Chapter 10

ERIA - Industry 4.0 and Circular Economy Readiness Self-Assessment Tool

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CHAPTER 10

ERIA-Industry 4.0 and Circular Economy Readiness Self-Assessment Tool

Venkatachalam Anbumozhi and Dian Lutfiana

1. Overview

An important role in building a combined strategy for Industry 4.0 and the circular economy are the results of the assessment of the readiness to adopt and adapt the initiatives. The readiness of policymaking and the business community is often defined as the ability to capitalise on future productivity and resource efficiency opportunities, mitigate risks and challenges, and be resilient and agile in responding to unknown future uncertainties. Amongst the policy considerations for assessing the readiness of national economies for Industry 4.0 and the circular economy are categories such as technology and innovation, trade and investment, institutional arrangements, sustainable production, consumption, and human resources development. In the area of the company standalone assessment of readiness, several categories of indicators are influential, including strategy and organisation, smart factory, digitalisation of operations, eco-products, data-driven services, and connectivity in the supply chain.

The Economic Research Institute for ASEAN and East Asia (ERIA)-Industry 4.0 and Circular Economy Readiness Self-Assessment Tool (ERIA-I4RCE) is aimed to help policymakers and businesses think about their readiness for change and implement the related decisions. This tool is developed based on in-depth studies conducted by ERIA and complements information and research presented elsewhere (ERIA, 2016; ERIA, 2018) and the capacity building programmes conducted at ERIA.

It includes separate sections for policymakers and company managers. While grounded in research, theory, and practice, the self-assessment tool has been verified by policymakers in the region and validated with a pilot firm-level assessment.

2. Purpose and Target Audience

The ERIA-I4RCE self-assessment tool is primarily a tool for policymakers and firm-level managers and those who advise them to evaluate their country and company readiness with indicators encompassing policies and regulations, procedural efficiency, and cross-cutting issues. It comprises a suite of indicators assessing categories of drivers, modifiers, and facilitators of transformation to Industry 4.0 and the circular economy in an integrated way. Policymakers, business decision makers, researchers, and educators can use this tool to assess readiness in two ways:

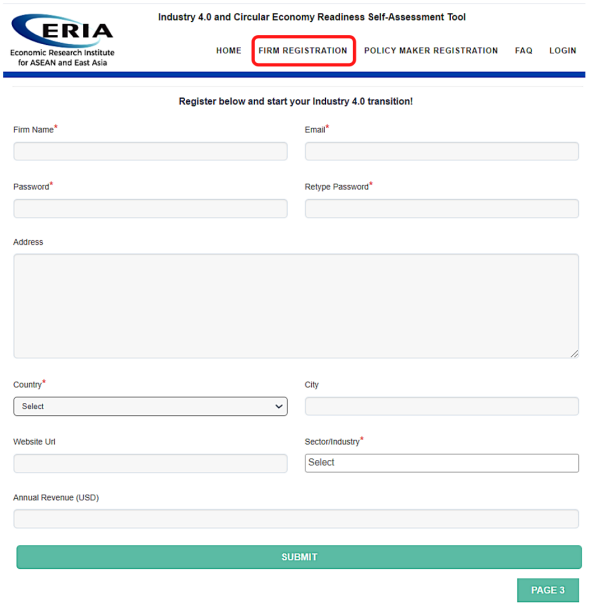
- Readiness to change from the established ways of doing things to address the identified strategy, needs, or opportunities available with Industry 4.0
- Readiness for the implementation of a specific programme, practice, or other policy intervention in support of the circular economy

The results of the integrated assessment will prepare the involved stakeholders for successful changes in initiatives and proactively build capacity in needed areas.

3. Tool Structure

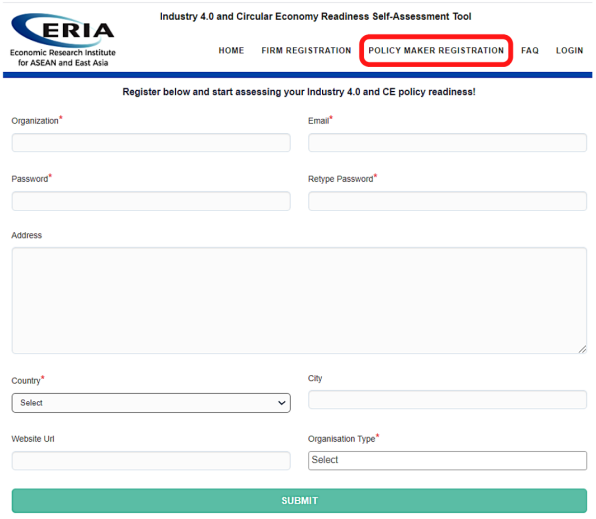
The self-assessment is divided into two sections: the firm section and the policymaker section. Each section has two parts to the assessment: first, assessment of Industry 4.0 readiness; and second, the extent of the circular economy in Industry 4.0, including an assessment of policy readiness for both Industry 4.0 and the circular economy. To begin the assessment, the assessor needs to register as either a firm or policymaker. The registration webpage aims to summarise the background of the organisation. Figures 10.1 and 10.2 show the registration page on the website.

