Chapter 9

Benchmarking of Regional Initiatives and National Policies towards Industry 4.0 and Circular Economy Transformation

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CHAPTER 9

Benchmarking of Regional Initiatives and National Policies for Industry 4.0 and Circular Economy Transformation

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1. Overview

The Fourth Industrial Revolution and circular economy offer huge potential for transforming the Association of Southeast Asian Nations (ASEAN) and East Asian economies and realigning the future of growth towards sustainability. The widespread impacts of Industry 4.0 and the circular economy affect not only the role of governments but also the effectiveness of existing regulatory frameworks. There is a growing concern for governments' agility, adaptability, and responsiveness to the rapid change in technologies and practices for ensuring the overall welfare of society. Less attention, however, has been accorded to governments' role as enablers, or even drivers of the transformation into the circular economy that is assisted by Industry 4.0 technologies. This may partly be due to the fact that many – if not most – of these advanced technologies are largely invented, owned, disseminated, and utilised within the private sector domain. As a result, governments' abilities to minimise the unintended consequences are also limited given the extent of knowledge and access to full information of the potential and risk of those technologies. In addition, the transboundary nature of global connectivity, enabled by technological advancements, and social networks place further challenges on governments to maintain their regulatory space, particularly in the absence of a global regime for technological governance and increased global and systemic risks, such as cybersecurity (ERIA, 2019).

On the upside, Industry 4.0 and the circular economy offer a possibility for governments to promote transparent, evidence-based, participatory, and sustainable public policymaking and delivery through the deployment of advanced technologies and improved resource use. To enhance preparedness and successfully reap the benefits, a more proactive, overarching, and forward-looking approach is needed. Enhancing readiness for Industry 4.0 requires a transformation in the government's approach, work processes, and mindset, not only to provide an effective policy response but also to drive the necessary shifts in regulatory frameworks to unleash the full potential. Agile governance is a prerequisite for a country's success, which implies a policymaking process that is adaptive, people-centred, inclusive, and sustainable with multi-stakeholder efforts being put at the core (ERIA, 2018; Regional 3R Forum, 2018).

2. Regional Initiatives Related to Industry 4.0

ASEAN is creating the conditions for emerging digital technologies to benefit people and the planet under the ASEAN Community blueprints. Those initiatives are grouped under the four enabling thematic clusters of science, technology and innovation; regulatory frameworks; infrastructure and trade connectivity; and human capital.

2.1. Science, Technology, and Innovation

Science and technology: Providing an environment that is conducive to the rise of advanced technologies lies at the heart of ASEAN's regional efforts in promoting innovation and technology. This is done by setting up relevant platforms for further collaborative efforts. The ASEAN Declaration on Innovation, adopted in 2017, encouraged the establishment of regional networks of joint research, capacity building and innovation initiatives that focus on topics that enhance science, technology, and innovation collaboration with global partners through such network organisations. This is one of the policies that promote excellence and relevance in public research and encourages stronger links amongst government, academia, industry, and society to strengthen their impact on science, technology and innovation. Following this, in 2018, the ASEAN Innovation Network was established with the objective of creating

deeper connections amongst the innovation ecosystems of the member countries and dialogue partners. Various elements in the ASEAN Economic Community Blueprint 2025 are linked to the dimension of innovation and technology, with relevant initiatives including those spearheaded by the regional Committee on Science and Technology and the Telecommunications and Information Technology Senior Officials Meeting, guided by the ASEAN Plan of Action on Science, Technology and Innovation 2016–2025 and the ASEAN ICT Masterplan 2020, respectively. Ongoing work under the Committee on Science and Technology includes the development of the Open Innovation and Entrepreneurship Platform, which was completed in 2019. The platform serves as a collective mechanism to engage and coordinate diverse regional and international stakeholders and to promote new entrepreneurs and technology development for the future and to challenge markets. Collaborative work with Dialogue Partners to set up new innovation platforms and centres is also being considered, including the ASEAN–India Innovation Platform and the ASEAN – Republic of Korea Innovation Centre.

Intellectual property: With the advent of technological advancements, intellectual property (IP) is a key vehicle to stimulate innovation and encourage technology commercialisation. Relevant work in ASEAN is guided by the 2016–2025 ASEAN Intellectual Property Rights Action Plan. Ongoing work includes the development of new networks of integrated IP services. There are 126 universities in ASEAN that have Technology Innovation Support Centres, which provide innovators with access to information and related services to help them exploit their innovation potential and create, protect, and manage their IP rights. Four ASEAN search databases on patents, trademarks, designs, and geographical indications are also available that support research and development work.

Patent: The number of patent applications filed in ASEAN has grown by about a 10% year-on-year average for the last five years since 2015 (Peramini, Fideles, and Karlina, 2019). New initiatives include the development of patent examination manuals on specialised fields, such as biotechnology and information and communication technology by IP Offices. Topics such as big data, Internet of Things (IoT), and artificial intelligence are all being integrated into capacity building activities to prepare the IP Offices for Industry 4.0.

