on sustainable industrial development principles which comprise of 14 aspects as well as cover all dimensions (i.e., social, environmental, and economy dimensions), and they are also specified as indicators of sustainable industrial development.(Federation of Thai Industries and Industrial Estate Authority of Thailand, 2018) Meanwhile, the Stock Exchange of Thailand determines the criteria for entrepreneurs to complete sustainability reports by following the Global Reporting Initiative Standards which contain various indicators.(Global Reporting Initiative, 2015)

Accordingly, developing SCP indicators is important in following up the achievement of implementation objectives based on SCP policies since the policies are complicated, relate to processes in diverse dimensions, and associate with many organizations (i.e., government, private and public sectors), and the objectives and goals of the policy implementation cannot be achieved if the indicators are not suitable. Besides, another rationale is that “implementing SCP indicator data in a

limited group or area conduces a small amount of data for developing sustainable development guidelines."(Office of Natural Resource and Environmental Policy and Planning (ONEP), 2017)

As observed, Thailand has not discovered a research review study involving ensuring whether the sustainability indicators of Thai manufacturing sectors which are currently used are practically suitable to the industrial development, investigating the difficulties in developing indicators which are suitable for assessing the sustainability of Thai industrial development and the limitations of using resources as well as examining the contexts of national policies that support the economic growth under a green economy and the indicators corresponding to the circular economy principles. Thus, the development of sustainable consumption and production indicators for an industrial sector according to circular economy principles in Thailand will be an important tool in assessing goals stated in the SCP Roadmap of Thailand.

1.2 Research Questions

1.2.1 What are the obstacles and limitations in implementing the existing sustainable development indicators for industries in Thailand?

1.2.2 What sustainable consumption and production indicators for Thai industries based on the Sustainable Consumption and Production Roadmap 2017-2038 and circular economy principle should be?

1.3 Objectives of the Study

1.3.1 To investigate the obstacles and limitations in implementing the existing sustainable consumption and production indicators for industries in the eco-factory program of the Industrial Estate Authority of Thailand and the Federation of Thai Industries, and in sustainability reporting of the manufacturing sector to the Stock Exchange of Thailand

1.3.2 To develop sustainable consumption and production indicators for Thai industries based on the Sustainable Consumption and Production Roadmap 2017-2038 and circular economy principle

1.4 Scope of the Study

1.4.1 Literature Review

The current study focuses on the sustainable development concept, sustainable development goals, sustainable consumption and production, circular economy principle and application as well as indicator development. In addition, research and studies in foreign countries which are relevant to the global reporting initiative standards, Thailand SCP roadmap 2017-2030, Eco-factory project as well as green industry mark of the Department of Industrial Works are emphasized in reviewing the literature.

1.4.2 Key Informants

The key informants are classified into two groups depending on methods as follows:

1.4.2.1 Survey and an in-depth interview and focus group meetings are conducted with representatives of entrepreneurs from the target industry group certified as an Eco-Factory and Eco Factory working group.

1.4.2.2 Focus group meeting, seminar and workshop are conducted with representatives of industries and experts from relevant sectors including Eco Industrial Development Division, Department of Industrial Works, Industrial Estate Authority of Thailand, representatives of the target industry group, Water and Environment Institute for Sustainability, Federation of Thai Industries.

1.4.3 Target group

The target group includes 8 groups of industries certified as an eco-factory having 64 percent of gross domestic product (GDP) original from manufacturing at current market prices in 2017 (overall GDP from manufacturing sectors in 2 0 1 7 valued at 4,196,801 trillion baht)(Thailand Textile Institute, 2019). The groups comprise of 168 industries including industries of food products, coke and refined petroleum products, chemicals and chemical products, rubber and plastic products, computer, electronic and optical products, electrical equipment, motor vehicles, trailers and semi-trailers and other transport equipment which obtain Certificate of the

Green Industry Level 4 or can be calculated as 67 percent of the total number of certified industrial factories as evidenced by the total number of 247 eco-industries (in November, 2020).

1.5 Expected Benefits of the Study

1.5.1 Recommendations of sustainable consumption and production indicators for industries that are consistent with the Sustainable Industry Development Policy in Thailand are proposed.

1.5.2 The sustainable consumption and production indicators for entrepreneurs in Thailand's industrial sectors correspond to national policies as well as Sustainable Consumption and Production Roadmap.

1.5.3 Relevant organizations, such as the Department of Industrial Works, Industrial Estate Authority, Federation of Thai Industries, and entrepreneurs in manufacturing sectors apply the sustainable consumption and production indicators.

1.6 Terms and Definitions

Sustainable consumption and production indicators for industry refers to sustainable development indicators for industry.

CHAPTER 2

LITERATURE REVIEW

The literature review in this study aims to develop the conceptual framework of developing sustainable development indicators or the sustainable consumption and production indicators practically suitable for Thai industries by focusing on reviewing relevant research and studies, government policies, and reports in Thailand and other countries. The contents in this section are as follow:

1) Sustainable development and sustainable development and goals
2) Circular economy principles and sustainable development indicators
3) The theory and conceptual framework of the sustainable consumption and production indicator development
4) The sustainable industrial development indicators in Thailand and international contexts

2.1 Sustainable Development: SD

2.1.1 Definition of Sustainable Development

Sustainable development and its definition initially appeared in the Our Common Future report published by World Commission on Environment and Development (WCED) in 1986, and sustainable development was regarded as "the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (United Nations Environment Programme, 2010)

Sustainable development comprises 3 keystones including a sustainable economy, environment, and society, and it is under the condition that sustainability occurs when physical, natural, and human capitals are suitably manipulated. Sustainable development aims to eradicate poverty, improve unsustainable

consumption and production as well as manipulate natural resources based on economic and social development.(United Nations Environment Programme, 2010)

United Nations Environment Programme (2008) Sustainable development identifies 5 types of capital involving both sustainable consumption and production. It also associates the consumption and services in order to improve the quality of life that is consistent with 5 types of capital as follows:

1. Natural capital refers to natural resources and energy that play an important role in production and services to maintain the quality of life, conserve renewable and non-renewable resources as well as sustain ecological balance.

2. Human capital covers health, knowledge, skill, and motivation entailing efficient productivity and good quality of life. Human capital also relates to learning opportunity, creativity as well as well-being.

3. Social capital involves institutions and mechanisms contributing to the development of human capital that interacts with family, community, business, labor, education, and trust.

4. Manufactured Capital deals with raw materials or real estates used in manufacturing or services. (e.g., tools, machines, buildings, and structures)

5. Financial Capital is capital associated with trading and ownership in the form of partnerships, bonds, and money.

The relationship of 5 capitals is illustrated in Figure 2.1.

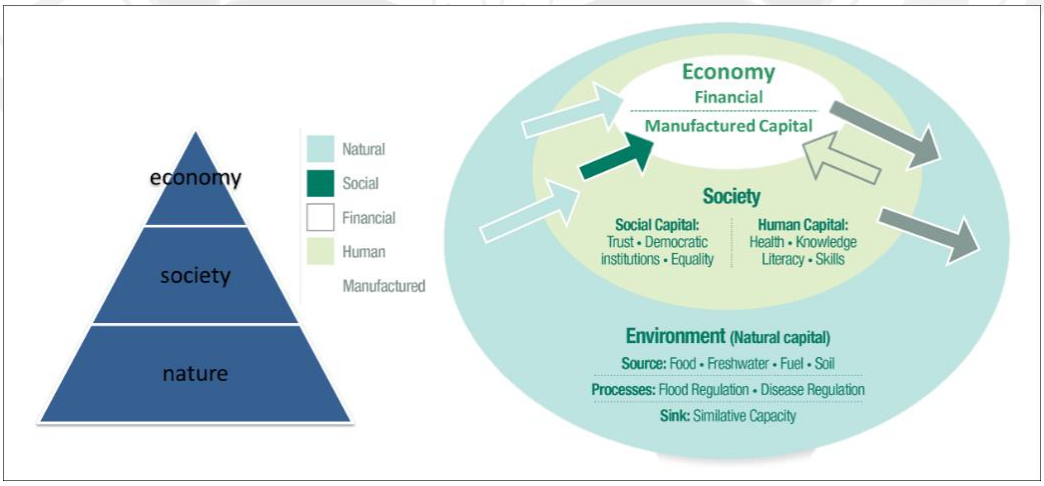

Figure 2.1 Inter-relationship between the five capital stocks

Source: United Nations Environment Programme (2008)

2.1.2 Sustainable Development Goals (SDGs)

2.1.2.1 Sustainable Development Goals (SDGs)

The United Nations Conference on Environment and Development (UNCED) or Rio+20 was held on 20-22 June 2012 in Rio de Janeiro, Brazil. After the Rio+20, the United Nations has established a development framework for transitioning to achieve the Millennium Development Goals (MDGs) by 2015 and consequently to accelerate progress on the Sustainable Development Goals (SDGs) which later indicated as Post-2015 Development Agenda. (Sachs, 2012; United Nations Environment Programme, 2015) Thailand participated in the 70th session of the United Nations General Assembly on September 25, 2015, at United Nations Headquarters in New York City, USA, and implemented sustainable development policy in the National Economic and Social Development Plan (2017-2021) which aimed to provide an opportunity for all sectors collaboratively create a happy society, reduce social inequality, eradicate poverty, promote the green economy, and develop environmentally-friendly consumption and production.(Office of the National Economic and Social Development Board, 2017)

United Nations Environment Programme (2015)The United Nations working group has developed the Sustainable Development Goals since 2013 and currently consists of 17 goals as follows:

1) End poverty in all its forms everywhere

2) End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

3) Ensure healthy lives and promote well-being for all at all ages

4) Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

5) Achieve gender equality and empower all women and girls

6) Ensure availability and sustainable management of water and sanitation for all

7) Ensure access to affordable, reliable, sustainable, and modern energy for all

8) Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all

9) Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation

10) Reduce inequality within and among countries

11) Make cities and human settlements inclusive, safe, resilient, and sustainable

12) Ensure sustainable consumption and production patterns

13) Take urgent action to combat climate change and its impacts

14) Conserve and sustainably use the oceans, seas and marine resources for sustainable development

15) Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

16) Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels

17) Strengthen the means of implementation and revitalize the global partnership for sustainable development

2.1.2.2 Sustainable Consumption and Production (SCP)

Conforming to the sustainable development goals, sustainable consumption and production in SDG 12 are defined by the United Nations that sustainable consumption and production refers to “the use of services and related products, which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of future generation”. (United Nations Environment Programme, 2010, 2012)

There are 4 key principles of sustainable consumption and production according to the as follows(United Nations Environment Programme, 2012):

1) Improving the quality of life without increasing environmental destruction and without compromising the resource needs of future generations.

2) Adjusting economic growth from environmental destruction by reducing materials or energy intensity of economic activities and reducing emissions and waste from material extraction, consumption, production, and disposal as well as promoting a change of consumption patterns in order to encourage producing goods and services with lower energy and material intensity without affecting the quality of life.

3) Applying life cycle thinking by considering impacts from all stages of the life cycle of consumption and production processes in order to expand original thinking that only emphasizes production impacts without regarding other factors, such as material extraction, consumption, production, and disposal.

4) Guarding against the re-bound effect, where efficiency gains are canceled out by resulting increases in consumption.

The concept of sustainable consumption and production derives from the United Nations Conference on Environment and Development (UNCED), byname Earth Summit, held in Rio de Janeiro in Brazil in 1992 that established the Agenda 21 resulted in signing the Framework Convention on Global Climate Change and subsequently progressed to the development of the Kyoto Protocol which was an environment-related treaty to reduce global warming in 1997. In the same year, the Department of Policy Coordination and Sustainable Development, United Nation, also exhibited the findings of 10 case studies of the developing countries involving consumption and production patterns. Those revealed that sustainable production which is an important part of the economic system as a supply-side requires environmental performance improvement, whereas sustainable consumption as a demand-side needs response-ability of quality of life as well as basic needs under the global carrying capacity.

In 2002, the World Summit on Sustainable Development (WSSD) was held during August 26 – September 4 in Johannesburg, South Africa, to review progress and accelerate Agenda 21. The conference entailed adopting two key documents including 1) Plan of Implementation for the WSSD which addresses measure in accelerating the approval for Agenda 21 and other resolutions from the UNCED to produce tangible results and 2) Johannesburg Declaration on Sustainable Development which is the political declaration mirroring the will of the international community to collaboratively follow the commitments of UNCED as well as the

action plans of WSSD that give an emphasis to the sustainable consumption and production. It leads to the conference of international parties participated by 115 experts from 59 countries and 9 international organizations to initiate sustainable consumption and production patterns and advances to developing an international collective effort, SCP global framework of programmes which was known as the Marrakech Process in 2003. The effort aimed to promote policy implementation and create sustainable consumption and production capacity that was a part of supporting the 10-Year Framework on Programmes of SCP (10YFP).(One Planet Network, n.d.)

Later in United Nations Conference on Sustainable Development (Rio+20) in 2012 in Rio de Janeiro that aimed to reaffirm the new political declaration for sustainable development, evaluate past processes and gaps of implementing key resolutions from the World Summit on Sustainable Development as well as identify new and upcoming challenges resulted from global leadership summit participated by 79 countries around the world collaboratively affirmed outcome documents, such as establishing an intergovernmental process to set Sustainable Development Goals (SDGs) with consideration of transparency in the preparation and approval by the United Nations General Assembly, expanding the involvement of private sectors and participation of business sector by inviting them to be responsible for creating “the company sustainability report” as well as certificating the 10-Year Framework on Programmes of SCP (United Nations Environment Programme, 2015) as presented in Figure 2.2.

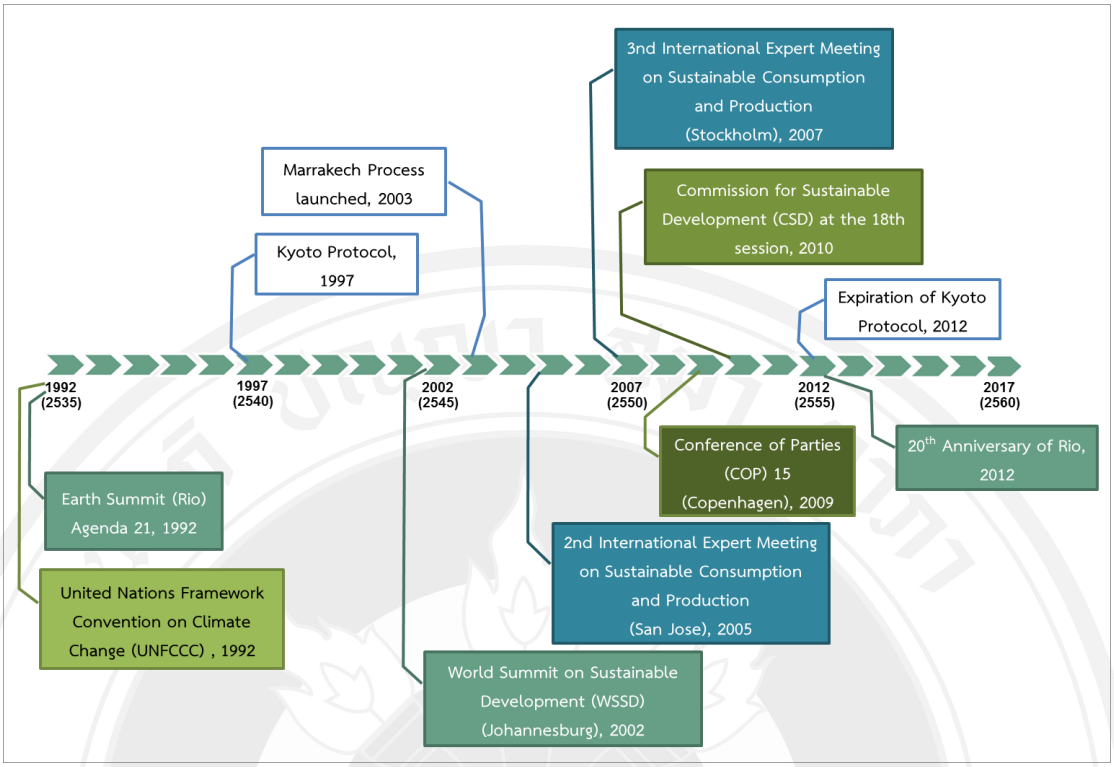

Figure 2.2 Timeline of sustainable consumption and production at an international level

Source: United Nations Environment Programme (2012)

2.2 Circular Economy

Circular economy (CE) is a widely accepted guideline nowadays that is a part of sustainable development due to the principles of CE which emphasize efficient resource circulation in the economy and ecosystem, future demand response towards products and services of the growing world population. It was expected that in 2050, there will be more than 9 billion world population, especially the middle-income population.(British Standards Institution, 2017) Under the limitations of natural resources and environmental impacts, CE is an approach in alternating a traditional linear economy procedure simply described as 'Take Make Use Dispose' into the sustainable economic growth by creating a system of production, product, service and business model that efficiently manipulate resources, use circulating materials, minimize material consumption as well as pay particular attention to waste streams and renewable energy resource. (British Standards Institution, 2017) The circular

model consists of 3 principles including 1) designing out waste and pollution, 2) keeping products and materials in use, and 3) regenerating natural systems. With these principles, CE builds economic, natural, and social capital.(Ellen Macarthur Foundation, n.d.) The circular economy creates two distinctive circles including 1) biological cycle where biologically-based materials are designed to feed back into the system that builds natural capital as well as restores renewable resources and 2) technical cycle where products, components, and materials are recovered into the economy by assembling to new or concentrated products, components, and materials.(British Standards Institution, 2017)

The circular economy concept has been variously developed by scholars since the 1960s. (British Standards Institution, 2017) It has been also increasingly applied to modern economic systems and industries in late 1970 (Ellen Macarthur Foundation, n.d.) The circular economy concept comprises the blue economy, performance economy, biomimicry, natural capitalism, industrial ecology and symbiosis, cradle to cradle, and regenerative design as presented in Figure 2.3. (British Standards Institution, 2017)

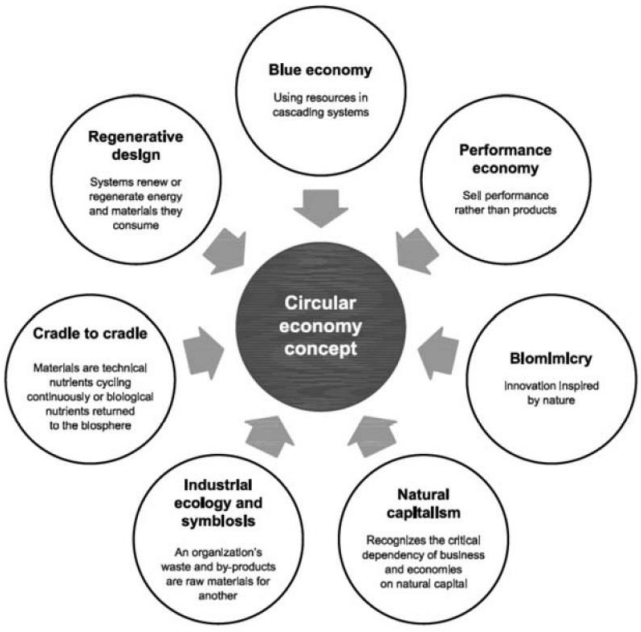

Figure 2.3 Circular Economy Concept

Source: British Standards Institution (2017).

BCG model of Thailand emphasizes the development of science, technology, and innovation (STI) as well as enhancement of productivity of most manufacturers who are on the base of the pyramid by applying uncomplicated technology and

innovation that helps reducing capitals, increasing productivity, and creating product diversity. Thai government employs the BCG model to accomplish at least 5 sustainable development goals including sustainable consumption and production, climate action, biodiversity conservation, partnerships to achieve the goal and consistency to Thailand's sufficiency economy philosophy driven by STI. (National Science and Technology Development Agency, n.d.)

Recently, there are various program and measures to promote CE principal application for Thai Industry by Ministry of Industry (MOI). In 2020, CE standard for organization was issued by Thailand Industrial Standards Institute (TISI) as well as CE working group assigned while CE product standards in process by them. Manual for Thai Industry to self-evaluate effectiveness of CE principals implementing was developed by Department of Primary Industries and Mines, MOI. At national level, CE committee under Office of the Prime Minister Ministry was appointed to integrate CE concept embedded to National Policy focusing on CE as tool boosting Economic effectiveness with Sustainable Development goals. To enhancing infrastructure, building as human resources, research and developments, Entrepreneur; Start Up are being support through several project since 2019(National Science and Technology Development Agency, n.d.).

2.2.1 Circular Economy Principle for Sustainable Industrial Development and SCP

Operation based on the circular economy principle is the sustainable development indicators related to economy and society development, disparity reduction, climate change, efficient resource management and good governance since the CE principle leads to natural resource management and sustainable consumption and production. (European Academies' Science Advisory Council, 2016)

At present, the circular economy principle has been accepted as the national economic development policy more than 10 years. For instance, Circular Economy Promotion Law has been established in China since 2008 entailing promoting CE operation in 3 levels including individual firm level enhancing eco design and cleaner production, eco-industrial park level promoting parties of Eco Industrial Town in districts and provinces, and Eco city/Eco province level contributing self-sustaining

resilient structure and function of natural ecosystem. China also has goals in promoting national sustainable consumption and production to create diverse recycling society.(The European Academies' Science Advisory Council, 2016) In addition, Japan has employed the CE principle in enacting Promotion of Effective Utilization of Resources since 1991 to mobilize Japanese society in recycling materials, such as glass, metal, plastic bottle and paper efficiently which conduces the environmentally friendly products as well as industries related to recycling. (European Academies' Science Advisory Council, 2016) In European Union countries, the CE principle is used to legislate laws involving Waste Electrical and Electronic Equipment (WEEE) in 2002. Later in 2005, the European Commission has drawn up the Action Plan Circular Economy Package of Closing the Loop – An EU Action Plan for the Circular Economy to be a tool in achieving the Sustainable Development Goals (SDG) within 2030, especially SDG 12 regarding to responsible consumption and production. This action plan is based on the concept of product life cycle in the production and consumption of environmentally friendly products in waste management, recycling, and secondary materials marketing, and emphasizes plastic materials, food waste, biological materials, waste from construction materials as well as investment, innovation and supervision of action plans. (The European Academies' Science Advisory Council, 2016) The policy and direction make the country succeed in circulating resource consumption, reducing environmental, economic and social impacts as well as building green economy along with responding environmentally friendly consumption and production which promotes the competitiveness of the business.

In Thailand, the government has developed new economic and social development strategic plan using BCG Economy Model. BCG Economy Model engages in bioeconomy, circular economy and green Economy emphasizing adding value to biological resource consumption and developing high-value products by linking with the circular economy utilizing various materials(National Science and Technology Development Agency, n.d.). The bioeconomy and circular economy are under the green economy that simultaneously develops economy and maintains environment balanced and sustainably. It is advantageous for Thailand having biodiversity and cultural diversity which benefit the competitiveness as well as

distribution to community that consequently reduce disparity, promote environmentally friendly and develop sustainably.

British Standards Institution (2017)The circular economy principle related to the industrial sector is the industrial ecology and symbiosis promoting the sustainable development of the industries. Industries can operate their production based on the circular economy principle in 6 areas including systems thinking, innovation, stewardship, collaboration, value optimization and transparency as presented in Figure 2.4 on the circular economy standards BS 8001:2017, and can be summarize by each area as follows:

1) Systems thinking is a holistic approach in determine organizational operation concerning adding value, consuming resources in the production process and crating worthiness for materials consumption that entail the sustainable resource management. This approach involves in the context of the entire product life cycle as well as responds both marketing and supply chain.

2) Innovation refers to the continuous innovation development for the sustainable resource consumption in the organization considering designs, production processes, products and services as well as business operation patterns. The use of innovation of the organization is a result of the research and development as well as the stakeholder collaboration leading to products and services that can promote the highest worthiness. Furthermore, the innovation can contribute the sustainable consumption and production of the organization.

3) Stewardship is an approach of managing impacts caused by explicit and implicit determination related to the organizational activities. The responsibility can help the organization determine issues on product production which reduces environmental and social impacts throughout product life cycle. This conduces management of obtaining materials, lowering natural costs, as well as reducing the risks from chemical use, employment or risks in the community and supply chain.

4) Collaboration is regarded as approach that the organization uses to create the internal and external involvement in order to maintain benefits and create business value together with business partners and customers to promote organizational success in the collaboration trustfully, create both technical and

practical collaboration leading to achieve the resource management goals (e.g., recycling) together.

5) Value Optimization relates to adding value and maximize benefit to products, materials and production components of the organization. This area is the enhancement of waste disposal efficiency in the production process after manufacturing with materials consumption reduction and sparing materials use by processing byproduct materials to use in other manufacturing in order to fully utilize materials and extend the materials life-span to make products last longer.

6) Transparency is an approach involving disclosure of organizational determination on different activities affecting ability in changing to use circular economy operation with the willingness to conduct clear, accurate, punctual, honest and complete communication. Transparency can help the organization disclose information of materials sources, product ingredients and product usage to the customers. However, the proprietary information or public privacy obligation information is excluded.

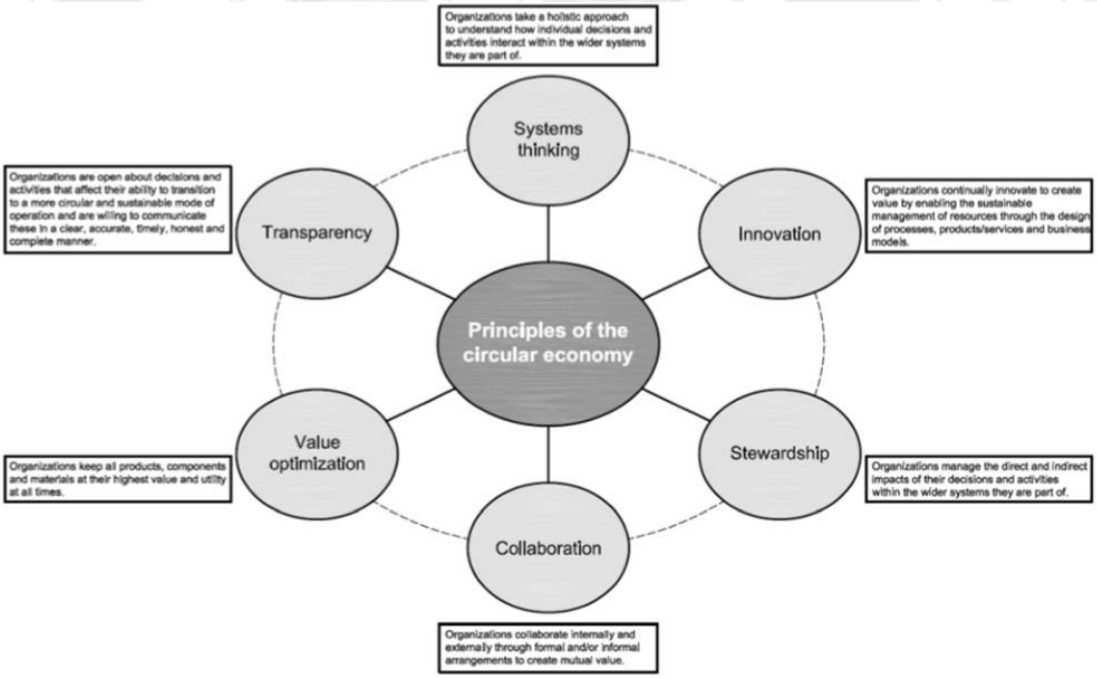

Figure 2.4 The Circular Economy Principles

Source: British Standards Institution (2017)

The benefits of circular economy to the organization at the macro level is the recovery of the economic system, economic growth and employment, natural cost maintenance as well as climate change reduction(British Standards Institution, 2017). For the micro level, circular economy principle promotes the organization in manufacturing sector the reduction of cost, expense caused by production process, materials and energy consumption, and concurrently increases returns due to ability of providing low-cost products leading to creating innovation and income, opportunity for new-service development (e.g., repairing, or hire-purchasing), income from value of byproduct, chance in accessing new markets, as well as opportunity for improving good relationships with customers due to the fact that the circular economy principle can promote customers' perception and communication, and enhance organizational recovery which provides the organization an ability to confront various problems, obstacles and pressures in running business effectively.(British Standards Institution, 2017; The United Nations Environment Programme, 2018; World Business Council for Sustainable Development, 2017; World Economic Forum, n.d.)

2.3 Theory of Indicators

Indicators are an important tool in analyzing changes and indicating key factors that should be considered in any action.(Segnestam, 2002; United Nations Environment Programme, 2012) The sustainable development indicators have been developed in the Earth Summit which Agenda 21 was ratified, and they support national decisions on sustainable development policies.(United Nations, 2007)

The objectives of SCP-related indicators developed by the United Nations are to measure operation progress toward a shift to the sustainable consumption and production pattern as well as to indicate drawbacks which should be improved in order to conduce successful goal achievement on the economy, society, and environment and eventually leads to the sustainable development. (United Nations Environment Programme, 2008)

In general, indicator development and reporting consist of 4 main components including 1) data which is a basic component of other components that

have not been analyzed, 2) indicators which come from processing and implementing data, such as performance reporting or considerations in policy formulation, 3) indices which are derived from managing and analyzing multiple sets of data or indicators as well as 4) information which is a result of analyzing data, indicators, and indices before supplementing a decision making (as presented in Figure 2.5)(Segnestam, 2002).

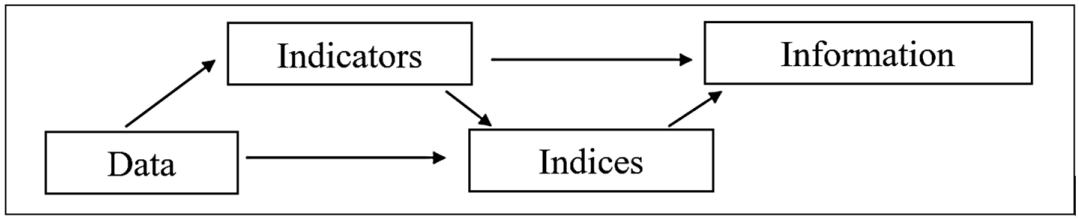

Figure 2.5 Relationship between data, indicators, indices, and information
Source: Segnestam (2002)

2.3.1 Indicator Development Framework

The European Environment Agency (EEA) develops an indicator framework of drivers, pressures, state, impact, and response (DPSIR) as presented in Figure 2.6 in order to be the indicator framework for reporting sustainable consumption and production entailing indicator development used for supplementing the political impacts in establishing an environmental quality policy. (European Environment Agency, 2010; Segnestam, 2002; United Nations, 2007) The DPSIR framework contains these five major terms which can be explained as follows:

Drivers are social factors affecting pressure that can be quantitatively measured, such as population growth, economic growth, technological advancement, and others. (Plubcharoensuk, n.d.)

Pressure involves human actions affecting the environment which ultimately entails environmental problems.

State refers to environmental conditions or states that need improvement or enhancement as well as changes of the natural resources and environment caused by pressure and response.

Impact accounts for the results of environmental changes affecting the economy, society, and environment.

Response is a level of social responsibility towards changes of environmental conditions, such as governmental, private/organizational, and public responses through policies, measures, actions to minimize the problems (Plubcharoensuk, n.d.; Segnestam, 2002).

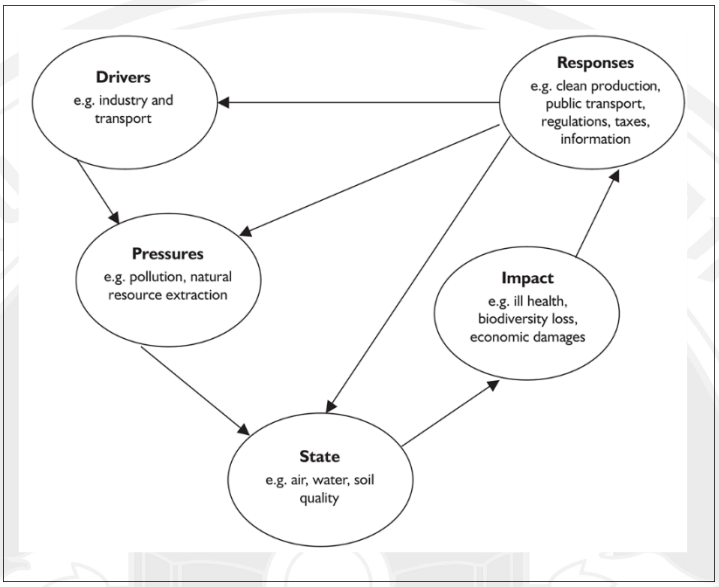

Figure 2.6 The DPSIR framework
Source: Segnestam (2002)

The United Nations Commission on Sustainable Development (UNCSD) developed a framework based on environmental or sustainable development themes in 1995 in order to be implemented as a measure for monitoring sustainable development that can be separated into 4 sections including social, environmental, economic, and institutional aspects (United Nations Conference on Sustainable Development, 2001 cited in Segnestam, 2002). Each aspect defines issues which should be considered as follows:

1) Social: Equity, Health, Education, Housing, Security, and Population

2) Environmental: Atmosphere, Land, Ocean, seas and coasts, Fresh-water, and Biodiversity

3) Economic: Economic structure, and Consumption and production patterns

4) Institutional: Institutional framework and capacity

2.3.2 Indicator Development Method of the National Statistical Office

Saeng-Arun (2016) a professional statistician from the National Statistical Office separated the indicator development method into 5 procedures as follows:

1) Identify objectives and goals clearly by considering what to measure

2) Analyze important components reflecting what meets the objectives

3) Develop indicators by using the analyzed components to define indicators and variables that reflect the components. An effective indicator needs direct relevance to objectives, clarity in design, clarity in design, realistic collection or development costs, high quality and reliability as well as place and time suitability. (Segnestam, 2002)

4) Reconsider the indicators by ensuring contextual consistency, examining the quality of relevant data whether it is complete and reliable as well as create metadata consisting of definitions, formulas, measurement units, and data details

5) Test the indicators by reviewing relevant data from at least 5 years, and observe trends and consistency by comparing with authentic situations and other sources

2.3.3 Example of Sustainable Consumption and Production Indicators

UNEP analyzes data from 20 developing countries and develops sustainable consumption and production indicator development framework including increasing capacity to sustain mutually-beneficial relationships and increasing ability to adapt.(United Nations Environment Programme, 2008) The framework covers four main aspects that are: compliance, efficiency, connectivity, and critical stock, and each aspect is also classified for macro-level, consumers, and producers as presented in Figure 2.7.

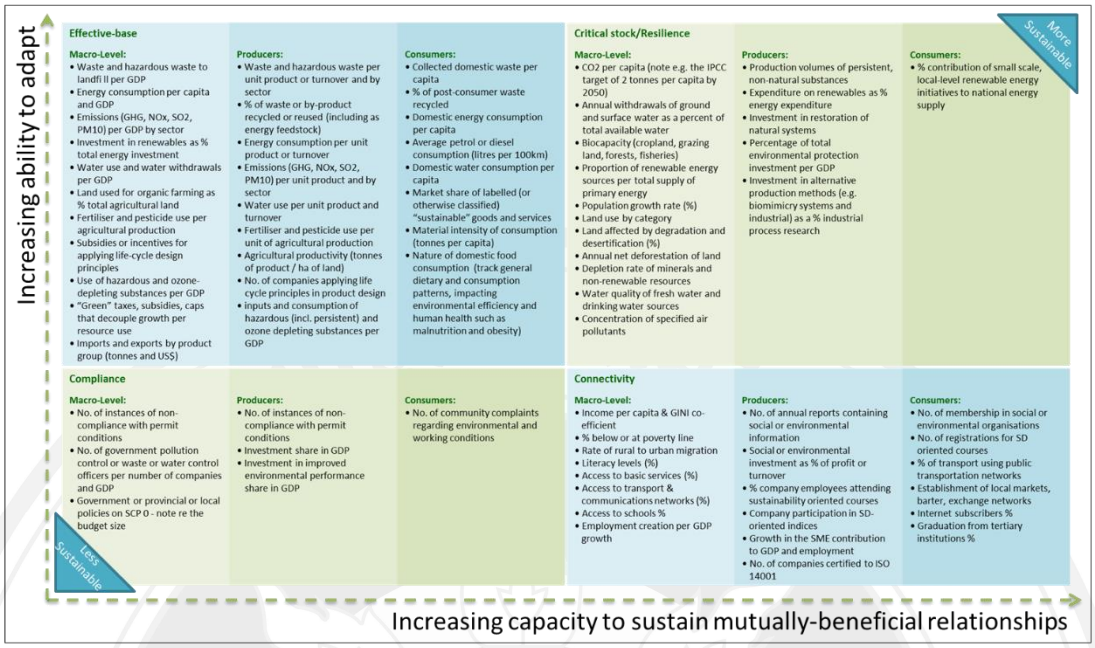

Figure 2.7 Example of sustainable consumption and production indicators for developing countries

Source: United Nations Environment Programme (2008)

2.3.4 Connectivity of Sustainable Consumption and Production and Sustainable Development Goals

In 2012, The United Nations Conference on Sustainable Development (Rio+20) (Rio + 20) established a sustainable development goal that covers the area of promoting sustainable production and consumption. In the conference of the government Working Group's team on Sustainable Development held in July 2014, 17 goals and 169 targets were accepted. Furthermore, there was a seminar on sustainable development related to 13 goals out of the total 17 goals as presented in Table 2.1. (Department of Economic and Social Affairs (United Nations), 2019; United Nations Environment Programme, 2015)

Table 2.1 Goals, targets and indicators of sustainable development related to sustainable consumption and production

SDG Area	Targets	Indicators
1 Poverty Eradication	1.5 By 2030, build the resilience of the poor and those in vulnerable situations, and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	1.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population 1.5.2 Direct economic loss attributed to disasters in relation to global gross domestic product (GDP) 1.5.3 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030 1.5.4 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies
2 End hunger, achieve food security	2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and that progressively improve land and soil quality	2.4.1 Proportion of agricultural area under productive and sustainable agriculture
3 Ensure healthy lives and promote well-being for all at all ages	3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	3.9.1 Mortality rate attributed to household and ambient air pollution 3.9.2 Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services) 3.9.3 Mortality rate attributed to unintentional poisoning
4 Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	4.7 By 2030, ensure all learners acquire knowledge and skills needed to promote sustainable development, including among others through education for sustainable development and	4.7.1 Extent to which (i) global citizenship education and (ii) education for sustainable development, including gender equality and human rights, are mainstreamed at all levels in (a) national education policies; (b)

SDG Area	Targets	Indicators
	sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship, and appreciation of cultural diversity and of culture's contribution to sustainable development	curricula; (c) teacher education; and (d) student assessment
6 Ensure availability and sustainable management of water	6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of fresh water to address water scarcity, and substantially reduce the number of people suffering from water scarcity	6.4.1 Change in water-use efficiency over time 6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
7 Ensure access to affordable, reliable, sustainable, and modern energy	7.2 Increase substantially the share of renewable energy in the global energy mix by 2030 7.3 Double the global rate of improvement in energy efficiency by 2030	7.2.1 Renewable energy share in the total final energy consumption 7.3.1 Energy intensity measured in terms of primary energy and GDP
8 Promote sustained, inclusive and sustainable economic growth	8.4 Improve progressively through 2030 global resource efficiency in consumption and production, and endeavour to decouple economic growth from environmental degradation in accordance with the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, with developed countries taking the lead	8.4.1 Material footprint, material footprint per capita, and material footprint per GDP 8.4.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
9 Build resilient infrastructure and promote inclusive and sustainable industrialization	9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, all countries taking action in accordance with their respective capabilities	9.4.1 CO_2 emission per unit of value added
11 Make cities and human settlements inclusive, safe, resilient and	11.b By 2020, increase by [x] per cent the number of cities and human settlements adopting and implementing integrated policies	11.b.1 Total resource flows for development, by recipient and donor countries and type of flow (e.g. official development assistance, foreign direct

SDG Area	Targets	Indicators
sustainable	and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, develop and implement, in line with the forthcoming Hyogo Framework, holistic disaster risk management at all levels	investment and other flows)
14 Conserve and sustainably use oceans, seas and marine resources	14.7 By 2030, increase the economic benefits to SIDS and LDCs from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	14.7.1 Sustainable fisheries as a proportion of GDP in small island developing States, least developed countries and all countries
15 Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss	15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems	15.a.1 Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems
17 Strengthen the means of implementation for sustainable development	17.16 Enhance international support for implementing effective and targeted capacity building in developing countries to support national plans to implement all sustainable development goals, including through North-South, South-South, and triangular cooperation	17.6.1 Number of countries reporting progress in multi-stakeholder development effectiveness monitoring frameworks that support the achievement of the Sustainable Development Goals

Source: United Nations Environment Programme, (2015); Department of Economic and Social Affairs, United Nations (UN). (2019).

2.4 Sustainable Consumption and Production Roadmap 2017 – 2037

Sustainable Consumption and Production Roadmap 2017 – 2036 proposed by the Working Group for SDG 12 is a sustainable consumption and production plan of Thailand which was developed accordingly to sustainable development goals, especially the 12th goal (Ensure SCP patterns) and other relevant goals as well as

Thai policies (e.g., the 20-year National Strategy, the 12th National Economic and Social Development Plan 2017-2021), and other specific plans (e.g., the Agricultural Sector Strategic Development Plan, Green Public Procurement Promotional Plan). (Office of Natural Resource and Environmental Policy and Planning (ONEP), 2017; Office of the National Economic and Social Development Board, 2017)The operation involving sustainable development in Thailand can be illustrated as presented in Figure 2.8.

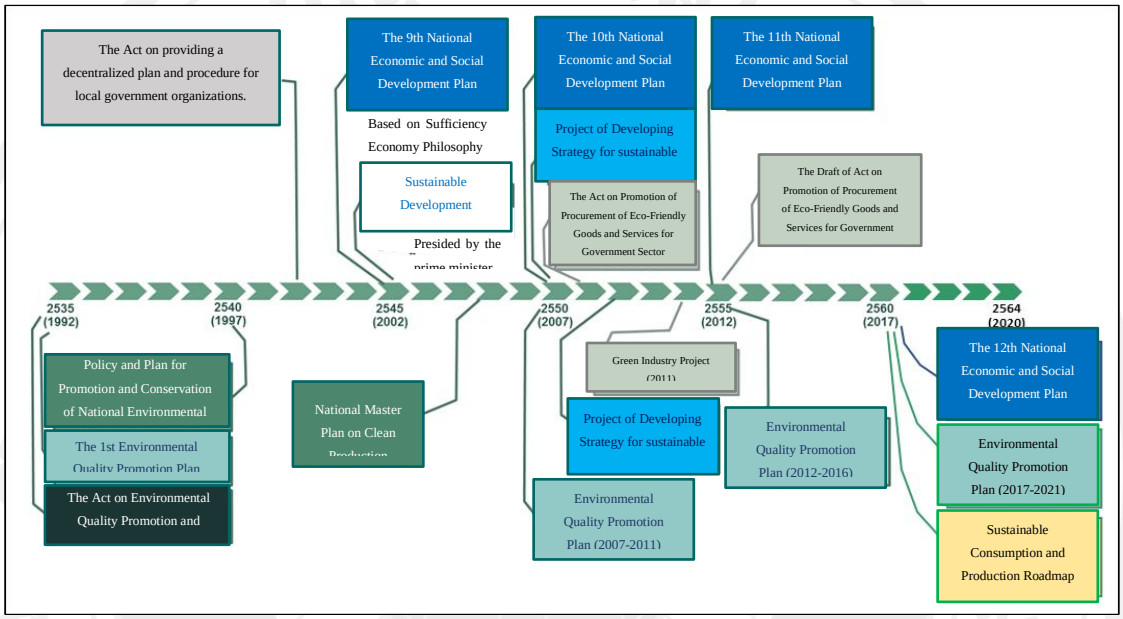

Figure 2.8 Thailand SCP Timeline

The vision of Sustainable Consumption and Production Roadmap 2017 – 2036 is that “Thailand is a leader of ASEAN on Sustainable Consumption and Production adopting the Sufficiency Economy concept and mobilizing through the integration of social innovation by 2036.”(Office of Natural Resource and Environmental Policy and Planning (ONEP), 2017) There are 3 missions of the roadmap including (1) shifting production patterns in all sectors and areas toward sustainable production, (2) shifting behaviors of citizens and public entities toward sustainable consumption patterns, and (3) mobilizing innovation and knowledge-based society in order to promote sustainable consumption and production.(Office of Natural Resource and Environmental Policy and Planning (ONEP), 2017) In addition, there are 2 targets which are as follows:

1. Production consists of the industry sector, agriculture and food sector, and service sector (including tourism).
2. Consumption includes green public procurement and eco-label, cities and local governments, and awareness-raising and education.

Besides, there are 3 strategies in mobilizing sustainable consumption and production including (1) lifting Thai society to meet the sustainable production strategy, (2) lifting Thai society to meet sustainable consumption strategy, and (3) lifting Thai society to apply supported factors for sustainability strategy (Office of Natural Resource and Environmental Policy and Planning (ONEP), 2017) Sustainable Consumption and Production Roadmap 2017–2036 can be exhibited in Figure 2.9.

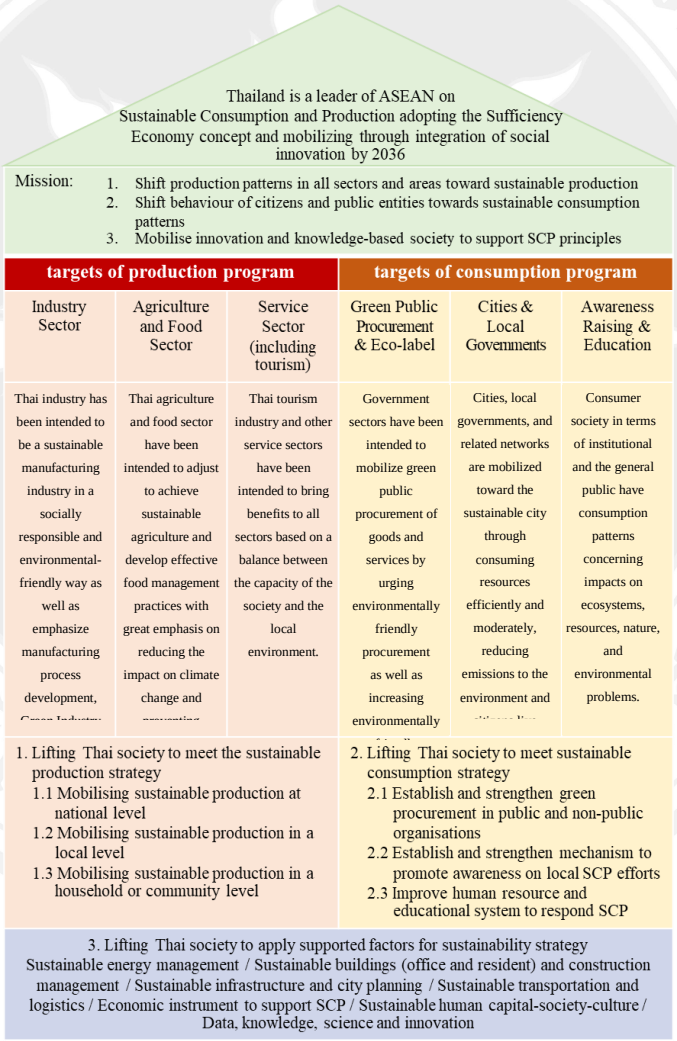

Figure 2.9 The Sustainable Consumption and Production Roadmap 2017–2036

Source: Office of Natural Resource and Environmental Policy and Planning (ONEP) (2017)

The target of the manufacturing sector is that “Thai industry has been intended to be sustainable manufacturing industry in a socially responsible and environmental-friendly way as well as emphasize manufacturing process development, Green Industry certification and integrated industrial waste management.” The procedures in mobilizing the manufacturing sector towards sustainability include consuming resources efficiently and cost-effectively, reusing and recycling waste from the production process, promoting a production process that does not affect the society and environment. In developing indicators for the manufacturing sector, the sustainable development targets (i.e., the 8th target and the 12th target) are considered and integrated with the relevant plan of Thailand, the Ministry of Industry Strategic Plan, 2017- 2021 as presented in Table 2.2 which shows that green industry and waste management are indicators of sustainable industrial consumption and production(Office of Natural Resource and Environmental Policy and Planning (ONEP), 2017).

Moreover, the SCP Roadmap was revised by Working Group for SDG 1 2 in 2020. goals, targets and indicators with action plan has been set for all sectors as in Figure 2.10.