Figure 10.1: Firm Assessment – Registration Webpage



Source: ERIA-Industry 4.0 and Circular Economy Readiness Self-Assessment Tool (http://i4r-eria.org/).

Figure 10.2: Policymaker Assessment – Registration Webpage



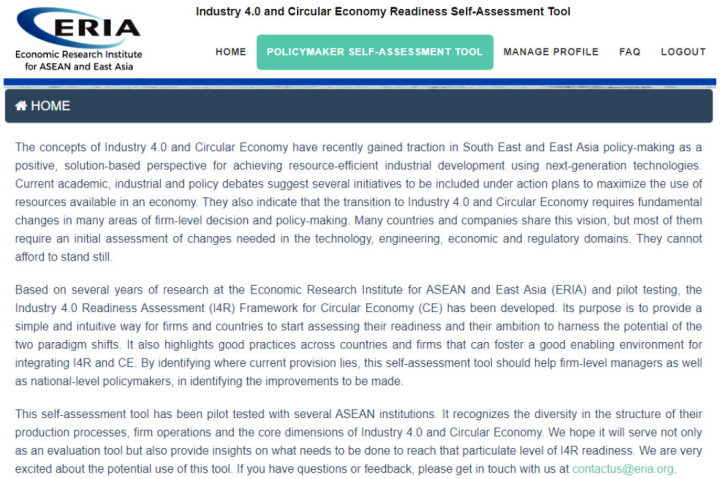
Source: ERIA-Industry 4.0 and Circular Economy Readiness Self-Assessment Tool (http://i4r-eria.org/).

After successfully registering, the user will be directed to the assessment page, which contains the assessment questions, assessor's profile page, and frequently asked questions (FAQ) as captured in Figures 10.3 and 10.4. An assessor can complete the assessment at a later time by logging in again to their account (Figure 10.5).

Figure 10.3: Firm Self-Assessment Webpage

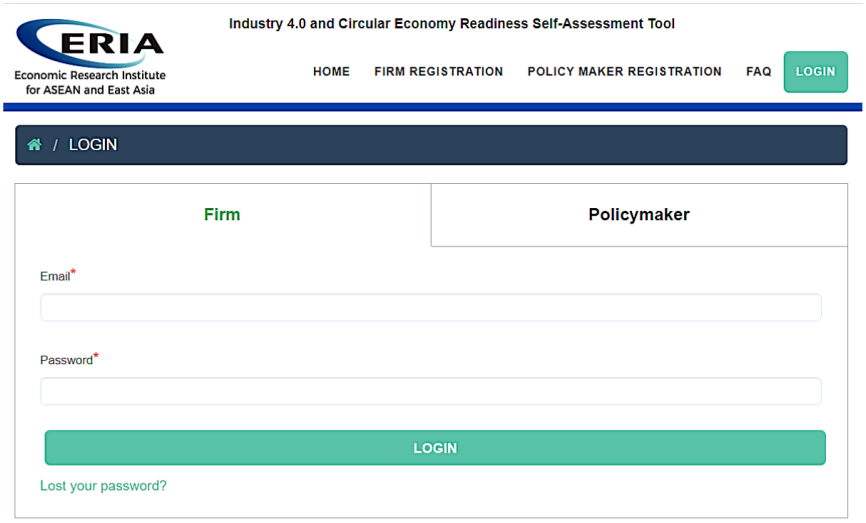
Source: ERIA-Industry 4.0 and Circular Economy Readiness Self-Assessment Tool (http://www.i4r-eria.org/survey)

Figure 10.4: Policymaker Self-Assessment Webpage



Source: ERIA-Industry 4.0 and Circular Economy Readiness Self-Assessment Tool (http://www.i4r-eria.org/survey)

Figure 10.5: Login Webpage



Source: ERIA-Industry 4.0 and Circular Economy Readiness Self-Assessment Tool (http://i4r-eria.org/login).