Furthermore, the ASEAN Patent Examination Cooperation, a regional work-sharing programme launched in 2009, allows for the sharing of search and examination results amongst member states to expedite the process of patent applications.

Cybersecurity: Efforts have been undertaken in various technical committees. To date, work has been done under the purview of the ASEAN Ministerial Meeting on Transnational Crime, Telecommunications and Information Technology Ministers' Meeting, ASEAN Ministerial Conference on Cybersecurity, ASEAN Cyber Capacity Programme, ASEAN Regional Forum Inter-Sessional Meeting on ICT Security, and the ADMM-Plus Experts' Working Group Meeting on Cyber Security. The ministerial meetings reaffirmed the need for ASEAN to take a holistic and more coordinated approach to regional cybersecurity cooperation and capacity building. Enhancing coordination between various platforms of the three pillars of ASEAN was also underscored. The meeting participants proposed the use of the International Telecommunications Union's Global Cyber Security Index as a possible benchmark for assessing and developing ASEAN's cybersecurity readiness. Commitment towards ensuring cybersecurity is likewise echoed at the highest political level. At the 31st ASEAN Summit, the Leaders adopted the ASEAN Declaration to Prevent and Combat Cybercrime and noted the ongoing efforts to develop an ASEAN Cyber Centre and Hub to further enhance cooperation in addressing cybercrimes in the future. At the bilateral level, the Memorandum of Understanding on Cooperation to Counter International Terrorism between ASEAN and Australia was signed in March 2018. The memorandum, which implements the 2016 ASEAN–Australia Joint Declaration for Cooperation to Combat International Terrorism, provides a framework to strengthen cooperation and collaboration between ASEAN and Australia in several areas, including in law enforcement cooperation, capacity building, and technical assistance.

2.2. Regulatory Frameworks

E-commerce framework: The growth of e-commerce in ASEAN requires strong regulatory frameworks for its further development. The ASEAN Work Programme on Electronic Commerce 2017–2025 identifies updating e-commerce legal frameworks and transparent national laws and regulations on e-commerce as two of its targeted outcomes under the element of modernising the legal framework. Opportunities for regional cooperation are evident. As one of the outcomes of the work programme

under the element of the e-commerce framework, ASEAN is currently developing the ASEAN Agreement on e-Commerce, which is expected to facilitate cross-border e-commerce transactions, create an environment of trust and confidence, and deepen cooperation on e-commerce in the region. The ASEAN Coordinating Committee on Electronic Commerce is also developing the ASEAN Guidelines on Accountability and Responsibilities of Online Intermediaries. Another relevant framework is the ASEAN Digital Integration Framework. The frameworks aim to monitor the progress of digital integration in ASEAN and improve ASEAN's digital ecosystem to maximise the benefits of ASEAN's digital integration initiatives.

Consumer protection: Amidst the fast-changing technological advancements, there is a heightened need for policymakers to ensure consumer protection. ASEAN work on consumer protection is guided by the ASEAN Strategic Action Plan for Consumer Protection 2016–2025, spearheaded by the ASEAN Committee on Consumer Protection. Ongoing initiatives include the development of the Guidelines on Cross-Border B2C Complaints and Code of Conduct for On-line Businesses.

Overall improvement in the quality of regulatory frameworks: An assessment is being done in specific areas related to Industry 4.0, such as e-commerce and consumer protection as explained above, as well as finance with the Working Committee on Financial Inclusion (WC-FINC) now developing the Guidance Notes on Digital Financial Services, overall improvements in the quality of regulatory practice remain key. Relevant initiatives in ASEAN include those under the ASEAN Work Plan on Good Regulatory Practice (2016–2025), such as the development of the ASEAN GRP Core Principles, which were finalised in 2018.

2.3. Infrastructure and Trade Connectivity

Infrastructure and connectivity: One of the characteristics of the ASEAN Economic Community Blueprint 2025 is enhanced connectivity and sectoral cooperation, which aims at enhancing economic connectivity involving various sectors, namely, transport, telecommunications, and energy, and in support of the vision and goals of the Master Plan on ASEAN Connectivity (MPAC) 2025.

Work is undertaken by the ASEAN Connectivity Coordinating Committee, National Coordinators, National Focal Points, and relevant ASEAN Sectoral Bodies, as well as Dialogue Partners and external parties, to implement projects under the 15 initiatives of the MPAC 2025. Efforts are currently undertaken to establish an initial list of potential priority infrastructure projects, conduct a study to advance sustainable urbanisation, and review how micro, small, and medium-sized enterprises (MSMEs) are responding to the challenges posed by the digital economy.