Table 2.2 Summary of indicators and goals of Sustainable Consumption and Production Roadmap 2017 – 2036

No.	Aspect	Indicator / Goal
1	Environmental operations	1.1 Number of factories certified as green industry (GI) increases 2,000 factories per year within 2021. 1.2 Number of industrial estates certified as Eco Industrial Town increase at least 4 places per year within 2021.
2		2.1 There are policies, regulations, and methods for reporting sustainability operations by asking listed companies on the Stock Exchange of Thailand to include the Environmental Social and Governance (ESG) into their business processes to create sustainable business value and report information regarding business operations and/or sustainability and listed companies with social responsibility within 2021. 2.2 There are reports conducted by highly successful entrepreneurs presenting the key operations and

No.	Aspect	Indicator / Goal
		sustainability indicators by classifying industry sectors within 2030.
3	Resources	3.1 Resource intensity reduces 10 percent within 2026 and reduces 15 percent by 2036.
4	Greenhouse gas	4.1 Overall industrial sectors reduce greenhouse gas emissions by 20 percent from the BAU within 2036.
5	Energy consumption in the manufacturing sector	5.1 Proportion of final energy consumption to GDP of overall industrial sectors and industries in each sector decline.
6	Technology	6.1 The proportion of GDP and Green GDP for industrial sectors increases every year due to the promotion of green industry, eco-industry, technological development, innovation and investment in environmental research and development, product distribution, and environmentally friendly product export.
7	Environmentally friendly products	7.1 The quantity of green-labeled products increases 25 percent within 2025 and 50 percent by 2036.
8		8.1 The quantity of products that receive all types of eco-labelling increases 100 percent within 2025 and 200 percent by 2036.
9	Waste	9.1 The total amount of harmful industrial waste is sent to the correct waste management system with 2021.
10		10.1 The rate of recycling industrial wastes reaches 50 percent within 2025.
11	Water	11.1 The water intensity in industrial sectors is declined by 25 percent with in 2036.
12	Pollutants	12.1 Emissions from industrial sectors are reduced by 30 percent within 2030 (the type of pollution may vary from region to region).

Source: Office of Natural Resource and Environmental Policy and Planning (ONEP) (2017)

Figure 2.10 Framework of the Sustainable Consumption and Production Roadmap 2017–2037 (Revised Version1)

Source: Office of Natural Resource and Environmental Policy and Planning (ONEP) (2020)

2.5 Industrial Sustainable Development Indicators

Developing sustainable development indicators for industrial entrepreneurs is a challenging task that requires the collaboration between entrepreneurs and public authorities/government agencies since sustainability identification can be considered in various dimensions as well as each industry group has different patterns of operation, business, and environmental impact(Ponomarenko, Marinina, Nevskaya, & Kuryakova, 2021; Sev, 2009; Staniškis & Arbaciauskas, 2009). Therefore, they are effort to develop indicators for industrial sector which can contribute sustainability of their industrial sector and simultaneously mobilize the national sustainable development policy.

2.5.1 Study of Sustainable Development Indicators in Foreign Industries

Feil, Schreiber, Haetinger, Strasburg, and Barkert (2019) review the use of sustainable industrial indicators of different manufacturing industries in the European Union, Asia, and the United States, published for 24 editions during 1988–2018 and found that the sustainability indicators in manufacturing with triple bottom line contain social, economic and environmental dimensions which have been employed since 1988. In addition, it is seen that the average of sustainability indicators in manufacturing is approximately 30 indicators from a total of 753 indicators. The indicators were processed into a new set that could be implemented to all types of industry. The difficulty and benefit analysis of implementing the new sustainability indicators revealed that this set of indicators is advantageous to the sustainability assessment of industries. Moreover, continuous improvement can promote easier, more convenient, and more efficient assessment.

Eseoglu, Vayvay, and Kalender (2014) investigate the assessment of sustainability performance indicators in manufacturing based on the life cycle assessment and eco-innovation to develop a framework of sustainable industrial assessment depending on 4 aspects including 1) environmental aspect, 2) social aspect, 3) economic aspect and 4) technological aspect. This study entails a set of sustainable industrial indicators relying on the life cycle assessment.

Joung, Carrell, Sarkar, and Feng (2013) investigate the sustainable industrial indicators by reviewing the indicators which are currently published as well as developing a set of indicators relevant to sustainable manufacturing that is explicit and demonstrates qualitative result with the total of 212 subordinating indicators which can be categorized into 5 dimensions as follow:

1) Environmental stewardship having 77 indicators
2) Economic growth having 23 indicators
3) Social well-being having 70 indicators
4) Technological advancement management having 12 indicators
5) Performance management having 30 indicators

Winroth, Almström, and Andersson (2012) review literature to develop sustainable industrial indicators which is practically suitable for industrial factory and

able to compare between industries. The indicators can be classified as a three-dimensional set of indicators involving 1) environment, 2) economy, and 3) society. Furthermore, the data collection for the developed sustainable industrial indicators can be presented as in Table 2.3 and 2.4.

Table 2.3 Sustainability Performance Indicators

Dimension	Aspect	Indicator	Unit
Environmental	Natural Resources	Land Consumption	m^2
		Water Consumption	m^3
		Recycled water	% of total consumption
		Purification of wastewater	% of total consumption
		Share reuse or recycled	% of total consumption
	Energy	Use of renewable energy	% of total energy
		Energy use (in relation to …)	kWh energy use per unit
		Idle energy losses	kWh idle time energy use
	Material	Material usage	kg or m^3 per unit
		Scrap rate	% of material usage
		Rate of packaging material	% of material usage
		Use of process additives	% of material usage
	Waste and emissions	Total solid waste	kg or m^3 solid waste
		Weight of hazardous waste	kg or m^3 hazardous waste
		Emission of ozone-depleting substances	kg or m^3 ozone-depleting substances
		Emissions causing acid rain (NO_x etc.)	kg or m^3 emission of NO_x etc.
		Emission of particles	kg emission of particles
		Emission of CO_2 from factory	kg emission of CO_2
		Environmental accidents	# of accidents
	Environmental legal and standard compliance	Cost for EHS compliance (time, liabilities, worker compensation, waste disposal)	Monetary units
		Compliance with ISO 14001/EMAS	Yes/No
		Environmental impact assessment is used (compliance)	Yes/No
Economic	Business and	Profit, profitability etc. according	Financial measures

Dimension	Aspect	Indicator	Unit
	finance	to annual Reporting legislation	
		Value added/employee (productivity)	Monetary units/# Monetary units
	Employees	Employment cost in relation to income sales	Yes/No
		Access to skilled personnel	Monetary units/hr
		Employee cost per hour	
	Customer	Rate of customer complaints	#/unit
		No. of new customers per year	#/year
	Development expenditure	No. of new products related to total # of products	# new/total #
		% of annual budget to R&D	%
	Production operation	Overall equipment Efficiency, OEE	%
		Productivity (production pace)	#hr
		Performance rate for manual labor	Time used/ideal time
		Utilization of manual labor	% utilization
		Delivery precision	% on time delivery
		Lead time	Days, hours
		Flexibility: Range, Time	Range metric, Time metric
		Maintenance	Ratio maintenance hr/units
	Supplier	Stops caused by suppliers	#
	Health and safety	No. of accidents	#
		Absence due to injuries or work related illness	# of days
		Elimination of hazardous work places	Yes/No
Social	Education and training	No. of training hours per employee	#
		Participation ratio in improvement groups	# of groups/# of employees
		Level of education	Average level
	Labor-management relations	Rate of temporary workers	# of temporary/# of permanent
		Rate of employees that are share holders	%

Dimension	Aspect	Indicator	Unit
	Diversity and equal opportunity	Equal opportunity	Yes/No
		Male to female ratios	% male, % female
		Cross functional teams for improvements	# of teams
		Non-discrimination Gender/Age/Ethnical/Sexual	Yes/No
		Company wage in comparison to local minimum wage	% ratio
	Human capital	No. of new employees per year	#
		Employee satisfaction rate	% satisfied employees
		Support for employee physical activity health care and medicine	Yes/No, amount
		Employee turnover	% annual turnover rate
		Responsibility and empowerment related to competence	Yes/No
		Clear job descriptions	Yes/No
		Promotion opportunities for all employees	Yes/NO

Source: Winroth et al. (2012)

Table 2.4 An example of well-defined indicator

Title	OEE (Overall Equipment Effectiveness)
Purpose	To monitor equipment performance and to identify improvement actions
Relates to	Scrap rate, speed rate, downtime rate
Formula	(Ideal cycle time) × (No. of quality approved items) / (Planned production time)
Frequency of measurement	Every day
Frequency of review	Once a year
Who measures?	Operator
Source of data	Disturbance data (planning system), quality records
Who owns the measure?	Production manager
Who acts on the data?	Operator, maintenance, operations management

Source: Winroth et al. (2012)

The GRI Standards are an international sustainability reporting standard developed by the Global Reporting Initiative in 1999. The key component, method, and framework for reporting cover economic, social, and environmental operations. (Tantimangkorn, 2017) The GRI sustainability reporting standards are globally accepted, especially by investors, that they contain the completeness of contents, transparency reflect ability, and social responsibility as presented in Table 2.5.

Table 2.5 Aspects of economic, environment and social concerned in GRI

Category	Economic	Environmental
Aspects	• Economic Performance • Market Presence • Indirect Economic Impacts • Procurement Practices	• Materials • Energy • Water • Biodiversity • Emissions • Effluents and Waste • Products and Services • Compliance • Transport • Overall • Supplier Environmental Assessment • Environmental Grievance Mechanisms

Category	Social			
Sub-Categories	Labor Practices and Decent Work	Human Rights	Society	Product Responsibility
Aspects	• Employment • Labor/Management Relations • Occupational Health and Safety	• Investment • Non-discrimination • Freedom of Association and	• Local Communities • Anti-corruption • Public Policy • Anti-competitive	• Customer Health and Safety • Product and Service Labeling • Marketing

Category	Economic		Environmental	
	• Training and Education • Diversity and Equal Opportunity • Equal Remuneration for Woman and Men • Supplier Assessment for Labor Practices • Labor Practices Grievance Mechanisms	Collective Bargaining • Child Labor • Forced or Compulsory Labor • Security Practices • Indigenous Rights • Assessment • Supplier Human Rights Assessment • Human Rights Grievance Mechanisms	Behavior • Compliance • Supplier Assessment for Impacts on Society • Grievance Mechanisms for Impacts on Society	Communications • Customer Privacy • Compliance

Source: Global Reporting Initiative (2015)

2.5.2 Indicators under the Project of Supporting Sustainable Industries in Thailand

2.5.2.1 Eco Factory

Eco-factory principles are developed by the Federation of Thai Industries which have been certified since 2015, and in the fiscal year 2017, the Federation of Thai Industries collaborated with the Industrial Estate Authority of Thailand to work on the principles. The main objective of eco-factory is to promote and encourage industrial entrepreneurs to be able to assess the performance of environmental management systems in conducting organizational activities involving life cycle perspective to reach sustainable development under the sufficient economy based on the maintenance of environmental, economic, and social balance by optimizing production efficiency, using resources effectively as well as maximizing green productivity. These are accomplished by applying eco-efficiency that is acceptable to the community and enable organizations to enhance the quality of life and environment in the community through supportive cooperation. The Department of Industrial Works and Industrial Estate Authority of Thailand has certified that the industries certified as eco-factory can equalize to achieving the certificate of Green Industry Level 4.

Eco Factory comprises of 3 main requirements including general requirements, specific requirements for eco-factory standards, and specific requirements for continual improvement. The eco-factory requirements can be concisely explained as presented in Figure 2.10.

General requirements are requirements that all organizations must initially accomplish. The requirements cover the implementation of laws, rules, and regulations related to the environment, energy, occupational health, and safety. In addition, there must be acceptable environmental management systems, such as the environmental management system reference (e.g., ISO 14001 Environmental Management System) which are consistent with the performance and size of the organizations. Besides, there must be no complaint on environment and safety or any serious accidents affecting external organizations within 1 year(Federation of Thai Industries and Industrial Estate Authority of Thailand, 2018).

Specific requirements for eco-factory standards can be divided into 2 major aspects including (1) an eco-efficiency emphasizing environmental and economic operations of the organization including raw material handling, energy management, water and wastewater management, air pollution management, greenhouse gas management, waste management, chemical and hazardous substance management, occupational health and safety management, logistics management, green supply chain management, green landscape management, and biodiversity management. (2) a society consisting of income distribution to the community and living with the surrounding community. Most of the management begins with reporting the organizational information on various aspects to be reference data for developing plans, goals, and operations in order to improve the management to be in accordance with the goals(Federation of Thai Industries and Industrial Estate Authority of Thailand, 2018).

Specific requirements for continual improvement refer to requirements indicating that the organization must be able to assess performance and identify at least 3 significant issues of the organization to continuously apply to the improvement. For this type of requirement, there must be two eco-efficiency requirements and one social aspect. (Federation of Thai Industries and Industrial Estate Authority of Thailand, 2018)

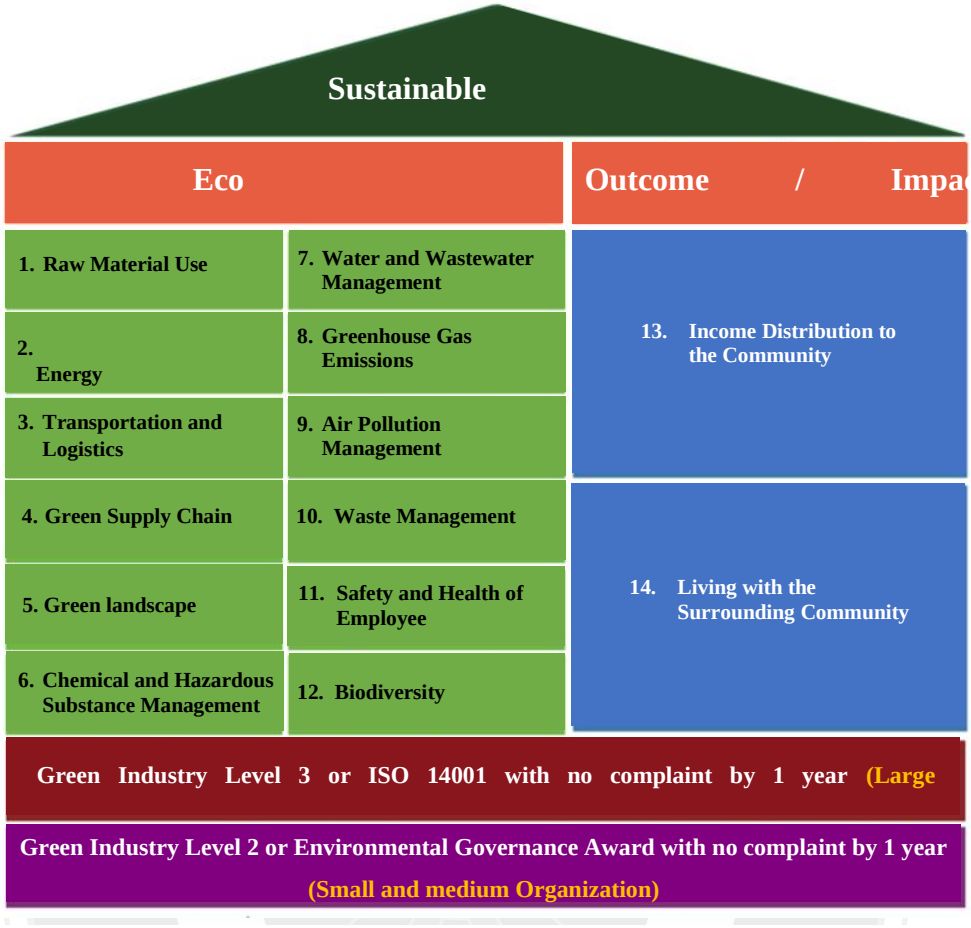

Figure 2.11 Eco Factory Framework and Requirements

Source: Federation of Thai Industries and Industrial Estate Authority of Thailand (2018)

2.5.2.2 Green Industry (GI)

The Ministry of Industry formally initiates the Green Industry Project in late 2010 by depending on the total quality management (TQM) integrated with the triple bottom line. The development and improvement of “Green Industry” principles are based on 2 key terms including continuous improvement and sustainable development of the organization. The Green Industry Project is conducted by making a memorandum of understanding (MOU) between organizations under the Ministry of Industry in order to make the industrial sector in Thailand a good image, reliable, and trustworthy. It is the starting point for developing the industrial sector towards a green economy resulting in a higher value of the country's GDP.

"Green industry" refers to an industry emphasizing the continuous improvement of production and environmental management for environmentally friendly operations as well as highlighting the social-responsible operations of both internal and external organizations throughout the supply chain for sustainable development.

There are 5 levels of developing green industry including (1) green commitment emphasizing policy formulation and organizational policy announcement, (2) green activities that the organization must develop environmental action plans and implement to achieve the goals, (3) green system that the organization must generate the environmental management system including formulating policies, planning operations, implementing, following up the implementation as well as reviewing and maintaining the system continuously, (4) green culture that the organization must establish an environmental and safety organizational culture relevant to the operation patterns and report to the public, and (5) green network that the organization must promote, develop and conduct environmental activities with stakeholders by covering the entire supply chain, community and consumers as well as publicize reports to the public(Department of Industrial Works, 2019a). The levels of developing green industry can be presented as in Figure 2.11.

Level 1, Green Commitment: In formulating environmental policy, the organization must demonstrate an intention in the environmental impact reduction or pollution prevention, sustainable resource use, climate change mitigation and adaptation, and protection and restoration of the natural environment. Additionally, the organization must announce the policy to all personnel in the organization.

Level 2, Green Activities: After the policy formulation and announcement, the environmental action plans are developed as specified in the policy. The action plans must explicitly include objectives, goals, operational procedures, responsibility designation, and operating-time specification.

Level 3, Green System: The organization must generate the environmental management system by initially formulating environmental policies approved by the chief executive officer, planning operations based on identifying important environmental issues of the organization, and developing the action plans

(as indicated in the Level 2), implementing policies and plans, and following up the progress of the implementation and assess the implementation systematically. Furthermore, in order to ensure that the organization still possesses an appropriate and efficient environmental management system, the chief executive officer needs to conduct a review of the organization's environmental management system according to the specified time.

Level 4, Green Culture: In addition to the systematic environmental management, the organization must promote organizational culture and environmental values to cover all aspects according to the Social Responsibility Standards ISO 26000 that entails operations that meet environmental ethics as well as respect, consider and respond the stakeholder benefits, environmental issues, and operations corresponding to international environmental guidelines. Besides, the results of the organization's green activities must also be reported to the public.

Level 5, Green Network: To expand the environmental responsibility to external stakeholders, the organization must promote, develop and conduct environmental activities with stakeholders by covering the entire supply chain, community, and consumers in order to maximize concrete success by encouraging the supply chain to comply with green industry criteria. Furthermore, there must be continuous development, promotion of community participation in developing community to stimulate consciousness, awareness, and promote sustainable consumption.

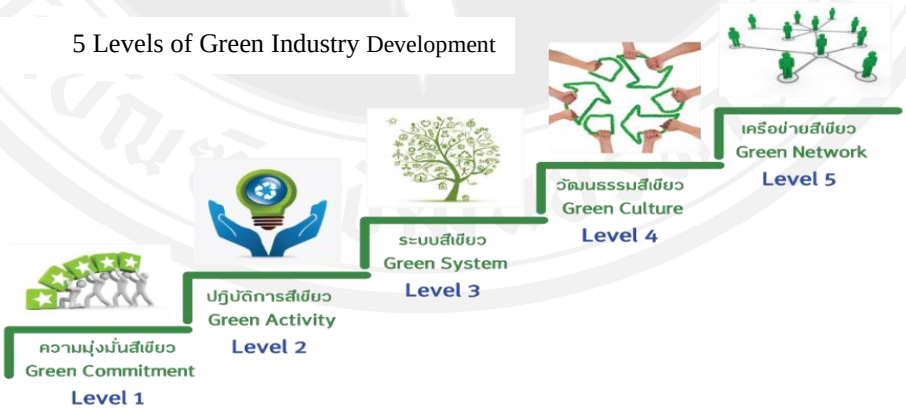

Figure 2.12 The development of green industry

Source: Department of Industrial Works (2019b)

2.6 Summary of literature review

The concepts of sustainable development and sustainable development goals refer to the sustainable environment, economy and society with balancing resource needs between present and future generations. Circular economy principle facilitates resource circulation and simultaneously increases more opportunities to create new business models for conserving natural resources as well as minimizing wastes on the ecosystem and society. CE principle is complementary on implementation for the conceptual framework of SCP for industry. SCP principles involve in improving the quality of life without environmental destruction, decoupling eco-efficiency, applying life-cycle thinking of consumption and production and guarding against rebound effect from higher consumption. Thai SCP Roadmap was developed to meet the Goal 12 of SDGs and national plan to achieved the Green Growth for all production sectors and consumption behaviors. Targets for production sectors required in roadmap consists of resource, renewable energy and renewable material consumption efficiency, material flow analysis, waste minimization, hazardous waste and air emission management as well as certified eco-label development(Office of Natural Resource and Environmental Policy and Planning (ONEP), 2017).

Indicator is a major tool for monitoring and assessing the level of targets obtained. The boundaries, objectives and related variables are needed to be clearly defined in the indicator development. In addition, an effective indicator should be able to reflect objective, clarity in design, and practical implementation in collecting data and developing costs. Furthermore, it has to meet quality, reliability and time suitability(Rahdari & Anvary Rostamy, 2015; Veleva & Ellenbecker, 2001).

There are various international studies related to the sustainable development indicator for industrial sectors and GRI standards in various aspects. However, the notion of SD indicators for general industry is still understudied. Therefore, the participation of stakeholders in identifying SD indicators for implantation is approached to develop indicators.

In Thailand, Green industry and Eco Factory have been promoted for sustainable development of Thai industry by the Department of Industry Work, Ministry of Industry and Federation of Thai Industries respectively. The levels of

Green Industry involving industry development consist of 5 level including Level 1 Green commitment, Level 2 Green Activities, Level3 Green system, Level 4 Green Culture and Level 5 Green network. Eco Factory criteria are developed to certified industrial sustainability, and it consists of 14 requirements covering resource efficiency, energy, water and wastewater management, waste and hazardous substance management, green supply chain, transportation and logistics, green area, greenhouse gas emission, safety and health of employee, biodiversity, income distribution to community and living with the surrounding community. Eco Factory criteria focus on eco efficiency and continuous improvement of industry. Notably, both Green industry and Eco Factory are voluntary scheme for Thai manufacturing sector under the support and incentive provided by the government in order to fulfil Eco Industrial Town and Eco Town action plan of Ministry of Industry. In addition, Eco Factory is recognized by DIW as Green Industry level 4.

CHAPTER 3

RESEARCH METHODOLOGY

The methodology for conducting research on developing Thai industrial sustainable development indicators or the sustainable consumption and production indicators (SCP indicators) consisted of reviewing literature related to the conceptual framework of sustainable development in an international context, the sustainable development goals (SDG), the 12th National Economic and Social Development Plan (SDG 12) and the sustainable indicator development as well as considering the sustainable indicator development in foreign countries, the Global Reporting Initiative standards (GRI standards) and Thai industrial sustainable indicator development under a Green Industry project proposed by the Ministry of Industry that is one of the indicators included in the sustainable consumption and production roadmap for manufacturing sectors in Thailand.

The conceptual framework for developing SCP indicators in the current study contained four dimensions involving the economy, environment, society, and good governance which was coherent to the circular economy principles. The indicator development (Draft 1) was initially developed by studying secondary data which was sustainability reporting of the target industry group certified as an eco-factory and follows by conducting the in-depth interview with representatives of the target industry group to analyze difficulties of the eco-industry indicator implementation as well as their comments on the indicators (Draft 1) to improve the indicators (Draft 2). Then the focus group meeting was conducted on representatives of the public and private sectors engaging in eco-industry certification in order to receive suggestions on the suitability of the SCP indicators (Draft 2). After that, the suggestions from the meeting were used to enhance the SCP indicators (Draft 3). Besides, the seminar for representatives of the entrepreneur in the target industry

group was organized to validate the implementation of indicators (Draft 3) on both practical and methodological aspects and to gather feedback in terms of indicator implementation benefits and drawbacks. The seminar results were summarized as recommendations for improvement and a conclusion of developing sustainable consumption and production indicators for an industrial sector according to circular economy principles in Thailand.

3.1 Conceptual Framework

The conceptual framework for developing SCP indicators for Thai industries or the sustainable development indicators was developed by categorizing into 4 aspects including economic indicators, environmental indicators, social indicators, and good governance indicators. These indicators were developed based on the reviewed studies related to GRI standards in foreign countries, eco-factory principles, and sustainability reporting of entrepreneurs of the target industry group.

In addition, the subordinate indicators in each aspect were developed depending on circular economy principles which consisted of systems thinking, innovation, stewardship, collaboration, value optimization, and transparency(British Standards Institution, 2017). These 6 aspects conduced industrial indicator development entailing cost-effective use of renewable resources in different ways (e.g., manufacturing products and materials with durability or manufacturing that meets the renewability, reuse, repair, upgrades, and reduced material use). The SCP indicators corresponding to circular economy principles were adapted to suit Thai industries by employing the recommendations and suggestions received from the focus group meeting with representatives of the public and private sectors involving indicator implementation, validating the practicality of indicator implementation by representatives of the entrepreneur in the target industry group as well as creating metadata of the conceptual framework to develop SCP indicators for sustainable development for Thai industries as presented in Figure 3.1.

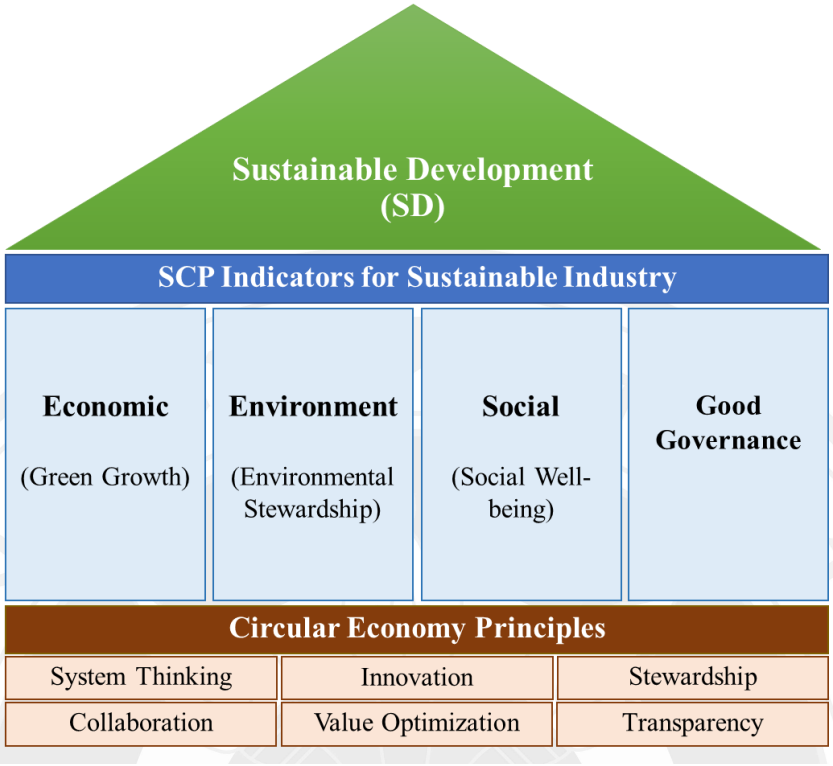

Figure 3.1 The conceptual framework of developing SCP indicators for sustainable development for Thai industries

Source: Joung, Carrell, Sarkar, and Feng, (2013); British Standards Institution. (2017); Scialabba (2013)

3.2 Research Procedures

The research procedures in the current study began with reviewing the literature, such as the secondary data (i.e., the sustainability reporting related to the sustainable development on the national policy and the sustainable indicator development at the industrial level in Thailand and foreign countries) in order to develop the 1st draft of SCP indicators which is consistent to the circular economy principles. Surveys and in-depth interview with the indicator developers, Eco-Factory indicator evaluators as well as representatives of the entrepreneur who obtain the Eco-Factory certification was then conducted to gather comments on the 1st draft, and the indicators were improved based on the comments to be the 2nd draft of SCP indicators. Additionally, the suitability of the 2nd-draft indicators was considered by Eco Factory working group that representatives of the public and private sectors

through conducting the focus group meeting and survey. After that, the suggestions from the seminar were used to enhance the indicators to be the 3rd draft of SCP indicators, and the workshop and survey for validating the 3rd-draft indicators by representatives of the target entrepreneur and Eco Factory working group were organized to consider the implementation practicality as well as to investigate the difficulties and recommendations in order to summarize the result of the study. The research procedures can be ordinally clarified as follows:

3.2.1 Development of the First draft of SCP Indicators

Develop the 1st draft of SCP indicators was initiated by top-down method by the researcher. Four set of indicators consisting of Environmental Indicators, Social Indicators, Economics Indicators and Good Governance Indicators were listed based on National Indicators; Eco-Factory criteria 2018 and SCP Roadmap, selected international studies related sustainable development, GRI and SAFA standards(Global Reporting Initiative, 2015; Scialabba, 2013). The circular economy principles were applied in selected process. The literature reviews are consisting of:

1) Review literature regarding the guidelines for developing SCP indicators of an industrial sector in Thailand by focusing on previous studies related to the sustainable indicator development of manufacturing sectors which is in accordance with Thai Sustainable Consumption and Production Roadmap corresponding to Circular Economy principles.

2) Review the sustainable development in foreign countries by observing their sustainable development goals and sustainable consumption and production (SCP).

3) Review literature regarding theories of industrial sustainable indicators by emphasizing foreign research relevant to the sustainable indicator concept, circular economy standard, SAFA and GRI standards.

4) Review literature regarding Thai 20-year Sustainable Consumption and Production Roadmap and Thai SCP indicators under the supporting policy of Thailand by highlighting the development of sustainable development indicators and SCP indicators integrated with the 12th National Economic and Social Development

Plan proposed by the Natural Resources and Environmental Policy and Planning, Ministry of Natural Resources and Environment.

5) Review the Sustainable Consumption and Production Action Plan related to the development of sustainable industrial development indicators proposed by the Ministry of Industry in terms of Green Industry project, the criteria and assessment of Eco Factory certification as well as Eco Industrial Town policy(Federation of Thai Industries and Industrial Estate Authority of Thailand, 2018).

3.2.2 Improvement of the Developed SCP Indicators

1) Randomly find key informants by surveying the target group including entrepreneurs of Thai manufacturing sector and representatives of the target industry group certified as Eco-Factory. There were 6 informants willing to conduct an in-depth interview.

2) Conduct an in-depth interview. The topics for interviewing were as follows:

(1) Opinions toward criteria of Eco-Factory indicators

(2) Difficulties of sustainable indicator development of the company, data collection, and eco-factory indicator implementation

(3) Policy and direction of circular economy operation of the entrepreneurs

The feedback on the 1st draft of SCP indicators which was gathered through a survey and an interview covering opinions toward the current indicators and difficulties of the Eco-Factory indicators used was applied to improve the indicators to be the 2nd draft.

3) Conduct focus group meetings and a survey to consider the 2nd-draft sustainable indicators for Thai industries. There were three focus group meetings with 36 informants including experts and others from related sectors who involved in developing evaluation and certification criteria as follows:

(1) Representatives of Industrial Estate Authority of Thailand (IEAT) or representatives of the Eco Industry Development Division, Department of Industrial Works, Ministry of Industry. (13 persons)

(2) Representatives or working-group members of Standard Development and Promotion of Eco Factory Working Group, Water and Environment Institute for Sustainability, Federation of Thai Industries (18 persons)

(3) Ecological and sustainable industrial development qualified experts and certified Eco Factory auditors. (5 persons)

The consideration criteria comprised of the criterion, indicator, number of indicators in different aspects and data collection. The result of the focus group meetings and the second survey was used to enhance the indicators to be the 3rd draft of SCP indicators.

4) Organize a seminar, workshop and the third survey to consider the 3rd-draft SCP indicators. There were 41 persons attending hybrid seminar,13 persons (industries) participated in workshop and 30 persons participated in the third survey. There were 78 informants (i.e., 3 participants participated in all three activities and 6 persons participated in two activities). With this number, there were 53 persons from industries and 17 Eco Factory working-group members and 8 persons were experts and auditors. The seminar and workshop provided an opportunity for experts, Eco Factory working group and entrepreneurs of the manufacturing sectors to validate indicators as well as to discuss these topics which were as follows:

(1) Establishing criteria for indicators

(2) Reporting about the developed indicators in different aspects, the suitability, and the data collection of industrial indicator implementation

(3) The expected benefits of the developed indicator implementation

(4) The expected difficulties and solutions of entrepreneurs for implementing the developed indicators

(5) The recommendations for further enhancement

5) Summarize the results and recommendations of developing SCP indicators to assess the development of sustainable industries in Thailand

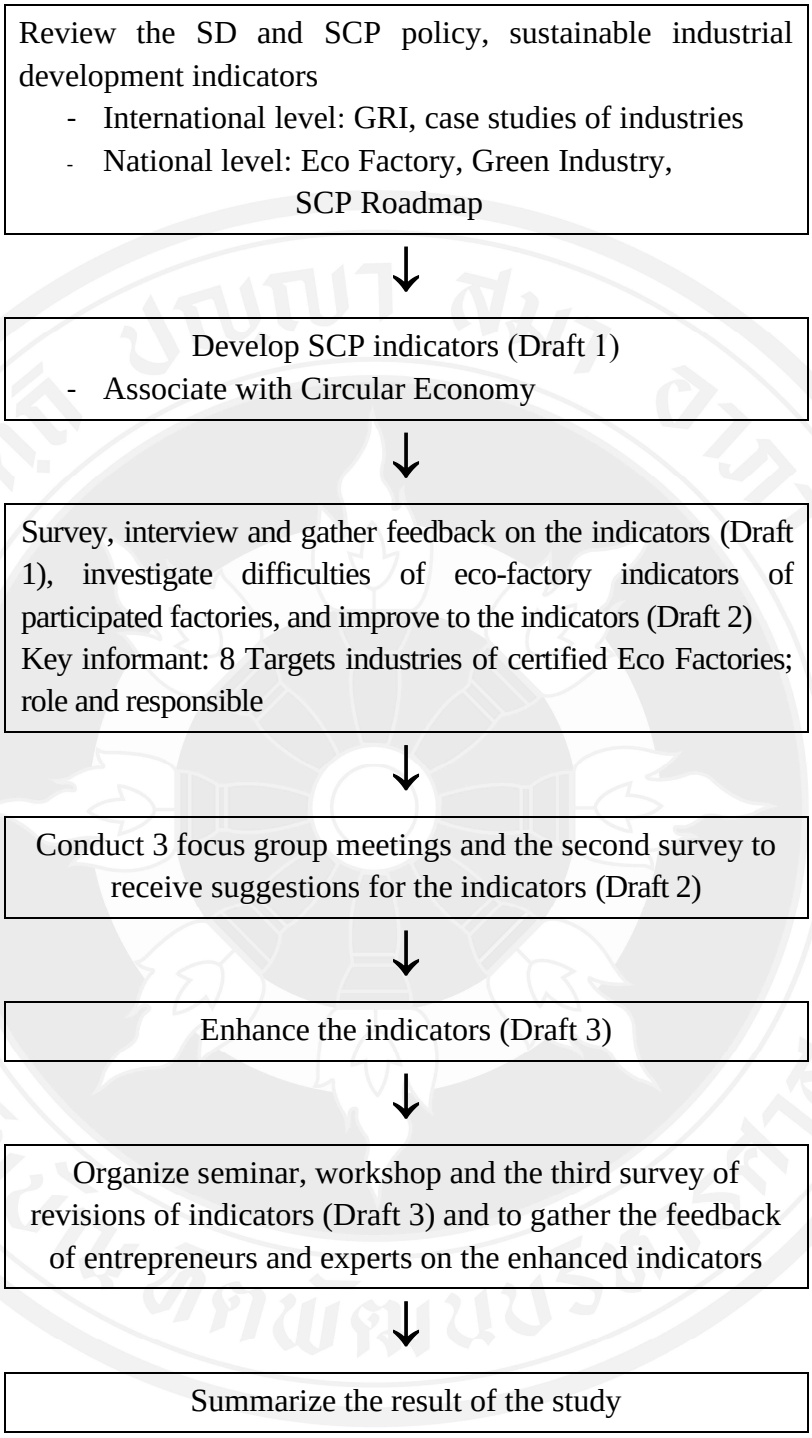

Figure 3.2 The research procedures of developing SCP indicator for Thai industries

3.3 Target Group

The target group included 8 groups of industries having 64 percent of gross domestic product (GDP) original from manufacturing at current market prices in 2017 (overall GDP from manufacturing sectors in 2017 valued at 4,196,801 trillion baht).(Thailand Textile Institute, 2019) The groups comprised of 168 industrial factories including industrial factories of food products, coke and refined petroleum products, chemicals and chemical products, rubber and plastic products, computer, electronic and optical products, electrical equipment, motor vehicles, trailers and semi-trailers and other transport equipment which obtain Certificate of the Green Industry Level 4 or can be calculated as 67 percent of the total number of certified industrial factories as evidenced by the total number of 247 eco-industries (in November,2020).

3.4 Key Informants

3.4.1 The first survey and In-depth Interview

Conduct survey and an in-depth interview to gather opinions toward the 1st-draft sustainable indicators for Thai industries from representatives of 16 companies which were included in the target industry group. These companies were selected by employing equal probability sampling through drawing lots of the simple random sampling without replacement method and the quota 10: 1 sample size. If there is a company that is unwilling to provide information, the draw lots will be repeated. However, the company were selected from company who willing to give in-depth interview in survey. The informants were a representative of company executives who is responsible for collecting company data or the company Eco-Factory indicator developer.

Survey questionnaires (appendix A-1) was sent to target industries through email with official letter signed by the Dean of the Graduate School of Environmental Development Administration, National Institute of Development Administration to inform objectives of study, questionnaires about their role, responsibilities and opinions towards Eco Factory regarding the experiences of the organization. There were 20 respondents and 76 representatives of factories. Lists of informants, sectors

and roles of the organizations in developing industrial sustainability indicators and in-depth interviewed were as follows:

Table 3.1 List of companies response in the first survey

No	Company name	Position	Role in developing industrial indicators	In depth interviewed	Remark
1	PTT Global Chemical Public Company Limited	Manager, Occupation Health and Environmental Division	Manager	✓	Representatives for 22 companies
2	IRPC Public Company Limited	Senior Manager	Indicator Data Collector	✓	Representatives for 25 companies)
3	Dow Chemical Thailand Limited.	Climate Change, energy and environmental specialist	Indicator Developer Indicator Data Collector		Representatives for 2 companies)
4	Thai Polyethylene Company Limited	Managing Director	Chief Executive Officer	✓	Representatives for 2 companies
5	Nawa Plastic Industry Company Limited.	Environmental Scientist	Indicator Data Collector		
6	Unique Plastic Industry Company Limited	Manager, Utility and Maintenance Department	Manager Indicator Developer Indicator Data Collector		

No	Company name	Position	Role in developing industrial indicators	In depth interviewed	Remark
7	Zeon Chemicals Asia Company Limited	Manager, Human Resource and Adminstrative Department	Manager		
8	Shin-Etsu Silicones (Thailand)Company Limited	HSE Specialist	Indicator Data Collector		
9	Modern Dyestuffs & Pigments Company Limited	Manager, Engineering Department	Manager		
10	JSR BST Elastomer Company Limited	HSE Engineer	Indicator Data Collector		
11	Aeroflex Company Limited	Supervisor, Project Manager	Indicator Developer Indicator Data Collector	✓	
12	Ajinomoto Sales (Thailand) Company Limited	Manager, Human Resource	Chief Executive Officer		
13	Thanakorn Vegetable Oil Products Company Limited	Chief Executive Officer	Manager Indicator Developer Indicator Data Collector		
14	Mitsubishi Electric Automation (Thailand) Company Limited	Manager, Maintenance Department	Indicator Data Collector	✓	

No	Company name	Position	Role in developing industrial indicators	In depth interviewed	Remark
15	Mitsubishi Electric Consumer Products (Thailand) Company Limited.	Specialist	Energy and Environmental (Data collector)		
16	HANA Microelectronics (Public) Company Limited.	Environmental Engineer	Coordinator		
17	Kobe Electronics Material (Thailand) Company Limited	General Manager	Manager		
18	Lion (Thailand) Company Limited	Supervisor	Indicator Data Collector	✓	
19	Chemical company (participate as personal)	SHE Manager,	Manager		
20	Dairy Home Social Enterprise Company Limited	Factory Manager	Manager		

The topics in conducting survey and an in-depth interview to improve the developed indicators to be the 2nd-draft SCP indicators for Thai industries consisted of opinions toward criteria, difficulties of Eco-Factory indicator implementation and policy and direction of circular economy operation of the entrepreneurs.

3.4.2 Focus Group Meeting and the second survey.

Conduct the focus group meeting with experts and others from promotion, assessment and certification sectors who were a part of developing criteria and sophisticated in Eco-Factory certification evaluation to consider the 2nd draft of

sustainable indicators for Thai industries. The second survey was conducted after focus group meeting. The result was used to enhance the indicators to be the 3rd draft of sustainable indicators for Thai industries.

Focus group online meeting was arranged and hosted by Water and Environment Institute for Sustainability (WEIS). The online meeting was participated by Eco Factory working group as well as experts, and there were two onsite meetings with 40 experts from academic Kasetsart University and Department of Eco Industrial Town Division, Department of Industrial Work, Ministry of Industry.

3.4.3 Seminar, workshop and the third survey

Organize a seminar to consider the 3rd-draft sustainable indicators for Thai industries. The seminar participants included representatives of the entrepreneurs from the manufacturing sectors. There were at 30 persons from industry and experts as well as government sectors. They provided information as those who are experienced and related to implementing the sustainable indicators for Thai industries. The result was to revise the 3rd draft of SCP indicators and issues data collecting of indicators for industry workshop. The industry workshop to brainstorm for practical issues for SCP indicators implementation and result of this activity provided the third revisions of 3rd draft of SCP indicators for the third survey with stakeholder. Therefore, the result of research was summarized to be the sustainable indicators for Thai industries.

3.5 Data Analysis

This study employed the grounded theory which is a systematic methodology in analyzing data by using content analysis to develop the SCP indicators. The content analysis is academically defined as a method for determining data or content in forms of writing or symbol of matters (e.g., pictures, movies, lyrics, etc.), and parsing, grouping, or categorizing data of the content reliable and valid (Neuman, 2000; Krippenndorff, 2004; Reitz, 2004 cited in Nokkaew, 2012). The procedures of data analysis in this study were as follows(Nokkaew, 2012):

1) Categorize data of SCP indicators into 4 aspects including economic indicators, environmental indicators, social indicators, and good governance indicators.

2) Grouping data of 4 aspects of SCP indicators depending on their sources. There were three sources including data from reviewing secondary data, survey, in-depth interview, and focus group meeting as well as seminar to analyze data by employing a triangulation technique in summarizing the SCP indicators.

3) Distribute the frequencies of data according to the SCP indicator categories and the groups of sources.

4) Summarize the result of data analysis by examining the frequencies in each aspect and group as well as summarizing based on triangulation and grounded theory.

CHAPTER 4

RESULTS OF STUDY AND ANALYSIS

This study was conducted using the grounded theory as well as top down and bottom-up stakeholder involvement to develop the sustainable consumption and production indicators (SCP indicators) based on the circular economy principle which are defined as the sustainable development indicators for Thai industries in the current study. The indicator development consisted of four main tasks which can be separated into seven subordinate procedures including 3-time survey and interviews of stakeholders, 3-time focus group meetings with Eco Factory Working Group members (i.e., representatives from Ministry of Industry, industry groups, public organizations, experts, certified auditors and consultants), as well as 1-time seminar for stakeholders and workshop to brainstorm practical issues of SCP implementation with the industry group. All tasks were conducted during December 6, 2020 - March 31, 2021. This study has received considerable cooperation from the Water and Environment Institute for Sustainability and the Federation of Thai Industries for providing contact lists of the target industries and supporting in both focus group meeting and seminar, the Thai Sustainable Consumption and Production Networks in collaborating in organizing the seminar as well as the Communities Association in assisting in the workshop. All tasks in the current study allowed stakeholders and parties who were interested in developing SCP indicators to participate in both top-down and bottom-up SCP indicator development.

This chapter will elaborate the result of the current research procedures, and contents include: (1) the literature review of international academic studies and standards related to industrial SD indicators and the 1st draft of SCP indicators that employed the integration between the Thai SCP Roadmap, the circular economy principle and Eco Factory indicators, (2) the summary of the result of the first

industry survey and interview to consider the development of the 2nd draft of SCP indicators, (3) the brief summary of the focus group meeting with the Eco Factory Working Group and the second survey that enhance the indicators to be the 3rd draft of SCP indicators, (4) the summary of seminar and workshop for practical implementation of the 3rd draft of SCP indicators participated by stakeholders, and (5) the summary of final version (the 3rd draft) of SCP indicators.

4.1 Development of the First Draft of SCP Indicator

4.1.1 The SCP Indicators Frameworks

The SCP indicators in the current research was defined as the sustainable development indicator for industries. This research defined sustainable development industry into four pillars consisting of environmental, social, economic and good governance pillars. According to SAFA, good governance pillar refers to the understanding towards corporate governance impacts on the corporate performance and economic performance of stakeholders in the supply chain. The good governance pillar corresponds to the Sustainable Development Goal 16 (SDG16) involving promoting inclusive institutions at all levels.

The indicators were drafted based on the key SCP principles defined by UNEP and CE principles which are currently a widely accepted practices or indicators of the industry. The SCP principles were employed to develop SCP indicators in the current research, and there were 4 key SCP principles according to the UNEP 2012 including (1) the improvement of the quality of life without increasing environmental degradation and compromising the resource needs of the next generations, (2) the separation of economic growth from environmental degradation by reducing material/energy intensity, reducing emissions and waste in industrial processes, and shifting product and service consumption patterns with lowering energy and material intensity without compromising quality of life, (3) the application of life-cycle thinking related to impacts from all life-cycle stages of the production and consumption process, and (4) the prevention of re-bound effects resulting in reducing consumption efficiency. (United Nations Environment Programme, 2012)

The rational and frameworks of developing the first draft of SCP indicators based on the circular economy principle for Thai industries are as below.

1) There are various international academic studies conducted on the industrial indicators for sustainable development, sustainable production and sustainability. These studies are internationally and well recognized in coherent with the sustainable development for industry, such as the GRI and Sustainability Assessment of Food and Agriculture systems (Scialabba, 2013).

2) Eco Factory criteria are voluntarily implemented for sustainable development in Thai industries.

3) Thai SCP Roadmap specifies goals, targets and indicators for Thai industries as a national plan associating the SDG goal, number 12, which involves "the sustainable development that aims to ensure sustainable consumption and production patterns" (https://sdgs.un.org/topics/sustainable-consumption-and-production)

4) Six principles under the circular economy concept are applied into drafting the indicators.