In terms of the question structure, the assessment uses a rating method for each indicator. The assessor needs to identify their firm or policy readiness based on level-based questions, where level 0 represent hesitators and level 4 represents frontrunners in considering implementing Industry 4.0 and the circular economy.

The next section provides more details on the assessment for both firms and policymakers.

3.1. Firm Self-Assessment

Industry 4.0 is talked about extensively as the Fourth Industrial Revolution that will have a major impact on manufacturing value-chains at both the local and global levels. This transformation is being driven by several foundational technological advances that enable sensors, machines, workpieces, and information technology (IT) systems to be linked along a value chain.

In such a rapidly evolving manufacturing landscape, nations and firms that are not ready to move towards an Industry 4.0 setting risk falling irrevocably behind their major competitors. From using Internet of Things (IoT) devices to providing teams with real-time supply chain data, and to utilising artificial intelligence (AI) for incorporate

inbuilt intelligence into factory automation, innovative firms across the world are using Industry 4.0 advances to transform their manufacturing efficiency. However, transitioning to Industry 4.0 presents many difficulties for firms. The most critical is their inability to self-evaluate their state of development regarding their Industry 4.0 vision, thereby making it difficult for them to identify specific steps that need to be taken in terms of actions, projects, and programmes. Using Industry 4.0 is also crucial to make the transition from a linear to a circular economy happen. A circular economy represents a fundamental and necessary alternative to the take-make-consume-dispose model that currently predominates the industrial production system.

To help firms to carry out this self-evaluation, ERIA's self-assessment tool provides a scoring rubric that will enable firms to assess their strengths and weaknesses concerning critical determinants that can influence the pace and quality of transition to an Industry 4.0 setting. The first part of this rubric aims to help firms assess their Industry 4.0 readiness (I4R) based on a study of international best practices that have been adopted by Industry 4.0 leaders. The second part of this rubric enables users to assess their I4R from the circular economy perspective. From a circular economy perspective, if well-designed and used effectively, Industry 4.0 can help to minimise the leakage of both biological and technical materials, especially the loss of raw materials, energy, and labour. The second part of the rubric is, therefore, aimed at helping firms ascertain the extent to which they have explicitly built-in circular economy considerations into their Industry 4.0 actions, projects, and programmes. Collectively, the findings of the two sets of evaluations should help firms to benchmark themselves against Industry 4.0 leaders with respect to Industry 4.0 readiness as well as the extent of the circular economy focus in their Industry 4.0 readiness.

A. Firm-level Assessment Framework of the Status of Industry 4.0 Readiness

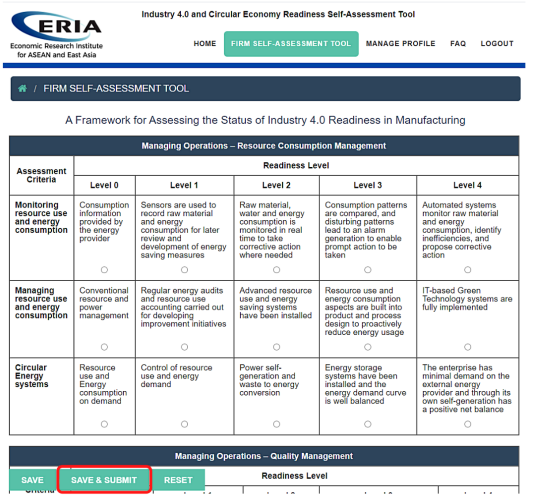
The assessor should complete each readiness criteria based on their experiences, and they suggested to involve the appropriate managers in charge of each determinant to reduce the bias of an individual manager. Additionally, it is suggested that the managers should be able to provide evidence to support the rating.

The assessment is organised into six components:

- Determinant 1: Strategy and Organisation – incorporating Industry 4.0 into the firm's strategies, innovation, leadership, and business models (6 items).
- Determinant 2: Plant and Equipment – readiness of the firm's infrastructure (i.e. machine, operating systems, IT, and data security) for implementing Industry 4.0 (4 items).
- Determinant 3: Information Technology Systems and Data Management – the level of the firm's IT systems, such as information sharing and interoperability using cloud storage (6 items).
- Determinant 4: Human Resources – human resource capabilities of the firm in utilising advanced technology (4 items).
- Determinant 5: Product Definition – the firm's delivery of products in association with its customisation potential, digital features, and life cycle assessment (3 items).
- Determinant 6: Managing Operations – resource consumption management (3 items), quality management (2 items), and supply chain management (5 items).