Trade facilitation and other relevant work: Relevant work in ASEAN also includes the timing to facilitate cross-border trade where the utilisation of technologies can serve as a means to achieving regional economic integration goals. Various initiatives under the different sectoral work plans, including on trade in goods, trade in services, and tourism as well as global value chains, can contribute to the enhancement of connectivity in the region. On trade facilitation, the ASEAN Solutions for Investments, Services and Trade was launched in 2016, providing a non-binding and consultative mechanism for the expedited and effective solution of operational problems encountered by ASEAN-based enterprises on cross-border issues. ASEAN has also developed the ASEAN Trade Repository, which provides a single point of access to all trade-related information of ASEAN Member States, such as tariff and non-tariff measures, rules of origin, national trade and customs laws and rules, and documentary requirements. While in tourism, the web-based ASEAN Tourism Professionals (ATP) Registration System, launched at the International Conference on ASEAN Mutual Recognition Arrangement on Tourism Professionals (MRA-TP) in 2016, provides not only a registration facility for certified ATPs but also serves as a job-matching platform between industry and ATPs across ASEAN, and a resource centre for all ASEAN MRA-TP related information.

2.4. Human Capital

ICT in education: Industry 4.0 has brought new challenges for human capital development, particularly given the different levels of access to training and education and the need to build digital capabilities. In the ASEAN Socio-Cultural Community (ASCC), strengthening the use of ICT in the education sector has been a key element in the ASEAN Work Plan on Education 2016–2020. To implement the work plan, new initiatives are undertaken through three main phases, namely the establishment of the

ASEAN Cyber University, as supported by ASEAN+3, to promote cross-border higher education mobility; improvement in online learning with a focus on higher education, led by the Republic of Korea (hereafter, Korea); and preparing ICT-ready teachers through the enhancement of teachers' competency, led by Singapore. These three phases aim to achieve the overarching goal of using ICT effectively for teaching and learning.

Technical and vocational education: Within the context of Industry 4.0, a greater focus has also been given to technical and vocational education. Work is currently underway towards the creation of ASEAN Technical and Vocational Education and Training (TVET) 4.0, which is part of Priority 4.2 of the ASEAN Work Plan on Education 2016–2020, i.e. strengthening regional harmonisation for the advancement of quality TVET transformation through networking, partnerships, and the mobilisation of TVET personnel and resources. Several expected outputs from the ASEAN TVET 4.0 initiative include the setting up of a strategic coordination platform to facilitate discussion on cross-cutting issues related to the harmonisation of TVET, including Industry 4.0, the development of regional guidelines and training modules/curricula for TVET personnel, such as teachers and in-company trainers, drafting of an orientation framework on quality in TVET, the establishment of a regional knowledge platform on TVET in the ASEAN region, and implementation of advanced regional training programmes for TVET personnel to develop pedagogical and institutional managerial capacity.

ICT and employment: Also under the ASCC, one of the activities in the ASEAN Labour Ministers' Work Programme 2016–2020, is a regional study on the impact of the use of ICT and outsourcing on employment relationships and on the adequacy of legislation in regulating employment relationships. Improvements in human capital are also addressed through initiatives to better integrate MSMEs into the digital economy. To this end, the ASEAN SME Academy provides online access to training and resources specifically developed and tailored to meet the needs of small and medium-sized enterprises (SMEs) operating in ASEAN. Meanwhile, the ASEAN SME Service Centre is a web portal with regional linkages, providing information crucial for SMEs to help them access regional and international markets.

3. National Policy Initiatives Related to Industry 4.0

A country's ability to implement Industry 4.0-type technologies is contingent on its economy-wide readiness, capacity, and alignment with its respective national priorities. A non-exhaustive list of major national initiatives related to Industry 4.0 undertaken by the countries in Southeast Asia is shown in Table 9.1. The focus is on the objectives of the initiatives, the implementing period, specific targets, priority areas, and implementing agencies. Most of the countries have put in place major, cross-sectoral, comprehensive national initiatives related to Industry 4.0. The strategic importance of having such cross-sectoral comprehensive initiatives is that it allows cross-sectoral cooperation and coordination, which is particularly important given the fact that the Industry 4.0 regime itself is emerging and is interdisciplinary in nature.

Table 9.1: List of Major National Initiatives in ASEAN Related to Industry 4.0

Country	Policy Initiatives/Strategies
Brunei Darussalam	National Digital Strategy 2016–2020 – National ICT White Paper for Brunei Darussalam (2016); The Digital Government Strategy 2015–2020 (2015); National Broadband Policy 2014–2017 (2014)
Cambodia	Cambodian ICT Masterplan 2020 (2014); Telecommunication ICT Development Policy 2020; signing of the MoU with Microsoft on ICT cooperation (2016)
Indonesia	Launch of 'Making Indonesia 4.0' Roadmap (2017); Indonesia Broadband Plan 2014–2019
Lao PDR	E-Government Development Plan 2013–2020 (2013); signing of the MoU with Microsoft (as part of Microsoft's National Empowerment Plan) (2016); National Strategies for Science and Technology Development 2013–2020 and Vision 2030 (2013)
Malaysia	Development of the National Industry 4.0 Policy Framework (2018); Establishment of Industry 4.0 High Level Task Force (2017); launch of the Centre of Excellence on Industry 4.0 (2017); launch of the Digital Free Trade Zone (DFTZ) Initiative and Pilot Project (2017); The Malaysian ICT Strategic Plan 2016–2020 (2016); launch of the National e-Commerce Strategic Roadmap (2016); 11th Malaysia Plan 2016–2020 (2015); National IoT Roadmap (2015); National Broadband Initiative (2006)
Myanmar	Development of the Digital Economy Development Masterplan (2017); Universal Service Strategy 2018–2020 (2018); e-Government Masterplan 2016–2020 (2014);
Philippines	Inclusive, Innovation-led Industrial Strategy (i3s) (2017); Philippines Digital Strategy 2011–2015 (2011); National Broadband Plan; e-Government Master Plan 2016–2020 (EGMP 2.0)