4.1.2 The Correspondence between the First Draft of SCP Indicators as well as SCP Roadmap and Eco Factory Criteria

According to the results of the literatures in 4.1.1, the first draft of SCP indicators was created by the researcher based on the top-down approach as presented in Table 4.1. The 1st draft of SCP indicators was compared to the SCP Roadmap for target industry sector and Eco Factory criteria to exhibit the indicator correspondence between the drafted SCP indicators as well as SCP Roadmap and Eco Factory criteria are shown in Table 4.2 and Table 4.3 respectively. The draft SCP indicators that extracted from international academic studies, SCP Roadmap and Eco Factory criteria is shown in Table 4.4

Table 4.1 The 1st draft of SCP indicators

Set of indicators	Indicator (Unit)
Environmental Indicators	
1. Resources/ Materials	1. Materials management efficiency / the quantity of main materials used per income (Ton/Million baht)
	2. Material usage / footprint (Ton or m^3)
	3. Consumption of recycling materials (% virgin material)
	4. Hazardous materials/chemicals (Ton or m^3)
	5. Scrap rate (% of finished product)
2. Energy	1. Energy management efficiency (kWh/Giga Joule/ Million baht)
	2. Electricity / energy consumption (kWh/Giga Joule)
	3. Energy intensity (kWh/product, K Joule/product)
	4. Reduction of energy consumption (kWh/Giga Joule)
	5. Use of renewable energy (% of total energy)
	6. Symbiosis energy (Giga Joule)
3. Water/Wastewater	1. Water and wastewater management efficiency (m^3/ Million baht)
	2. Water consumption / total water withdrawal by sources (m^3)
	3. Volume of water reused or recycled (m3/total used water or % of water consumption)
	4. Volume of water discharge (m^3)
	5. Symbiosis wastewater (m^3)
4. Air / emission / gas emission / heat emission	1. Air emission management efficiency (kg SOx, NOx, VOC/ Million baht)
	2. Emission of ozone-depleting substances (kg emission)
5. Greenhouse gas management	1. Greenhouse gas intensity (tonCO2e/Million baht, product)
	2. Emission of CO_2 from factory / GHG emission (tonCO_2e)
6. Solid waste	1. Solid waste inventory / profile / flow diagram (#)
	2. Volume of solid waste (kg or m^3 of solid waste)
	3. Solid Waste reuse / recycle (kg)
	4. Waste reduction & disposal (kg or m^3 of hazardous waste)
7. Hazardous waste	1. Volume of hazardous waste / material (m^3)
8. Logistics	1. Transportation and logistics management efficiency (#)
	2. Reverse logistics, customer returns (#)
9. Suppliers	1. Percentage of new suppliers that were screened using environmental criteria (% of total suppliers)
	2. Significant actual and potential negative environmental impacts in

Set of indicators	Indicator (Unit)
	the supply chain and action taken (# / total suppliers)
10. Product development / manufacturing	1. Quantity of recycling / reuse / remanufacturing (kg or m^3 of material)
	2. Durability level (#)
	3. Environmentally friendly design / Eco-design (# of product)
	4. Eco-innovations (# of product or project)
11. Sustainable product certification (materials, products)	1. Third Party Eco-Label (e.g., Green Label, Carbon Footprint, Water Footprint) (# of product)
	2. Self-Declare (# of product)
12. Environmental spending/investments/ management	1. Green areas / buffer zone (% area)
	2. Environmental spending / protection expenditures and investments by type (monetary unit)
13. Technology	1. Recycling technology (# of project)
	2. Remanufacturing technique (#)
	3. Recovery technique (#)
Social Indicators	
1. Employees	1. Turnover index (#)
	2. Proportions of permanent staffs and temporary staffs (#)
	3. Discrimination/male to female ratios/gender/age/sexual/child labor (%male, %female)
	4. Wages and benefits (% ratio)
	5. Programs for skills management and lifelong learning / indigenous knowledge / training of the employees (in hours) / capacity development / sustainable awareness (#)
2. Security and safety at work	1. Health and security / safety / elimination of hazardous workplaces/ergonomics / absence due to injuries or work-related illness / deaths / effective occupational health and safety management for staffs and related persons (Y/N, # of day absence, # of days)
	2. Ergonomic (#)
	3. Healthy working environment (e.g., air, sound, light)
3. Clients/ consumers	1. Number of complaining consumers (#)
	2. Total number of incidents of non-compliance with regulations and voluntary codes concerning marketing communications, including advertising, promotion, and sponsorship, by type of outcomes (#)
4. Community and stakeholders	1. Engagement of the community / living with the surrounding community (Y/N)

Set of indicators	Indicator (Unit)
	2. Local partnerships / Integration to the society (Y/N)
	3. Investments to benefit community / income distribution to the community (Y/N)
Economic Indicators	
1. Gross revenue	1. Gross revenue value (Monetary units)
2. Cost / expense	1. Employee / labor cost/ Expense with wages (Monetary units)
	2. Ratios of standard entry level wage by gender compared to local minimum wage at significant locations of operation (%)
	3. Expense with taxes / Payment to government (Monetary units)
	4. Environmental expense (Monetary units)
	5. Operational expense (Monetary units)
	6. Energy cost (Monetary units)
	7. Recycling cost (Monetary units)
	8. Disposal cost (Monetary units)
	9. Remanufacturing Cost (Monetary units)
3. Profit	1. Liquid profit (Monetary units)
	2. Retained earnings (Monetary units)
4. Investments	1. Overall equipment Efficiency (%)
	2. Investment in R&D activities / technology transfer (Monetary units)
	3. Sustainable process innovation (Monetary units)
5. Suppliers	1. Local suppliers / spending on local suppliers (#)
	2. Local Procurement / product procurement or services from the community (#)
Good Governance Indicators	
1. Corporate ethics	1. Mission statement (Y/N)
2. Accountability	1. Transparency (Y/N)
3. Participation	1. Stakeholder dialogue (#)
	2. Grievance procedures (Y/N)
4. Risk management	1. Sustainable Risk Management Action Plan (Y/N)
5. Holistic management	1. Sustainability Management Plan (Y/N)
	2. Full-cost accounting / material flow cost accounting (Y/N)
6. Ethics	1. Ethical behavior (Y/N)
	2. Anti-corruption (Y/N)

Table 4.2 The comparison between the 1st draft of SCP indicators and SCP Roadmap indicators

SCP indicators		SCP roadmap indicators
Set of indicators	Indicator (Unit)	
Environmental Indicators		
1. Resources/ Materials	1. Materials management efficiency / the quantity of main materials used per income (Ton/Million baht) 2. Material usage / footprint (Ton or m^3) 3. Consumption of recycling materials (% virgin material) 4. Hazardous materials/chemicals (Ton or m^3) 5. Scrap rate (% of finished product)	• SCP 2: Resource Intensity
2. Energy	1. Energy management efficiency (kWh/Giga Joule/ Million baht) 2. Electricity / energy consumption (kWh/Giga Joule) 3. Energy intensity (kWh/product, K Joule/product) 4. Reduction of energy consumption (kWh/Giga Joule) 5. Use of renewable energy (% of total energy) 6. Symbiosis energy (Giga Joule)	• SCP 2: Energy Intensity • SCP 9: Capacity of renewable energy in developing countries
3. Water/Wastewater	1. Water and wastewater management efficiency (m3/ Million baht) 2. Water consumption / total water withdrawal by sources (m^3) 3. Volume of water reused or recycled (m3/total used water or % of water consumption) 4. Volume of water discharge (m^3) 5. Symbiosis wastewater (m^3)	• SCP 2: Water intensity
4. Air / emission / gas emission / heat emission	1.Air emission management efficiency (kg SOx, NOx, VOC/ Million baht) 3. Emission of ozone-depleting substances (kg emission)	• SCP 4: Environmental impact compared to economic

SCP indicators		SCP roadmap indicators
Set of indicators	Indicator (Unit)	
		(NH3, NMVOC, NOx, SO_2, N, P)
5. Greenhouse gas management	1.Greenhouse gas intensity (tonCO2e/Million baht, Product) 2.Emission of CO_2 from factory / GHG emission (tonCO_2e)	• SCP 4: Carbon dioxide emission form industrial sector annually
6. Solid waste	1.Solid waste inventory / profile / flow diagram (#) 2.Volume of solid waste (kg or m^3 of solid waste) 3.Solid Waste reuse / recycle (kg) 4.Waste reduction & disposal (kg or m^3 of hazardous waste)	• SCP 5: Percentage of reuse and recycle industrial waste per total industrial waste
7. Hazardous waste	1.Volume of hazardous waste / material (m^3)	• SCP 4: Percentage of hazardous industrial waste managed by appropriate management system
8. Logistics	1.Transportation and logistics management efficiency (#) 2.Reverse logistics, customer returns (#)	
9. Suppliers	1.Percentage of new suppliers that were screened using environmental criteria (% of total suppliers) 2.Significant actual and potential negative environmental impacts in the supply chain and action taken (# / total suppliers)	
10. Product development / manufacturing	1.Quantity of recycling / reuse / remanufacturing (kg or m^3 of material) 2.Durability level (#) 3.Environmental friendly design / Eco-design (# of product) 4.Eco-innovations (# of product or project)	
11. Sustainable product	1.Third Party Eco-Label (e.g., Green Label,	• SCP 6: Number

SCP indicators		SCP roadmap indicators
Set of indicators	Indicator (Unit)	
certification (materials, products)	Carbon Footprint, Water Footprint) (# of product) 2.Self-Declare (# of product)	of products certified by Green Label • SCP 6: Number of products certified by all types of Eco-labelling
12. Environmental spending/investments/ management	1.Green areas / buffer zone (% area) 2.Environmental spending / protection expenditures and investments by type (monetary unit)	• SCP 4: Percentage of hazardous industrial waste managed by appropriate management system
13. Technology	1.Recycling technology (# of project) 2.Remanufacturing technique (#) 3.Recovery technique (#)	
Social Indicators		
1. Employees	1.Turnover index (#) 2.Proportions of permanent staffs and temporary staffs (#) 3.Discrimination/male to female ratios/gender/age/sexual/child labor (%male, %female) 4.Wages and benefits (% ratio) 5.Programs for skills management and lifelong learning / indigenous knowledge / training of the employees (in hours) / capacity development / sustainable awareness (#)	
2. Security and safety at work	1.Health and security / safety / elimination of hazardous workplaces/ergonomics / absence due to injuries or work-related illness / deaths / effective occupational health and safety management for staffs and related persons (Y/N,	

SCP indicators		SCP roadmap indicators
Set of indicators	Indicator (Unit)	
	# of day absence, # of days)	
	2.Ergonomic (#)	
	3.Healthy working environment (e.g., air, sound, light)	
3. Clients/ consumers	1.Number of complaining consumers (#)	
	2.Total number of incidents of non-compliance with regulations and voluntary codes concerning marketing communications, including advertising, promotion, and sponsorship, by type of outcomes (#)	
4. Community and stakeholders	1.Engagement of the community / living with the surrounding community (Y/N)	
	2.Local partnerships / Integration to the society (Y/N)	
	3.Investments to benefit community / income distribution to the community (Y/N)	
Economic Indicators		
1. Gross revenue	1.Gross revenue value (Monetary units)	
2. Cost / expense	1.Employee / labor cost/ Expense with wages (Monetary units)	
	2.Ratios of standard entry level wage by gender compared to local minimum wage at significant locations of operation (%)	
	3.Expense with taxes / Payment to government (Monetary units)	
	4.Environmental expense (Monetary units)	
	5.Operational expense (Monetary units)	
	6.Energy cost (Monetary units)	
	7.Recycling cost (Monetary units)	
	8.Disposal cost (Monetary units)	
	9.Remanufacturing Cost (Monetary units)	
3. Profit	1.Liquid profit (Monetary units)	
	2.Retained earnings (Monetary units)	
4. Investments	1.Overall equipment Efficiency (%)	
	2.Investment in R&D activities / technology transfer (Monetary units)	

SCP indicators		SCP roadmap indicators
Set of indicators	Indicator (Unit)	
	3.Sustainable process innovation (Monetary units)	
5. Suppliers	1.Local suppliers / spending on local suppliers (#) 2.Local Procurement / product procurement or services from the community (#)	
Good Governance Indicators		
1. Corporate ethics	1.Mission statement (Y/N)	
2. Accountability	1.Transparency (Y/N)	• SCP 6: Operation of quality assessment for disclosure of listed companies for development.
3. Participation	1.Stakeholder dialogue (#) 2.Grievance procedures (Y/N)	• SCP 6: Operation of quality assessment for disclosure of listed companies for development.
4. Risk management	1.Sustainable Risk Management Action Plan (Y/N)	• SCP 6: Operation of quality assessment for disclosure of listed companies for development.
5. Holistic management	1.Sustainability Management Plan (Y/N) 2.Full-cost accounting / material flow cost accounting (Y/N)	• SCP 2: Percentage of factory / industrial estate using Material Flow Analysis (MFA)
6. Ethics	1.Ethical behavior (Y/N) 2.Anti-corruption (Y/N)	

Table 4.3 The comparison between the 1st draft of SCP indicators and Eco Factory criteria

SCP indicators		Eco Factory criteria
Set of indicators	Indicator (Unit)	
Environmental Indicators		
1. Resources/ Materials	1. Materials management efficiency / the quantity of main materials used per income (Ton/Million baht) 2. Material usage / footprint (Ton or m^3) 3. Consumption of recycling materials (% virgin material) 4. Hazardous materials/chemicals (Ton or m^3) 5. Scrap rate (% of finished product)	• Raw Material Usage • Chemical
2. Energy	1. Energy management efficiency (kWh/Giga Joule/ Million baht) 2. Electricity / energy consumption (kWh/Giga Joule) 3. Energy intensity (kWh/product, K Joule/product) 4. Reduction of energy consumption (kWh/Giga Joule) 5. Use of renewable energy (% of total energy) 6. Symbiosis energy (Giga Joule)	• Energy Management
3. Water/Wastewater	1. Water and wastewater management efficiency (m^3/ Million baht) 2. Water consumption / total water withdrawal by sources (m^3) 3. Volume of water reused or recycled (m3/total used water or % of water consumption) 4. Volume of water discharge (m^3) 5. Symbiosis wastewater (m^3)	• Water and Waste Water Management
4. Air / emission / gas emission / heat emission	1. Air emission management efficiency (kg SOx, NOx, VOC/ Million baht) 2. Emission of ozone-depleting substances (kg emission)	• Air Pollution Control
5.Greenhouse gas management	1. Greenhouse gas intensity (tonCO2e/Million baht, Product)	• GHG Emission Management

SCP indicators		Eco Factory criteria
Set of indicators	Indicator (Unit)	
	2. Emission of CO_2 from factory / GHG emission ($tonCO_2e$)	
6. Solid waste	1. Solid waste inventory / profile / flow diagram (#) 2. Volume of solid waste (kg or m^3 of solid waste) 3. Solid Waste reuse / recycle (kg) 4. Waste reduction & disposal (kg or m^3 of hazardous waste)	• Waste Management
7. Hazardous waste	1. Volume of hazardous waste / material (m^3)	• Chemical • Waste Management
8. Logistics	1. Transportation and logistics management efficiency (#) 2. Reverse logistics, customer returns (#)	• Transportation and logistic
9. Suppliers	1. Percentage of new suppliers that were screened using environmental criteria (% of total suppliers) 2. Significant actual and potential negative environmental impacts in the supply chain and action taken (# / total suppliers)	• Green Supply Chain
10.Product development / manufacturing	1. Quantity of recycling / reuse / remanufacturing (kg or m^3 of material) 2. Durability level (#) 3. Environmental friendly design / Eco-design (# of product) 4. Eco-innovations (# of product or project)	• Raw Material Usage
11.Sustainable product certification (materials, products)	1. Third Party Eco-Label (e.g., Green Label, Carbon Footprint, Water Footprint) (# of product) 2. Self-Declare (# of product)	• Water and Waste Water Management • Waste Management • GHG Emission Management
12.Environmental spending/investments	1. Green areas / buffer zone (% area) 2. Environmental spending / protection	• Biodiversity

SCP indicators		Eco Factory criteria
Set of indicators	Indicator (Unit)	
/ management	expenditures and investments by type (monetary unit)	
13. Technology	1. Recycling technology (# of project) 2. Remanufacturing technique (#) 3. Recovery technique (#)	
Social Indicators		
1. Employees	1. Turnover index (#) 2. Proportions of permanent staffs and temporary staffs (#) 3. Discrimination/male to female ratios/gender/age/sexual/child labor (%male, %female) 4. Wages and benefits (% ratio) 5. Programs for skills management and lifelong learning / indigenous knowledge / training of the employees (in hours) / capacity development / sustainable awareness (#)	
2.Security and safety at work	1. Health and security / safety / elimination of hazardous workplaces/ergonomics / absence due to injuries or work-related illness / deaths / effective occupational health and safety management for staffs and related persons (Y/N, # of day absence, # of days) 2. Ergonomic (#) 3. Healthy working environment (e.g., air, sound, light)	• Safety and Employee Health
3. Clients/ consumers	1. Number of complaining consumers (#) 2. Total number of incidents of non-compliance with regulations and voluntary codes concerning marketing communications, including advertising, promotion, and sponsorship, by type of outcomes (#)	
4. Community and stakeholders	1. Engagement of the community / living with the surrounding community (Y/N) 2. Local partnerships / Integration to the society (Y/N)	• Outcome of Communities • Quality of Life in Surrounding

SCP indicators		Eco Factory criteria
Set of indicators	Indicator (Unit)	
	3. Investments to benefit community / income distribution to the community (Y/N)	Communities
Economic Indicators		
1. Gross revenue	1. Gross revenue value (Monetary units)	
2. Cost / expense	1. Employee / labor cost/ Expense with wages (Monetary units)	
	2. Ratios of standard entry level wage by gender compared to local minimum wage at significant locations of operation (%)	
	3. Expense with taxes / Payment to government (Monetary units)	
	4. Environmental expense (Monetary units)	
	5. Operational expense (Monetary units)	
	6. Energy cost (Monetary units)	
	7. Recycling cost (Monetary units)	
	8. Disposal cost (Monetary units)	
	9. Remanufacturing Cost (Monetary units)	
3. Profit	1. Liquid profit (Monetary units)	
	2. Retained earnings (Monetary units)	
4. Investments	1. Overall equipment Efficiency (%)	
	2. Investment in R&D activities / technology transfer (Monetary units)	
	3. Sustainable process innovation (Monetary units)	
5. Suppliers	1. Local suppliers / spending on local suppliers (#)	• Outcome of Communities
	2. Local Procurement / product procurement or services from the community (#)	
Good Governance Indicators		
1. Corporate ethics	1. Mission statement (Y/N)	
2. Accountability	1. Transparency (Y/N)	
3. Participation	1. Stakeholder dialogue (#)	• Quality of Life in Surrounding Communities
	2. Grievance procedures (Y/N)	
4. Risk management	1. Sustainable Risk Management Action Plan (Y/N)	

SCP indicators		Eco Factory criteria
Set of indicators	Indicator (Unit)	
5. Holistic management	1. Sustainability Management Plan (Y/N) 2. Full-cost accounting / material flow cost accounting (Y/N)	• Raw Material Usage • Biodiversity • Quality of Life in Surrounding Communities
6. Ethics	1. Ethical behavior (Y/N) 2. Anti-corruption (Y/N)	

Table 4.4 The 1st draft of SCP indicators frameworks

Set of Indicators	International Indicators*					National Indicators	
	1	2	3	4	5	Eco Factory	SCP Roadmap
Environmental Indicators							
1. Resources/ Materials							
1. Materials management efficiency / the quantity of main materials used per income (Ton/Million baht)		✓		✓	✓	✓	✓
2. Material usage / footprint (Ton or m^3)		✓		✓	✓	✓	✓
3 Consumption of recycling materials (% virgin material)	✓			✓		✓	✓
4 Hazardous materials/chemicals (Ton or m^3)	✓	✓	✓	✓		✓	✓
5 Scrap rate (% of finished product)		✓					✓
2. Energy							
1. Energy management efficiency (kWh/Giga Joule/ Million baht)						✓	✓
2. Electricity / energy consumption (kWh/Giga Joule)	✓	✓	✓	✓	✓	✓	✓
3. Energy intensity (kWh/product, K Joule/product)				✓		✓	✓
4. Reduction of energy consumption (kWh/Giga Joule)				✓		✓	✓
5. Use of renewable energy (% of total energy)	✓	✓	✓			✓	✓
6. Symbiosis energy (Giga Joule)						✓	

Set of Indicators	International Indicators*					National Indicators	
	1	2	3	4	5	Eco Factory	SCP Roadmap
3. Water/ Wastewater							
1. Water and wastewater management efficiency (m^3/ Million baht)						✓	✓
2. Water consumption / total water withdrawal by sources (m^3)	✓	✓	✓	✓	✓	✓	✓
3. Volume of water reused or recycled (m^3/total used water or % of water consumption)	✓	✓				✓	✓
4. Volume of water discharge (m^3)				✓		✓	✓
5. Symbiosis wastewater (m^3)						✓	✓
4. Air / Emission / Gas Emission / Heat Emission							
1. Air emission management efficiency (kg SOx, NOx, VOC/ Million baht)		✓		✓		✓	✓
2. Emission of ozone-depleting substances (kg emission)							
5. Greenhouse gas management							
1. Greenhouse gas intensity (tonCO_2e/Million baht, Product)						✓	✓
2. Emission of CO_2 from factory / GHG emission (tonCO_2e)		✓	✓	✓	✓	✓	✓
6. Solid Waste							
1. Solid waste inventory / profile / flow diagram (#)						✓	
2. Volume of solid waste (kg or m^3 of solid waste)	✓	✓		✓		✓	
3. Solid Waste reuse / recycle (kg)					✓	✓	✓
4. Waste reduction & disposal (kg or m^3 of hazardous waste)					✓	✓	✓
7. Hazardous Waste							
1. Volume of hazardous waste / material (m^3)	✓	✓	✓	✓		✓	✓
8. Logistics							
1. Transportation and logistics management efficiency (#)	✓					✓	
2. Reverse logistics, customer returns (#)	✓					✓	
9. Suppliers							

Set of Indicators	International Indicators*					National Indicators	
	1	2	3	4	5	Eco Factory	SCP Roadmap
1. Percentage of new suppliers that were screened using environmental criteria (% of total suppliers)				✓		✓	
2. Significant actual and potential negative environmental impacts in the supply chain and action taken (# / total suppliers)				✓		✓	
10. Product Development / Manufacturing							
1. Quantity of recycling / reuse / remanufacturing (kg or m^3 of material)			✓			✓	
2. Durability level (#)							
3. Environmentally friendly design / Eco-design (# of product)							
4. Eco-innovations (# of product or project)							
11. Sustainable Product Certification (materials, products)							
1. Third Party Eco-Label (e.g., Green Label, Carbon Footprint, Water Footprint) (# of product)	✓		✓			✓	✓
2. Self-Declare (# of product)						✓	✓
12. Environmental spending/investments/ management							
1. Green areas / buffer zone (% area)						✓	
2. Environmental spending / protection expenditures and investments by type (monetary unit)	✓			✓			✓
13. Technology							
1. Recycling Technology (# of project)			✓				
2. Remanufacturing Technique (#)			✓				
3. Recovery Technique (#)			✓				
Social Indicators							
1. Employees							
1. Turnover index (#)	✓			✓			
2. Proportions of permanent staffs and temporary staffs (#)							

Set of Indicators	International Indicators*					National Indicators	
	1	2	3	4	5	Eco Factory	SCP Roadmap
3. Discrimination/male to female ratios/gender/age/sexual/child labor (%male, %female)	✓	✓		✓	✓		
4. Wages and benefits (% ratio)	✓	✓		✓	✓		
5. Programs for skills management and lifelong learning/indigenous knowledge/training of the employees (in hours)/capacity development/sustainable awareness (#)	✓	✓		✓	✓		
2. Security and safety at work							
1. Health and security / safety / elimination of hazardous workplace / Absence due to injuries or work-related illness / deaths / effective occupational health and safety management for personnel and related persons (Y/N, # of day absence, # of days)	✓	✓	✓	✓	✓	✓	
2. Ergonomic (#)						✓	
3. Healthy working environment (e.g., air, sound, light)	✓					✓	
3. Clients/ consumers							
1 Number of complaining consumers (#)	✓		✓	✓			
2. Total number of incidents of non-compliance with regulations and voluntary codes concerning marketing communications, including advertising, promotion, and sponsorship, by type of outcomes (#)							
4. Community and stakeholders							
1. Engagement of the community / living with the surrounding community (Y/N)	✓			✓		✓	
2. Local partnerships / integration to the society (Y/N)	✓		✓			✓	
3. Investment to benefit community corporate social responsibility / income distribution to the community (Y/N)	✓					✓	
Economic Indicators							

Set of Indicators	International Indicators*					National Indicators	
	1	2	3	4	5	Eco Factory	SCP Roadmap
1. Gross revenue							
1 Gross revenue value (Monetary units)	✓			✓			
2. Cost / expense							
1. Employee / labor cost/ expense with wages (Monetary units)	✓	✓	✓	✓			
2. Ratios of standard entry level wage by gender compared to local minimum wage at significant locations of operation (%)							
3. Expense with taxes / Payment to government (Monetary units)							
4. Operational expense (Monetary units)							
5. Remanufacturing Cost (Monetary units)							
6. Environmental expense (Monetary units)	✓		✓	✓			
7. Energy cost (Monetary units)							
8. Recycling cost (Monetary units)							
9. Disposal cost (Monetary units)							
3. Profit							
1. Liquid profit (Monetary units)	✓	✓			✓		
2. Retained earnings (Monetary units)				✓			
4. Investments							
1. Overall equipment Efficiency (%)		✓					
2. Investment in R&D activities / Technology Transfer (Monetary units)	✓		✓	✓			
3. Sustainable process innovation (Monetary units)			✓				
5. Suppliers							
1. Local suppliers / spending on local suppliers (#)	✓			✓		✓	
2. Local Procurement / product procurement or services from the community (#)					✓	✓	
Good Governance Indicators							
1. Corporate Ethics							
1. Mission statement (Y/N)					✓		
2. Accountability							

Set of Indicators	International Indicators*					National Indicators	
	1	2	3	4	5	Eco Factory	SCP Roadmap
1. Transparency (Y/N)					✓		✓
3. Participation							
1. Stakeholder Dialogue (#)					✓	✓	✓
2. Grievance Procedures (Y/N)					✓	✓	
4. Risk Management							
1. Sustainable Risk Management Action Plan (Y/N)					✓		✓
5. Holistic Management							
1. Sustainability Management Plan (Y/N)					✓	✓	
2. Full-Cost Accounting / Material Flow Cost Accounting (Y/N)					✓	✓	✓
6. Ethics							
1. Ethical behavior (Y/N)					✓		
2. Anti-corruption (Y/N)							

Remark * International Indicators

1. Feil, Alexandre. Schreiber, Dusan. Haeitinger, C. and Strasburg, Virgilio. 2019. Sustainability Indicators for Industrial Organizations: Systematic Review of Literature. Sustainability. 11.
2. Mats, Winroth. Almström, Peter. and Andersson, Carin. 2012. Sustainable Indicators at Factory Level - A Framework for Practical Assessment. 62nd IE Annual Conference and Expo 2012.
3. Eseoglu, G., Vayvay, O., & Şimşit, Z. T. (2014). Assessment of Sustainability Performance Indicators in Manufacturing. In Proceedings of Global Conference on Engineering and Technology Management.
4. Global Reporting Initiative (GRI). 2015. G4 Sustainability Reporting Guidelines: Reporting Principles and Standard Disclosures. Retrieved January 17, 2020 from ttps://www.globalreporting.org/resourcelibrary/GRIG4-Part1-Reporting-Principles-and-Standard-Disclosures.pdf. (Ref. 4)
5. Food and Agriculture Organization of the United Nations. 2014. SAFA Sustainability Assessment of Food and Agriculture Systems Guidelines Version 3.0. Retrieved March 18, 2020 from http://www.fao.org/3/a-i3957e.pdf.

4.1.3 Summary of the first draft

The 1st draft of SCP indicators was developed based on the framework indicated in chapter 3. It consisted of 28 sets of indicators and 78 sub-indicators as shown below.

1) Environmental indicators 13 sets of indicators, 39 sub-indicators
2) Social indicators 4 sets of indicators, 13 sub-indicators
3) Economic indicators 5 sets of indicators, 17 sub-indicators
4) Good Governance indicators 6 sets of indicators, 9 sub-indicators

List of literature reviewed for developing the 1st draft of SCP indicators are:

1) International academic studies conducted on the industrial indicators for sustainable development, sustainable production and sustainability. GRI and Sustainability Assessment of Food and Agriculture systems(Scialabba, 2013)

2) Eco Factory criteria

3) Thai SCP Roadmap specifies goals, targets and indicators for Thai industries as a national plan

Six principles under the circular economy concept are applied into drafting the indicators

4.2 Results of the First Industry Survey and the 2nd Draft of SCP Indicators Development

The first survey aimed to receive comments on Eco Factory implementation of the industries and the 1st draft of SCP indicators. There were 8 sectors which could be divided into 168 firms of the target industries certified as Eco Factory (as of November 2020) which equaled to 68% of total certified Eco Factory having 247 firms (as of November 2020). The questionnaire including the details of the first draft of SCP indicators were sent to assigned contact person of each company via email. (see Appendix A-1). The official letter to explain the objectives of study were also presented. There were 20 participants responding the survey after several follow-ups by email and telephone. The 76 certified firms are represented to the participants. Some participants are responsible for the Eco Factory projects for the group company. Thus, the results of survey should be accounted for 45.2% of target industries and 30.8% of total target industries certified Eco Factory. The in- depth interview was conducted (January-February 2021) after receiving questionnaire response attaching the notice of willingness to participate in the in-depth interviews spending about 1-1.30 hour. There are 6 participants from 5 industry sectors for interview. The survey results and in-depth interview would be used for developing the second draft of SCP indicators.

4.2.1 Results of the First Industry Survey

The conclusion of the survey using questionnaires with 20 participants can be calculated and presented in percentage,and can be summarized as below.

1) Role for developing industrials sustainability indicators of participants has 55% of Indicator Data Collector, 45% Manager, 20% Indicator Developer and 10 % Chief Executive Officer. Most of participants play more than one role.

2) The result of factories certified as Eco Factory is for 100%, ISO 14001 for 85%, GI 3 for 55% and other for 25%.

3) Participants are from Chemical and Chemical Products for 35%, Plastic Product for 35%, Petrochemical and Refined Petroleum Products for 25%, Electrical equipment for 20%, Synthetic Rubber for 10%, Part and Vehicle Equipment for 10%, other for 5%.

4) Their opinions towards Eco Factory showed that 65% agreed that implementation Eco Factory are suitable for SD in the organization, 45% have benefits and obstacle in implementing some indicators, and 35% noticed that some criteria should improve.

5) Their opinions towards the SD indicators showed that 90% agreed that industrial sustainability indicators should be based on circular economy principle.

6) Their opinions towards the SCP indicators based on circular economy showed that 60% agreed that the indicators cover the key issues of the sustainable industrial development and Eco Factory criteria, 40% indicated that indicators should be improved ,30% agreed that the indicators are in accordance with the circular economy principle and 20% agreed that the indicators are practical for an operation of Thai industries.

Evaluation of survey can be summarized as presented in Figure no4.1 to Figure no 4.8 and in Appendix B-1

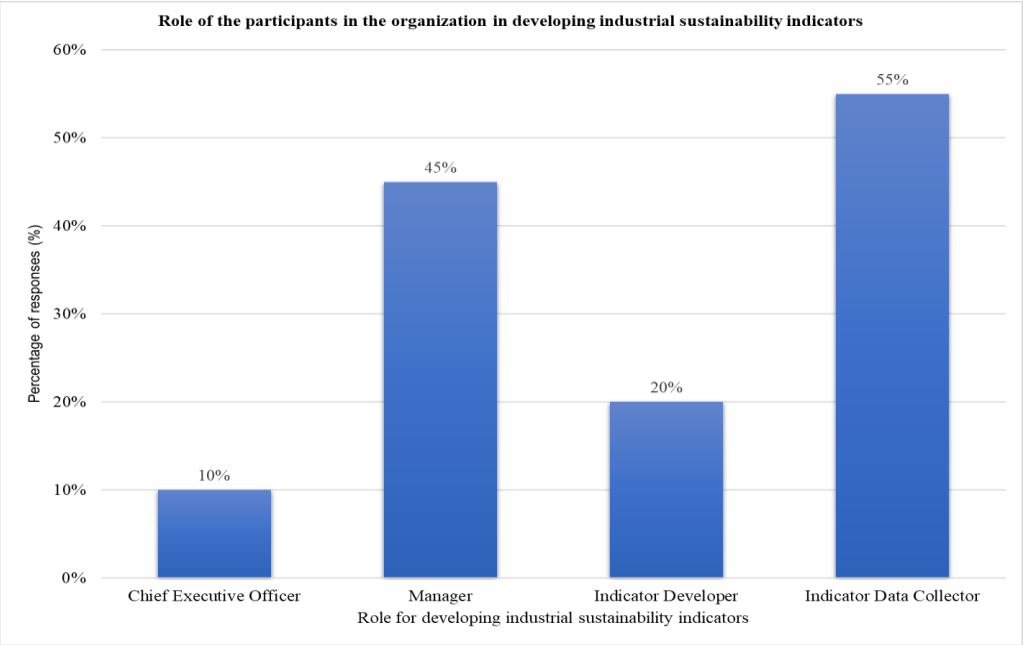

Figure 4.1 Percentage of responses on the role of the participants in the organization in developing industrial sustainability indicators

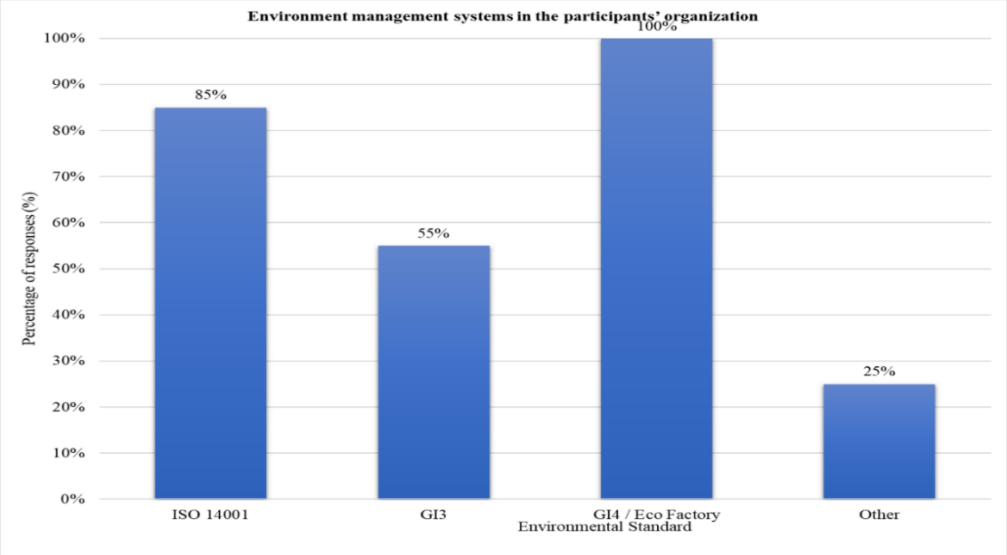

Figure 4.2 Percentage of responses on environmental management systems implemented in the participants' organization

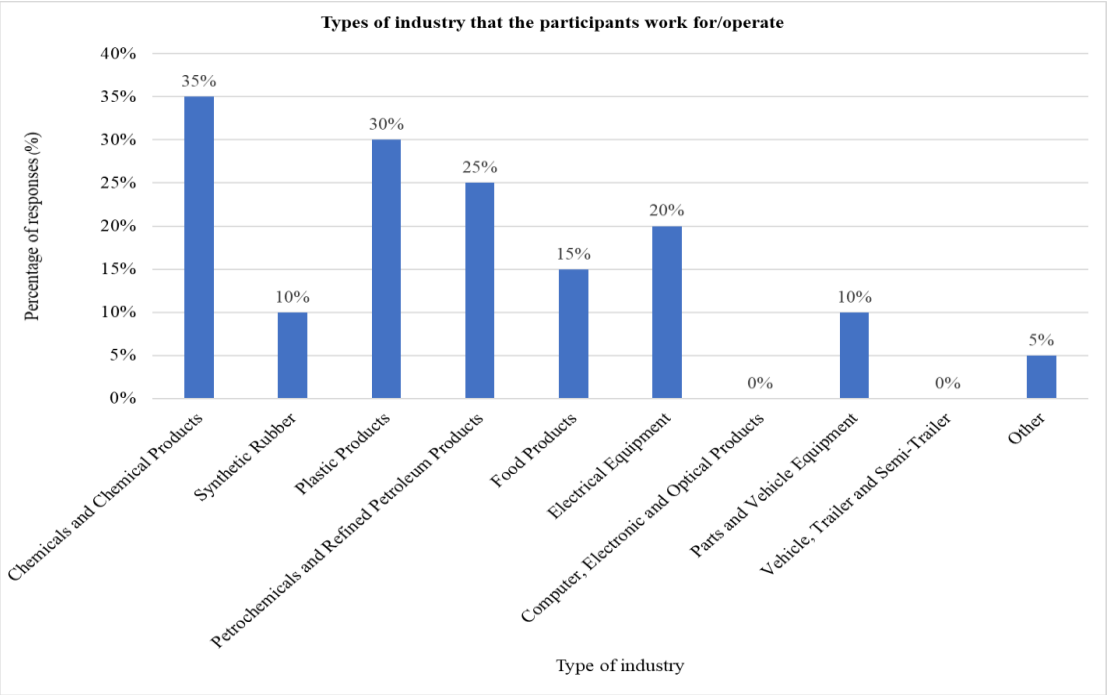

Figure 4.3 Percentage of responses on the types of industry that the participants work for/operate

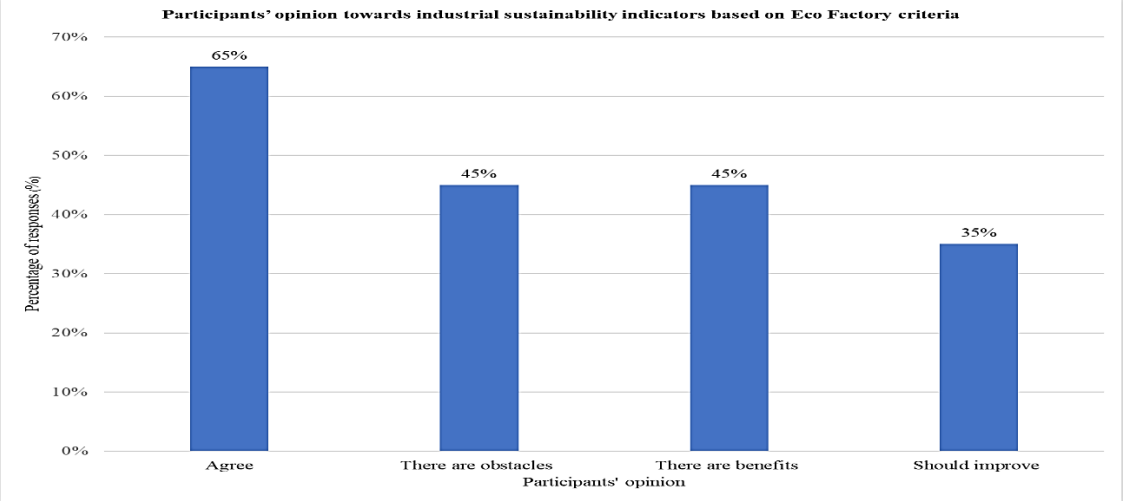

Figure 4.4 Percentage of responses on participants' opinions towards industrial sustainability indicators based on Eco Factory criteria

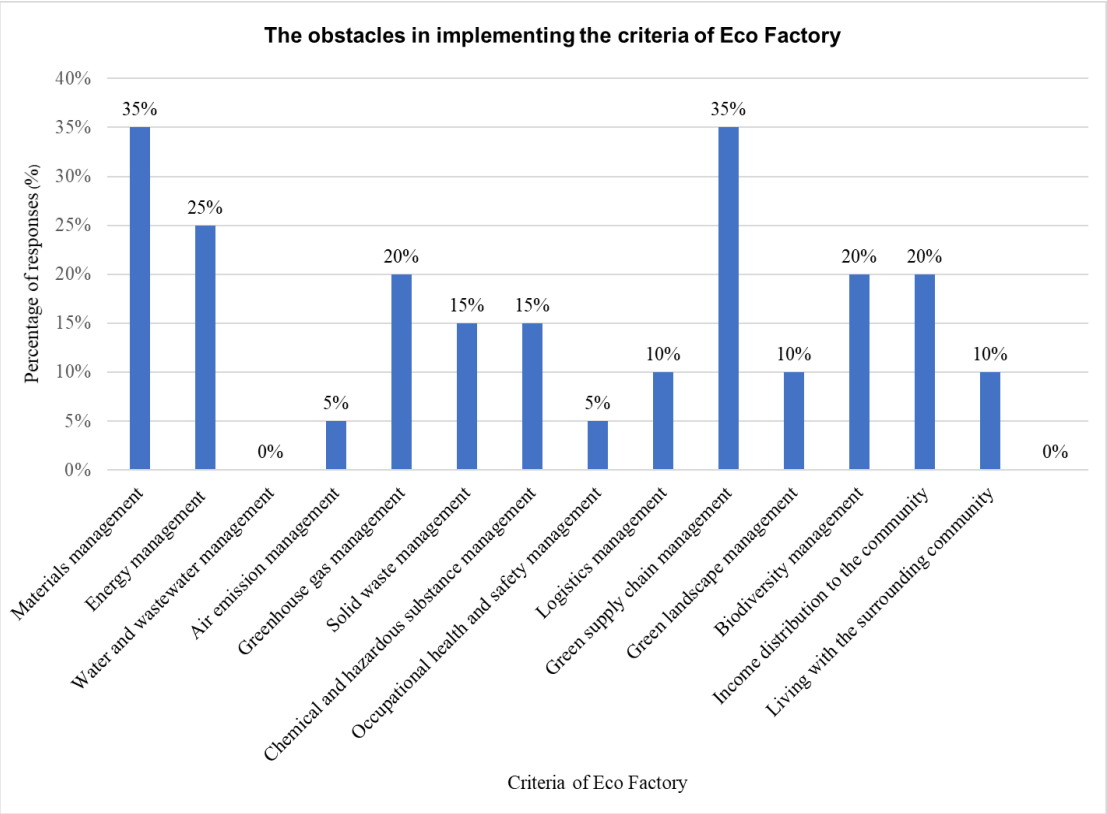

Figure 4.5 Percentage of responses on the obstacles in implementing the criteria of Eco Factory

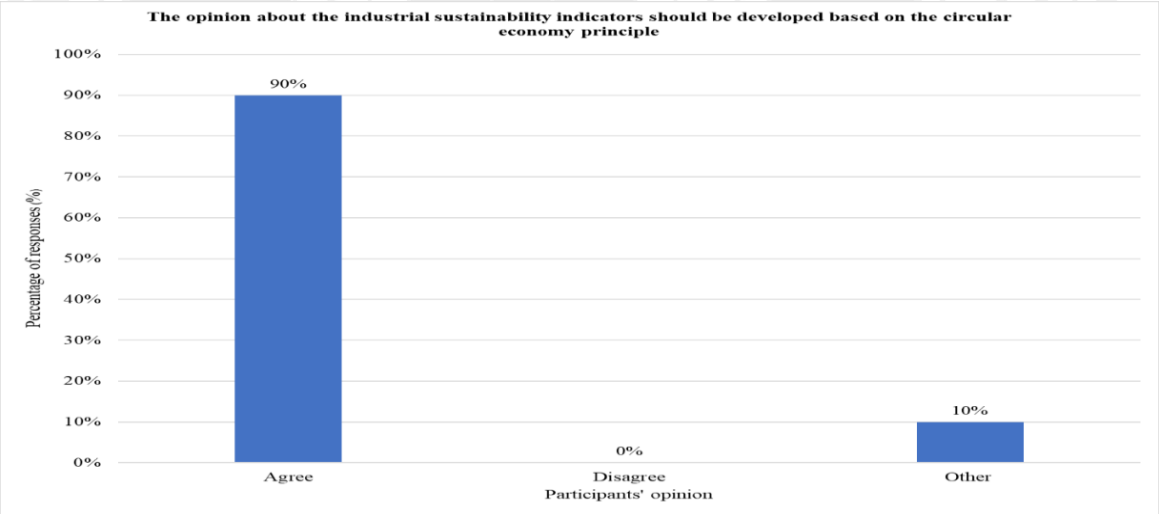

Figure 4.6 Percentage of responses on participants' opinions towards industrial sustainability indicators based on Eco Factory criteria

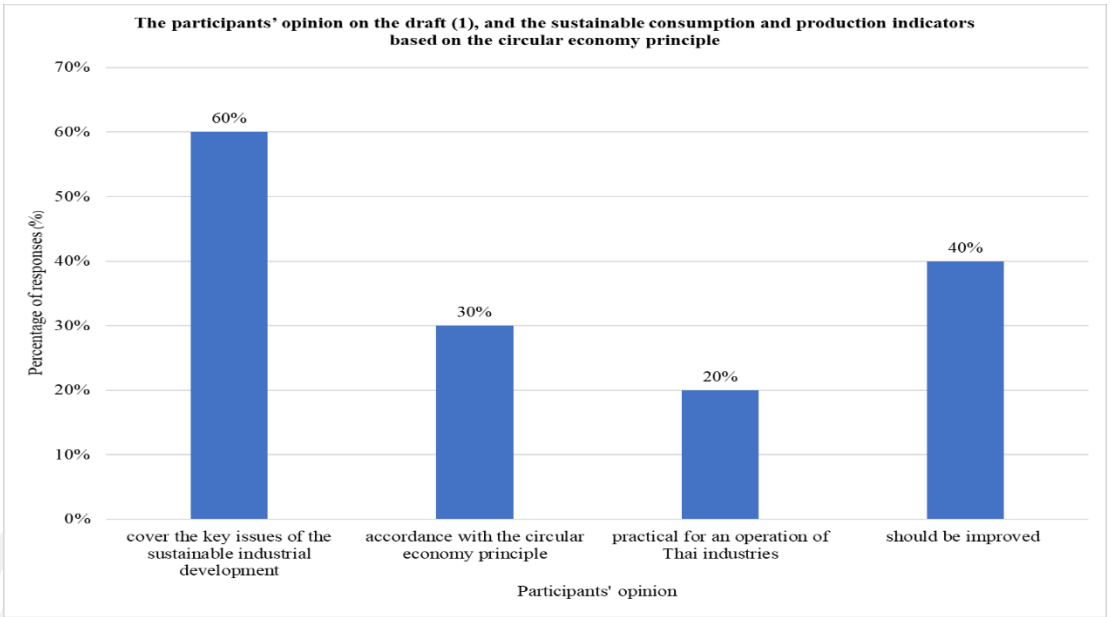

Figure 4.7 Percentage of responses on the opinions towards the draft (1), and the sustainable consumption and production indicators based on the circular economy principle

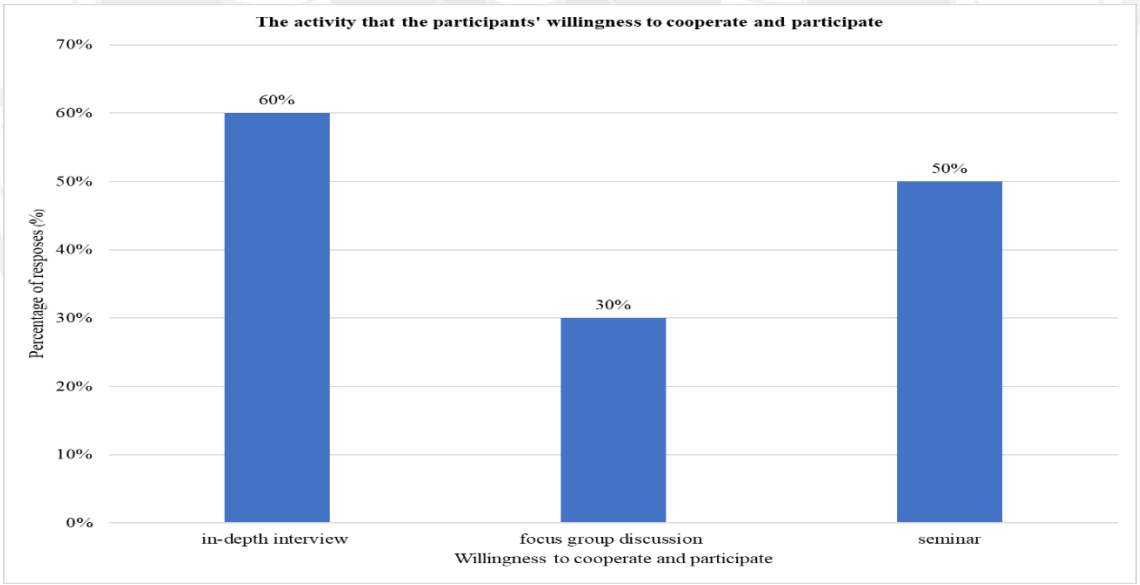

Figure 4.8 Percentage of responses on the participants' willingness to cooperate and participate in any activities during Dec 2020 - Feb

Additional comments and suggestions of the participants for improving the 1st draft of SCP indicators are as below.

1) Opinions towards the sustainability indicators for Thai industries

The benefits of implementing indicators based on Eco Factory criteria and Eco Factory certification.

(1) The factory can develop the efficiency of different operations, and reduce factory expense to conduce sustainable development.

(2) The operation result of the factory in economic, social and environmental dimensions can be systematically monitored, and the production cost can be continuously reduced as a result of clear goals and measures. In addition, there are more operations for sustainable organizational development and more interactions with communities and local organizations.

(3) The trust on the factory and surrounding community as well as value and positive organizational image to customers and partners are created. Moreover, the factory can be a model in environmental conservation.

(4) There are explicit operation and examination guidelines for implementation based on criteria which can provide an opportunity for the factory to see issues that can be improve the operations to be in the better (economic, social and environmental) direction.