Figure 10.6 shows the readiness assessment for the determinant of 'Managing Operations – Resource Consumption Management'. If a manager needs further coordination in order to complete the assessment, they can save their progress and continue at a different time by clicking on the 'save' button.

Figure 10.6: Readiness Assessment of Resource Consumption Management



Source: ERIA-Industry 4.0 and Circular Economy Readiness Self-Assessment Tool (http://www.i4r-eria.org/survey)

B. Firm-level Assessment of Industry 4.0 Readiness for the Circular Economy

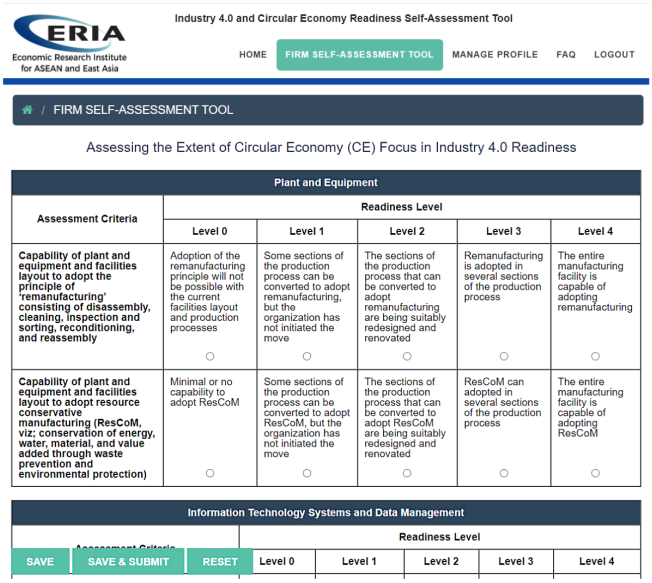
This assessment is to identify the readiness of the firms to integrate the circular economy into their business actions, projects, and programmes. Similar to the previous assessment of Industry 4.0 readiness, firms are suggested to involve multiple appropriate managers in charge of each area to respond to the criteria.

Similar to part A, it is organised into six similar determinants:

- Determinant 1: Strategy and Organisation – willingness to consider circular economy aspects in the firm's strategies (4 items).
- Determinant 2: Plant and Equipment – the plant's capability to accommodate resource conservative manufacturing/ResCoM (2 items).
- Determinant 3: Information Technology Systems and Data Management – consideration to incorporate circular economy principals into the firm's operations (1 item).
- Determinant 4: Human Resources – incorporating circular economy value into the firm's networks (1 item).
- Determinant 5: Product Definition – developing sustainable designs for the firm's products (2 items)
- Determinant 6: Managing Operations – resource consumption management (1 item), quality management (1 item), and supply chain management (2 items).

An example of the assessment criteria for the circular economy on a firm's plant and equipment (determinant 2) is illustrated in Figure 10.7.

Figure 10.7: Determinant 2 – Plant and Equipment



Industry 4.0 and Circular Economy Readiness Self-Assessment Tool

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Assessing the Extent of Circular Economy (CE) Focus in Industry 4.0 Readiness

Plant and Equipment					
Assessment Criteria	Readiness Level				
	Level 0	Level 1	Level 2	Level 3	Level 4
Capability of plant and equipment and facilities layout to adopt the principle of 'remanufacturing' consisting of disassembly, cleaning, inspection and sorting, reconditioning, and reassembly	Adoption of the remanufacturing principle will not be possible with the current facilities layout and production processes	Some sections of the production process can be converted to adopt remanufacturing, but the organization has not initiated the move	The sections of the production process that can be converted to adopt remanufacturing are being suitably redesigned and renovated	Remanufacturing is adopted in several sections of the production process	The entire manufacturing facility is capable of adopting remanufacturing
Capability of plant and equipment and facilities layout to adopt resource conservative manufacturing (ResCoM, viz; conservation of energy, water, material, and value added through waste prevention and environmental protection)	Minimal or no capability to adopt ResCoM	Some sections of the production process can be converted to adopt ResCoM, but the organization has not initiated the move	The sections of the production process that can be converted to adopt ResCoM are being suitably redesigned and renovated	ResCoM can adopted in several sections of the production process	The entire manufacturing facility is capable of adopting ResCoM

Information Technology Systems and Data Management					
Assessment Criteria	Readiness Level				
	Level 0	Level 1	Level 2	Level 3	Level 4

SAVE | SAVE & SUBMIT | RESET

Source: ERIA-Industry 4.0 and Circular Economy Readiness Self-Assessment Tool (http://www.i4r-eria.org/survey)

3.2. Policymaker Self-Assessment

National policies and institutions matter in driving both Industry 4.0 and the circular economy. Thus, the policy readiness assessment toolkit is specifically designed for government agencies and institutions who are involved in making national policy with regards to Industry 4.0 and the circular economy. The first part of the self-assessment provides a rubric to enable policymakers to assess their policy readiness with regards to Industry 4.0, while the second part enables policymakers to assess their policy readiness for the circular economy.