Country	Policy Initiatives/Strategies
Singapore	AI.SG Initiative (2017); Research Innovation Enterprise 2020 Plan (2016); Industry Transformation Programme (2016); Intelligent Nation 2015 (2015); National Robotics Program (2015); Smart Nation (2014)
Thailand	Digital Government 2017–2021 (2017); Thailand 4.0 (2016); National Digital Economy Master Plan (2016–2020); Digital Economy Master Plan (2015)
Viet Nam	Prime Minister's Directive 16/CT-TTg on Strengthening Access to the Fourth Industrial Revolution (2017); Ministry of Industry and Trade's Decision 4246/QD-BCT (2017); Prime Minister's Decision 844/QD-TTg (2016); 2020 Broadband Plan (2016)

ICT = information and communications technology, IoT = Internet of Things, MoU = memorandum of understanding.
Source : Compiled by the authors from various documents.

4. National Targets for Resource Use Efficiency under the Circular Economy Paradigm

In developing circular economy policies that are based on resource efficiency principles, governments should include provisions for measuring baselines, quantifying problems, setting targets, and monitoring the progress towards achieving them through benchmarking. Quantitative targets and indicators are useful in determining the level of change required while also allowing for comparisons between companies or different government initiatives (Park, Sarkis, and Wu, 2010). At the same time, targets are useful at the national level to orient action by governments. Furthermore, indicators can help in measuring the progress of specific actions to improve resource efficiency against the predefined targets.

Recent reviews of resource efficiency in the fast-growing economies of Asia have shown that the definition of national quantitative targets is important to show ambition, create a commitment, and send clear policy signals for a circular economy. For example, the World Energy Council (2008) found that quantitative targets for improving energy efficiency could help avoid disjointed actions and provide a long-lasting context for energy efficiency policies. Setting energy efficiency targets can form the basis for monitoring national policy outcomes and tracking progress.

Resource efficiency targets must be sufficiently clear for key stakeholders, such as specific government agencies, industry, and consumers, to understand them and act on them. The targets should integrate different policy fields and provide verifiable interim results for material flow indicators and targets (Li et al., 2010).

A recent evaluation showed that several countries in the region have now adopted national energy efficiency programmes with quantitative targets. Yearly monitoring is usually a requirement of such programmes.

ASEAN has initiatives to measure resource efficiency across its national economy. Table 9.2 presents the national targets for achieving material, energy, and water efficiency in selected countries. Some countries have set ambitious resource productivity, recycling, and waste reduction targets in the water and energy sectors. The targets undergo yearly performance measurements and are supervised. Japan, China, and Singapore are other countries that have set targets in all three key areas of resource efficiency, which includes material efficiency. Overall, targets for achieving resource efficiency are more commonly used than material or water efficiency targets.

Table 9.2: Resource Efficiency Targets in ASEAN and East Asia

Country	Material Efficiency	Energy Efficiency	Water Efficiency
Philippines	Achieve a waste conversion rate of at least 25% by 2025	Reach average annual energy savings of 23 million barrels of fuel oil equivalent	
Singapore	• Reach 60% of household waste recycling by 2025 • Achieve a recycling rate of 70% by 2030	Improve energy efficiency by 35% from 2005 levels by 2030	Reduce domestic water consumption to 140 litres per person per day by 2030
Thailand		Reduce energy consumption by 13% in 2010 and 20% in 2020	Reduce water use by 10% between 2020 and 2030
Viet Nam		Reduce total energy consumption by 3%–5% (2010–2015) and then by 5%–8% (2015–2020)	

Source: Compiled by authors from various documents.

5. National Policy Initiatives for the Circular Economy

Comprehensive policies comprising both regulatory and market-based tools are needed to achieve the circular economy. Once goals and targets for resource efficiency have been set, governments need to assess what policy tools and instruments are available to achieve them and how these can be effectively implemented. Several recent reports discuss policy instruments that may be used to promote resource efficiency. Currently, governments have a wide choice of different instruments to formulate a sound policy framework for resource efficiency. In ASEAN over the past two decades, policy instruments have gradually evolved from traditional command-and-control regulations to economic instruments, information-based measures, and voluntary initiatives. An optimal mix of policy instruments will frequently include all four of these approaches. It is unusual for a single market-based policy instrument, such as extended produced responsibility, to operate in isolation in ASEAN countries (Walls, 2006). In most situations, a mix of instruments is used to tackle a specific circular economy problem. There are many advantages to using a mix of policy instruments, including: (a) accounting for the multi-aspect nature of circular economy challenges, (b) enhancing the effectiveness of one instrument with the help of another and vice versa, and (c) reducing administrative costs and improving enforcement possibilities (Yoshida, Shimamura, and Aizawa, 2007).