(5) The good government dimension should be added.

(6) The tier-1 vendors can be encouraged to promote environmental management to meet the level 5 of Eco Industry.

(7) The working system can be urged to aware of environment, social responsibility and economy around the factory.

2) Suggestions for improving specific requirements for Eco Factory

(1)It is unnecessary to have many indicators in each dimension, so there should be an emphasis on the indicators having the key impacts in each dimension.

(2)The principles of some indicators in each dimension cannot be concretely active which makes the implementation conduct difficultly.

(3)The threats to biodiversity should be reduced, and the indicators should be specified by avoiding impacts on biodiversity (the scores should be 0 and 5 only).

(4)The specified biodiversity related to the communities and public-sector stakeholders is too difficult and too broad for controlling and monitoring in the long run.

3) Opinions towards the indicators in economic, environmental, social, and good governance dimensions in the first draft of SCP indicators based on the circular economy principle for Thai industries

The results can be listed as below and demonstrated as in Table 3.1

(1) Other comment is that there should be filing the information that has been evaluated to develop the benchmark, and it will be beneficial to the self-evaluation of the factory in conducting business benchmarking. In addition, the revenue indicators should not be touched.

Table 4.5 Opinions for improving indicators

Set of indicators	Opinions
Environmental Indicators	
1. Resources/ Materials	• Calculating in efficiency per revenue may confront with obstacles in collecting data as most entrepreneurs normally do not provide the confidential information to outsiders or even insiders if it is not a public company. • The calculation in monetary unit cannot be met due to currency volatility and the world economy. • Different industries should have different indicators based on industrial contexts of each industry. • Each business has different limitations on materials management efficiency. Thus, the report can be conduct but should not be compulsory. • The quantity of recycle materials consumption is effective for B2C business, but difficult for B2B business. • The volume of hazardous materials consumption

Set of indicators	Opinions
	which is based on the existing law is enough. • The scrap rate in each business cannot be equal, so the report can be conduct. However, there should not be compulsory criteria. • The efficiency of material consumption per product produced should be measured. • % of good products or products which are in accordance with the specs should be added to examine the efficiency of material consumption as a product. • The quantity per the base year should be calculated. Due to the diversity of products in each company, calculating materials management efficiency will generate unclear result. • The pre-recycle consumer content (%) and post recycle content (%) should be added as the LEED standard have requirements in reporting recycle content (%) in two categories. Accordingly, building materials for construction must be reported to calculate the scores. • There should be data separation between materials that can be controlled separately. • Indicators will not be comprehensive if it is a food industry or an industry that consume light-wight materials. • The indicators should be clearly stated whether it is the quantity of reduced materials, or the total amount of materials consumed.
2. Energy	• Energy management efficiency cannot be compared with the revenue because revenue depends on the

Set of indicators	Opinions
	product price and the volume of products sold depending on many factors, such as oil price and economy. Therefore, it should be compared with the specific energy consumption. • Indicators should be based on the Energy Management Act which has the Department of Alternative Energy and Energy Efficiency (DEDE) in controlling overlapping reports of the factories. • The indicators should focus on energy consumption efficiency in production per product unit. • There should be an encouragement in consuming renewable energy and promotion of more consumption incentives. • Some factories cannot operate symbiosis energy indicator as they do not generate energy themselves and buy energy from others. • The energy consumption standard should be provided. • Consumption of other energy, such as LPG and NGV natural gas should be added.
3. Water/Wastewater	• The volume of water and wastewater consumption cannot compare to the revenue as there are many factors affecting more or less water consumption of the factory, such as the volume differences of production or the unequal softness and hardness of water from different natural sources that generate more or less blow-down water released from coolant control system of the factory. • The volume of water consumption should be compared with the unit of products produced.

Set of indicators	Opinions
	• Measuring the volume of water consumed or recycled cannot be conducted in every factory. • Some factories cannot operate symbiosis wastewater indicator due to limited area which should be supported by the public sector. • Some factories consume less water in their production process, so they invest on building the closed systems by depending on the law. • Goals should be specified to reduce water consumption per year per water source.
4. Air / emission / gas emission heat emission	• Calculating efficiency per revenue may confront with obstacles on collecting data as using monetary unit has risks on currency fluctuations and economic conditions. • Some industries have indicators higher than the standards or those specified by law which entails lower scores of the evaluation. • The emission should not be calculated in efficiency, but should refer from the pollution emission control law. • The emission per year should be measured, and there should be reduction plans. • There should be an engagement goal in reducing combustion to reduce air emission. • The emission of ozone cannot be examined by organizations.
5. Greenhouse gas management	• Calculating efficiency per revenue may confront with obstacles on collecting data • The indicator should compare per ton of product rather than compare per million baht.

Set of indicators	Opinions
	• The emission per year should be measured. • The emission reduction plans should be examined. • The goal of net zero GHG emission should be specified. • As the factory has no SO_x NO_x emission, other parameters should be selected or there should be an omission for parameter.
6. Solid waste	• BCG should be applied in the indicator criteria, and the criteria should not be a boundary outside the factory because there are tax problems and permission. • The indicators should be based on the existing waste management law which is the standard of the Department of Industrial Works. No need to create new criteria. • The solid waste released should be examined by specifying the control as zero waste to landfill. • The measurement criteria of the utilization of exported solid waste should be specified to see how much of utilizing as materials or others (excepted incineration). • The non-hazardous waste should be considered based on THSI criteria. • The hazardous and non-hazardous types of solid waste should be categorized.
7. Hazardous waste	• The unit should be specified as weight in ton or kg. • The measurement criteria of the volume of hazardous waste produced per year should be specified. • The measurement criteria to control the reduction of

Set of indicators	Opinions
	hazardous waste per year should be specified. / The goal of reducing reused hazardous waste should be defined. • The LCA of products, especially disposal, should be added. • Types of hazardous waste should be more clearly specified, or there should be the classification of hazard levels and its disposal.
8. Logistics	• More complaints from transportation should be added. Legal examinations are a direct hindrance in the logistics management. • Goals per year should be specified. • Training should be organized before conducting the examination.
9. Suppliers	• The indicator on number of suppliers and the proportion of green supplier should be specified to encourage more suppliers to engage in the sustainable development. • Environmental criteria in the evaluation should be clearly specified. • The measurement criteria in evaluating suppliers which are more appropriate than the current criteria should be employed as they may not understand and not want to participate in the Green Industry. • % of supplier tube at got G2 in 100% is too difficult. Specifying goal100% is needed for major suppliers only.
10. Product development / manufacturing	• Initial criteria should be begun with the boundary inside the factory because handling outside the factory is difficult.

Set of indicators	Opinions
	• Some industries should have more clear evaluation criteria or guidelines because they may be suitable for their own industry only and cannot be applied in other factories. • Turnovers of green products per total product turnovers should be measured to encourage more green product production. • The indicators should be able to include main development and sub-department level to expand the scope of development and data collection.
11. Sustainable product certification (materials, products)	• Some industries should have additional criteria or guidelines for clear evaluation as they may be suitable for their own industry only and cannot be applied in other factories, such as factories of water supply, wastewater treatment or gas production. • The label compared to user safety, such as ROHs, flame spread standards or specific product standards should be added. • Certification should be applicable to all industries or product types. • There should be an opportunity in allowing using factory's certification certified by the large-scale organization has a committee in approving the certification.
12 Environmental spending/investments/ management	• Green areas should be improved so that the company can operate within the factory area or with reforestation projects in other areas. The investment indicators from the greenhouse gas management organization, such as the carbon price mechanism, should be used to mobilized the investment in

Set of indicators	Opinions
	reducing carbon. • The environmental activities should be measures by calculating in CO2 reduced. • The measurement criteria for green areas or the number of trees per area should be specified if the factory does not have areas in growing more trees. • Green area development should not specify or enforce on additional issues, and should not expand the areas.
13. Technology	• Evaluation methods should be specified if the factory already have the best technology. • There should be more support for low-efficiency factory.
Social Indicators	
1. Employees	• Some industries should have specific criteria as they may not be able to conduct evaluation if they use the general criteria. • There should be standards under Thai labor law without considering on additional criteria. • The inclusion policy of the organization should be considered. Measuring the number of % male and female do not correspond to the society nowadays due to unequal numbers between male and female population. • Measuring Employee potential development program in hour cannot indicate whether the employees have higher potentials. • Wages and benefits are normally a confidential information of the company. Therefore, the confidential information should be replaced by the

Set of indicators	Opinions
	nonconfidential information. • The management level should be separated according to the number of employees and the size of the company. For example, the small-scale companies basically have shorter career path than the large-scale companies.
2. Security and safety at work	• IFR 9K and GRI should be added, and the comparative items in the same industry should be specified and defined. • The indicators should be divided based on the size of the company and the working nature of each department.
3. Clients/ consumers	• Claims & complaints are internal information of the company which may confront negative feedbacks after the disclosure. • Communication for improvement should be emphasized in examining the timing of responding to customers feedback to take care of customers. • The engagement in solving problems should be specified as an indicator.
4. Community and stakeholders	• The number of product purchases and services should be specified • Creating income to the community should be added. • Various CSR contributions to the community/society should be considered. • Identify stakeholder should be classified whether it is stakeholder / community. • The discussion issues from the meeting should be specified as the priority, and there should be a goal of monitoring.

Set of indicators	Opinions
	• Other indicators for small-scale companies should be added.
Economic Indicators	
1. Gross revenue	• Some companies have many factories or industries which may not be able to be separated into individual factory, and this entails inability to collect the data. • The indicators should be based on the good governance principles disclosed to the public, or may be applied the criteria of the Stock Exchange of Thailand to be more comprehensive. • Gross revenue of the company should be measured and the related indicators should be specified to calculate the sources of gross revenue.
2. Cost / expense	• Some companies have many factories or industries which may not be able to be separated into individual factory, so the data collection cannot be conducted or the data collected is not completed or the expense is higher or lower than the market. However, some company may use the data in the evaluation. Therefore, there should be the consideration for each factory. • Only expense and budget of the environmental stewardship should be measured.
3. Profit	• Some companies have many factories or industries which may not be able to be separated into individual factory, and this entails inability to collect the data. • There should be depending on the good governance principles in information disclosure to the public, or

Set of indicators	Opinions
	there may be applying the criteria of the Stock Exchange of Thailand to be more comprehensive.
4. Investments	• Some companies have many factories or industries which may not be able to be separated into individual factory, and this entails inability to collect the data. • Data on overall equipment efficiency cannot be collected, and it is not beneficial to the measurement for this indicator as the equipment which has efficiency drop in the energy consumption is one of the environmental criteria. • The investment on environmental projects should be considered. • Some factories nowadays are lack of knowledge and understanding on Overall equipment Efficiency (OEE). Hence, there should be providing knowledge before evaluating the indicators implementation to prevent unexpected obstacles. For example, some factories have a high expense due to the lack of knowledge and understanding.
5. Suppliers	• % of local green procurement should be measured to urge green producers to mobilize the production inside the country. • The local supplier issues should be considered. • There should be beginning with the understand business value chain assessment of supplier risk criteria supplier to promote local suppliers and local procurement • Besides the product procurement and employment, the engagement in other aspects should be added due

Set of indicators	Opinions
	to the problems on the insufficient qualification of local people.
Good Governance Indicators	
1. Corporate ethics	• The implementation criteria based on the social responsibility standards (e.g., ISO26000, CSR-DIW, OECD Guidelines and other Corporate Responsible Instruments and other related standards) should be employed. • Code of conduct and its criteria should be considered, and the CG rating should be added. • The working operations should be added instead of explaining policies.
2. Accountability	• The implementation criteria based on the social responsibility standards (e.g., ISO26000, CSR-DIW, OECD Guidelines and other Corporate Responsible Instruments and other related standards) should be employed.
3. Participation	• The implementation criteria based on the social responsibility standards (e.g., ISO26000, CSR-DIW, OECD Guidelines and other Corporate Responsible Instruments and other related standards) should be employed. • There should be company scale categorization.
4. Risk management	• Additional emerging risk should be considered. • There may be legal non-compliances compared to the feed that the companies have to expense if they do not manage risks.
5. Holistic management	• The data of cost is confidential, but the sustainability management plan is not. Thus, there should be collecting data of the sustainability management

Set of indicators	Opinions
	plan. • Cost should not be concerned for this indicator. • All data of full cost accounting/material flow-cost accounting for the company which is not the public company cannot be conducted that entails inability to achieve the goals as the data is not comprehensive or the actual data.
6. Ethics	• The CAC certification, receiving complaint processes, complaint results and solutions of complaints should be conducted

In summary, the objective of the first survey was to receive comments from the target industries on their experiences of Eco Factory implementation, obstacles, benefits, sustainability and their points of view towards the first draft of SCP Indicators. There were 20 participants who represented 76 of 247 certified Eco Factory companies in total (in Nov 2020, FTI), and could be regarded as 45.2 % of targeted industries (i.e., 8 targeted industries from total 168 certified Eco Factory). Findings from the survey were as follows:

1) The participants roles in developing sustainability indicators were 55% Indicators Data Collector, 45% Manager, 20% Indicator Developer and 10% Chief Executive Officers. Most of them had more than one role, and they were from up-steam and mid-steam industry as evidenced by Chemical and Chemical Products, Plastic Products, and Petrochemical Industries and Refined Petroleum Product for 60%.

2) The opinions of participants showed that implementing Eco Factory was suitable for SD in their organization (65%), receiving benefits (45%), having obstacles (45%) and suggesting for some criteria improvement (35%.) The benefits consisted the reduction of operation cost to conduce sustainable development, the improvement of company image and trust on factory by communities, and the raise of environmental, social-responsible and economic awareness of a company. The

obstacles and suggestions for the improvement of Eco Factory requirement were mainly on the key impacts in each dimension and specific impacts on biodiversity.

3) 90% of responses accepted that SD indicators should be based on CE principles. The opinions on the first draft of SCP indicators showed that 60% of participants agreed that indicators covered the key issues of the sustainable industrial development and Eco Factory criteria, and 40% of participants agreed that the indicators should be improved. Additionally, 30% of participants opined that the indicators were consistent with the Circular Economy principle, and only 20% of participants claimed that the indicators were practical for an operation of Thai industries.

4) Opinions towards the improvement of the Environmental Indicators included there should be adjustment of measurement unit of sub-indicators related to resources, energy, emissions and wastes by using intensity unit per product instead of monetary and avoiding absolute value. Performance measurement should be applicable for resources consumption, greenhouse gas emission and logistics. There should be allowance for different industries to have different indicators based on industrial contexts on material consumption and sustainable product certification (guidelines for evaluation). The supplier, environmental expenditure and technology evaluation method should be provided.

5) Opinions towards the improvement of Social Indicators and sub-indicators included employee should be based on Thai Labor law and do not measure the number of percentages of male and percentage of female. Indicators for security and safety at work should be divided based on company size. Moreover, community and stakeholders should be added into creating income and considering various CSR contribution to the community/society.

6) Opinions towards the improvement of Economic Indicators and sub-indicators included gross revenue, cost/expense, profit and investments sub-indicators should not be able to separate in individual factory if companies have many factories located the same area. Investments sub-indicator in case of overall equipment efficiency knowledge should be provided before evaluating the indicator implementation and investment on environmental project should be considered.

Besides, the supplier percentage of local green procurement should be measured to urge green producers to mobilize the production locally.

7) Opinions towards the improvement of Good Governance Indicators included social responsibility standards such as ISO 26000, CSR-DIW, OECD Guidelines and other related standards should be added as implementation criteria for corporate ethics, accountability and participation sub-indicators. The CAC certification, receiving complaint processes, complaint results and solutions of complaints should be conducted

4.2.2 Results of In-depth Industry Interview

The participants in this in-depth interview were 6 representatives from 5 manufacturing sectors and the target industry group certified as an Eco-Factory. The objective of the interview was to elaborate participants' responses replied in the questionnaire as well as acquire information about their experiences in implementing the sustainable development through Eco Factory and international standards as GRI or DJSI. The questions in the interview were as follows:

1) Opinions toward criteria of Eco Factory indicators, obstacles in implementing the indicators and suggestions for improving the criteria

2) The benefits of indicators implementation based on Eco Factory criteria

3) Opinions and suggestions for improving the SCP indicators based on the circular economy principle

The interview could be summarized as follows:

Factory (No.1)

This participant who received Eco Factory certification in the petrochemicals and refined petroleum products industry sector is in senior management level and has 20-years experiences in the industry and 5-year working in the eco-factory and the environmental projects. In addition, this participant is responsible for eco-factory projects for 25 factories under same corporate.

The opinions and suggestions of the participant (Factory No.1) could be summarized as follows:

1) Eco Factory criteria on living with the surrounding community and income distribution to the community is difficult to increase community satisfactions that require higher scores for recertification of Eco Factory criteria. Additionally, the criteria of green supply chain should include the types of self-declaration product by suppliers.

2) The benefits of implementing indicators based on Eco Factory criteria in the factory are the better communication within the industry group, the enhancement of operating monitoring and collecting data.

3) The SCP indicators should cover the key issues of the sustainable industrial development, eco-factory criteria and the circular economy principle. Moreover, there should be the teams responsible for specific tasks in implementing SCP indicators, such as sustainable development consulting team, verifying team and reporting team.

4) Materials and wastewater indicators should be flexible for data collection due to the variety of the types of materials and amount of water consumption per product produced.

5) The criteria of indicators related to environment pollution laws should be specified into performance levels better than compulsory requirement standards.

6) Greenhouse gas emission calculation should be accepted to use company emission factors: EF (not only national data base) that EF derived from factory in house electricity generation plant. This EF would be depended on type of fuel (input of power plant) and different from national data base source.

Factory (No.2)

This participant who received Eco Factory certification in chemicals and chemical products, the petrochemicals and refined petroleum products as well as plastic products industry sectors is in senior management level and has 20-years experiences in the industry (related to environment and occupational health and safety management) and 5-year working in corporate social responsibility activities. In addition, this participant is responsible for eco-factory projects for 22 factories under same corporate.

The opinions and suggestions of the participant (Factory No.2) could be summarized as follows:

1) The factory has installed software for operation system in accumulating data on environmental impacts (e.g., emission, solid waste, wastewater, etc.), resource consumption, energy, safety, accident record and CSR management system, and supporting sustainability reporting in 2020. Therefore, the manual system of the data collecting had upgraded into automatic operation system.

2) The factory does not have any obstacles in implementing Eco Factory indicators as the policy of the factory emphasizes on green industry and sustainability as well as corresponds to the international SD standard regarding GRI, DJSI. Therefore, only extensive practices and resources in accomplishing the target indicators are needed.

3) The benefits of indicator implementation based on Eco Factory criteria of the factory cover facilitating internal benchmarking and enhancing efficiency of resource consumption certified by third-party verification.

4) The SCP indicators cover the key issues of the industrial sustainable development and Eco-Factory criteria. However, the indicators related to the circularity may have implementation limitations due to industrial waste law. Besides, implementing SCP indicators in the SME should be concerned due to the lack of resources and implementation capability.

Factory (No.3)

This participant who received Eco Factory certification in petrochemicals and refined petroleum products industry sector is in executive management level and has 30-years experiences in the industry and 3-to-5-year working in sustainable products issues. In addition, this participant is responsible for Eco-Factory projects policy.

The opinions and suggestions of the participant (Factory No.3) could be summarized as follows:

1) As the Eco Factory criteria are suitable and beneficial for the sustainable development in the organizations and the large-scale industries, it might be an obligation to implement the criteria in the operations of the factory to gain cost saving outcome. In addition, there should be some assistants in the operation based on

the criteria in community aspects, and the-large scale factory should play a mentor role for SME in implementing the indicators based on Eco Factory criteria.

2) Eco Factory projects should be integrated with other similar Green Industry projects hosted by the government through using the harmonized criteria and avoiding repetitive activities (e.g., awarding). In addition, the Eco Factory criteria should be revised by cooperating with the Department of Industrial Works, Ministry of Industry, in this year.

3) SCP indicators should be improved by deleting the monetary unit of resource intensity indicator and indicators in the economic dimension related to the confidential data of private organizations. However, sustainable product indicators should specify the proportion of eco product turnover and total product turnover.

4) The green supply chain indicator in environmental dimension should combine green materials and self-declaration approach as the certified green product should be limited to approved vendor list for purchasing. Technology should not be an indicator because of its process-related tools. Besides, the indicators should demonstrate environmental outcome.

5) The employee indicators in social dimension should not account gender issues, such as male to female ratio.

6) Eco Factory projects should promote providing more education tools (e.g., E-learning tool) for the industry group, especially SME group as the majority of Thai industries.

Factory (No.4)

This participant who received Eco Factory certification in the synthetic rubber and plastic products industry sector is in middle management level and has 15-years experiences in the industry and 5-year working in Eco Factory and project related to sustainable development standard.

1) Eco Factory criteria in the living with the surrounding community and income distribution to the community are problematic for the implementation due to the lack of cooperation from local NGOs group resulting in medium to low grade levels of the stakeholder engagement.

2) Water / wastewater indicator is not applicable for the factory due to the small volume of water input in production process.

3) Air emission intensity in product and monetary unit cannot be able to calculate as there is no software program supported.

4) More sub-indicators, such as the number of accidents, complaints of transportation process, ethical indicators, code of conduct of anti-corruption and sustainable product certification, and product safety standard (e.g., flammability standards) should be added in the logistics indicators.

Factory (No.5)

This participant who received Eco Factory certification in the parts and vehicle industry sector is in middle management level and has 20-years experiences in the industry and 3-year working in Eco Factory.

1) There are not many benefits of indicators implementation based on Eco Factory criteria of the factory because of a small number of incentives from industrial estate where the factory is located. Therefore, the tax incentive should be offered.

2) There are various obstacles in following the Eco Factory criteria and SCP indicators including the supporting fund from government for data collection tool in measuring materials consumption in production process, the higher cost of raw material vendors (same quality as uncertified suppliers) based on green supply chain criteria requiring the certification of eco product or ISO 14001 standard. Green area criteria have a high cost of maintenance as its boundary covers areas outside the factory.

3) Based on the experiences of the participant, suppliers normally tend to reduce expense by avoiding providing information as awarding customers. However, the turnover will increase 20% more if the information is provided as certification cost. For the indicator in the social dimension, there is a problem that local manpower may lack of commitment to work compared to manpower in other area which can affect the competitiveness of the factory.

Factory (No.6)

This participant who received Eco Factory certification in the consumer product industries sector is a senior staff in supervisor management level and has 20-years experiences in the industry and 3-year working in Eco Factory.

1) Corporate policy aims to govern the sustainable development of various consumer products of the factory by certifying Eco Label, Water Footprint Label, Carbon Footprint Label and Green Label.

2) There are many benefits of the indicator implementation based on Eco Factory criteria, for example in resource consumption reduction, better relationship with surrounding community and increasing customers' and business partners' trust towards the factory and products produced.

3) Productivity improvement of employee as voluntary should be a basic organizational culture. In addition, teamwork assignments in production and process improvement should be focused, and the Target production and environmental management should be reported daily.

4) The obstacles in implementing the indicator based on Eco Factory criteria are on the indicator of occupational health and safety management a due to the zero-accident specification in the goal as well as the indicator of absence due to injuries that is difficult to meet its target of existing definition as there are around 2,000 employees in the factory.

5) Recycle materials, wastewater, and hot water have already consumed regularly in production.

Summary of in-depth interview of six representatives of Eco-factory companies who participated in the first survey could be explained as follows.

1) Opinions toward criteria of Eco Factory indicators, obstacles in implementing the indicators and suggestions for improving the criteria included considering the use of company emission factors for greenhouse gas emission calculation, data collection tool in measuring materials consumption in production process for occupational health and safety management. Additionally, green area criteria have a high cost of maintenance as its boundary covers areas outside the specified factors. It was problematic on the implementation criteria on living with the

surrounding communities and income distribution to the community, for example, some factories had no surrounding communities. Hence, they suggested that this criteria , the-large scale factory could play a mentor role for SME in implementing, and facilitating internal benchmarking and enhancing efficiency of resource consumption certified by third-party verification.

2) The benefits of indicators implementation based on Eco Factory criteria were better communication within the industry group, enhancement of operating monitoring and collecting data, resource consumption reduction and better relationship with surrounding community and increasing trust towards the factory and products produced customers and business partners.

3) Opinions and suggestions for improving the SCP indicators based on the Circular Economy principle included, 1) the flexibility of data collection due to the variety of the types of materials and amount of water consumption per product produced for materials and wastewater indicators specified in performance levels which was better than compulsory requirement in the environmental pollution laws, 2) deleting the monetary unit of resource intensity indicator and economic dimension related to the confidential data of private organization, 3)combining green materials and self-declaration approach for green supply chain indicator to approve vendor list for purchasing,4) deleting technology indicator because of its process-related tools, 5) limitations for implementation of the indicators related to the circularity material due to industrial waste law, and 6) adding sub-indicators e.g., the number of accidents, complaints of transportation process, ethical indicators, code of conduct of anti-corruption and sustainable product certification. In addition, implementing SCP indicators in the SME should be concerned due to the lack of resources and implementation capability, and there should be the teams responsible for specific tasks in implementing SCP indicators, such as sustainable development consulting team, verifying team and reporting team.

4.2.3 The 2nd Draft of SCP Indicators Development

The first draft of SCP indicator contained 28 sets of indicators having 78 sub-indicators. In these numbers, there were 13 environmental indicators with 39 sub-

indicators, 4 social indicators with 13 sub-indicators, 5 economic indicators with 17 sub-indicators, and 6 good governance indicators with 9 sub-indicators. The survey result of the 1st draft of SCP indicators showed that there were 70%-100% of the industries agreed with the improvement, meanwhile 30-95% of the industries did not. The result implied that most of the drafted SCP indicators are accepted by the industries due to the high percentage having more than 50%. The second draft of SCP indicators were revised based on the suggestions from the survey and in-depth interviews as follows:

1) Environmental indicators

(1) Some sub-indicators should be adjusted, and the indicators of materials resource efficiency, water and wastewater intensity and greenhouse gas emission intensity should be adjusted by measuring per product instead of the monetary unit as well as avoiding absolute value sub-indicators. The air emission management efficiency should be modified as using the volume of air emission reduction to show the higher performance.

(2) The number of accidents sub-indicator and complaints of product transportation process per year sub-indicator should be added in the logistics indicators.

2) Social indicators

(1) The proportions of permanent staffs and temporary staff sub-indicator should be deleted from the employee indicators due to the unpracticality of employment in the business.

The justification and the lack of labor workforce of Thai Industry was one of the main problems due to Thai population structure and relying on migrant workers. The outsources or subcontract works were a general practice to improve company competitiveness.

3) Economic indicators

(1) The ratios of standard entry level wage by gender compared to local minimum wage at significant locations of operation sub-indicator should be deleted from the cost/expense indicators as it was not practical for employment in some business and there were various types of industry.

4) Good governance indicators

(1) The code of conduct for mission statement sub-indicator should be added in the corporate ethics indicators.

The reasons for revising indicators were that most of target industries were upstream and midstream producers of commodity goods. Therefore, raw material and product price should be sensible to global market. Furthermore, air emission performance of industries was pressured by monitoring of the government and local communities, and there was a regular complaint about air pollution causing unproper maintain of air pollution abatement process. Hence, accidents and complaints should be recorded to be a normal practice for the company in monitoring and creating social responsibility. Besides, the lack of labor workforce of Thai Industry was one of the main problems due to Thai population structure and relying on migrant workers. The outsources or subcontract works were a general practice to improve company competitiveness and code of conduct for large scale companies.

4.2.4 Summary of the 2nd draft

The 2nd draft SCP indicators was developed after the 1st survey (20 respondents, 76 representatives of the factories) and in-depth interview (6 respondents) with target industry. The 1st draft of SCP Indicators was revised and improved based on suggestions of the survey and in-depth interview as shown below.

1) Environmental indicators. Sub-indicators of materials resource efficiency, water and wastewater intensity and greenhouse gas emission intensity were adjusted by measuring per product instead of the monetary and avoiding absolute value sub-indicators. Air emission management efficiency should be modified to the volume of air emission reduction to show the higher performance. Added in the logistics indicators, were the number of accidents sub-indicator and complaints of product transportation process per year.

2) Social indicators. The proportions of permanent staffs and temporary staff sub-indicator should be deleted from the employee indicators due to the unpracticality of employment in the business.

3) Economic indicators. The ratios of standard entry level wage by gender compared to local minimum wage at significant locations of operation sub-indicator

should be deleted from the cost/expense indicators as it was not practical for employment in some business and there were various types of industry.

4) Good governance indicators. The code of conduct for mission statement sub-indicator should be added in the corporate ethics indicators.

In sum, 6 sub-indicators of the 1St draft were deleted. The second draft of SCP indicators were revised, and there were 28 sets of indicators with 72 sub-indicators as follows:

1) Environmental indicators including 13 sets of indicators and 39 sub-indicators

2) Social indicators including 4 sets of indicators and 9 sub-indicators

3) Economic indicators including 5 sets of indicators and 15 sub-indicators

4) Good governance indicators including 6 sets of indicators and 9 sub-indicators

The second Draft of SCP indicators was presented in the Appendix A-2 Table 1

4.3 Focus Group Meetings and the 3rd Draft of SCP Indicators Development

4.3.1 Results of the Focus Group Meetings

The objective of focus group meeting is to receive comments from Eco Factory Working Group and experts, consultants from private and government sectors who have involved in promoting sustainable development of Thai Industry through Eco Factory Project that is responsible by Federation of Thai Industries, FTI and financial support by Industrial Estate Authority of Thailand (IEAT). These groups play very important roles in Eco Factory Project, such as developing criteria, encouraging implementation and incentives for industries, and providing services on both consultations and certifications. They participated in the focus group meeting through online meeting on Feb 10, 2021, hosted by FTI. The meeting also included the expert groups from Kasesart University, Bangkok, and government officers from Eco Industrial Division, Department of Industrial Work, Ministry of Industry on Feb

22, 2021. There were 36 participants in total participating in three focus group meetings.

Agenda of the focus group meeting are as follows:

1) Research topics in brief: Literature review and SCP indicators development framework

2) Report: survey results of the first draft of SCP indicators to develop SCP indicators (2draft)

3) Discussion and recommendation on SCP indicators (2draft)

Summary of discussion and recommendation from Eco Factory Working Members and experts are as follows:

4.3.1.1 Environmental dimension

1) Unit of indicators should be reported in terms of intensity or percentage without presenting monetary value and absolute value which do not imply factory resource efficiency. However, absolute value of material and energy can be an optional for industry, and benefit to accumulate in national target set.

2) Industry has awareness and incentive to show an operation performance in term of intensity when recertification is required.

3) Air emission particulate matter 2.5 ($PM_{2.5}$) and biodiversity indicators should be added due to its impact on environment and ecology system by some industry.

4) Stakeholder symbiosis should include agricultural sectors in case of feasibility and benefit shared with industry.

5) Recycling and reusing material indicators could be defined as circularity indicators.

6) Biomaterial and techno-material terms may be used for indicators instead of only renewable material.

7) Hazardous waste and material indicators should be separated. Hazardous chemical consumption indicator may not be appropriate for some industry, such as chemical and petrochemical industry.

8) Symbiosis indicators could be considered in a practical context of industries, especially their flows in supply chain.

9) Product development/manufacturing, sustainable product certification and technology indicators should be combined as Eco design and Eco innovation indicators since they are under the same approach.

4.3.1.2 Social dimension

Community and stakeholder indicators should be scored as 1 to 5 of the magnitude of stakeholder engagement for sustainable development level. Large-scale industry would perform activities as mentor roles to support relevant SD activities of SME industries and classified them as social indicators. In addition, stakeholder engagement should include stakeholders similar to CSR-DIW. The management of changing indicators that concern community stakeholder should be considered as social indicators.

4.3.1.3 Economic dimension

Gross revenue indicators should be optional by economic resilience indicator that improve their risk management from publicity organization income. Supplier indicators should be enhanced on greening supply chain except flexibility.

4.3.1.4 Good governance dimension

Criteria for good governance indicators should be linked between SCP and Eco Factory or mechanism implementation of Circular Economy policy.

4.3.1.5 SCP conceptual framework and Circular Economy principles should be more explicitly relevant to the indicators, especially on material consumption indicators. Themes and cross cutting issues including national policy (BCG, Green Public Procurement) may be considered to develop the indicators. Indicator of Eco efficiency factor should be applied to measure the sustainable development achievement according to the World Resource Institute recommend (factor 4 to10).

4.3.1.6 Expert recommended that total number of SCP indicators should be confined to be manageable by industry. For monitoring and reporting of industry, SCP indicators would be classified into two groups including internal and external purposes. Small & medium and large-scale industry should be criterial to

categorize SCP indicators. The draft of SCP indicators tested through pilot implementation project should be organized to verify industries on practical aspects.

4.3.1.7 SCP Roadmaps are integrated by Green Industry, Eco Town and Eco Factory as targets. Therefore, SCP indicators should align with these targets.

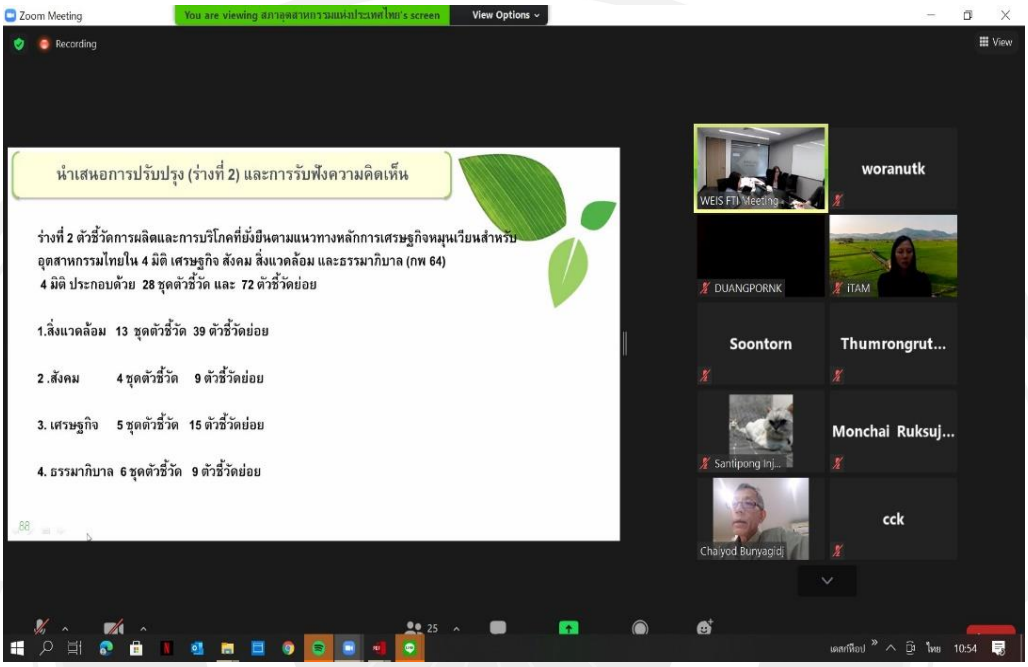

Figure 4.9 Illustration of the online focus group meeting on Feb 10, 2021 at WEIS, FTI

Figure 4.10 Illustration of the onsite focus group meeting with expert group from Kasetsart University and WEIS, FTI on Feb 22, 2021.

Figure 4.11 Illustration of the onsite focus group meeting with Eco Industrial Division, Department of Industrial Work, Ministry of Industry, on Feb 22, 2021

Summary of the focus group meetings could be summarized that there were three focus meetings (i.e., one online meeting and two onsite meeting) and there were 36 persons jointed the meeting. The purposes of these activities were to collect suggestions of second draft SCP indicators from Eco Factory Working members, experts, consultants from private and government sectors to develop the third draft of the indicators by using top-down approach. Suggestions on environmental dimension of SCP Indicators included using the intensity unit or percentage instead of monetary term applied, adjusting optional indicators to be absolute value of material and energy including $PM_{2.5}$ in air emission indicators, allowing agriculture sector for stakeholder symbiosis if feasible, accounting recycling and reuse material as circularity indicators and adding Eco-design/Eco innovation indicator for product development/manufacturing indicators, sustainable product certification and technology indicators.

Recommendations for social indicators were emphasized on the score magnitude of stakeholder engagement for community and stakeholder indicators, and the management of changing for community stakeholder as social indicators. Improvement for economic dimension was on accounting gross revenue indicators as optional, and enhanced greening supply chain for supplier indicators. For good governance dimension, the association between good governance indicators and the circular economy policy was recommended. Moreover, the SCP conceptual framework and Circular Economy principles, national policy BCG, Green Public Procurement should be more explicitly relevant to the indicators. Total number of SCP Indicators should be confined to be manageable by industry. Monitoring and reporting of industry, SCP indicators should be classified into two groups including internal and external purposes. Besides, small & medium and large-scale industry should be criterial to categorize SCP indicators

4.3.2 Results of the 2nd Survey

The second surveys aimed to receive comments of the second draft of SCP indicators from Eco Factory Working Group members, experts and certified auditors who involved in the Eco Factory promotion and criteria development. The questionnaire and the 2nd draft of SCP indicators were submitted during the focus

group meetings (online meeting on February 10, 2021 and offline meeting on February 22, 2021) and by email. There were 5 participants in the survey which can be accounted for 18% of Eco Factory Working Group members (28 persons). The questionnaire can be divided into three sections, and the summary of survey as below.

The results in each sections of the questionnaire are as follows:

Section 1: the personal information on the role of participants in developing industrial sustainability indicators

1) There are 3 participants out of 5 who play the role on the working group of Eco Factory scheme promotion and development.

2) There are 2 participants out of 5 who play the role on the Eco Factory certification auditor and Eco Factory consultant.

3) There is 1 participant out of 5 persons who play the role on the technical committee for Eco Factory scheme.

4) There is 1 participant of 5 persons that who play the role on the working group of Eco Industrial Town promotion and development.

Section 2: Opinions towards sustainability indicators for Thai industries under Eco Factory project

1) Participants' opinions towards the industrial sustainability indicators based on Eco Factory criteria can be summarized that there are 2 participants out of 5 agreed that the indicators are suitable for sustainable development for Thai industries, and 4 participants of 5 indicated that the Eco Factory requirements, such as green supply chain and income distribution to the community, should be improved.

2) According to the obstacles in implementing Eco Factory indicators based on participants' roles, 11 indicators out of 14 have obstacles on the operation. One of participants suggested that there should be an application of indicators of biodiversity compared to the SCP indicators reflecting the sustainability of ecosystems in living together of creatures.

Section 3: The development of sustainability indicators for Thai industries

1) All participants agree that there should be the development of industrial sustainability indicators that correspond to the circular economy principle.

2) Number of participants agreed that the attribute of the industrial sustainability indicators based on the circular economy principle and Sustainable Consumption and Production Roadmap can be summarized as follows.

(1) There were 3 participants out of 5 agreed that the indicators could collect data easily, there was information that the industry have already had, and the indicators could evaluate easily and uncomplicatedly.

(2) All of 5 participants agreed that the indicators had clear measurement unit, duration and boundary, and they were examinable and transparent.

(3) There were 4 participants out of 5 agreed that the indicators were quantitative and qualitative indicators.

(4) There were 3 participants out of 5 agreed that the indicators could be comparable within the industry.

(5) All of 5 participants agreed that the indicators could quantitatively measure in total and/or per unit (e.g., volume of total energy consumption per year or volume of energy consumption per production unit per year).

(6) There were 4 participants out of 5 agreed that the indicators could indicate activities of sustainable industrial development and support industrial sustainability reporting.

(7) There were 4 participants out of 5 agreed that the indicators correspond to local and national sustainability indicators and international affairs, such as global warming.

(8) There was 1 participant out of 5 specified suggestions as below.

(8.1) There should be comprehensive indicators corresponding to the operation based on the circular economy principle from resource procurement to product and service management after ending product life-cycle. The Life Cycle Assessment (LCA) may be used to evaluate environmental impacts of products throughout life cycle, product lifespan or activities and services, such as resource procurement, production, product usage, cradle-to-grave waste management and transportation throughout product life-cycle.

(8.2) The SCP indicators should not be redundant and should be the indicators that can practically operate correspondingly to the SCP indicators

3) All of 5 participants provided opinions for improving the sustainable consumption and production indicators based on the circular economy principle in 4 dimensions including environmental, social, economic, and good governance dimensions for the 2nd draft of the SCP indicators are as follows.

Environment indicators

1) Resource efficiency should be evaluated in term of intensity for consumption of resource, materials, water, energy, solid waste and greenhouse gas emission.

2) Content recycling should be calculated in the proportion of recycled material content per total materials.

3) Inventory of energy should be list by type of energy sources, ratio of renewable energy consumption and energy wasted.

4) Air emission indicator should be demonstrated as intensity, such as air emission per product produced.

5) Environmentally friendly innovation technique sub-indicator should be included in the technology indicators.

6) Logistics indicators should be covered inventory of product management, raw material degradation and others logistics activities.

7) The sustainable product certification indicators should be presented as percentage of eco product certification, such as the Third-Party Label & Self Declare Label per product produced.

8) There should not be Self-Declare Eco Label indicator.

9) Extended Producer Responsibility should be added.

10) Risk management of environmental impacts (from the operation) on biodiversity and eco system should be accounted.

11) Symbiosis boundaries should be extended to surrounding agricultural area.

Social Indicators

1) The employment indicators should be considered on the information disclosure to the public without negative business impacts or personal

rights. The labor and child employment as well as practical legal compliance should be clearly specified.

2) Disabled employee employment of the community should be added in employee indicators.

3) Community and stakeholder indicators, such as engagement framework, should be considered to cover all stakeholders including local public and private sectors. The support and promotion on income distribution to community should be collaborated with the Corporate Share Value (CSV) due to sustain mutual benefits in the future.

Economic indicators

1) The green procurement and economic resilience sub-indicators should be added in the economic dimension.

Good governance indicators

1) The risks in different aspects such as business risk, product quality risk, environmental risk and safety risk etc., in the Sustainability Management action sub-indicator should be specified.

4) The overview opinions towards the sustainable consumption and production indicators based on the circular economy principle of the second draft of SCP indicators are as below.

(1) There were 4 participants out of 5 agreed that indicators cover all important issues of the sustainable industrial development and Eco Factory criteria.

(2) There were 2 participants out of 5 agreed that the indicators correspond to the circular economy principle.

(3) None of 5 participants agreed that the indicators are practically suitable for the operation of Thai industries.

(4) All of 5 participants agreed that the 2nd draft of SCP indicators based on the circular economy should be improved.