The policy readiness toolkit for Industry 4.0 is a macro-level policy assessment that focuses on policies that are directly related to driving Industry 4.0. The assessment mainly considers six important policy thrusts that would provide the environment for enabling the industry to transform their business activities. The policy thrusts include assessing the regulatory and institutional framework environment; education and human capital; science, technology and innovation policy; business technology promotion policy; digital transformation; and trade and investment policy environment. These policy environments are crucial in driving and catalysing the business uptake to move towards Industry 4.0.

Policymakers should consider all the dimensions as a holistic framework as each dimension is interrelated.

Similarly, the policy thrust for the circular economy considers five policy thrust areas. The intention is to capture the institutional and regulatory readiness for the circular economy as well as the driving factors, such as education and awareness, public-private collaboration, the business support system, and infrastructure system readiness to embrace the circular economy. For instance, the institutional and policy thrust incorporates various policies related to circularity, namely, waste management, energy and standards including strategies related to resource productivity, and the adoption of remanufacturing principles.

Collectively, the findings of the two sets of assessments should help policymakers to benchmark themselves concerning policy Readiness for Industry 4.0 and the circular economy at the national level. The findings of this evaluation should help policymakers to make the policy transition by identifying their strengths and weaknesses

This section elaborates the assessment from the policy perspective associated with the readiness for Industry 4.0 and the circular economy, aiming to measure the current status of policy readiness and identify policies that complement and catalyse the drivers to promote and accelerate Industry 4.0 and a sustainable economy.

A. Policy-level Assessment Framework for Industry 4.0 Readiness

This framework aims to identify the policy dimensions that are essential in driving industry 4.0 and the circular economy. There are six areas needed to be identified to stimulate market activities and prevent regulatory failure for Industry 4.0 and circularity implementation.

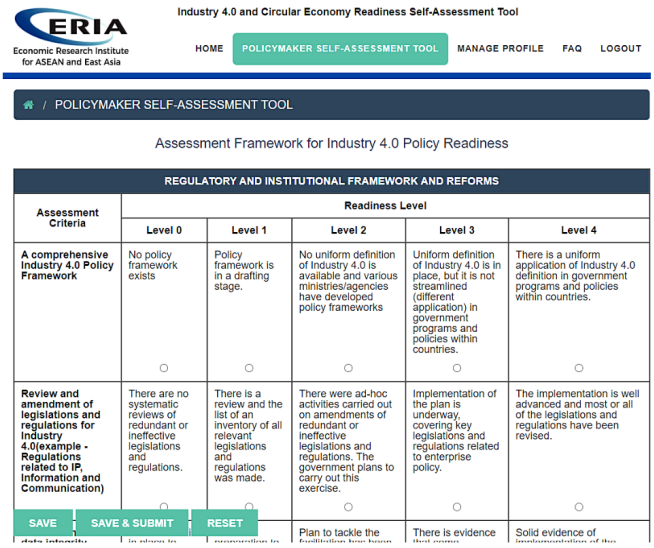
The rating system measures level 0 as the least ready and level 4 as a frontrunner/ expert in the matter. Therefore, the six areas are as follows:

- Area 1: Regulatory and Institutional Framework and Reforms – regulatory preparedness and institutional ability to coordinate activities in achieving Industry 4.0 (8 items).

- Area 2: Education – including human capital, to ensure the policy is ready to prepare the workforce and provide skills that are in demand by the newly emerging industries (4 items).
- Area 3: Science, Technology, and Innovation (STI) – related to a strategic approach to STI policies, R&D programmes, and innovation (4 items).
- Area 4: Business Technology Promotion – policy related to ICT technology and business promotion towards digitalisation (2 items).
- Area 5: Digital Transformation – related to smart technology standards, IoT, data security, and support for creative industries (3 items).
- Area 6: Trade and Investment Policies – emphasis on investment promotion in strategic sectors of Industry 4.0 and international cooperation (3 items).

For area 3 to area 6, these assessments are basically to identify policies related to infrastructure readiness to support Industry 4.0. Figure 10.8 shows some sample questions for area 1, 'regulatory and institutional framework and reforms'.