The challenge for policymakers in ASEAN is to select an appropriate combination of policy instruments to meet specific objectives while also having a positive economic and social impact. Policy instruments should be combined in a way that provides a balanced and sound approach to promoting resource efficiency while being tailored to the unique context of local or national conditions. They must also be mutually reinforcing and without perverse incentives.

To achieve greater resource efficiency, policymakers try to shift companies' or householders' actions from current wasteful practices to those that conserve resources. These attempts usually call for a twofold policy approach, which includes both measures aiming to phase out the undesirable product and behaviour as well as measures to increase the market for more sustainable products.

In addition, shifting from less desirable products and behaviours (laggards) to better ones (front runners) requires policies that stimulate innovation, both for individual products and at the system level. For example, in addition to improving the fuel efficiency of automobiles, there is also a need to support the development of new energy sources for vehicles, to facilitate the dissemination of social innovations such as car sharing, to improve public transportation systems as viable alternatives to cars, and to reduce mobility needs through better city planning.

There are four generic groups of policy instruments being adopted in ASEAN countries that can be used to promote the circular economy. It is important to note that it is usually difficult to categorise a policy measure as being purely 'regulatory', 'economic', 'information-based', or 'voluntary'. Instead, there is often overlap between them.

5.1. Regulatory Instruments

Traditional regulatory instruments set legal standards in relation to resource efficiency and performance, pressures, or outcomes. They are often referred to as command-and-control instruments in the economic literature and have traditionally been favoured by governments to carry out environmental policy. Regulatory instruments are policy mechanisms that are non-voluntary in nature and they compel resource use change by the threat of penalties for non-compliance. Penalties are set by legislation and are used to influence the behaviour of users by encouraging them to avoid punishment for non-compliance. Traditional regulatory instruments have several benefits, which explain their widespread use in circular economy policymaking. For governments, the setting of standards is inexpensive, and the goals for policy achievement are clear. They also impose minimum performance requirements and mandate compliance.

On the other hand, traditional regulatory instruments are often seen as inflexible and costly to enforce, and they provide incentives only to avoid penalties rather than to improve outcomes. Also, industries are reluctant to follow the regulations, arguing that uniform regulation ignores the unique situation of each company and imposes excessive costs due to the ineffective allocation of the compliance burden. This resistance can even make some regulations impossible to implement. The

shortcomings of traditional regulatory instruments and the difficulties of implementing them effectively do not imply that they should be avoided or replaced. Rather, it is important to develop more dynamic and flexible policy approaches to a circular economy. This can be achieved by combining regulatory instruments with other types of policy tools and by introducing regulatory instruments sequentially.

In recent years, we have seen a trend in the development and implementation of more innovative and flexible regulatory instruments to promote resource efficiency in other parts of the world, which individual countries can look into. They typically not only include standards on emissions or technologies and environmental liability but also extend producers' responsibility via product take-back, environmental controls, enforcement through permits and inspection by authorities, and other measures to mobilise public action to change the patterns of production and consumption in order to improve resource efficiency.

Many countries in ASEAN and East Asia region have introduced regulatory instruments to promote resource efficiency. These include: (a) laws and regulations to promote energy efficiency and renewable energy (for example, New Zealand's Energy Efficiency and Conservation Act 2000, Japan's Energy Conservation Law 1997 and 2008 and its Top Runner standard programme, China's Energy Conservation Law 1998 and 2008, and India's Energy Conservation Act 2001); (b) laws and regulations to promote resource efficiency and sustainable production and consumption (for example, Japan's reduce, reuse, and recycle (3R) laws and China's Circular Economy Law 2008 and Cleaner Production Law 2002); and (c) laws to promote low-carbon and green growth, such as Korea's Framework Act on Low Carbon and Green Growth initiated in 2009. These new regulatory instruments typically define various stakeholders' responsibilities (including those of governments at all levels, businesses, and consumers) and combine the traditional command-and-control and legal liability approach with economic instruments, information disclosure, and governmental procurement measures.

5.2. Economic and Market-based Instruments

The two most notable advantages of economic instruments over traditional regulation are their cost-effectiveness and their ability to provide incentives for innovation and improvement beyond a certain level of performance.

However, in order to obtain the desired effects, economic instruments usually require sophisticated institutions for implementing and enforcing the instruments, particularly in the case of charges and tradable permits.

Charges and taxes need to be collected, and monitoring is required to avoid 'free-riding' practices. Tradable permits are particularly challenging in implementation; creating a well-functioning market may require a fairly large administration, and the regulated entities usually need training in how to use the permit market effectively. Another drawback of economic instruments is that their effects on resource consumption are not as predictable as under a traditional regulatory approach. There are many different types of economic instruments, such as subsidies (including the removal of environmentally harmful subsidies), taxes (on emissions or products), rebates (on tax and purchases of resource-efficient products), tradable permits, and deposit refund schemes.