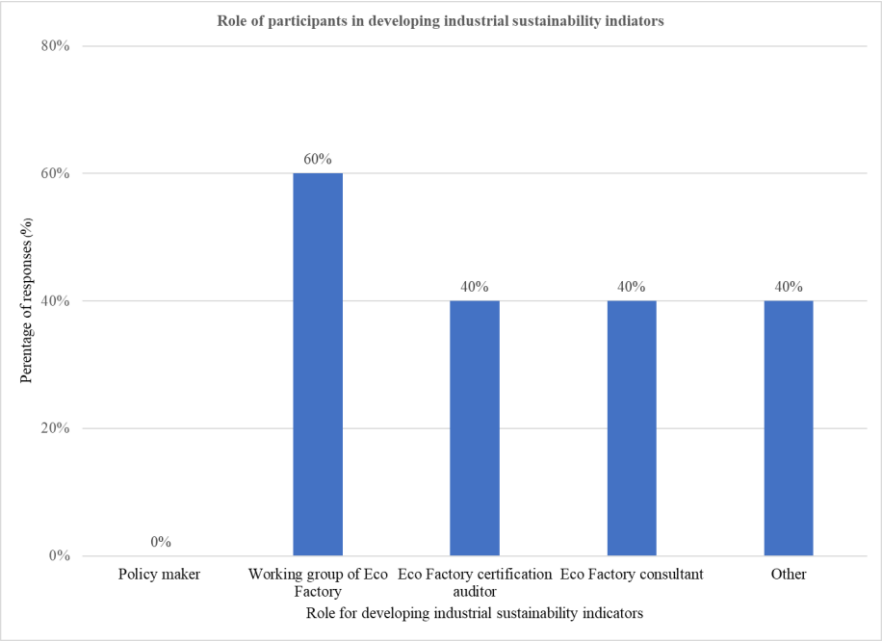

Figure 4.12 Percentage of responses on the roles of participants in developing industrial sustainability indicators

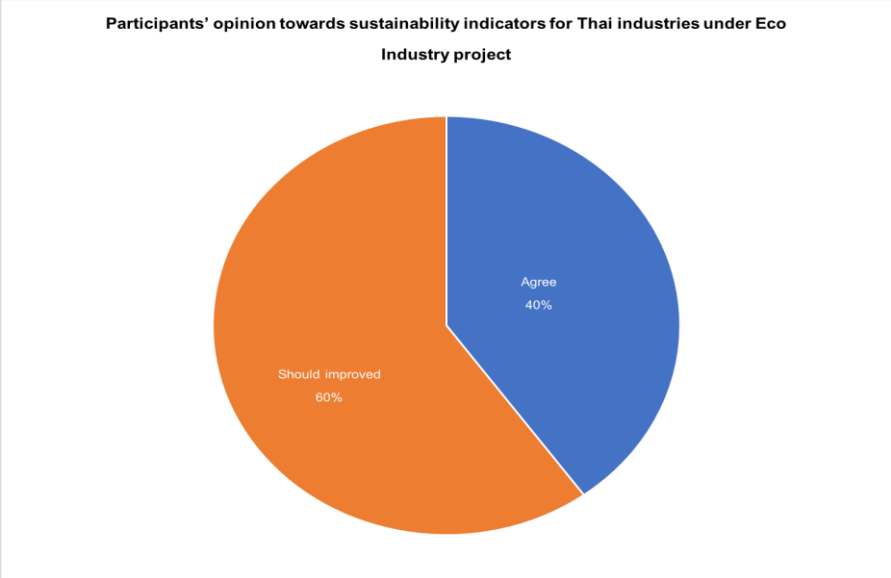

Figure 4.13 Percentage of responses on the opinions towards industrial sustainability indicators based on Eco Factory criteria

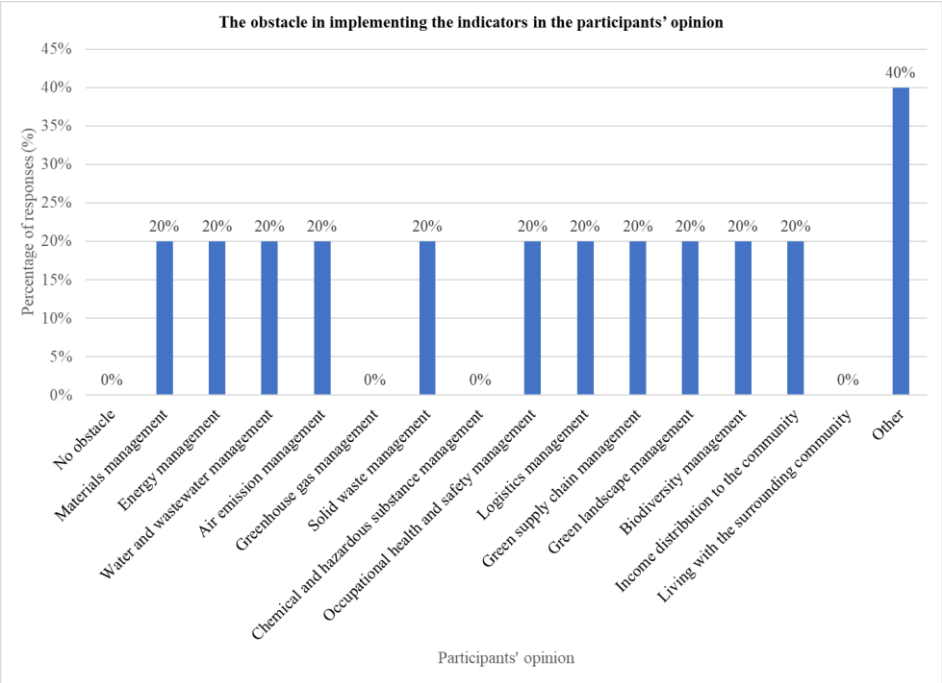

Figure 4.14 Percentage of responses on the obstacles in implementing the indicators in the participants' opinions

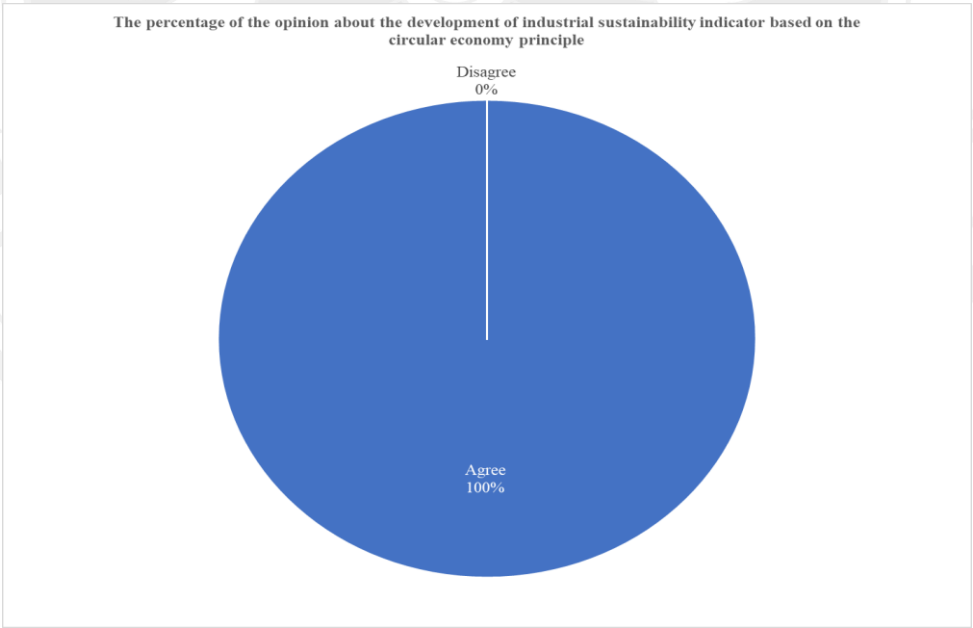

Figure 4.15 Percentage of responses on the percentage of the opinions towards the development of industrial sustainability indicators based on the circular economy principle

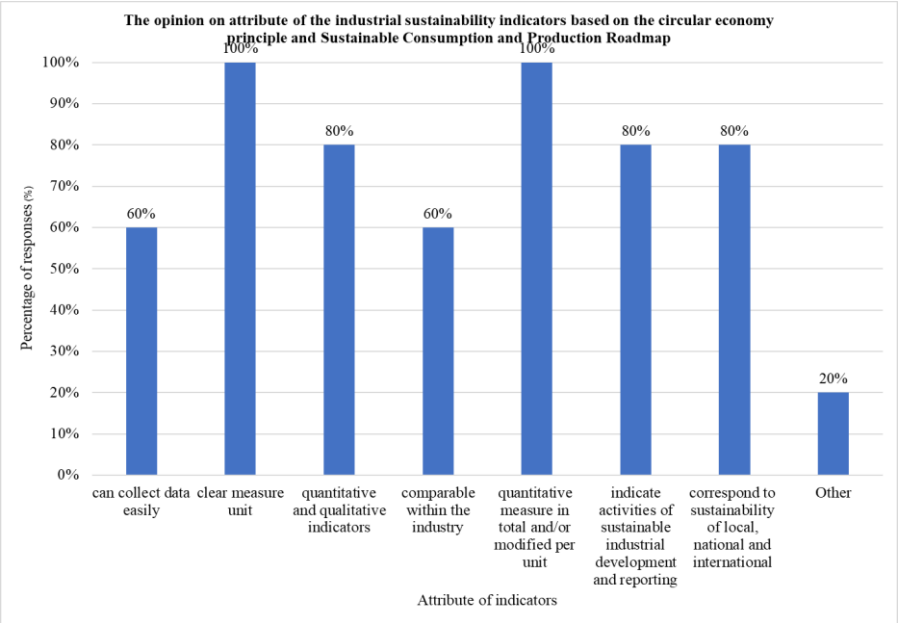

Figure 4.16 Percentage of responses on the opinions towards the attributes of the industrial sustainability indicators based on the circular economy principle and Sustainable Consumption and Production Roadmap

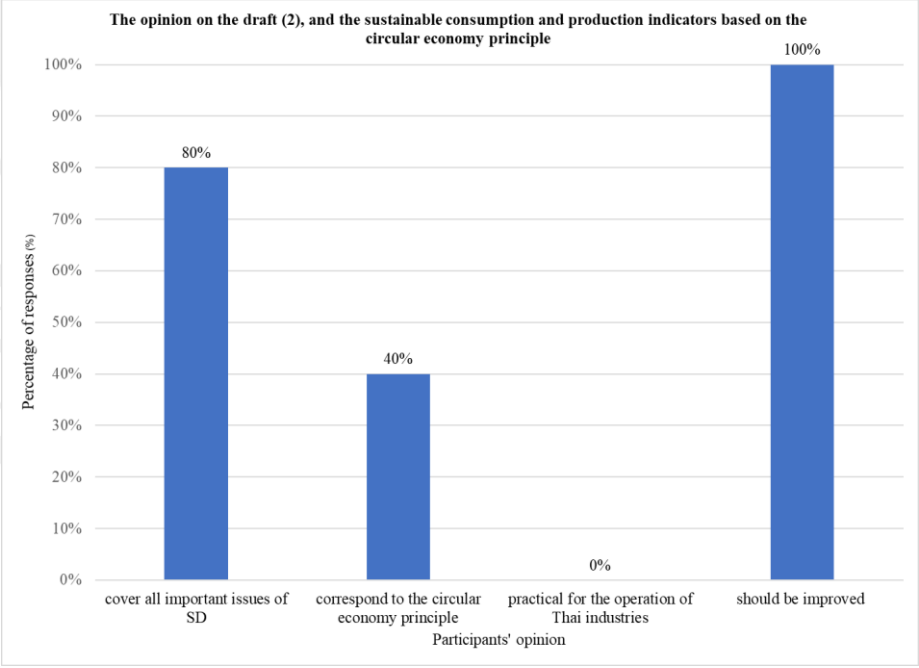

Figure 4.17 Percentage of responses on the opinions towards the draft (2), and the sustainable consumption and production indicators based on the circular economy principle

Summary second survey, there were 5 out of 28 Eco Factory working group members participated in the second survey. The second survey aimed to receive opinion toward sustainability for Thai industry under Eco Factory project and suggestion for second draft SCP Indicators. There were 2 out of 5 participants agreed that Eco Factory are suitable for sustainable development for Thai industries. But all 5 participants indicated that 11 indicators out of 14 indicators of Eco Factory should be improved (such as green supply chain, in come distribution to the community) and they have obstacle to implement. Most of them have consensus that industrial sustainability indicator should correspond to the circular economy principles and Sustainable Consumption and Production Roadmap as well as national sustainability indicators and international affairs such as global warming. Their opinion about SCP indicators were uncomplicate to evaluate indicator, ease for data collecting, having quantitative and qualitative indicators and comparable within the industry. Suggestion for SCP Indicators for Environment indicators were intensity of resources efficiency and air emission, calculated recycle content as proportion of recycled material content per total material, listed inventory type of energy source and ratio of renewable energy consumption and energy wasted, supplementary technology indicators for environmentally friendly innovation technique, covered logistic indicators with inventory of all types of material including product management, accounted percentage of eco product certification as sustainable product certification indicators and added Extend Producer Responsibility as indicators. Suggestion for Social Indicators were employee indicators disclosure without negative business impact and added disabled employee employment, including Corporate Share Value as community and stakeholder indicators. Green procurement and economic resilience should be added in Economic indicators. Sustainability Management action sub-indicators of Good governance indicators should cover business risk, product quality risk , environmental; and safety risk

4.3.3 The 3rd Draft of SCP Indicators Development

The 3rd draft of SCP indicators was developed by employing the top-down approach and collaborating with stakeholders who are Eco Factory Working Group

members and experts on involvement promotion, criteria development and certification. The stakeholders also have extensive academic and consultation experiences related to the sustainable development (SD) for Thai industry through several activities of national and regional program, such as Green Industry, Eco Industrial Town, Eco Label, Green Procurement, Eco design, Life Cycle Impact Assessment Environmental Management standard, Cleaner Production, Eco efficiency, Circular Economy Standards, and Greenhouse Gas Management. Most suggestions towards improving the indicators of these stakeholders from three focus group meetings were summarized as in the recapped topic in 4.3.1 as well as the summary of the 2nd survey in 4.3.2. The 3rd draft of SCP indicators was created based on the suggestions and recommendations on the second draft of SCP indicators. The justification adjustment was the industry indicators based on the circular economy principle under the sustainable production and consumption framework.

The third draft of SCP indicators were revised based on the results of the focus group meetings and survey on the 2nd draft of SCP indicators, and the revision for the 3rd draft of SCP indicators could be summarized as below.

4.3.3.1 Environmental indicators

1) Resource and materials sub-indicators should be adjusted to explicitly correspond to the circular economy and SCP framework to be able to demonstrate materials recyclability as well as renewable materials and virgin materials consumption.

2) More materials, water and wastewater, energy, air emission, greenhouse gas, solid waste and hazardous waste inventory sub-indicators should be added.

3) More symbiosis of material, energy and water and wastewater sub-indicators and hazardous waste intensity sub-indicators should be added.

4) The environmentally friendly product and service procurement sub-indicators should be specified in the supplier indicators to enhance the sustainable consumption of industry.

5) The sub-indicator of product design according to circular economy principle as well as promoting sustainable consumption should be specified in the product development & manufacturing indicators.

6) The sustainable product certification to promote circular economy business model sup-indicators should be specified in product with take-back policies or extend product responsibility indicators.

4.3.3.2 Economic indicators

The local procurement / product procurement or service from community sub-indicators in the supplier indicators should be adjusted to relate to green procurement to create more practicality and sustainable consumption in the factory.

4.3.3.3 Good governance indicators

Corporate ethics indicators should add ISO2600, CSR DIW, OECD Guidelines CSR standard for mission statement sub-indicators.

The third draft of SCP indicators were revised, and there were 28 sets of indicators with 81 sub-indicators as follows.

1) Environmental indicators including 13 sets of indicators and 44 sub-indicators

2) Social indicators including 4 sets of indicators and 13 sub-indicators

3) Economic indicators including 5 sets of indicators and 16 sub-indicators

4) Good governance indicators including 6 sets of indicators and 8 sub-indicators

The set of indicators of second draft and third draft SCP indicators are the same; however, the number of sub-indicators were increased by 9 sub-indicators. The third draft of SCP indicators was presented in the Appendix B-2. Table 1

4.4 Seminar and Workshop for Practical Implementation of the 3rd Draft of SCP Indicators

The seminar and workshop aimed to obtain stakeholder recommendations of practical implementation for the third draft of SCP indicators. The top-down and bottom-up approaches were employed to develop the indicators by applying in the seminar and providing an opportunity for experts and target industries to join in the same forum to discuss on the 3rd Draft of SCP indicators. To minimize information failure for the discussion, information and knowledge on SCP Roadmap and circular economy principles were provided in seminar before the discussion session. Recommendations and suggestions from seminar were considered to revise the third draft of SCP indicators (revised version1). According to the top-down approach, the researcher needed to issue and elaborate the draft boundaries and data collection framework to the stakeholders to utilize in revising the indicators to be the 3rd draft of SCP indicators as well as needed to provide a data-collection workshop to the target industry to improve indicators to be suitable for Thai industries. Suggestions of stakeholders from seminar and workshop on the practical data collection indicators were analyzed for the third survey to verify the 3rd draft of SCP indicators (revised version 2) and finalized study of the SCP indicators.

4.4.1 The Summary of Seminar on SCP Indicators

The seminar were organized by Thai Sustainable Consumption and Production Network cooperates Water and Environment Institute for Sustainability, Federation of Thai Industries and Graduate School of Environmental Development Administration , the National Institute of Development Administration, the seminar topic “The Sustainable Consumption and Production Indicator Development Based on the Circular Economy Principle for Thai Industries” on Thursday, February 25, 2021, at the Meeting Room of PTT Group (Room 1012), Federation of Thai Industries, and online conference via Zoom. The participants in this seminar were 44 participants and could be separated into 10 persons in the meeting room and 34 persons in the online conference. This event was honored by the President of the Thai Environment

Institute (TEI) and the Chairman of Thai Sustainable Consumption and Production Network (Thai SCP Network) to preside over the seminar.

1) President of TEI and Chairman of Thai SCP Network gave a talk on the topic “the Direction of Sustainable Industrial Development under the Context of Mobilizing Sustainable Consumption and Production” by introducing the indicators of SCP Roadmap 2017-2037 consisting of 11 goals and 8 indicators related to the manufacturing sector. In addition, he also presented important policies in other countries, such as the European Green Deal, Green Growth Japan, and Plan for Climate & Clean Energy in the United States as well as Thailand Mobilization Strategies Using BCG Economic Model 2021-2026.

2) The Deputy Executive Director Thailand Greenhouse Gas Management Organization (Public Organization) (TGO) and the Chairman of Technical Sub-committee, No 5: Circular Economy, Thai Industrial Standards Institute (TISI) and the Secretary-General of Thai Sustainable Consumption and Production Network presented “the Circular Economy Standards: Thai Enterprise Certification” that TISI currently designated the National Inspection Testing and Certification Standard (NITC) 2-2019 which comprised 5 sections including Section 1: General background, introduction, terminology and definitions and circular economy and corporate affiliations, Section 2: Circular economy principles, Section 3: Framework of implementation based on circular economy principles, and Section 4: Recommendations on support mechanisms and business models and suggestions on circular economy issues and considerations.

3) The Senior Director of Water and Environment Institute for Sustainability (WEIS), Federation of Thai Industries, and the Executive Committee of Thai Sustainable Consumption and Production Network, presented experiences and challenges in Eco Factory development and projects of the Water and Environment Institute for Sustainability. Additionally, the BCG strategies with are the national policies are integrated and applied in the Federation of Thai Industries.

4) The Researcher, the Environmental Development Department, the National Institute of Development Administration, introduced the research results of the Sustainable Consumption and Production Development based on the Circular

Economy Principle for Thai Industries and the survey results of the questionnaire of industries' opinions towards SCP indicators (Draft 1) and focus group meeting with Eco Factory Working Groups and experts on February 10 and February 22 by presenting recommendations on the indicators in 4 dimensions including environment, society, economy and good governance as well as presenting the 3rd draft of SCP indicators which the received comments were as follows:

5) Senior Director WEIS

(1) The operation including measuring implementation processes and results of Eco Factory indicators illustrated that there are many Eco Factory indicators, and the drafted indicators are more than those Eco Factory indicators. Therefore, it is good if the drafted indicators fundamentally cover all dimensions. However, there should be more specific consideration on each dimension, each group, each area as well as significant issues of what the researcher will evaluate for measuring the sustainability.

(2) The Eco Factory indicators focuses on measuring the impacts on areas, but the drafted indicators are similar to the existing standard criteria of the factory. Therefore, there may be no outcome or impact of implementing the indicators based on the criteria. Hence, more criteria in reflecting outcome/impact which entails sustainability in the area, country or world should be concerned.

(3) Generally, the development of Eco Factory indicators adopts the existing indicators to be a base in developing by carefully considering economic, social and environmental indicators which can reflect and respond the Eco Industrial Town which is criterial in specifying the indicators. However, the current research is based on the circular economy principle. Therefore, the researcher should use its goals in specifying the indicators as well as describing all criteria, and then should categorize the indicators into the must-do and should-do groups and allow entrepreneurs choose the indicators for implementing in their factory. This research will be beneficial in the future if there are researchers used some indicators in the current research which are already extensive in developing new criteria or indicators.

(4) The researcher should identify the key indicators developed as sustainability indicators and other indicators related to the circular economy principle to know what goals can be achieved.

6) The Deputy Executive Director TGO

(1) The research title and result do not represent using the circular economy principle in developing SCP indicators. There are key terms of circular economy including resource consumption, waste reduction and economic value which should be reflected in the drafted SCP indicators as although the drafted indicators cover many dimensions, they do not reflect the cores of circular economy principle.

(2) If the CE principles is used, clarifying how to consume resources, how to manage waste, what risk in the economic dimension is too high, or how economic opportunity occur in the resource management will make the research more explicit and nonrepetitive. In addition, the number of the drafted indicators can be reduced as the researcher has to emphasize solely the circular economy principle. Otherwise, the drafted indicators will overlap the Eco Factory indicators.

(3) There are 2 frameworks of the indicator development in the current research including the sustainability in 4 dimensions (i.e., environmental, social, economic, and good governance dimensions) and the dependence on circular economy in 6 principles. Therefore, only one framework should be focused. For example, if the circular economy is focused, the good governance dimension will be excluded due to the stewardship in the circular economy principle concerning the transparency and collaboration that reflects good governance itself. When there are many frameworks, there will be many indicators, and some are redundant for reflecting the circular economy principle which make the drafted indicators ambiguous about how they correspond to the circular economy. Nevertheless, the sustainability of the drafted indicators is clearly illustrated. If the research title is adjusted by excluding the circular economy principle, it will be consistent to the drafted SCP indicators as research emphasizing on the sustainability is basically a part of sustainable development without weighing on the circular economy.

7) President of TEI and Chairman of Thai SCP Network

(1) The drafted indicator development is a combination of 2 frameworks that entails a large number of indicators which may make the research obscure and confused. Hence, there should be only one principle.

(2) The focus on the circular economy principles normally contributes measuring SCP indicators as the circular economy can generate many outcomes and impacts, but boundaries should be more specifically defined to reduce the number of indicators. Moreover, the researcher needs to use the principles instead of standards since the standards are automatically consisted in the indicator development. There are other principles besides the circular economy principle, such as Eco Industrial Town which may contribute to the research in some ways.

(3) There should be measuring the levels, such as percentage of achievement based on the indicators, and specifying that the operations conducted are more essential than the law.

(4) The small number of indicators may be more effective in measuring the operations of the factory and may be easier for the factory in implementing the indicators. Some drafted SCP indicators, such as the consumption, are located far from the factory but can associate to the factory. The high or low levels of this association should be more specific by identifying clear boundaries and simultaneously limit the number of indicators as a large number of indicators may cause the obstacles when they are implemented.

(5) There should be the indicator piloting with entrepreneurs whether they accept the indicators and can collect data based on the indicator or not.

(6) The title should be adjusted into "*the Sustainable Consumption and Production Development by Integrating with the Circular Economy Principle for Thai Industries*".

8) Chairman of Eco Factory Working Group, IWES, FTI

As an entrepreneur, he would like to give a comment that nowadays, there are 200 entrepreneurs who participated in the Eco Factory project (voluntary project), and their factory has some potentials to meet Eco Factory criteria from around 70,000 entrepreneurs over the country. As there are more indicators in the drafted SCP

indicators, it will be difficult in collecting data. Therefore, there should be a compromise for small-scale factory, such as easing the process or being compulsory for some indicators.

9) Advisor of Thai SCP Network and National Science and Technology Development Agency

(1) The indicators should be separated into 2 sections including (1) must-have section which consists of minimum requirements approving whether it is sustainable or not, and (2) should-have section which the factory collect data itself and does not have to disclose the results that are different from Eco Factory indicators which specifies only the must-have section.

(2) The economic value reflecting the circular economy principle should be added as the drafted SCP indicators do not mention on this point.

(3) According to the discussion of entrepreneurs, there should not be reporting data on gender (number of male and female), but the number of questionnaire respondents. The gender issue is important, but it is not necessary to report. The factory should have this data for only monitoring the proportion of male and female employees to demonstrate fairness that is consistent with social ratios. Thus, this will be specified in the should-have section, and the researcher should consider from the proportion of questionnaire respondents and integrate with other reasons.

(4) The indicators should be clearly specified and provide the opportunity for entrepreneurs to answer and explain. For example, the indicators of inventory of primary and secondary materials and other resources as well as the quantity of consumption have many definitions to follow but the answer is limited as specifying whether have or do not have. There may be providing an opportunity to explain important materials considered by the entrepreneurs themselves because for the current drafted SCP indicators, the entrepreneurs have to specify all materials even some materials is consumed in very small quantity and have very small significance to the entrepreneurs. The term of other resources should be clearly defined whether they refer to water or energy, or whether they are excluded as water and energy have already been specified in other indicators.

(5) The indicator development in this research is an SCP indicator development, but nowadays, the circular economy principle is extensively emphasized. The framework used in the current research is SCP indicators without weighing on the circular economy principle as the circular economy principle is not the base in developing the indicators, but the SDG 4 supported by circular economy principle as only some indicators related to the circular economy principle, such as scrap rate indicator.

(6) Some indicators should adjust their name, such as the good governance corresponding to the stewardship of the circular economy principle, in order to make the indicators clearly correspond to circular economy principle.

10) Senior staff, TEI

(1) There are a large number of the indicators. If the factory participates in other projects and has to collect the data under those projects, there will be overlapping data collection. Hence, reducing overlapping processes can reduce the number of indicators.

(2) There should be description of goals and boundaries to help entrepreneurs in collecting data.

11) Director V Green and Lecturer Kasetsart University

(1)The theme should be clearly specified which the theme in the current research is specified as environment, society, economy and good governance. The larger or smaller number of indicators depends on the research objectives and outcomes which will delivered to further studies in the future. There may be a set of recommended indicators that entrepreneurs have to conduct (1) context analysis (2) materiality assessment and (3) stakeholder analysis, choose the suitable indicators by themselves, and do not have to conduct all chosen indicators if the set of recommended indicators is too large.

(2)The researcher should carefully concern about the levels of indicators separating in main issues and subordinate issues which the subordinate issues are normally in the main issues, such as no need for profiling inventory in the material intensity calculation as the factory basically has its own data on inventory.

In summary, seminar was organized as hybrid (on-site and online) under topic “The Sustainable Consumption and Production Indicators Development Based on the Circular Economy Principle for Thai Industries”. There were 44 participants,10 persons on site (mainly speakers) and 34 persons online (mainly industries). The President of TEI and the Chairman of Thai SCP Network presented on the topic “the Direction of Sustainable Industrial Development under the Context of Mobilizing Sustainable Consumption and Production” by introducing the indicators of SCP Roadmap 2017-2037 related to the manufacturing sector, important policies in other countries, such as the European Green Deal, Green Growth Japan, Thailand Mobilization Strategies Using BCG Economic Model 2021-2026. The Deputy Executive Director TGO and the Chairman of Technical Sub-committee, No 5: Circular Economy, TISI and the Secretary-General of Thai SCP Network presented “the Circular Economy Standards: Thai Enterprise Certification” that TISI currently designated the NITC 2-2019 which comprised 5 sections including Section 1: General background, introduction, terminology and definitions and circular economy and corporate affiliations, Section 2: Circular economy principles, Section 3: Framework of implementation based on circular economy principles, and Section 4: Recommendations on support mechanisms and business models and suggestions on circular economy issues and considerations.

The Senior Director of WEIS, Federation of Thai Industries, and the Executive Committee of Thai S C P Network, presented experiences and challenges in Eco Factory development and projects of the WEIS, the BCG strategies with are the national policies are integrated and applied in the Federation of Thai Industries. The researcher, presented results of the study and the survey results of the questionnaire of industries’ opinions towards SCP indicators (Draft 1) and focus group meeting with Eco Factory Working Groups and experts and recommendations on the indicators in 4 dimensions including environment, society, economy and good governance as well as presenting the 3rd draft of SCP indicators. There were comments and suggestions from seminar as follows.

1) The third draft SCP indicators based on circular economy principles covered all dimensions including Eco Factory indicators. But indicators should be

more specific consideration specifically on dimension, group, evaluating of significant issues of sustainability with reflecting impact and outcome of implementation by industry. There should be specified goals of the indicators with describing all criteria and categorizes the indicators into two group as required and optional criteria to implement by factory.

2) The research title should be revised to reflect circular economy principle in developing SCP indicators. The title should be adjusted into “The Sustainable Consumption and Production Development by Integrating with the Circular Economy Principle for Thai Industries.

3) The key terms as resource consumption, waste reduction and economic value in the drafted SCP should be correspond the cores of circular economy principle. Clarification of resource consumption and waste management should be specified with the risk and opportunities of economic dimension; thus, it will make the research more explicit and nonrepetitive.

4) The number of drafted indicators should be reduced to focus more on circular economy principles. Development of SCP indicators based on the circular economy principles would contribute several outcomes and impacts. Boundaries should be defined to reduce the number of indicators. Other standard such as Eco Industrial Town should be considered.

5) The measuring level of achievement based on indicators such as percentage unit and specific requirement for implementation would be more essential than the law. The small number of indicators and clarified indicators boundaries would ease the factory to implement. Boundaries. There should be the indicator piloting with entrepreneurs whether they accept the indicators and can collect data based on the indicator or not.

6) There were only 200 entrepreneurs (from total 70,000 factories in Thailand) who participated in the Eco Factory project (voluntary project), and their factories had some potentials to meet Eco Factory criteria. As there were more indicators in the drafted SCP indicators, it would be difficult in collecting data for small- medium scale factory. Therefore, there should be some specified indicators suitable for small-scale factory to facilitate their implementation process.

7) The indicators should be divided into 2 categories (1) minimum requirement section to approve whether it is sustainable or not, and (2) should - have section for factory to collect data itself and does not have to disclose the results that are different from Eco Factory indicators which specifies only the minimum requirement section.

8) The economic value reflecting the circular economy principle should be added as the drafted SCP indicators. The Social Indicators, the proportion of male and female employees should be monitored to demonstrate fairness that is consistent with social ratios. The gender issue is important, but it is not necessary to report.

9) The indicators should be clearly specified and provide the opportunity for entrepreneurs to answer and explain. For example, the indicators of inventory of primary and secondary materials and other resources as well as the quantity of consumption have many definitions to follow. The term of other resources should be clearly defined whether they refer to water or energy, or whether they are excluded as water and energy have already been specified in other indicators.

10) The indicator development in this research is an SCP indicator development, but nowadays, the circular economy principle is extensively emphasized. The framework used in the current research is SCP indicators without focusing on the circular economy principle as the circular economy principle is not a base of developing the indicators, but the SDG 4 supported by circular economy principle as only some indicators related to the circular economy principle, such as scrap rate indicator. Some indicators should be adjusted their names, such as the good governance corresponding to the stewardship of the circular economy principle.

11) There may be a set of recommended indicators that entrepreneurs have to conduct such as (1) context analysis (2) materiality assessment and (3) stakeholder analysis, choose the suitable indicators by themselves, and do not have to conduct all chosen indicators if the set of recommended indicators is too large The researcher should carefully be concerned about the levels of indicators separating in main issues and subordinate issues which the subordinate issues are normally in the main issues.

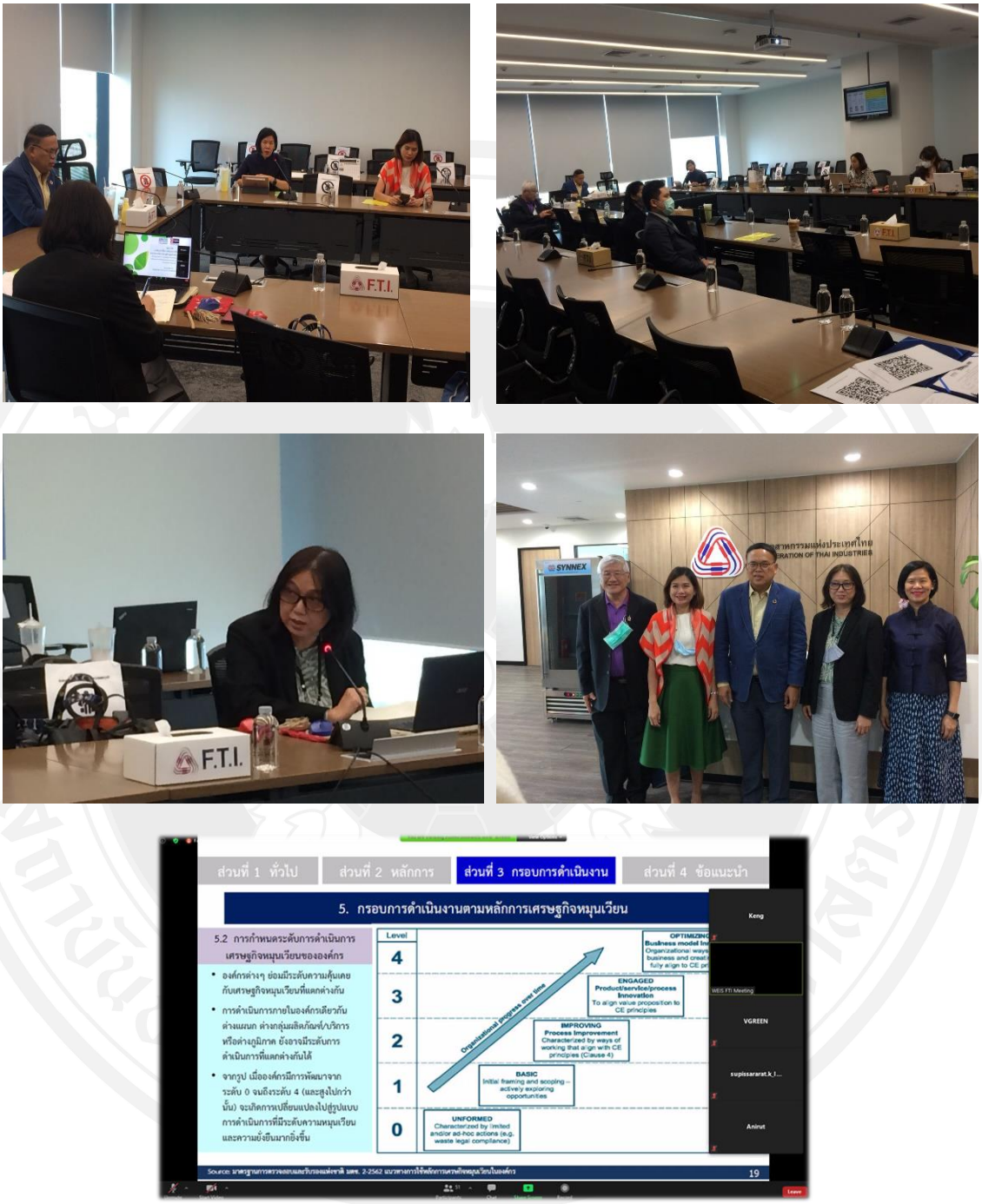

Figure 4.18 Illustrations of the Seminar on Feb 25, 2021

4.4.2 Workshop on Practical Framework for Data Collection of SCP Indicators

The workshop was organized by cooperating with the Community Partnership Association (CPA) on March 15, 2021, at 9.00 a.m. – 03.00 p.m., at Kantary Bay Hotel Rayong with CPA office and their active members from 76 factories certified in Eco Factory program which are the target industry sectors in the current research.

The CPA aimed to promote the sustainable development their business by collaborating with communities in Map Ta Phut Industrial Estate in Map Ta Phut district, the largest industrial estate of Thailand. The vision of CPA is Green City promoting Eco Industrial Town and the proactive operation beyond corporate social responsibility activities with communities. The researcher and CPA manager invited their member staffs that have various expertise in environmental, circular economy, social, good governance operation and occupation health and safety expert. There were 13 participants participated in the workshop. The agenda of the workshop consisted of CPA managers gave a presentation on their roles and activities to promote and support Eco Industrial Town and sustainable development industry in Ma Ta Phut district with communities. The researcher introduced research concept, two survey results and data collection framework of the 3rd draft (revision 1) of SCP indicators based on the circular economy principle and emphasized on objective of workshop to practically confine the SCP indicators based on the circular economy issues feasible to Thai industries according to their involvements of industry sustainability concepts by dividing into two group including the environmental indicators group and the social, economic and good governance indicators group to brainstorm about the improvement of indicators, priority of sustainability and disclosure issues. Participants then gave opinions and recommendations towards the suitability of the drafted SCP indicators in the perspectives of entrepreneurs. The result of workshop was organized to develop the 3rd draft (revision 2) of SCP indicators and a questionnaire (see details in appendix A-3) for final stakeholder surveys to conclude the SCP indicators of the current research.

Figure 4.19 Illustration of workshop on Practical Framework for Data Collection of SCP Indicators with the Community Partnership Association (CPA) on March 15, 2021, at Kantary Bay Hotel Rayong

4.5 The Final Version of SCP Indicators

The final process of developing SCP indicators was conducted based on the grounded theory to reconfirm the SCP indicators using data from the third survey participated by the target stakeholders.

The questionnaire of the third survey provided comprehensive information about boundaries and data collection of each sub-indicators to facilitate selecting choices in the questionnaire, and the indicator implementation and suggestions towards the governmental policy were enquired. The integrated top-down and bottom-up approach was employed in the survey. This final version of SCP indicators in the current study was revised based on the results of survey analysis and justification of SCP and CE concept, industry indicators of Thai SCP Roadmap (revised version 1) and major practices of international sustainable industries in four pillars.

4.5.1 The Thrid Survey

The third survey were conducted after the data collection workshop with the industry group. The revision of the third draft of SCP indicators was conducted by following responses of the workshop. There were 30 participants including 20 industries, 10 Eco Factory working group and experts in the survey which can be accounted for 35% of total number of questionnaire-sent

The questionnaire of goals, boundaries and collecting data of each set of SCP indicators was delivered via email to the participants including the target industries and Eco Factory Working Group members. See Table4.6 and appendix A-3

The questionnaire consisted of three sections as follows:

1) Opinions of target industries towards SCP indicator development (draft 3) based on the circular economy principle for Thai industries

2) Opinions of Thai entrepreneurs towards SCP indicators level classification in responding national and international SD goals

3) Recommendations for SCP indicator development based on the circular economy principle for Thai industries benefiting industrial development in the future and other issues of mobilizing indicator development in the future.

Table 4.6 Goals, boundaries and framework for collecting data of the 3rd Draft SCP indicators (revised version2)

Environmental Indicators

Indicator (Unit)	Goals/Boundaries Framework for collecting data
1. Resources/ Materials	Goal: Resource consumption efficiency, natural resource economics under the sustainable development policy Boundary: Factory
1.1 Primary and secondary material intensity/ the quantity of primary and secondary materials used per product, wt./product unit	Define primary and secondary materials clearly based on EIA or the commercial registration, calculate the quantity of primary and secondary materials used (water and fuel is excluded) in production in the whole year and the number of products per year, analyze primary and secondary material intensity per product, profile the quantity of materials from material inventory, implement the indicators to monitor total quantity of material consumption per year and material intensity per product per year, and present data using graph from the specified base year.
1.2 Consumption of recycled materials/product (weight / product), % virgin materials/ product, material recyclability (amount of recyclable material/ total amount of materials contained in a product, %recycled materials and renewable materials/ total amount of	Goal: Resource consumption efficiency using recycling natural resources Boundary: Factory and network, partner, consumer Calculate the quantity of recycled and virgin materials contained in products as some recycled and virgin materials are the waste from production process. Calculate the quantity of recycled materials from production process. The profile from the material inventory will be calculated as: • Percentage of recycled materials/product • Percentage of new materials/product • Percentage of recyclable materials contained in a product • Percentage of using recycled and renewable materials/total amount of materials

Indicator (Unit)	Goals/Boundaries Framework for collecting data
materials	
1.3 % amount of renewable materials / total raw materials	Goal: Increasing efficiency of using renewable materials in production Boundary: Factory Calculate sustainable material consumption by using profiling renewable material consumption per total raw materials from inventory of material consumption, production and product, and calculate in percentage of renewable materials compared to total material consumption without including water and fuel consumption
1.4 Scrap rate (% of finished product) or percentage of non-standard products	Goal: Increasing efficiency of material consumption, and reducing waste from production based on the sustainable development policy Boundary: Factory Evaluate efficiency of material consumption, profile finished products from standardized production process, law and obligations of the delivery to the customer, compare under-standard products entailing being waste/by-product which cannot be delivered to customer, and calculate percentage of by-product per total standardized products (define by-product /scrap which is a no-longer-usable finished product that is normally disassembled and renewed or recycled in the production process)
1.5 %Symbiosis materials/ total materials	Goal: Reducing material consumption, environmental impacts and waste from production process, expenditure on waste treatment Boundary: Factory and network, related network engagement Calculate efficiency of material consumption based on the circular economy principle, sustainable production utilizing waste or by-product from other processes to be materials in production process in the factory, reduce resource consumption and virgin material, manage waste in the industry, and profile the quantity of waste material or by-product from other production processes to be used in the production to compare total materials required, percentage of symbiosis of materials compared to total materials by calculating the quantity over a year of production.
1.6 Percentage of hazardous materials/product	Goal: Reducing the environmental impacts and hazardous materials, reducing risks on safety, occupational health, environment in production process and product consumers, and reducing product waste disposal expenditure

Indicator (Unit)	Goals/Boundaries Framework for collecting data
	Boundary: Factory, supply chain, partner Calculate weight of the hazardous substance from inventory profile of total materials used in production process compared to the quantity of materials used in production process in a year, and present impacts of hazardous substances on the ecosystem and human, hazardous materials management in production process, communication to consumers and partners using material safety data sheet (MSDS) and product waste disposal.
1.7 Inventory profile of primary materials, secondary materials and other resources, and the quantity of using raw material inventory and profile (Y/N)	Goal: Increasing efficiency of planning management, resource consumption and waste from production process Boundary: Factory To use materials profile for organizational production efficiency management. Conduct materials and quantity inventory and profile diagram, present the orders of materials flows quantitatively and qualitatively, and present diagram of material consumption in each process. The diagram consists of quantitative data of weight or quantity. Conduct and present the result of calculating the balance of raw materials in production process, waste of production process, products for customers, by-product, and waste products from production process.
2. Energy 2.1 Energy Intensity (kWh/product, K Joule/product)	Goal: Increasing efficiency of energy in production process, reducing environmental impacts caused by global warming Boundary: Factory To evaluate efficiency of energy consumption throughout production process, and to reduce energy consumption. Calculate volume of total energy consumption per year on energy consumption in production process in the form of electrical energy (kWh) and heat energy compared to energy intensity per product.
2.2 % Use of renewable energy/total energy	Goal: Increasing proportion of using renewable energy per total energy, reducing environmental impacts caused by global warming Boundary: Factory Calculate total energy consumption in production process, volume of electric energy from renewable energy sources (e.g., solar, wind, hydro-, biomass) compared to the proportion of total energy consumption using

Indicator (Unit)	Goals/Boundaries Framework for collecting data
	data from inventory profile of energy consumption and energy types.
2.3 % symbiosis energy / total energy or and % energy recovery / total energy	Goal: Increasing efficiency of energy consumption, reducing loss and environmental impacts caused by global warming Boundary: Factory Calculate the volume of total energy in production process per year in the form of electric energy (kWh) or Joule compared to symbiosis energy or energy recovery, such as consumption of wasted heat energy and heat energy from wastewater, disposal of non-reusable or non-recyclable waste in burning for heat energy. Retrieved from: https://www.ceguide.org/Strategies-and-examples/Dispose/Energy-recovery, use data from inventory profile of energy consumption and energy types, and evaluate the percentage of symbiosis energy compared to total energy consumption or percentage of energy recovery in production process compared to total energy consumption.
2.4 energy profile / inventory	profile energy consumption and energy type inventory
3. Water/ Wastewater	
3.1 The volume of water consumption/product, wastewater/product, water intensity/wastewater intensity (volume /product)	Goal: Increasing efficiency of water consumption, worthiness of water resource economics, reducing loss and environmental impacts Boundary: Factory Calculate the volume of water consumption per year by calculating the volume of raw water from water sources and water from different types of renewable water process (e.g., reverse osmosis) of the factory, clearly define water consumption from different types of water source (e.g., surface water, underground water, rainwater stored in the factory area, water supply purchase), calculate the volume of total water consumption without subtracting the volume of recycled or reused water, calculate water intensity per produced products, calculate the volume of wastewater per the volume of generated water in a year. All calculation uses the data from inventory profile of water consumption, wastewater, water balance, and water-consuming activities and wastewater in each production process.
3.2 % Volume of water reuses or recycled / total	Goal: Increasing efficiency of water reuses, worthiness of water resource economics, reducing loss and environmental impacts

Indicator (Unit)	Goals/Boundaries Framework for collecting data
used water	Boundary: Factory To calculate the percentage of water reuses or the volume to recycled water compared to total water consumption, calculate the volume of water based on item 3.1, and calculate the volume of total recycled and/or reused water in the factory to calculate the percentage of overall recycled and/or reused water consumption in a year per total water of the factory in a year. Use data from profile inventory of the volume of water consumption, wastewater, water balance, and water-consuming activities and wastewater in each production process.
3.3 % Symbiosis wastewater / total wastewater	Goal: Reducing environmental impacts, water consumption and water treatment expenditure, increasing efficiency of water resource consumption Boundary: Factory Calculate percentage of importing wastewater from other establishments or exporting wastewater to other establishments compared to the volume of wastewater (after deducting the volume of wastewater for recycling and/or reusing) which is treated and discharged out of the factory. Calculate the volume of total wastewater in the entire system after deducting the volume of wastewater for recycling and/or reusing in a year and use to calculate the percentage of wastewater exported to other establishments for utilizing or to surrounding agricultural areas or wastewater imported from other establishments for utilizing in production process per the volume of wastewater (after deducting the volume of wastewater for recycling and/or reusing) of the factory in a year. Use data from profile inventory of the volume of water consumption, wastewater, water balance, and water-consuming activities and wastewater in each production process.
3.4 Water and wastewater balance / inventory	Goal: Planning water consumption management, increasing efficiency of water resource consumption, reducing environmental impacts Boundary: Factory Profile inventory of the volume of water consumption, wastewater, water balance, and water-consuming activities and wastewater in each production process.
4. Air / emission / gas	Goal: Protecting environmental impacts caused by air emission, maintaining air quality, workplace environment and surrounding

Indicator (Unit)	Goals/Boundaries Framework for collecting data
emission / heat emission	community
4.1 Volume or intensity of air emission below level indicated by the law (ppm SOx, NOx, VOC others)	Boundary: Factory Evaluate the efficiency of air emission management of the factory, investigate the level of air emission intensity reduction which is better than the law specified, measure and calculate air emission using the methods specified by the law or based on the notification of Department of Industrial Works, calculate volume or intensity of air emission based on intensity levels or heat emission specified by the law for specific industry or basic data from EIA of the factory, investigate the difference of volume or level of average intensity per year of air emission in the form of turbulence or heat emission, and report better volume specified by law.
4.2 Intensity of particle matter emission/PM 2.5 (ppm)	Goal: Prevention environmental impacts caused by air emission, maintaining air quality, workplace environment and surrounding community Boundary: Factory Calculate efficiency of managing particle matter emission from production process, measure the intensity of particle matter emission PM 2.5 around the factory, measure and calculate air emission based on method specified by the law, investigate the average intensity of particle matter emission PM 2.5 around factory and pattern of the volume of air emission intensity reduction which is better than the level specified by law (PM10 at present).
4.3 Air emission inventory and profile	Goal: Planning air emission management and reducing environmental impacts Boundary: Factory Profile inventory of air emission and sources, types and volume
5. Greenhouse gas management	Goal: Managing environmental impacts caused by greenhouse gas emission in production process and organizational activities
5.1 Greenhouse gas intensity (wtCO_2e /product)	Boundary: Factory, supply chain, product distribution, product life cycle To evaluate greenhouse gas manageability and greenhouse gas intensity per product. Calculate the volume of greenhouse gas of the in a year from electricity, fuel and materials consumption, transportation, and packaging based on

Indicator (Unit)	Goals/Boundaries Framework for collecting data
	ISO 14064 standard, calculate carbon dioxide equivalent content (CO_2e) using calculation standards specified by Thailand Greenhouse Gas Management Organization (Public organization) or equivalent, and deduct carbon offset of the organization, calculate CO_2e and the quantity of products produced in a year, and calculate CO_2e intensity per product.
5.2 Total emission reduction of GHG from factory/year (wtCO_2e / year)	Goal: Reducing environmental impacts caused by greenhouse gas emission and consumption of energy and chemicals from production process and organizational activities Boundary: Factory, supply chain, product distribution To evaluate greenhouse gas reducibility Calculate percentage of total GHG emission reduction of the factory based on ISO 14064 standards or credit GHG, calculate the reduction volume compared to the base year in CO_2e unit.
5.3 Greenhouse gas inventory / profile	Goal: Planning the management of reducing environmental impacts caused by greenhouse gas from energy and chemicals consumption and organizational activities Boundary: Factory, supply chain, product distribution, product life cycle Profile greenhouse gas emission inventory
6. Solid waste 6.1 Solid waste (Non-hazardous waste) inventory / profile / flow diagram (#)	Goal: Planning the management of reducing environmental impacts caused by solid waste from resource consumption and organizational activities ๅ Boundary: Factory Profile inventory of solid waste, profile and flow diagram in each production process
6.2 Volume of solid waste/product, solid waste (non-hazardous waste) intensity (weight /product)	Goal: Reducing environmental impacts caused by solid waste from production process, increasing efficiency of solid waste (non-hazardous waste) management Boundary: Factory Calculate volume of total solid waste in production process before recycling and reusing waster each year and use to calculate solid waste intensity per product.
6.3 % solid waste (non-hazardous waste) reduction per year compared to the	Goal: Reducing solid waste in production process to reduce environmental impacts, increasing efficiency of resource consumption

Indicator (Unit)	Goals/Boundaries Framework for collecting data
base year	Boundary: Factory
% recycle, reuse, recovery solid waste, waste to value (Upcycle)	Calculate the volume of reduced solid waste in the factory in percentage and total solid waste in production process in the specified base year and calculate the volume of reduced solid waste from % recycle, reuse, recovery solid waste, waste to value (upcycle).
7. Hazardous waste	
7.1 Intensity of hazardous waste or volume of hazardous waste per product (weight /product)	Goal: Reducing hazardous waste in production process to reduce environmental impacts Boundary: Factory, supply chain Calculate the volume of hazardous waste based on the law (Department of Industrial Works), calculate the volume of hazardous waste in production process throughout the supply chain, and investigate the proportion of hazardous waste per product.
7.2 Inventory profile of hazardous waste and hazardous material inventory /profile (Y/N)	Goal: Planning the management of hazardous waste in production process to reduce environmental impacts Boundary: Factory, supply chain Profile inventory of hazardous waste and hazardous materials, hazardous materials storage system and hazardous waste based on specified law standards and MSDS database of hazardous waste, and management training manual for related personnel.
8. Logistics 8.1 Transportation and logistics management efficiency (#)	Goal: Increasing efficiency of resource consumption, reducing production costs, environmental impacts and loss from organizational activities Boundary: Factory, supply chain, customer Investigate efficiency from the evaluation of logistics management based on the action plans involving achieving goals for reducing costs, adding value to products, and reducing environmental impacts caused by resource, materials, energy and time consumption, transportation in production process and product distribution to partners and customers of the organization.
8.2 Reverse logistics, customer returns management (#)	Goal: Increasing efficiency of resource consumption and resource renewability from customer returns or by-products which are reused or recycled in production, reducing production costs, environmental impacts and loss from organizational activities

Indicator (Unit)	Goals/Boundaries Framework for collecting data
	Boundary: Factory, supply chain, customer Investigate efficiency from the evaluation of reverse logistics management based on the action plans involving achieving goals for reducing costs, adding value to products, and reducing environmental impacts caused by resource, materials, inventory, energy and time consumption, inventory transportation, and taking renewable resources from produced products back into the system based on the close-loop circular economy principle focusing on Recycle or Reuse or Repair or Remanufacture.
8.3 Number of accidents, complaints, and product transportation per year (#)	Goal: Increasing efficiency of product distribution, reducing risks of problems on business image and marketing, creating satisfaction to partners and customers Boundary: Factory, supply chain, partner, customer Evaluate managing accidents and complaints from transportation affecting customers and society by gathering data from the number of transportation accidents in the factory, warehouse, processes of product distribution to partners and customers, and gathering data in the number of accidents, complaints per year, solution management, complaint protection and proactive action plans based on cause, complaint and accident analysis from complaint channels on transportation impacts reported by customers or publics.
9. Suppliers 9.1 % new suppliers that were screened using environmental criteria / total suppliers (%)	Goal: Increasing efficiency of resource consumption, increasing potential of environmentally friendly production in the long run, reducing risks of environmental, social and economic impacts caused by running business Boundary: Factory, partner Develop green supply chain, apply environmental criteria in selecting new suppliers compared to total suppliers, establish environmental evaluation criteria with new suppliers and producers of the factory in procuring materials, resources, equipment and services, may identify the evaluation frequency and cycle to provide suppliers the evaluation based on the time frame corresponding to the sustainable development of the organization in different dimensions, develop action plans by collaborating with suppliers which do not meet necessary criteria or recruiting new suppliers continuously, and evaluate the report of

Indicator (Unit)	Goals/Boundaries Framework for collecting data
	percentage of suppliers which meet necessary criteria compared to total suppliers.
9.2 Significant actual and potential negative environmental impacts in the supply chain and action taken (# / total suppliers)	Goal: Reducing risks of environmental impacts caused by running business, enhancing potential of developing green supply chain and environmentally friendly production Boundary: Factory, partner Evaluate the potential of reducing negative significant environmental impacts occurred in the supply chain and measures in reducing impacts on the supply chain compared to the total number of suppliers. Gather data of the number of action plans and operations with organizational suppliers which have potential in creating negative environmental impacts by depending on the evaluation based on the environmental criteria for suppliers and producers in procuring materials, resources, equipment and services in each year, specify time frame of the action plans corresponding to the sustainable development of the organization in different dimensions, develop action plans by collaborating with suppliers to reduce negative environmental impacts according to the action plan goals, report the number of suppliers which engage in the operations based on the action plan and achieve goals in a year, and reduce quantitative and qualitative environmental impacts compared to total suppliers at present.
9.3 Number of suppliers providing environmentally friendly product and service procurement compared to total suppliers (# / total suppliers)	Goal: Enhancing potential of environmentally friendly production in the organization, reducing risks of environmental, social and economic impacts caused by running business Boundary: Factory, partner Evaluate product procurement and services from suppliers which provide environmentally friendly products and services, establish environmentally friendly product and service criteria by emphasizing based on standard criteria which are accepted nationally and internationally, announcement of public sector, independent organizations, or agencies to use in procuring materials, products and services from the standardized suppliers. In case of there is on standard for some types of materials, products or services, develop criteria by collaborating with suppliers based on research database, criteria of agencies or independent organizations, gather the number of total

Indicator (Unit)	Goals/Boundaries Framework for collecting data
	suppliers which meet the necessary criteria and the amount of value (monetary) in procuring materials, products and services per year compared to total suppliers of the factory, and report in proportion of the number of suppliers and cost of environmentally friendly products and services.
10. Product development / manufacturing 10.1 Environmentally friendly design / Eco-design (# of product) • % of products designed for disassembly, reuse or recycling / total product • Durability level (#product/year) • Eco-innovations (# of project/year)	Goal: Designing environmentally friendly products to increase the efficiency of using renewable resources in the system, reducing risks of environmental, social and economic impacts caused by running business based on the circular economy principle Boundary: Production unit and design unit of factory, partner, customer Producing products and innovations of the organization in each year which focuses on environmentally friendly design by creating engagement in the supply chain, partners and customers to respond the goals and objectives of the users, investing innovation development, and promoting participation from the public sector in mobilizing policies, measures as well as customer and consumer motivation in purchasing environmentally friendly products. The environmentally friendly design covers: • Products designed for disassembling, reusing or recycling Calculate the proportion of products with disassemble, reusable or recyclable design to promote renewable resource in production process based on the closed loop or open loop under the circular economy principle, design and produce by creating collaboration in both inside and outside the organization, such as partners, customers and public sector to expand the organizational capability in using renewable resources from disassemble, reusable or recyclable products in each year. • Durability level (#) Calculate the number of products which are expanded their usage durability or product services of the organization in each year, and improve durability level in terms of design and production process, engagement creation throughout the supply chain, partners and customers to expand the shelf life of products to respond the policies, goals and objectives of the users, increase the efficiency of resource consumption of the organization. The engagement may include various

Indicator (Unit)	Goals/Boundaries Framework for collecting data
	processes, such as providing knowledge, creating consumers' awareness on resource consumption, or developing enterprises in enhancing usage durability. • Calculate the number of factory's projects on environmentally friendly innovative production per year. • Report the environmental impacts reduced from environmentally friendly product production per product to create awareness of partners and consumers compared to the number of products. • Report the percentage of the number of products with environmentally friendly design per year compared to total products produced by the factory each year. • Report the projects of environmentally friendly innovative production of the organization per year.
11. Sustainable product certification (materials, products) 11.1 Third Party Eco-Label (e.g., Green Label, Carbon Footprint, Water Footprint) (# of product) Self -Declare (# of product)	Goal: Building the trust of partners and consumers towards environmentally friendly product production, increasing opportunity for environmentally friendly market segmentation and product production business, supporting the green procurement, reducing environmental impacts in operations Boundary: Factory, partner, consumer To evaluate capacity of products or materials which are developed sustainably and certified Type 1 and 3 Eco-Label, and Type 2 label certification, self-certifying manufacturer. Report the number of products or materials from production process that meets the necessary criteria, receives Type 1 and 3 Eco-Label from the independent organization, such as Green Label from the public sector organization, or Water Footprint Label and Carbon Footprint from private organization, and/or the number of products and materials which receive Type 2 label, self-certifying manufacturer.
11.2 Products with take-back policies in place or extend product responsibility (# of product/ year)	Goal: Expressing social responsibility, building the trust of partners and consumers, reducing environmental impacts caused by product waste disposal Boundary: Factory, partner, consumer Evaluate take-back policies to reduce environmental impacts and increase the efficiency of resource consumption, such as recycle

Indicator (Unit)	Goals/Boundaries Framework for collecting data
	remanufacturing, and report the number of products under these policies.
12. Environmental spending/investments/ management	Goal: Expressing responsibility to society, reducing environmental impacts caused by running business, improve and/or protect environmental quality, and ecosystem in the factory and local areas
12.1 Green area / buffer zone (% area/year)	Boundary: Factory area and buffer zone or surrounding community area To evaluate intention of the organization in conducting operation to increase green area around the factory or in the buffer zone between the factory and community. Calculate the increased green area in percentage from the total factory area using green area from the factory area in the base year or from EIA database. In case of restrictions on increasing green areas within the factory, calculate the increase of green area by evaluating area that is a buffer zone between the factory and community where is under the responsibility of the factory and calculating as percentage of total area of the factory (the green area inside the factory is excluded). Report the percentage of increased green area per year.
12.2 Environmental spending / protection expenditures and investments by type (monetary unit/year)	Goal: Expressing responsibility to society, reducing environmental impacts caused by running business and resource consumption, improve and/or protect environmental quality Boundary: Factory, supply chain, partner To evaluate intention of the organization in environmental impact management and proactive environmental management from operation expenditure and organizational investment. Calculate money from expenditure or investment on protective environmental operation in the factory and/or expenditure or investment on supporting partners and supply chain in reducing environmental impacts, protecting environmental problems throughout the product life cycle from production process, material consumption, packaging, transportation to product waste disposal. Report the amount of money from mentioned activities /year and occurred environmental impacts.
13. Technology 13.1 Recycling technology (# of project),	Goal: Building potential of using renewable resources based on the circular economy principle, reducing environmental impacts caused by running business Boundary: Factory, and/or supplier of the factory, partner

Indicator (Unit)	Goals/Boundaries Framework for collecting data
remanufacturing technique (#) or recovery technique (#), technology for implementation the circular economy principle (#)	To evaluate the use of technology in production process to make the resource consumption in production process correspond to the circular economy principle. Report the number of total projects and/or recycling technology or technique including recycling technology, remanufacturing technique, recovery technique per year as well as report the number of total technology for application to enable the operation based on circular economy principles per year in the organization or support the engagement of partners or suppliers to promote close-loop and open-loop resource consumption in production process in the factory.