Figure 10.8: Sample Questions for Area 1: Regulatory and Institutional Framework and Reforms



Source: ERIA-Industry 4.0 and Circular Economy Readiness Self-Assessment Tool (http://i4r-eria.org/survey).

B. Assessment Framework for Circular Economy Policy Readiness

Five policy thrust areas are assessed to capture the policy readiness for circular economy implementation, as follows:

- Area 1: Institutional and Regulatory Framework for Circular Economy – related to circular economy policy frameworks, awareness initiatives, resource efficiency strategies, and standard regulation (8 items).
- Area 2: Education, Information and Awareness – promoting circular economy into the educational system and public campaigns (2 items).
- Area 3: Collaboration and Partnership Platforms – public-private partnerships, voluntary industry participation, and R&D programmes in the circular economy (3 items).
- Area 4: Business Support Systems for Circular Economy – policy-related financial incentives and non-financial support (2 items).
- Area 5: Public Procurement, Infrastructure and Technology – enabling public procurement and investment to promote Industry 4.0 and the circular economy (3 items).

4. Summary of Industry 4.0 Readiness for the Circular Economy Self-Assessment Results

For the readiness assessments for both firms and policymakers, the rating system uses measurements based on the scores obtained from each criterion. Firms and policymakers will obtain the following information based on the completed self-assessment.

1. Background information
   This information will be necessary to grasp the nature of the firm or economy and its competitiveness status, future strategic plans, challenges, risks faced, and mitigation strategies set.

2. Rating 'Industry 4.0 readiness' and 'circular economy readiness' based on determinants and areas

Both for firms and policymakers, the results show the rating of the elements of 12 determinants and 6 sub-determinants for firms, and 11 areas of policy readiness assessment. Both assessments reflect the level of readiness for Industry 4.0 and the circular economy of the firm and policies.

In the case of a firm assessment, it is important to engage multiple managers that are in charge of these areas to determine the level of Industry 4.0 readiness and circular economy for Industry 4.0. This helps to avoid potential bias from an individual manager. Moreover, it is also necessary for the managers to provide evidence to support their responses.

After the completion of the assessment, the results will be presented in a scoring table and radar diagram. Firstly, the scores are calculated based on the responses for each criterion, where each level translates to a score, as elaborated in Table 10.1.

Table 10.1: Scoring Based on Readiness Level

Readiness Level	Score
Level 0	0
Level 1	1
Level 2	2
Level 3	3
Level 4	4

Source: Authors, based on Chapter 3 of this publication.

The following section shows the scoring system for firms' self-assessment, which is also applied for assessing the policy readiness of Industry 4.0 and the circular economy.

In this assessment, there are 33 criteria, and each criterion has a maximum score of 4. Therefore, the maximum score for all criteria is 132. Based on this scoring, the assessor will be able to determine the status of Industry 4.0 as listed in Table 10.2.

Table 10.2: Status of Industry 4.0 Readiness

Score Range	Classification
0–33	Hesitator
34–66	Potentialist
67–99	Experienced
100–132	Expert or frontrunner

Source: Authors, based on Chapter 3 of this publication.

For the circular economy assessment, there are only 14 criteria. Therefore, the maximum score for all criteria is 56. Based on this scoring, the status of the circular economy focus on Industry 4.0 readiness is classified as in Table 10.3.