5.3. Information-based Measures

Information-based measures have become more popular in ASEAN recently. This is partly because of the lower costs of dissemination brought by information technology. These policy instruments provide information about the resource efficiency of certain products, services, or systems in a standardised manner so that consumers and investors can make more informed decisions. Approaches such as public information campaigns, eco-labelling schemes, research and development, and the public disclosure of a company's environmental performance are used to generate knowledge about the adoption of resource-conserving practices. Information-based measures may be mandatory or voluntary.

One of the advantages of information-based measures is their low implementation costs compared with the complex administration need for regulatory instruments. In addition, they can raise public awareness about more sustainable consumption patterns and provide incentives to companies for reducing their environmental burden in order to avoid competitive disadvantage. Information-based measures can also enhance the effectiveness of economic instruments, such as environmental taxes, especially if they convey information on private benefits. Conversely, the effectiveness of information-based measures largely depends upon the reactions of the information

recipients (Karl and Orwat, 1999). Approaches such as eco-labelling can be ineffective in markets where consumers have low awareness levels of environmental issues or where the amount of discretionary spending is low.

One of the most common information-based measures in ASEAN is the use of eco-labelling schemes. These schemes display information about the environmental performance of a product or service so that consumers can make informed choices when purchasing. Several states have introduced programmes to help create a market preference for resource-efficient products and equipment. For example, the Green Leaf Scheme has been developed to conserve resources, reduce pollution, and improve waste management. Environmental certification is awarded to products – such as refrigerators, computers, air conditioners, and building materials – which are shown to have the least detrimental impacts on the environment. Participation in the scheme is voluntary. Another regional example is Singapore's Energy Smart Building Labelling Programme, which seeks to promote energy-efficient buildings. This eco-label awards office buildings, hotels, and retail malls that perform in the top 25% in terms of energy efficiency within their cohort.

Education at the firm level and consumer level is another important information-based measure and is critical to the decision-making process. ASEAN countries have introduced educational programmes to enhance knowledge in their populations about resource-efficient behaviour. For example, the Government of Thailand introduced the 'Re-thinking Waste-in-Schools Education Programme' to promote awareness of resource efficiency issues within school communities. The Bureau of Energy Efficiency has proposed an environmental tax reform that entails a reconsideration of the present tax system. It seeks to use the revenue from environmental taxes to reduce the tax burden on beneficial economic activities, such as investment or employment. It thereby shifts the tax burden towards the 'bads', such as pollution, waste, and resource depletion and away from the 'goods' such as employment, income, and investment.

Opinions differ concerning the effectiveness of voluntary initiatives to achieve circular economy outcomes. On the one hand, voluntary initiatives are more flexible than traditional regulatory instruments.

Geller et al. (2006) found that voluntary agreements between governments and the private sector can be effective, especially in situations where regulatory instruments are difficult to enact or enforce. In Europe and Japan, for example, voluntary agreements have led to significant reductions in industrial waste use in a number of sectors.

In contrast, voluntary initiatives usually work well when people also have another incentive to change their behaviour. It is believed that voluntary initiatives are likely to be more effective if there is a threat of command-and-control regulation being put into use (Bengtsson et al., 2010). For instance, Price (2005) found that initiatives that combine voluntary efforts with a mix of incentives and penalties have higher participation rates and are generally more successful at meeting their predetermined targets.

Management standards, such as the ISO 14000 series, can also be understood as a voluntary initiative. Although such standards are not policy tools in a strict sense, they can be used by policymakers for circular economy goals, for example, by requiring all major suppliers and governmental agencies to be certified. In addition, ISO 14000 management systems require the certificate holder to identify key indicators of environmental impacts, set targets, and follow up on achievements.

Firm-based resource efficiency standards are also emerging as an important influence on the circular economy in ASEAN countries. These standards are uniformly applied to all plants worldwide and are not tied to the local regulatory requirements of the place where they are located. This typically means that a plant is required to go beyond compliance with local and national standards in order to meet firm-based global environmental standards. Economic globalisation is the underlying key driver for firm-based resource efficiency standards. There is also growing external pressure on firms and industries around resource efficiency and pollution issues, which makes firms face the risk of damage to their brand reputation (Angel and Rock, 2005). Nowadays, firms are challenged with managing complex global production networks at multiple sites of production with different regulatory expectations and with a need to respond to a variety of end-market regulations. As a consequence, firms are adopting their own global standards as a necessary way to operate their global production networks.

6. Current Sectoral Policies That Promote Resources Efficiency and Support the Circular Economy

6.1. Resource Efficiency

Resource efficiency can be defined as the amount of materials needed to produce a particular product. Material efficiency can be improved in two ways. First, by reducing the amount of materials contained in the final product. Second, by reducing the amount of materials that enter the production process but end up in the waste stream. Numerous countries in ASEAN have implemented national policies to promote material efficiency (Table 9.3).