Social Indicators

Indicator (Unit)	Goals/Boundaries Framework for collecting data
1. Employees	Goal: Using human resources efficiently, maintaining efficiency of working performance
1.1 Turnover rate (%)	Boundary: Company, factory
	To evaluate organizational ability in maintaining human resources that have a potential and receive working capacity promotion by evaluating from the proportion of employee resignation.
	Calculate the proportion of permanent employees who have been developed to be able to perform regular tasks in different departments in a year compared to the average number of total permanent employee in the factory by reporting this indicator each year or may evaluate the turnover rate in administration and operation level, and define working duration of potential permanent employee in the organization due to the unequal relative weight of personnel. Therefore, the impacts of losses from employee turnover index on the organization may not equal in each department in the organization.
1.2 Nondiscrimination including gender/age/sexual/child labor (% male, % female)	Goal: Promoting the human rights protection of the organization, the ethics in human resource development, the sustainable development
	Boundary: Company, factory
	Evaluate organizational employment guidelines based on the human rights principles with nondiscrimination including gender, age, child labor and employee compensation per benefit.
	Evaluate regulations for the employment of the organization, report of employment of the organization each year, the number of employees including male, female and disabled person, prohibition of child labor employment, proportion of male and female employee, employment equality representing nondiscrimination, growth opportunity in the organization and regulations under the governmental employment law.
	Calculate % of permanent employees, the number of male, female and/or disabled person (optional) in each position of each level.
1.3 Programs for skills management and lifelong learning / Indigenous Knowledge / training of the	Goal: Developing human resources of the organization, organizational development opportunity and efficiency of the operation
	Boundary: Company, factory
	Evaluate potential development of personnel in the organization in different levels and dimensions which corresponds to the sustainable operation goals

Indicator (Unit)	Goals/Boundaries Framework for collecting data
employees (in hours) / capacity development / sustainable awareness (#)	of the organization, evaluate the report of the organizational personnel development, goals and operation based on the action plan of training permanent employees in different position in each department, record the evaluation of training need, training matrix (e.g., online training) of necessary skills based on responsibility of personnel in each level, enhancing knowledge to suite position progress of employee in each aspect, such as technology, innovation, management, working safety, chemicals, eco, organizational resource consumption, local cultural society for providing employee understanding on collaboration between community and organization, etc. Evaluate course contents as well as workshop and academic training hours corresponding to the organizational goals, personnel workloads and results of personnel competence assessment before and after training, and evaluate activities, contents, training methods related to creating the sustainable development awareness for employees in the organization, and results of changing behavior of employees who have been trained. Summarize the number of training hours for employees and the change of employees' potentials in different dimensions and report the change of working performance efficiency of employees. Guidelines are identified as mandatory • annual plan + SD contents, annual evaluation is classified into administrative levels including • Need to have and Voluntary, • Programs for skills management and lifelong learning (by clearly exemplifying) • Nice to Know, Nice to be.
2. Security and safety at work 2.1 Health and security / safety / elimination of hazardous workplace / absence due to injuries or work-related illness / deaths / effective occupational health and safety management for personnel and related persons (Y/N, # of day	Goal: Maintaining human resources and protecting economic loss caused by working accidents Boundary: Company, factory, employee To manage the occupational health and safety, safety in the workplace, absence due to work-related illness or death. Evaluate occupational health and safety guidelines under the law and ISO45001 standard (optional), record working performance of safety officers, establish the safety-health plan to promote PSM (Process Safety Management) for risked factory, organize annual safety training for permanent and new employees and safety drills, provide personal safety gears and install safety gears in the workplace, such as fire extinguishers, air and dust filters and chemical spill protection.

Indicator (Unit)	Goals/Boundaries Framework for collecting data
absence, # of days)	Report the number of employee absence and/or factory shutdown due to working accidents, or employee absence and illness due to work-related reason in a year.
2.2 Ergonomic (#)	Goal: Preventing the loss of personnel potential, increasing production efficiency and productivity of the organization Boundary: Company, factory, employee To evaluate the workplace management based on ergonomics of employees in each department. Evaluate documents of the guidelines, the equipment system planning, the sections related to working performance of employees in each department, such as conveyor system, packing, transporting, the posture and the nature of movement of employees in working with equipment, the equipment in the organization, working frequency and duration of each department based on ergonomics, record the monitoring, the abnormality and exhaustion caused by working movement of employees, the modification of the ergonomics system when the blueprint, structure, equipment and working are adjusted, and the investigation of working performance, ergonomic design and working efficiency impacts affecting employees.
2.3 Healthy working environment (e.g., air, sound, light)	Goal: Protecting accidents, maintaining personnel potential, increasing production efficiency, and promoting healthy working of the organization Boundary: Company, factory, employee To evaluate environmental management, which is healthy for working, on air, sound and light for employees in the organization. Evaluate documents relevant to working environment design and documents of assessing, monitoring and reporting environmental conditions for working, such as Preventing the impacts of loud noise of the working equipment, light for working in each section, air and heat exhaust ventilation system to protect against heat stress during working. Investigate the report of environmental management based on the action plans and goals of the organization (optional).
3. Clients/ consumers 3.1 Number of complaining consumers (#), total number of	Goal: Maintaining the market share of the organization and the satisfaction of the customers Boundary: Company, factory, customer (first tier) The number of complaining consumers from purchasing product and services.

Indicator (Unit)	Goals/Boundaries Framework for collecting data
incidents of non-compliance with regulations and voluntary codes concerning marketing communications, including advertising, promotion, and sponsorship, by type of outcomes (#)	Respond in case of the cause happened by the company. The number of problems from products which do not meet the quality standards according to the law or company requirements as advertised or agreements with consumers or customers. Evaluate the record of the number of impacts caused by the customer complaints in a year, the number of problems from products which do not meet the quality standards according to the law or agreements with consumers or customers or advertisements broadcasted to customers, the promotion and complaints from customers, partners and related persons, the solutions, adjustments and standards in preventing recurrence of complaints and standards problems by considering from suitability work plan of resource allocation of the organization towards the levels of problems.
4. Community and stakeholders	Goal: Living with locals, reducing the risk of conflicts and coexistence problems in the community area due to sharing natural resource consumption and maintaining environmental quality
4.1 Engagement of the community / living with the surrounding community (Y/N)	Boundary: Company, community in the area around the factory and locality To evaluate the capacity in creating engagement and living with the surrounding community. Evaluate policies, activity plans and processes of creating engagement of the community and operation of the factory in a year in different dimensions to enhance the income and quality of life of people in the community, such as hiring people in the community, receiving services of the community, using organizational resources to develop the quality of life of people in the community, enhancing gaining income of the community enterprises, promoting skill development, supporting community public events in health, education, religion and local culture.
4.2 Local partnerships / Integration to the society (Y/N), number of partnership networks	Goal: Building partnership with local partners, reducing risks of conflicts of common interest with community due to the natural resource consumption, promoting creating economic benefits Boundary: Factory, factory in surrounding area, partner, local public and private network To evaluate building partnership with local partners and participation networks of local factory, the case of large-size factory supporting small-size factory in the local areas and the local integration and community development.

Indicator (Unit)	Goals/Boundaries Framework for collecting data
	Evaluate activities and results of operating building partnership with partners to create mutual benefits quantitatively and qualitatively in economic, social and environmental dimensions to collaborate in the sustainable development, such as supporting local government organizations to solve waste management problems, air quality and water quality, promoting raising local awareness to enhance the ecosystem and biodiversity, promoting large-size factory in supporting small-size factory in developing environmental personnel, collaborating with the public sector in resource support or helping local public sector, developing natural resource recovery, applying technology in industries and local services (e.g., using local renewable energy by supporting the technology transfer of local factories and maintaining local public equipment by factory entrepreneurs in the local area).
4.3 Investment to benefit community corporate social responsibility / income distribution to the community (Y/N)	Goal: Supporting creating economic opportunity for the community and organizations through organizational investment, reducing risk of conflicts of common interest with community and related networks Boundary: Factory, community, local public sector network To evaluate organizational investment with local community to distribute income to community and create social responsibility of the factory in the local area that concurrently benefits to the factory and community as well as creating value for business with society.
Creating shared value (Y/N)	Evaluate project activities collaborating community and locality participation and co-creating benefits and income in each year, such as the factory allows local people to be a subcontractor in used-product sorting in the recycling process under the co-investment between the factory and locality in procuring equipment and machine that entails local people have income and the factory get business benefits as well as concurrently controls quality and manage logistics effectively.

Economic Indicators

Indicator (Unit)	Goals/Boundaries Framework for collecting data
1. Gross revenue 1.1 Gross revenue value (Monetary units) (Y/N)	Goal: Increasing efficiency of gaining revenue and economic status of the organization Boundary: Company, factory To evaluate the economic status of the organization using the data of total annual gross revenue of the organization from the organizational financial report approved by the auditor in the fiscal year specified by the organization.
2. Cost / expense • Employee / labor cost/ Expense with wages (Monetary units) report in the organization, benchmark with business groups in the same type (classified by function) • Environmental expense (Monetary units), waste disposal expense, expense for improving environment, recycling waste, waste monitor expense	Goal: Increasing efficiency of cost management, managing operation expense, increasing intention in developing business for organizational sustainability, reducing environmental impacts, managing resources worthily Boundary: Company, factory Gather data of annual cost and expense of the organization using the accounting report approved by the auditor including employee wages per year compared to business groups in the same type, environmental expense, environmental activity expense, operation expense, recycling cost, and waste disposal cost and expense.
3. Profit • Liquid profit (Monetary units)	Goal: Increasing efficiency of running business from the continuous profitable business turnovers, enhancing accompanying of gaining income and running business sustainably Boundary: Company, factory

Indicator (Unit)	Goals/Boundaries Framework for collecting data
• Retained earnings (Monetary units)	Gather data of benefits and liquid profits of the organization each year using the record of accounting report approved by the auditor.
4. Investments 4.1 Overall equipment efficiency (%) OEE	Goal: Investing to increase the efficiency of using equipment in production, increasing intention in developing running business for organizational sustainability, reducing environmental impacts, managing resources worthily Boundary: Factory, partner Calculate the efficiency of production equipment, report % of efficiency by duration based on the plans compared to year and time that the machine run in production, (up-time) (%) in the specified database, and report relevant investment information to improve efficiency per year from the accounting report approved by the auditor.
4.2 Investment in R&D activities / technology transfer % / revenue	Goal: Increasing intention in developing running business for organizational sustainability using budget of the investment on research and development, organizational technology transfer, reducing environmental impacts, managing resources worthily, adding value Boundary: Factory, partner, public, private, and educational sector network partnership Report the investment in each year by calculating in the total income per year. The investment is on research, development, technology transfer in the factory, co-investment with partners, public, private, and educational sector network partnership, and other related investment, such as transferring technology inside the organization and/or partners and returns from investment by budget in the accounting report approved by the auditor.
4.3 Sustainable process innovation (% / revenue)	Goal: Increasing intention in developing running business for organizational sustainability using budget of the investment on innovation development for sustainability in production process Boundary: Factory, partner, public, private, and educational sector network partnership Report the investment in each investment year, investment on innovation process for sustainability in the factory which may collaborate with partners, public, private, and educational sector network partnership as well as gather budget for investment on innovation process for sustainability

Indicator (Unit)	Goals/Boundaries Framework for collecting data
	from the accounting report approved by the auditor.
5. Suppliers 5.1 Local suppliers / spending on local suppliers (% spending for local suppliers / total spending)	Goal: Increasing intention in developing running business for organizational sustainability by supporting local business which is procured by the suppliers, reducing environmental impacts caused by transportation and product distribution from the procurement Boundary: Factory, partner, community (suppliers in the country – first tier) Report the number of suppliers which conduct local procurement each year compared to total suppliers of the organization, gather budget of organization's local supplier procurement per year from the accounting report approved by the auditor.
5.2 Green Procurement (% spending for green procurement / total spending)	Goal: Increasing intention in developing running business for organizational sustainability by conducting green procurement to reduce environmental impacts and express social responsibility Boundary: Factory, partner Report budget for green procurement and total environmentally friendly product and service procurement of the organization per year based on the accounting report approved by the auditor.

Good Governance Indicators

Indicator (Unit)	Goals/Boundaries Framework for collecting data
1. Corporate Ethics 1.1 Mission statement, code of conduct (Y/N), operation under ISO26000 CSR DIW, OECD guidelines CSR	Goal: Ethics in running business Boundary: Factory, partner, customer, community Evaluate policies and guidelines for organizational ethics, evaluate documents and policies of the organization in running business, treating employees in the organization, external network, trading with fairness, legality, transparency, social and human-right responsibility or using international ethics standards.
2. Accountability 2.1 Transparency (Y/N)	Goal: Promoting good governance responsibility of organizational operation Boundary: Factory, partner, customer, consumer, community Evaluate guidelines, working regulations, record of documents on accountability and transparency on production, resource consumption, organizational management and product and service distribution.

Indicator (Unit)	Goals/Boundaries Framework for collecting data
3. Participation 3.1 Stakeholder Dialogue (#)	Goal: Promoting good governance of engagement of related network in organizational operation and complaint management Boundary: Factory, partner, personnel (in the organization) Evaluate guidelines and working regulations, record of documents on activities in communicating for personnel engagement in the organization, partner, customer, consumer and community receiving operational impacts corresponding to the corporate ethics, accountability on production, resource consumption, organizational management and product and service distribution, create stakeholder dialogue in all dimensions related to running business, complaint channel which has a system to respond dialogue or receive feedback outside and inside the organization.
3.2 Grievance Procedures (# of complaints and # of solved complaints)	Report the number of complaints of local network, community, public sector and partner, and procedures in solving organizational complaints (outside the organization).
4. Risk Management 4.1 Sustainable Risk Management Action Plan (Y/N)	Goal: Promoting good governance responsibility of Risk Management Action Plan in managing sustainability Boundary: Factory, partner, customer, consumer, community, related network Evaluate the record of risk management plan of the sustainability development covering organizational operation in environmental, economic, social and goo governance dimensions, plans for resource and responsibility allocation, level of possible risk in different dimensions and operational risk level reduction (Stock Exchange of Thailand Guideline https://www.setsustainability.com/page/esg-risk).
5. Holistic Management 5.1 Sustainability Management Plan (Y/N)	Goal: Promoting good governance responsibility of Sustainability Management Plan of the organization corresponding to the organizational sustainable development goals, Thailand's sustainable development policies and responding international hot issues Boundary: Factory, partner, customer, consumer, community, related network Establish organizational sustainability management plan, evaluate record of action plans covering organizational operation in environmental, economic, social and goo governance dimensions corresponding to the sustainability

Indicator (Unit)	Goals/Boundaries Framework for collecting data
	policies of the organization, national sustainable development policies responding international hot issues and resource and responsibility allocation plan corresponding to Risk Management Action Plan specified in Stock Exchange of Thailand Guideline (https://www.setsustainability.com/page/sustainability-management-process).
5.2 Full-Cost Accounting / Material Flow Cost Accounting (Y/N)	Goal: Promoting good governance of sustainability management in resource consumption in the operation Boundary: Factory, partner, customer, consumer, community, related network Evaluate report and record in conducting full-cost accounting and material flow cost accounting in all system throughout product life cycle by beginning with determining the framework based on the organizational potential (it is not necessary to conduct all products, but the main products should be focused.), specifying time period clearly to use for internal and external organizational management and to conduct proactive management in reducing impacts on economic, environmental, social and good governance dimensions.
6. Ethics 6.1 Ethical behavior (Y/N) Anti-corruption (Y/N)	Goal: Ethics in running business Boundary: Factory, partner, customer, public, local and private network Evaluate record and organizational ethics guidelines, results of working performance and monitoring operation results reflecting cultures and ethics of personnel in the organization in different levels inside and outside the factory, with partners, customers, consumers and public, local and private networks. Evaluate international standards of compliance, anti-corruption of the organization and management of solving complaints on different aspects, especially on anti-corruption of the organization. Evaluate the result of ethic test (% of examiner per total personnel, received scores).

Result of survey could be summarized as follows:

The result of section 2: Opinions of target industries towards SCP indicator development (draft 3) based on the circular economy principle for Thai industries as shown in Table Appendix B-3.

1) Environmental Dimension

(1) The number of indicators should be reduced to promote the emphasis on objective achievement and feasible benchmark.

(2) Indicators should be categorized into subordinate indicators, such as materials, energy, waste etc. Materials indicator should be divided two groups including % virgin materials and % circular materials (i.e., recycle materials, renewable materials, and symbiosis).

(3) It is seen that many subordinate environmental indicators were changed to consistent with the circular economy principle which entails less emphasis or reduction on indicators in other dimensions.

(4) Some terms, such as energy symbiosis, wastewater symbiosis, hazardous materials, recycling materials consumption, material recyclability, renewable material, eco design and sustainable product require explicit definition.

(5) Inventory should not be a part of indicator sets, and the inventory information of materials should be confidential for a factory.

(6) Some calculation methods of data collection and implementation of boundaries through supply chain of indicators, such as greenhouse, environmentally friendly design, air emission, technology, suppliers, and logistics should be revised.

(7) Sub-indicators, such as environmentally friendly design, eco design and product take-back policy are not practical and applicable for the intermediate product types (business to business).

(8) The sub-indicators including environmental spending, investment and management should be moved to the economic dimension, and the green area or buffer zone indicators should be extended to implementing throughout industrial estates group as Eco Factory indicators requires increasing green areas of surrounding community of the factory.

(9) Indicators related to material sources, such as material import reduction, should be added by considering ability in reducing materials import from looking for materials substitutes in the country. This can contribute the national economy on material import substitution and value-add benefits.

2) Social Dimension

(1) The turnover rate (%) sub-indicator should not be included in employee indicators as it does not have direct relationship to the organization efficiency directly. In addition, it does not directly reflect the goal of circular economy principle. Nondiscrimination sub-indicators should cover the nationalities, religions, and minorities/natives. Moreover, the specified child labor should be more defined to cover the forced labor.

(2) The security and safety at work indicators should not include sub-indicators on ergonomics due to the subjective evaluation and limited operation capability when the indicators are implemented in the large-scale factory. The monitoring criteria should be specified in the sub-indicators of health and security, safety, elimination of hazardous workplace, absence due to injures or work-related illness by using static records including Injury Frequency Rate (IFR), Injury Severity Rate (ISR) in calculating in order to be able to conduct the benchmark between factories. Besides, severe accidents and management system standards should be specified as sub-indicators.

(3) Not only employing people from the surrounding community based on the indicators should be emphasized, but the internal employment of the factory should also be added in the community and stakeholder indicator. Furthermore, the investment to benefit community corporate social responsibility should be moved to economic dimension.

(4) Social indicators should be measurable and monitorable. Indirect impacts of social indicators, such as crating job and providing opportunity to access standard quality of recycle product or services should be able to be considered.

3) Economic Dimension

(1) The economic dimension should explicitly be adjusted by considering and moving overlapped economic indicators or sub-indicators in other dimensions to the economic dimension.

(2) Gross revenue, profit and investment indicators are confidential information for company. These indicators have no relationship to the sustainable development, only some of their sub-indicators including environmental expense, sustainable process innovation and green procurement are partially consistent with the sustainable development. The economic dimension should account on the relationship between investment, creating revenue and expenditure related to sustainability, not on general accounting. If there are many factories in the area, the separated distribution of factory expenditure will be too difficult and unable to evaluate its operation.

(3) The definitions of investment indicators, such as % overall equipment efficiency (OEE), should be clarified. Data collection of large-scale factories which may have 100-1000 units of machines installed is unable to cover every unit.

(4) The measurement of local supplier sub-indicator in monetary unit cannot indicate environmental impacts based on the goal. Therefore, measurement should not compare this unit. In addition, sub-indicators on green procurement and environmentally friendly products under ISO 14000 do not cover all industries which may conduce obstacles in operating indicators of some industry sectors.

(5) Green procurement sub-indicator should include the ISO 20400 sustainable procurement standard as there is no indicator of products and services involving circular economy principle directly.

4) Good Governance Dimension

(1) All indicators with subjective measurement may not be able to meet the assessment efficiency toward to improvement direction. The framework and guideline of Environmental Social, and Good governance (ESG) indicators

development should correspond to the circular economy and waste management business context.

(2) The operation of ethics indicators should be combined with ethical trade issues, such as fair trade, monopoly markets aspect, blocking SME or start-up business by excluding the personnel issue or labor relations aspects.

(3) Transparency indicators and related issues, such as code of practices, stakeholder analysis, and stakeholder participation should apply the management of change sub-indicator to evaluate stakeholder impacts.

(4) Anticorruption and bribery ISO 17001 standard, sustainability report or sustainable development report based on the Eco Factory scheme or GRI standards should be added in the good governance dimension.

(5) Risk management indicator should follow ISO 18000 standard and monitoring by using the guideline of the Committee of Sponsoring Organizations of the Treadway Commission (COSO).

5) Other Comments

(1) The SCP indicator development based on the circular economy (CE) principle should contain the indicators focusing on the sustainable development according to SCP 12 SD Goals and or CE principle without diversifying and duplicating indicators of other issues which entails proper number of indicators to proceed.

(2) The CE and SDG frameworks having appropriate criteria for developing indicators for various industrial sectors should be carefully specified to suit specific implementation and industrial type of each industry sector.

(3) There should be an additional definition for similar sub-indicators. For example, the similar terms including recycling, remanufacturing and recovery technique should provide clear definitions and boundaries.

(4) The SCP indicators should compare with existing standards related to SD indicators, such as the SD report proposed by the Stock Exchange of Thailand (SET) or the Dow Jones Sustainability Indices (DJSI). Moreover, these indicators

should be aligned with the Eco Industrial Town requirement to enhance implementation concretely.

(5) The SCP indicators may be a good tool and proper indicators for the large-scale industries in achieving the sustainable development goals. However, data collection for these indicators may be difficult for small-scale and medium-scale industries in implementing.

The result of section 3: Opinions of Thai entrepreneurs towards SCP indicators level classification in responding national and international SD goals by assessing SCP indicators reporting.

1) There are 20% of participants disagreed with classifying SCP indicators, and this result can be concluded into three level including good, very good and excellent. The participants' reasons of disagreement and suggestions on the SCP indicator report and category report are as follows:

2) The SCP indicators should be specified to suit each type of industry as all indicators may not be applicable to all types of industry, and there should be specifying the industrial levels for beginners. Annual operation of the factory in each year may have some indicators which may not be able to achieve the goals. Therefore, there should be criteria for specifying levels based on scores in each indicator.

3) There should be the analysis and level specification according to the scale of industry (i.e., small, medium and large industry). In addition, indicators should be classified as materiality based on types of industry.

4) There are several suggestions for SCP indicators' level specification ranking into level of 1 - 4. Percentage and score interpretation in evaluating can be divided into levels as presented in Table 4.7 below.

Table 4.7 The percentage and score interpretation of industrial level specification

No.	Number of Level Specification Criteria	Interpretation
1	3	Level 1: Integration < 50% Level 2: Good 51 < x < 80 Level 3: Best practice 81 < x < 100
2	3	Level 1: Good ≥ 70 scores Level 2: Very Good ≥ 80 s cores Level 3: Excellent ≥ 90 scores
3	4	Level 1: Require improvement Level 2: Good Level 3: Very Good Level 4: Excellent

1) In each level of indicator, the specification criteria should precisely measure the industrial levels. For Good level (beginner) does not have to achieve all indicators. The level specification criteria should be flexible for implementation of specific industry as some indicators cannot be applicable in some special situations, such as some industries in Thailand are in a phase of rehabilitation from the COVID-19 pandemic. Thus, the Cascade criteria should be employed to measure the progress of implementing the indicators. For instance, if the factory needs to be in Very Good level, it is required to pass all criteria in the Good level in order to progress indicators in all dimension simultaneously.

2) The indicator report will promote advantages and disadvantages in running business. Therefore, if the indicator report has to be conducted, it should be compulsory. For example, conducting reports for listed companies must allocate sufficient and appropriate indicators as well as there should not be too many indicators so that companies of different scales can follow and operate the indicators without difficulties. If the company can operate well, there should be complimenting or awarding.

3) The SCP indicators of Thai industries should be developed to be a standard, and there should be specifying public organizations for evaluating the indicators in order to make the evaluation reliable, can build confidence to industries

implementing the indicators as well as create incentives for operations of the industries in each level to mobilize indicator implementation.

The result of section 3: Recommendations for SCP indicator development based on the circular economy principle for Thai industries benefiting industrial development in the future and other issues of mobilizing indicator development in the future.

4) There should be piloting indicators in the pilot-ready industries and reviewing obstacles and difficulties for monitoring each indicator in order to gain information conveniently before the results are expanded. In addition, there are supports from financial sector, educational sector and public sector in piloting the sustainable development of SCP indicators. The result expansion also provides guidelines for developing and enhancing interesting indicators not only the self-report indicator, and ease for implementing in the larger scale. Besides, the indicators should be applied in industrial rehabilitation after the COVID-19 pandemic.

5) There should be committees from the related sectors in reviewing indicators, and the review should be conducted periodically, such as every 3 years of conformity assessment (e.g., inspection, certification, or verification to promote the positive images for the industry and related networks).

6) The SCP indicators suit the implementation in the organizations that applied CE Guideline for Organization proposed by TISI in their performance evaluation.

7) The indicators should be organized based on industrial sectors or industry group by considering Business Continuity Management (BCM) in the indicators. The disclosure to the public of some indicators entails business risk; therefore, there should be the minimum disclosure for some indicators and considering information disclosure in the international level if needed (e.g., GRI) may be later conducted. As observed, the industries required to disclose more information than it should be, they will have less interest in engagement.

8) The public sector should support the growing factories which are in the same business chain, and in the same location or business area in order to ease creating symbiosis in collaborating in business-to-business project development.

9) The indicator development information center should be established to develop indicator implementation to achieve the goals. For example, the public sector should provide on-site workshop for the small-scale factories, which may have insufficient labors and other difficulties, to support and motivate them in different aspects.

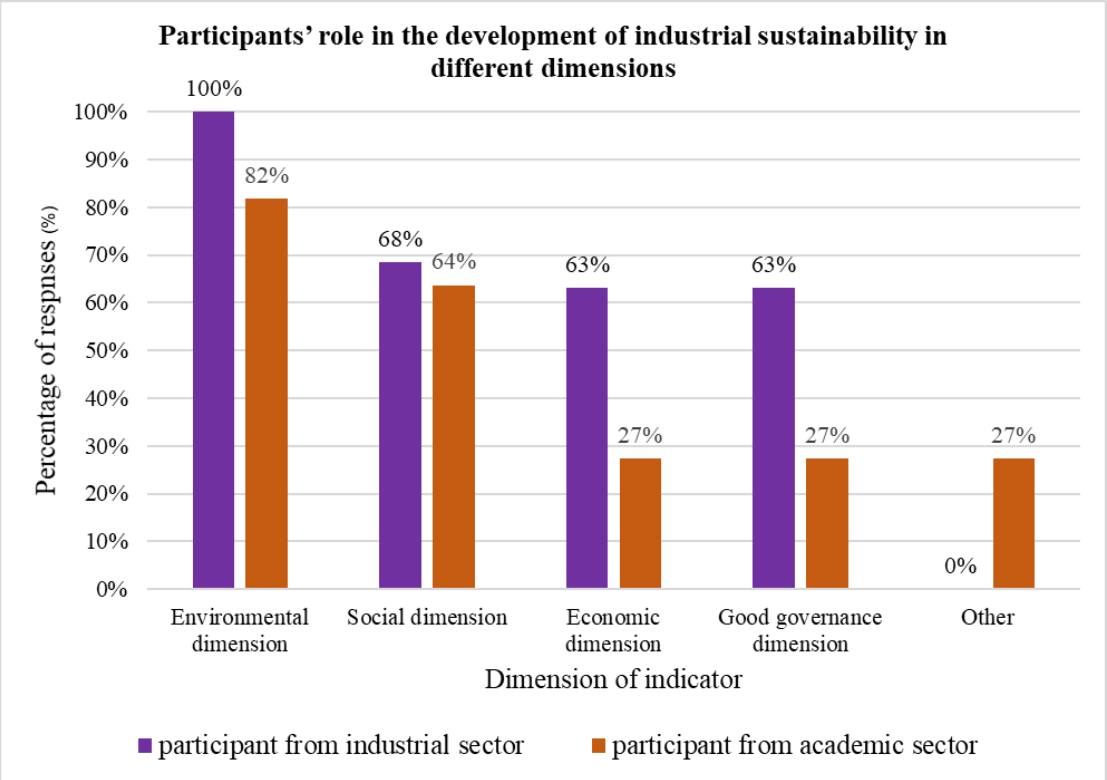

Figure 4.20 Percentage of responses on participants' role in developing, collecting data, and giving advice in the development of industrial sustainability indicators of the organization or industry in different dimensions

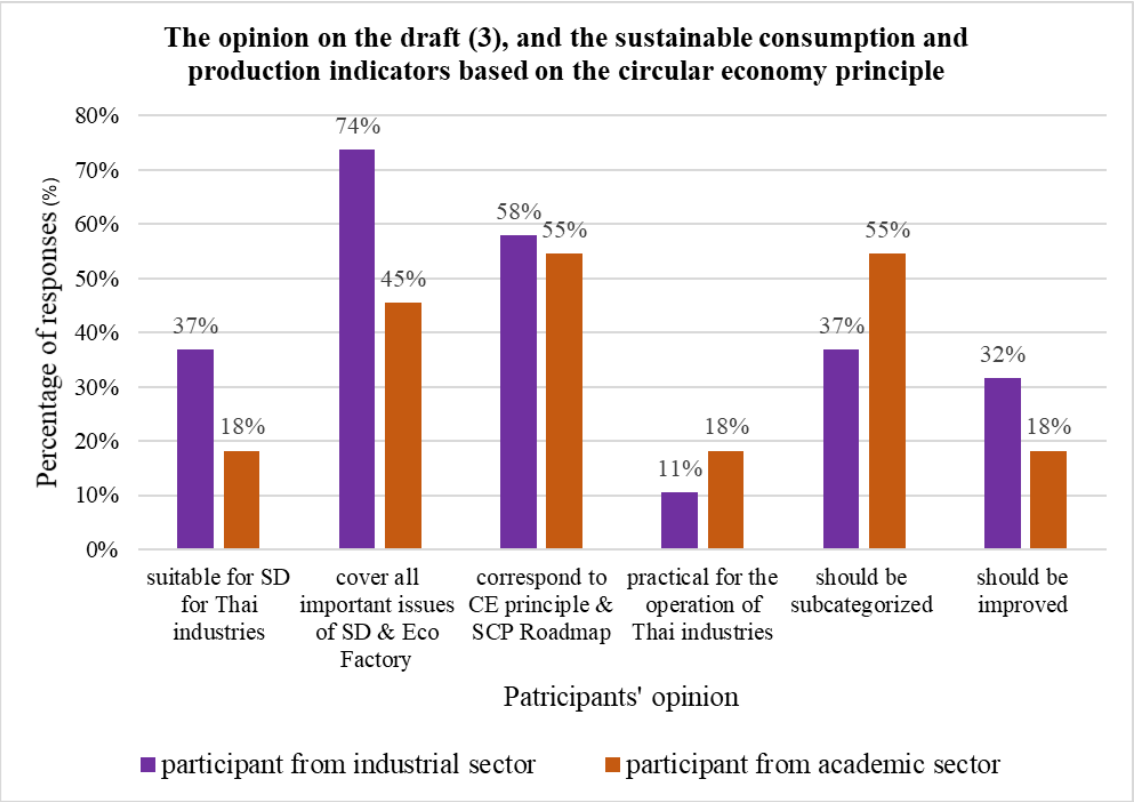

Figure 4.21 Percentage of responses on participants' opinions on the draft (3), and the sustainable consumption and production indicators based on the circular economy principle

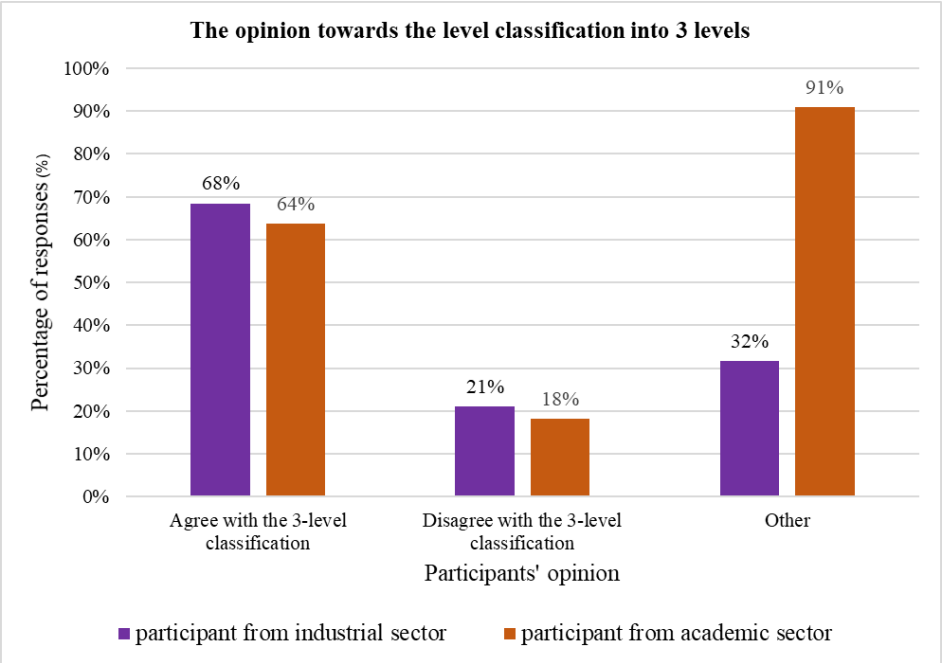

Figure 4.22 Percentage of responses about the opinions towards the levels of indicator classification

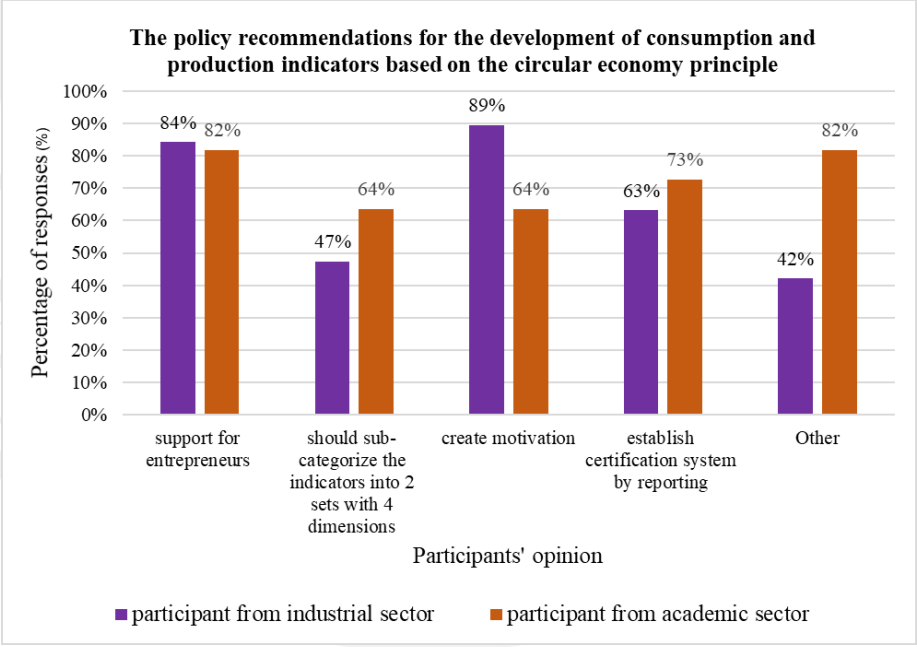

Figure 4.23 Percentage of responses on the policy recommendations for the development of consumption and production indicators based on the circular economy principle

Final Version of SCP Indicator Justification for Adjustment

The SCP indicators based on circular economy for Thai industries under the sustainable development framework are formulated in four pillars including environment, society, economy and good governance. The indicators and sub-indicators in the final version were as below.

1) There are 26 indicators with 60 sub-indicators

2) Percentage of indicators could be presented as 42.3% of environmental indicators, 15.4% of social indicators, 19.2% of economic indicators, and 23.1% of good governance indicator.

3) Percentage of sub-indicators comprised 53.3% of environmental sub-indicators, 18.3% of social sub-indicators, 15% of economic sub-indicators, and 13.4 % of good governance sub-indicators.

4) Environmental dimension contained 11 sets of indicators with 32 sub-indicators, Social dimension contained 4 sets of indicators with 11 sub-indicators, Economic dimension contained 5 sets of indicators with 9 sub- indicators, Good governance dimension contained 6 sets of indicators with 8 sub-indicators

The number of set of indicators were equal to other studies recommend for the industrial sustainable development. The final version of SCP indicators based on circular economy enhancing four pillars of sustainable development for industry of the research can be concluded as below.

1) Environmental indicators should be able to monitor resource efficiency by measuring resource intensity, materials circularity, and renewable materials and energy. There should be the reduction of emission, waste reduction, symbiosis, logistics efficiency, technology and eco innovation in the sustainable production and cleaner production as well as eco label product and environmentally friendly supplier in the sustainable consumption.

2) Social indicators should be able to integrate corporate responsibility to all stakeholders by covering employees, customers and consumers as well as communities.

3) Economic indicators should be enhanced on the sustainable economy by monitoring gross revenues, profit, expense, cost, R&D investment, overall equipment efficiency to evaluate investment of machine and green purchasing spending to extend sustainable development commitment and green partnership opportunities.

4) Good governance indicators should support the environmental, social and economic integration which can strengthen the target achievement of the factory. Others dimensions and assurance organization towards the sustainable development should be specified in the corporate ethics, risk management, holistic management and ethics behaviors indicators.

The final SCP indicators compared with 1st draft SCP and justification adjustment to declare the indicators corresponding to the SCP and circular economy principles (see Table 4.5).