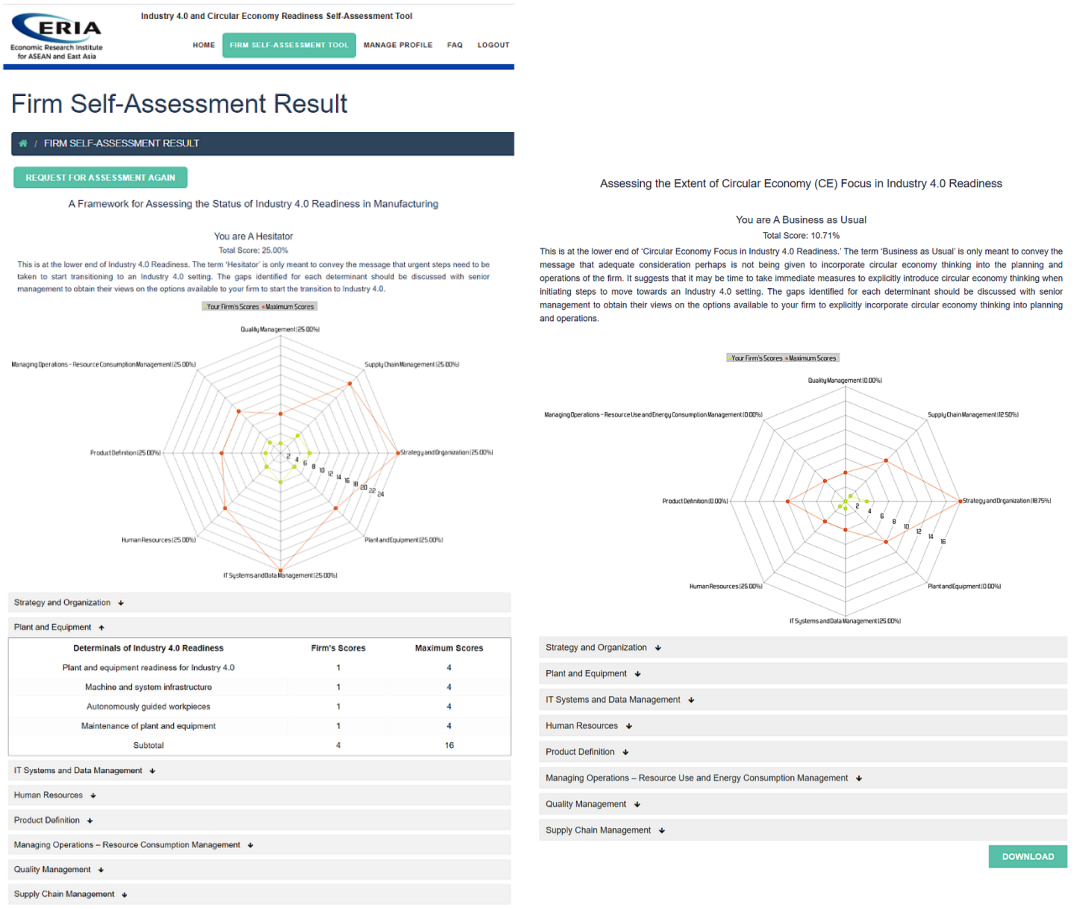
Table 10.3: Status of Circular Economy Focus on Industry 4.0 Readiness

Score Range	Classification
0–14	Business-as-usual
15–28	Circular economy beginner
29–42	Circular economy fast adopter
43–56	Circular economy leader

Source: Authors, based on Chapter 3 of this publication.

Furthermore, the accumulated results, generated from the actual values obtained and the maximum values, are illustrated using a 'radar diagram'. Two different radar diagrams represent the status of the Industry 4.0 readiness level and the circular economy focus on Industry 4.0. Essentially, the managers or policymakers can redo their assessment if there is a significant change in their industry or policies regarding Industry 4.0 and circular economy readiness. Figure 10.9 shows an example of the complete results of a firm self-assessment that can also be downloaded by the assessor.

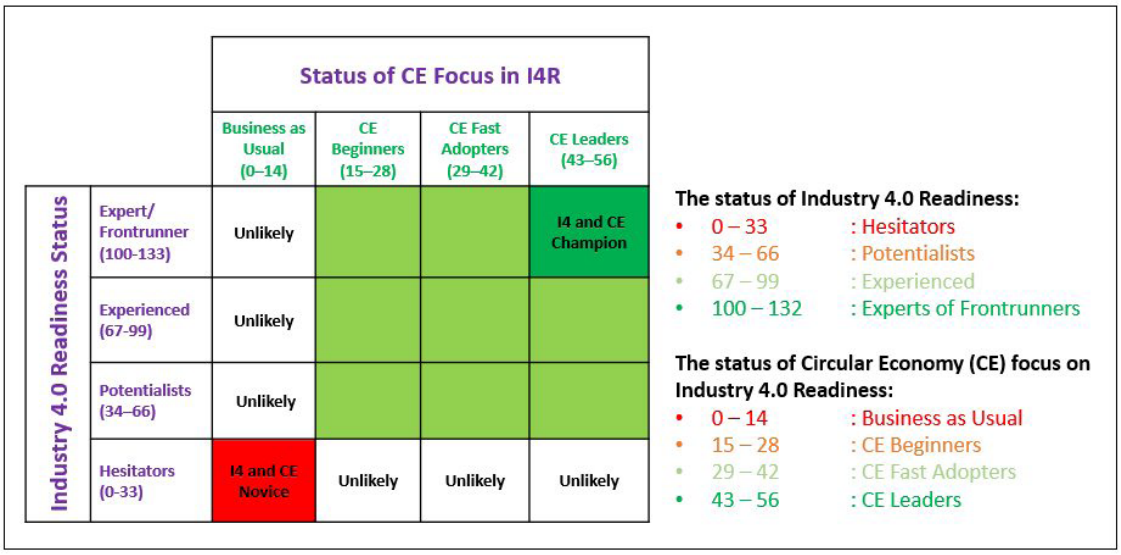
Figure 10.9: Example of Completed Results of a Firm Self-Assessment



Source: Authors' analysis.