Table 9.3: Examples of National Policies, Laws, and Regulations to Promote Resource Efficiency

Country	Policy Initiatives/Strategies
Cambodia	• Law on Environmental Protection and Natural Resource Management (1996) • Sub-decree on Solid Waste Management (1999)
Indonesia	• Environmental Protection and Management Act No. 32 (EPMA 32/2009) • Law No. 18/2008 on Municipal Solid Waste Management: 3R as the Principle Approach for Waste Management Law No, 33/3009 on Hazardous Waste • Government Regulation No. 81/2012 on 3Rs and EPR President Regulation No. 97/2017 on Policy and National Strategy of MSW • GP 101/204 Packaging under Law 18/2008; Government Regulation (e-waste) under Law 39/2009
Malaysia	• Solid Waste and Public Cleansing Management Act (2007): Aims to improve the collection, recycling, and disposal of solid waste. Prescribed recycling and separation of recyclables. • National Strategic Plan for Solid Waste Management (2005): Comprehensive efforts to promote the reduction, reuse, and collection of solid waste. There are eight regulations on 3R within the solid waste act. • Environmental Quality Act 1974
Philippines	• National 3R policies: Set the goal of achieving a waste conversion rate of at least 25% (2000). • Ecological Solid Waste Management Act (2000): Mandates management for 'zero waste' as a national policy. Requires local governments to recycle 25% of waste collected. • PD 1152 – Philippine Environment Code (1977), RA 8749- Philippine Clean Air Act of 1999 RA 9275- Philippine Clean Water Act of 2004

Country	Policy Initiatives/Strategies
Singapore	• Green Plan 2012: Has a 'zero landfill' objective. Includes a national recycling programme for households launched in 2001 with the target of 60% recycling by 2012. The recycling rate in 2009 was 57%, to 70% by 2030, with the goal of becoming a zero-waste nation. • Environmental Public Health (general waste collection) Regulations; Environmental Public Health (toxic industrial waste regulations)
Thailand	• Enhancement and Conservation of National Environmental Quality Act (1992), Factory Act (1992), and Public Health Act (1992); maintenance of public sanitary order Act 1992 • Regulation on National Waste Management System 2007, Draft WEEE Act, Draft Waste Management Act, Draft Promotion of 3Rs and Utilization of Waste • National Solid Waste Management Master Plan, Action Plan 'Thailand Zero Waste', 2016
Viet Nam	• National 3R Strategy: Sets 3R targets for 2020. • Environmental Protection Law (2005): Includes 14 provisions to promote 3R and related activities. • Law on Environmental Protection 2014 (amended in 2014) • National Solid Waste Management Master Plan to 2025, Vision to 2050

3R = reduce, reuse, recycle.
Source: Compiled by the authors.

Resource efficiency has also developed into an important issue for local governments, which introduced the smart city and eco-town concepts to support the circular economy and resource scarcity associated with rapid economic development. The smart city operation plan requires low resource consumption, low emissions of pollutants, and minimal waste discharge using the 3R principles. Smart city plans also recognise that the development of a circular economy is an important strategy for economic and social development, and industrial enterprises are required to reduce resource consumption and recycle waste materials (Organisation for Economic Co-operation and Development, 2016). The governments also allocate funds for businesses to encourage innovation in recycling technologies. Furthermore, the central government provides tax breaks to enterprises using resource-efficient technologies and equipment. The enforcement of smart cities requires the enactment of supporting regulations; some of these have been enacted while others are still being drafted. Another important future step outlined in the law is the development of a Smart City Development Plan, which will outline the major tasks and measures necessary for achieving a circular economy. In addition, it will define indicators for the rates of waste reuse and recycling.

6.2. Energy Efficiency

Energy efficiency is associated with economic efficiency and includes technological, organisational, and behavioural changes towards a circular economy. The introduction of energy efficiency policies brings multiple benefits to national economies. The industry sector in ASEAN countries accounts for about 30%–45% of total commercial energy consumption. It is one of the largest contributors to carbon dioxide emissions after the power sector. A broad analysis of industrial energy-use patterns shows that seven sectors account for about 60% of industrial energy consumption: (a) cement, (b) pulp and paper, (c) fertiliser, (d) iron and steel, (e) textiles, (f) aluminium, and (g) chlor-alkali. Most of the plants in these sectors are large units, and few of them are operating under the public sector. Although no detailed baseline of energy consumption data for industrial consumers is available from a single source, it has been found from several individual studies that significant potential exists for energy efficiency improvements in industry. Various energy sector studies also show that there are wide variations in specific energy consumption (energy required to produce one unit of the product) within the same industrial subsector using comparable technology. Though some units exhibit energy efficiency levels that are at the global frontier, a large number of units operate at much lower energy efficiencies. This indicates that there is substantial scope for energy efficiency improvements within industrial sectors.