Table 4.8 Comparation between the 1st draft of SCP indicators and justification adjustment

The 1st draft SCP indicators	Final SCP indicators and justification SCP Roadmap and CE principles	
	Indicators	justification SCP Roadmap and CE principles
Environmental Indicators		
1. Resources/ Materials	1. Resources/ Materials	SCP 2: Resource Intensity
1.1 Materials management efficiency / the quantity of main materials used per income (Ton/Million baht)	1.1 Material intensity/the quantity of main materials used per product	SCP 4: Percentage of hazardous industrial waste managed by appropriate management system
1.2 Material usage / footprint (Ton or m^3)	1.2 Consumption of recycling material/product (weight/product), % virgin material/product, material recyclability (amount of material can be recycled/ total amount	CE principles: System Thinking, Stewardship, Value Optimization
1.3 Consumption of recycling materials (% virgin material)		
1.4 Hazardous materials/chemicals (Ton or m^3)		
1.5 Scrap rate (% of finished		

The 1st draft SCP indicators	Final SCP indicators and justification SCP Roadmap and CE principles	
	Indicators	justification SCP Roadmap and CE principles
product)	of material contain in product 1.3 % amount of renewable materials / total raw materials or % amount of material recyclability/ total raw material 1.4 % Symbiosis material/ total material (if applicable) 1.5 Percentage of hazardous materials/product or proportion of hazardous materials/materials used in production	
2. Energy 2.1 Energy management efficiency (kWh/Giga Joule/ Million baht) 2.2 Electricity / energy consumption (kWh/Giga Joule) 2.3 Energy intensity (kWh/product, K Joule/product) 2.4 Reduction of energy consumption (kWh/Giga Joule) 2.5 Use of renewable energy (% of total energy) 2.6 Symbiosis energy (Giga Joule)	2. Energy 2.1 Energy intensity/product 2.2 % Use of renewable energy/total energy 2.3 % symbiosis energy/total energy or % waste heat recovery/total energy (if applicable)	SCP 2: Energy Intensity SCP 9: Capacity of renewable energy in developing countries CE principles: System Thinking, Stewardship, Collaboration, Innovation
3. Water/Wastewater 3.1 Water and wastewater management efficiency (m^3/	3. Water/Wastewater 3.1 The volume of water consumption/ product,	SCP 2: Water intensity CE principles: Stewardship, Collaboration,

The 1st draft SCP indicators	Final SCP indicators and justification SCP Roadmap and CE principles	
	Indicators	justification SCP Roadmap and CE principles
Million baht) 3.2 Water consumption / total water withdrawal by sources (m^3) 3.3 Volume of water reused or recycled (m3/total used water or % of water consumption) 3.4 Volume of water discharge (m^3) 3.5 Symbiosis wastewater (m^3)	wastewater/ product, water intensity/ wastewater intensity (volume /product) 3.2 % Volume of water reuses or recycled / total water used 3.3 % Symbiosis wastewater/total wastewater (if applicable)	
4. Air / emission / gas emission / heat emission 4.1 Air emission management efficiency (kg SO_x, NO_x, VOC/ Million baht) 4.2 Emission of ozone-depleting substances (kg emission)	4. Air / emission / gas emission / heat emission 4.1 Volume or intensity of air emission below level indicated by the law (ppm SO_x, NO_x, VOCs others) 4.2 Intensity of particle matter emission/$PM_{2.5}$ (ppm)	SCP 4: Environmental impact compared to economic (NH_3, NMVOC, NO_x, SO_2, N, P) CE principles: Stewardship
5. Greenhouse gas management 5.1 Greenhouse gas intensity ($tonCO_2e$/ Million baht, Product) 5.2 Emission of CO_2 from factory / GHGs emission ($tonCO_2e$)	5. Greenhouse gas management 5.1 Greenhouse gas intensity ($kgCO_2e$/product) 5.2 Total GHG reduction from factory/year (compare reduction with base year)	SCP 4: Carbon dioxide emission form industrial sector annually CE principles: System Thinking, Stewardship
6. Solid waste 6.1 Solid waste inventory / profile / flow diagram (#) 6.2 Volume of solid waste (kg	6. Solid waste 6.1 Volume of solid waste/product, solid waste intensity (weight	SCP 5: Percentage of reuse and recycle industrial waste per total industrial waste CE principles: System Thinking,

The 1st draft SCP indicators	Final SCP indicators and justification SCP Roadmap and CE principles	
	Indicators	justification SCP Roadmap and CE principles
or m^3 of solid waste) 6.3 Solid Waste reuse / recycle (kg) 6.4 Waste reduction & disposal (kg or m^3 of hazardous waste)	/product) 6.2 % Solid waste (non-hazardous) reduction per year (compare reduction with base year) 6.3 Scrap rate (% of finished product) or percentage of non-standard products (if applicable)	Stewardship, Innovation, Value Optimization
7. Hazardous waste 7.1 Volume of hazardous waste / material (m^3)	7. Hazardous waste 7.1 Intensity of hazardous waste or Volume of hazardous material per product (weight/product)	SCP 4: Percentage of hazardous industrial waste managed by appropriate management system CE principles: Stewardship
8. Logistics 8.1 Transportation and logistics management efficiency (#) 8.2 Reverse logistics, customer returns (#)	8. Logistics 8.1 Transportation and logistics management efficiency (#) 8.2 Reverse logistics, customer returns management, closed loop management (#) 8.3 Number of accidents, complaints, and product transportation per year (#)	CE principles: Stewardship, Collaboration, Value Optimization, Transparency
9. Suppliers 9.1 Percentage of new suppliers that were screened using environmental criteria (% of total suppliers) 9.2 Significant actual and	9. Suppliers 9.1 Significant actual and potential negative environmental impacts in the supply chain and action taken (#/total	CE principles: System Thinking, Stewardship, Collaboration

The 1st draft SCP indicators	Final SCP indicators and justification SCP Roadmap and CE principles	
	Indicators	justification SCP Roadmap and CE principles
potential negative environmental impacts in the supply chain and action taken (# / total suppliers)	suppliers) 9.2 Number of suppliers providing environmentally friendly product and service procurement compared to total suppliers (#/total suppliers) 9.3 % new suppliers that were screened using environmental criteria / total suppliers (%) (if applicable)	
10. Product development / manufacturing 10.1 Quantity of recycling / reuse / remanufacturing (kg or m^3 of material) 10.2 Durability level (#) 10.3 Environmental friendly design / Eco-design (# of product) 10.4 Eco-innovations (# of product or project)	10. Manufacturing/ Technology 10.1 Recycling Technology (# of project) 10.2 Remanufacturing Technique (#) 10.3 Recovery Technique (#) 10.4 Eco-innovations (# of production process or project)	CE principles: System Thinking, Stewardship, Collaboration, Innovation
11. Sustainable product certification (materials, products) 11.1 Third Party Eco-Label (e.g., Green Label, Carbon Footprint, Water Footprint) (# of product) 11.2 Self-Declare (# of product)	11. Sustainable Product / Sustainable material 11.1 Environmentally friendly design/ Eco-design designed for disassembly, reuse or recycling/total product, durability level (# of product)	SCP 6: Number of products certified by Green Label SCP 6: Number of products certified by all types of Eco-labelling CE principles: System Thinking, Stewardship, Collaboration, Transparency, Value Optimization

The 1st draft SCP indicators	Final SCP indicators and justification SCP Roadmap and CE principles	
	Indicators	justification SCP Roadmap and CE principles
	11.2 Eco Label: Third Party Eco-Label (e.g., Green Label, Carbon Footprint, Water Footprint), Self-Declare (# of product)	
	11.3 Products with take-back policies in place or Extend product responsibility (# of product)	
12. Environmental spending/investments/ management		SCP 4: Percentage of hazardous industrial waste managed by appropriate management system
12.1 Green areas / buffer zone (% area)		CE principles: Stewardship, Collaboration
12.2 Environmental spending / protection expenditures and investments by type (monetary unit)		
13. Technology		CE principles: System Thinking, Stewardship, Innovation, Collaboration, Value Optimization
13.1 Recycling technology (# of project)		
13.2 Remanufacturing technique (#)		
13.3 Recovery technique (#)		
Social Indicators		
1. Employees	1. Employees	CE principles: System Thinking, Stewardship
1.1 Turnover index (#)	1.1 Turnover index (#)	
1.2 Proportions of permanent staffs and temporary staffs (#)	1.2 Nondiscrimination / Inclusion including gender/age/sexual/ religion / forced label child labor	
1.3 Discrimination/male to female ratios/gender/age/sexual/child labor (%male, %female)		

The 1st draft SCP indicators	Final SCP indicators and justification SCP Roadmap and CE principles	
	Indicators	justification SCP Roadmap and CE principles
1.4 Wages and benefits (% ratio) 1.5 Programs for skills management and lifelong learning / indigenous knowledge / training of the employees (in hours) / capacity development / sustainable awareness (#)	1.3 Programs for skills management and lifelong learning/indigenous knowledge/training of the employees (in hours)/capacity development/ sustainable awareness (#)	
2. Security and safety at work 2.1 Health and security / safety / elimination of hazardous workplaces/ergonomics / absence due to injuries or work-related illness / deaths / effective occupational health and safety management for staffs and related persons (Y/N, # of day absence, # of days) 2.2 Ergonomic (#) 2.3 Healthy working environment (e.g., air, sound, light)	2. Security and safety at work 2.1 Health and security / safety / Elimination of hazardous workplaces/ Absence due to injuries or work-related illness / Deaths / effective occupational health and safety management for personnel and related persons (Y/N, # of day absence, # of days) 2.2 Healthy working environment (e.g., air, sound, light, Ergonomic)	CE principles: System Thinking, Stewardship, Transparency
3. Clients/consumers 3.1 Number of complaining consumers (#) 3.2 Total number of incidents of non-compliance with regulations and voluntary codes concerning marketing communications, including advertising, promotion, and	3. Clients/consumers 3.1 Number of complaining consumers (#) 3.2 Total number of incidents of non-compliance with regulations and voluntary codes concerning marketing	CE principles: Stewardship, Transparency

The 1st draft SCP indicators	Final SCP indicators and justification SCP Roadmap and CE principles	
	Indicators	justification SCP Roadmap and CE principles
sponsorship, by type of outcomes (#)	communications, including advertising, promotion, and sponsorship, by type of outcomes (#)	
4. Community and stakeholders 4.1 Engagement of the community / living with the surrounding community (Y/N) 4.2 Local partnerships / Integration to the society (Y/N) 4.3 Investments to benefit community / income distribution to the community (Y/N)	4. Community and stakeholders 4.1 Engagement of the community / living with the surrounding community (Y/N) 4.2 Local partnerships / Integration to the society (Y/N) 4.3 Investments to benefit community Corporate Social responsibility / income distribution to the community (Y/N) 4.4 Creating shared value (Y/N)	CE principles: Stewardship, Transparency, Collaboration
Economic Indicators		
1. Gross revenue 1.1 Gross revenue value (Monetary units)	1. Gross revenue 1.1 Gross revenue value (Monetary units) (Y/N)	CE principles: Transparency, Value Optimization
2. Cost/expense 2.1 Employee / labor cost/ Expense with wages (Monetary units) 2.2 Ratios of standard entry level wage by gender compared to local minimum wage at significant locations of operation (%)	2. Cost/expense 2.1 Employee / labor cost/ Expense with wages (Monetary units) 2.2 Environmental expense (Green area/buffer zone (% area) biodiversity, disposal cost ,recycling cost, monitoring waste	CE principles: System Thinking, Transparency, Value Optimization, Innovation

The 1st draft SCP indicators	Final SCP indicators and justification SCP Roadmap and CE principles	
	Indicators	justification SCP Roadmap and CE principles
2.3 Expense with taxes / Payment to government (Monetary units) 2.4 Environmental expense (Monetary units) 2.5 Operational expense (Monetary units) 2.6 Energy cost (Monetary units) 2.7 Recycling cost (Monetary units) 2.8 Disposal cost (Monetary units) 2.9 Remanufacturing Cost (Monetary units)	expense) (Monetary units)	
3. Profit 3.1 Liquid profit (Monetary units) 3.2 Retained earnings (Monetary units)	3. Profit 3.1 Liquid profit (Monetary units) 3.2 Retained earnings (Monetary units)	CE principles: Transparency, Value Optimization
4. Investments 4.1 Overall equipment Efficiency (%) 4.2 Investment in R&D activities / technology transfer (Monetary units) 4.3 Sustainable process innovation (Monetary units)	4. Investments 4.1 Overall equipment Efficiency (%) 4.2 Investment in Eco innovation activities (R&D Sustainable process, Technology Transfer (Monetary units)	CE principles: System Thinking, Value Optimization, Innovation, Stewardship
5. Suppliers 5.1 Local suppliers / spending on local suppliers (#) 5.2 Local Procurement / product procurement or services from	5. Suppliers 5.1 Local suppliers / spending on local suppliers (#/Monetary units)	CE principles: Collaboration, Stewardship

The 1st draft SCP indicators	Final SCP indicators and justification SCP Roadmap and CE principles	
	Indicators	justification SCP Roadmap and CE principles
the community (#)	5.2 Green Procurement (Monetary units/ year) 5.3 Sustainable Procurement ISO 204000	
Good Governance Indicators		
1. Corporate ethics 1.1 Mission statement (Y/N)	1. Corporate ethics 1.1 Mission Statement, Code of conduct (Y/N), operation under ISO26000 CSR DIW, OECD Guideline CSR	CE principles: Stewardship, Transparency
2. Accountability 2.1 Transparency (Y/N)	2. Accountability 2.1 Transparency (Y/N), Sustainability report GRI	SCP 6: Operation of quality assessment for disclosure of listed companies for development. CE principles: Stewardship, Transparency
3. Participation 3.1 Stakeholder dialogue (#) 3.2 Grievance procedures (Y/N)	3. Participation 3.1 Stakeholder dialogue (#) 3.2 Grievance procedures (Y/N)	SCP 6: Operation of quality assessment for disclosure of listed companies for development. CE principles: Collaboration, Stewardship, Transparency
4. Risk management 4.1 Sustainable Risk Management Action Plan (Y/N)	4. Risk management 4.1 Sustainable Risk Management Action Plan (Y/N) Risk Management ISO 38000	SCP 6: Operation of quality assessment for disclosure of listed companies for development. CE principles: System Thinking, Innovation, Stewardship, Innovation, Value Optimization
5. Holistic management 5.1 Sustainability Management Plan (Y/N) 5.2 Full-cost accounting / material flow cost accounting (Y/N)	5. Holistic management 5.1 Sustainability management plan (Y/N) 5.2 Full-cost accounting / material flow cost accounting (Y/N)	SCP 2: Percentage of factory / industrial estate using Material Flow Analysis (MFA) CE principles: System Thinking, Innovation, Stewardship, Innovation, Value Optimization

The 1st draft SCP indicators	Final SCP indicators and justification SCP Roadmap and CE principles	
	Indicators	justification SCP Roadmap and CE principles
6. Ethics 6.1 Ethical behavior (Y/N) 6.2 Anti-corruption (Y/N)	6. Ethics 6.1 Ethical behavior (Y/N) 6.2 Anti-corruption (Y/N) ISO 37001	CE principles: Stewardship, Transparency

4.5.3 Summary the Final Version of SCP Indicators

The 3rd draft of SCP indicators was developed and verified by the 5 activities described in 4.3, 4.4 and.4.5.1 From those activities the industries had opinions towards the obstacles of implementing the SD indicators similar to the experts, Eco Factory working group, and public sectors. Regarding the obstacles of implementing the indicators based on the Eco Factory criteria containing 14 criteria, the experts claimed that there were obstacles on 11 criteria in implementing the indicators (such as biodiversity, materials management and green supply chain, Green landscape management) which was consistent to most stakeholders. The obstacles of the implementation based on the same criteria were encountered by both groups the experts and the industry. The specified obstacles were significant as the industrial entrepreneurs who gave opinions towards the improvement are in the manufacturing companies in the large-scale upstream industries that utilize the intense and modern production technology as well as have readiness of human resources and capitals. Moreover, some of them have conducted the report based on the GRI international sustainability reporting and they are in the DJSI List. Thus, the obstacles were mainly on Eco Factory criteria.

All comments and suggestions were taken into consideration to improve the indicators. In summary, the final version of SCP indicators for sustainable development for Thai industries consisted of 4 dimensions (26 sets of indicators, 60 sub-indicators) as follows:

1) Environmental dimension (11 sets of indicators, 32 sub-indicators): These indicators corresponded to the indicators in SCP Roadmap on 5 goals out of 8 goals for manufacturing sector, CE principle, system thinking, innovation, value

optimization, and stewardship in terms of indicator operation by covering Life Cycle Thinking , impacts of product life cycle, efficiency of resource consumption, intensity renewable materials and renewable energy, hazardous material, % symbiosis, waste and wastewater, energy intensity, greenhouse gas management, logistics, technology and supplier.

2) Social dimension (4 sets of indicators, 11 sub-indicators): These indicators expressed the social responsibility of the organization that reflected the sustainability of the organization responsible to stakeholders in all dimensions as well as the creation of collaboration, stewardship and transparency for worker, customers, consumers, communities, and employees based on the CE principles.

3) Economic dimension (5 sets of indicators, 9 sub-indicators): These indicators could track the economic sustainability of the organization which were revenues and profits, employment expense, environmental expense, the investment on research and development, Eco innovation, technology transfer and machine usage efficiency, green procurement and local procurement.

4) Good governance dimension (6 sets of indicators, 8 sub-indicators): These indicators strengthened sustainable development of the organization with the indicators of corporate ethics, ethical behavior, accountability, sustainable risk management action plan, holistic management and participation. Furthermore, these indicators helped tracking whether the operation of the organization was sustainable and efficient. Figure 2 showed the final version of SCP indicators in 4 dimensions.

The number of set indicators were equal to other studies recommend for the industrial sustainable development (Feil et al., 2019). The important perspectives of stakeholders towards the sustainable development framework emphasized on environmental issues and gave higher weight on economic indicators in Eco efficiency than other indicators, such as indicators of technology and production equipment investment efficiency or social indicators. The sustainable development needed to create balance in all dimensions simultaneously; therefore, there should be sufficient indicators to monitor and evaluate the sustainable development progress in short term, medium term, and long term. (Garbie, 2016)

CHAPTER 5

CONCLUSION, DISCUSSION AND RECOMMENDATIONS

This study aimed to develop sustainable development indicators corresponding to the 20-year SCP Roadmap which indicates goals and indicators for the industrial sector in Thailand as well as the circular economy principles which is a long-term strategic plan of Thailand at present purposing the national industrial development goals, such as the BCG Model which is an integration of bioeconomy, circular economy and green economy.(National Science and Technology Development Agency, n.d.)

Nowadays, the indicators for Thai industries for the sustainable development corresponding to the sustainable development plan and direction are understudied. Therefore, this research was conducted on the target industrial sector where the sustainability indicators are voluntarily implemented under the project of Eco Factory FTI, and it is accepted by the public sectors in supporting the development plans of the Eco Industrial Town (EIT) as well as the Sustainability City. (Federation of Thai Industries and Industrial Estate Authority of Thailand, 2018)

There were 2 objectives in the current research. The first objective was to investigate sustainable consumption and production indicators for industries nowadays as well as difficulties and limitations in using the indicators conducting on Eco-Factory case studies in the Industrial Estate Authority of Thailand and the Federation of Thai Industries. The second objective was to develop sustainable consumption and production indicators for Thai industries based on the Sustainable Consumption and Production Roadmap 2017-2037 (Revised Version) and circular economy principles.

This research employed the stakeholder involvement on the target group to exchange the experiences in developing indicators through the in-depth interview, focus group meeting as well as seminar and workshop.

The research achieved the objectives and the sustainable indicator development of SCP indicators based on the circular economy principles. The entrepreneurs and public-sector representatives of the Federation of Thai Industries who participated in the current research provided the recommendations and comments on the improvement of the sustainable development indicators of the factory, the Eco Factory indicators and the Eco Industrial Town indicators in order to correspond to the circular economy principle which is the sustainable competitive direction of Thai industries. The limit of study is majority of industries size joined the researched were large scale size. In 2018, Thai manufacturing consisted of 2,152 large scale firms and 527,485 small and medium scale firms.(Korwatanasakul Upalat & Paweenawat Sasiwimon Warunsiri, 2020) In this research, the industrial sector recommended to implement the developed SCP indicators to be a pilot project to be suitable practical guidelines in providing information and resources as well as encouraging motivation of the industries in implementing the sustainable development indicators. Accordingly, the further studies should investigate developing sustainable development indicators for large-scale, medium-scale and small-scale industries, establishing indicators as a framework for all industries which can concurrently implement with the specific indicators of industrial group and indicator data collection suitable for working operation, studying Sustainability Assessment simultaneously with indicator development using Econometrics in evaluating indicators in association contexts between environment, society and economy, and developing in each aspect of sustainability, such as environmental sustainability, economic sustainability, social sustainability to promote sustainable development integration.

5.1 Conclusion

This qualitative study was conducted using the grounded theory as well as top down and bottom-up approaches in developing indicators. These approaches are

accepted as a suitable for the indicator development for practical implementation. (Chamaret, O'Connor, & Récoché, 2007; Feil et al., 2019; Hristov & Chirico, 2019; Khadka & Vacik, 2012) The target group in the current research including 8 groups of industries certified as an Eco Factory having 64% of gross domestic product (GDP) original from manufacturing at current market prices in 2017(Thailand Textile Institute, 2019). The groups comprise of 168 industries including industries of food products, coke and refined petroleum products, chemicals and chemical products, rubber and plastic products, computer, electronic and optical products, electrical equipment, motor vehicles, trailers and semi-trailers and other transport equipment which obtain Certificate of the Green Industry Level 4 or as 67% of the total number of 247 Eco Factory (in November, 2020).

The research reviewed literature on the development of SD indicators for international industrial sectors and the accepted SD indicator standards, such as the international academic studies, Eco Factory criteria, SCP roadmap, CE principle. The indicators development in the current research employed three surveys of stakeholders including target industries, Eco Factory working group, related government and experts. In addition, the in-depth interview was conducted on industries, and the focus group meetings was conducted on experts and governments who are responsible for Eco Industrial Town promotions. The duration of the surveys, focus group meetings seminars and workshops to receive recommendations and comments from stakeholder involvement was 4 months from December 2020 to March 2021. There were 30 participants who are representative of 76 factories from the industrial sector as well as around 40 participants who are experts, public-sector representatives and others. The research achieved the objectives as follows:

The results of the implementation based on Eco Factory criteria of the industrial sector revealed 35% of needs on improvement and there were two major obstacles of indicator implementation from 20 participants as follows:

1) The highest obstacle was on material consumption indicators and green supply chain indicators having 35% of participants opinion.

2) The obstacle on energy indicators with 25%, biodiversity indicators with 25% and income distributions to community indicators with 25%.

Meanwhile, the benefit of the sustainable development of the organization was 65% as well as there were reduction of resource expense and promotion of positive image to communities and customers which could create more systematic development plans, and environmental resource and emission management goals.

In the current research, the 26 sets of indicators with 60 sub-indicators were developed, and these indicators could be categorized by dimension as follows:

1) Environmental dimension having 11 sets of indicators with 32 sub-indicators

2) Social dimension having 4 sets of indicators with 11 sub-indicators

3) Economic dimension having 5 sets of indicators with 9 sub-indicators

4) Good Governance dimension having 6 sets of indicators with 8 sub-indicators

The boundaries and data collection framework were specified and defined in each indicator in order to benefit the implementation of the industrial sectors in the future. Final SCP indicators were correspondent with Circular Economy principles and accounted for by sub indicators as bellows

1) System thinking principle 12 sub indicators
2) Innovation principle 6 sub indicators
3) Stewardship principle 24 sub indicators
4) Collaboration principle 15 sub indicators
5) Value optimization principle 9 sub indicators
6) Transparency principle 8 sub indicators

According to the research, the SCP indicator development based on CE principle to evaluate the sustainable development for Thai industries consists of 4 dimensions including environment, society, economy and good governance. The first 3 dimensions out of the interrelated 4 dimensions were consistent with the Triple Bottom Line (TBL) framework for sustainable development consisting of 3 TBL of People, Planet and Profit, defined by Elkington (1998) as a nested spheres model having environmental, social and economic dimensions that overlap in the middle entailing the sustainable development of the organization, or the Venn diagram having similar dimensions but having some limitations due to the inability to prioritize

operations on each organizational dimension.(Barbier & Burgess, 2017; Correia, 2019) In this research, the proposed model integrates the 3 TBL and the Venn diagram to exhibit the association of SCP indicators as shown in Figure 5.1 (Venkatasamy R., n.d.).

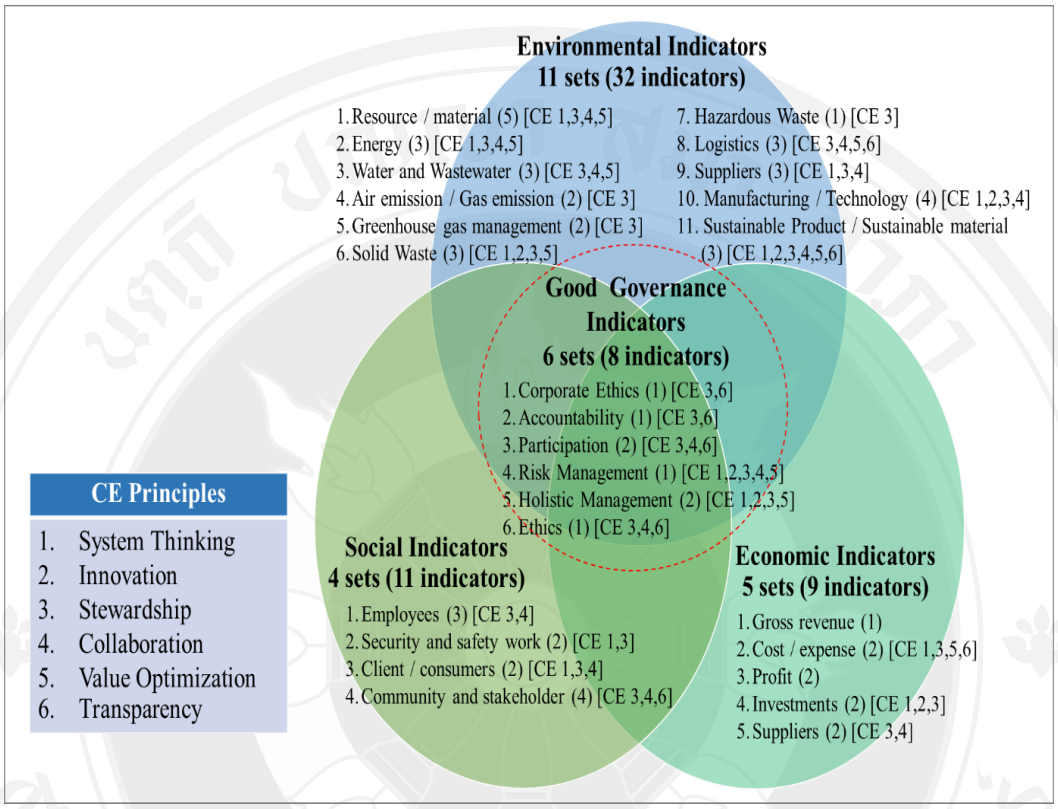

Figure 5.1 Sustainable Consumption and Production Indicators for Industrial Sector According to Circular Economy Principles in Thailand

Table 5.1 Final sets of SCP indicators identified according to the 6 CE principles

CE Principles	Environmental	Social	Economic	Good Governance	Total
1. System Thinking	6	2	2	2	12
2. Innovation	3	n/a	1	2	6
3. Stewardship	11	4	3	6	24

CE Principles	Environmental	Social	Economic	Good Governance	Total
4.Collaboration	7	3	1	4	15
5.Value optimization	6	n/a	1	2	9
6. Transparency		1	1	4	8

The roles of indicators in each dimension can be explained as follows:

1) The good governance dimension has indicators interrelated in three dimensions. It creates the system of strengthening sustainable development of the organization as the indicators of corporate ethics, ethical behavior, accountability and participation can efficiently track the operation of the indicators in social, environmental and economic dimensions.(Aras & Crowther, 2008) Concurrently, the indicator of Sustainable Risk Management Action Plan can track the organizational sustainability management, control resource and energy consumption and waste in order to promote the worthiness in the economy and environment. Additionally, the indicators in three dimensions play a role in the operation of the organization.

2) The environmental dimension contains 11 sets of indicators and 32 sub-indicators corresponding to the indicators in SCP Roadmap on 5 goals out of 8 goals for manufacturing sector. This dimension covers the efficiency of resource consumption in terms of intensity per product and percentage of consuming materials, renewable materials and renewable energy, hazardous material, percentage of symbiosis, waste and wastewater, energy intensity, greenhouse gas management and supplier. These sets of indicators can be counted as tracking the operation of the industry related to the sustainable consumption as a consumer of resources and energy in manufacturing, and the sustainable production as the indicators are implemented to reduce production drawbacks, consume renewable materials, and reduce waste in the production by utilizing eco-innovation technology in recycling remanufacturing and recovery to produce sustainable product and sustainable materials corresponding to the circular economy principle. Meanwhile, the indicators of reverse logistics can support the closed-loop materials and product management that circulates resources in the production. The indicators correspond to CE principle, system thinking, innovation, value optimization, and stewardship in terms of indicator operation by

covering Life Cycle Thinking concerning the impacts throughout the product life cycle.

3) The social dimension consists of 4 sets of indicators and 11 sub-indicators that express the social responsibility of the organization in the dimension of non-discrimination in the organization based on religion, gender or disability who are responsible for consuming resources in the manufacturing efficiently and receive the potential development along with promotion of awareness on sustainable development, safety at work, attempt to maintain personnel in the system by examining employee resignations to improve the efficiency of the organization, responsibility in living with community and stakeholders, consideration of satisfaction of customers and consumers that can reflect the sustainability of the organization responsible to stakeholders in all dimensions as well as the creation of collaboration, stewardship and transparency for customers, consumers, communities and employees based on the CE principle.

4) The economic dimension comprises 5 sets of indicators and 9 sub-indicators that track the economic sustainability of the organization as there are indicators showing revenues and profits along with the indicators exhibiting employment expense and environmental expense which may have both positive and negative economic impacts on the organization. For example, the high expense of waste treatment can cause negative impacts, or low recycling expense can entail opportunities to create business efficiencies. The indicators of investment and machine usage efficiency can help the organization evaluate the investment worthiness of using new machinery in manufacturing or management based on CE in bringing the existing machines not being used to their full potential by sharing with other organizations. The indicators can also help evaluate the investment in research and development of Eco innovation in production and technology transfer. In addition, the supplier indicators reflecting green procurement and local procurement can provide opportunities for the organization in the long-term sustainable development in terms of creating opportunities for production potential development as well as environmentally friendly trade.

5.2 Discussion

This part describes the result of the development of SCP indicators based on the circular economy principle by integrating with processing opinions of stakeholders who have been working under the sustainable industrial development of Thailand for over a decade. This data can help the researcher discuss issues related to the research questions and objectives by integrating experiences on the sustainable industrial development in different related aspects. However, the SCP indicators developed in this study are based on CE principles adhering to international approaches of the sustainable development industry. (Banaitė & Tamošiūnienė, 2016; Feil et al., 2019) This discussion section that follows presents the analysis of the research results in relation to the work of other the researchers.

5.2.1 Eco Industrial Town Criteria for Eco Factory: Pressure from communities

The development of Eco Factory indicator criteria is derived from the development of Eco Industrial Town with 5 dimensions, 20 aspects and 41 indicators.(Industrial Development Division, 2019) The Eco Factory is one that adheres environmentally friendly operations for the sustainable development by emphasizing the development and improvement of production process as well as the environmental management on the basis of social responsibility inside and outside the organization throughout the supply chain continuously and sustainably.

This concept is the due to the pressure of industrial estates being located in areas with surrounding communities, resulting in conflict between the two groups. These communities are traditional agricultural communities or communities that migrate to areas near industrial sites and are later affected by environmental impacts such as air emissions, wastewater, as well as impacts upon their culture and way of life, especially from upstream and mid-stream industrial estates such as petrochemical industry, chemical industry and related industry in Map Ta Phut Industrial Estate, Rayong Province, during 1988-2006. This concept entails coexistence through mutual benefit between public, industrial and social sectors via the self-adjustment of stakeholders. Thus, the Eco Industrial Town development indicators emphasize the

coexistence between factory and community, especially in the dimension of responsibility to society and surrounding community as well as employment in the community area.

Almost all industries in Map Ta Phut Industrial Estate are a large-scale industry and upstream or mid-stream industrial estates. Over the past decade, these industries have collaborated in the form of a Community Partnership Association (CPA), conducting social responsibility activities in the area that strengthen community quality on the education of youth, public health and community enterprise career promotion. In addition, the CPA encourages members to obtain Eco Factory certification. As of March 2021, 76 CPA members had sought to obtain certification from the FTI, or 30.7%, of the total of 247 members. Therefore, the CPA managers are one of the Eco Factory working groups who play a role in developing and promoting Eco Factory. The CPA managers basically come from the middle management of a large-scale company who is a founding member of the CPA and responsible for managing CSR activities of CPA in the area. CPA manager is also a permanent position with 4-year terms of work that promotes the continuity of industrial resource allocation and involvement in CSR activities. Thus, the organization, cooperation or association can reduce problems as well as prevent impacts between factory groups and communities proactively. Hence, the CPA members are continually accepted by the communities, local public and private sectors and industries.

However, most members of the CPA which are the public companies listed on the stock exchange conduct sustainability reports based on the Global Reporting Initiative (GRI) and Dow Jon Sustainability Index (DJSI) standards that create confidence among investors in the stock exchange towards the organizational sustainability which is internationally accepted. The GRI sustainability reporting specifies indicators in each dimension and the reporting framework requires the industrial entrepreneurs to procure a consulting company to conduct an annual report as the personnel in the organization are only responsible for collecting data and the production department is mainly responsible for compiling environmental and resource consumption reports.

Explicitly, the Eco Factory criteria at present is directly derived from the need to reduce pressure due to the coexistence of industry and community, and respond to the governmental policies in managing environment rather than associating commercial industrial sustainability and creating confidence among investors towards operational sustainability. Meanwhile, most industries in Thailand are a medium-scale and small-scale which is experiencing a lack of resources as well as limitations of potential in implementing the sustainable development indicators. In addition, there is only one medium-scale industry in the food industry group that can obtain Eco Factory certification.

Therefore, it can be claimed that the expansion of the sustainability of the Eco Factory industry is limited since there are only 247 industries requesting the certification from the total of more than 70,410 manufacturing industries registered with the Department of Industrial Works, Ministry of Industry, in December 2020, with 3.7 million workers and 7.65 trillion baht investment.

Thai industries have significant economic, social and environmental impacts as they consume resources and energy to produce products for consumers in the country and for export resulting in waste, chemical and air emissions. Therefore, associating manufacturing with sustainable development in terms of services, commercial, educational and public sectors in different dimensions that are significant to the quality of life in the society and ecosystem is essential. If producers truly aim to accomplish the production of sustainable products and services they require appropriate and adequate indicators for monitoring and evaluation, mechanisms which can mobilize the development of innovation and efficient resource consumption according to the principles of Green Growth.

5.2.2 SCP and Circular Economy Sustainable Development Driven

The indicator development using SCP based on the circular economy principle in Thai industries will result in the mobilization of the industrial sustainability associated with the macro-level plans of Thailand. However, it is necessary to define the sustainable industrial development and generally accepted indicator framework practically.(Azapagic & Perdan, 2000) Moreover, the circular economy supports the sustainable development to achieve the sustainable development goals based on SCP.

Accordingly, the current research is intended to serves as a tool in the initial development of the sustainability indicator framework for Thai industries by employing the circular economy as to the best of the researcher's knowledge there is no research on using indicators evaluating the levels of sustainable development and which consider the micro-level indicator association of entrepreneurs and the macro-level indicator of the sustainable development mobilization. The indicator consideration mainly employs the top-down approach involving public sector, academic sector and experts based on the development goals of Eco Industrial Town without the direct emphasis on sustainability of each factory in different practical aspects.

Sustainable development, which almost all countries are commitment to achieving, has resulted from the resource consumption imbalance, urbanization and the need to enhance the quality of life of the world population, as well as promote the decoupling of resource consumption and eco efficiency (i.e., doing more with less, or consuming less resources but creating more economic benefits). The successful countries, such as USA, members of the EU, and Japan are developed countries that have managed resource consumption along with utilizing innovations and renewable resources efficiently, creating awareness of consumers and civil society as well as promoting law enforcement in terms of both economic incentives and Polluter-Pays Principle. The aforementioned management has helped industrial entrepreneurs in these countries emphasize sustainable development for more than 20 years by focusing on the social responsibility of their companies.

The European Commission (2001) defined Corporate Social Responsibility (CSR) as "a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis". Therefore, CSR is an efficiency measurement of the company concerning the economy, society and environment representing the sustainable development at company level under the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 2007). CSR corresponds to the operation of Sustainable Consumption and Production (SCP) which falls under SDG 12, which concerns ensuring sustainable consumption and production patterns under the SCP concept.

The United National Environment Programme proposed the concept of sustainable consumption and production which refers to “the use of services and related products, which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of future generations” (United Nations Environment Programme, 2015). The circular economy principle in manufacturing industries promotes continuous renewable resource consumption in the system under the concept of resource consumption in a holistic ecosystem, corporate responsibility and transparency by using innovation and involvement to maximize the value of production, create opportunities for new business as well as reduce poverty in the society. The sustainable development of the industries based on SCP has to consume resources and energy in the production efficiently in order to be competitive in the economy and increase income of the organization with less resource consumption and without pollution. Hence, the development under the circular economy principle equates to the sustainable development support. The operation of SCP is illustrated in Figure 5.2.

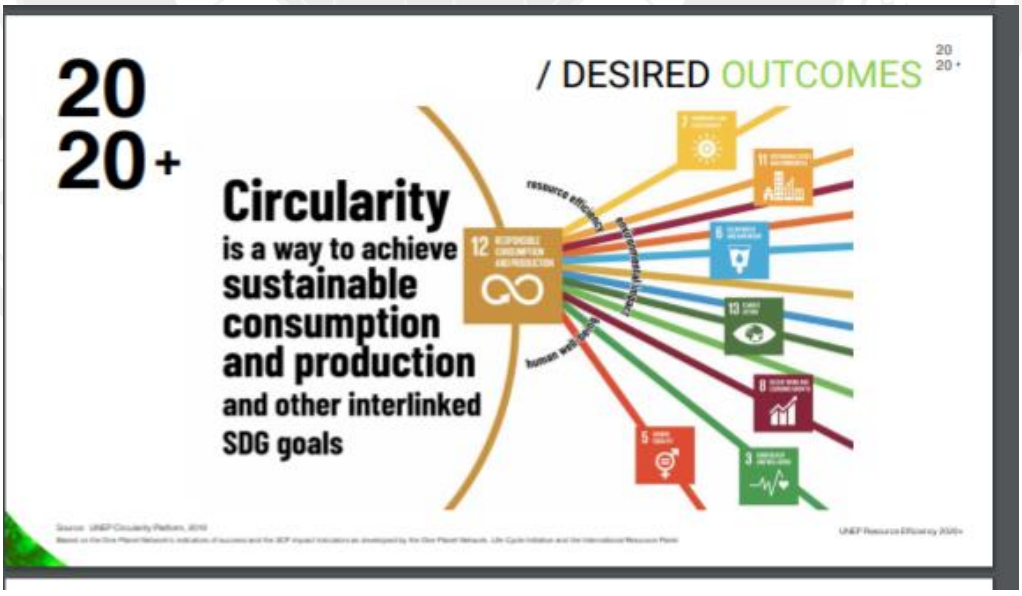

Figure 5.2 The relationship between the circular economy principle, SCP and SDG
Source: The United Nations Environment Programme (2018)

However, the sustainable development for industries at the micro-level does not currently have supporting theoretical underpinnings or explicit definitions of terms since defining sustainability depends on the mindset of related personnel in the organization.(Bell & Morse, 2000) Past studies over past 20 years have focused on the differences in industrial sustainability indicators, as well as developing industrial indicators and sustainable development evaluation criteria, especially criteria based on the Bellagio STAMP which is a widely quoted reference point for measuring sustainable development, and contains 10 major principles to assess the progress of an organization as follows (Bell & Morse, 2018):

1) Principle 1: Guiding Vision and Goals
2) Principle 2: Holistic Perspective
3) Principle 3: Essential Elements
4) Principle 4: Adequate Scope
5) Principle 5: Practical Focus
6) Principle 6: Openness
7) Principle 7: Effective Communication
8) Principle 8. Broad Participation
9) Principle 9: Ongoing Assessment
10) Principle 10: Institutional Capacity

Furthermore, the assessment is also related to the sustainable development comprising of indicators that have macro and micro association as presented in Figure 5.3.(Janik & Ryszko, 2019)

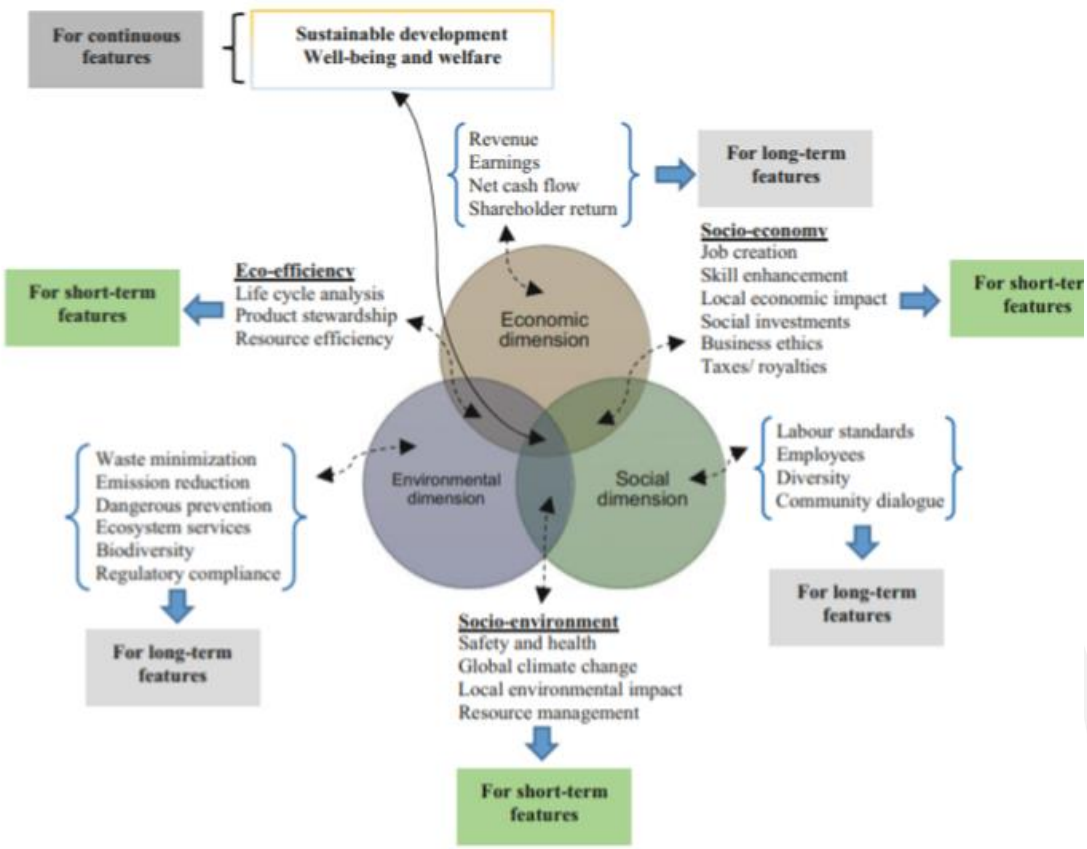

Figure 5.3 Micro-Macro Measurement of Sustainability

Source: Garbie (2016)

At present, there appears to be no research studying the association between the sustainable development indicators for Thai industries at the organization and company levels as well as the macro level. Some studies only focus on an association or specific industrial sector goal or an application of Eco Factory indicator criteria in evaluating activities or goals under the specific certification conditions which the industrial enterpernures have to follow.

5.2.3 SCP indicators according to CE Principles: lesson learned from this study

This qualitative research developing indicators by employing the grounded theory method is based on the hypothesis that the developed sustainable development indicators for Thai industries are the SCP indicators corresponding to the international sustainable development indicators, Eco Factory criteria, and SCP Roadmap based on

the circular economy principle having four dimensions considered as four pillars for SD. In addition, the developed indicators are associated with the policy indicators as well as micro and macro indicators. Regarding the first draft of developed SCP indicators are based on the stakeholders who play a role in developing and implementing the sustainable development indicators for Thai industries. These stakeholders are the majority group in Thailand and have been working for this issue more than 5 years to formulate a theoretical model of sustainable development indicators for Thai industries by collecting data, reviewing literature, surveying, interviewing and conducting focus group meetings, seminars and workshops. Thus, the researcher can outline the lessons learned from the current research and posit the following observations:

1) Stakeholders from the industrial sector have opinions towards the obstacles of implementing the sustainable development indicators similarly to the experts, Eco Factory working group, and public sectors. Regarding the obstacles to implementing the indicators based on the Eco Factory criteria containing 14 criteria, the experts claim that there are obstacles 11 criteria in implementing the indicators, which is consistent with most stakeholders considering that the Eco Factory criteria is suitable for sustainable development. However, the obstacles to the implementation based on the same criteria encountered by both groups, including the expert group, play a role in promoting, monitoring, evaluating and certifying. In contrast, the industry group plays a role only in collecting data and reporting operational outcomes based on the production criteria of each industry, criteria that should be improved both in terms of industrial operations as well as evaluation and certification based on the recommendations of the industrial sector, such as increasing green areas each year, promoting biodiversity and inter-factory symbiosis, creating income to the surrounding community as well as applying symbiosis principle of the factory into community such as by utilizing the effluent of the factory for agriculture or using the nonhazardous waste as materials in the production of community products. It is assumed that the implementation obstacles come from the application of the criteria for all types of industry, evaluation conditions are neither flexible nor adequate for practicality, or exclusions of the specified implementation for some indicators. Therefore, the current research surveyed the obstacles and opinions towards the

improvement of the Eco Factory criteria. The specified obstacles are significant as the entrepreneurs who gave their opinions towards the improvement are in the large-scale upstream industries that utilize intense and current production technology as well as have access to human resources and capital. Moreover, some of them conduct reporting based on the GRI international sustainability reporting and they are on the DJSI List. Thus, the obstacles are mainly based on Eco Factory criteria.

2) The perspectives of stakeholders towards the sustainable development can be separated into emphasizing environmental issues and weighing economic indicators in Eco efficiency more so than other indicators, such as indicators of technology and production equipment investment efficiency or social indicators related to the proportion of male and female laborers. Thus, it can be implied that the perspectives do not cover sustainable economy and sustainable society as the indicators are the key tools for monitoring, communicating and providing knowledge similar to reporting of national GDP which can communicate levels of national economic strength, employment and capital but cannot indicate the resource consumption sustainability, the environmental problems caused by the economy, or the use of technology to increase economic production efficiency. The sustainable development needs to create balance in all dimensions simultaneously; therefore, there should be sufficient indicators to monitor the sustainable development progress in the short-, medium- and long-term as presented in Figure 5.3.

3) The perspectives of the expert stakeholders towards the indicator development is that CE is the main indicator in the sustainable development rather than SCP that is supplemented by CE principle as shown in Figure 5.3 and Figure 5.4.

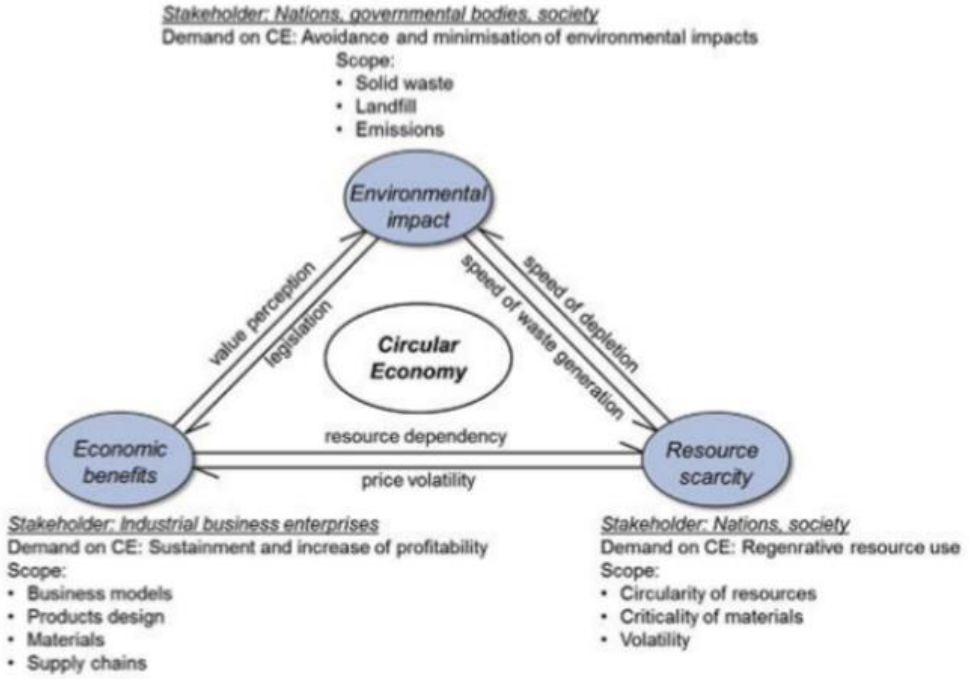

Figure 5.4 Integral Approach of Circular Economy

Source: Sanchez-Ortiz, Rodríguez-Cornejo, Río-Sánchez, and García-Valderrama (2020)

After reviewing the literature, there appears to be no study integrating the two concepts to develop sustainable development indicators for industries at the micro level.(Janik & Ryszko, 2019; Moraga et al., 2019) However, the indicators of these two concepts are always interrelated and complementary. Although the scholars consider that combining the two concepts entails a large number of indicators, the representatives from the industries do not mention the number of indicators. Furthermore, it is clear that most roles of entrepreneurs and experts are related to environmental indicators. Regarding the third survey, all participants from the industrial sector (20 subjects) have work experience on the environmental indicators with 100%, social indicators with 68%, and economic indicators which equal to good governance indicators at 63%. Meanwhile, the experts (10 subjects) have work experience on the environmental indicators with 82%, social indicators with 64%, and only 27% for economic indicators and good governance indicators as presented in Figure 4.16. These figures indicate that most participants play more than one role, and the industrial entrepreneurs have work experience covering various dimensions more

than the participants in academic fields who are responsible for research and development of policies for Thai industries. Hence, the perspectives on the sustainability indicator development are consequently different on the emphasis of CE or SCP.

In Thailand, no study has been conducted on indicator development in conjunction with the evaluation of sustainable development level. Moreover, the CE concepts is new and only a limited number of case studies applying CE as the indicator implementation for Thai industries have been conducted. In contrast, the public sector in the EU, China and Japan have been integrating the CE concept into national policies for more than 10 years, and employ the CE concept in strengthening the economy to increase GDP and improve national development.(European Academies' Science Advisory Council, 2016) This can promote new business which increases efficiency of renewable resource consumption in the economic system, enhances cultural potential, as well as reduces the social burden of waste disposal, environmental impacts caused by the manufacturing process and linear consumption.

The indicator implementation is solely a benchmark tool to measure goals and needs with competitors. Benchmarking can promote the highest benefits to the organization as the benchmark can be used to improve the organization significantly by facilitating the comparison of indicators using benchmarking to analyze the gaps to investigate the best practices which is a key to success in creating distinction from competitors. In addition, it also promotes creativity in the improvement as the indicators are tools indicating the capacity and providing knowledge and communicating improvement both inside and outside the organization. Moreover, it is used to evaluate and monitor the levels of performance in following goals specified by the organization as well as measuring the level of correspondence to the goals of international sustainable development (e.g., reducing greenhouse gas emission).