Based on the two assessment frameworks and analysis, Figure 10.10 summarises a possible combination for Industry 4.0 readiness and the extent of circular economy focus on Industry 4.0 readiness. However, it should be noted that the matrix in Figure 10.10 shows possible combinations that are unlikely to be valid. For instance, it is somewhat unlikely that an Industry 4.0 'hesitator' would be a 'circular economy leader'. Thus, it is necessary to conduct further in-depth analysis to determine the position of the firm in the matrix.

Figure 10.10: Circular Economy-focused Industry 4.0 Readiness Matrix



I4.0 = Industry 4.0, I4R = Industry 4.0 readiness.
Source: Authors, based on Chapter 3 of this publication.

5. Development of a Blueprint for Transition towards an Industry 4.0 and Circular Economy Champion

The findings from the integrated assessment can be used to develop a collective, broad understanding of any institution's (firm/country) readiness for change and implementation and to identify areas of development. After the Industry 4.0 readiness and circular economy assessment has been carried out, the next stage will be identifying the approaches that should be taken to facilitate planning to become a champion in Industry 4.0 and the circular economy. This self-assessment suggests six steps that can be applied by decision makers (policymakers or firm managers) to plan their further actions towards becoming frontrunners.

- Step 1: Use the two assessment frameworks to reach a consensus on immediate feasible actions that can be taken.
- Step 2: Use the outcomes of the discussion in Step 1 to define a vision for the short term and the longer term.

- Step 3: Identify partnerships needed both at the upstream and downstream end of the supply chain to implement the actions, projects, and programmes.
- Step 4: Appoint a steering committee to review the implementation of the actions, projects, and programmes and ensure that the circular economy Industry 4.0 readiness transition proceeds as envisaged.
- Step 5: Build internal capabilities as well as supply chain capabilities to enable effective implementation.
- Step 6: Strive for perfection through radical improvements (kaikaku) supported by continuous improvement.

This information will inform the implementation, planning, and capacity building required in several areas.

6. Instructions to Users of the Readiness Self-Assessment Tool

Before using this self-assessment tool, institutions should consider who, when, and how it should be administered.

Who should participate in the self-assessment?

This self-assessment tool is designed to be used by individuals or institutions that are responsible for overseeing or guiding the Industry 4.0 and circular economy transformation efforts through changes and implementation processes. The team/individual should have diverse expertise and perspectives from across agencies and departments and be able to adapt and adopt the transformational changes.

When should the assessment tool be used?

Individuals or institutes may use this tool at different points in the design of the change and implementation process:

- At the beginning of the Industry 4.0 and circular economy change process, the firm-level manager or policymaker can use the assessment tool to check the readiness.
- Before selecting a specific category for technology and management intervention under the Industry 4.0 or circular economy categories, the tool can be used to assess the readiness for implementation.

- While researching or piloting an intervention, individuals or institutes can use the assessment tool to stimulate changes in readiness and identify capacity-building needs.

How should individuals or institutes administer the self-assessment tool?

Before administering the self-assessment tool, a designated individual or team of experts should clearly communicate the purpose of the tool and how it will be used. They may refer to the previous chapters of this book to orient themselves or others to have a clear understanding of the basic concepts of Industry 4.0 readiness for the circular economy. They should also remind participants of the importance of a candid examination of readiness and in assigning the scores so that assessment is impartial, motivated, and capacity is built.

A group of individuals as members of a team could also complete the assessment and take an average score to rate the extent of readiness. Some teams may ask members to complete the assessment individually, and then tally individual responses to inform a collective response and discussions. Government agencies or departments within a firm may find it useful to serve as a facilitator for discussions and help the group come to a consensus when rating various items.

To rate items, the individuals or teams that take the assessment will need to consider the existing sources of in-house information, data, and whether they need additional information. When necessary, collecting additional data may extend the time involved in the assessment process; however, doing so should better inform and shape decisions for moving forward. The assessment results obtained and the analysis of the hidden, and not obvious, knowledge of future actions can be of substantial benefit to the stakeholders related to the development of corporate strategies and policies for raising the index of readiness.

For further assistance with using this self-assessment tool and assessing the readiness of Industry 4.0 and the circular economy, please email: contactus@eria.org or visit www.i4r-eria.org.

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