Table 9.4: Examples of National Policies, Laws, and Regulations to Promote Energy Efficiency

Country	Policy Initiatives/Strategies
Indonesia	National Energy Policy (2006): Framework policy that seeks to increase energy efficiency and promote renewable sources of energy.
Malaysia	10th Malaysia Plan (2011–2015): Includes energy efficiency objectives, such as intensifying energy efficiency initiatives in the industry, transport, and commercial sectors, also promoting the greater use of renewable energy for power generation and by industry.
Philippines	• National Energy Efficiency and Conservation Program (2004): Seeks to achieve the efficient use of energy to minimise environmental impacts. Target to achieve average annual savings of 23 million barrels of fuel oil equivalent and 5,086 gigatonnes of carbon dioxide emissions avoidance. • Philippine energy efficiency Project (2009–2013); Lighting Industry Waste Management Guidelines

Country	Policy Initiatives/Strategies
Singapore	Energy Efficient Singapore Strategy (2009): Promotes the adoption of energy-efficient technologies and measures by addressing market barriers to energy efficiency. Builds capacity to drive and sustain energy efficiency efforts and to develop the local knowledge base and expertise in energy management. Raises awareness amongst the public and businesses to stimulate energy behaviour and practices. Promotes research and development to enhance Singapore's capability in energy-efficient technologies.
Thailand	• National Energy Strategy (2005): Key component was the efficient use of energy to reduce energy consumption by 13% by 2008, by 20% by 2009, and by 50% by 2030. • Energy Conservation Promotion Act (1992, revised in 2007): Promotes the use of energy-efficient materials and equipment by setting energy-efficient standards. • National Energy Policy and Development Plan (2006): Seeks to promote energy efficiency by setting standards for energy-intensive appliances and the labelling of products. • The National Integrated 5-Year Plan (2014–2021) on the Management of Waste Electrical and Electronic Equipment (WEEE) (2015)
Viet Nam	• National Energy Efficiency Program (2006–2015): Seeks to coordinate efforts for improving energy efficiency, reducing energy losses, and implementing extensive measures for the conservation of energy. • Law of Energy Conservation and Efficiency Use (2011–2015): Target to reduce total energy consumption by 3%–5% (2006–2010) and then by 5%–8%. • 16/2015/QD-TTg (batteries, lubricant oils, and end-of-life vehicles

Source: Compiled by authors.

7. Conclusion

With rapid economic growth, the resource consumption rate has increased greatly in ASEAN and East Asia. Soon, most of the countries will be facing formidable challenges in resource shortages. Therefore, implementing circular economy principles along with Industry 4.0 is crucial for Asia's process industries and municipal governments. Based on the meta-analysis in several economies of the region, it is understood that governments have instituted the basic policies for developing Industry 4.0 and a circular economy, with the aim of improving the efficiency of resources and energy and thereby achieving sustainable development.

Based on the trajectory of Industry 4.0-readiness and circular economy-enhancing initiatives, three stages of transformation can be conceptualised. The first stage is to implement initiatives on the areas of ICT, national broadband, and e-government. These are typically conducted by countries that just embark on their journey in the

digital economy. National broadband initiatives usually give a focus on broadband access, both coverage and affordability. E-government has also been identified as a focus area in 'early stage' initiatives. These include Cambodia's ICT Masterplan 2020, Lao PDR's E-government Development Plan (2013–2020), and Myanmar's E-government Masterplan 2016–2020.

The second stage is to deliver a specific initiative on Industry 4.0 and a major national initiative on digital strategy for those at a later stage of Industry 4.0 readiness-enhancing development. In ASEAN, these include Thailand 4.0 and Making Indonesia 4.0, and ongoing efforts by Malaysia to develop the National Industry 4.0 Policy Framework as well as Brunei Darussalam's National Digital Strategy 2016–2020, the Philippines' Digital Strategy 2011–2016, and Viet Nam's Prime Minister Directive 16/CT-TTg on the Strengthening of the Ability to Access the Fourth Industrial Revolution. For the case of Thailand, however, Thailand 4.0 as an aspirational economic model came relatively early in the journey and has later driven the development of strategies such as those on digital government that were implemented by other ASEAN countries in the earlier stages.

The third stage focuses on more advanced technology-specific initiatives or themes. This is done by advanced countries such as Singapore, which is currently undertaking initiatives in areas such as artificial intelligence, robotics, IoT, advanced manufacturing, and smart nation. Other countries, such as Malaysia and Thailand, have also commenced similar initiatives, such as Robotics Malaysia, which is a government-academia-industry collaboration project to develop the resources needed to develop a sustainable robotics industry in Malaysia, and the setting up of the Center of Robotic Excellence in Thailand to develop at least 150 prototype robots.

However, more attention is needed for setting the targets, identification process, and institutional integration of Industry 4.0 for the circular economy. Traditionally, creating economic value and promoting environmental stewardship have been regarded as a zero-sum game. One important way of escaping this zero-sum game is to use innovative financing and an integrated policy approach involving the application of regulatory, economic, and voluntary policy instruments, as demonstrated by progress in implementing policies that support Industry 4.0 circular economy concepts.

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