5.3 Recommendations

This research on the sustainable indicator development for Thai industries has been conducted corresponding to SCP Roadmap according to the CE principle using stakeholder involvement. The operation of indicators covered in this research is

a challenge in terms of implementation that achieves the development goals of Thai industries since the proposed indicators have different dimensions that should be developed in their structure in terms of resources, personnel for industrial and academic sectors, improvement of regulations and related laws to avoid obstacles to implementation and promote collaboration and understanding on specifying the definitions and meanings of collaborating to reduce the barriers to working together and reduce entrepreneurs' expense, providing opportunities and income distribution to create mutual benefits between the industrial sector and community. The indicators developed in this research are indicators used in the industrial sectors of many countries; nevertheless, the contexts, societies, cultures, resources and laws in each country are different, indeed, the production system and technology in the manufacturing systems around the world are being continually transferred, exchanged and developed. In other words, sustainable development in each society is different, even though they have the same overall goals.

5.3.1 Recommendations for implementation of the indicators

The recommendations for the implementation of SCP indicators based on the circular economy principle for Thai industries are as follows:

5.3.1.1 There should be a pilot project supporting practical implementation in the industrial sector by separating into groups based on the industrial types including upstream, midstream and downstream industries or based on the industrial sizes including large-scale, medium-scale and small-scale industries. This is due to the differences in readiness conditions in implementing the indicators, such as the environment of the upstream, midstream and downstream industries, or technology utilization, resource sources, employment, market and investment.

A pilot project should be conducted with cooperation of Eco Industrial Development Division, Department of Industrial Work, Industrial Estate, OIE, specific industry associations, Federation of Thai Industries and Management System Certification Institute (Thailand).

5.3.1.2 It should be required that entrepreneurs and organizations periodically review indicators, such as every 3 years, and there should be standards, evaluation and certification based on the circular economy standard of Thai Industrial

Standard Institute (TISI), specific industry associations, Federation of Thai Industries and Management System Certification Institute (Thailand).

5.3.1.3 There should be the consideration of supporting the information provision and workshops at the organizations to promote the readiness of the industries interested in support for sustainability reporting and indicator implementation. Networks of collaboration can also be created where large-scale industries which have the readiness for conducting sustainable development can mentor and support the medium- and small-scale industries where a lack of readiness is an issue. This can be facilitated by specific industry associations, the Federation of Thai Industries and Management System Certification Institute (Thailand).

In addition, relevant agencies should apply the proposed indicators as follows:

1) Corporate Management and Sustainable Development Supervisor in the synthetic rubber and plastic products industry should apply the data from the resource intensity indicator into the development of indicators of the affiliated company.

2) Environmental and Occupation Health Division in the chemicals and chemical products industries and the petrochemical and refined petroleum products industries should academically utilize the indicators to be a reference in proposing recommendations towards the improvement of data collection in the organization. Such a division can present indicator criteria as a director and representative of the company in receiving feedback on the development of industrial sustainability indicators, especially in the Petrochemical Industry Group of the Federation of Thai Industries.

3) Community Partnership Association could derive benefits from participating in the workshops for collecting data on the SCP indicators based on CE principle. This would provide an opportunity for exchanging knowledge on indicator implementation corresponding to CE principle for factory members, and the association can also use the knowledge to expand the activities of promoting the association members to improve indicators.

4) Eco Industrial Development Division, Department of Industrial Work, Ministry of Industry should use the data of indicators to improve Eco Industrial

Town indicators to correspond to the CE as it the policy of the public sector in the BCG Model industry development.

5) Water and Environment Institute for Sustainability, Federation of Thai Industries could use some parts of the data from the current research to improve Eco Factory criteria.

5.3.2 Recommendations for future studies

5.3.2.1 Future studies should investigate industrial sustainability evaluation along with developing the sustainable development indicators by specifying indicators within a general framework for industry and indicators with specific framework for each industry group.

5.3.2.2 The criteria of the sustainable development levels (e.g., good, very good and excellent) as suggested in the indicator evaluation of the current research should be studied.

5.3.2.3 The indicators in each dimension should be investigated to develop a practical guideline for collecting data for the industrial sector, monitoring, evaluating and defining boundaries to serve as a standard for sustainability reporting of organizations.

5.3.2.4 The future studies should develop the sustainable development indicators that can measure organizational performance or develop the indicators as composite indicators for ease of communication.

5.4 Limitations of the study

The industrial target of this research was mainly large-scale and multinational companies, most of which are listed the Stock Exchange of Thailand. There were only two small medium-scale companies included in this study. Therefore, study results may not be applicable to small- and medium-scale organizations.

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APPENDIX

Appendix A

Appendix A-1 Questionnaire of the first survey

Development of Sustainable Consumption and Production Indicators for Industrial Sector According to Circular Economy Principles in Thailand

This questionnaire is a part of a PhD. degree of Miss Peeraporn Palapleevalya, the Graduate School of Environmental Development Administration, the National Institute of Development Administration

Objectives of the Study

1. To investigate sustainable consumption and production indicators for industries nowadays as well as difficulties and limitations in using the indicators conducting on Eco-Factory case studies in the Industrial Estate Authority of Thailand and the Federation of Thai Industries, and report sustainable development of the manufacturing sectors in the Stock Exchange of Thailand
2. To develop sustainable consumption and production indicators for Thai industries based on the Sustainable Consumption and Production Roadmap 2017-2037 and circular economy principle

Please answer all questions and reply to the researcher.

Miss Peeraporn Palapleevalya

Tel: 061-929-8246

Email : ppnoiscp@gmail.com

Or Submit the questionnaire to Miss Peeraporn Palapleevalya

98/180 Village No. 2, Krisada Lagoon Village41,

Bang Khu Wiang Subdistrict, Bang Kruai District,

Nonthaburi 11130

Section 1 Personal Information

All your personal information will be treated strictly as confidential by the researcher, and used for contact purposes only

1. Name – surname : _____
   Company
   _____
   Position _____
   Telephone number_____ Email : _____
2. Your role in the organization in developing industrial sustainability indicators. (You can choose more than 1 answer.)
   - ◯ Chief Executive Officer
   - ◯ Manager
   - ◯ Indicator Developer
   - ◯ Indicator Data Collector
   - ◯ Other (please specify):

   _____
3. What are environment management systems in your organization? (You can choose more than 1 answer.)
   - ◯ ISO 14001 Standard
   - ◯ Green Industry Level 3, Green System
   - ◯ Green Industry Level 4, Eco Industry Certification
   - ◯ Other standards equivalent to ISO 14001 (please specify)

   _____
4. What type of industry that you work for/operate? (you can choose more than 1 answer)
   - ◯ Chemicals and Chemical Products
   - ◯ Synthetic Rubber
   - ◯ Plastic Products
   - ◯ Petrochemicals and Refined Petroleum Products
   - ◯ Food Products
   - ◯ Electrical Equipment
   - ◯ Computer, Electronic and Optical Products
   - ◯ Parts and Vehicle Equipment
   - ◯ Vehicle, Trailer and Semi-Trailer

◯ Other (please specify): _____

Section 2 Your opinion towards sustainability indicators for Thai industries

5. Your opinion towards industrial sustainability indicators based on Eco Factory criteria.

◯ Agree that they are suitable for the sustainable development in the organization.

◯ There is an obstacle in implementing the indicators (please specify in item 6).

◯ The benefits from implementing indicators based on Eco Factory criteria and Eco Factory certification (please specify).

_____

_____

_____

◯ There should improve specific requirements for Eco Factory (please specify).

_____

_____

_____

6. Your obstacle in implementing the indicators, please specify.
(You can choose more than 1 answer.)

◯ Materials management
◯ Energy management
◯ Water and wastewater management
◯ Air emission management
◯ Greenhouse gas management
◯ Solid waste management
◯ Chemical and hazardous substance management
◯ Occupational health and safety management
◯ Logistics management
◯ Green supply chain management
◯ Green landscape management
◯ Biodiversity management
◯ Income distribution to the community
◯ Living with the surrounding community
◯ Other (please specify) :

_____

7. Do you think that industrial sustainability indicators should be developed based on the circular economy principle?
   - ◯ Agree
   - ◯ Disagree
   - ◯ Other (please specify):

   _____

Section 3 Cooperation or interest in participating in the activities of developing sustainability indicators for Thai industries

(The researcher reserves the right for the target industry group and the related sectors in participating only.)

8. Your opinion towards the indicators in economy, environment, society, and good governance dimensions in the draft (1) and the sustainable consumption and production indicators based on the circular economy principle, please answer by following the document of Table1 (in the attachment).

9. What do you think about the draft (1), and the sustainable consumption and production indicators based on the circular economy principle as presented in the document of Table1 (in the attachment)? (You can choose more than 1 answer.)
   - ◯ The indicators cover the key issues of the sustainable industrial development and eco-industry criteria.
   - ◯ The indicators are in accordance with the circular economy principle.
   - ◯ The indicators are practical for an operation of Thai industries.
   - ◯ The indicators based on the circular economy principle should be improved by following the document of Table 1.
   - ◯ Other, please specify:

   _____

10. Are you willing to cooperate and participate in any activities during Dec 2020 - Feb 2021?
(You can choose more than 1 answer.)

- ◯ You are willing to give 1-time in-depth interview around 1.30-2 hours.
- ◯ You are willing to give 1-time focus group discussion around 3 hours (Jan 2021).
- ◯ You are willing to participate in 1-time seminar/developing the sustainable consumption and production indicators based on the circular economy principle around 3 hours (Feb 2021).

Thank you for your support for the information in this study.
For more information and submission, please contact:

Miss Peeraporn Palapleevalya
98/180 Village No. 2, Krisada Lagoon Village41,
Bang Khu Wiang Subdistrict, Bang Kruai District,
Nonthaburi 11130
Tel. 061 – 929 – 8246 Email:

Table 1 Opinion survey form (draft) of the sustainable consumption and production indicators for industrial sector according to circular economy principles in Thailand (December 2020)

Environmental Indicators

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
1. Resources/ Materials	• Materials management efficiency / the quantity of main materials used per income (Ton/Million baht) • Material usage / footprint (Ton or m^3) • Consumption of recycling materials (% virgin material) • Hazardous materials/chemicals (Ton or m^3) • Scrap rate (% of finished product)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....
2. Energy	• Energy management efficiency (kWh/Giga Joule/ Million baht) • Electricity / energy consumption (kWh/Giga Joule) • Energy intensity (kWh/product, K Joule/product) • Reduction of energy consumption (kWh/Giga Joule) • Use of renewable energy (% of total energy) • Symbiosis energy (Giga Joule)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
			....	....
3. Water/Wastewater	• Water and wastewater management efficiency (m^3/ Million baht) • Water consumption / total water withdrawal by sources (m^3) • Volume of water reused or recycled (m^3/total used water or % of water consumption) • Volume of water discharge (m^3) • Symbiosis wastewater (m^3)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....
4. Air / emission / gas emission / heat emission	• Air emission management efficiency (kg SOx, NOx, VOC/ Million baht) • Emission of ozone-depleting substances (kg emission)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
			....	....
5. Greenhouse gas management	• Greenhouse gas intensity (tonCO_2e/Million baht, Product) • Emission of CO2 from factory / GHG emission (tonCO_2e)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....
6. Solid waste	• Solid waste inventory / profile / flow diagram (#) • Volume of solid waste (kg or m^3 of solid waste) • Solid Waste reuse / recycle (kg) • Waste reduction & disposal (kg or m^3 of hazardous waste)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
			....	....
7. Hazardous waste	• Volume of hazardous waste / material (m^3)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....
8. Logistics	• Transportation and logistics management efficiency (#) • Reverse logistics, customer returns (#)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
			....	....
9. Suppliers	• Percentage of new suppliers that were screened using environmental criteria (% of total suppliers) • Significant actual and potential negative environmental impacts in the supply chain and action taken (# / total suppliers)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....
10. Product development / manufacturing	• Quantity of recycling / reuse / remanufacturing (kg or m^3 of material) • Durability level (#) • Environmental friendly design / Eco-design (# of product) • Eco-innovations (# of product or project)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
			....	....
11. Sustainable product certification (materials, products)	• Third Party Eco-Label (e.g., Green Label, Carbon Footprint, Water Footprint) (# of product) • Self-Declare (# of product)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....
12. Environmental spending/investments/ management	• Green areas / buffer zone (% area) • Environmental spending / protection expenditures and investments by type (monetary unit)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
			....	....
13. Technology	• Recycling technology (# of project) • Remanufacturing technique (#) • Recovery technique (#)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....

Social Indicators

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
1. Employees	• Turnover index (#) • Proportions of permanent staffs and temporary staffs (#) • Discrimination/male to female ratios/gender/age/sexual/child labor (%male, %female) • Wages and benefits (% ratio) • Programs for skills management and lifelong learning / indigenous knowledge / training of the employees (in hours) / capacity development / sustainable awareness (#)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....
2. Security and safety at work	• Health and security / safety / elimination of hazardous workplaces/ergonomics / absence due to injuries or work-related illness / deaths / effective occupational health and safety management for staffs and related persons (Y/N, # of day absence, # of days) • Ergonomic (#) • Healthy working environment (e.g., air, sound, light)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other .....
3. Clients/ consumers	• Number of complaining consumers (#) • Total number of incidents of non-compliance with regulations and voluntary	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because:

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
	codes concerning marketing communications, including advertising, promotion, and sponsorship, by type of outcomes (#)		....	☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other .....
4. Community and stakeholders	• Engagement of the community / living with the surrounding community (Y/N) • Local partnerships / Integration to the society (Y/N) • Investments to benefit community / income distribution to the community (Y/N)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other .....

Economic Indicators

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
1. Gross revenue	• Gross revenue value (Monetary units)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....
2. Cost / expense	• Employee / labor cost/ Expense with wages (Monetary units) • Ratios of standard entry level wage by gender compared to local minimum wage at significant locations of operation (%) • Expense with taxes / Payment to government (Monetary units) • Environmental expense (Monetary units) • Operational expense (Monetary units) • Energy cost (Monetary units) • Recycling cost (Monetary units) • Disposal cost (Monetary units) • Remanufacturing Cost (Monetary units)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....
3. Profit	• Liquid profit (Monetary units)	☐ Totally	☐ Agree, but	☐ Disagree, should

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
	• Retained earnings (Monetary units)	agree	should improve as follows:	improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....
4. Investments	• Overall equipment Efficiency (%) • Investment in R&D activities / technology transfer (Monetary units) • Sustainable process innovation (Monetary units)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....
5. Suppliers	• Local suppliers / spending on local suppliers (#) • Local Procurement / product procurement or services from the community (#)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....

Good Governance Indicators

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
1. Corporate ethics	• Mission statement (Y/N)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....
2. Accountability	• Transparency (Y/N)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....
3. Participation	• Stakeholder dialogue (#) • Grievance procedures (Y/N)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
			....	☐ 3. Cannot implement ☐ 4. Other ....
4. Risk management	• Sustainable Risk Management Action Plan (Y/N)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other ....
5. Holistic management	• Sustainability Management Plan (Y/N) • Full-cost accounting / material flow cost accounting (Y/N)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the organization ☐ 3. Cannot implement ☐ 4. Other
6. Ethics	• Ethical behavior (Y/N) • Anti-corruption (Y/N)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree, should improve because: ☐ 1. Cannot collect data ☐ 2. Do not correspond to the sustainability of the

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
			.....	organization
			.....	☐ 3. Cannot
			.....	implement
			.....	☐ 4. Other .....
				.....

Appendix A-2 Questionnaire for the second Survey

Development of Sustainable Consumption and Production Indicators for Industrial Sector According to Circular Economy Principles in Thailand

This questionnaire is a part of a PhD. degree of Miss Peeraporn Palapleevalya, the Graduate School of Environmental Development Administration, the National Institute of Development Administration.

Objectives of the Study

3. To investigate sustainable consumption and production indicators for industries nowadays as well as difficulties and limitations in using the indicators conducting on eco-factory case studies in the Industrial Estate Authority of Thailand and the Federation of Thai Industries, and report sustainable development of the manufacturing sectors in the Stock Exchange of Thailand

4. To develop sustainable consumption and production indicators for Thai industries based on the Sustainable Consumption and Production Roadmap 2017-2037 and circular economy principle

Please answer all questions and reply to the researcher.

Miss Peeraporn Palapleevalya

Tel: 061-929-8246

Email : ppnoiscp@gmail.com

Section 1 Personal Information

All your personal information will be treated strictly as confidential by the researcher, and used for contact purposes only

11. Name – surname :
    _____
    Company
    _____
    Position _____
    Telephone number_____ Email :
    _____

12. Your role in developing industrial sustainability indicators.
(You can choose more than 1 answer.)

- ◯ Policy to promote sustainable industrial development
- ◯ Working group of Eco Factory scheme promotion and development
- ◯ Eco Factory certification auditor
- ◯ Eco Factory consultant
- ◯ Other (please specify)

_____

Section 2 Your opinion towards sustainability indicators for Thai industries under Eco Industry project

13. Your opinion towards industrial sustainability indicators based on Eco Factory criteria.

◯ Agree that they are suitable for sustainable development for Thai industries.

◯ There should be improved specific requirements for Eco Factory (please specify).

_____

14. According to your role involving in the Eco Factory operation, is there any obstacle in implementing the indicators? And how?
(You can choose more than 1 answer.)

- ◯ No obstacle
- ◯ Materials management
- ◯ Energy management
- ◯ Water and wastewater management
- ◯ Air emission management
- ◯ Greenhouse gas management
- ◯ Solid waste management
- ◯ Chemical and hazardous substance management
- ◯ Occupational health and safety management
- ◯ Logistics management
- ◯ Green supply chain management
- ◯ Green landscape management
- ◯ Biodiversity management
- ◯ Income distribution to the community
- ◯ Living with the surrounding community
- ◯ Other (please specify) :

_____

Section 3 The development of sustainability indicators for Thai industries

15. Do you agree there should be the development of industrial sustainability indicators that correspond to the circular economy principle?
    - ◯ Agree
    - ◯ Disagree
    - ◯ Other (please specify):

    _____

16. You think that the industrial sustainability indicators based on the circular economy principle and Sustainable Consumption and Production Roadmap should consist of the attribute(s) as follows: (You can choose more than 1 answer.)
    - ◯ The indicators can collect data easily, they are information that the industry already has, and they can evaluate easily and uncomplicatedly.
    - ◯ The indicators have clear measure unit, duration and boundary, and they are examinable and transparent.
    - ◯ The indicators are quantitative and qualitative indicators
    - ◯ The indicators can be comparable within the industry.
    - ◯ The indicators are quantitative measure in total and/or modified per unit (e.g., volume of total energy consumption / year or volume of energy consumption / production unit / year).
    - ◯ The indicators can indicate activities of sustainable industrial development and support industrial sustainability reporting.
    - ◯ The indicators correspond to local and national sustainability indicators and international affairs, such as global warming.
    - ◯ Other (please specify) :

    _____

17. What do you think about the sustainable consumption and production indicators based on the circular economy principle in 4 dimensions including economy, environment, society, and good governance in the draft 2? Please answer in the attached document of Table1.

18. In the overview, what do you think about the sustainable consumption and production indicators based on the circular economy principle in the draft 2? You can choose more than 1 answer.
    - ◯ The indicators cover all important issues of the sustainable industrial development and Eco Factory criteria.
    - ◯ The indicators correspond to the circular economy principle.
    - ◯ The indicators are practically suitable for the operation of Thai industries.
    - ◯ The drafted indicators based on the circular economy should be improved as specified in the document of Table1.
    - ◯ Other, please specify -

_____

_____

19. You are willing to engage and participate in any activities during Feb 2021.
    - ◯ You are willing to give an interview or give additional comments.
    - ◯ You are willing to participate in seminar/developing the sustainable consumption and production indicators based on the circular economy principle for industries for 1 time spending around 3 hours (25 Feb 2021).

Thank you for your support for the information in this study.
For more information and submission, please contact:

Miss Peeraporn Palapleevalya
98/180 Village No. 2, Krisada Lagoon Village41,
Bang Khu Wiang Subdistrict, Bang Kruai District,
Nonthaburi 11130
Tel: 061 929 8246 Email: ppnoiscp@gmail.com

Table 1 Opinion survey form (draft2) Opinion survey of the sustainable consumption and production indicators for industrial sector according to circular economy principles in Thailand

(February 2021)

Environmental Indicators

Set of indicators	**Indicator (Unit)**	**Agree**		**Disagree**
		Do not improve	**Should improve**	
1. Resources/ Materials	1.1 Materials management efficiency / the quantity of main materials used per product, material intensity 1.2 Consumption of recycling materials (% virgin material) 1.3 Hazardous materials / chemicals (ton or m3) 1.4 Scrap rate (% of finished product)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
			------------ ------------ ------------ ------------ ------------ ------------	
2. Energy	2.1 Energy management efficiency, Energy Intensity (kWh/product, K Joule/product) 2.2 Electricity/Energy consumption (kWh/ Giga Joule) / year 2.3 Reduction of energy consumption (kWh/Giga Joule) 2.4 Use of renewable energy (% of total energy) 2.5 symbiosis energy (Giga Joule)	☐ Totally agree	☐ Agree, but should improve as follows: ------------	☐ Disagree because ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	**Should improve**	
			------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------	
3. Water/Wastewater	3.1 Water and wastewater management efficiency (m^3/product) 3.2 Water consumption / Total water withdrawal by sources (m^3) 3.3 Volume of water reused or recycled (m^3/total used water or % of water usage) 3.4 Volume of water discharge (m^3) 3.5 Symbiosis wastewater (m^3)	☐ Totally agree	☐ Agree, but should improve as follows: ------------	☐ Disagree because ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------ ------------

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
			....	
4. Air / emission / gas emission / heat emission	4.1 Air emission management efficiency (kg SOx, NOx, VOC others), the amount of reducing air emission 4.2 Emission of ozone-depleting substances (kg emission)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....
5. Greenhouse gas management	5.1 Greenhouse gas intensity (tonCO_2e	☐ Totally agree	☐ Agree, but should improve	☐ Disagree because

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
	/Product) 5.2 Emission of CO_2 from factory / GHG emission (tonCO_2e)		as follows:	.....
6. Solid waste	6.1 Solid waste inventory / profile / flow diagram (#) 6.2 Volume of solid waste (kg or m^3 of solid waste) 6.3 Solid Waste reuse / recycle (kg) inside factory 6.4 Waste reduction & disposal (kg or m^3 of hazardous waste)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
			....	
7. Hazardous waste	7.1 quantity of hazardous waste / material (kg)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because .....
8. Logistics	8.1 Transportation and logistics management efficiency (#) 8.2 Reverse logistics, customer returns (#) 8.3 The number of accidents, complaints of product transportation processes per year	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....
9. Suppliers	9.1 Percentage of new suppliers that were screened using environmental criteria (% of total suppliers) 9.2 Significant actual and potential negative environmental impacts in the supply chain and action taken (# / total suppliers)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
			....	....
10. Product development / manufacturing	10.1 Quantity of recycling / reuse / remanufacturing (kg or m^3 of material) 10.2 Durability level (#) 10.3 Environmental friendly design / Eco-design (# of product) 10.4 Eco-innovations (# of product or project)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
			....	
11. Sustainable product certification (materials, products)	11.1 Third Party Eco-Label (e.g., Green Label, Carbon Footprint, Water Footprint) (# of product) 11.2 Self-Declare (# of product)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....
12. Environmental spending/investments/ management	12.1 Green areas / buffer zone (% area) 12.2 Environmental spending / protection	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
	expenditures and investments by type (monetary unit)		....	....
13. Technology	13.1 Recycling Technology (# of project) 13.2 Remanufacturing Technique (#) 13.3 Recovery Technique (#)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....

Social Indicators

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
1. Employees	1.1 Turnover index (#) 1.2 Discrimination / Inclusion Gender/Age/Sexual/Child labor (% male, %female) 1.3 Wages and benefits (% ratio 1.4 Programs for skills management and lifelong learning / indigenous knowledge / training of the employees (in hours) / capacity development / sustainable awareness (#)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....
2. Security and safety at work	2.1 Health and security / safety / elimination of hazardous workplaces / absence due to injuries or work-related illness / deaths / effective occupational health and safety management for staffs and related persons (Y/N, # of day absence, # of days) 2.2 Ergonomic (#) 2.3 Healthy working environment (e.g., air, sound, light)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....
3. Clients/ consumers	3.1 Number of complaining consumers (#) 3.2 Total number of incidents of non-compliance with regulations and	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
	voluntary codes concerning marketing communications, including advertising, promotion, and sponsorship, by type of outcomes (#)		....	....
4. Community and stakeholders	4.1 Engagement of the community / living with the surrounding community (Y/N) 4.2 Local partnerships / Integration to the society (Y/N) 4.3 Investments to benefit community / income distribution to the community (Y/N)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....

Economic Indicators

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
1. Gross revenue	1.1 Gross revenue value (Monetary units)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....
2. Cost / expense	2.1 Employee / labor cost/ Expense with wages (Monetary units) 2.2 Expense with taxes / Payment to government (Monetary units) 2.3 Environmental expense (Monetary units) 2.4 Operational expense (Monetary units) 2.5 Energy cost (Monetary units) 2.6 Recycling cost (Monetary units) 2.7 Disposal cost (Monetary units) 2.8 Remanufacturing Cost (Monetary units)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....
3. Profit	3.1 Liquid profit (Monetary units) 3.2 Retained earnings	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because .....

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
	(Monetary units)		.....	....
4. Investments	4.1 Overall equipment efficiency (%) 4.2 Investment in R&D activities / technology Transfer (Monetary units) 4.3 Sustainable process innovation (Monetary units)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....
5. Suppliers	5.1 Local suppliers / spending on local suppliers (#) 5.2 Local Procurement / product procurement or services from the community (#)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....

Good Governance Indicators

Set of indicators	Indicator (Unit)	Agree		Disagree
		Do not improve	Should improve	
1. Corporate Ethics	1.1 Mission statement (Y/N) code of conduct	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....
2. Accountability	2.1 Transparency (Y/N)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....
3. Participation	3.1 Stakeholder dialogue (#) 3.2 Grievance procedures (Y/N)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....
4. Risk management	4.1 Sustainable Risk Management Action Plan (Y/N)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....
5. Holistic management	5.1 Sustainability Management Plan (Y/N) 5.2 Full-cost accounting / material flow cost accounting (Y/N)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....
6. Ethics	6.1 Ethical behavior (Y/N) 6.2 Anti-corruption (Y/N)	☐ Totally agree	☐ Agree, but should improve as follows:	☐ Disagree because ....

Appendix A-3 Questionnaire for the third Survey

The Questionnaire of the Development of Sustainable Consumption and Production Indicators for Industrial Sector According to Circular Economy Principles in Thailand

This questionnaire is a part of a PhD. degree of Miss Peeraporn Palapleevalya, the Graduate School of Environmental Development Administration, the National Institute of Development Administration.

Objectives of the Study

1. To investigate sustainable consumption and production indicators for industries nowadays as well as difficulties and limitations in using the indicators conducting on eco-factory case studies in the Industrial Estate Authority of Thailand and the Federation of Thai Industries, and report sustainable development of the manufacturing sectors in the Stock Exchange of Thailand
2. To develop sustainable consumption and production indicators for Thai industries based on the Sustainable Consumption and Production Roadmap 2017-2037 and circular economy principle

Please answer all questions and reply to the researcher.

Miss Peeraporn Palapleevalya

Tel: 061-929-8246

Email : ppnoiscp@gmail.com

Section 1 Personal Information

All your personal information will be treated strictly as confidential by the researcher, and used for contact purposes only

20. Name – surname :

_____

Company

_____

Position

_____

Telephone number_____ Email : _____

21. Your role in developing, collecting data, and giving advice in the development of industrial sustainability indicators of the organization or industry in different dimensions.
(You can choose more than 1 answer.)
☐ Environmental dimension
☐ Social dimension
☐ Economic dimension
☐ Good governance dimension
☐ Other (please specify)
_____

Section 2 Your opinion towards the draft 3 of sustainability indicators for Thai industries in the current study

3. The researcher summarized the draft 3 of the sustainable consumption and production indicators based on the circular economy in 4 dimensions including environment, society, economy and good governance which were improved to suite Thai industries using the focus group meeting (Dec 2020–15 Mar 2021) conducted on the representatives of the target Eco-Factory entrepreneurs and working group of Eco Factory scheme promotion and development, Eco Factory certification auditors, and Eco Factory consultants as well as the workshop with Community Partnership Association to receive information on goals/ boundaries and guidelines for collecting data of the indicators, readiness for implementing the indicators, order of importance of the indicators, disclosure of the draft of sustainable consumption and production based on the circular economy principle as presented in the document of Table 1. You can access to the document by scanning the QR-Code.

SCAN ME

Table 1 the sustainable consumption and production based on the circular economy principle **for Thai industries, goals boundaries and guidelines for collecting data of the indicators**

☐ Agree that the indicators are suitable for the sustainable development for Thai industries.

☐ The indicators cover all important issues of the sustainable industrial development and Eco Factory criteria.

☐ The indicators correspond to the circular economy principle and mobilizing the Sustainable Consumption and Production Roadmap.

☐ The indicators are practically suitable for the operation of Thai industries.

☐ The indicators should be subcategorized due to a large number of indicators. For example, the environmental indicators should be categorized into sub-indicators (i.e., resources and materials, chemicals, water, solid waste, wastewater, hazardous waste, energy, and greenhouse gas) as well as inventory indicators (i.e., materials, chemicals, solid waste, water, and wastewater).

☐ The sustainable consumption and production indicators in the draft 3 should be improved based on the document of Table1, please specify.

- Environmental dimension should be improved on_____
_____
_____
_____
- Social dimension should be improved on_____
_____
_____
_____
- Economic dimension should be improved on_____
_____
_____
_____
- Good governance dimension should be improved on_____
_____
_____
_____
- Other, please specify_____
_____
_____
_____

Section 3 Your opinion towards the development of consumption and production indicators based on the circular economy principle for sustainable development of Thai industries

1. Your opinion towards the levels of sustainable development of Thai sustainable development entrepreneurs in responding national and international sustainable development goals based on the evaluation of sustainable consumption and production indicator reporting (in Table 1) can be classified into 3 levels as follows:

1) **Good**: The reporting on the consumption and production indicators in all dimensions is conducted, but can be partly disclosed to the public. The evaluation result shows the achievement of all indicators specified.
2) **Very Good**: The reporting on the consumption and production indicators can be entirely disclosed to the public. The evaluation result shows the achievement of all indicators specified, and the goal achievement of organizational indicators can be presented at the same level or more than the indicators specified in Thailand's consumption and production roadmap and related goals according to Thailand's sustainable industrial development strategy.
3) **Excellent**: The reporting on the consumption and production indicators is excellently conducted. The evaluation result shows the achievement of all indicators specified, and the sustainable development goals are achieved accordingly to the international SDG goals to respond global issues, such as the climate change.

Your opinion towards the level classification.

☐ Agree with the 3-level classification.
☐ Disagree with the 3-level classification because (please specify)_____

_____

_____

by re-classifying as follows:_____

_____

_____

_____

☐ Other, please specify_____

_____

_____

2. Your policy recommendations for the development of consumption and production indicators based on the circular economy principle benefiting Thai industry development in the future and mobilizing implementation support in the future. (You can choose more than 1 answer.)

☐ There should be a support for entrepreneurs who are interested in the sustainable development (in the large, medium, and small scales) by piloting the implementation of sustainable consumption and production indicators based on the circular economy principle that cooperates with public and private sectors to be a framework for developing sustainable development for general industries and sustainability reporting in the future.

☐ The development of sustainable indicators for Thai industries should sub-categorize the indicators into 2 sets with 4 dimensions including general indicators for all industries for set 1 and indicators for industries in the specific industrial sector corresponding to the level of potential for enhancing the sustainable development of such industries for set 2.

☐ The related public and private sectors should create motivation, such as tax, accessibility of sustainable development funds, environmentally friendly procurement of the public sector, research development and promotion, etc.

☐ Establishing certification system by reporting consumption and production indicators for sustainable development of Thai industries and positive-image promotion between the industries and related networks

☐ Other, please specify_____

_____

Thank you for your support for the information in this study. Please submit the questionnaire within March 31, 2021, via email:
ppnoiscp@gmail.com

For more information and submission, please contact:
Miss Peeraporn Palapleevalya Tel: 061 929 8246

APPENDIX B

APPENDIX B-1 Result of the first survey

1. Results of observation for 1st Draft of SCP indicators

Total number of participants who response the questionnaire are 20 persons

Section 1 Personal Information

Table B-1.1 Percentage of responses on the role of the participants in the organization environment management systems in the participants' organization and type of industry work for

Lists of information	Number of responses (persons)	Percentage (%)
1.1 Role of the participants in the organization in developing industrial sustainability indicators		
1) Chief Executive Officer	2	10%
2) Manager	9	45%
3) Indicator Developer	4	20%
4) Indicator Data Collector	11	55%
5) Other		
1.2 Environment management systems in the participants' organization		
1) ISO 14001 Standard	17	85%
2) Green Industry Level 3, Green System	11	55%
3) Green Industry Level 4, Eco Industry Certification	20	100%
4) Other standards equivalent to ISO 14001	5	25%
1.3 Type of industry that the participants work for/operate		
1) Chemicals and Chemical Products	7	35%
2) Synthetic Rubber	2	10%
3) Plastic Products	6	30%
4) Petrochemicals and Refined Petroleum Products	5	25%
5) Food Products	3	15%
6) Electrical Equipment	4	20%

Lists of information	Number of responses (persons)	Percentage (%)
7) Computer, Electronic and Optical Products	0	0%
8) Parts and Vehicle Equipment	2	10%
9) Vehicle, Trailer and Semi-Trailer	0	0%
10) Other	1	5%

Section 2 Participants' opinion towards sustainability indicators for Thai industries

Table B-1.2 Participants' opinion towards sustainability indicators for Thai industries

Lists of information	Number of responses (persons)	Percentage (%)
2.1 Participants' opinion towards industrial sustainability indicators based on Eco Factory criteria		
1) Agree that they are suitable for the sustainable development in the organization	13	65%
2) There is an obstacle in implementing the indicators	9	45%
3) The benefits from implementing indicators based on Eco Factory criteria and Eco Factory certification	9	45%
4) There should improve specific requirements for Eco Factory	7	35%
2.2 The obstacles in implementing the criteria of Eco Factory		
1) Materials management	7	35%
2) Energy management	5	25%
3) Water and wastewater management	0	0%
4) Air emission management	1	5%
5) Greenhouse gas management	4	20%
6) Solid waste management	3	15%
7) Chemical and hazardous substance management	3	15%
8) Occupational health and safety management	1	5%
9) Logistics management	2	10%
10) Green supply chain management	7	35%
11) Green landscape management	2	10%
12) Biodiversity management	4	20%

Lists of information	Number of responses (persons)	Percentage (%)
13) Income distribution to the community	4	20%
14) Living with the surrounding community	2	10%
15) Other	0	0%
2.3 The industrial sustainability indicators should be developed based on the circular economy principle		
1) Agree	18	90%
2) Disagree	0	0%
3) Other	2	10%

TableB-1.3 The participants' opinion on the draft (1), and the sustainable consumption and production indicators based on the circular economy principle

Lists of information	**Number of responses (persons)**	**Percentage (%)**
3.1 The participants' opinion on the draft (1), and the sustainable consumption and production indicators based on the circular economy principle		
1) The indicators cover the key issues of the sustainable industrial development and Eco Factory criteria.	12	60%
2) The indicators are in accordance with the circular economy principle.	6	30%
3) The indicators are practical for an operation of Thai industries.	4	20%
4) The indicators based on the circular economy principle should be improved	8	40%
5) Other	3	15%
3.2 The willing to cooperate and participate in any activities during Dec 2020 - Feb 2021		
1) willing to give 1-time in-depth interview around 1.30-2 hours	12	60%
2) willing to give 1-time focus group discussion around 3 hours	6	30%
3) willing to participate in 1-time seminar/developing the sustainable consumption and production indicators based on the circular economy principle around 3 hours	10	50%

Table B-1.4 Participants' opinion towards the indicators in economy, environment, society, and good governance dimensions in the draft (1)

Set of indicators	Agree				Disagree							
	Do not improve		Should improve		Cannot collect data		Do not correspond to the sustainability of the organization		Cannot implement		Other	
	person	%	person	%	person	%	person	%	person	%	person	%
Environmental Indicators												
1. Resources/ Materials	6	30%	12	60%	1	5%	0	0%	0	0%	1	5%
2. Energy	12	60%	7	35%	0	0%	0	0%	0	0%	1	5%
3. Water/Waste Water	11	55%	7	35%	0	0%	0	0%	0	0%	2	10%
4. Air / Emission / Gas Emission / Heat Emission	10	50%	8	40%	0	0%	0	0%	0	0%	2	10%
5. Greenhouse gas management	13	65%	5	25%	0	0%	0	0%	0	0%	2	10%
6. Solid Waste	13	65%	6	30%	0	0%	0	0%	0	0%	1	5%
7. Hazardous Waste	12	60%	8	40%	0	0%	0	0%	0	0%	0	0%
8. Logistics	12	60%	3	15%	1	5%	0	0%	2	10%	2	10%
9. Suppliers	12	60%	4	20%	2	10%	0	0%	2	10%	1	5%
10. Product	14	70%	4	20%	0	0%	0	0%	2	10%	0	0%

Set of indicators	Agree				Disagree							
	Do not improve		Should improve		Cannot collect data		Do not correspond to the sustainability of the organization		Cannot implement		Other	
	person	%	person	%	person	%	person	%	person	%	person	%
Development / Manufacturing												
11. Sustainable Product Certification (materials, products)	14	70%	5	25%	0	0%	1	5%	0	0%	0	0%
12. Environmental spending/investments/ management	13	65%	6	30%	0	0%	0	0%	1	5%	0	0%
13. Technology	14	70%	2	10%	1	5%	0	0%	0	0%	3	15%
Social Indicators												
1. Employees	12	60%	0	0%	0	0%	3	15 %	0	0%	0	0%
2. Security and safety at work	18	90%	0	0%	0	0%	0	0%	0	0%	0	0%
3. Clients/ consumers	17	85%	0	0%	0	0%	1	5%	0	0%	0	0%
4. Community and stakeholders	14	70%	0	0%	0	0%	1	5%	0	0%	0	0%
Economic Indicators												
1. Gross revenue	14	70%	0	0%	1	5%	1	5%	0	0%	0	0%
2. Cost / expense	12	60%	0	0%	0	0%	2	10 %	2	10%	0	0%
3. Profit	12	60%	0	0%	2	10%	2	10 %	1	5%	0	0%
4. Investments	12	60%	0	0%	2	10%	1	5%	0	0%	0	0%

Set of indicators	Agree				Disagree							
	Do not improve		Should improve		Cannot collect data		Do not correspond to the sustainability of the organization		Cannot implement		Other	
	person	%	person	%	person	%	person	%	person	%	person	%
5. Suppliers	14	70%	0	0%	0	0%	1	5%	1	5%	0	0%
Good Governance Indicators												
1. Corporate Ethics	15	75%	0	0%	1	5%	0	0%	0	0%	0	0%
2. Accountability	17	85%	0	0%	1	5%	0	0%	0	0%	0	0%
3. Participation	17	85%	0	0%	0	0%	0	0%	0	0%	0	0%
4. Risk Management	16	80%	0	0%	0	0%	0	0%	0	0%	0	0%
5. Holistic Management	14	70%	0	0%	2	10%	0	0%	1	5%	0	0%
6. Ethics	10	90%	0	0%	0	0%	0	0%	0	0%	0	0%

APPENDIX B-2 Result of the second survey

2. Results of observation for 2nd Draft of SCP indicators

Total number of participants who response the questionnaire are 5 persons

2.1 Section 1 Personal Information

Table.B-2.1 Role of participants in developing industrial sustainability indicators

Role of participants	Number of responses (persons)	Percentage (%)
1. Policy maker to promote sustainable industrial development	0	0%
2. Working group of Eco Factory scheme promotion and development	3	60%
3. Eco Factory certification auditor	2	40%
4. Eco Factory consultant	2	40%
5. Other	2	40%

Table.B-2.2 Participants' opinion towards sustainability indicators for Thai industries under Eco Factory project

Lists of information	Number of responses (persons)	Percentage (%)
2.1 The opinion towards industrial sustainability indicators based on Eco Factory criteria		
1) Agree that they are suitable for sustainable development for Thai industries	2	40%
2) There should be improved specific requirements for Eco Factory	3	60%
2.2 According to the participants' role involving in the Eco Factory operation, any obstacle in implementing the indicators in the participants' opinion		
1) No obstacle	0	0%

Lists of information	Number of responses (persons)	Percentage (%)
2) Materials management	1	20%
3) Energy management	1	20%
4) Water and wastewater management	1	20%
5) Air emission management	1	20%
6) Greenhouse gas management	0	0%
7) Solid waste management	1	20%
8) Chemical and hazardous substance management	0	0%
9) Occupational health and safety management	1	20%
10) Logistics management	1	20%
11) Green supply chain management	1	20%
12) Green landscape management	1	20%
13) Biodiversity management	1	20%
14) Income distribution to the community	0	0%
15) Living with the surrounding community	1	20%
16) Other	2	40%

Table.B-2.3 Participants' opinion on the development of sustainability indicators for Thai industries

Lists of information	Number of responses (persons)	Percentage (%)
3.1 The industrial sustainability indicators should be developed based on the circular economy principle		
1) Agree	5	100%
2) Disagree	0	0%
3) Other	0	0%
3.2 The attribute of the industrial sustainability indicators based on the circular economy principle and Sustainable Consumption and Production Roadmap should be		
1) The indicators can collect data easily, they are information that the industry already has, and they can evaluate easily and uncomplicatedly.	3	60%

Lists of information	Number of responses (persons)	Percentage (%)
2) The indicators have clear measure unit, duration and boundary, and they are examinable and transparent.	5	100%
3) The indicators are quantitative and qualitative indicators.	4	80%
4) The indicators can be comparable within the industry.	3	60%
5) The indicators are quantitative measure in total and/or modified per unit (e.g., volume of total energy consumption / year or volume of energy consumption / production unit / year).	5	100%
6) The indicators can indicate activities of sustainable industrial development and support industrial sustainability reporting.	4	80%
7) The indicators correspond to local and national sustainability indicators and international affairs, such as global warming.	4	80%
8) Other	1	20%
3.3 The participants' opinion on the draft (2), and the sustainable consumption and production indicators based on the circular economy principle		
1) The indicators cover all important issues of the sustainable industrial development and Eco Factory criteria.	4	80%
2) The indicators correspond to the circular economy principle.	2	40%
3) The indicators are practically suitable for the operation of Thai industries.	0	0%
4) The drafted indicators based on the circular economy should be improved	5	100%
5) Other	0	0%
3.4 The willing to engage and participate in any activities during Feb 2021		
1) willing to give an interview or give additional comments.	4	80%
2) willing to participate in seminar/developing the sustainable consumption and production indicators based on the circular economy principle for industries for 1 time spending around 3	2	20%

Lists of information	Number of responses (persons)	Percentage (%)
hours		

APPENDIX B-3 Result of the third survey

Total number of participants who response the questionnaire are 30 persons consist of

- Participants from industrial sector 19 persons
- Participants from academic sector 11 persons

Section 1 Personal Information

Table B-3.1 Participants' role in developing, collecting data, and giving advice in the development of industrial sustainability indicators of the organization or industry in different dimensions

Dimensions of indicators	industrial sector (19 persons)		academic sector (11 persons)		total (30 persons)	
	Number of responses (persons)	Percentage (%)	Number of responses (persons)	Percentage (%)	Number of responses (persons)	Percentage (%)
1. Environmental dimension	19	100%	9	82%	28	93%
2. Social dimension	13	68%	7	64%	20	67%
3. Economic dimension	12	63%	3	27%	15	50%
4. Good governance dimension	12	63%	3	27%	15	50%
5. Other	0	0%	3	27%	3	10%

Table B-3.2 The participants' opinion on the draft (3) , and the sustainable consumption and production indicators based on the circular economy principle

Participants' opinion	industrial sector (19 persons)		academic sector (11 persons)		total (30 persons)	
	Number of responses (persons)	Percentage (%)	Number of responses (persons)	Percentage (%)	Number of responses (persons)	Percentage (%)
1. Agree that the indicators are suitable for the sustainable development for Thai industries.	7	37%	2	18%	9	30%
2. The indicators cover all important issues of the sustainable industrial development and Eco Factory criteria.	14	74%	5	45%	19	63%
3. The indicators correspond to the circular economy principle and mobilizing the Sustainable Consumption and Production Roadmap.	11	58%	6	55%	17	57%
4. The indicators are practically suitable for the operation of Thai industries.	2	11%	2	18%	4	13%
5. The indicators should be subcategorized due to a large number of indicators.	7	37%	6	55%	13	43%
6. The sustainable consumption and production indicators in the draft 3 should be improved	6	32%	2	18%	8	27%

Table B-3.3 opinion towards the development of consumption and production indicators based on the circular economy principle for sustainable development of Thai industries

Participants' opinion	industrial sector (19 persons)		academic sector (11 persons)		total (30 persons)	
	Number of responses (persons)	Percentage (%)	Number of responses (persons)	Percentage (%)	Number of responses (persons)	Percentage (%)
3.1 The opinion towards the level of indicator classification						
1) Agree with the 3-level classification	13	68%	7	64%	20	67%
2) Disagree with the 3-level classification	4	21%	2	18%	6	20%
3) Other	6	32%	10	91%	10	33%
3.2 The policy recommendations for the development of consumption and production indicators based on the circular economy principle benefiting Thai industry development in the future and mobilizing implementation support in the future.						
1) There should be a support for entrepreneurs who are interested in the sustainable development (in the large, medium, and small scales) by piloting the implementation of sustainable consumption	16	84%	9	82%	25	83%

Participants' opinion	industrial sector (19 persons)		academic sector (11 persons)		total (30 persons)	
	Number of responses (persons)	Percentage (%)	Number of responses (persons)	Percentage (%)	Number of responses (persons)	Percentage (%)
and production indicators based on the circular economy principle that cooperates with public and private sectors to be a framework for developing sustainable development for general industries and sustainability reporting in the future.						
2) The development of sustainable indicators for Thai industries should sub-categorize the indicators into 2 sets with 4 dimensions including general indicators for all industries for set 1 and indicators for industries in the specific industrial sector corresponding to the level of potential for enhancing the sustainable development of such industries for set 2.	9	47%	7	64%	16	53%
3) The related public and private sectors should create motivation, such as tax, accessibility of sustainable development funds, environmentally friendly procurement of the	17	89%	7	64%	24	80%

Participants' opinion	industrial sector (19 persons)		academic sector (11 persons)		total (30 persons)	
	Number of responses (persons)	Percentage (%)	Number of responses (persons)	Percentage (%)	Number of responses (persons)	Percentage (%)
public sector, research development and promotion, etc.						
4) Establishing certification system by reporting consumption and production indicators for sustainable development of Thai industries and positive-image promotion between the industries and related networks	12	63%	8	73%	20	67%
5) Other	8	42%	9	82%	9	30%

BIOGRAPHY

Name-Surname Peeraporn Palapleevalya

Academic Background
-Bachelor of Engineering in Chemical Engineering, King Mongkut's Institute of Technology, Thonburi, Thailand,1986
-Master of Science in Environmental and Natural Resources Economics (International Program),Chulalongkorn University, Thailand, 1998

Experience
- 1986-1991-Asst Manager Product Integrity , Arco Toy, Ltd.
- 1992-1995-Manager Consumer Products Laboratory,SGS (Thailand) Ltd.
- 1995-2002-Senior Project Manager, Business and Environment Program, Thailand Environment Institute.
- 2002- Manager, The Industrial Environment Institute, The Federation of Thai Industries
- 2002-2019-Director, Textile Testing Center, Thailand Textile Institute
- 2019-Present-Advisor SCP, Econovation Konsultants Co. Ltd
- 2021-Present-Project Manager, Circular Economy Innovation Policy Forum Project, Sustainable Consumption and Production Association (Thailand)
- 2003-2019-Member of Technical Barriers to Trade Committee, Ministry of Industry
- 2014-Present-Member of Foundation Committee, Asia Pacific of Roundtable of Sustainable Consumption and Production
- 2018-Present-Member of committee Thailand SCP Network
- 2018-Present-Committee of Water footprint Assessment and Certification System Environment and Water institute, Federation of Thai Industry
- 2003,2009- Participating in Training of Advanced Life Cycle Assessment (LCA) and Eco Design, the Association for Overseas Technical Scholarship (AOTS), Japan
- 2007- Participating in APEC Australia 2007, Senior Official Meeting III (SOM III), Chemicals Dialogue Industry Pre-meeting and Chemicals Dialogue, Cairns, Queensland, Australia
- 2007 Participating in the First Thai-EU Business Forum, Ministerial Level Meeting, visiting European Trade Brussels, Belgium